Master's Thesis

Master Innovation Sciences

Directionality in mission-oriented innovation:

an assessment of the directionality challenges in the mission towards a carbon-free electricity system in the Netherlands

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by

Jeroen van der Teems

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Supervisor
Prof. dr. Koen Frenken
Full Professor in Innovation Studies
Copernicus Institute of Sustainable Development, Utrecht

Internship supervisor
Evy Beekers, MS
Consultant Strategy & Innovation
KPMG, Amstelveen, Netherlands

Second assessor
Dr. ir. Matthijs Janssen
Assistant Professor
Copernicus Institute of Sustainable Development, Utrecht

Jeroen van der Teems

Innovation Sciences
Universiteit Utrecht

Student number
5642140

Correspondence via:
Jeroenvanderteems@gmail.com

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Abstract

Background. Mission-oriented and transformative innovation policy are increasingly gaining attention from policymakers, particularly in the light of grand societal challenges. Societies are faced with major challenges such as climate change and ambitious goals are set to address those challenges. This also implies a larger responsibility for policy makers to set directions in which socio-technical transitions need to move to address the societal challenges.

Theory. Providing such directions is coined *directionality*. Apart from that the interpretation of what directionality entails differs between literature streams, there is currently also little empirical evidence on how directionality manifests itself in practice or how practitioners can achieve directionality in practice. In order to provide more guidance and aid in the understanding of what challenges may emerge during the process of translating societal goals into actionable policy, a conceptual framework was created to identify directionality challenges.

Aim. The aim of this study was to apply the framework to a new case study, namely the mission towards a carbon-free electricity system in 2050 in the Netherlands. This mission contributes to the overarching Dutch climate goals to become climate by 2050. This mission is exceptionally well suited for assessing directionality, considering that the energy transition has an impact on entire societies and thus arguably requires the right directions at the right times. In addition, this study also contributes to literature by applying the framework to a novel case, and it contributes to the understanding of practitioners what directionality challenges they may face.

Method. A combination of desk research (policy briefs, reports, official documents) and 18 interviews with relevant stakeholders were utilised to assess the directionality challenges that are experienced in the context of the mission.

Results. A total of ten directionality challenges were identified: handling goal conflicts, defining system boundaries, identifying realistic pathways, formulating strategies, realising destabilisation, nurturing public engagement, mobilising relevant policy domains, identifying target groups, accessing intervention points, and governance. The new 'mission governance' that built upon the existing Top Sector governance was found to be unclear.

Discussion/Conclusion. Goals are clear to an extent, though there is demand for more directionality to be provided by the government. As many activities are currently undertaken in a sectoral perspective, there is a need for a more integrated approach that goes beyond sectoral or policy domain boundaries. The Netherlands is making efforts to facilitate this through national plans.

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1. Introduction

Recently, the goals and practices of innovation policies have evolved to encompass addressing societal challenges, particularly in the form of sustainable transitions. Growing global recognition of the importance of sustainable development is marked by a shift in paradigmatic thinking and becomes increasingly prevalent through political agendas, such as the European Green Deal. The urge for transformative change in industrial societies is not necessarily a new phenomenon. The seminal work of Meadows et al. in 1972, "The Limits to Growth," argued that sustainable management of growth would be necessary to prevent ecological and economic collapse in the 21st century (Meadows et al., 1972). The report generated significant public attention and has been influential in shaping debates on sustainable development and environmental protection. Innovation is recognised as a means to achieving transformative change (Haddad et al., 2022). Nevertheless, individual product or process innovations at the firm level alone may not be sufficient to achieve long-term change. Instead, reconfigurations of actors, institutions, and practices in entire production and consumption systems may be required to achieve meaningful socio-technical transitions (Weber & Rohracher, 2012).

In order to address grand societal challenges, transformative change may thus be necessary, which differs from conventional innovation policy. To date, three frames of innovation policy have been identified, each with distinct models of innovation and actor roles (Schot & Steinmueller, 2018). The first frame, established after World War II, focused on government support for science and R&D as a means of promoting growth and addressing market failures. The second frame emerged in response to the globalisation of the world in the 1980s. Innovation policy within the second frame emphasised competitiveness and national systems of innovation. The third frame emerged recently since social challenges, such as the Sustainable Development Goals (United Nations, 2015), have entered the policy arena. The premise that innovation per se does not equate social advancement and that innovation may be related to externalities calls for transformative change and highlights the shortcomings of previous innovation policies in addressing sustainability. Historically, innovation policies primarily focused on promoting economic growth and fostering the capability of national economies or industrial sectors to generate innovations. While certain challenges are yet to be overcome (Alkemade et al., 2011), innovation policy is undergoing a shift in focus (Wanzenböck et al., 2020). This change has given rise to a resurgence of interest in mission-oriented innovation policy (MIP), which has its roots dating back to the 1960s and 1970s and has previously tackled significant technological challenges such as the Apollo – or "man on the moon" – mission (Mazzucato, 2018b). Today, MIP addresses issues such as ageing, climate change, energy security, environmental sustainability, food security, and health (European Commission, 2011; Larrue, 2021a; OECD, n.d.).

In order for missions to succeed, missions benefit from clear directionality (Bergek et al., 2023; Janssen et al., 2020; Parks, 2022; Wanzenböck et al., 2020; Wesseling & Meijerhof, 2021). Weber and Rohracher (2012, p. 1042) define directionality as promoting innovations that "contribute to a particular direction of transformative change." However, directionality in transformative change does not exist in isolation and does not imply only a single pathway is suitable to meet missions. Rather, it is one element alongside demand articulation, policy coordination, reflexivity, and experimentation (Grillitsch et al., 2019; Schot & Steinmueller, 2018; K. M. Weber & Rohracher, 2012). Little empirical evidence currently exists about how directionality is implemented (Parks, 2022).

Research aim

In this study, we aim to explore the directionality and associated challenges for the mission towards "an entirely carbon-free electricity system by 2050", one of the missions in the Dutch Mission-oriented

Topsector and Innovation Policy (MTIP) (Ministry of Economic Affairs and Climate Policy, 2019b). The central research question holds:

> ***How can mission-oriented innovation policy be improved by learning from the directionality of the transition of the electricity system in the Netherlands?***

In order to answer the main research question, it has been divided into more concrete sub-questions as outlined below.

1) *How is the focal mission currently governed in the Dutch MTIP?*

The first sub-question provides a factual foundation for how the mission is currently governed within the Top Sectors. This is relevant as the Top Sectors used to be primarily responsible for stimulating innovations within the respective sectors. When the missions were introduced in 2019, a 'mission governance' structure was added on top of the existing structure, which creates a complex 'mission arena' (Wesseling & Meijerhof, 2023). It is therefore relevant to assess how the governance has been, and is, perceived. The participation of a wide variety of stakeholders is considered to be vital for both the direction and legitimacy of MIP (Wanzenböck et al., 2020). Considering that MIP shapes new roles and responsibilities, it is critical to review the perceived roles that stakeholders fulfil in the system (Braams et al., 2021; Mazzucato, 2015). This may indicate alignment – or misalignment – of theory with practice.

2) *What directionality challenges do policy makers face in the Dutch energy transition?*

In this study, we conceptualise mission directionality as a series of "translation steps", applying the directionality framework by Bergek et al. (2023) to the Dutch mission to transform the electricity system. The framework will highlight strengths and weaknesses with regard to directionality challenges that policy makers may face in transformative policy. In short, this means we will evaluate the policy objectives, logics, domains, and leverage within the mission to identify what challenges are encountered. Furthermore, it contributes to the empirical validation of the new framework.

3) *How can the mission directionality be improved?*

Finally, we will build on all the knowledge retrieved through the preceding sub-questions to present a holistic and formative synthesis of how the mission is currently directed and what directionality challenges are encountered. Consequently, this synthesis aims to derive conclusions and formulate recommendations as to how the implementation of mission directionality can be further improved.

Relevance

A formative assessment of the transition of the electricity system in the Netherlands is crucial (ter Weel et al., 2022). The proposed analysis in this study in not exhaustive, but will provide an early reflection of the lessons learned in the first four years since the start of the mission in 2020. The transition plays an important part in reducing greenhouse gas emissions, considering that 35% of all CO_{2eq}-emissions in the Netherlands come from the energy industries (European Commission & Directorate-General for Energy, 2022); globally, 70% of said emissions are considered to be part of the energy sector, accounting for industries, transport, and heating (Ritchie et al., 2020). Electrification in the Netherlands is undergoing rapid development, e.g., indicated by a relatively high adoption rate of electric vehicles (ICCT, 2021), an increasing annual electricity consumption (CBS, 2022a), and a recent report by the main grid operator TenneT that the Dutch electricity network is under high pressure (TenneT, 2023a). Furthermore, projects to expand the electricity network are delayed due to conflicting policy to reduce nitrogen emissions (Netbeheer Nederland, 2023a), and the Dutch government has recently indicated that the governance model and involvement of stakeholders within the Dutch MTIP shall be reviewed (Ministry of Economic Affairs and Climate Policy, 2022a). Moreover, this study aims to fill the gap in literature on how directionality is implemented (Parks, 2022). These factors combined mandates an assessment of the mission directionality.

Reader guide

In Chapter 2, the theoretical framework will be discussed. The concept of *directionality* will be explained by exploring the innovation and transition literature streams, followed by reasoning as to why it is relevant to place directionality at the core of this study. In Chapter 3, the context in which this study was placed will be highlighted, including the focal mission and the broader policy frames it is embedded in. Next, the used methodology will be explained in Chapter 4, followed by the results in Chapter 5. In Chapter 6, as the end of the first term of the innovation programmes is approaching, the experiences of the MTIP – particular in relation to directionality – were briefly assessed. Synthesising the findings, in Chapter 7 overarching themes are highlighted, placed into perspective, and further discussed, as well as their meaning and implications. Finally, in Chapter 8 the final conclusions are drawn.

2. Theoretical framework

2.1 From market fixing to market creating

The market failure theory posits that government intervention in the economy is only legitimate if it seeks to correct instances in which markets are unable to allocate resources efficiently (Arrow, 1951). This intervention thus aims to fix markets that are characterised by externalities, which – for example – can be the case with public goods, basic research, and environmental pollution. Public goods, which are non-rivalrous and non-excludable, may not or only little be invested in by private firms as they are unable to reap the benefits from them; the same principle applies to basic research that is difficult to be appropriated, and in the case of environmental pollution, firms may be forced to internalise the costs of that pollution through a carbon tax.

In addition to market failures, Klein Woolthuis et al. (2005) distinguishes four main types of system failures: infrastructural, institutional, network interaction, and capabilities failures. System failures are based on national innovation systems that are not effective due to issues within the system, for instance, a lack of knowledge and competencies (i.e., *capacities failure*) may pose a bottleneck to innovation. On top of that, Weber and Rohracher (2012) define a third form of failures, called 'transformational failures'. Transformational failures include the elements that cause systems to remain in the status quo, and are thus unable to transform to the desired configuration needed to address societal challenges. These failures include directionality, demand articulation, policy coordination, and reflexivity failures.

Mazzucato (2016) argues that public policies are aimed too much at fixing markets, rather than creating new ones. Instead, in order to address societal challenges such as climate change or energy, a market-creating view of policy is necessary. In this view, the state takes on a more active role in directing and transforming existing markets or creating new ones in the light of societal needs. This can be especially helpful in markets that are locked-in to certain trajectories that halt the desired transformative change (Unruh, 2000). Such policy would not depend on the market as a means to achieve transformative change, but rather redefine the market as an outcome itself. Mission-oriented innovation systems and policy aim to address aforementioned barriers and difficulties to achieving systems innovation (Hekkert et al., 2020; Mazzucato, 2016). Directionality is one of the key elements in mission-oriented innovation systems and policy (Janssen, 2020; Wesseling & Meijerhof, 2023).

2.2 Directionality

Directionality concerns the direction of innovations and targeted reconfiguration of socio-technical systems, and thereby goes beyond the traditional, more open-ended and generic innovation policy that aims to foster economic growth, national competitiveness, and innovation in general, for example by stimulating investments in R&D (Schot & Steinmueller, 2018). Instead, science, technology, and innovation policies are increasingly oriented towards addressing grand societal challenges, such as climate change (Hekkert et al., 2020; Wanzenböck et al., 2020).

A key element of mission-oriented innovation policy and transformative innovation policy is considered to be directionality (Hekkert et al., 2020; K. M. Weber & Rohracher, 2012; J. Wesseling & Meijerhof, 2023). Although both literature streams recognise the importance of directionality, they differ in how directionality is defined and what role it plays in policy (Haddad et al., 2022). In transformative innovation policy, directionality follows from policy that determines solution pathways that should lead to the desired socio-technical change the policy aims to address, particularly when little consensus among relevant stakeholders is present as to what direction is desirable. In other words, directionality in this context arises from an inability of regime actors to address transformative needs, which consequently requires (top-down) policy interventions to apply pressure on the regime while enabling the development and upscaling of innovative niches (Kivimaa & Kern, 2016; Steward, 2012); this implies that ideally solutions arise from the bottom-up and policy serves as a corrective means. In mission-oriented innovation policy, directionality is set in a more proactive manner by pre-defining specific missions that should provide the direction towards the supposed change. This implies an ex-ante top-down approach wherein solutions do not necessarily originate from within the system that is supposed to change. Mazzucato (2016), for instance, describes this notion as 'market creating', thus moving beyond the traditional, reactive 'market fixing' rationale. In that context, governments would aim to shape the enabling conditions by which future markets can be shaped, for instance, by "*tilting the playing field in the direction of the desired goals*" (Mazzucato, 2018a) to create expectations and drive private investment. Nevertheless, during the process of identifying and selecting acceptable solution pathways, bottom-up involvement of a variety of actors plays a role in mission-oriented innovation policy as well, for instance, to strive towards policy that is supported by a broad range of relevant stakeholders and to allow for contestation processes (Kattel & Mazzucato, 2018). Moreover, as in transformative innovation policy, interventions may take place during the implementation of the mission as priorities shift and solutions evolve and develop further, which may give rise to alternative solution pathways (Mazzucato, 2018). As such, scholars have drawn attention to the relevance and importance of reflexivity for mission-oriented innovation policy (Wesseling and Meijerhof, 2023).

The concept of working with missions has recently gained traction in the field of innovation policy, which aims to provide guidance to actors within the relevant systems (Mazzucato, 2016, 2018; Hekkert et al., 2020, Wanzenbock et al., 2020; Haddad et al., 2022). Indeed, some argue that directionality may well be the most fundamental implication of missions (Mazzucato, 2018; Robinson and Mazzucato, 2019), which could be explained by the notion that directionality in mission-oriented innovation policy focuses on providing directions through ambitious, actionable, measurable, and time-bound goals (Mazzucato, 2018; Janssen et al., 2020; Wanzenbock et al., 2020). In comparison, transformative innovation policy typically tends to be more open-ended and bottom-up, although this does not imply that transformative innovation policy cannot be directional or that missions cannot be open-ended and bottom-up either; this depends on the objective and context in and for which the policy is developed (Haddad et al., 2022; Schot and Steinmueller, 2018; Wanzenbock et al., 2020).

Transformation failures

Weber and Rohracher (2012) introduced the concept of transformation failures to legitimise government intervention, in addition to market and system failures (Klein Woolthuis et al., 2005), as they argued that market and system failures – albeit being useful and valid – are "*confined to addressing structural deficits in innovation systems, and do not give sufficient justice to the kinds of arguments from the multi-level perspective that have been identified at preventing processes of transformative change from occurring in a socially and politically desirable way*" (Ibid, p. 1042). In other words, they provided a novel view on the underlying rationales to ground innovation policy (Haddad et al., 2022). It is important to realise that the concept of 'failures' presupposes ideal markets or systems, which may be affected by deficiencies or shortcomings. From an evolutionary standpoint, some failures might as well be normal tensions, both as a result of market or system dynamics or due to processes of change (Weber and Rohracher, 2012). In this context, partly effective but suboptimally performing transitions may nevertheless still be experiencing elements that could therefore be classed as a 'failure'. This term is embedded in policy-making and economics. One type of transformation failure that Weber and Rohracher (2012) identified was the failure of directionality, which refers to societal challenges that require transformative change in a particular direction but suffer from a lack thereof. In such a context, direction is needed to develop acceptable long-term solution pathways, concentrating research efforts to "*enable cumulative knowledge development and learning*" (Ibid, p.

1042), and stimulating innovation activities through setting collective priorities and strategic policies; accounting for the fact that stimulating innovations in general, i.e. innovations without a particular direction, will not all be helpful in addressing the grand challenge. An example of such direction can be seen in the current debates about climate change, for instance the debates about how our energy systems will – or rather, should – look like in the future. In an attempt to address climate change, current debates argue for transitioning from energy forms that rely on fossil fuels to sustainable and renewable energies. In this context, the strategic direction of innovations could therefore include the explicit prioritising of (research) projects on sustainable energy rather than stimulating projects that aim to improve current situations. While one could argue that improving is positive by definition, in the context of directionality failure, the latter does not necessarily hold up as that could also include projects (considering directionless policy would stimulate any form of innovation) that aim to improve the energy efficiency of fossil fuel sources. As such, the outcome of the latter would be positive on the one hand (improved energy efficiency), but on the other hand continue to support socio-technical configurations that are no longer considered to be sustainable (negative); in other words, it would fail to contribute to the desired transformative change. Overcoming directionality failures call for improved governance, including new constellations of actors (Kuhlmann & Rip, 2014), and "*require clear articulation of broad societal and socio-economic challenges for which concrete actions can be supported to contribute towards desired transformative change*" (Robinson & Mazzucato, 2019, p. 938). As grand challenges can be broad and therefore lack a sufficient scope, a key step towards providing directionality is translating the societal challenge into concrete problems (Robinson and Mazzucato, 2019) and determine the system boundaries of the system that is supposed to undergo the desired change (Bergek et al., 2023).

Directionality failure may sometimes be confused with market failures. For instance, anticipatory myopia refers to situations in which organisations underinvest in their ability to identify and pursue new long-term opportunities (Salmenkaita & Salo, 2010). The latter is sometimes mentioned as an example of a lack of directionality (Könnölä et al., 2021), while it rather addresses a market failure that justifies more investment in R&D without implying a specific direction of change (Weber and Rohracher, 2012). Other market failure arguments, such as corrective measures to curb negative externalities including carbon pricing through the EU Emissions Trading System (EU-ETS), may contribute to particular directions by favouring and disfavouring select configurations, although conceptually not providing the required orientation in terms of specific priorities (Weber and Rohracher, 2012). Weber and Rohracher (2012) therefore argue that technology-specific policies – rather than technology-neutral policy – are required to provide explicit direction, which is supported by literature on environmental innovation and societal transitions (Azar & Sandén, 2011; Jacobsson & Bergek, 2011). Nevertheless, depending on the focal challenge that the mission or transformation aims to resolve and the used framing, a particular (set of) solutions will inevitably be favoured over others (Azar and Sandén, 2011; Wesseling and Meijerhof, 2023). As such, the set of solutions that emerge may be shaped intentionally as well as involuntarily (Schlaile et al., 2017). In addition, shared visions with regard to future configurations are to be established to overcome directionality failures (Weber and Rohracher, 2012). Looking again at the example of energy systems, this implies the development of guiding visions as to how our future energy system looks like, what technologies are to be included or excluded, how the infrastructure should be laid out to support those technologies, and so on, which are shared among relevant stakeholders that are capable of implementing those visions; in short, the visions should provide orientation for policy development.

Addressing directionality goes beyond vision-building

Vision-building alone, however, is not sufficient with regard to directionality; it also requires coordination across the relevant stakeholders as societal challenges such as climate change are ‘wicked’ problems that are characterised by contestation, complexity, and uncertainty (Weber and Rohracher, 2012; Wanzenbock et al., 2020). Therefore, stakeholders may have varying (conflicting) opinions and problem and solution divergence may be high, resulting in a lack of consensus on the particular direction to take (Wanzenbock et al., 2020). This type of coordination, allowing for bottom-up influence and negotiation and deliberation processes to develop a broadly supported and shared policy direction, is one way to go about addressing directionality (Schot & Steinmueller, 2018; Weber and Rohracher, 2012). A different method implies more top-down guidance by policy makers. As mentioned earlier, when it comes to grand challenges, not all innovations may be helpful or could even result in worse outcomes than anticipated (Schot & Steinmueller, 2018). In the context of directionality, top-down guidance could be provided by policy makers assessing the societal consequences of possible solution pathways, followed by making explicit choices as to what pathways and innovation activities are (socially) acceptable and desired to address the challenge at hand, as well as making decisions on phasing-out unsustainable paths (Bergek et al., 2023; Foray, 2019; Hausknost & Haas, 2019; Mazzucato, 2016). This implication demonstrates the political nature that comes with providing directionality (Grin et al., 2010; Hausknost & Haas, 2019; Jacobsson & Lauber, 2006), considering that making such choices will inevitably result in picking ‘winners and losers’ and may result in contestation from the latter group, such as incumbents that prefer to maintain the current socio-technical regime (Kuzemko et al., 2016; Wanzenböck et al., 2020). In the ‘political arena’ that follows, power and agency play an important role in determining the direction that is ultimately taken (Haddad et al., 2022). Power and agency are bidirectional in this context. For instance, on the one hand, incumbents that are challenged by particular policy directions can employ inertia, push their own agendas, and use agenda-setting strategies in an attempt to stop or slow down the desired socio-technical change; on the other hand, incumbents can be engaged or stimulated (both voluntarily and involuntarily) to support and implement the desired changes (Haddad et al., 2022; Johnstone et al., 2017). Alternatively, incumbents could be replaced by new entrants, for example through what Schumpeter described as the process of *creative destruction* (Kivimaa and Kern, 2016) or what Johnstone et al. (2017) referred to as *destructive recreation*.

Directionality in policy instruments and innovation systems

Implementing directionality in practice can be achieved through a mix of policy instruments, such as information (e.g., by allowing consumers to make better-informed choices), financial incentives (e.g., subsidies, R&D programmes, fiscal benefits), voluntary agreements (e.g., firms shaping shared visions to give rise to new markets), tradable permits (e.g., carbon pricing through EU-ETS), taxes and charges (e.g., taxes on unsustainable energy technologies based on carbon emissions), and regulations and standards (e.g., setting maximum emission levels by law) (Gupta et al., 2007). Instruments may prove to be useful for guiding the direction of change (Weber and Rohracher, 2012), which in the innovation sciences literature is recognised as one of the functions that are important for innovation systems to perform well (Hekkert et al., 2007). Hekkert et al. (2007) describes the function as the “*activities within the innovation system that can positively affect the visibility and clarity of specific wants*” (Ibid, p. 423), which can be influenced by societal preferences and choices over resource allocation. The function operates within a spectrum where it’s both influencing and influenced by other innovation system functions. In other words, innovation system functions are likely to interact and have effects on the fulfilment of other functions, leading to feedback loops that Hekkert et al. (2007, p. 426) call “*motors of change*”. A typical example of a positive feedback loop in the field of sustainable energy is the setting of visions or targets, such as reaching a particular share of renewable energies by a specific year in the future to limit greenhouse gas emissions. This provides legitimacy and incentives to allocate resources to facilitate knowledge creation and experimentation, leading to new expectations about technologies and entrepreneurial activities to valorise and implement the raised knowledge. The feedback loop can also become negative, for example, when expectations are high but performance turns out to be disappointing during demonstration projects; in such cases, entrepreneurial activities and legitimacy may decrease, resulting in less allocation of resources and less knowledge development (Hekkert et al., 2007). When it comes to providing directionality through policy instruments, the instruments serve to identify and stimulate particular paths that are considered acceptable and/or desirable to bring about the socio-technical change it seeks to realise (Weber and Rohracher, 2012). Depending on the complexity of the focal problem or system at hand, single policy instruments may not be sufficient to provide the required guidance and direction; instead, a portfolio of instruments – or policy mix – may be needed (Kivimaa & Kern, 2016; Rogge & Reichardt, 2016; K. M. Weber & Rohracher, 2012).

This is particularly the case for societal grand challenges such as the Sustainable Development Goals, considering it spans many facets across various systems and domains, and touches upon a large number of aspects that are important to the functioning of society. Schot and Steinmueller (2018) therefore argue that the conventional innovation policy frames, which were primarily aimed at stimulating research and development and national systems of innovation, are no longer able to address these grand challenges and the externalities they bring about. In order to address them, Schot and Steinmueller (2018) describe a third frame that is emerging and focuses on socio-technical system change by drawing attention to anticipation, experimentation, participation, and directionality. In this context, they refer to the directionality failure that Weber and Rohracher (2012) described in their transformative failures framework. Addressing directionality failures is a difficult and complex task according to Schot and Steinmueller (2018). The transformative change frame takes directionality as the starting point to determine what is necessary to bring about the desired socio-technical system change. Part of the challenge here is what Weber and Rohracher (2012) describe as the importance for policy makers to set collective priorities and make choices over acceptable development paths, as described earlier, to inform and incentivise other actors into contributing to that path. This implies the political process of stabilising and destabilising i.e., making explicit choices what options may be included and what options are to be excluded or phased out (Alkemade et al., 2011; Turnheim & Geels, 2012). We also described that such choices may be contested as deliberation and negotiation processes could very well highlight diverging views and thus lead to conflict. Stirling, 2009) embraces the notion of having a diverse set of options available to avoid making explicit choices too early on and highlights the importance of approaching the challenge with an open mind and with mild guidance (Hekkert et al., 2020), including looking at options beyond the boundaries that incumbents set. In that sense, directionality is not necessarily about converging towards a particular (set of) options, but also about diverging and opening up innovation policies to include a variety of different pathways; this implies a dynamic nature of directionality, wherein the level of guidance and normativity may depend on the specific objective, context, and transition phase (Elzen et al., 2011; Hekkert et al., 2020; Rotmans et al., 2000; Schlaile et al., 2017). Opening up innovation policies and allowing for a greater diversity of options may be helpful in early stages to nurture opportunities to challenge the status quo and dominant (possibly locked-in) views of the socio-technical system of interest. Indeed, providing directionality is not a single transaction. Rather, it involves a long-term process during which newly configured structures and institutions will need to emerge and sustain to give rise to the desired socio-technical system configurations (Janssen et al., 2020). The process of opening up also implies exploring for long-term structural solutions rather than committing fully to short-term solutions (or 'quick wins'), which in the long term may not yield the desired performance result or even reinforce undesired lock-ins (M. J. Janssen et al., 2020). However, at some point, (final) options will need to be selected to bring about a converging view of the desired system elements. This can be partly explained by taking into account the concept of innovation system functions that were described earlier (Hekkert et al., 2007). Convergent views will result in a stronger guidance of the search function, leading to concentration of knowledge development, resources, and build-up of capabilities in the areas that are most promising to accelerate progress towards meeting the challenge (Hekkert et al., 2007; Wanzenbock et al., 2020). This, in turn, may also lead to other positive feedback loops within the innovation system, including providing markets (formation) more legitimacy. An important aspect to realise is that given the complexity of societal challenges such as the Sustainable Development Goals, there will likely need to be a mix of solutions rather than a 'one-size-fits-all' solution, and there may be overlap between both options and challenges. Policies that are aimed at socio-technical changes therefore may face complex ex-ante and continuing trade-offs between views and options Schot and Steinmueller (2018). According to Grin et al. (2010), varying views during a transition are not required to be completely compatible with one other. Rather, it is more fruitful to focus on the common elements that stakeholders share. Finding a balance between the available options and providing directionality as to what options to pursue has been identified as a challenge for practitioners (J. H. Wesseling et al., 2020).

Is directionality convergent or divergent, or both?

That problems and solutions can be both divergent and convergent is also argued by Wanzenbock et al. (2020), who recognise that the character of innovation policy is shifting from being mostly 'neutral' to becoming more directional programmes (Mazzucato, 2013, 2016) that formulate societal needs and their articulation into demand (Boon & Edler, 2018) and break up path dependencies in the existing system (Schot and Steinmueller, 2018). They view societal problems and solutions along three dimensions of 'wickedness': contestation, complexity, and uncertainty (Wanzenbock et al., 2020; see also Alford & Head (2017)). In the previous paragraph, we outlined our interpretation of situations in which diverging and converging views may play a role. Wanzenbock et al. (2020) follows a similar explanation, by characterising divergent problems and solutions as contested, complex, and uncertain, while convergent problems and solutions are characterised as uncontested, well-defined, and informed. Put differently, for scenarios where there is a collective understanding of a convergent problem, articulating well-defined and accessible research and innovation objectives, as proposed recently by Mazzucato (2018), may indeed serve as an effective tool for targeted transformation. This approach facilitates the translation and operationalization of a shared vision for the future into tangible missions and projects, complete with explicit goals and target values that are achievable and consonant with the desired future state. However, the question of how innovation can aid in realising these missions remains unresolved and uncertain at this stage, necessitating exploration and experimentation with various solution types before settling on a predominant set of solutions. Based on the ensuing problem-solution typology, Wanzenbock et al. (2020) propose a process-centric perspective on mission-oriented innovation that imparts directionality. They delineate three alternative pathways for achieving convergence between problems and solutions in order to progress from complex, so-called 'wicked', problems to legitimate solutions. This approach is anticipated to expedite both the legitimacy of a mission and the resultant solutions. The three policy pathways defined by them are problem-led, solution-led, and a hybrid pathway, each showcasing distinct trajectories through which a mission-oriented methodology can tackle the complexities inherent in a societal challenge from both the problem and solution perspective. Through this approach, Mission-Oriented Innovation Policy (MIP) aims to foster problem-solution configurations that achieve sufficient stability to function as a common framework and directional guide. This includes offering guidance to traditional market or system-based innovation policies to bolster the creation, dissemination, and integration of technological and/or institutional innovations. In short, Wanzenbock et al. (2020, p. 3) define mission-oriented innovation policy 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 challenge, and the active role of policy in ensuring coordinated action and legitimacy of both problems and innovative solutions across multiple actors".

Mission-oriented innovation systems

A relevant aspect of interest with regard to directionality in mission-oriented innovation policy is that of temporality. Socio-technical changes, or transitions, typically require a long time to progress through various stages to develop, take off, and accelerate before stabilisation occurs (Rotmans et al., 2000); missions are often formulated in such a manner that they must be achieved within a particular time frame (Mazzucato, 2018; Janssen et al., 2020). In line with what has been discussed earlier with regard to problem and solution divergence and convergence processes (Wanzenbock et al, 2020), a variety of possible development pathways may be explored – pathways that can focus on particular technologies that offer solutions for the objective at hand, for which policy support can vary over time. This implies that from a purely technological point of view, such as through the concept of technological innovation systems (TIS), it may be difficult to study transitions that involve multiple technologies such as transitions of entire energy systems. Indeed, TIS studies (Meijer et al., 2006; Negro et al., 2012) have shown periods of altering urgency and policy support leading to stagnation and decline, for instance as a result of less directionality (through the earlier discussed innovation system function guidance of the search (cf. Hekkert et al., 2007)). Hekkert et al. (2020) has therefore developed the mission-oriented innovation system (MIS) concept, to allow for studying the innovation system around a particular mission, which implies neutrality to technologies and could thus provide insight into the impact of directionality on the mission. Wesseling and Meijerhof (2023) developed an initial approach to studying MIS by building on the literature on mission-oriented innovation policy, governance, transition studies, and innovation systems. They argue that, although these literature streams are traditionally separate from one another, each underline "*the directionality provided by governance constellations across sectors, disciplines and geographical levels, involving strategic stakeholder deliberation and balancing short and long term*" (Ibid, p. 2). In addition to the presence and nature of directionality within the MIS, Wesseling and Meijerhof (2023) also argue that "*well-informed reflexivity and coordination to prevent unintended exclusion of potential solutions*" (Ibid, p. 10). This implies that missions ideally originate from broadly supported agreements between a variety of relevant stakeholders that hold the ability and are committed to implement the ambitions into practice (Loorbach, 2010; Mazzucato, 2018b; Schot & Steinmueller, 2018; Smith & Stirling, 2010; J. H. Wesseling et al., 2014). Moreover, public participation by citizens has become an increasingly important aspect of democratic decision-making with regard to societal challenges, such as environmental matters (Akerboom & Craig, 2022; Bickerstaff & Walker, 2005). Thus, where innovation policy has traditionally involved the *triple helix* – academia, industry, and government (Etzkowitz & Leydesdorff, 1995) – newer generations of policy require more advanced and more complex interactions. Examples of such models include the *quadruple helix*, which added the public and civil society, and the *quintuple helix*, which added the perspective of natural environments (Carayannis et al., 2012). The latter has been proposed to aid in environmental decision-making to implement socio-ecological transitions, such as transitions of energy systems to curb global warming (Carayannis et al., 2012). In the Netherlands, the triple and quadruple helices are sometimes also referred to as the 'golden triangle' (*gouden driehoek*) and 'Dutch diamond', respectively (AIV, 2016; TNO, n.d.).

As part of the MIS analysis, Wesseling and Meijerhof (2023) distinguish three sub-elements that contribute to directionality: problem directionality, solution directionality, and reflexive governance, which replaces and provides a more detailed interpretation of the original 'guidance of the search' system function (cf. Hekkert et al., 2007). They conceptualise problem and solution directionality as "[t]he way in which different societal problems are included and prioritised" and "*the factors that* *determine how stakeholders search for and invest in [promising] solutions*" that are capable of achieving the mission, respectively (Ibid, p. 6). In addition to the problems and solutions that are determined and influenced by one another (Wanzenbock et al., 2020), institutions and institutional entrepreneurs (which are "*actors that initiate and engage in the changing process [of institutions]*" (Haddad et al., 2022, p. 21)) may influence the underlying conditions within what Wesseling and Meijerhof call the 'mission arena' (Wesseling and Meijerhof, 2023; Grillitsch et al., 2019). The mission arena in this context "*refers to the actors that are engaged in the [..] mission governance*" (Wesseling and Meijerhof, 2023, p. 3), which should provide direction to pursue the mission. Directions in this sense can be both stabilising as well as destabilising (Turnheim and Geels, 2012). For instance, regime actors may oppose socio-technical changes while new entrants may be looking to change the 'rules of the game' or take advantage of new business opportunities as a result of evolving technical alternatives, and thereby affect the rate and direction of innovation (Geels, 2004; Markard et al., 2015). The mission arena strives to integrate these forces to allow for the advancement of innovative solutions that contribute to the mission. For instance, some actors within an arena in relation to an energy transition may lobby for the phase-out of natural gas in favour of renewable energy (which could accelerate the mission progress) while other actors may argue against it due to vested interest (which could delay or avoid action). Ultimately, the resulting governance decisions and actions that originate from the mission arena aim to steer the direction in which the MIS develops (Wesseling and Meijerhof, 2023). This typically is a process of evolution rather than a predefined blueprint, which (Rip, 2019) coins "*de facto* governance". When it comes to institutional entrepreneurship, policy could be directed towards promoting such entrepreneurial activities that aim for the desired socio-technical configuration, including destabilisation of socio-technical regimes that are supposed to be transformed (Turnheim & Geels, 2013). Given that missions may not require just technological but also social solutions, and that the envisioned end-stage of what the mission aims to achieve may depend on a set of such solutions rather than a one-dimensional approach, solution directionality in particular can be complex. Wesseling and Meijerhof (2023) take a 'mission-generically' approach when it comes to solution directionality, which they elaborate as "assessing system functions for mission solutions in general while critically reflecting on solution-type-specific exceptions" (Ibid, p. 10). For instance, in the case of a mission that is aimed at renewable energy, this implies appraising the available solutions rather holistically, rather than assessing the system functions for e.g. wind or solar energy individually. The interrelatedness of solutions that arises from this practice, in combination with the levels of synergy between and integration of actors within the mission arena that may span across sectoral and governance levels (Kattel and Mazzucato, 2018; Schot & Steinmueller, 2018; Grillitsch et al., 2019; Weber and Rohracher, 2012), implies that coordination and reflexive governance are important aspects to mission governance as well, to apply appropriate directionality to the mission and to readjust the mission's problems and solutions and governance actions throughout the process as developments are made as a result of evolving systemic and technological conditions (Wesseling and Meijerhof, 2023; Mazzucato, 2018; Janssen et al., 2020).

2.3 Framework for understanding directionality

The existing literature sheds light on the essential elements that determine the directionality of MIP. However, there is a lack of guidance on how to implement directionality in practice. Specifically, there is a need for guidance on how to translate grand challenges into concrete policy agendas and implement policy mixes to achieve these agendas (Haddad et al., 2022). While it is recognised that Weber and Rohracher's (2012) framework provides a seminal contribution to the literature by building on previous 'failures' frameworks (i.e., market and structural failures) and acknowledges directionality, it does not actually address it (Haddad et al., 2022).

Wittmann et al. (2021) have developed a framework to guide mission owners in effectively carrying out missions, which fills the gap by providing guidance. The framework includes more than 140 diagnostic questions grouped into 28 analytical dimensions, which cover three translation processes: mission formulation, mission design, and mission implementation. This comprehensive tool is recommended for external evaluators of mission-oriented policies as it enables the identification of strengths and weaknesses at different stages. However, although the framework is holistically designed around mission governance and is useful for evaluating missions in general or at specific stages, it does not explicitly consider directionality as a distinguishing feature.

Bergek and colleagues (2023) seek to bridge this gap by offering a new framework that, like Wittmann and colleagues (2021), views the translation of grand challenges or missions into concrete policies as a set of "translation processes." However, the Bergek et al.'s (2023) framework places directionality at its core, recognising that not all innovations contribute equally to addressing societal challenges. Policymakers must make choices and provide directions to select desirable solution pathways (Schot & Steinmueller, 2018; K. M. Weber & Rohracher, 2012). To develop this framework, Bergek et al. (2023) built upon the work of Diercks et al. (2019), which included three dimensions: policy objective, policy logic, and policy domain. Expanding this framework, they define a fourth dimension: policy leverage. Across these four dimensions, eight main directionality challenges have been identified through literature, namely: handling goal conflicts, defining system boundaries, identifying realistic pathways, formulating strategies, realising destabilisation, mobilising relevant policy domains, identifying target groups, and accessing intervention points (Bergek et al., 2023; Diercks et al., 2019).

The first dimension is centred on establishing clear objectives that encompass effective visions, transparent motives, and potential trade-offs between conflicting motives to ensure legitimacy among diverse stakeholders. This can be difficult when stakeholders hold diverging views on the problems at hand, which makes it essential to develop a clear direction while avoiding overly inclusive visions that provide little guidance. Policymakers must formulate policy agendas at various levels of governance, which can result in different priorities and interpretations of issues. The alignment of these can be a major challenge. To provide clarity and direction, policymakers can break down broad societal challenges into measurable and realistic intermediary missions that are time-bound and targeted.

The second dimension concerns policy logic, which is how policy is rationalised. Traditionally, state intervention has been based on market and structural failures and functional innovation system weaknesses, while more recently, transformational failures have been given attention. Policymakers must choose which paths to include in their policy and which to exclude, including destabilisation of the sociotechnical sector to be addressed. This can be challenging, as it requires envisioning a wide variety of options and pathways, assessing their legitimacy to deliver the desired outcome, and considering potential negative impacts on affected parties. Destabilising unsustainable paths that should be phased out is particularly challenging, as it can directly impact others who may not accept such actions socially or legally.

The third dimension of innovation policy pertains to the relevant domains that need to be addressed to effectively tackle societal challenges. While innovation policy has traditionally been limited to specific domains, such as sectors, a more comprehensive approach is needed to address complex challenges that may span multiple domains. However, this does not mean that domain-specific policies should be disregarded altogether. Rather, policymakers should focus on ensuring that policies are coordinated and coherent across different domains (e.g., in the case of energy transitions: aligning energy sector-specific policy with environmental policy), which can be a difficult task as it requires governments to adopt a more integrated approach to policy making, moving away from compartmentalised departmental silos.

Bergek et al. (2023) added a fourth dimension to their framework, which is policy leverage. This dimension considers the jurisdiction and reach of policymakers and provides a practical perspective to the policymaking process, enabling or constraining policymakers' ability to provide directionality. To ensure that their policies are effective, policymakers need to have formal jurisdiction over the issues addressed by their policy. However, this is not always the case as different ministries and government agencies have jurisdiction over different areas, which may limit the policymakers' ability to intervene in some sectors. Additionally, innovation systems and socio-technical configurations can operate at different scales, such as local, regional, national, and international levels, making it difficult for policymakers to access some intervention points. Policymakers must therefore identify problems and intervention points that are within their jurisdiction and reach, or be able to coordinate across various jurisdiction levels and geographical scales.

The framework was conceptually derived from literature and empirically grounded by evaluating a case study of a climate mission in the process industry in Sweden. An overview of the directionality challenges framework is displayed in **Table 1**.

3. Towards a carbon-free electricity system in the Netherlands

The energy transition refers to the systemic shift from reliance on fossil fuels to the use of low-carbon energy sources. The primary driver of this transformation is the urgent need to curb global greenhouse gas emissions to zero to address climate change and other sustainable societal challenges (Kabeyi & Olanrewaju, 2022; Ritchie et al., 2020). The energy transition has been debated for multiple decades since the 1990s. The Paris Agreement of 2015 aims to limit global warming to below 2°C and to achieve carbon neutrality by 2050 (UNFCCC, 2015). Approximately 70% of the world's greenhouse gas emissions are generated by the energy sector, which encompasses transport, heating, and industrial use (Ritchie et al., 2020). Wind power and solar photovoltaic systems have been identified as having the most significant potential to address the issue of climate change, given relatively high energy production and relatively low adoption costs per functional unit (IPCC, 2020). The shift towards renewable energy sources has been spurred by the increased feasibility, cost-effectiveness, widespread acceptance, and public support in recent years (IPCC, 2020).

In the Netherlands, the energy sector has been subject to various directional forces since the 2010s. In 2013, an Energy Agreement for sustainable growth was initiated and came about through collaboration between the Dutch government, employers, trade unions, environmental organisations, and others. This Agreement provided an agreed upon direction towards energy conservation and the uptake of renewable energy sources (Ministry of Economic Affairs and Climate Policy, 2013). The Agreement was, however, inadequate according to a non-profit organisation called Urgenda. Consequently, Urgenda sued the State of the Netherlands in 2013 for supposedly not doing enough against climate change. Following a long-lasting legal process, in 2019, the Dutch Supreme Court made a landmark decision to uphold previous decisions by lower courts made in 2015 and 2018, outlining the obligation of the State to reduce greenhouse gas emissions by at least 25% by the end of 2020 compared to 1990 (Supreme Court of the Netherlands, 2019). The decision was made on the basis of the European Convention on the Protection of Human Rights and Fundamental Freedoms (ECHR) and the legally binding nature of the Paris Agreement – which the State had signed in 2015 (UNFCCC, 2015) – as the court concluded that the State has a legal duty to protect its citizens against climate change. By the end of 2020, the objective was reached with a 25.5% reduction compared to 1990, partly as a consequence of closing coal power plants (CBS, 2022b). As a consequence of the Urgenda Climate Case, environmental organisations including Milieudefensie and Greenpeace sued Shell in 2019 on the same basis, albeit adding that – in addition to nation states – individual corporations have a legal duty as well. The Hague District Court has mandated that Shell decrease its Scope 1, 2, and 3 emissions (encompassing emissions from both its own operations and those from its suppliers and consumers) by 45% by 2030, as compared to 2019 levels. (The Hague District Court, 2021).

Table 1. Summary of the conceptually derived directionality challenges. Adopted from Bergek et al. (2023).

Directionality Challenge (DC)	Definition	Translation step
1. Handling goal conflicts	Prioritise between different and sometimes conflicting aspects of an overarching goal as well as between this goal and already existing ones.	Policy objective
2. Defining system boundaries	Define the problem and the focal system so that a wide enough set of alternative solutions is included while considering sectoral specificities.	Policy objective
3. Identifying realistic pathways	Identify and prioritise a wide enough range of feasible transition options and pathways that can be realized within the given timeframe.	Policy logic
4. Formulating strategies	Analyse system strengths and weaknesses for multiple pathways, formulating appropriate measures and strategies.	Policy logic
5. Realising destabilisation	Implement policies that motivate change rather than dismantle the transformative capacity.	Policy logic
6. Mobilising relevant policy domains	Identify, enrol, and coordinate relevant policy domain actors at different governance levels and with different jurisdictions.	Policy domain
7. Identifying target groups	Find relevant actors, which by different means can act upon the identified pathways and adjust strategies to these target groups.	Policy leverage
8. Accessing intervention points	Identify (industry-specific) supply- and demand-side points of entry within reach for various interventions.	Policy leverage

In 2011, the Netherlands initiated the so-called 'Top Sectors', which came about in response to halting innovation as a consequence of the financial crisis in 2008. The initiative encompassed nine critical economic sectors which played a pivotal role in the Dutch economy, namely: agriculture, horticulture, logistics, high-tech systems and materials, life sciences and health, chemicals, creative industry, energy, and water (Topsectoren, 2016). The Top Sectors strategy was updated in 2019 to embrace a mission-oriented top sector and innovation policy orientation, focusing on addressing key societal issues (OECD, n.d.). To combine the strengths of both sectoral and challenge-driven approaches, the new policy focused on linking the innovative strengths of the Top Sectors to solving social challenges through a mission-oriented approach (OECD, n.d.). The mission-driven approach is innovative in that it involves public and private Top Sector partners, including significant participation from businesses, in the collaborative creation and implementation of policy agendas for four societal dimensions. In 2019, the Dutch Ministry of Economic Affairs and Climate Policy – in collaboration with five other ministries, knowledge institutes, Top Sector partner, and regional societal organisations – created four Integral Knowledge and Innovation Agendas to address societal challenges across four social themes, including the energy transition and sustainability, which are focused on 25 missions defined by the government to "*challenge the Top Sectors to produce concrete solutions*" (Ministry of Economic Affairs and Climate Policy, 2018 (p. 3), 2019b, 2019a).

3.1. Overview of the Dutch Mission-oriented Innovation Policy

The MTIP consists of 25 missions across four themes. The themes include Energy Transition and Sustainability (ET&S), Agriculture, Water, and Food, Health and Healthcare, and Security. An overview of the themes and missions is provided in **Table 2**. The missions in the MTIP were developed on the initiative of the government; the implementation of these missions was the responsibility of various departments, who, together with the existing top sectors, knowledge institutions, industry, social organisations, and regional governments, formulated well-considered and widely supported missions. It was important that social challenges were central and translated into concrete goals. Finally, how these goals should be achieved was further explained in 'Knowledge and Innovation Agendas' (KIAs); the KIAs were developed per theme, with the top sectors playing a significant role.

In the context of transformative innovation policy, (Goetheer et al., 2018) recognises two types of missions: 'transformer missions' and 'accelerator missions'. Transformer missions focus on the development of a new, more comprehensive – often technology-driven or triggered – broad transformation process or a significant transition, of which the solutions are only partially known or understood. Transformer missions often require a system change in which not only technological development and (broader!) innovation accelerate, but also much more far-reaching changes are required in terms of social acceptance, application, and use. Moreover, a transformer mission requires accompanying measures, such as initiating, (co-)financing, and realising a new infrastructure, supportive laws and regulations, and the development of new business models. Accelerator missions, on the other hand, are much more specific and aimed at accelerating technological development and boundary-pushing application thereof. In this study, we recognize the 25 missions in the MTIP as transformer missions, as they are broadly formulated and have a socio-technical change in mind that often involves multiple dimensions. Some missions have interim goals, which can often be characterised as accelerator missions. For example, the ET&S mission "Zero-emission mobility of people and goods by 2050" has interim goals such as "By 2030 there will be 1.9 million electric vehicles" and "By 2030, a third of all energy consumption in mobility will be renewable"; although the mission is broadly oriented towards mobility in general, the interim goals are specifically aimed at accelerating the adoption of electric vehicles and the use of renewable energy within the mobility sector.

Table 2. Overview of the themes and missions of the Dutch MTIP. *Adopted from* Top Sectors (2019).

Themes	Missions
Energy Transition and Sustainability	● **Overarching goal:** 49% reduction of national greenhouse gas emissions by 2030, aiming for 95% lower emissions by 2050 compared to 1990. ● An entirely carbon-free electricity system by 2050. ● A carbon-free built environment by 2050. ● Carbon-neutral industry with reuse of raw materials and products by 2050. ● Zero-emission mobility of people and goods by 2050. ● A sustainable and completely circular economy by 2050, with resource use halved by 2030.
Agriculture, Water and Food	● Reduction of the use of raw and auxiliary materials in agriculture and horticulture by 2030 and creating the maximum possible value from all end products and residuals by utilising them as fully as possible (circular agriculture). ● By 2050, the agricultural and nature system will be net carbon-neutral (Joint mission with energy transition and sustainability). ● The Netherlands will be climate-proof and water-resilient by 2050. ● By 2030, we will produce and consume healthy, safe and sustainable food, while supply chain partners and farmers get a fair price for their produce. ● A sustainable balance between ecological capacity and water management vs. renewable energy, food, fishing and other economic activities, where this balance must be achieved by 2030 for marine waters and by 2050 for rivers, lakes and estuaries. ● The Netherlands is and will remain the best-protected and most viable delta in the world, with timely future-proof measures implemented at a manageable cost.
Health and Healthcare	● By 2040, all Dutch citizens will live at least five years longer in good health, while the health inequalities between the lowest and highest socio-economic groups will have decreased by 30%. ● By 2040, the burden of disease resulting from an unhealthy lifestyle and living environment will have decreased by 30%. ● By 2030, the extent of care provided to people within their own living environment (rather than in health-care institutions) will be 50% more than today or such care will be provided 50% more frequently than at present. ● By 2030, the proportion of people with a chronic disease or lifelong disability who can play an active role in society according to their wishes and capabilities will have increased by 25%. ● By 2030, quality of life for people with dementia will have improved by 25%.
Security	● By 2030, organised crime in the Netherlands will have become an excessively high-risk and low-return enterprise, thanks to a better insight into illegal activities and cash flows. ● By 2035, the Netherlands will have a navy fit for the future, which will be able to respond flexibly to unpredictable and unforeseen developments. ● By 2030, the Netherlands will have operationally deployable space-based capabilities for defence and security. ● Cyber security: the Netherlands will be in a position to capitalise, in a secure manner, on the economic and social opportunities offered by digitisation. ● By 2030, the armed forces will be fully networked with other services and through the integration of new technologies, so that they can act faster and more effectively than the opponent. ● Supply and demand will come together more quickly to implement successful short-cycle innovations. ● By 2030, security organisations will be capable of collecting new and better data, so that they are always one step ahead of the threat. ● By 2030, the role of security professional will be among the 10 most attractive professions in the Netherlands.

To provide concrete direction for innovation activities related to missions and their sub-goals, multi-year innovation programs (MMIPs) have also been developed. An example of an MMIP for the aforementioned mission and interim goals is "Innovative propulsion and use of sustainable energy carriers for mobility." The MMIPs are specific programs that cover the entire knowledge and innovation chain. The MMIPs explicitly state which knowledge and innovation activities are needed, according to current insights, for the different parts of the innovation chain regarding: research, development, pilots/demonstration, and implementation. As such, the MMIPs can motivate innovation in certain directions and encompass various dimensions to achieve innovations. However, (M. Janssen, 2020) noted that "*the observation that the MMIPs contain comprehensive strategies for combining various innovation-related developments [..] does not automatically imply they are also more selective in terms of the total number of technologies or innovation topics they address.*" The extent to which MMIPs provide direction for innovations may therefore be relative. To implement the KIAs and MMIPs, policies are developed for, for example, subsidy schemes, two prominent examples of which are NWO calls and RVO tenders. Through such schemes, projects can claim, for example, (co-)financing or advice. In addition to the four themes, the MTIP has two additional components: key technologies (in some cases also 'key methodologies') and social earning capacity.

Theme ‘Energy transition and sustainability’ and the focal mission

The first theme of the MTIP is Energy Transition & Sustainability (**Table 2**). This theme is based on three agendas: circular economy, future-proof mobility systems, and the Integral Knowledge and Innovation Agenda (IKIA) for Climate and Energy. The latter was adopted from the Climate Agreement that was formed in 2019. The IKIA was the product of negotiations between more than a hundred different parties with the aim of combating climate change (MinEZK, 2019). The ET&S theme has one overarching ‘main’ mission to reduce 49% of the national greenhouse gas emissions by 2030, while aiming for 95% lower emissions by 2050 compared to 1990 levels. To break this herculean task down into actionable goals, five more targeted missions have been formulated (**Table 2**). One of these missions is to move towards “[a]n entirely carbon-free electricity system by 2050”, which is the mission that will be assessed in this study. The mission focuses particularly on solar and wind energy, with intermediate missions for 2030 to produce at least 35 TWh electricity through wind and solar energy (>15 kW) and 49 TWh electricity through wind at sea (Ministry of Economic Affairs and Climate Policy, 2019b).

The missions in the MTIP were developed on the initiative of the government; the implementation of these missions was the responsibility of various departments, who, together with the existing top sectors, knowledge institutions, industry, social organisations, and regional governments, formulated well-considered and widely supported missions. It was important that social challenges were central and translated into concrete goals. Finally, how these goals should be achieved was further explained in 'Knowledge and Innovation Agendas' (KIAs); the KIAs were developed per theme, with the top sectors playing a significant role.

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3.2. Evolution of the Dutch innovation policy landscape

In order to have a broader understanding how innovation policy has developed over the past few decades until now, a brief over of the evolution will be provided in this section.

Since the 1950s, following the end of World War II, the focus of innovation policy has been mainly on driving private R&D through subsidies, tax breaks and better intellectual property protection (Rathenau, 2020). This is what Schot and Steinmueller (2018) described as the first frame of innovation policy. The rationale behind this policy was that the government should play a greater role in funding research and encourage companies to invest more in R&D so that the economy can benefit from it through commercialising knowledge and scientific discoveries (Rathenau, 2020; Schot & Steinmueller, 2018). In addition, the legitimation for state intervention in markets was based on the phenomenon of market failure. Since firms have an inherent motive to invest in markets in which they can appropriate products and services, there was less investment in R&D that was socially desirable (Arrow, 1962; Nelson, 1959). This is the case, for example, in public goods markets. In the 1980s, the Dutch innovation policy focus shifted more towards enhancing research and development of core technologies. From the 1990s, innovation systems thinking became more dominant, which is described as the second frame of innovation policy according to Schot and Steinmueller (2018). There was a strong emphasis on addressing system failures, which in this context was particularly relevant in terms of cooperation and coordination within innovation systems (Rathenau, 2020; Schot & Steinmueller, 2018). Mainly within the national context, actors within innovation systems were encouraged to enter into public-private partnerships, for instance between knowledge institutes and companies. This also focused more on entrepreneurship and connecting supply and demand (Schot and Steinmueller, 2018). From the 2000s onwards, innovation policy in the Netherlands became more thematic in nature and focused on sectors, allowing attention to be drawn to a number of core areas and technologies. To achieve this, the government cast itself as a facilitator between actors from industry and knowledge institutes to jointly set agendas on where the national focus with regard to innovation should lie. These core areas became "*flowers and food, high-tech systems and materials, water, chemistry, creative industry, and pensions and insurance.*" (Fagerberg & Hutschenreiter, 2020, p. 290). Between 2006 and 2010, sectors were supported through ten Innovation Programmes (den Hertog et al., 2012); this programmatic approach was used to give a significant boost to public-private investments in the core areas in which the Netherlands could and wanted to excel, and additionally brought attention to the importance of human capital and internationalisation as well (Fagerberg & Hutschenreiter, 2020).

Besides specific policies on innovation and enterprises, environmental and sustainability policies have become more important since the beginning of this century. Schot and Steinmueller (2018) recognise this as the third and most recent frame of innovation policy (see **Figure 1**). This third frame aims to holistically connect social and environmental challenges, such as climate change and ageing populations, that call for transformative change of socio-technical systems (Schot and Steinmueller, 2018) – beyond mere economic objectives (Diercks et al., 2019). In the first decade of this century, the Netherlands therefore had a policy based on transition management (Kemp et al., 2009; Rotmans et al., 2001). Within this policy, public and private parties as well as academia and civil society organisations came together to jointly focus on transition challenges (Nill et al., 2009), including specific policies to reduce greenhouse gas emissions. However, these policies came to an end after the 2011 elections (Fagerberg & Hutschenreiter, 2020). What followed was the Top Sectors policy in the same year. As a result of the global financial crisis in 2008, the Netherlands had fallen into a recession and the economic performance had decreased. The Dutch government was forced to make savings to the annual budgets and firms saved on investments, leading to innovation to halt. In response to that, the Netherlands initiated the so-called 'Top Sectors', which aimed to strengthen the national economy and competitiveness (through encouraging private R&D) by uniting public and private actors from the government, academia, and industry – also referred to as the golden triangle and the triple helix. This composition allowed for the engagement of a variety of stakeholders that each could voice their demands and needs, contribute to the innovative capabilities of the Dutch innovation systems, and enabled coordination and collaboration as well as knowledge diffusion and valorisation. The initiative encompassed nine critical economic sectors which played a pivotal role in the Dutch economy, namely: agri&food, horticulture and propagation materials, logistics, high-tech systems and materials, life sciences and health, chemicals, creative industry, energy, and water. Collectively, these sectors "*accounted for over 80% of business R&D (96% in 2010) and for just under 30% of value added and of employment*" in 2011 (OECD, 2014, p. 26). Albeit the main objectives of the Top Sectors were of economic nature, the involvement of public stakeholders – such as the government – also resulted in non-economic benefits, including closer cooperation and knowledge exchange between the triple helix partners. As (M. Janssen, 2020) puts it: "*Jointly exploring options to exploit promising innovations fits with the view that driving innovation is not so much a matter of economic policies, but rather also of accommodating a wide range of changes needed to make an innovation succeed (or to avert undesired effects).*"

Five years after the start of the Top Sectors approach, in 2017, an evaluation was conducted and recommended to align the Top Sectors with societal challenges (Dialogic, 2017), which was in line with the recognition that taking a multidisciplinary approach and bringing about collaboration and coordination between a public and private stakeholders (public-private partnerships; PPPs) – which were at the core of the Top Sectors – were crucial in order to enable innovations to address targeted societal challenges (Fagerberg & Hutschenreiter, 2020; OECD, 2014). Similar recommendations were made earlier as well by, for instance, the Dutch Advisory Council for Science, Technology and Innovation (AWTI) and OECD in 2014 (AWTI, 2014; OECD, 2014). The evaluation concluded that the top sector policy certainly had benefits, including the strengthening of networks and cooperation between different parties contributing to the innovative capabilities in the Netherlands, a better match between the knowledge needed within the top sectors and the knowledge provided by knowledge institutes, and a strong development of human capital. However, drawbacks were also noted, including the observation that the policy had little success with regard to market creation and in driving radical innovation, and that the governance should be simplified (Janssen et al., 2012).

In response to repeated advice to bring the Top Sectors policy more in line with societal challenges, as well as the fact that at the same time the European Union was working on a successor to the expiring Horizon 2020 innovation policy and moving towards the mission-driven Horizon Europe programme (Fagerberg & Hutschenreiter, 2020), the Dutch government decided to implement missions in national innovation policy as well, driving goals to address societal challenges; this policy was announced as the Mission-oriented Topsector and Innovation Policy (MTIP) (Ministry of Economic Affairs and Climate Policy, 2018a, 2019b). The primary aim of this policy approach was "*to connect the strongly developed Top Sectors to the missions and innovation challenges*" (Ministry of Economic Affairs and Climate Policy, 2019c, p. 3) and to "challenge the Top Sectors to produce concrete solutions" while also acknowledging the role of the government "*to create the right framework conditions for innovation*" (Idem, p. 4). In addition, the announcement of the MTIP came along with endorsements of the importance of continuing the Top Sector's focus on human capital generation and internationalisation, as well as enhancing the competitiveness of the Dutch economy and recognising the economic potential for the Netherlands to be a frontrunner of sustainable solutions (Ministry of Economic Affairs and Climate Policy, 2019b).

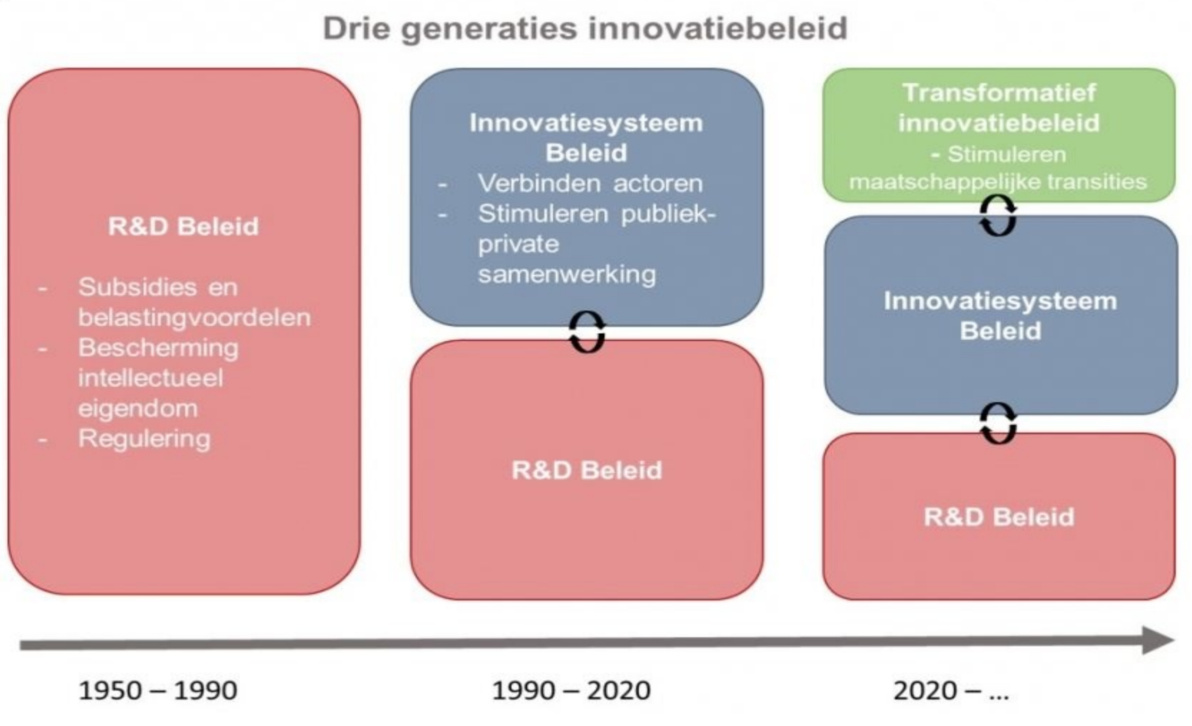

Figure 1. Three generations innovation policy (in Dutch). *Adopted from* Rathenau (2020)*; based on* (Schot & Steinmueller, 2018).

4. Methodology

In this study, triangulation was applied by utilising multiple methods to acquire the relevant data. Triangulation enhances the trustworthiness of the results by approaching problems from multiple perspectives (Zhang & Wildemuth, 2005). The scope of the analysis was on the directionality challenges, as defined by Bergek et al. (2023). These challenges were applied to a single case study: the mission-oriented policy around the Dutch mission towards an “entirely carbon-free electricity system by 2050”. This approach allowed the identification of perceived difficulties that challenge the directionality of the mission and thus contributed to addressing the shortcomings in practical knowledge on directionality in mission-oriented innovation policy (Köhler et al., 2019). Furthermore, the case study provided a unique geographical and institutional context (Flyvbjerg, 2006), which allowed for learning from real-life examples beyond conceptual frameworks and the integration of various perspectives (Baxter & Jack, 2008).

The research design falls into several categories, as outlined by (Hancock & Algozzine, 2006). Initially, it serves an *explanatory* purpose, striving to identify the causal links between the implementation of mission-oriented (innovation) policy and the directionality (challenges) that emerge in the socio-technical landscape of the mission. The case study is also *intrinsic*, as the study offers insights and recommendations for the involved stakeholders. Lastly, the study is *instrumental* in advancing the theoretical understanding of directionality challenges, particularly within the framework of Bergek et al. (2023).

The research as presented in this study is based on a combination of desk research and interviews, which will be further elaborated upon in this section.

4.1 Desk research

The first phase of the study included desk research. This involved analysing primary documents, such as policy briefs, letters to the parliament, research agendas, roadmaps, and vision documents, as well as secondary sources including public information and reports. Official documents were acquired through the websites of the Dutch government (*rijksoverheid.nl/documenten* and *zoek.officielebekendmakingen.nl*), Netherlands Enterprise Agency (*rvo.nl/klimaat-energie*), Climate Agreement (*klimaatakkoord.nl/documenten*) and the Top Sector Energy (*topsectorenergie.nl*). Search strings included the mission formulation: “*an entirely carbon-free electricity system by 2050*” in English and “*een volledig CO2-vrij elektriciteitssysteem in 2050*” in Dutch. While the first search queries were conducted in March 2023, additional queries were conducted throughout the study period (March–August 2023) in order to stay updated with the latest developments. The primary documents often referred to other documents that would go into further detail of elements related to the mission, such as the Climate Agreement itself or the MMIPs that were designed for the mission, and these were included as well if found relevant to the study topic. The purpose of the desk research was to develop understanding of the mission, its objectives, and the context in which it is embedded, as well as any early insights into the directionality challenges that stakeholders may perceive during the translation of the mission into practice. The desk research thereby also provided starting points for the interviews.

4.2 Interviews

The next phase of the study included interviews. When it comes to directionality, studying it exclusively through desk research can be problematic as what is written on paper does not always accurately represent what is actually happening in practice. This study therefore largely builds upon the experiences shared in the interviews. The interviews were designed to gather multi-perspective insights from key stakeholders that either help design or are affected by the directionality of the mission. For the collection and processing of the data acquired through the interviews, directed qualitative content analysis was used (Bengtsson, 2016; Zhang & Wildemuth, 2005). The analysis was prepared in line with the suggested method by (Assarroudi et al., 2018) to ensure reliability and rigour. During the interview phase, an internship was undertaken at KPMG Advisory. The industrial stakeholders were included through KPMG's network.

Sampling strategy

The selection of key informants to be included in the interviews was based on purposive sampling. This is a selective, non-probability sampling strategy that allows for the inclusion of interviewees that are relevant to the studied subject (Palinkas et al., 2015). Interviewees were purposively selected for their role in the mission towards an entirely carbon free electricity system. The formulation of the missions was conducted by a wide variety of stakeholders (Ministry of Economic Affairs and Climate Policy, 2019c) that can be categorised in the triple helix, which refers to the interaction between academia, industry, and government (Etzkowitz & Leydesdorff, 1995). In the context of this mission, the government articulates the grand challenges that the country faces and needs to address as well as the legal frameworks, academia provides the knowledge base and research programmes related to the innovation required to realise the mission, and industry bears the capacity and responsibility to implement solutions that address the mission. The Top Sectors allows for the triple helix actors (see **Figure 2**) to collaborate and give rise to innovative solutions within the context of the sectoral specificities (AWTI, 2016). In the context of the innovations needed to realise the mission, the Top Sectors manage the innovation programmes (MMIPs), and can therefore be considered a party of their own as well. The interviews were set to balance these groups, thereby allowing for a balanced sum of perspectives as to what directionality challenges are currently perceived (**Table 3**). More specifically, the selection criteria for interviewees were as following: they were required to be aware of the mission and either (A) conducted relevant research, B) worked on plans or programmes to realise the mission or elements relevant to the mission, or (C) be a key player in the Dutch electricity sector.

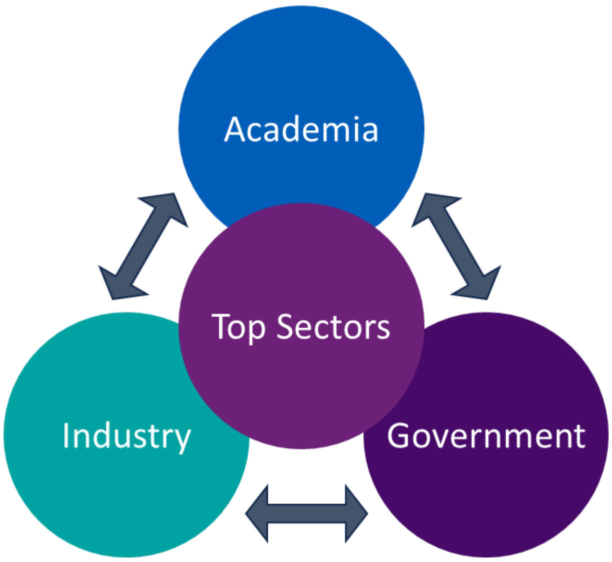

Figure 2. Typical triple helix model that displays the interconnectedness between government, academia, and industry. In the context of the focal mission, the Top Sectors operate in the middle.

A total of 18 interviews were conducted with a total of 19 interviewees (one interview included two interviewees): 5 (semi-)government, 5 academia, 4 industry, and 5 Top Sector Energy (see **Table 3**). In total, 43 interviewees were sampled and invited to an interview, of which 19 (44%) accepted and participated in the study. Those that did not participate either did not respond (n=17), forwarded the request to someone else (n=2), did not have sufficient time (n=3), or were on leave (n=2). Three interviewees (included in the statistics above) were acquired through snowballing, i.e., they were recommended by earlier interviewees. As more interviews had been conducted, the same phenomena were brought up and increasingly revealed no new or additional information about the studied subjects. This confirms that the number of interviews was appropriate to capture the relevant directionality challenges of the mission, as 'saturation' had been reached (Hennink & Kaiser, 2022; Saunders et al., 2018).

Conducting the interviews

The interviews were all conducted online via Microsoft Teams across May, June, and July 2023 and lasted between 30 to 75 minutes (54 minutes average). The audio was recorded after informed consent was provided by the interviewees to allow for transcription. Verbalisations were transcribed literally to capture the context in which things were said (Zhang & Wildemuth, 2005); however, observations during the interview (such as non-verbal communication) were not transcribed unless they were meaningful to the context (Schilling, 2006). As such, the focus was mainly on the analysis of manifest content (i.e., the transcripts), though when relevant, latent content (e.g., the interviewee's attitude or the interpretation of manifest content) was included as well (Assarroudi et al., 2018). After transcription, the interviewees were granted to check the transcripts for accuracy; only two interviewees opted in to receive the transcript and no issues were raised. After the conclusion of the transcripts, the audio recordings were destroyed.

The interviews were semi-structured (Doody & Noonan, 2013), meaning that an interview guide was used including predetermined questions and that interviewees were allowed to deviate as long as the discussed topics remained relevant to the subjects of interest (Hsieh & Shannon, 2005). This allowed for information that had not been considered yet to emerge. The interview guide was based on the directionality challenges as defined by Bergek et al. (2023) and inspired by the conceptualisation of directionality as elaborated upon in Chapter 2 The interview guide can be accessed in the **Appendices**.

Table 3. Overview of the included interviewees.

Category	Date	Label	Duration (min)	Organisation	Area of Expertise
(Semi-)government	11 July	G-1	75	EZK	Business & Innovation
(Semi-)government	28 June	G-2	60	EZK	Climate & Energy
(Semi-)government	17 May	G-3	65	RVO	Energy Transition & Innovation
(Semi-)government	30 May	G-4	30	Netbeheer Nederland	Energy Transition
(Semi-)government	21 June	G-5	55	Netbeheer Nederland	Energy Policy
Academy	31 May	A-1	60	UU	Regulation & Governance of the Energy Transition
Academy	8 June	A-2	60	UU	Sustainable Energy Supply
Academy	26 May	A-3	45	RUG	Energy & Sustainability
Academy	4 July	A-4	50	TU Delft	Energy Systems Analysis
Academy	21 June	A-5	35	NWO	Knowledge and Innovation Convenant
Industry	29 June	I-1	60	Ørsted	Ventures and Open Innovation
Industry		I-2			Regulatory Affairs
Industry	9 June	I-3	45	Essent	Regulatory Affairs
Industry	2 June	I-4	40	Eneco	Innovation
Cross-sectional	24 May	T-1	65	Top Sector Energy	Offshore Energy
Cross-sectional	20 June	T-2	45	Top Sector Energy	Urban Energy
Cross-sectional	18 July	T-3	60	Top Sector Energy	Energy & Industry
Cross-sectional	26 June	T-4	60	Top Sector Energy	New Gas
Cross-sectional	3 July	T-5	60	Top Sector Energy	Urban Energy

Data analysis

The unit of analysis was the helical groups that were described earlier in this chapter, and the unit of observation were the individuals that were allocated to those groups (**Table 3**). As for the interview guide, the directionality challenges – as described by Bergek et al. (2023) – formed the basis of the analysis as well. Each directionality challenge was included as a distinctive category, under which themes and observed phenomena were sub-categorised. As such, the analysis in this study was inductive of nature (Zhang & Wildemuth, 2005); directed content analysis is characterised by applying an existing theory with predefined coding categories (the directionality challenges) to provide guidance (Hsieh & Shannon, 2005). In addition to the directionality challenges as categories, two additional categories were included for the analysis of 'governance' and 'experiences with the MTIP'. The coding was conducted by the author of this study; it was considered acceptable not to include two coders in this case, considering that the predefined categories were clearly defined and were unambiguous, which were assumed not to result in any inter-coder disagreement. The sub-categories were iteratively validated and refined until consistency was achieved (Weber, 1990). Following coding, the identified themes and categories were explored for any relationships or patterns, both within and across (sub-)categories (Zhang & Wildemuth, 2005). The interviews were also abductive in nature (Timmermans & Tavory, 2012), considering that they were not only applied to the framework of Bergek et al. (2023) for the identification of directionality challenges, but also served to reflect on the framework itself and provide suggestions for improvement or extension.

Trustworthiness

Trustworthiness of directed content analysis can be evaluated based on four criteria: credibility, transferability, dependability, and confirmability (Lincoln & Guba, 1985). This differs from the conventional validity, reliability, and objectivity criteria (Zhang & Wildemuth, 2005). (Nowell et al., 2017) provides a step-by-step approach to conducting a thematic analysis and describes the steps that are briefly described below in greater detail.

Credibility refers to the confidence in the findings through the construct of the study and the merits of the researchers, and includes activities such as prolonged engagement, persistent observation, triangulation, peer debriefing, negative case analysis, referential adequacy, and member-checking (Lincoln & Guba, 1985). While the author's knowledge and experience in the field that was in the scope of this study cannot be described as an 'expert' (thus decreasing credibility), efforts were made to acquire the required background information and the semi-structured interviews and the approach to manifest data allowed for the real experts to share their insights and form the basis of analysis (thus increasing credibility). Various activities (including persistent observation, triangulation, negative case analysis, and member-checking) have been included in the process of conducting the interviews and analysing the data, as described earlier. Additionally, peer debriefing was applied by having regular meetings in which the results were interpreted and discussed.

Transferability refers to the extent to which the findings can be applied to other cases. For this, Lincoln and Guba (1985) recommend providing 'thick descriptions' so that other researchers can assess the data and put them into perspective. As with any case study, the general applicability to other cases is limited due to the specific context of the focal mission and may thus not be (directly) applicable to other cases in which missions are applied. Nonetheless, in the Results section of this study, the findings are presented in a detailed manner; the approach to working with manifest data also allowed for capturing the context in which statements were made.

Dependability refers to external audits for evaluating the accuracy of the findings, interpretations, and conclusions. While peer debriefing was applied (to increase credibility), this study did not include external audits of the data (analysis).

Confirmability refers to the extent to which the findings are not influenced by bias from the researcher. In order to increase confirmability, external audits, triangulation, reflexivity, and process information can be used (Lincoln and Guba, 1985). As mentioned before, triangulation was applied here by making use of various sources. In addition to that, reflexivity could be described to have emerged from peer debriefing by including multiple interpretations of the data and comparing those to expert knowledge and experiences, thus leading to both convergent and divergent understandings of the findings and in case of the latter, contesting any hidden beliefs, perspectives, and assumptions of the author (Lincoln and Guba, 1985). Moreover, any changes in response to difficulties during the analysis process were discussed with the supervisor.

5. Results: mapping the directionality challenges

In this section, the directionality challenges for the mission as elaborated upon.

5.1. Handling goal conflicts

In the realm of mission-oriented innovation policy, one of the most complex and pressing challenges is the issue of 'handling goal conflicts'. This challenge arises when different policy objectives – whether they pertain to sustainability, economic growth, or social well-being – collide or are at odds with each other. The difficulty for policy makers lies not just in setting ambitious goals, but in making prioritised choices that balance these conflicting objectives. This issue is particularly salient in complex contexts where societal issues like climate change are at stake, given the wide variety of policy topics and stakeholders that may be affected by policy choices, as well as the multiple governance layers that are involved – from local and regional to national and international. Transforming conflicts into opportunities and resolving goal conflicts is therefore a cornerstone for the successful implementation of mission-oriented innovation policies.

Goals of the Dutch MTIP

Traditionally, the Netherlands has been among the most competitive and innovative countries in the world. The foundation to support this position has been the promotion of innovation based on three main pillars: (1) generic innovation policy that all innovative companies can benefit from, for example, through tax concession for R&D expenditures (WBSO) and a reduced corporate tax rate for profits derived from R&D activities; (2) encouragement of the supply of risk-bearing financing for innovative companies and projects, among other things through the Seed Capital scheme and the Dutch Venture Initiative; and (3) the promotion of public-private participation (PPP) between the business sector, government, and knowledge institutions (the triple helix approach). In doing so, public knowledge institutions are encouraged to allocate part of the research funds to themes that are relevant to the business sector, and companies are stimulated to invest in public research. Public-private collaboration is expected to contribute to a better utilisation and dissemination of knowledge, which should enable innovations to emerge more easily (Ministry of Economic Affairs and Climate Policy, 2018a).

However, societal challenges, such as the energy transition, required a new approach. This approach builds on the Dutch Top Sectors that had been initiated in 2011, that connect industry with the government and knowledge institutes. Before the mission-oriented approach was taken, the focus was to a large extent on export and international competition (Interviewee G-3). A stronger focus on the national and economic opportunities of several major societal themes was the central starting point for the renewed Top Sectors approach (Ministry of Economic Affairs and Climate Policy, 2018c). Within this framework, maintaining a solid knowledge base and public-private participation were key starting points. The aim was to achieve programmes that were embedded both in policy and in society. Furthermore, SMEs (small and medium-sized enterprises) and startups, as well as challengers of incumbents, were intended to be given a stronger position in the formulation and implementation of public-private programmes (Ministry of Economic Affairs and Climate Policy, 2018c) to provide opportunities for valorisation and market creation. The Innovation Credit (*Innovatiekrediet*), MIT (*Mkb-Innovatiestimulering Regio en Topsectoren*), Small Business Innovation Research (SBIR), and Technology Pact (*Techniekpact*) were continued (Ministry of Economic Affairs and Climate Policy, 2018a). In addition, technological development of 'key technologies' were acknowledged as playing a key role in addressing societal challenges and were also one of the central starting points of the new Top Sectors approach. Finally, apart from the targeted themes, a number of general policy goals were addressed, including human capital, internationalisation, valorisation, digitalisation, and 'social earning capacity' (*maatschappelijk verdienvermogen*), as well as stimulating R&D investments to reach the national target of 2.5% GDP and strengthening the Dutch business climate (idem). Besides these factors, the missions also aim to address behaviour, legislation, and affordability (Ministry of Economic Affairs and Climate Policy, 2019c). The Dutch mission-oriented approach is appreciated by the OECD as "*among the most ambitious mission-oriented strategic frameworks*" because it brings together economic sectors and societal missions in a joint programming and implementation of research and innovation (Larrue, 2021b).

MMIPs

As stated before, the original task for the electricity sector as agreed upon in 2019 was to reduce CO2 emissions by at least 20.2 Mtons by 2030 (Ministry of Economic Affairs and Climate Policy, 2019b), although the target was made more stringent in 2021 following the instalment of the new cabinet Rutte IV (Rijksoverheid, 2021a). By 2050, electricity production in the Netherlands will have to be entirely carbon-free. The interim goals for the sector were that by 2030, at least 35 TWh of electricity will have to be generated annually through onshore wind and solar energy (>15kW); and that at least 49 TWh of electricity will be generated by offshore wind. Apart from stimulating innovations, the government also explicitly acknowledged the importance of an integrated approach to technical, social, economic, ecological, spatial, and legal challenges that may halt such innovations (Ministry of Economic Affairs and Climate Policy, 2019b).

The mission will be achieved within the context of the Climate Agreement and the corresponding IKIA for the Climate and Energy theme that followed. The IKIA forms the guiding agenda and should pave the way towards 2050 and the interim goals for 2030. In order to address the innovations needed for these goals, two Multi-year Mission-oriented Innovation Programs (MMIPs) were formulated, namely "Renewable electricity at sea" (MMIP 1) and "Renewable electricity generation on land and in the built environment" (MMIP 2). In short, both programmes aim to upscale the production of renewable electricity, albeit each targeting a different domain (offshore and onshore, respectively). The MMIPs are governed by the Top Sector Energy and are mainly aimed at three key elements that should enable a successful energy transition: (1) cost reduction, (2) integration of large amounts of sustainable electricity into the energy system, and (3) integration of sustainable electricity production systems into the ecological and spatial environment. In addition to that, MMIP 2 specifically aims to accelerate the social enthusiasm surrounding onshore renewable electricity generation (Ministry of Economic Affairs and Climate Policy, 2019b).

Particularly offshore wind energy is considered one of the most important means to achieve climate neutrality by 2050 in the Netherlands (RVO, 2021b). The wind energy has evolved much faster than initially expected (Interviewee T-1), especially in the context of cost reduction. While the interviewee acknowledged the importance of all three key elements, the first term of the MTIP (2019–2023) was still mainly targeted at cost reduction for wind energy, and less so on topics such as integration. In 2018, Vattenfall was awarded the tender for Dutch wind farm Hollandse Kust Zuid, which was the world's first wind farm to be built without public funding. Further cost reductions are necessary to support the business case of wind energy in the light of challenging market conditions and increased inflation (Interviewee I-1, I-2; Rabobank, 2023) and to support alternative options that contribute to the energy transition such as hydrogen (see e.g., the HEROW initiative), considering that electricity costs account for a significant portion of the hydrogen production costs (Interviewee T-1; IRENA, 2021). Currently, the business case of wind energy is under pressure due to challenging market conditions, which is seen as a potential threat to meeting the capacity goal of 21 GW by 2030 (Interviewee I-1; Rabobank, 2023). Interviewee T-1 expects that the industry will continue to work towards cost reduction, even if it is not a key priority in innovation programmes of the Top Sector Energy. They also noted that the integration topics become increasingly more important over time: considering that offshore wind electricity is rapidly growing, solutions must be found to integrate all that electricity into the Dutch energy system in a balanced manner. Furthermore, legislation is continually made more stringent with regard to the ecological effects of offshore wind farms and they must be either not harmful or – preferably – beneficial; outside of the scope of this study, but relevant in this context, is also circularity of entire value chains (Interviewee I-2, T-1; (Rijksoverheid, 2022a). In fact, the Dutch government has indicated they will not tolerate any concessions with regard to harmful ecological factors of offshore wind farms, even if this means that the implementation or ability to meet the interim goals for 2030 may suffer delays (Ministry of Economic Affairs and Climate Policy, 2022b). For the upscaling of renewable energy production on land and in the built environment, factors such as social acceptance and public participation were indicated as key elements (Interviewee T-1).

The MTIP – and thus MMIPs – generally have a national scope (Interviewee T-1). In other words, the innovations that are pursued and the projects that are funded should contribute to the *Dutch* energy transition. Interviewee T-1 noted that there have been proposals for offshore energy projects that contribute to the development of offshore energy, however, that they were not accepted by EZK/RVO because they did not directly contribute to the national perspective. Over the years, however, collaborative initiatives have increased around the North Sea. Initiatives such as the Esbjerg and Ostend Declarations (Rijksoverheid, 2022g, 2023e) provide legitimacy to pursue and fund projects that cross national borders, especially in the context of internationally interconnected energy systems (Interviewee I-1, I-2, T-1). The Netherlands additionally participates in a plethora of collaboration networks to drive technological development and innovations necessary for the energy transition, including (but not limited to) the European Technology and Innovation Platform for Photovoltaics (ETIP PV), European Technology and Innovation Platform on Wind energy (ETIPWind), European Strategic Research and Innovation Agenda (SRIA), Clean Energy Transition Partnership (CETP), and the Interreg North Sea Programme (Top Sector Energy, 2021). For a broader overview of the international embeddedness of the mission, see **box 1**.

Another challenge with offshore wind energy is matching supply and demand. Apart from the question whether the capacity of 21 GW (Ministry of Economic Affairs and Climate Policy, 2022b) will be met by 2030 (Interviewee I-1), there were also concerns about how we will distribute that capacity in case we do reach it (Interviewee A-3). Roughly half (11 GW) can be integrated into the high voltage electricity network, however, the other half cannot and will thus have to be distributed in a different manner, e.g., by connecting it directly with energy-intensive industrial clusters near the shore or converting it into green hydrogen (Ministry of Economic Affairs and Climate Policy, 2022b).

Box 1. The international context of addressing grand challenges and sustainability has paved the way to mission-oriented innovation.

Although the concept of 'mission-oriented innovation' is relatively new, working with objectives or 'missions' is not new and has been around for decades. Over time, goals have evolved over time in response to new developments, possibilities, insights, and events. In this box, a brief overview of various policy directions that are relevant to the context of this study will be highlighted.

In 2009, the Lund Declaration highlighted the need for a visionary approach to Science, Technology, and Innovation (STI) policy. It stressed that Europe should concentrate on addressing societal challenges and called for European leadership in cutting-edge research and development. Shortly afterwards, the European Union presented its long-term strategy for 2050, which aimed to reduce greenhouse gas emissions by 80-95% by 2050; later in 2018, as a result of revision following the Paris Agreement and European Green Deal, this ambition was increased to net-zero emissions (European Commission, n.d.-b). The Kyoto Protocol was adopted by the United Nations in 1997 and its first commitment period was between 2008–2012, which was guided by the objective to reduce greenhouse gas emissions by 5% relative to 1990 levels (UNFCCC, n.d.-b). During the second period (the Doha amendment, 2013–2020), parties committed to reduce emissions by 18% (UNFCCC, n.d.-a). Around the same time, the European Union set the 20-20-20 climate and energy targets, which were aimed at reducing greenhouse gas emissions by 20%, increasing the share of renewable energy consumption to at least 20%, and achieving at least 20% energy savings by 2020 (European Commission, n.d.-a). In addition, the European Strategic Energy Technology (SET) Plan aims to boost the transition towards a sustainable energy system by stimulating the development of low-carbon technologies (European Commission, n.d.-e), and the previous Horizon 2020 programme aimed at reducing the dependency on fossil fuels. The Horizon 2020 programme was succeeded by Horizon Europe, of which its 'cluster 5' programme aims for a climate-neutral Europe by 2050 (RVO, 2021a).

Around 2015, the Sustainable Development Goals were launched by the United Nations. In the context of the energy transition, the aims were – among others – to increase the share of renewable energy in the global energy mix and improve energy efficiency, as well as reducing greenhouse gas emissions by 43% by 2030 and have net zero emissions by 2050. In the same year, the UN's Paris Agreement was adopted. While the Agreement did not force specific emission targets (Member States were expected to set their own targets, so-called 'Nationally Determined Contributions'), it was widely acknowledged that greenhouse gas emissions should be reduced by 48% by 2030 and reach net-zero by 2050 to hold the global warming temperature increase below 1.5 °C (IPCC WG3, 2022). The G7 called all signing parties to implement national climate plans in line with the Paris Agreement in 2016 whilst also calling for cessation of fossil fuel subsidies by 2025 and supporting the Mission Innovation initiative (in which the Netherlands participates), which aims to accelerate clean energy innovation. A year later, in 2017, the Netherlands joined the Powering Past Coal Alliance, an alliance that aims to accelerate the fossil fuel phase-out of unabated coal-fired plants; in 2021, the United Nations presented the Glasgow Climate Pact, which aims to phase-out the use of unabated coal (UK Government, 2021).

More recently, the European Union presented its 2030 Climate Target Plan and Fit for 55 package as part of the European Green Deal. In order to establish the ambitions as legally binding targets, the European Climate Law was introduced, which mandates that each Member State must reach emission reductions of at least 55% by 2030, compared to 1990 levels. The aim is to translate ambitions into concrete policy and anchor the climate goals in legislation. The overall ambition is to reduce greenhouse gas emissions by at least 55% by 2030 and to have net zero emissions by 2050 (European Council, n.d.). Furthermore, in response to the 2022 escalation of the Russo-Ukrainian War and the following global energy market disruption, the European Commission presented its REPowerEU Plan. This plan focuses on – among others – energy efficiency, increasing renewable energy shares, and the construction of a new energy infrastructure across Europe to make the Union independent from Russian fossil fuels well before 2030. Along with its ambitious goals, REPowerEU increased the EU's target for renewables from 40% (from the 'Fit for 55' package) to 45% (European Commission, n.d.-d). What REPowerEU meant for climate policy is further explained in **box 2**.

This overview indicates that, while mission-oriented policy is a relatively new concept, working with missions or (long-term) objectives and visions are not new. In fact, the focal mission of this study is likely the result of – or at least strongly inspired by – the evolution of goals in the international landscape.

Others were more optimistic and pointed at the rapid scaling of solar and wind energy production as evidence that ambitious goals can be met, and expects that by 2035, 90% of the Dutch electricity could come from solar and wind energy (Interviewee A-4). However, this optimism is not without caveats. Significant challenges, such as the need for energy storage, backup options like hydrogen plants, and matching supply with demand, still need to be addressed; the interviewee wondered whether the development of hydrogen, for instance, will be rapid enough to be ready by 2035 (Interviewee A-4). The European Scientific Advisory Board on Climate Change recommends a carbon-neutral fuel supply by 2040 in Europe (European Scientific Advisory Board on Climate Change, 2023). The current pace of change was considered not sufficient to meet this target, and hydrogen stands out as a particularly promising avenue – in combination with the upscaling of renewable electricity – to accelerate progress toward this goal (Interviewee A-4).

There is, however, an inherent uncertainty with regard to the match in timing between the supply profile of offshore wind energy and the demand profile of e.g. industry; such mismatches could lead to a (temporary) negative business case for offshore wind energy or grid congestion due to the integration of large amount of electricity that are not utilised sufficiently and must be exported to neighbouring countries (Ministry of Economic Affairs and Climate Policy, 2022b). The Dutch government aims to minimise these uncertainties and potential mismatches through three means: (1) the government engages with industrial clusters and local authorities located near potential sea network landing sites to involve them in the process (also mentioned by Interviewee A-3); (2) the government focuses on boosting industrial demand for electricity, in line with the Electrification Roadmap (Rijksoverheid, 2021b); and (3) the government aims to form binding agreements with the 20 largest industrial CO2 emitters to achieve additional emissions reductions (idem).

Programmatic alignment

The Dutch government additionally aimed to align the national strategy with the programmes of the European Union (Ministry of Economic Affairs and Climate Policy, 2018a; Rijksoverheid, 2019c) and the UN Sustainable Development Goals (Ministry of Economic Affairs and Climate Policy, 2019c). The Dutch government also aimed to align their national mission-oriented innovation policy with the research and innovation policy, as well as the available resources in that context, in the European Union. Horizon Europe followed on Horizon 2020, for which 95.5 billion Euros is available for the period of 2021–2027. The programme seeks to enhance Europe's competitiveness through the promotion of scientific research and innovation in the context of societal challenges and 'moonshot' missions, including combating cancer and climate change.

The alignment with European initiatives is now actively pursued, as indicated by Interviewee G-1. For example, since 2018, the European Commission has been offering State aid through its Important Projects of Common European Interest (IPCEI) programmes. These programmes foster international cooperation and funding for large-scale projects that, while nationally executed, have significance that transcends national boundaries and aligns with the EU's strategic objectives (Interviewee G-2). One such IPCEI initiative, referred to as Hy2Use, aims to lower carbon emissions by promoting sustainable industrial processes using hydrogen in its production, utilisation, transport, and storage. Initially, the Dutch government had to react *ad hoc* to IPCEI calls due to a lack of a comprehensive strategy (Interviewee G-1). However, the government has since developed its National Technology Strategy (*Nationale Technologiestrategie*; see (TNO et al., 2023))). This strategy outlines the technological fields where the Netherlands aims to excel in, thereby guiding which IPCEI initiatives it may join (Interviewee G-1). The government also recognises that, as part of its commitment to sustainability, tough decisions about societal elements might sometimes be unavoidable ((Ministry of Economic Affairs and Climate Policy, 2023e) Interviewee G-4). These decisions could influence the future of sectors. However, there were reservations among interviewees about whether the government will actually make such decisive choices, considering its political nature. Instead, the government may simply focus on shaping market conditions and leave the fate of individual sectors to market forces (Interviewee G-1, A-1, A-2, A-3).

Box 2. Impact of the 2023 escalation in the Russo-Ukrainian War.

The conflict in Ukraine has had profound repercussions on the perspectives and practices surrounding the Dutch energy transition. One of the interviewees draws attention to the immediate chaotic consequences of the war on the global energy market, highlighting the increased costs that instigated a paradigm shift in public perception (Interviewee I-3). The economic ramifications that followed have been a strong driver in this respect. Although such high costs are not the most desirable incentives, they have proven to be virtuous catalysts in prompting individuals to reflect on the imperatives of energy efficiency and the sustainability of their households. Moreover, the conflict underscored the precariousness of over-reliance on specific nations for energy resources and resulted in the realisation that the Netherlands – and Europe as a whole – depends on Russia for its natural gas supply. Such reliance doesn't only manifest in monetary strains, as evidenced during the escalation in 2022-2023, but also accentuates the vulnerabilities tied to geopolitical fluctuations. The latter becomes all the more salient when a nation's energy supply is no longer guaranteed in the event of a cessation of energy supply by a domain supplier (Interviewee I-3). The war also resulted in the realisation that resources such as gas and electricity are not an unequivocal guarantee. Missteps in energy planning can thus suddenly put a nation's energy supply at risk.

Due to the conflict, the European initiative REPowerEU was inaugurated with the primary objective of expediting the discontinuation of gas imports from Russia. Historically, Europe has been notably reliant on external sources for its energy needs, with approximately two-thirds of its demand being sourced internationally (Interviewee A-3). Despite this long-standing reliance, the continent has not previously perceived such dependency as problematic. However, the war in Ukraine served as a watershed moment, leading to a realisation about the potential vulnerabilities associated with such a high level of dependence (Interviewee A-3, I-3). In August 2021, Russia alone accounted for a remarkable 41% of the EU's external energy sources, and due to the conflict this share plummeted to 9% in August 2022 (Interviewee A-3). The conflict underscored the potential risks tied to the security of energy supply, especially when set against the backdrop of escalating geopolitical tensions. This heightened consciousness regarding energy security and geopolitical dependency is a recent phenomenon, predominantly triggered by the events of the war.

In the wake of the conflict in Ukraine, a silver lining identified by another interviewee was the increased awareness with regard to energy and energy contracts (Interviewee T-5). This elevated understanding, however, does not come without challenges. The interviewee underscores that prevailing regulations may act as impediments to advancements in this domain. While there is an ongoing effort to introduce and reform legislative measures to address these challenges, the pace of such legislative action is deemed insufficient by the interviewee. This suggests an urgent call for more expedient policy reform in the energy sector.

For the societal challenge of energy and climate, the Dutch government began working on the Climate Agreement in early 2018 with a large number of stakeholders, following its intention to take measures in response to the Paris Agreement (Rijksoverheid, 2019a) and taking a longer-term perspective than the Energy Agreement from 2013 (Rijksoverheid, 2013a). What the Paris Agreement means for the Dutch climate policy is elaborated upon in **box 3**. The Agreement aimed to set a guide on how the nation will achieve the ambitious goal of reducing greenhouse gas emissions by 49% in 2030 compared to 1990 in the Netherlands. Five sector tables (electricity, built environment, industry, agriculture and land use, and mobility) were responsible for providing the possible options that could contribute to this goal and determining the necessary efforts and tools to achieve the goals for 2030 whilst also accounting for the necessary steps towards 2050. The sector tables also indicated what knowledge and innovation challenges these goals bring about; these challenges come together in an integrated knowledge and innovation agenda (KIA) for climate and energy that, coupled with Climate Agreement, guides the course for the necessary knowledge and innovation efforts. This KIA also included the agenda of the Top Sector Energy and other relevant top sectors that contribute to the theme (Ministry of Economic Affairs and Climate Policy, 2018a).

The central goal of the Climate Agreement was to reduce the national greenhouse gas emissions with 49% by 2030 and with 95% by 2050 compared to 1990 levels (Rijksoverheid, 2019b), and was coupled directly to the Energy Transition and Sustainability missions of the MTIP (Ministry of Economic Affairs and Climate Policy, 2019b). The focal mission in the context of this study is to achieve an entirely carbon-free electricity system by 2050. In order to reach the goal of 49% reduction, the electricity sector was estimated having to reduce CO2-emissions with at least 20.2 Mton by 2030 (Rijksoverheid, 2019b), and in order to support the energy transition across sectors, the needed capacity of electricity in the Dutch energy mix was estimated to be between 35 and 75 GW (150-320 TWh) (Ros & Daniëls, 2017). In the Coalition Agreement of Rutte IV, the cabinet agreed to increase the CO2-reduction goal from 49% to 55% by 2030 (Rijksoverheid, 2021a). The goal to reduce 55% was not necessarily the goal of the Dutch cabinet; rather, it was the aim of the European Green Deal and was also implemented in the European Climate Law in 2021, thus mandating Member States to take the necessary measures at the national level to meet the target, and in the Dutch Climate Act in 2023 (Rijksoverheid, 2023c). The Dutch government, however, took an extra step and anticipated a reduction of 60% as a safety margin

(Rijksoverheid, 2021a); in order to reach this goal, the cabinet recently proposed additional climate measures (Ministry of Economic Affairs and Climate Policy, 2023b). Particularly for the electricity sector, the additional climate measures meant an additional 4.0 Mton CO2-emission reduction and included the aim to be carbon-free by 2035 instead of 2050, which they aim to achieve by stimulating the implementation of 3 GW offshore solar energy, repurposing of natural gas plants to support the hydrogen pathway, and an obligation for solar farms to incorporate batteries into their farms (Ministry of Economic Affairs and Climate Policy, 2023b) – all of which need innovation to succeed.

Part of the difficulty of the energy transition is also the historic security of energy supply (*leveringszekerheid*). TenneT reported that security of supply may not be guaranteed anymore by the established norms from 2030 onwards, given the major changes that are currently undertaken in the energy system and the intermittency of renewable energy sources as well as dependencies on other countries (TenneT, 2023d). Interviewee T-2 indicated that this may be inevitable to continue with the transition, while emphasising the necessity of protecting households (Interviewee T-2). Furthermore, natural gas was considered a stable energy source that can be utilised in a sustainable manner to bridge the gap and guarantee security of supply, even though efforts are being made to phase it out from the built environment (Interviewee G-2; (Uitvoeringsoverleg Elektriciteit, 2022). A realistic approach was advocated for trading off goals whilst acknowledging that goals should not be pursued at all cost (Interviewee A-3); on the other hand, Interviewee A-4 put emphasis on the necessity to accelerate the transition and that any delays will lead to worse climate change outcomes.

Box 3. What does the Paris Agreement mean for the Dutch climate policy and, in line with that, the innovation policy? (based on PBL, 2016)
The climate goals from the Paris Agreement correspond to a maximum cumulative emission of approximately 250-400 Gt CO2 or 600-1200 Gt CO2 (starting from 2015) for a reduction of 1.5 and 2 degrees Celsius, respectively. Research shows that a worldwide maximum cumulative emission of about 600-1200 GtCO2 from 2015 gives a likely chance (of more than 66 percent) of staying below 2 degrees Celsius. For 1.5 degrees Celsius, emissions would have to be limited to a value in the order of 300-400 Gt CO2. These maximum CO2 emissions are also called carbon budgets. The Dutch objective for a 2 degrees Celsius goal corresponds to a reduction of CO2 emissions of around 85-95 percent by 2050. The 1.5 degrees Celsius goal would in that case correspond to an emission reduction of 100 percent by 2050; or in other words, this means a complete decarbonisation of the Dutch energy supply by 2050. In order to achieve this goal, stringent climate policy is required, which goes beyond the existing policy goals. Especially with relation to the development of technologies such as renewable energy sources and carriers. The MMIPs are designed to focus on the innovation needs by sector and topic. With respect to the focal mission, MMIP 1 and MMIP 2 (and cross-sectorally MMIP 13) are the mission-oriented innovation programmes that target innovations.

When the MTIP was announced in 2019, the letter to parliament explicitly stated that working with missions would lead to interweaving agendas of the departments, Top Teams, and European governments (Ministry of Economic Affairs and Climate Policy, 2018a). While interviewees acknowledge that missions have led to more collaboration between parties (Interviewees G-1, T-1), it has not yet fully resulted in a seamless integration of topics and agendas (Interviewees G-1, G-3, G-5, A-5, T-1). For instance, sectoral compartmentalisation is persistent (Interviewee G-1, G-2, G-3, T-1) – meaning that many challenges are still approached within sectors – while the missions (should) allow for more holistic approaches. While the interviewees acknowledge that sectoral or programmatic approaches are and will remain to be necessary (Interviewee T-1), there is also a demand for more integrated approaches. To provide an example: the production of renewable energy is at the core of the electricity sector and, to a lesser extent, the built environment sector, while the uptake of that energy depends on the goals and progress of sectors such as industry (e.g., by the pace at which industries electrify) and mobility (e.g., by the adoption rates of solar panels and electric vehicles) as well as innovations such as smart software that connects and integrates local sustainable assets (Interviewee I-4; (Eneco, 2023); all these different sectors and programmes operate in parallel, but require balancing and harmonisation with one another as well, in order to prevent bottlenecks to emerge.

Interviewee G-5 gave an example of how operators of solar farms sometimes build in areas where land prices are relatively low, while the local demand there may also be relatively low. This can cause local congestion on the grid due to a mismatch in supply and demand. Previously, anyone with a building permit was eligible to get a connection from the local grid operator, but this has somewhat changed due to problems with grid congestion. As of 2021, operators need to first receive a positive indication from the grid operator before they obtain a permit from the local government (Liander, n.d.), which is an agreement that originates from the Climate Agreement (Rijksoverheid, 2019b). Such a strategy is more aligned with what is possible within the system, rather than blindly encouraging the construction of solar farms. Another solution mentioned during the interviews is promoting local solutions, for example, by giving regions more or less subsidy for such projects based on the situation on the local grid (Interviewee A-4). This would incentivise operators to divert to locations that are more suitable. The interviewee emphasised that, regardless, the pace of the transition should not be slowed down – even if that results in bottlenecks; otherwise, meeting the goals may be jeopardised.

Environmental Visions

The Dutch Environmental Visions (*Omgevingsvisie*; OVI) serve as a comprehensive spatial planning framework that outlines the country's long-term vision for the physical environment. This vision encompasses various aspects of society, including urban development, transportation, agriculture, and energy, aiming for a more sustainable, economically robust, and socially inclusive future (Ministry of the Interior and Kingdom Relations, 2020).

In the context of energy transition, the national OVI (NOVI) is particularly important because it aims to guide how and where new forms of renewable energy production should be incorporated into the relatively densely populated Dutch landscape. This involves addressing complexities around spatial planning, such as where to place new wind turbines, solar farms, electrolysers, or other renewable energy installations, while taking into account ecological concerns, existing land use, and social acceptance – particularly in the context of the built environment (Top Sector Energy, 2021). Next to the NOVI, environmental visions are also designed at the municipal (GOVI) and provincial (POVI) levels to capture the local and regional contexts (VNG, 2018).

Various goal conflicts are to be anticipated by the OVIs, including spatial conflicts (e.g., the interests of agriculture or the built environment may clash with the need for new solar or wind farms), economic or ecological conflicts (e.g., while offshore wind energy may contribute to the renewable energy targets, it might also affect fishing zones – both economically for the fishing industry and ecologically for the local sea flora and fauna), social acceptance conflicts (e.g., public or local resistance against new energy installations, often referred to as "not in my backyard" sentiments), infrastructural conflicts (e.g., clustering energy-intensive industry versus installing new infrastructure for the transport of energy), and intersectoral conflicts (e.g., competing demands for electricity or land use between sectors such as the built environment, mobility, and industry) (Ministry of the Interior and Kingdom Relations, 2020). The Netherlands is currently also working on a programme (*Programma Energiehoofdstructuur*; PEH) that aims to guide what main energy infrastructure is needed for the future energy system, including high voltage infrastructure, electrolysers, large energy plants, and storage facilities – specifically accounting for the quality of the living environment and cost reduction (Rijksoverheid, 2019a, 2023d). The OVIs and PEH together provide guidance to the Regional Energy Strategies (RES) and their national programme (NP RES).

National Growth Fund vs. KIC/MTIP

The National Growth Fund is an investment fund focused on long-term earning potential (Ministry of Economic Affairs and Climate Policy, 2021). This growth fund is not a tool within the KIC or the MTIP; the conditions for consortia and projects are also not tied to societal challenges. However, the experiences gained within the Top Sectors and the collaborations within the ecosystems around the MTIP are considered relevant in the context of the Growth Fund. For example, many of the project groups that applied for funding in the first round of the Growth Fund originated from networks around the MTIP. In this way, while not directly related, the Growth Fund can serve as a significant capital injection for existing Public-Private Partnerships (PPPs), facilitating the scaling and implementation of innovation to strengthen new and existing ecosystems (Ministry of Economic Affairs and Climate Policy, 2021).

Nitrogen policy

The Netherlands currently faces a nitrogen crisis as a result of excessive nitrogen oxides and ammonia emissions, leading to excessive deposition; this has been deemed the result of ‘timid policymaking’ as the issue has been known for decades (Interviewee A-3). As a result of the crisis, many construction projects are halted and delayed, including energy infrastructure projects (Interviewee G-1, G-3, G-5, A-3, I-4), while the construction of offshore wind farms have been granted exemption (Ministry of Economic Affairs and Climate Policy, 2022b). Exemption can only be granted when projects address urgent societal issues (Rijksoverheid, 2022e). It was therefore not understood well why some projects were granted exceptions, but not energy infrastructure projects (Interviewee G-5). While the interviewee acknowledges the importance of the nitrogen policy, they also underscored the crucial importance of energy infrastructure for the success of the energy transition, and this sentiment was further underscored by the Dutch TSO/DSOs (Netbeheer Nederland, 2023c; TenneT, 2023e).

Governance

Besides the *presence* of goal conflicts, the way they are *coordinated* is relevant as well. According to the interviewees, intergovernmental collaboration across programmes, topics, and departments is increasing since the missions were adopted in 2019 (Interviewees G-1, G-2, G-5). This allows for better alignment of sectoral or departmental goals that operate in the same domains. However, much is still approached from within the sectors and, as such, stakeholders have identified a need for an integrated plan, which is at the core of the National Plan Energy System (*Nationaal Plan Energiesysteem*; NPE) that is planned to be finished by the end of 2023 (Interviewee G-3).

The political nature of trading off priorities or setting directions was seen as one of the complexities that may give rise to conflicts, especially when decisions are needed that are considered controversial or sensitive (Interviewee G-1, I-3). As Interviewee I-3 puts it (own translation): "*There are sometimes aldermen that do not dare to communicate inconvenient truths with their local citizens, such as that certain options are expensive, and instead opt to keep everything in public hands to avoid resistance. [..] Or they have no idea what options are suitable in their local context and randomly pick one that is most convenient. [..] That is not the way we can build a new system [that is needed for the energy transition].*" While the benefits to citizens must be placed at the forefront of such directions, there is also a need for political courage and leadership (Interviewee I-3). Furthermore, the interviewees identified a need for the government to work more together (Interviewee I-3) and to take on a long-term vision in which the focal goals are prioritised (Interviewee G-4), as it is currently unclear what the priorities are (Interviewee G-3); based on that, incentives should be designed to pave the way for all relevant stakeholders in the system (Interviewee I-3). The interviewee noted that the government is currently too invested in 'band-aid measures' that provide temporary solutions to problems, rather than guiding the process over longer periods of time; the NPE is the first step in this direction (Interviewee G-2, G-4). Tough choices are now needed in the short term, which may incur costs that are controversial, but that bring long-term successes; the interviewee considers that one of the main challenges at this moment in the transition, especially with a relatively unstable cabinet: "*how do you establish plans with a long-term horizon that can be truly sustained, that is the real crux of the matter. [..] I think that the climate in the Netherlands, where thinking is still polarised along left-right lines and is becoming increasingly populist and extreme, makes it more challenging to make choices [and] to stick to a long-term course*" (Interviewee G-4). Thus, instead of focusing on 'easy wins' and short-term goals, stakeholders were said to need to focus more on the long-term visions, which may require new frameworks for subsidy schemes that prioritise different factors (Interviewee G-3, A-4). For instance, the interviewee memorised a particular programme within a MOOI call – Brain for Buildings – which they said is a coherent programme aimed at better managing energy use in building with a wide variety of parties. Despite being one of those programmes that were needed at the time, it was difficult to compete with other projects in the call as various smaller projects that targeted specific technological developments scored higher, and that the programme only just made it. They also recalled other programmes in the built environment, such as WarmingUp and IEBB, which are also coherent programmes aimed at the long-term. The interviewee emphasised that, in their vision, mission-oriented programmes are supposed to be long-term and go beyond technological development – and which should be facilitated, even if the costs are relatively high (Interviewee A-4).

Finally, a myriad of separate Acts – each with their own objectives and contexts – govern environmental procedures and permissions, leading to bureaucratic bottlenecks that impede projects that contribute to the transition. The Dutch government has therefore been making efforts to streamline this complex legislative landscape and aims to consolidate 26 Acts – comprising a total of 4,700 articles – along with 120 General Administrative Orders (*Algemene Maatregelen van Bestuur*) and 120 Ministerial Regulation (*Ministriële Regelingen*) into one unified Environmental Act (*Omgevingswet*) that comprises 349 articles, 4 GAOs, and approximately 10 MRs.

Summary

This challenge concerns the difficulties involved in making priorities between different and sometimes conflicting goals. The overall objective is to reduce greenhouse gas emissions to curb climate change, and the focal mission strives towards this goal within the context of the electricity system. However, while the mission itself makes no reference to economic factors, the Dutch government has listed a wide variety of such and other objectives as well, which largely builds upon the previous Top Sectors approach (Ministry of Economic Affairs and Climate Policy, 2021). For instance, goals such as enhancing the national competitive advantage or stimulating innovation per se via generic instruments do not automatically contribute to the aim of the mission. To what extent and how synergies are realised between the various goals, both in the context of the innovation policy as well as the broader agreement and policy around the transition, remained rather unclear during the study. Pursuing goals implies making choices, choices that will bring about socio-economic effects for stakeholders in the focal system; such effects can be of significance across various governance levels, which means that handling goal conflicts is a very complex matter, especially in the case of transitions of the energy system.

The climate goal of the Netherlands is in line with the international ambitions (see **boxes 1** and **2**). As goals become more ambitious over time, the government continually has to reassess their policy and take additional measures.

5.2. Defining system boundaries

This challenge involves identifying the core issue and the focus area that the mission should address (Bergek et al., 2023). The focus area should combine a range of potential solutions that address the mission with the specificities and needs of the sector(s) in which the mission is operated. The delineation of the missions as well as the interpretation of the overarching goal by policy makers, and the specificities of the mission arena (Wesseling & Meijerhof, 2023), ultimately determine the specific system boundaries that are applied to a mission. These boundaries, in turn, determine the overall direction of policy by guiding attention away from some problems and solutions and towards others (Wanzenböck et al., 2020).

In the implementation of the climate goal in the Dutch electricity system, the translation of the mission to have an entirely carbon-free electricity system by 2050 has resulted in various system boundaries.

System boundaries

First, the mission explicitly aims at the electricity system, which limits the boundaries of the extent to which the mission contributes to the energy transition. One thing is certain (Interviewee G-3): electricity will make up for a significant portion of the future energy system, regardless of the specific strategy that Netherlands decides to take (IRENA, 2019; Netbeheer Nederland, 2023d). This implies that decarbonising the electricity system will significantly contribute to the climate goal. However, this also means that the mission – and particularly its innovation programmes MMIP 1 and MMIP 2 – are largely focused on renewable energy, with particular attention for wind and solar PV. Alternative options such as nuclear energy are technically in the scope of the mission and the Netherlands has committed to investigating the potential of nuclear energy in the future energy mix in addition to wind, solar, and geothermal energy (Rijksoverheid, 2021a), albeit the application of the technology has been controversial in the political arena and in society. The government is currently investing significant funds into the development of hydrogen as well, such as the recent reservation of 9 billion Euros in June 2023, which is considered a necessary element of the transition to take off electricity from the offshore wind farms in the North Sea and to distribute larger quantities of energy separately from the electricity grid (Ministry of Economic Affairs and Climate Policy, 2022b). Although hydrogen is thus an important option to complement the electrification and further upscaling of renewable energy in the Netherlands, it is not considered within the scope of the mission and, instead, has its own TKI (New Gas) and programme.

Second, while supply and demand are acknowledged as important topics within MMIP 1 and 2, the mission itself is formulated in such a way that it is the production side that is addressed. Through the mission's targets and interim goals, explicit emphasis is put on the upscaling of the production capacity. Other missions and corresponding programmes are more focused on the demand side. For instance, mission C aims to stimulate the electrification of industry and mission D the adoption of electric vehicles and renewable electricity utilisation in the mobility sector (Rijksoverheid, 2019c). In order to guide and aim for an optimal match in demand and supply, the Dutch government works with the Electrification Roadmap, which is part of the Climate Agreement (Rijksoverheid, 2021b). The solutions on the demand side will thus be provided by other missions and their innovation programmes (Interviewee T-1, T-3, T-4, T-5), and the same principle applies to goal conflicts that may emerge along the way (cf. DC1).

Third, while addressing the overarching goal to curb carbon emissions, the mission may have a different context depending on the type of policy, such as energy policy, climate policy, and innovation policy. In the innovation policy, for instance, particular attention is – as explained earlier – put on cost reduction and upscaling the production capacity of wind and solar energy; while in the energy policy, a greater emphasis is put on the energy system as a whole and where it is traded off against alternative energy sources and carriers (Rijksoverheid, 2023a). The implementation of the innovation policy around the mission is thus much more focused in that sense, although there were interviewees that argued that the mission is formulated too vaguely and thus does not provide the required guidance (Interviewee G-3) or that innovation programmes in the Netherlands are not mission-oriented to begin with and are, instead, stimulate rather generic innovations (Interviewee A-2, A-4).

Fourth, in line with the previous paragraph, while the mission is part of both the Climate Agreement and the MTIP, its context may differ. As mentioned before, the MTIP is targeted at stimulating innovations within a narrowed down domain, while the Climate Agreement has a more holistic approach to curbing carbon emissions. The difference in boundaries in this case is, for instance, that the mission in the context of the MTIP lies within electricity from wind and solar PV, while the context of the Climate Agreement considers what role electricity plays in the wider energy system, along with its complementary alternatives.

Fifth, not all innovations are fruitful in the light of regulatory boundaries. For instance, bottom-up initiatives such as energy cooperations and communities were seen as potential solutions to both stimulating decentral energy networks that are capable of implemental local energy production and usage, and as a means to involve citizens within the transition (Interviewee A-1; Unie van Waterschappen (2021); and cf. DC6). However, current legislation complicates running such initiatives. For instance, cooperations are legally not allowed to supply energy to their own members and must comply with the same legal requirements as professional companies such as Eneco (Interviewee A-1, T-2).

Finally, in some documents, the mission explicitly targets CO2 emissions, while in others it targets ‘carbon’ or ‘greenhouse gas’ emissions. It remained unclear whether the Dutch strategy is solely aimed at reducing emissions from carbon dioxide, or whether it aims more generally at eliminating all greenhouse gas emissions (typically referred to as CO2-equivalent emissions), such as methane (CH4) and nitrous oxide (N2O) – which are more potent greenhouse gases than CO2 and are thus increasingly of interest as well. The focus on CO2-equivalent emissions allows for a more comprehensive approach to decarbonisation, as it takes into account all the different gases that contribute to climate change. This is particularly important in the energy sector, where different processes can emit different types of greenhouse gases. For example, natural gas power plants emit both CO2 and methane, and the latter has a much higher global warming potential over a 20-year period. Therefore, the mission to achieve a carbon-free electricity system by 2050 would likely benefit from reducing all types of greenhouse gas emissions.

Systemic elements

Other than these, the system of the mission is further bounded by systemic elements, including technological, regulatory, economic, social, and environmental boundaries.

Technological: The transition from a system primarily based on fossil fuels to one based on renewable energy sources involves a significant shift in the technological makeup of the system, with increased use of technologies like wind turbines, solar panels, and energy storage systems. The technological boundary here is about deciding which technologies to prioritise and how to integrate them into the existing system.

Regulatory: Achieving the ambitious targets requires a supportive regulatory environment, including policies and regulations that incentivize renewable energy, discourage fossil fuel use, and facilitate the integration of new technologies into the electricity system.

Economic: The system transition involves significant investments in new infrastructure, technologies, and human capital, as well as incentivising the adoption of solutions. At the same time, it can lead to economic opportunities, such as job creation in the renewable energy sector. The economic boundary here involves balancing the costs and benefits of the transition and ensuring that it is affordable, just, and that it contributes to the economic prosperity of the nation.

Social: The energy transition can have significant social impacts, both positive and negative. On the positive side, it can lead to cleaner air, job creation, and increased energy independence. On the negative side, it can involve disruptions to existing industries and jobs, and potential increases in energy or living costs. The social boundary involves managing these impacts and ensuring a just transition that benefits all segments of society.

Environmental: The primary goal of the energy transition is to reduce greenhouse gas emissions and mitigate climate change. However, the transition also needs to take into account other environmental impacts, such as the impacts of renewable energy projects on local ecosystems and landscapes. The environmental boundary here involves ensuring that the transition contributes to broader environmental sustainability goals beyond just reducing emissions.

In the context of the mission, these system boundaries are interconnected. For instance, the choice of technologies (technological boundary) is influenced by regulatory policies (regulatory boundary) and economic considerations (economic boundary), and can have social and environmental impacts (social and environmental boundaries). Taken together, there may be a variety of options available in each individual helix, but those that are shared among each of the systemic boundaries are the options that should be prioritised. A holistic approach to the energy transition involves recognising these interconnections and designing policies that address multiple boundaries simultaneously. For instance, a policy that promotes offshore wind energy could involve measures to drive innovation to support technological development (technological boundary), provide economic incentives to support the business case (economic boundary), streamline permitting procedures (regulatory boundary), stimulate ecological considerations by including them as decisive tender criteria (environmental boundary), and engage with local communities to boost social acceptance (social boundary).

Summary

In mission-based policy-making, the crux of the challenge lies in pinpointing the central issue and corresponding focus area. This area should not only address the mission's goals but also be finely tuned to the specific needs and nuances of the sectors where the mission is to be implemented. For example, in the Dutch objective to create a completely carbon-free electricity system by 2050, the boundaries set by policymakers primarily spotlight renewable energy, particularly wind and solar power. While this focus is instrumental in achieving climate goals, it's essential to note that these boundaries guide the policy's overall direction, drawing attention to particular problems and solutions at the expense of others.

Interestingly, the mission's focus is more on enhancing production capacity rather than balancing supply and demand, which are covered by other programs. For instance, other missions aim to stimulate industrial electrification and the adoption of electric vehicles, thereby addressing the demand side of the equation. Additionally, the mission's interpretation varies depending on the policy context, whether it's energy policy, climate policy, or innovation policy. Each has its own set of priorities; for example, innovation policy may prioritise cost reduction while energy policy might consider the broader energy system trade-offs.

The mission is further constrained by systemic elements that include technological, regulatory, economic, social, and environmental boundaries. These systemic elements are not isolated; they are deeply interconnected. The choice of technology, for instance, is influenced by regulatory policies and economic considerations, which in turn have social and environmental impacts. A truly effective approach to energy transition would therefore be holistic, recognizing these interconnections and formulating policies that simultaneously address multiple systemic boundaries. Such an approach ensures not just the mission's success but also its alignment with broader sustainability goals and societal needs.

5.3. Identifying realistic pathways

Depending on how system boundaries are defined, the next step is to identify realistic pathways for the transition. This ensures a diverse array of practical options and pathways that can be achieved within the specified time frame of the mission. Academics have shed light on simultaneously cultivating multiple options and paths (Wanzenböck et al., 2020). This involves taking into account various timelines and the views of a broad spectrum of stakeholders. Identifying and mapping all potential pathways may be an overwhelming task depending on the focal missions and its context. Nonetheless, it is important to note that there will typically be a finite set of options to consider within the constraints of time and system boundaries (cf. the policy objective).

Pathways towards a carbon-free electricity system

There are many uncertainties in the course of the energy transition, however, stakeholders may develop scenarios based on which generic conclusions, outcomes, pathways, and choices can be derived. This study did not aim to map the realistic pathways as that is ultimately a task for the involved system stakeholders that are expected to implement and realise the mission. To this extent, six documents are highlighted (see **Table 4**) that are expected to pave the way to identifying realistic pathways in the context of the Dutch mission towards a carbon-free electricity system: NPE, Roadmap Electrification in Industry, Roadmap Offshore Wind, Roadmap Energy Storage, Integral Infrastructure Reconnaissance 2030–2050 (Integrale energiesysteemverkenning 2030–2050; II3050), TenneT’s Target Grid vision, and the Outlook Energy System 2050 (*Outlook Energiesysteem 2050*). Note that this list is not exhaustive and that (elements of) documents may be based on one another.

Table 4. Examples of documents that are intended to guide the pathways in the context of the Dutch mission towards a carbon-free electricity system.

National Plan Energy System (NPE) (Rijksoverheid, 2023a)

- Electricity will become the largest source of energy in the Dutch energy system – particularly through offshore wind – to support direct electrification and provide a source for green hydrogen.
- Hydrogen will play a systemic role in the energy system, particularly within industry and to anticipate an international trading and distribution hub.
- There is also an intention to build a capacity of 3.5-7GW of nuclear energy to diversify the energy mix and contribute to the robustness of the energy system.
- By 2035, the electricity system shall be entirely carbon-free. Until then, maximum growth of the electricity capacity and system are considered ‘no-regret’.
- Utilisation of smart energy systems and (price) incentives and access to the energy market for new players to implement flexibility in the system.

Roadmap Electrification in Industry (Rijksoverheid, 2021b)

- The industrial electricity demand is expected to rise to 30-80 TWh by 2030 and 80-130 TWh by 2050 (of which 10 and 26-46 GW will come from offshore wind energy). This will be associated with respective CO_2 reductions of 9-20 and 20-45 Mton. An electricity capacity of 80 TWh (60% of the industrial energy demand in 2050) is considered 'no-regret'.
- The government is considered to play an important role as the initiator and orchestrator of this process and in setting the right conditions for industrial electrification.

- The stakeholders identify the following four essential steps forward: (1) a need for clear policy goals and tools for industrial electrification (e.g., via SDE++). To achieve goals by 2030, these goals and tools need to be provided by the end of 2023; (2) develop generation and flexibility, in conjunction with industrial demand; (3) accelerate the scaling-up of the distribution infrastructure (via existing structures such as PIDI, MIEK, and CES). Until 2030, rapid expansion of electricity infrastructure and the development of hydrogen infrastructure are essential; and (4) develop a programmatic approach to innovations and knowledge dissemination. Innovation, scaling up, and reducing risks and costs are an essential part of the path to the required scale of electrification.

Roadmap Offshore Wind (Ministry of Economic Affairs and Climate Policy, 2022b)

- More offshore wind energy (21 GW instead of 11 GW) is needed to achieve the climate target of 55% less CO2 emissions by 2030. The expected electricity demand for 2050 is between 38 and 72 GW (Cleijne et al., 2020).
- Key points for offshore wind development in the Netherlands: (1) the Netherlands focuses on generating 50 GW of offshore wind energy by 2040 and 70 GW by 2050; (2) it is expected that part of the generated offshore wind energy will be converted into hydrogen at remote offshore 'energy hybs'; (3) the government intends to initiate a North Sea Energy System Development Programme (*Ontwikkelprogramma Energiesysteem Noordzee*) to ensure the development of new technologies and policy frameworks for further growth of offshore wind energy beyond 2030; and (4) the Dutch government continues with the 'one-stop-shop' principle for licensing anything related to the generation of wind energy and the offshore grid.
- In addition to the developments of wind at sea, plans regarding land connections are also important. In collaboration with the government, businesses, civil society organisations, citizens, and other stakeholders, work is being done on the Programme for the Investigation of Cable Landing Points for Offshore Wind Energy (*Programme Verbindingen Aanlanding Wind Op Zee*; VAWOZ) for the years 2031-2040. The program is to be established in the first quarter of 2025. A separate programme has been set up for the Eemshaven (called PAWOZ), one of the industrial clusters in the Netherlands.
- By the end of 2023, an Energy Infrastructure Plan for the North Sea 2050 (*Energie Infrastructuur Plan Noordzee 2050*) is also expected to be drawn up. It will outline what is needed in the field of infrastructure for the further roll-out of offshore wind (and solar PV) after 2030, the production of hydrogen at sea including options for the reuse of existing gas infrastructure, and the interconnected electricity and hydrogen transport infrastructure to the mainland of the Netherlands and surrounding North Sea countries.

Roadmap Energy Storage (Ministry of Economic Affairs and Climate Policy, 2023a)

- Energy storage is seen as a means to support the further development of the electricity system. Large-scale electricity storage, for instance, has great potential to reduce curtailment and batteries are recognised as an option to support the electricity grid.
- The possibilities that electricity storage currently offers are not yet aligned with the needs. To this extent, the roadmap recommends further research on home and neighbourhood batteries, to continue the encouragement of adoption of electric vehicles, and to provide national guidance to prevent uncontrolled proliferation of batteries.

Integral Infrastructure Reconnaissance 2030–2050 (II3050) (Netbeheer Nederland, 2023d)

- Four scenarios to develop the energy (and electricity) system of the future:
    - National leadership: limited industrial shrinkage; strong electrification; very high

renewable energy production; limited nuclear energy; extensive district heating networks.
    - Decentralised initiatives: significant reduction in energy-intensive industry; departure of certain industries; strong electrification, but also hydrogen in industry; very high renewable energy generation; use of 'energy hubs'.
    - European integration: no to very limited industrial shrinkage; new industry for synthetic molecules while maintaining CCU and bio-carbon; green gas, also from imports, alongside electrification and hydrogen; CCS remains, and use of blue hydrogen also present; partial hydrogen in the built environment; base load from nuclear energy.
    - International trade: significant reduction in energy-intensive industry; relocation of certain industries to abroad; lots of hydrogen shifting to bio, CCS, DAC, and electrification; major hydrogen imports; full use of hydrogen in the built environment.
- The II3050 provided a set of recommendations for policymakers, among of which:
    - Develop a vision for the energy sources and carriers that are needed in the future energy system;
    - Determine which energy-intensive (basic) industry fits into the climate-neutral vision of the Netherlands;
    - Step away from the ‘copper plate’ paradigm and establish in legislation that not everyone can request or expand capacity everywhere and at all times;
    - Build flexibility into the energy system through stimulation, scaling up, and innovation. Ensure that flexibility measures contribute to balancing the energy system and preventing congestion at all voltage levels;
    - Establish cross-sectoral plans to prevent multiple sectors from overestimating their share of the same limited available energy carriers;
    - Intensify collaboration within Europe.

TenneT’s (TSO) Target Grid vision (TenneT, 2023b)

- In order to achieve a carbon-free electricity system by 2045, TenneT strongly recommends policymakers to make use of the principles as outlined by the NPE and Target Grid.
- Reserve space for new high-voltage connections and substations (based on the Spatial Planning Memorandum (Ministry of the Interior and Kingdom Relations, 2023), Programme for Main Energy Infrastructure (Rijksoverheid, 2023d), and VAWOZ (RVO, 2023c).
- Resolve the nitrogen deadlock for electricity network expansion projects (e.g., by implementing RED III). The nitrogen deadlock limits not only the energy transition but also further growth in sustainable housing construction and the greening of the economy (e.g., due to network congestion, firms are no longer guaranteed a connection, which can result in delays to their electrification efforts).
- Relieve congestion on the electricity grid. Give grid operators the mandate to coordinate the locations of batteries. Refer to the National Action Programme Network Congestion (*Landelijk Actieprogramma Netcongestie*) for this (Rijksoverheid, 2022d).
- Ensure sufficient CO2-free controllable power plants for supply security.
- Give TenneT the legal task of constructing hybrid interconnectors. Align industrial sustainability with the growth of carbon-free electricity production (mainly from offshore wind and nuclear energy) by connecting and timing supply and demand of production and consumption patterns.

Outlook Energy System 2050 (Expertteam Energiesysteem 2050, 2023b)

- The expert team considers the goals of climate neutrality by 2050 to be feasible. In order to achieve this, it is deemed necessary to have a carbon-free energy system by 2040-2045 and a carbon-free electricity system by 2035. These interim goals are also considered feasible and realistic, provided that the Netherlands forms a clear vision and now acts quickly and dares to make choices.
- Electricity will become the main component of the energy system in the Netherlands, although molecular energy carriers will also continue to be necessary, but in a more limited form. Therefore, maximum focus should be placed on electrification and aligning demand with supply.
- Interests will likely come under pressure during the transition and resistance to change will likely arise, depending on the process followed. This makes it all the more important to involve all societal parties in the transition. Employing citizen assemblies for issues with a long-term and system perspective provides insight into important conditions for the transition and contributes to transparency and public support. It is important to be clear about the role and influence of the advice so that citizens know what their mandate is. A well-prepared and organised citizen or town council enables citizens to provide valuable and relevant advice.
- A clear division of roles for relevant stakeholders in the transition, along with timely clarity on desired behaviour and investments, is considered essential. A mix of policy instruments is needed to give citizens and companies the right incentives to contribute to the transition. Regulation with adequate enforcement often leads to quicker results than pricing, but pricing remains necessary. Spatial policy, infrastructure, and information provision are also part of this mix. The government should also provide incentives to ensure that the financial sector transforms. For execution, sufficient resources (knowledge, people, materials, space) must be available, and in cases of scarcity, prioritisation should take place based on the end vision. Investments in innovation, knowledge development, and knowledge sharing aimed at cohesive system changes are relevant prerequisites.

In 2022, the network operators conducted a quick scan of the coalition agreement of Rutte IV and what it meant for the ambitions of the energy system (Netbeheer Nederland, 2022b). They concluded that the government must provide more directionality, otherwise the climate goals cannot be met. Furthermore, directionality is needed urgently considering that developments require considerable lead times of ten years. As 2030 is approaching, the Dutch government must therefore focus on predictable and reliable policy with a distant horizon. The network operators came to seven conclusions to provide a required directionality (Netbeheer Nederland, 2022b):

1. A directive structure that includes financial aids, regulatory norms, and incentives to facilitate the development of expansive electrolysis, battery technologies, demand-side management, hydrogen reserves, and thermal energy storage;
2. Binding commitments to ensure a growing and timely demand for electricity, along with adequate funding in adaptive solutions like boilers, energy storage, and demand-side adjustments;
3. Comprehensive governance is needed across all elements of new energy supply chains to foster the growth of hydrogen, eco-friendly gases, thermal energy, and Carbon Capture and Storage (CCS). This is considered an essential element of the future energy system by the network operators;

4. The formulation of a European strategy to harmonise various national energy portfolios and major continental energy infrastructures, including interconnecting systems, gas and hydrogen transit networks, and marine energy grids;
5. Strengthening of human capital, supplementary financing for local grid operators, and expedited land-use planning processes;
6. Introduction of revised pricing mechanisms, mandatory utilisation of smart systems, and territorial planning initiatives to match supply and demand;
7. Implementation of the NPE to realise the energy transition. A coordinated and cross-sectoral strategy is imperative to make this transition a reality.

Rationale of making choices

The evolving energy system was described during the interviews: transitioning from a centralised, demand-driven fossil fuel-centric structure to a decentralised system that is driven by sustainable sources from primarily solar and wind energy, and more supply-driven (Interviewee T-5). Yet, while the drift is away from an entirely top-down model, a fully bottom-up system is not the endpoint either. Centralised energy sources, like offshore wind farms and expansive onshore energy parks, remain pivotal. The system's trajectory, however, points to diminished top-down operations, with increased reliance on digital tools, energy storage, conversion, and adaptability. Large-scale industries have already modulated their energy consumption for years, utilising storage buffers and energy management tactics, but the rise in 'net congestion' has underscored the urgency for innovative solutions (Interviewee T-3). Looking forward, a focus on smart energy systems and energy management, aimed at not only addressing network congestion but also leveraging fluctuations in the costs and availability of renewable energy, was seen as necessary (Interviewee T-5).

Post-2030, the need for electricity is projected to rise, underscoring the importance of boosting the national production capacities, notably through upscaling wind energy at the North Sea (Interviewee A-4). Nuclear energy stands as a potential alternative and intentions to build two new nuclear plants was included in the coalition agreement of Rutte IV (Rijksoverheid, 2021a), however, thus far the only commitments made with regard to nuclear energy has been investigating its potential (Interviewee G-1, G-3). It was questioned whether delving into nuclear energy is a sensible use of official resources, given that the share of nuclear energy has always – and is expected to continue to be (see NPE, for instance) – relatively small (Interviewee G-3). Given that building new nuclear power plants will likely be very costly and that – in the current plans – nuclear energy will primarily serve as a flexibility option during for example *dunkelflaute* (periods in which supply of wind and solar energy are below demand), some interviewees questioned whether it is a good choice (Interviewee G-3, A-2). The viability of nuclear energy could hinge on its necessity for producing sustainable bunker fuels in the future, which would otherwise demand substantial electricity or hydrogen (Interviewee G-3). However, there is uncertainty regarding whether wind and solar energy will prove adequate, which requires alternative options to be explored to guarantee the robustness of the electricity system and, thereby, the future energy system; these alternatives could be coupled with the rationale of upscaling of the production of renewable electricity, for example through the adoption of Power-to-X solutions (Interviewee A-2). Another interviewee noted that while the Dutch government is refining its nuclear policy, the Topsector Energy has sometimes interfered with this process as they do not appear to be in favour of exploring such options. Nevertheless, efforts are being made to mobilise action and work on building expertise in the area. Moreover, the interviewee drew attention to the possibility of incorporating a MMIP for nuclear energy in 2024 (Interviewee G-2).

It has been argued that the electricity system has been reasonably addressed in the past few years and that the necessary progress has been made. The real challenge in the energy transition therefore currently lies in addressing energy derived from fuels and heat, and how those – in addition to electricity – can be harmonised in the future energy system (Interviewee A-4). Solutions like hydrogen, CCS, and bio-energy were mentioned as viable options to this extent.

'No-regret' solutions

In the context of the Dutch energy transition, various components and strategies as 'no-regret' options. As highlighted before, the (concept version of the) NPE and the Roadmap Electrification in Industry recognise major upscaling of the national electricity capacity – translated into both electricity production from renewable energy sources such as wind and solar, and the expansion and reinforcement of the electricity network – as 'no-regret' (Rijksoverheid, 2021b, 2023a). Furthermore, while the IEA recently reported that a share of 50% renewable electricity is feasible (IEA, 2022), the Climate Agreement strives towards a share of 70% renewable electricity out of all generated electricity (Rijksoverheid, 2019b), and in the European Union, Member States need to generate at least 42.5% of their energy (electricity, gas, and heat) in a sustainable manner as part of the Renewable Energy Directive (European Commission, n.d.-c). These views were also underscored by the recent Outlook Energy System 2050 (Expertteam Energiesysteem 2050, 2023b) and highlighted during the interviews (Interviewee G-3, G-5, A-3, A-4). Taken together, the road to electrification is inevitable and thus 'no-regret', providing certainty to policymakers and other system stakeholders to fully commit to the pathways that can realise electrification, legitimise decisions, re-evaluate regulations, and design policy instruments to support it; taking a proactive approach to this would be a key enabling factor for many other transition activities (Interviewee G-3). Other solutions, such as household insulation in the built environment have long been considered no-regret as well. However, recent dialogues have begun to scrutinise this once certain perspective, questioning whether household insulation might actually result in a net cost (Interviewee A-3). Nonetheless, the provision of subsidies alleviates some of these concerns, rendering insulation economically viable and making it 'no-regret' after all. Despite such concessions, the necessity for a pragmatic approach to implementing 'no-regret' options was emphasised, implying that subsidies are finite and that affordability – especially for citizens – is an important element of just and affordable transitions (Interviewee A-1, A-3; (Ministry of Economic Affairs and Climate Policy, 2022c). The significant ambitious increase poses multifaceted challenges for the Netherlands, including infrastructural, financial, and organisational obstacles (Interviewee A-3). Firstly, the objective necessitates an overhaul of the entire energy system to accommodate the increased electricity usage. While the expansion may be practically feasible, the interviewee expects it to be an expensive pathway, particularly when compared to utilising molecular transport systems. Secondly, the administrative complexity in a densely populated and water-rich nation like the Netherlands should not be underestimated. The need to navigate a myriad of procedures and permits, and involving local policymakers and citizens, complicates the rapid expansion further. Lastly, the interviewee noted a noticeable hesitancy among electricity distributors to make the required investments for expansion. They considered this the result of uncertainties regarding the return on investment (Interviewee A-3). While the network operators acknowledged this, they noted that they require a mandate from the government to expand the network more proactively (Interviewee G-5).

With regard to energy efficiency, interviewee A-3 referred to the globally observed *iron law* that energy efficiency improves at a steady rate of approximately 1% annually (also see (ODYSSEE-MURE, 2018) for insights from the European Union). Achieving a twofold increase in this rate, pushing it to 2% would pose a great challenge and require considerable subsidy expenses. In this context, under the pretext that energy that one does not use, does not have to be generated nor transported either

(Interviewee I-3), it is posited that energy efficiency remains an integral facet of the transition. However, it cannot be regarded as a singular *panacea* (Interviewee A-3, A-4) and requires consumption behaviours to alter (Interviewee I-3) and may even mean that the concept of the *copper plate* paradigm has to be reconsidered (Interviewee T-2, T-5). What this may mean for the copper plate will be further explored later in this chapter.

Energy savings, flexibility, and storage

According to interviewee A-4, while the European Union's policy encompasses normative standards pertaining to various appliances and vehicles, such as washing machines, motors, and cars, the Dutch government's efforts in spurring energy savings leave much to be desired. Although there exists some policy pertaining to energy savings, it lacks the ambition and drive required to significantly advance the cause of energy savings in the country. Industry actors that are large energy consumers have been managing their energy consumption for years, and the current issues pertaining to network congestion has led to the implementation of more energy flexibility solutions (Interviewee T-4). However, energy savings and flexibility in households is much more difficult to achieve, according to the interviewee, referring to a lack of incentives that for example the current 'net metering' regulation suffers from. Furthermore, the tariff structures, which are anchored to the size of a connection rather than its actual utilisation size, further hinders the progress of energy flexibility in households. The interviewee did point out that slowly, more providers are emerging that offer dynamic energy tariffs for individual consumers, referring to relatively new and emerging organisations such as Tibber and Zonneplan (Interviewee T-5). At this moment, roughly 3% (compared to 1% in 2022) of the Dutch population has a dynamic energy contract (Interviewee T-5; Tableau Public, 2023), which might appear insignificant, however, set against the backdrop where very few previously switched energy providers, it signifies a noteworthy shift in consumer behaviour in recent years. Indeed, in the new anticipated Energy Act, all Dutch energy providers shall be obliged to offer dynamic energy contracts.

Without such normative policy, actors can still pursue energy savings and flexibility themselves. During the interviews an example of a large office building was provided: such buildings currently heat up in the early morning hours before most employees arrive, and then follow a stand-by pattern for the rest of the day; this thus causes a large spike of energy demand during a one- or two-hour time frame (Interviewee I-1). The interviewee pointed out that there are dynamic heating and cooling systems available on the market, and that by slightly adjusting the intensity of the cooling or heating over longer periods of time, office buildings can optimise their energy demand considerably, especially when extrapolated across a vast array of buildings. As research endeavours continue to explore enhanced efficiency rates and macro-level solutions, the interviewee posited that it remains imperative to also acknowledge the transformative potential of micro-scale innovations to optimise energy demand and consumption patterns.

Storage in batteries

There are various methods to store energy, one of which includes storage in batteries. Recently, the Dutch government proposed a new package of climate measures, including an obligation for solar farms to incorporate batteries for storage (Rijksoverheid, 2023b; Interviewee A-3). However, interviewees noted that battery technologies are still undergoing developmental phases and, as such, definitive conclusions regarding their applicability, roles, or suitability in particular scenarios still remain elusive at this point of time (Interviewee T-1, T-2). Furthermore, present-day batteries – particularly those that are based on lithium – were viewed predominantly as tools for short-term energy storage, suitable for durations of hours or less. Their efficacy wanes when considering longer storage periods, such as entire seasons. However, Interviewee A-3 referred to an economic assessment, in which the costs and benefits associated with a 38 MW solar PV farm in the Netherlands was assessed based on two different scenarios. The first scenario entailed the expansion of the local electricity network to allow the solar PV park to feed its electricity directly into the grid with minimal curtailment. This approach was a more conventional one that aims to deal with grid congestion by increasing network capacity. The second scenario proposed a more innovative approach that incorporated both medium-term (electrolysis and hydrogen storage) and short-term (batteries) energy storage solutions, while also accounting for some curtailment. The assessment revealed that the second option was more economically viable in terms of net costs, especially in the context of the congestion area in which the park was to be built. The interviewee thus argued that the conventional paradigm that network expansion is the primary solution to issues such as network congestion does not hold up in all scenarios, and that alternative approaches that incorporate advanced storage technologies and system flexibility might offer more economical solutions (Interviewee A-3). Indeed, battery parks could act as short-term energy buffers in the future energy system, mitigating network congestion issues, according to interviewee G-5. Employing tenders might stimulate battery park development, although it's imperative to cater to regional nuances to avoid local mismatches (Interviewee G-5). A notable challenge lies in the legal restrictions imposed on operators managing batteries, given that battery discharging is categorised as energy production in the Netherlands, and there exists a clear demarcation between production and transportation (i.e., organisations are legally prohibited from being active on both spectrums; Kuiken & Más, 2019). Complications further arise from the nation's singular electricity pricing strategy, juxtaposed with the local nuances of supply-demand dynamics, which occasionally complicates net operators' roles and the utility of batteries (Interviewee G-5).

Responding to the challenges presented by phasing out adjustable energy sources and concurrently scaling up renewable energies, TenneT has projected a requirement of 9 GW of battery capacity by the year 2030 (TenneT, 2023f). Given the current high transportation costs, the business propositions surrounding such ambitious projects are not inherently lucrative (Interviewee I-3). A viable solution could see grid and network operators pinpointing optimal locations for battery installations (which was also echoed by TenneT’s Target Grid vision; (TenneT, 2023b) and subsequently organising tender processes for these areas, mirroring the successful wind energy management strategy previously employed in the Netherlands (Interviewee G-5). A first step into this direction has been provided by a roadmap, on which TenneT communicated their expectations for how much battery power is required for systems stability by 2030 per province. Another plausible avenue involves TenneT directly investing in battery technologies and tendering out flexibility provisions. Without employing the tender process, location premiums, driven by the identification of 'optimal sites' by grid and network operators, could inflate land prices, consequently negating the intended benefits. Such tenders could also provide a governance mechanism, mitigating potential risks (Interviewee I-3, T-2). However, legal barriers exist, as network operators are prohibited from making battery investments. Additionally, the economic model surrounding batteries, including cost distribution and stakeholder responsibilities, is currently still under scrutiny and research (Interviewee T-2). Batteries find their current application in balancing markets. Should these markets reach saturation, their business viability could plummet, rendering them unprofitable. Interestingly, while batteries aim to address balancing, their role in alleviating network congestion is ambiguous, considering that batteries still make use of the same network when they release the energy and thus do not directly alleviate the issue of peak demand that causes the congestion. In fact, batteries may occasionally even exacerbate congestion (Interviewee T-2, T-5).

However, as Interviewee T-2 pointed out, the arena of energy storage extends beyond battery systems. The spectrum of alternatives encompasses heat and cold networks, flow batteries, and phase-changing materials, among other methods. A potential solution for the long-term storage includes the Compressed Air Energy Storage (CAES) technology (Interviewee I-4), which stores excess energy by compressing air and storing it underground, which can later be released, expanded, and converted back to electricity during periods of high demand; it was designed to serve as a load balancer in future energy systems that would primarily rely on intermittent sources such as solar and wind energy (H. Lund & Salgi, 2009). The interviewee also mentioned hydrogen as a potential energy carrier of the future, but clarified that while advancements in battery and hydrogen technologies have been made in recent years, the road to rendering battery- and hydrogen-based energy storage economically sustainable remains challenging (Interviewee I-4). Another interviewee considered hydrogen storage a more cost-effective alternative to batteries and emphasised its superior long-term storage capacities (Interviewee A-3).

Stepping away from the *copper plate* paradigm

Central to the discussion of the direction of the transition is the long-standing *copper plate* paradigm, which presumes the system has ample capacity to transport the required volumes of electricity (Kuiken & Más, 2019). Given the rising interest in renewable energy sources and their inherently distributed nature, the relevance and efficacy of the copper plate model have come under scrutiny. Historically, the Dutch electricity infrastructure was envisioned as a 'copper plate', where electricity could flow freely across regions without encountering significant technical or economic barriers. Such a model was instrumental in fostering a unified market, ensuring competitive pricing, and optimising power generation resources. However, the rise of renewable energy sources has illuminated some potential constraints of this model. Renewable sources like wind, solar, and hydro have variable outputs and are often located far from demand centres, and the Dutch network operators recently called for the copper plate approach to be let go given the physical and financial limits it brings about (Netbeheer Nederland, 2023c; Interviewee G-5). This therefore raises the question to what degree we should maintain the copper plate approach or whether we should strive towards a decentralised energy network (Kuiken & Más, 2019; Interviewee G-3, G-4, G-5, A-3, I-3, I-4, T-2, T-3, T-5). Merely "*adding more copper into the ground*" (Interviewee I-4) is no longer considered the primary solution to capacity issues (Netbeheer Nederland, 2023d). Instead, smart and on-demand energy solutions offer better opportunities (Interviewee G-5). Furthermore, a *loosely coupled* energy infrastructure was mentioned as a potential pathway as well (Interviewee G-3). The concept of 'loosely coupled' signifies that a system's capacity for innovation is tied to its flexibility to change or introduce new decentral elements or networks without making the whole system unstable (see also the Outlook Energy System 2050; Expertteam Energiesysteem 2050, 2023). The production and usage of energy should be localised as much as possible in those decentralised networks for greater efficiency and sustainability (Interviewee G-3). Nevertheless, transitioning to a loosely coupled system would not only be a technological challenge, but also existing market structures and regulatory frameworks.

Historically, network operators have been mandated to only expand the network if a demand already existed, and work as cost-effective and -efficient as possible considering that overinvestments were punished for. That paradigm is currently shifting towards more proactive expansion to prepare for future demand, which could lead to temporary overdimensioning (Interviewee G-5). One of the primary issues at the moment is the disconnect between where energy parks are built – usually in areas where land is relatively inexpensive – and where the energy is actually needed or consumed (Interviewee G-3, G-5). Network operators therefore argue for *energy planning* (*energieplanologie*) to provide more normative directionality and to incorporate new institutions to support the transition (Interviewee G-5, (Netbeheer Nederland, 2022b). It was argued that the current subsidy scheme of SDE may exacerbate this geographical mismatch, considering that the scheme does not account for location-specific needs and thus tends to subsidise the most cost-effective projects without considering their geographic relevance (Interviewee G-3). The interviewee therefore suggested revising the financial instruments and assessment frameworks to include criteria such as *justice* and *robustness*. By incorporating these factors, energy projects could be evaluated and subsidised based on a broader set of criteria than just cost-effectiveness; and this would make it possible to develop projects that are more expensive than other options but are more socially equitable and resilient (Interviewee G-3).

Partly due to the fact that the Netherlands is experiencing net congestion across the country as a result of lagging behind with the network expansion (Interviewee G-4, G-5; (Netbeheer Nederland, 2023b). However, this also requires new legislation and institutions, as well as a culture shift within the relevant (supervisory) organisations that are involved in this process, to legitimise the new paradigm (Interviewee G-4). Some also refer to the situation as a 'chicken and the egg' paradox: what needs to come first, demand for electricity to legitimise network expansion or network expansion to legitimise the transition to electrification (and thus creating demand)?

Analysing the daily utilisation patterns of the network capacity reveals suboptimal usage during most of the day, with an exception of around 5 to 7 PM in the afternoon (Interviewee G-5). Consequently, while strategies like over dimensioning cater to future electricity network requirements and represent a commendable pre-emptive measure, optimising currently underutilised capacities throughout the day becomes a major opportunity to resolve local issues, especially to counter peak capacities (Interviewee G-5, T-2). Particularly solutions within industries appear fruitful, considering their relatively large share in consumption. Incentivising collaborative local initiatives, especially within industrial parks, are thus considered a pivotal option as well (Interviewee T-2). Corporations, confronted with increasing sustainability mandates, are therefore forced to strategically invest in a transformation of their energy profile. The industrial sector possesses an intrinsic flexibility, exemplified by the potential for production cycles that can be shifted to other moments of the day (Interviewee T-2, T-5). Indeed, with grid capacities being reached, new connections are frequently denied, therefore requiring alternative approaches. Interviewee T-5 mentioned the potential of *smart energy services*, such as alternative contractual arrangements. Such contracts may specify conditions, such as that firms may use a certain amount of energy during off-peak hours, thereby facilitating better load management. The interviewee cited a case where a company successfully reduced its energy consumption merely by altering its operational routines. This underscores the effectiveness of seemingly simple changes in substantially affecting energy usage patterns (Interviewee T-5). Smart energy services also encompass digital automation and battery technologies, contributing to more efficient load management. Emphasis was put on that the future of energy systems may lie not just in expanding capacity but in intelligently managing what we already have (Interviewee I-4, T-5).

Local energy networks

Local generation and consumption of energy is the most cost-effective approach for Transmission System Operators/Distribution System Operators (TSO/DSOs) and companies (Interviewee G-4). To this extent, the creation of "energy hubs", wherein energy production and consumption remain localised, have been suggested as potentially beneficial (Interviewee I-3). While this system offers significant benefits, it does introduce constraints as well, such as preventing companies from selling their energy (contracts) to other entities. For effective implementation, structures like energy cooperatives or Energy Service Companies (ESCo) can be set up. Regardless of the structure, the interviewees stress the importance of setting strict conditions for maintaining local energy production and usage, identifying and communicating benefits for companies, network operators, municipalities, and provinces (Interviewee G-4, I-3). Moreover, once a couple thousand of such energy communities exist, we will need intermediary actors as well for conducting local energy usage prognoses (e.g., through Balance Responsible Parties, BRPs), as the demand on network operators would otherwise grow too large (Interviewee I-3). Both technical and legislative challenges are inherent to setting up such 'micro energy grids', for example with relation to energy 'sharing' in apartment complexes, sometimes also referred to as collective self-consumption (Interviewee A-1, I-4, T-2). The Top Sector Energy aims to address concepts such as collective self-consumption in the newly anticipated Energy Act (*Energiewet*). However, Interviewee T-2 pointed out that the current draft of this legislation appears conservative on energy sharing (Interviewee T-2; Tweede Kamer der Staten-Generaal, 2023).

In the Netherlands, the concept of local energy prices, especially within a decentralised energy grid, raises concerns about its practicality and societal implications (Interviewee G-5). The country traditionally adheres to a national energy pricing model. This approach is rooted in the principles of ensuring a non-discriminatory market and upholding (social) justice. While, from a technical standpoint, local pricing could be a viable option, it presents a challenge from a societal perspective. Adopting local energy prices could lead to potential inequities between regions. For instance, residents located in proximity to energy-rich regions like the North Sea might benefit from lower energy prices due to their relative proximity to the landing positions of offshore wind energy, while those farther away could face higher costs due to transport fees. Such a pricing disparity could be perceived as unjust. An alternative consideration is the implementation of local net tariffs. However, this proposal presents its own set of challenges. Introducing localised net tariffs might inversely affect those living near the North Sea, as they would potentially incur higher costs due to their proximity to major cable infrastructure, thereby once again raising fairness concerns (Interviewee G-5).

Local energy hubs or decentralised clusters were embraced as a way to harmonise the supply and demand of energy more effectively (Interviewee T-3. The interviewee acknowledges the potential of the concepts to revolutionise how energy is managed at the community level and potentially making the entire system more resilient and efficient. However, the interviewee also struck a note of caution when it comes to deliberately creating industrial clusters when this requires them to relocate, for instance in the case of forming local communities of 'cluster 6' companies. They pointed out that the geographic placement of many such businesses is not arbitrary but is often based on historical factors or the availability of specific resources. Given these constraints, the interviewee emphasised that relocating established businesses to form energy-efficient clusters is not a straightforward solution (Interviewee T-3). Moreover, not all actors can realistically be clustered. The interviewee pointed out an exception, Nyrstar, which is a zinc producer who has a direct connection to the high-voltage electricity network due to its large electricity consumption. For large-scale industries like hydrogen production through electrolysis, the interviewee suggests that these should ideally be located near the sources of renewable energy. For instance, the positioning of electrolysis plants will likely be close to the coast, near offshore wind farms, allowing for a more efficient and cost-effective operation. The interviewee further cited a drafted plan to move artificial fertiliser production from Chemelot to Rotterdam, which is an indication that such changes are already underway (Interviewee T-3).

European interconnective network

Europe is in the conceptual phase of developing a continental hydrogen transport system, colloquially referred to as the "European Hydrogen Backbone (EHB) initiative" (Amber Grid et al., 2022). The Netherlands, with its historically intricate transport infrastructure stemming from a rich natural gas legacy, is among the pioneering nations in this domain via the Dutch gas infrastructure operator GasUnie. Given the strategic positioning of the Netherlands, as well as its legacy on the natural gas market, the country is coined as the future market leader – together with Germany – in Europe for the global hydrogen market (Amber Grid et al., 2022). The vision encompasses connecting individual national networks to foster an interconnected transportation system, bridging regions like Spain with Northwest Europe and connecting the northern to southern parts of the continent (Interviewee A-3).

This interconnectivity would capitalise on regional strengths, allowing, for instance, solar-abundant regions like Southern Europe to convert their solar energy to green hydrogen and export it for application to the north. However, while transportation is a key focus, a parallel evolution of the broader value network is essential as well. Notably, aside from the emergent regulations, such as RED III (European Commission, n.d.-c), which mandates hydrogen utilisation for industries (Interviewee I-2, T-3), complementary developments were perceived as lacking by the interviewee (Interviewee A-3).

The interviewee underscores the North Sea's potential role in the European energy landscape, extending the reference beyond merely the Dutch territorial waters to include the entire North Sea and its adjoining regions, such as the United Kingdom, Denmark, and Sweden. Future energy demands might see Europe leaning heavily on Scandinavian nations and possibly parts of the Baltic region (Interviewee A-3). While the efforts of increasing renewable energy generation within the national context are considered commendable, the interviewee foresees a continuation of energy imports from neighbouring territories, as the Netherlands – and the EU as a whole – has historically always imported energy from other regions in the world. For instance, countries with a lot of solar power and more available space, such as in Southern Europe or even North Africa, could consider building major solar farms, convert the solar energy into hydrogen, ammonia, or other energy carriers, and then transport the carriers to other nations, for example through the hydrogen backbone (Interviewee A-3). The interviewee emphasised a practical approach, considering that the Netherlands is a densely populated nation and that, while acknowledging the importance of finding solutions to become more sustainable, that the country should be cautious not to be blanketed with solar panels when neighbouring nations like Germany offer much more space and others like Spain and Italy offer solar power abundance. With the right infrastructural frameworks in place, the Netherlands could revert to its traditional practice of energy trading and importation (as also envisioned in the EHB report; (Amber Grid et al., 2022), a model that the interviewee insists has historically been efficient and effective, thereby cautioning against narrow-minded perspectives that advocate for energy solutions that are exclusively nationally oriented (interviewee A-3).

Box 4. The opportunities of Carbon Capture and Storage (CCS) in relation to a carbon-free electricity system.

While CCS does not directly contribute to the electricity system, it was highlighted during the interviews as having an indirect effect and considered one of the multiple options towards a carbon-free electricity system, along with the electrification efforts of various sectors.

Carbon Capture and Storage (CCS) is considered a cost-effective methodology for curbing CO2 emissions, particularly when dealing with pure CO2 (Interviewee A-3, A-4, I-4). Estimations suggest that, with pure CO2, the cost of employing CCS ranges between 30-40 EUR per ton (Interviewee A-4). This calculation pertains primarily to the transportation and storage phases of the captured CO2, with pipelines as the medium resulting in minimal expenses. In some instances, experts even project potential costs as low as 25 EUR per ton for pure CO2 (Interviewee A-4). However, the purification of CO2 accounts for the bulk of the associated costs. To provide a comparative perspective, the financial implications of CCS remain relatively modest when juxtaposed with the capital previously allocated to the development of the wind and solar energy markets (Interviewee A-3). The Dutch government has amplified its investments in CCS, e.g. in partnerships with major emitters (Interviewee A-4, Rijksoverheid, n.d.).

CCS has traditionally been an uncomfortable option for policy makers as it comes with both advantages and disadvantages that have been traded off with each other (Rooijers et al., 2018). One of the common arguments that have dominated the public debate regarding CCS has been that it legitimises the fossil industry to continue operations, thereby halting the development of renewable energy alternatives (Rooijers et al., 2018; Interviewee A-4). However, as the Netherlands steers its course towards industrial decarbonisation, the timeframe leading up to 2030 will inevitably witness CCS taking centre stage as the primary strategy to combat escalating carbon emissions in a relatively short term (Interviewee T-3). When contemplating the path forward to foster environmental sustainability among significant energy consumers, the debate oscillates between governmental imposition of stringent regulations versus relying on market-driven forces. The inherent challenge of the latter is the probable delay in tangible progress. Without explicit directions, many companies will likely rely on CCS as it's currently the cheapest option per ton of avoided CO_2, even though electrification may eventually be more cost-effective in a world where CO_2 emissions have a higher price, e.g., imposed via the ETS (Interviewee T-3). The interviewee further emphasises the pivotal role of strategic policies tailored to bridge the gap between contemporary economic pragmatism and impending economic imperatives. For example, within the petrochemical domain, various actors appear to be willing to pursue a direct transition to electrification (Interviewee T-3). However, without government support, these firms feel compelled to prioritise investments in CCS. Once this route is taken, it becomes locked-in for the foreseeable future as the natural course for companies is to ensure returns on these investments before contemplating alternate avenues. Therefore, custom-made agreements, which the Netherlands were working on (Ministry of Economic Affairs and Climate Policy, 2023d), that provide companies with the certainty they need to make substantial investments in the final solutions could be beneficial. Though, with the recent dissolution of the government, the future of such arrangements is uncertain. However, if continued, these agreements could significantly contribute to the companies investing in end solutions rather than interim solutions (Interviewee T-3).

CCS is expected to play a major role in the industrial decarbonisation in the Netherlands through 2030 (Interviewee T-3). Applications that use low-temperature heat will be prioritised for the electrification efforts, while high-temperature applications will receive more attention beyond 2030. The electrification of low-temperature heat is said to frequently run into grid congestion issues, especially outside major industrial hubs. While the high-voltage electrical infrastructure in these hubs is considered adequate, enhancements may be necessary for medium and low-voltage systems within them. The most pressing grid congestion challenges exist outside these major hubs, particularly in areas defined as "cluster 6" in the Climate Agreement. This category includes businesses not associated with large industrial hubs, like paper mills and companies in the food, glass, and ceramic sectors. These industries have the potential to transition to electric boilers and heat pumps, but often encounter logistical hurdles due to limited electrical grid capacity (Interviewee T-3)

Summary

Various pathways towards a carbon-free electricity system (and ultimately a climate-neutral energy system) have been shaped based on scenarios in the past few years. While most plans remain open to alternative pathways and technologies, the focus in the Netherlands is put on a major shift from fossil fuels (like coal and natural gas) to renewable electricity (like wind and solar PV), particularly in the form of offshore wind energy in the North Sea. In synergy with the upscaling of renewable electricity, hydrogen has become a key element for making the future energy system more robust. Both wind and solar PV, and hydrogen, are undergoing rapid development, e.g., through the efforts of the MMIPs of the MTIP.

Electrification is widely considered a ‘no-regret’ solution. While this provides certainty and legitimacy to solutions that contribute to this extent, stakeholders have also warned of the costs and risks of stimulating electrification too rapidly – particularly in the light of public support for the transition. Apart from the rapid upscaling of renewable energy, stakeholders put emphasis on energy savings, flexibility, and storage opportunities as well. Furthermore, the traditional *copper plate* paradigm of the electricity system was questioned whether that is still the way to approach our electricity distribution, or if a decentral network of ‘loosely coupled’ local networks or energy hubs are better solutions to realise the integration of large amounts of renewable electricity into the energy system.

5.4. Formulating strategies

One of the primary challenges for policymakers interested in fostering specific technological avenues (cf. DC3) is the identification of systemic strengths and weaknesses that may accelerate or impede the mission. Formulating strategies to tackle these issues requires careful planning and thoughtful approach.

Various frameworks exist to study systemic strengths and weaknesses, including the technological innovation system. The complexity of such reviews increases considerably when multiple pathways are (to be) pursued, which is the case in a complex transition of the electricity system (and as part of a larger transformation of the energy system as a whole), considering that not a single pathway will be adequate for achieving the climate goals; rather, a combination of pathways will likely be pursued simultaneously. To this extent, a new innovation system framework has been suggested, namely the mission-oriented innovation system (MIS; Hekkert et al., 2020). Conducting such a review was out of the scope of this study, however, through policy documents, stakeholder interviews, and previous literature, various insights were captured.

Providing clarity, certainty, and incentives

Directionality starts with a vision (cf. DC1) and mapping the system boundaries (cf. DC2) and the potential pathways (cf. DC3) that fall in the scope of the mission and are considered feasible. Once these steps have been completed, policymakers shall assess the pathways and formulate strategies to tackle them. To this extent, the importance of incentives in guiding the Dutch energy transition was a recurring theme throughout the interviews. Interviewee I-3 stressed the need for both European norms and national initiatives to incentivise organisations to embrace desirable pathways. They referred to the Netherlands' efforts to transition from grey to green hydrogen: "*While agencies like RVO are striving to align producers and consumers to drive the green hydrogen market, the Netherlands currently imports green ammonia due to its insufficient renewable electricity production*" (Interviewee I-3).

Interviewee T-4 pointed out that the European Union is currently formulating a green hydrogen strategy, which also has gained attention from Dutch policymakers. The strategy entails offering incentives (the 'carrots') such as subsidies to guarantee a sufficient green hydrogen supply while also implementing enforcement measures (the 'sticks'), such as a 42% green hydrogen obligation for industry (Interviewee T-4; Leguijt et al., 2022). In essence, the government is diligently working to set directives, shape a vision, and bolster hydrogen growth in the Netherlands and support its development through the upscaling of renewable electricity from wind and solar energy (Interviewee T-4). In fact, the government explicitly stated in 2022 that it aimed to provide more certainty for system stakeholders (Rijksoverheid, 2022b). Furthermore, the Netherlands will decommission coal plants by 2030 (see chapter 'Realising destabilisation'), making the nation predominantly reliant on renewable sources. This reliance underscores the challenge posed by the intermittent nature of wind and solar energy, and calls for other options to be added to the 'mix' as well (Interviewee I-3). The interviewee pointed at the potential of large batteries (also see DC3), however, present legislation classifies batteries as consumers, not producers, thereby making large-scale application more complex, as the energy stored in batteries must be repurchased (Interviewee I-3, T-2). Various stakeholders have therefore lobbied for changing the legal designation of batteries (Interviewee T-2). Additionally, the technology is currently expensive due to high transport costs (Interviewee I-3). Highlighting the broader financial implications for consumers, the interviewee further observed that even if electricity costs fall (in the context of lower electricity prices due to a mismatch between supply and demand), energy bills will rise, largely due to transport expenses that will continue to increase as the infrastructure expands – which may reduce public acceptance of potential pathways. Hence, there is an inherent need to incentivise reduced energy consumption.

Meanwhile, Interviewee G-5 noted the potential benefits of promoting collaboration structures, such as energy communities, and offering rewards for their establishment. They advocated for broader systemic shifts that encompass not only technological but also behavioural changes. Financial incentives can be crucial in guiding the desired behavioural shifts, considering that monetary incentives have been proven to be effective means to encourage behavioural change (Interviewee G-5; White et al., 2019).

Interviewee G-4, on the other hand, pinpoints a current lack of certainty that hinders long-term investments. They refer to the II3050 study, which provided four scenarios for how the future energy system may look like, but did not provide explicit choices to which scenarios should be committed (see DC3). The interviewee emphasised that this commitment should come from the central government. It is evident that future developments will include solutions such as heat pumps and smart charging within the mobility domain. Consequently, it is imperative for the government to formulate appropriate incentives and tariff regulations to support the implementation of those solutions. Delaying decisions or lacking incentives will result in missed opportunities. Prompt policy formulation facilitates market readiness and growth, and was therefore advocated for (Interviewee G-4). Another interviewee touched upon some of the practical challenges faced in the energy transition, such as a limited workforce, spatial constraints, and bureaucratic rigidities (Interviewee G-3). By drawing parallels with historical projects like the Delta Works, the interviewee underlined that if a challenge is perceived as critical, stakeholders will take prompt action. To this extent, a marked change over the past half-decade in the urgency with which these issues are viewed was noted (Interviewee G-3, A1). While intervention might be construed as governmental interference, a stance not generally popular in Dutch political discourse, they stressed the need for guidance.

Given the extended time frame required for the development and deployment of energy systems, it is crucial for governments to act promptly in making long-term decisions, particularly if they aim to achieve specific goals by 2050. The North Sea Energy Outlook Report underscores this point, highlighting the need for choices that align with a 2050 vision to bolster long-term growth (Cleijne et al., 2020). This would include reducing uncertainties and paving the way for investments, rather than focusing solely on short-term gains. To avoid getting stuck on a particular path (i.e., path dependency) when a clear long-term vision is lacking or incomplete, it is important to maintain multiple pathways available.

With regard to net capacity issues (which will be highlighted in greater detail later in this chapter), Interviewee T-5 proposed offering financial incentives to disconnect solar panels if network capacity is an issue during peak periods. Currently, consumers with solar panels have to shut them off during such periods, or pay a fee to return their electricity to the network – which has spurred a public debate whether solar panels are still an attractive solution for consumers. Additionally, adopting smaller inverters and deliberately reducing some solar output could be beneficial. It was further stated that price incentives can play a significant role in encouraging flexibility and dynamic response, both at a smaller scale like dynamic charging of electric vehicles and at a larger industrial scale (Interviewee I-1). Moreover, potential market and regulatory roadblocks could hinder the implementation of innovation. For instance, current regulations prevent individuals from selling self-produced solar electricity to neighbours. Market model adjustments could potentially accelerate the energy transition and address challenges like network congestion (Interviewee I-4).

Lastly, policy clarity is considered crucial in guiding industry decisions. Industries typically face long lead times when making fundamental changes and will hesitate to commit without a clear return on investment. Hence, long-term policy visions, the right set of instruments, and attractive business cases are essential for achieving desired objectives (Interviewee G-1). The complex interplay between government and industry in shaping the energy sector is important to consider. While the Dutch government plays an active role in providing permits and guidance, it also relies on industry expertise. The government's uncertainty about rapidly changing developments makes it challenging to set exact requirements (Interviewee T-4), hence underscoring the importance of setting short-term milestones alongside long-term visions. One of the interviewees highlighted the *ripple effect* of market uncertainty on investments: a lack of confidence can make stakeholders hesitant, slowing down progress towards climate and energy goals (Interviewee I-4). Government intervention or changes in regulations may contribute to this uncertainty, potentially affecting the private sector's willingness to invest in energy transition projects.

Demand for green energy is reportedly rising, driven by government policies as well as sustainability initiatives within the industrial sector and large corporations. Customers are increasingly asking for *green* energy, which creates a market for renewable energy (Interviewee I-4); this involves households, but also corporate clients who are incorporating green energy as part of their Corporate Social Responsibility (CSR) initiatives and broader sustainability policies. Companies also see a role for themselves to serve as a guide to its customers in their transition toward sustainability. The concept of different "degrees of greenness" was mentioned during one of the interviewees, differentiating between "dark green" and "light green", referring to energy that may not be 100% ‘green’ but which is labelled as such through credits or offsetting (Interviewee I-4).

To summarise, the critical role of clear, long-term policy directions was highlighted in fostering industry participation in the energy transition. Uncertainty, whether from rapidly changing technology or fluctuating government policy, could pose a significant barrier to investment and innovation. To balance the need for innovation with market realities, experts suggested a mix of specific short-term milestones and broader, longer-term visions, and anchor those in long-term national plans. This multi-faceted approach can help both government and industry stakeholders navigate the complexities of the energy landscape, fostering a more robust and accelerated transition towards sustainability.

Network congestion

Problems

In recent years, the Netherlands has been facing increasing network congestion in its electricity network, and one of the interviewees noted that they felt the topic only got the necessary attention until it had become an acute issue within society (Interviewee T-2). One of the issues highlighted during the interviews as to having contributed to this issue was that network operators were encouraged not to invest in network expansion until it is deemed necessary (Interviewee G-5, T-2). For a long time, the focus had primarily been on the upscaling of renewable energy generation, without sufficient attention to how this energy will be transmitted and distributed (i.e., integrated into the energy system, one of the key elements of the MMIPs). As the electricity system is rapidly evolving and become fundamentally different than it is now, as well as congestion becoming a more serious and prevalent problem, the roles of network operators is shifting (Interviewee G-5): they are no longer seen merely as passive players who simply manage the infrastructure; instead, they are increasingly acknowledged as key actors in designing and planning the future energy system. The current challenges faced by network operators are largely allocated to being feasibility issues (*maakbaarheidsproblemen*). This involves not just technical constraints, such as how to manage flows of electricity from diverse sources, but also systemic issues like how to create the incentives for more sustainable network usage or how to innovate in the regulatory environment (Interviewee G-5). Some argue the ambition to upscale renewable energy was already known many years ago and that network operators could have anticipated better before the congestion would occur (Interviewee A-3). Interviewee A-4 further criticised this attitude of the network operators and argued that they should have been more proactive as well, given that the ambitious objectives of upscaling renewable electricity from wind and solar energy was established a long time ago already. In other words: the network operators should have been more foresightful as to what was bound to happen in the near future (Interviewee A-4). According to Netbeheer Nederland, this is a common critique, which they believe is understandable from different perspectives but nevertheless unduly at the same time, as the network operators are in fact aware of what is needed, but that they are not capable of doing everything they may want as a result of "i*nappropriate (legal) frameworks, procedures, and financing by the government*" (Netbeheer Nederland, 2022a). While it is the government's responsibility to instruct network operators what they can or cannot proactively invest in (Interviewee A-4), operators can take a leading role by advocating what they feel is necessary from an infrastructural perspective. Network operators therefore currently collaborate with municipalities and provinces in the integral programming of the environment and recently published the II3050 study (see DC3) to provide guidance to the government (Interviewee G-5).

There are two types of congestion right now: supply congestion, whereby renewable energy developers cannot deliver their energy to the network, and demand congestion, whereby companies want to become more sustainable and electrify but they are unable to receive guarantees from the distribution companies (Interviewee G-3, G-4). Consumers, particularly those interested in contributing to renewable energy solutions, might also find themselves unable to connect their solar panels to the network, or are unable to return excess energy to the grid. This issue not only frustrates individual consumers but can also stifle the overall growth of the solar energy sector (Interviewee A-3). This causes issues on both ends of the spectrum. Moreover, the expansion of the electricity network goes slower than expected. Recently, a working group of the *Uitvoeringsoverleg Elektriciteit* published a report that suggested accelerating the deadline for carbon neutrality of the electricity system from 2050 to 2035 (Uitvoeringsoverleg Elektriciteit, 2022). In the light of current issues, it remains to be seen whether this is a feasible option (Interviewee G-3, G-4). This situation serves as a cautionary tale for planners and policymakers. It emphasises the importance of holistic planning that takes into account not just energy production but also the complexities of distribution and grid capacity. Solving the issue of grid congestion is not just a technical challenge but also a strategic one that involves balancing multiple variables, including consumer needs, market development, regulatory frameworks, and infrastructure capabilities. There must be solutions to this issue by no later than 2030, as the full planned offshore wind capacity of 21 GW can likely not be distributed via the electricity network alone (see DC1).

The current approach to dealing with congestion was criticised for being 'overly focused on repair measures' (*pleistermaatregelen*); in other words, stakeholders mentioned that they felt there is too much focus on alleviating existing problems without contemplating what the optimal future system should look like and working towards that (Interviewee I-3). Interviewee T-2 further added that there are currently no incentives in place (such as dynamic network tariffs) to resolve congestion issues on low voltage grids. This lack of proactive measures leads to recurring problems that eventually need reactive solutions. On the mid-voltage grids, the interviewee points to the lack of a market for congestion tenders. Without economic incentives, the interviewees see little motivation for stakeholders to find sustainable solutions to these issues (Interviewee I-3, T-2).

Solutions

The first step for operators in resolving congestion is to pinpoint the source and analyse use patterns within the local network (Interviewee G-5). For national grid operators like TenneT, this is generally more straightforward, as the cause is often a large-scale installation. Regional operators face greater challenges due to the complexity of low-voltage networks, which involve many more actors and factors affecting capacity. Once the root cause has been identified, the immediate approach usually involves congestion management. This typically means that operators collaborate with businesses to explore ways to adjust their production schedules, a strategy that has proven particularly useful in industrial parks (Interviewee G-5). According to the interviewee, this approach has been successful in regions such as Noord-Brabant and Limburg. However, in areas like Friesland, Groningen, and Utrecht, the situation is currently more tense as the limits of what congestion management offers are reportedly nearly reached (Interviewee G-5). These regions are experiencing limits to what congestion management can achieve, making it harder to implement effective solutions. Priority is given to households when it comes to grid connections. For residential consumers, there is usually always an option to connect to the electrical grid, except in rare cases were regional networks experience congestion. In contrast, large commercial consumers face greater challenges in securing a connection to the grid (Interviewee G-5). The current congestion maps can be accessed via (Netbeheer Nederland, 2023b) for the low-to-mid voltage grids and (TenneT, 2023c) for the high voltage grids.

Network operators are exploring various strategies to manage demand and prevent congestion (Interviewee G-5). Among these strategies are capacity reduction contracts, group contracts, and tariff regulations for large consumers directly connected to the grid. Group contracts, in particular, are designed for clusters of firms that share specific capacity levels. These firms are expected to negotiate among themselves to balance capacity efficiently. However, implementing such group contracts is more complex in practice than initially thought, largely because the existing infrastructure must be capable of supporting these types of agreements. Group contracts might be most effective in industrial settings where monitoring capacity demand is more easily. The situation is more challenging in the built environments like residential areas. Low-voltage networks in these settings are susceptible to unpredictable spikes in capacity demand, especially when a neighbourhood experiences rapid electrification, such as a surge in the adoption of electric vehicles. While individual households may not have a significant impact, the collective shift in a neighbourhood can create challenges that are difficult to anticipate or manage (Interviewee G-5).

Structured collaboration could thus be a powerful tool for alleviating congestion. Various forms of cooperative arrangements – such as industry clusters, energy communities, energy cooperatives, and owners' associations – can contribute to this effort (Interviewee G-5, T-2, T-5). For example, a local residential community might implement a 'load balancing system' to manage the integration of solar panels, electric vehicle charging stations, and batteries in a way that is optimal for the local context. These local communities can self-manage their energy balance at the micro-level, both in terms of drawing power from the grid (e.g., for electric vehicle charging) and contributing power back to the grid (e.g., by storing energy in and discharging from local batteries). Offering incentives to establish these collaborative structures, and rewarding participants for their efficient use of the grid, could encourage more sustainable practices of this sort (Interviewee G-5). One example in the residential setting is smart charging for electric vehicles: most people arrive home at the end of the afternoon or early evening, plug in their vehicles, and do not need to use them again until the next day. This creates a large time window for efficient charging that takes into account both the local network capacity and energy costs, thereby making better use of the network's resources (Interviewee G-5). Pilot projects exploring these concepts are underway, however, existing legislation does not yet fully support such initiatives. For optimal harmonisation of supply and demand, collaborative efforts involving larger consumer groups are essential; such collective approaches also add a layer of flexibility to energy consumption at the end-user level (Interviewee T-2).

According to the Expertteam Energiesysteem 2050 (Expertteam Energiesysteem 2050, 2023b), and echoed by Interviewee T-2, the electrical grid will need to incorporate significant flexibility by 2040, regardless of what the future energy landscape may look like or what specific pathway the Netherlands may take. Interviewee A-3, however, questions the feasibility of this, citing current congestion issues in various regions as reported by TenneT (TenneT, 2023c), along with an apparent nationwide increase in such problems. Interviewee T-2 countered by arguing that adding flexibility to the grid can substantially mitigate these congestion issues, covering much of the needed net capacity. For instance, they argued that enhancing grid flexibility can partly be achieved through institutional adaptations, such as influencing consumer behaviour. Examples include encouraging the smart charging of electric vehicles or timing the use of appliances, such as washing machines, to periods when supply exceeds demand, e.g., through dynamic energy pricing. They stated further that automation through e.g., smart energy grids could facilitate the transition and make it more user-friendly (Interviewee T-2).

In order to mitigate the issue of energy parks being built in areas that are incompatible with the electricity system load balancing at the local level (as referred to in 'Handling goal conflicts'), apart from utilising intelligent spatial planning based on the needs and capacities of the electricity network, the government could strategically utilise the SDE(++) subsidy programme (Interviewee A-4). Specifically, greater subsidies could be provided for projects located in areas with lower congestion levels, compared to those in high-congestion zones. This incentive structure would naturally encourage companies operating these parks to relocate to less congested areas, and it could compensate for differing ground prices. However, the interviewee acknowledges that this approach comes with its own set of challenges. Regions negatively impacted by such policy decisions could raise concerns on the basis of equal opportunities and fair treatment, arguing that they are being disproportionately disadvantaged by the government's strategic use of subsidies (Interviewee A-4). Alternatively, normative policy could be utilised, such as requiring solar farm operators to request a positive transport indication from the local network operator that they can receive a connection to the grid before the company receives a permit to construct their farm on that specific location (Interviewee G-4, G-5). In fact, this currently already happens for the SDE++, SCE and OWE subsidies; without a positive indication, the RVO will not take applications into consideration (Liander, n.d.). Furthermore, network operators wish to introduce 'energy planning' (*energieplanologie*) to contribute to future plans and prevent poorly managed energy regions; 'energy planning' in this context refers to guiding the spatial planning of energy projects to optimally integrate them into the energy system and to match demand and supply: what are the local needs, what is required to meet those needs, and where and by whom (Interviewee G-4, G-5, (Netbeheer Nederland, 2022c).

Not all interviewees argued for state intervention. Indeed, one of them argued that market dynamics should largely be left to regulate the balance between electricity supply and demand (Interviewee T-4). In a market-based system, prices are naturally set by the interplay of supply and demand. For instance, an oversupply of electricity coupled with low demand could lead to plummeting prices, while high demand and limited supply could push prices upwards. The electricity market is in a constant state of evolution, sometimes resulting in an excess of renewable energy that leads to negative pricing and vice-versa. The interviewee believes that as markets mature, it will establish new equilibriums. For example, by the time there are two million homes with solar panels producing excess electricity, there will likely also be a corresponding number of electric vehicles, data centres, or electrolysis facilities that could absorb this surplus. However, this requires time to develop and may be mismatched along the way (Interviewee T-2, T-4). Indeed, the current challenge is that the rate at which renewable electricity production capacity, especially from solar PV, is being developed exceeds the demand that can absorb it – be it through home batteries, electric vehicles, or other means. The interviewee anticipates that as the market matures, more consumers will capitalise on periods of low or even negative pricing by storing electricity in home batteries or electric vehicles, or using it for other applications like heating or production processes. As a result, the expectation is that the market will self-regulate to reduce extreme price fluctuations. The consumption patterns will adjust to price signals, decreasing consumption during high-price periods and increasing it during low-price periods. This will lead to a smoother curve of price peaks and valleys (Interviewee T-4). Alternatively, if negative prices persist over longer periods of time and affect the underlying business models, pricing could – to a degree – be mitigated through flexibility measures (Interviewee T-2).

TenneT is reportedly considering dynamic pricing models based on time-of-use, although the implementation of such a model within an evolving, dynamic energy system that accommodates fluctuating renewable sources like wind and solar was considered complicated (Interviewee I-2). Interviewee I-1 offered additional perspectives on how to address grid challenges. For instance, in industrial processes requiring heat, production could be adjusted according to energy availability, effectively serving as a form of demand response. Moreover, creating energy buffers not limited to just the electricity grid can help to balance supply and demand. According to the interviewee, pricing incentives can be highly effective in encouraging a flexible, dynamic response to supply and demand imbalances. These incentives could apply at multiple scales, from small-scale applications like dynamic electric vehicle charging to larger industrial operations (Interviewee I-1). The importance of international interconnections, like those at the North Sea, were also mentioned as a potential method for easing grid congestion. Such interconnections would allow for better balancing of the grid by enabling the transfer of energy between different regions and countries (Interviewee T-1). Finally, grid flexibility could be enhanced through a tendering system to incentivise innovations and solutions aimed at making the energy system more adaptable (Interviewee I-3).

Sufficient subsidies and knowledge

The existing subsidy framework for energy is becoming inadequate according to Interviewee I-3, who calls for a paradigm shift to create new incentives. They suggested a focus on encouraging decentralised production and consumption of renewable energy. One possibility could be to introduce producer tariffs to offset the escalating transport costs that are currently paid for by consumers. The interviewee anticipates that debates about electricity grid tariffs will surface in the coming years. They raised the question whether socialisation of these costs is still a viable option, or if alternative funding methods, like government or pension fund investments, should be considered instead. Addressing this complex issue necessitates a holistic, systems-thinking approach that takes into account the interplay between tariffs, subsidies, and system conditions (Interviewee I-3).

With regard to subsidies for offshore energy, a prolonged debate between EZK, RVO, and Top Sector Energy was highlighted, which was regarding the viability of 'floating wind' technology (Interviewee T-1). While EZK and RVO contended that floating wind was unsuitable for subsidy programmes due to its limited applicability in the Dutch waters (due to shallow waters), Top Sector Energy argued that supporting the technology could give Dutch companies a competitive export advantage (which used to be one of the pointers of the Top Sectors). The counter-argument from EZK/RVO was that while an export position would be economically beneficial, and while it would contribute to sustainability in general, it would not significantly contribute to the *Dutch* energy transition. This debate illustrates the challenges involved in delineating boundaries and selecting solutions into the policy framework (cf. policy objective). International agreements like those made in Esbjerg/Oostende (Rijksoverheid, 2022g, 2023e) could potentially encourage the Netherlands to explore energy options beyond its own borders and in collaboration with other nations (Interviewee I-1, I-2, T-1).

Hindrances to the commercialisation of innovations often lie in gaps in knowledge transfer and financial support, particularly the lack of *patient capital* that can sustain startups and new technologies over the long term (Interviewee G-1). Furthermore, the SDE++ subsidy programme has been effective in promoting wind energy and is now aimed at doing the same for solar PV. The interviewee acknowledged this kind of state support as a critical step in overcoming the *valley of death*, a phase wherein renewable technologies like wind and solar face challenges in becoming cost-competitive with cheaper fossil-based technologies (Interviewee G-1). The interviewee further questioned the discontinuation of subsidies for electric vehicles. The discontinuation is said to undermine long-term stability and eliminates the incentive to adopt electric vehicles; they argued that this creates uncertainty about whether the necessary conditions for transitioning to cleaner technologies will be maintained (Interviewee G-1). Moreover, the 'fragmentation of the subsidy landscape' is a topic of interest that requires more attention. The interviewee noted that subsidies are often categorised based on the Technology Readiness Level (TRL), which ranges from fundamental research to demonstration projects. In the Netherlands, different budgets are usually allocated to particular TRL levels, while the European Union offers subsidies for more comprehensive projects that span multiple TRL levels. In the latter case, a project only has to apply for subsidy once and can adjust budgets for each phase of the project based on the results of the previous phase. This approach could potentially streamline funding processes, providing a more seamless transition from research to application, and eliminate redundancies and inefficiencies in the existing subsidy frameworks (Interviewee G-1).

The availability of climate and growth funds and other financial instruments in supporting energy innovations were perceived positively (Interviewee G-2). However, to meet ambitious targets, like those laid out in the NPE, the interviewee expected that there will likely be a need for more extensive funding. When evaluating existing programmes under energy innovation, such as the HER (*Hernieuwbare Energie Regeling*), DEI (*Demonstratie Energie-Innovatie*), and MOOI (*Missiegedreven Onderzoek, Ontwikkeling en Innovatie*), knowledge institute Dialogic found that these instruments are effective (van Wijk et al., 2022). They offer a solid trajectory from fundamental research to the commercial scaling of technologies, eventually feeding into the SDE programme for promoting non-profitable renewable energy generation (Interviewee G-2). Despite their effectiveness, the interviewee recognised a constant demand for more funding, and programmes are continually revised to address any gaps that stakeholders may identify. In 2013, the Netherlands presented its Energy Agreement (Rijksoverheid, 2013b). The agreement targeted a robust domestic market for offshore wind energy as a strategy to meet the commitment to obtaining 16% of its energy from renewable sources by 2020, although this target was later reduced to 14%. The focus on offshore wind energy was allocated partly to overcome spatial constraints that limited the expansion of onshore wind and solar energy (van der Loos et al., 2021), although this was later questioned during the interviews (Interviewee A-1); according to the interviewee, the offshore and onshore energy sectors have developed separately. The government also allocated specific funding for offshore wind projects, thereby separating it from the general pool of renewable energy subsidies (van der Loos et al., 2021).

With regard to the balance between stimulative (subsidies, grants) and normative (regulations, laws) policy instruments, it was noted that subsidies offer ample opportunities at this moment, however, that regulations should allow for more experimentation. For this to happen, they argued that innovation is needed not just in technologies but also in market regulation. In this context, a key role for the government is seen to innovate in the area of market regulation; a more experimental approach to regulatory frameworks could accelerate the development and adoption of innovations and help address challenges more efficiently (Interviewee I-4). Beyond the conventional subsidy programmes, larger funds such as the National Growth Fund (*Nationaal Groeifonds*) and Climate Fund (*Klimaatfonds*) were noted as promising initiatives that bring about major opportunities for large and innovative projects (Interviewee G-2, T-5). The SolarNL project (National Growth Fund, 2023b), which focuses on domestic production of sustainable and circular solar panels (as opposed to importing solar panels from China), was highlighted during the interviews as a promising project. Besides, these funds provide significantly more substantial funding compared to existing instruments (Interviewee G-2, T-5).

The competitive nature of the subsidy application process was seen as a positive factor that drives companies to put forth their best proposals (Interviewee T-5). With regard to subsidies for energy generation and storage, the interviewee mentioned the possibility of subsidising batteries at solar or wind parks – which is an option that is considered by the Dutch government (Ministry of Economic Affairs and Climate Policy, 2023a) – especially to meet national obligations following the Urgenda court ruling that mandated the Dutch government to implement emission reductions (Supreme Court of the Netherlands, 2019). However, the high costs of such subsidies were a reason of concern (Interviewee T-5). The interviewee further argued for a technology-neutral approach. Subsidies should not be given for flexibility options like batteries and instead advocated for market mechanisms to govern the sector. However, in the context of sustainability goals and the desired levels of solar and wind energy, subsidies for batteries might still be beneficial (Interviewee T-5).

The markets of wind and solar energy

Offshore energy innovation system

The Esbjerg and Ostend Declarations (Rijksoverheid, 2022g, 2023e) provide more legitimacy and certainty to market actors (Interviewee I-1), although the declarations more or less confirm objectives and agreements that had previously been agreed upon and, as such, it could be viewed as a political c.q. public relations statement (Interviewee I-2). The ambition to transform the North Sea into a 'green powerhouse' is considered a realistic goal, though it requires carefully coordinated development (Interviewee A-3). For instance, achieving goals like 3-4 GW (or preferably 6-8 GW) of electrolyser capacity by 2030 will require a corresponding investment in renewable electricity generation, derived mainly from offshore wind or solar energy. If the installation of electrolysers outpaces the availability of renewable electricity (e.g., when a significant share is allocated to other purposes), it could become a bottleneck and delay the overall development. The installation of electrolyser capacity should thus be developed in tandem with offshore energy resources (Interviewee A-3). The interviewee estimates that, if there is a need for 5 GW electrolyser capacity by 2030, there will need to be a corresponding 10-15 GW offshore energy capacity. They were positive about the feasibility of these ambitions and noted that the European Union aims to have 30-40 GW of electrolyser capacity by 2030; hence, this shows that the European Union is actively contributing to the development of a value network for (green) hydrogen, which could help alleviate pressure on individual countries to develop their own markets (Interviewee A-3). The planning and coordination of these activities, especially the integration of hydrogen into the renewable energy system, appear to be a central challenge. It requires not just technological solutions but also strategic policy alignment, both nationally and at the European level.

Interviewee I-2 emphasised that the market is currently operating without subsidies, pointing to the Hollandse Kust Zuid wind farm as the first Dutch wind farm that was financed without any subsidies. However, the interviewee also shared various challenges facing the offshore wind market. This includes pressures on the supply chain, rising costs of materials and personnel, and uncertainties like ecological impact, such as zog effects and bird migration (Interviewee I-2). Interviewee I-1 noted that, despite the absence of financial subsidies, the Dutch government has shown a clear ambition in wind energy. Targets for gigawatt production have been set and wind farms are designated to contribute to those targets. However, the interviewee also highlighted existing challenges, such as delays in the current tender processes, high degrees of competition, and high project costs along with inflation and interest rates, which are putting prices under pressure. The interviewee further pointed at the strain on the supply chains of major wind turbine manufacturers like Vestas and Siemens. Innovations have an impact on the entire supply chain; for instance, a larger turbine may require larger installation ships (Interviewee I-1, T-1). With the current installed capacity of 4 gigawatts and a target of 21 gigawatts by 2030, and accounting for the current challenges, the interviewees expressed uncertainty regarding the feasibility of the Dutch goals, also considering that projects generally take roughly 5 years to move from planning to construction. Notably, shortly after the interview, Vattenfall announced its cessation of development of their 1.4 GW Norfolk Boreas offshore wind farm due to "*challenging market conditions"* and stated that "*financial frameworks have not adapted to reflect the current market conditions*" (Vattenfall, 2023, p. 11). These challenges were also identified in the Dutch Offshore Wind Market Report 2023 by the RVO (RVO, 2023a). Overall, both interviewees suggest that while the wind energy sector in the Netherlands has made significant strides, there are numerous challenges and uncertainties that could impact its future growth. These challenges range from economic and supply chain issues to ecological concerns and regulatory delays, pointing to a complex landscape that companies and policymakers will have to navigate carefully. The overarching theme here is that while subsidy-free operation is an achievement, it doesn't alleviate the need for strategic planning and strong governmental support, especially in setting clear and achievable goals. To achieve this, a clear direction to future demand is considered crucial for developing reliable business cases in this environment (Interviewee I-1, I-2). Moreover, demand development is required, as proper planning and investment are needed to ensure a stable and growing demand for wind energy (Interviewee I-2). Another emerging theme is biodiversity and ecological factors that are becoming increasingly important. The interviewee suggested that the government could incentivise this through tender rewards, as is currently taking place (see e.g., tender criteria for wind farm IJmuiden Ver Alpha and Beta). A third area of concern is the multifunctionality of offshore wind farms, which would e.g., allow fishermen to use the environment of the wind farm to continue fishing; multifunctional wind farms could also maintain public support for these projects (Interviewee I-2). Finally, decisions that impact the offshore wind market should consider long-term implications rather than (solely) targeting short-term gains; to an extent, financial capabilities are still weighed considerably for tender points for offshore wind farms and, as such, it could incentivise actors to win tenders based on financials rather than addressing the aforementioned elements (Interviewee I-1, I-2).

With regard to the challenges in the supply chain of the offshore wind market, Interviewee T-1 mentioned the possibility of standardisation with the aim of optimisation. Although discussions are ongoing in the industry, for example within the Dutch industry organisation NWEA, Interviewee I-2 was generally not in favour of standardisation for several reasons. First, they pointed out that larger turbines are more ecologically friendly as they require less installation work and pose fewer obstacles for birds. Therefore, limiting the size of turbines could negatively impact the sector's ability to mitigate its ecological footprint. Second, the interviewee noted that attempts of standardisation at the European level have been unsuccessful so far. They argued that only standardisation at that level could be beneficial as it provides a levelled playing field across the industry; unilateral standardisation by the Netherlands could put the country at a disadvantage internationally. Third, the interviewee questioned whether standardisation is even necessary in the first place, or if alternative solutions like early planning for tenders, might suffice (Interviewee I-2). Interviewee I-1 added that standardisation could happen via industrialisation and that it does not necessarily need to be tied to national policies.

For instance, a supply chain party could take that step and build an industrialised, automated plant producing a specific type of wind turbine on a large scale. Interviewee I-1 and I-2 both agreed that with the planned growth in wind energy, industrialisation will likely occur naturally, and at some point, the supply chain will conclude that it is no longer cost-effective to build even larger turbines. Thus, while both interviewees see potential merits in standardisation, they also caution against forcing it through policy, especially when it could compromise ecological benefits and international competitiveness. They proposed that market dynamics and industrialisation could naturally lead to some level of standardisation.

When asked about the negative impact of grid congestion and mismatched supply and demand profiles on the business case for offshore wind, Interviewee I-1 cited hydrogen (see **box 5** for more insights) as a promising medium for energy storage, allowing for large-scale and potentially seasonal energy storage to help balance the grid. In addition to hydrogen, they also mentioned ongoing exploration of smaller-scale storage solutions such as flow batteries, liquified air, and other chemical compounds. Interviewee I-2, however, emphasised the need for regulatory changes to help stabilise the business case for offshore wind projects. They referred to a recent report by TNO (TNO, 2022) that warned of a negative business case for offshore wind developers by 2030 if additional policy measures are not introduced. They argued for changes in tendering procedures, where *demand development* could be added as an evaluative factor. This would help coordinate the alignment of supply and demand within the same tendering process, thus mitigating risks (Interviewee I-2).

Onshore energy innovation system

The importance of balancing the supply and demand in the development of renewable energy markets was stressed as well during the interviews (Interviewee G-4). If offshore wind, for example, is scaled up too rapidly without concurrent electrification in the industry, the offshore wind business model may eventually become non-viable. This could lead producers and suppliers to exit the market. The Dutch government has attention for it at the moment, but the interviewee was unsure whether that attention translates into concrete actions. The interviewee further drew an analogy with the tailor-made agreements with large industry actors: that it takes a lot of time to go from the drawing board to actual action (Interviewee G-4). The lag between planning and execution is evident not just nationally, but also at the regional level. Municipal transition plans, according to the interviewee, are currently inadequate in providing the required direction or certainty for regional infrastructure developments; choices between whether a neighbourhood will devote to electrification or heat networks, for instance, are reportedly lacking. These gaps in planning can create logistical challenges for network operators who need to understand which areas should be prioritised for development (Interviewee G-4). When it comes to electricity infrastructure, wind energy is more favourable than solar energy. This is because wind energy tends to demonstrate more evenly distributed patterns of production. Solar energy, on the other hand, can generate enormous peaks of power, requiring significant expansion in infrastructure to manage these surges. The interviewee emphasised that power and capacity are two different considerations that should be factored into decisions about which types of renewable energy to prioritise (Interviewee G-4). Likewise, according to Interviewee A-4, solar photovoltaic installations in the built environment are preferable over solar PV parks on land. This perspective is based on the notion that using already developed spaces (like rooftops, parking structures, or integrated building designs) for solar installations can be more efficient and less disruptive to natural landscapes. As a result, the interviewee argued that the government should structure the SDE(++) subsidy programme to favour these types of installations. Specifically, a higher proportion of SDE(++) funds should be allocated to encourage solar PV in the built environment as opposed to land-based solar parks (Interviewee A-4). The trade-off between maximising energy output and minimising environmental impact is an important consideration in this respect as well.

While large, land-based solar parks might generate power more efficiently, they can also consume valuable land and disrupt local ecosystems. In contrast, integrating solar PV into the built environment can make better use of existing structures, thereby conserving land and potentially increasing public support for solar energy. This is a policy consideration that can have broader implications for how governments choose to incentivise different forms of renewable energy. Solar panels are currently economically viable for households, according to Interviewee T-5, making the net metering regulation (*salderingsregeling*) less crucial for this sector, although a public debate has emerged about the economic attractiveness of solar panels and adoption is reportedly halting.

While it may seem counterintuitive, the automatic curtailment of solar panels is not necessarily a negative development (Interviewee T-5). Solar parks, for instance, are often connected to only 70% of their generation capacity. The excess energy generated during peak solar activity is virtually worthless, making it an economic decision to curtail some of the generation while also avoiding net congestion. In considering whether to invest in infrastructure to manage these peaks (i.e., continually expanding the network to meet the peak demands), the interviewee draws an analogy to road infrastructure: on sunny days, many people might go to the beach. Local roads might experience congestion as a result of all the traffic, as the local road network is not prepared to handle such a load normally. In such a case, it does not make much sense to build a six-lane road to the beach, just to meet the peak capacity on a few sunny days. The interviewee applied the same logic to energy infrastructure, arguing against significant overdimensioning of the electricity network. Additionally, despite advances in energy storage and hydrogen conversion technologies, the interviewee underscored that the goal is not to operate solar installations at 100% capacity at all times anyway, as it may not be economically beneficial to do so given the current use patterns. Instead, the interviewee advocates for a balanced approach between grid costs and energy production. The interviewee acknowledged that we will likely see much more energy storage and conversion in the future, not with the aim to harvest 100% out of each installation, but to use as much green energy (e.g., by converting it to green hydrogen) as possible and curtail less (Interviewee T-5).

Before the major shift happened around 2015, the Dutch photovoltaic innovation system faced several systemic challenges. A 2011 study found that the system lacked adequate 'guidance of the search' as a key issue, which lies at the core of directionality (personal communication). Frequent changes in subsidy schemes led to market hesitancy among both consumers and producers, and subsidies were not tailored for specific technologies, creating a volatile market and shifting focus to exports. This lack of focus hindered the formation of a strong domestic advocacy group for PV technologies. In 2013, the innovation system was largely made up of small and medium-sized enterprises (SMEs), indeed focusing primarily on exports (Vasseur et al., 2013). While networks for knowledge-sharing were in place, political networks were inconsistent, leading to regulatory uncertainties that hampered local entrepreneurs and investors. SMEs were more geared towards foreign markets due to the limited size and incentives in the domestic market. Despite available research grants, there was a shortage of both human and financial resources to adequately stimulate market growth. Additionally, lobbying efforts to prioritise PV technologies were largely ineffective. The study identified a ‘vicious cycle’ due to the lack of ‘guidance of the search’ and inconsistent market formation instruments (Vasseur et al., 2013). More recently, in the building-integrated PV (BIPV) innovation system, a 2022 study found that Dutch government policies – while setting renewable energy and building performance targets – lacked focus on commercialisation. Market regulations are more geared towards cost-efficient CO2 reduction, sidelining the importance of societal acceptance. Additionally, the authors noted a human capital deficit (Vroon et al., 2022).

Box 5. Strategic insights acquired with regard to the development of hydrogen, in relation to the upscaling of renewable electricity in the Netherlands.

While hydrogen is officially not a part of the focal mission of this study, it is arguably an important synergistic element with renewable electricity in the future energy system; thus, suggesting a certain degree of interdependence between the development of hydrogen and the development of renewable electricity. Hydrogen has particularly been noted to hold promise for the electrification of the industrial sector and to alleviate pressure on the electricity network, and the electricity needed for hydrogen production is expected to be largely sourced from renewable energy, with particular attention for offshore wind (Interviewee T-1, T-3, T-4). In this box, a brief overview of its meaning in the context of the mission is provided.

Until very recently, the Dutch government did not consider hydrogen to be a player in the short term (at least not until 2040), but its development has evolved much faster than expected in recent years that it has become a viable option, for example in tandem with the production of electricity from offshore wind (Interviewee T-1, T-4). The seriousness is underscored by major investments in the further development and implementation of the technology (Top Sector Energy, 2023; Interviewee T-4). The Dutch government aims to establish 3-4 gigawatts of electrolysis capacity by 2030 (Ministry of Economic Affairs and Climate Policy, 2020). Gasunie is tasked with constructing the hydrogen infrastructure connecting industrial clusters (Interviewee T-4). Interviewee A-2 referred to the current progress as an example of a 'hype cycle', a period of heightened expectations followed by disillusionment before eventual normalisation. While direct electrification is more efficient in most cases, hydrogen serves a unique purpose in scenarios where direct electrification is not feasible (Interviewee T-4). Hydrogen's most significant value lies in its ability to convert electrons into molecules, enabling long-term storage and long-distance transport. This makes it possible to access renewable energy on a global scale. Despite its benefits, the market fundamentals for hydrogen are still evolving, and there is considerable uncertainty about the potential returns on hydrogen investments, efficiency, and safety. Furthermore, there is also a need for more certainty about consumption obligations, green certificates, and market values (Interviewee I-2). The development of renewable electricity is a significant factor affecting the profitability of hydrogen production, as electricity costs account for a significant portion of the hydrogen production costs (Interviewee T-1; IRENA, 2021). Therefore, reducing the costs of offshore wind energy becomes crucial for making hydrogen an economically viable option. Despite the potential, there are concerns about the profitability of hydrogen, especially in terms of long-term storage. The numerous conversions required to store hydrogen make its economic feasibility questionable, thus requiring careful consideration of its role in a long-term sustainable energy strategy (Interviewee T-1). To this extent, interviewees emphasised the need for government intervention to stimulate the nascent (green) hydrogen market, especially as industries face increasing obligations to become more sustainable (Interviewee A-3, T-2). They noted that the European Union is drafting legislation like RED III, which may potentially require industries to obtain 42% of their energy from renewable (green) hydrogen (Interviewee A-3, T-2; (Leguijt et al., 2022). The adoption of this legislation would create an immediate and significant demand for green hydrogen, pushing both its development and market prices. To prepare for such regulatory shifts, local collaborations should be incentivised at industry parks (Interviewee A-3, T-2). Given that a market for green hydrogen is not yet fully developed, there is thus a pressing need for policy measures to facilitate its growth. Investing in hydrogen technology is currently expensive, partly due to the need to import green ammonia for hydrogen production (Interviewee I-3). However, investing now is considered crucial for building a backbone for hydrogen in the Netherlands, as the market is expected to change rapidly in the next five years with an increase in suppliers and subsequent cost reductions (Interviewee I-3). The interviewee suggested the introduction of a Contract for Difference (CFD) model or subsidies to incentivise early adopters, particularly when competing with cheaper options like grey hydrogen (Interviewee I-3).

Interviewee A-3 stated that the Dutch government has already subsidised a 1 MW electrolyser in 2021 (see (Sluijters, 2021) and the construction of a 100 MW plant is planned for 2024, however, much larger projects are necessary to further stimulate the market. They referred to OPEX subsidies that the US is currently applying to green hydrogen projects: for each kilogram of green hydrogen produced, producers can receive up to $3 subsidy (Parkes, 2022); when the production of one-kilogram costs $5, it can then be sold for $2 to break-even. The US has reportedly allocated $4.5 billion to this effort (Interviewee A-3). While effective for stimulating the development of demand for a new market, the interviewee also emphasised that this is a costly and finite policy instrument. Nonetheless, a similar approach could greatly accelerate hydrogen market development in the EU (Interviewee A-3). The hydrogen market also finds support from the mobility sector, including hydrogen cars and hydrogen fuels for aviation and shipping. Within the EU and the Netherlands, discussions with major industry players aim to shift towards hydrogen use, which is seen as part of the broader energy puzzle. Regional initiatives, such as Europe's first Hydrogen Valley in the Netherlands, are also a part of this effort (Interviewee A-3). The acceleration in the development of salt caverns for hydrogen storage can be challenging, but would add another piece to the broader energy puzzle, helping buffer the energy system (Interviewee A-3). The Netherlands is seen as an early adopter of hydrogen technology, largely due to the need to alleviate net congestion and the limitations of the existing electricity system (Interviewee A-3). For the hydrogen market to develop faster, collaboration between industry and the knowledge sector is considered crucial. The interviewee refers to the Groenvermogen proposal for the National Growth Fund, which aims to invest in hydrogen value chain development. However, the bridge between industry and knowledge institutes proved to be more difficult than initially expected (Interviewee A-3). The fact that GroenvermogenNL has been granted large investment funds indicates both the urgency and perceived important in accelerating the development of hydrogen infrastructure in the Netherlands (Interviewee G-2). However, scaling up hydrogen infrastructure bears significant challenges and uncertainties on its own, particularly regarding the deployment of large-scale electrolysers and their locations, as this requires careful planning; the interviewee referred to the OVI frameworks: NOVI, POVI, and GOVI (Interviewee G-2). Interviewee I-1 suggested that these facilities should ideally be located at the landing points of offshore wind farms, such as Borssele and Rotterdam in the Netherlands. This approach would make it possible to generate hydrogen directly and distribute it through pipelines, thereby avoiding the need for significant grid expansions. It could also utilise the existing gas network for more efficient energy transportation (Interviewee I-1).

Addressing challenges in hydrogen development, the Interviewee T-4 pointed to several key areas based on his expertise: (1) Insufficient availability of renewable electricity: Currently, there is not enough renewable electricity to meet the demand. While there are ambitious plans for scaling up offshore wind and solar energy, further capacity expansion is needed. (2) Scaling up electrolysers: Electrolysers, which produce hydrogen, need to be scaled up and improved in terms of efficiency, robustness, flexibility, and cost reduction. Innovation is required to advance this technology, and spatial planning is needed to determine where electrolysers are to be built. (3) Policy: The clarity and consistency of policies at the European Union and national levels are crucial; this clarity is slowly being implemented, but it is not clear enough yet. Policies should support and incentivise green hydrogen while allowing flexibility in using renewable electricity for electrolysers. The recently published Renewable Energy Directives (RED II and RED III) at the European level were said to provide clarity on the criteria for qualifying green hydrogen. However, more clarity is required regarding the future goals beyond 2030, 2035, and 2040, as well as the subsidy instruments the government will employ to support hydrogen development (Interviewee T-4). Indeed, as investment decisions need to be made now to achieve the 2030 targets due to lead times, the practical implementation and availability of hydrogen infrastructure become critical for industries to comply with future regulations (Interviewee I-2). (4) Financing: Financing hydrogen projects is linked to the associated risks. Currently, risks are high due to technological uncertainties and unclear policies. Increased clarity and confidence in the technology will enhance investor confidence. The current net tariffs were also said to have significant implications for the economics of hydrogen production via electrolysis (Interviewee I-2). The issue stems from the fact that these tariffs are structured around peak loads. However, electrolysers are designed to even out these peaks by consuming excess energy when it is abundant. This discrepancy means that the current tariff system essentially penalises the very behaviour it should encourage. To remedy this, the interviewee suggested that tariffs should better reflect actual usage costs. (5) Demand for green hydrogen: Although there is significant potential demand for green hydrogen, its price is currently higher than that of grey hydrogen, even with a CO2 penalty. Subsidies are necessary to make green hydrogen competitive on the global market and stimulate market development, and normative policy such as the EU ETS to create level playing fields. (6) Societal acceptance: Engaging society and providing accurate information is vital. Maintaining public support requires transparency, safety measures, and effective communication to address any concerns or questions from the public (Interviewee T-4).

While rapid development and investments are now being made, it was emphasised that it is crucial to learn from the existing 10 to 12 hydrogen projects in the Netherlands before scaling up further (Interviewee T-4). The interviewee advised against rushing into additional projects, as there is still a shortage of green hydrogen. Instead, the focus should be on gaining experience and sharing knowledge until around 2025 when a more substantial scale-up can be considered. After 2030, explicit decisions should be made with regard to how much the Netherlands will make use of direct electrification and how much energy should come from hydrogen (or other sources). The Electrification Roadmap (Rijksoverheid, 2021b) should guide this process (Interviewee T-4) Interviewees I-1 and I-2 highlighted the "chicken-and-egg" problem that is faced: offshore wind tenders currently tend to demand a certain capacity as "offtake" for e.g., future hydrogen production. However, they noted that there is not yet demand for this. Efforts are being made to get industrial partners on board to match supply and demand of green hydrogen (Interviewee I-1, I-2).

A recent study that investigated the innovation system surrounding hydrogen technologies in the Netherlands identified the absence of quality, a long-term vision, and clear guidelines as hindering factors to the development of hydrogen (Broekstra, 2023). These shortcomings related to institutional bottlenecks, inadequate capabilities among stakeholders, and poor network quality. Such issues lead to a negative cycle that hampers resource allocation and market development, discouraging further investment in hydrogen technologies. The market for hydrogen was still nascent, mostly driven by pioneering companies. To break the current stagnation, the government was advised to take a leading role by introducing targeted policies and financial incentives. For instance, clear and binding targets for green hydrogen production could act as a catalyst (e.g., in line with the RED III guidelines for industry). These policy measures should aim to reduce the cost gap between hydrogen and its alternatives, thereby making hydrogen projects more financially attractive. Collaborative efforts with other stakeholders are essential, particularly in sectors where hydrogen can have the most impact in reducing carbon emissions (Broekstra, 2023).

Valorising knowledge

The significance of valorisation in research, especially within the context of the Knowledge and Innovation Covenant (KIC), was highlighted by Interviewee A-5. They pointed out that research proposals for KIC calls must include an impact plan that encourages researchers to think critically about the societal challenges their research is aimed to address. This is essential as KIC calls are typically thematic, linking them intrinsically to societal issues. Researchers are urged to identify how their work could benefit societal partners and to engage these partners during the proposal stage (Interviewee A-5). In essence, the focus is on generating impactful research that directly addresses specific challenges, thereby bridging the gap between academia and societal needs. Transferring the knowledge acquired through research back to societal partners is still a work in progress. The NWO (*Nederlandse organisatie voor Wetenschappelijk Onderzoek*) has been adapting to this new approach, including establishing procedures and preparing thematic calls. The KIC programme for 2020-2023 was initiated relatively recently as all parties involved required time to make the necessary changes (both organisationally and practically); thus, it is too early to evaluate how effectively knowledge is currently being valorised. However, the NWO has some strategies in mind to facilitate this transfer, such as organising reflection days where project leaders come together with interested actors and can present their findings. Formal reports are also required to ensure that the results can be disseminated. Furthermore, keeping the KIA teams and Top Sectors updated on these results is crucial for future planning and potentially addressing new research topics (Interviewee A-5). In summary, the interviewee outlined the ongoing efforts to link scientific research more closely with societal needs and challenges, both in the design phase and the subsequent dissemination of results. This approach aims to create a more efficient and impactful innovation ecosystem, though its effectiveness is yet to be fully assessed.

Independence from other countries

The Netherlands strives towards independence from other countries. While this is generally a positive goal for nations, Interviewee A-3 pointed to the historic dependability of the Netherlands – and European Union – on other countries for their energy supply, hence suggesting that independence can be good but has its limits and it is not necessary to strive for full independence. The geopolitical risk of the Netherlands being dependent on other countries for essential resources like natural materials, however, could very well jeopardise achieving climate goals (Interviewee A-1). For instance, if geopolitical relations diminished, trade could be limited. A major part of the energy transition involves photovoltaic panels that are largely imported from China; in fact, the Netherlands was the world's largest PV panel importer in 2021 and 2022 (van Gastel, 2023). The Netherlands lacks native resources useful for items like batteries, making them inherently dependent on external sources and thereby countries (Interviewee A-1). A National Growth Fund project, SolarNL, focuses on domestic production of sustainable and circular solar panels, and aims to mitigate the Dutch dependence on China while contributing to other domestic factors such as employment (Interviewee G-1, G-2, T-5; (National Growth Fund, 2023a). EZK are reportedly evolving their approaches to be more selective and geopolitically aware (Interviewee G-1). While they have historically been technology-neutral and origin-neutral (i.e., not making explicit choices as to what technologies should be pursued and where innovations come from), changes are being made to account for risks, as the Dutch government understands the strategic risks of being overly reliant on other countries, especially when geopolitical tensions arise (Interviewee G-1). On the other hand, while resource scarcity might lead to temporary delays, one of the interviewees argued that it will not fully stop the transition (Interviewee A-2). Drawing from their professional experience, they indicated that there is often enough material availability and if not, there is always potential for substitutes to continue progress. However, they also recognise the current challenges in the electrification of e.g., automobiles, citing restrictions on the availability of elements such as lithium and cobalt (Interviewee A-2).

Systems thinking

Government support is considered a critical element, both in terms of investments and guarantees, for the implementation of the required systemic changes (Interviewee I-3). The interviewee pointed at industry parks to illustrate the importance of creating incentives for firms to make a transition to more sustainable practices. Without a tangible benefit, firms are unlikely to invest in making the switch. They further stressed the importance of adopting a systems-thinking approach in policy-making. Using the example of sustainable industry parks that make use of energy communities, the interviewee highlighted the need to integrate Balance Responsible Parties (BRPs) into the system. BRPs oversee the balance at one or multiple access points to the transmission grid, ensuring that the TSO/DSO does not have to manage these points themselves. Policy makers were criticised for often focusing too much on technical aspects and theoretical calculations at the expense of considering practical insights (Interviewee I-3).

According to Interviewee T-1, "innovation" has been included as a distinctive criterion in the tendering process for offshore wind projects in recent years, starting with tenders like Hollandse Kust Noord and Hollandse Kust West that have "systems integration" and "ecology" as focal points. The inclusion of these factors serve as a powerful incentive for actors in the sector to invest in these areas significantly, exemplified by a tender project for the Hollandse Kust West, where a staggering €70 million or more was invested in ecological aspects alone (Interviewee T-1; Rijksoverheid, 2022e). These investments are much larger than the relatively modest funding for innovations that the Top Sectors can offer to projects. The interviewee thus characterised the policy-driven incentives, such as tender criteria, as having a "flywheel effect" on driving innovation and integrating these critical factors into the industry; and argued that integration factors into tender criteria is at the core of providing directionality (Interviewee T-1). According to them, tender criteria have evolved to become more directive following the formation of the cabinet of Rutte IV and the introduction of the Climate Agreement. It was noted that before 2019, the focus of the tenders was primarily on more traditional aspects like reliability and costs. Policy makers at that time did not think it was the government's role to steer the market in directions like ecology or systems integration. However, with the new government and shifting perspectives, the tendering process now includes these as distinctive criteria. For example, the tender for IJmuiden Ver now even includes a criterion for dedicating a certain amount of capacity to offshore solar. According to the interviewee, this directional approach by the government can serve as an effective instrument for steering the whole sector towards more sustainable and integrated development (Interviewee T-1).

Challenges are arising from the free-market-driven development of solar PV farms. Companies often opt for cheaper areas to build these farms, leading to a mismatch between local supply and demand, resulting in grid congestion (Interviewee G-4). The installation time for solar parks is also significantly shorter than the time required to expand the grid, causing further issues. The role of network operators is evolving to include more active participation in site allocation for energy parks, a process that Netbeheer Nederland coins as 'energy planning' (Interviewee G-5). This approach suggests a more coordinated approach between governmental bodies and net operators to ensure that the grid can accommodate new energy inputs, thus avoiding congestion and inefficiencies. While it might ensure better coordination, Interviewee A-4 argues that it should be implemented carefully to avoid slowing down the construction of energy parks, as delays exacerbate climate change issues. The upcoming spatial planning programme for the required energy infrastructure (PEH; Rijksoverheid, 2023d) and the NPE (Rijksoverheid, 2023a)) serve as key tools in guiding this complex transition (Interviewee G-2). These documents are expected to clarify roles, responsibilities, and guidelines, and serve as a roadmap for all stakeholders involved in the energy system. These upcoming plans are seen as critical for ensuring that the energy transition occurs in a way that is both efficient and sustainable. By integrating inputs from multiple sectors, including industry and net operators, the plans aim to provide a comprehensive approach to managing the energy system (Interviewee G-2).

Interviewee G-5 coined the dilemma in balancing supply and demand as a 'chicken or the egg' case: industries may be reluctant to commit unless infrastructure is already in place, but operators are required to build infrastructure only if there is proven demand. This has led to a re-evaluation of the traditional minimalist approach to building infrastructure, as it is becoming increasingly evident that it is not sustainable for the green transition (Interviewee G-5). The previous financial incentives to keep infrastructure minimalistic are waning due to practical issues like grid congestion. Currently, there is a shift towards a more future-oriented approach, albeit this realisation has come somewhat late in the Netherlands (Interviewee G-4, G-5). Currently, network operators are expanding their focus beyond just electricity to consider other forms of energy, envisioning the future energy system as an interconnected whole. This perspective is evidenced, for example, in the recent study conducted by network operators, the II3050 (Interviewee G-4, G-5; (Netbeheer Nederland, 2023d). Studies like II3050 aim to provide a rationale for decisions and potential interventions, a necessary step given that network operators are publicly funded. Therefore, any alterations to the infrastructure and investment choices must be justified on societal grounds. (Interviewee G-4). The various points together paint a picture of a complex, evolving landscape where different stakeholders, including energy companies, network operators, and policymakers, are grappling with the challenges and opportunities of transitioning to greener, more sustainable energy systems. There needs to be an appropriate balance between economic viability, technological feasibility, and long-term sustainability, all while facing the urgent need to mitigate climate change.

Interviewee A-3 addressed the challenge of balancing the rapid scaling of renewable energy sources with the ability of the electrical grid to handle the increased load. If the implementation of renewables outpaces the expansion of the grid, it could lead to significant delays, negatively affecting both economic development and sustainability goals. The sentiment here echoes the concern raised by Interviewees G-4, G-5, and T-2 about grid congestion and the mismatch between supply and demand in the electricity network. Rapid electrification without adequate infrastructure planning can thus become a ‘double-edged’ sword. The interviewee further advocated for a broader, European-scale approach to energy planning. They argued that an excessive concentration of wind and solar parks within the Netherlands could lead to "landscape pollution," which could, in turn, reduce public acceptance for renewable energy projects. This could thus become a significant obstacle for the green transition. Instead, the interviewee suggests leveraging resources from other European countries, specifically mentioning the North of Europe, like Scandinavia, where geographical and demographic conditions are more favourable for the large-scale development of renewable energy sources like biomass and wind (Interviewee A-3). This diversification could also reduce the pressure on the Dutch grid and landscape. This way of systems thinking aligns with the approach proposed by other experts earlier. Considering the energy transition on a broader scale allows for more effective planning and implementation, leveraging different resources and infrastructural strengths across countries. It may also mitigate the challenges of grid congestion, landscape impact, and public acceptance, making the energy transition more sustainable and widely supported.

The systems thinking approach also encompasses looking beyond just the supply side of the transition and including considerations with regard to demand development. Specifically, it was suggested that industries should be incentivised or regulated to adopt cleaner energy sources like hydrogen or implement CCS technologies (Interviewee G-4). This multi-faceted approach is essential for a balanced and sustainable energy transition. The interviewee also noted the discrepancy between the systems-based approach taken by net operators and the more fragmented approach seen in the government, where multiple departments often handle different elements of the energy sector. This lack of integrated thinking can impede effective planning and execution of sustainable energy initiatives. Various scarcities must be considered in the policymaking process, including financial resources, physical space, human capital, energy, and infrastructure (Interviewee G-4). These are limiting factors that influence the feasibility of different energy transition options. By incorporating these constraints into the planning process, policymakers can develop more realistic and achievable strategies.

A common criticism of climate measures, which is the cost-to-impact ratio, is that the Netherlands are pursuing a climate mitigation measures plan that is estimated to cost 28 billion Euros while reducing the temperature increase by 0.00036 degrees Celsius. Interviewee A-4 challenged the framing of the issue by arguing that the calculations only take into account short-term temperature reductions (in this case, by 2030) and are therefore inherently misleading. Such calculations fail to account for the ongoing benefits of these measures in subsequent decades and additionally neglects the prevention of various downstream consequences like water shortages, sea-level rise, health issues, migration, and famine (Interviewee A-4). Furthermore, the IPCC stance is that while reducing emissions comes with a cost, these expenses are necessary for mitigating the long-term impacts of climate change. In a global context, the cost of these measures represents a relatively small percentage of the world's GDP (approximated at around 1% to 2%), which the interviewee considers an investment in a more sustainable and stable future (Interviewee A-4). The interviewee thereby provided a perspective that offers a counter-narrative to the short-term, cost-centric viewpoints that question the value of climate investments. By reframing the issue to include the long-term benefits and the avoided costs of inaction—both in terms of economic loss and human suffering—he advocates for a broader understanding of what's at stake. This aligns with the systems thinking approach, emphasising that policy decisions should not be evaluated solely on immediate outputs but should also account for longer-term outcomes and system-wide impacts.

The interplay between technology, business models, legislation, and consumer behaviour highlight the multi-dimensional nature of innovation needed in the energy sector (Interviewee T-5). It's not just about advancing technology but also about crafting sustainable business models, regulatory frameworks, and consumer behaviours that together can foster a successful and sustainable energy transition. Innovation should thus be seen in a broader context, where social, legislative, and even psychological factors play a significant role, beyond the technological dimension (Interviewee T-5).

Summary

Formulating strategies in response to potential pathways to achieve the focal mission allows for making choices and developing concrete plans for mission implementation. While this study did not aim to perform a systemic analysis, such as an assessment of the mission-oriented innovation system, the results shed light on what are currently the merits and challenges at this stage of the transition.

Explicit attention was drawn to the need for the government to provide clarity, certainty, and incentives. This could be achieved through broadly supported national plans (cf. DC3), concrete choices on what to develop and when and where, and providing the instruments – such as subsidies and regulations – for the system actors to act upon these plans and strategies.

The markets for wind and solar energy have undergone significant development in the past years, however, challenges have currently emerged in the offshore wind market. While tenders have been realised without subsidies, some tender projects are now halted due to challenging market conditions, and the value chain appears to be experiencing stress. It was considered essential to continue to support market actors and their business cases in their efforts of upscaling renewable energy. The interim goals for 2030 – while considered feasible and realistic – may not be reached if these issues are not addressed, which could result in a delay in the progress towards the future energy system.

Besides the value chain, network congestion was identified as a major issue as well, which may hamper sectoral electrification. Efforts are being made to alleviate the pressure on the network, however, further action is required, including enhanced spatial planning of energy projects. Moreover, a systems thinking approach (cf. policy objective) will likely be necessary to guide the transition process across sectors and holistically for all energy sources and carriers.

5.5. Realising destabilisation

The task of realising destabilisation involves the balancing act of driving transformative shifts while preserving the innovation capabilities of existing industries. Policymakers are crucial in this regard, as they must oversee the phase-out of structures that are considered no longer desirable in the future system and that conflict with the societal objectives of the mission. In the context of this study, this mainly refers to the phase-out of fossil fuels. Various approaches to destabilisation may be employed, ranging from exerting pressure on current regimes to initiating landscape-level changes (Kanger et al., 2020; Kivimaa & Kern, 2016).

The practical component of realising destabilisation presents challenges for policy makers. One of the key issues is finding equilibrium between making normative choices to for example delegitimise the current constellations or providing incentives for incumbents to encourage and support them to participate in the transition whilst not negatively affecting them. Policies that are too disruptive may lead to counterproductive outcomes, such as firms moving abroad, rather than adhering to sustainable practices. To this extent, Bergek et al. (2023) cites two examples (the Montreal protocol and the regulation on chlorine use in the Swedish pulp and paper industry) that demonstrate that destabilisation policies are often developed in cooperation with the focal industry, and that rigorous regulations typically do not come into play until transition pathways have been identified (cf. DC3). This draws a resemblance with the Dutch efforts of negotiating custom agreements with the twenty largest emitters of carbon dioxide in the Netherlands (Ministry of Economic Affairs and Climate Policy, 2022d).

As a result, the successful deployment of destabilising policies often depends on the ability to create viable transition pathways that can be executed without incumbent involvement, as well as navigating external constraints on what policies can be put into action.

Phase-out of coal and natural gas

In 2019, the Dutch parliament agreed with a bill for a new law, namely the 'law prohibiting the use of coal in electricity production (*wet verbod op kolen bij elektriciteitsproductie*; Ministry of Economic Affairs and Climate Policy, 2018b), which came into effect in 2022. Initiated by the Rutte III Cabinet, the law implements the Urgenda ruling of 2015 (Supreme Court of the Netherlands, 2019) and the 2017 coalition agreement (Rijksoverheid, 2017) stipulation that mandated the closure of the remaining coal power plants in the Netherlands no later than 2030. The measure was designed to reduce greenhouse gas emissions in the Netherlands, which is expected to lead to an emission reduction of 20 Mton CO2 in 2030 (Rijksoverheid, 2017), however, as part of the energy production will spill over to foreign countries, the reduction at the European level is expected to be 8 Mton CO2 (Tweede Kamer der Staten-Generaal, 2019).

The decommissioning of coal-fired power plants implies the reduction of dispatchable capacity within the energy mix. Renewable sources, such as wind and solar, yield variable amounts of energy contingent upon weather conditions. During periods when these sources cannot generate sufficient power, such as during a so-called *Dunkelflaute*, reliance is shifted to capacities that can be deployed irrespective of the weather (Interviewee T-1, I-3). If, for any reason, the Netherlands turns out not to be ready to meet its energy demand by 2030, the government could decide to maintain its coal plants longer. However, considering the rationale of the phase-out as well as the legal obligations that for example came forward from the Urgenda case, one could wonder to what extent that is a realistic policy option (Interviewee A-1, I-3). Moreover, it is considered crucial to phase-out unsustainable pathways to ensure a timely and just transition, even if that causes friction along the way, as that is interpreted as an inherent characteristic of transitions (Interviewee T-2). Natural gas plants are anticipated to be the last to be decommissioned, serving as the ultimate source of dispatchable power. One interviewee even considered it possible that these plants may never fully cease operations, but instead remain functional to address potential power gaps. However, this scenario raises questions regarding the cost-effectiveness of such operations, given that the facilities would likely only be activated for relatively brief periods when the vast majority of energy will be provided by renewable energy sources such as solar and wind (Interviewee T-2). Despite the phasing-out of coal for the production of electricity, the Netherlands still provides 37.5 billion euros in tax benefits for fossil fuels to this day, which has led to widespread criticism due to the perceived lack of decisive action to phase out these 'subsidies' for fossil fuels (Milieudefensie et al., 2023). The Dutch government claims to be phasing out these benefits, but argues that it cannot be done too quickly to keep the transition manageable for companies (Tweede Kamer der Staten-Generaal, 2023b).

Natural gas shaped the economic and industrial legacy of the Netherlands. Discovered in 1959, the field in Groningen was the ninth largest natural gas field in the world (Sandrea, 2006), accounted for 90% of residential heating in 2018 (IEA, 2020), and allowed the Netherlands to become the second largest agricultural exporter in the world (Viviano, 2017). As the Netherlands has slowly been running out of natural gas, fracking was used to reach reserves at greater depths, which ultimately caused underground disruptions and led to tremors that damaged thousands of residential buildings (Tweede Kamer der Staten-Generaal, 2023a). Partly as a result of public dissent and protest, in combination with a growing sentiment that the fight against climate change should be ramped up, as well as the Urgenda case that found the Dutch government obligated to significantly reduce greenhouse gas emissions, the Dutch government decided to shift away from natural gas and be completely gas-free by 2050; this particularly pertained to residential heating in the built environment, also referred to as the heat transition (*warmtetransitie*) (Koster et al., 2022; Ministry of Economic Affairs and Climate Policy, 2016). Despite these factors, one interviewee questioned whether the public issues in Groningen were decisive for the shift and instead argued that green and sustainability politics have been the main drivers of the phase-out and that it would have happened regardless (Interviewee A-3). Indeed, momentum for a Dutch energy transition was already started in 2013 with the Energy Agreement for Sustainable Growth (Ministry of Economic Affairs and Climate Policy, 2013).

The acceleration of the phase-out of unsustainable pathways, which has reportedly been relatively *sluggish* in the Netherlands, is a positive development according to Interviewee G-5. However, it presents challenges and necessitates a circumspect approach to avoid rushing the process. While coal and natural gas serve as dispatchable power sources, the essence of power adjustment lies in balancing and flexibility, which could also be achieved through batteries and 'power-to-X' technologies (Interviewee G-5; see also Lund et al., 2015). Moreover, by shifting to supply-oriented directionality, as opposed to the long-standing demand-driven approach, the transition can be guided more effectively. While the production sector seems ready to transition rapidly, the demand side remains less prepared according to Interviewee G-5. Thus, for effective balancing of supply and demand, strategic directionality is required, with network operators positioned to spearhead this change (Interviewee G-5). To achieve a balanced phase-out of natural gas and coal and concurrently upscale wind and solar energy, it necessitates a systems thinking approach (cf. DC4) where the supply and demand – particularly industrial demand – are aligned (Interviewee T-1). Any misalignment can lead to an imbalance in the energy network, necessitating other mitigation solutions, such as batteries, hydrogen, nuclear energy, or even the continuation of natural gas and coal plants if the transition stalls to unacceptable dimensions. Policy makers must consider network balancing when planning the fossil energy phase-out. Social acceptance for the energy transition could drastically decline if companies or even citizens suddenly face a lack of energy delivery. Phasing out fossil fuels irrespective of emerging issues, while merely hoping for the best, would be an overly optimistic strategy

(Interviewee T-1). Ultimately, however, it is critical to acknowledge that the future energy system will inherently exhibit volatility and may not offer the same supply guarantees that have since been taken for granted (Interviewee G-5). Additionally, the energy price is currently determined by the marginal costs of the most expensive power plant (Interviewee T-1, T-2). Renewable energy has no marginal costs, so if only renewable energy remains in the energy mix – which is more or less the ultimate goal for the future energy system (cf. the insights derived from DC3) – this implies that renewable energy would have to be offered at a zero rate. However, this is impractical, as it would undermine the business case for renewable energy. This factor must thus be considered during the fossil fuel phase-out process (Interviewee T-1, T-2).

The progression towards the phasing out of non-renewable energy sources is viewed as a positive and broadly accepted step in the right direction, as without such pressure, the transition towards renewable energy sources could be unacceptably slow, although a slow pace could theoretically still persist even under governmental impetus. (Interviewee A-2, A-3). However, it is crucial to tread carefully, to avoid the precipitous emergence of issues associated with the rapid upscaling of renewable energy, problems that could become financially draining. Particularly with regards to the phasing out of natural gas, a note of caution should be sounded, given the potential to utilise natural gas in an environmentally friendly way, for example, by implementing carbon capture and storage (CCS) technologies to sequester CO2 underground (Interviewee A-3). Historically, political decisions have inhibited the development of CCS technologies, partly because they were viewed, as of 15 years ago, as providing a justification for continued reliance on coal and other fossil fuels, a practice which the broader goal of decarbonisation sought to terminate. This perception, especially prevalent in the Netherlands and Northwestern Europe, ruled out the consideration of CCS as a feasible option. However, global perspectives, such as those from the Intergovernmental Panel on Climate Change (IPCC) – a body comprising individuals with extensive expertise in this field – have advocated for CCS as a relatively safe and cost-effective option (IPCC WG3, 2005). Disregarding CCS in the broader energy mix may necessitate a more costly approach to climate policy. Given that escalating costs tend to erode social acceptance, the international consensus leans towards the validity of CCS as a legitimate option. Although it can be seen that there is a resurgence with regards to CCS, the interviewee pointed out that valuable time has been lost due to that the option was dismissed for years (Interviewee A-3). In light of current issues, such as the noticeable grid congestion associated with wind and solar energy, the preservation of natural gas as a flexible energy source appears to be a prudent decision, as supported by the II3050 study that was published by the Dutch grid operators in 2023: natural gas continues to play an important role for dispatchable capacity until at least 2040 and during the transition period until hydrogen becomes a viable buffer, and is then slowly phased out towards 2050 unless the Netherlands opt for European integration of its energy system (Interviewee G-2, G-4; Netbeheer Nederland, 2023d). While coal plants must shut down by 2030, there is no such legislation for natural gas plants. In fact, natural gas plants are subjected to carbon emission capping through the EU ETS scheme and are permitted to participate in emission trading (Interviewee A-2). Moreover, the Dutch government intends to tighten the existing fees for carbon emissions in the Tax Plan for 2023 and advocate for the implementation of the EU Carbon Border Adjustment Mechanism to establish an international level playing field when the EU ETS will no longer offer free emission rights for electricity producers and industrial parties around 2040 (Ministry of Economic Affairs and Climate Policy, 2022d). One interviewee highlights the significance of natural gas as a transition fuel in the gradual progression towards a hydrogen-based energy system. This is underscored by the overarching necessity of safeguarding energy supply security, with natural gas serving as a stable energy source until there is widespread adoption of heat pumps in households and full-scale hydrogen utilisation in industries. However, the precise timeline for this transition, as well as the integration of these diverse energy sources, remains an area of uncertainty (Interviewee G-2). Indeed, the Dutch Expert Team Energy System 2050 (*Expertteam Energiesysteem 2050*; ETES2050) published an interim report in 2022, in which they argued that the energy and electricity systems must be carbon-neutral by 2040 and 2035, respectively, if the Netherlands desire to be climate neutral by 2050, and that options such as CO2 and biomass should be considered legitimate (IPCC WG3, 2005). Interviewee G-3 supported the ETES2050 outlook and additionally points out the importance of making decisions regarding bunker fuels, as the continued production of bunker fuels in the Netherlands would have major implications for the future energy demand, for example, in terms of the anticipated size of the electricity system (i.e., there are questions whether the electricity system will have to be expanded two or three fold, or even five or six fold, and whether such ambitions can be realised within three decades) if e.g. industry would become predominantly electric while maintaining or increasing energy demand (Interviewee G-3). The interim report by ETES2050 stated that there is significant uncertainty regarding bunker fuels and the efficiency of other (industrial) options, including hydrogen (Expertteam Energiesysteem 2050, 2022). While the government may set goals for the phase-out of dispatchable power such as coal and natural gas, individual firms may push destabilisation agendas that accelerate the transition. For instance, Eneco is proactively working to make their own energy sources more sustainable, for example by phasing out natural gas faster than mandated and achieving for climate neutrality by no later than 2035 through its One Planet Plan, with a particular focus on replacing gas power plants with district heating (Interviewee I-4; Eneco, n.d.).

Another interviewee posits that the existing infrastructure for natural gas is adaptable enough to accommodate both CCS and hydrogen transportation (Interviewee T-4). In the Netherlands, the current natural gas infrastructure is designed with redundancy. For instance, the network extending from Groningen to Rotterdam consists of five pipelines. The proposed establishment of a hydrogen backbone would allow the conversion of one of these pipelines to facilitate hydrogen transportation, while the remaining three to four pipelines would continue to transport natural gas as required. While the surplus capacity provides distinct transportation, it would technically even be possible to amalgamate hydrogen and natural gas in the same pipelines, however, there is currently no existing policy in the Netherlands to do this. Furthermore, should it be concluded that the extant natural gas pipelines are no longer sufficient, then construction of new pipelines – a routine practice not perceived as a significant obstacle by the interviewee – could be initiated. Consequently, the interviewee does not perceive the cohabitation of multiple utilities within the infrastructure or the necessity of new pipeline construction as significant challenges, which underscores the flexibility and adaptability inherent in the infrastructure planning paradigm of the Netherlands (Interviewee T-4).

Making choices

In order to incentivise corporations to transition towards more beneficial trajectories, regulatory measures such as European standards and norms should be implemented (Interviewee I-3). This may necessitate the involvement of national entities to shape the right conditions and provide assurances. For instance, for the transition from grey to green hydrogen, the RVO is striving to align producers and consumers to stimulate the market, while the importation of green ammonia is currently necessary given that the Netherlands does not generate sufficient renewable electricity yet to support hydrogen production (Interviewee I-3). By the year 2030, the decommissioning of coal plants will render the Netherlands partly dependent on renewable energy sources. Given the inherent instability of wind and solar power, alternative solutions may be required, such as battery storage. However, current high transportation costs and legislative constraints, which view batteries as consumers rather than producers, render this option expensive. Although reclassifying batteries as producers could potentially eliminate transportation costs, this raises questions of social acceptability of such solutions as consumers may then bear increased costs (Interviewee I-3). It is considered imperative that choices are made in a timely manner to provide the required certainty to commit long-term investments (Interviewee G-4, I-3). The II3050 study stipulated four potential scenarios for the future energy system as envisioned by the Dutch grid operators (Netbeheer Nederland, 2023d). This should aid the government to make guiding choices and to be informed as to what transition pathways are available. Even more so, EZK is said to desire the grid operators to provide explicit instructions that they believe is necessary to effectuate the transition; as an example, the grid operators performed a quick scan in 2022 to instruct the new coalition of Cabinet Rutte IV what essential intervention by the central government would be to stimulate the transition (Interviewee G-4; Netbeheer Nederland, 2022b). Nonetheless, the government bears the responsibility to determine what path or paths shall be pursued to provide such certainty. These choices must be made in a timely manner, according to Interviewee G-4, as certain pathways may become infeasible if you miss critical decision-making points due to the lead time of development, e.g., the development of advanced infrastructure. "*There are several critical decision-making moments. [..] At a certain moment, if no choice is made, well, then you also make a choice [..] And if you do not seize that moment, that moment is simply gone. [..] Decisions need to be made at a certain point because you need the entire lead time to facilitate the development [..] of a technology or to build the required infrastructure*" (Interviewee G-4).

In the public debate, governments are sometimes asked to make explicit choices as to which companies or industries should have a 'right to exist' in the Netherlands. Among the interviewees, it was deemed unlikely that the Dutch government will ever make such explicit choices (Interviewee G-1, G-3, G-4, A-1, A-2, T-3), however, it may exercise choices concerning the type of companies or allocation of specific locations for distinct purposes; this level of directive approach is necessary, which can be achieved through the design of conditions that apply to industries (Interviewee G-4). For instance, rather than outrightly declaring that refineries are prohibited, conditions could be established such as stipulating the type of energy, end products, or emission limits are permitted in the Netherlands. Based on these conditions, all system actors can subsequently develop and adjust their policies (Interviewee G-4). The potential relocation of high-energy industries to other nations due to the Netherlands' commitment to carbon neutrality was also touched upon during the interviews. The government is said to have a moral obligation to address polluting industries, especially within the Global North, Global South equality perspective, and given that the Netherlands has historically had a relatively large carbon footprint (Interviewee A-1). One of the interviewees referred to a recent study that mitigated these apprehensions, suggesting that the implications of such relocations may not be as consequential as initially feared, and thus the argument against taking climate action over the fear of losing industry does not necessarily hold up (Interviewee G-3). They contend that relocations within Europe may not pose a substantial issue due to the commonality of regulations across the European Union. If industries were to relocate to countries that have less strict regulations, it could result in net worse conditions for the global climate challenge (Interviewee G-3, A-1). However, the interviewees also underscore the necessity to account for international justice, observing that some countries may gain from the employment opportunities presented by relocated industries. Interviewee G-3 concludes with the assertion that economic landscapes are always in a perpetual state of flux. The Netherlands once derived significant advantages from its natural gas reserves, for instance in Slochteren, but as these reserves dwindle and gas fields are closed, the country will need to adapt and identify new strategies to attract and retain industries. The interviewee argues that for each segment of industry that departs, another will reemerge, including industries that are not energy-intensive such as ASML. Moreover, regardless of policy decisions, industries are constantly in a state of evolution when viewed from an evolutionary-economics perspective (Interviewee G-3).

A significant proportion of energy consumption is linked to base industries, indicating that the energy transition concurrently necessitates a substantial industrial transition (Interviewee A-1, A-2). They suggest that industries where the Netherlands excels, such as the chemical process industry, have prospered due to factors like advantageous geographical positioning and access to natural gas resources. However, as natural gas reserves diminish, the question emerges as to whether these industries can maintain their success. One of the interviewees argues that there are grounds for optimism regarding the future of these industries and underscore the North Sea's wind resources as a valuable energy source in a renewable world, which could potentially replace the role of natural gas in the industry (Interviewee A-2). The potential exploitation of the North Seas as a 'green powerhouse' (Rijksoverheid, 2022g, 2023e), consisting of wind and solar energy derived from the North Sea, in combination with hydrogen, for industrial purposes. These industries are often situated along the coastline, in proximity to the North Sea, enabling the immediate consumption of the generated energy (Interviewee A-2). However, some proponents argue this energy could also be utilised directly by society (Interviewee G-3), for instance, within the built environment, thus indicating the necessity for strategic decision-making. Interviewee A-2 adds that these decisions are typically market-driven. They advocate that the basic energy requirements of households, encompassing electricity, heating, and mobility, should be prioritised. Furthermore, they highlight that from a climate perspective, the specific application of this 'green' energy – whether domestic or industrial – is immaterial. In consideration of the long term, the interviewee refers to studies indicating that if all industry were eliminated, there would be a surplus of electricity, particularly considering what could be generated from the North Sea. Thus, they assert, the Netherlands could continue to support a considerable industrial sector. However, the question of whether this sector matches the current scale, is marginally less, or remains relatively constant is an open-ended issue that they anticipate will be the subject of debate for the near future (Interviewee A-2).

Not all choices are to be made by nations, but can also be shaped by EU policy and legislation. The EU is currently drafting legislation (such as the Renewable Energy Directive, RED III) that will mandate industries to procure at least 42% of their hydrogen from renewable fuels of non-biological origin, which may provide significant pressure on industries to transition (Interviewee T-2, I-2; European Commission, n.d.-c). It is, however, imperative to combine this legislation with the EU ETS to provide the right incentives for industry stakeholders (Interviewee T-3). For instance, the EU ETS system should enable green hydrogen to be cost-effective compared to grey hydrogen, by adding more pressure on carbon pricing.

Summary

Creating destabilisation to facilitate the transition to a carbon-free electricity system is seen as an important element of the energy transition. The mission itself does not provide for the phasing out of certain options or technologies; this falls under the Climate Agreement and the subsequent Climate Policy. However, the phasing out of, for example, electricity production from coal combustion and the phasing out of natural gas from the built environment (see mission B) does contribute to creating a new market, namely that of renewable electricity from wind and solar energy.

It was emphasised during the interviews that renewable electricity is intermittent. Given the fact that there is a simultaneous phase-out of adjustable capacity (e.g., the phase-out of coal), it was pointed out that it is important to keep an eye on the progress of the transition, to ensure that on the one hand the scaling up of renewable energy and on the other hand the phasing out of the adjustable capacity proceeds in a balanced manner, and that the security of supply is not endangered. The phase-out should not proceed too quickly if it turns out that other factors are at play, such as the affordability of the transition; if the costs become exorbitantly high, it could undermine societal support.

Some also argued for decisions to be made about which industries still have a right to exist in the Netherlands, or whether certain industries should be abandoned to achieve our goals. It was pointed out that it does not necessarily have a negative effect if certain industries disappear from the Netherlands and that markets always move dynamically. At the European level, policy is needed to create a level playing field between countries, so that countries that pursue a strong phase-out policy are not disadvantaged compared to neighbouring countries and are thus limited in their objectives.

5.6. Nurturing public engagement

In the context of citizen involvement in local decision-making processes, two core areas of consideration emerge from the interviews: the imperative for clear preconditions for citizen involvement and the need for a new approach by policy-makers in designing a well-functioning system (Interviewees A-1, I-3).

Clear preconditions for citizen involvement

A primary concern highlighted by Interviewee I-3 is the necessity for municipalities and provinces to establish distinct preconditions for citizen participation. Without such guidelines, misunderstandings may occur as participants are likely to have differing expectations as to what extent they can influence the plans and in what manner they can contribute to decision-making. Without up-front clarity, citizen participants may be dissatisfied if their expectations do not match up with what their actual input entails. The interviewee provides an example of a failed attempt to involve local citizens in planning a solar farm in the Dutch province Groningen. As no clear instructions were provided to citizens, one had the impression that they would be able to decide about matters such as the height of wind turbines, while others were more under the impression that they would be able to influence the distribution of revenue (Interviewee I-3). The interviewee additionally states local policy-makers often reason out of ignorance because they might fear public resistance and may not know how to handle that resistance. Resistance to change is inevitable (Interviewee I-3, A-1, A-2), and as such, clear articulation of why a particular option – or combination of options – is the best for their local context, and clear instructions to fostering a constructive approach towards local developments, are vital (Interviewee I-3). In order to realise a well-functioning system to make this happen, as well as to facilitate public participation under the right preconditions, Interviewee I-3 calls for a strategic shift in policy-making, which they explain as a “new modus operandi”. Such a systematic change would not only articulate the scope of citizen input but would also promote a culture where public resistance is acknowledged, engaged with, and managed. This shift in approach resonates with the need for clear preconditions and recognises the importance of proactive rather than reactive strategies in public participation, and that of transparent communication (Interviewee I-3). These insights were underscored by a recent report on public participation (Expertteam Energiesysteem 2050, 2023a). A clear articulation of preconditions for citizen involvement may also enhance engagement of those that are willing to participate, as not all citizens may be interested in participation and rather may prefer to be left alone (Interviewee A-2). Interviewee A-2 elaborated on the benefits of citizen participation, offering a more nuanced perspective. While acknowledging its value, they were sceptical about the general public's interest and proficiency in technical matters. Instead, they championed the role of technical experts in overseeing these processes. Drawing an analogy, the interviewee compared the role of discussion leaders in citizen participation to that of religious leaders in the past: figures who would often provide explanations for why "things are the way they are" and why certain directions are the right ones. They further characterised the sensation derived from this participatory approach to the comforting embrace one might feel from a social worker and described it as a “fuzzy warm feeling.”

Public participation

In the interviews, various aspects of citizen participation and public engagement in the Dutch energy transition were explored. The insights acquired provide a multifaceted appreciation of the complexity, challenges, and potential benefits of engaging the public in energy-related decisions.

Public participation in decision-making

An important part of resistance against energy-related projects may be the consequence of poorly organised decision-making processes in the Netherlands, which one of the interviewees argues was the case between the 2000s and around 2015, and which reportedly caused significant mistrust between governments and citizens (Interviewee A-1). They argue that before 2015, spatial planning for large-scale wind farms – as an example of energy-related spatial planning – were based on three criteria: spatial availability, distance to the built environment, and sufficient wind speeds. For instance, if there was a 'circle on the map' with sufficient space, it was likely that the wind farm could be built there. Current practices strive to involve the local contact better, to ensure that solutions are integrated in the environment in a smart and just manner (Interviewee A-1).

During the interview, the interviewee was also asked whether they believe that there are sufficient opportunities for the public to get involved in local decision-making processes, considering that nation states are bound to meeting goals within a specified time frame that fall under EU legislation. Despite the urgency of meeting EU goals, Interviewee A-1 asserts that public participation must remain even if time is a pressing factor for two reasons: 1) public participation is a fundamental component of a democratic constitutional state, and 2) from political science studies, the interviewee knows that the execution of plans can ultimately proceed more quickly if there is sufficient room for local interests and values (Interviewee A-1).

The Climate Agreement's provision for local ownership of wind and solar farms illustrates an effort to balance costs and benefits within communities (Interviewee A-1). This was a form of financial participation and was meant to strike a balance between the costs and benefits of a citizen's immediate environment to increase public acceptance of such large energy projects (Rijksoverheid, 2019b). For instance, this would have to prevent '*energy cowboys*' to build such energy farms and withdraw all the (financial) benefits from the Netherlands while local citizens experience the burden, such as health issues, umbral shadows, and noise disturbance, as such practices would likely result in a reduction of social acceptance; it is currently unknown that what extent completed projects actually live up to this agreement as it was a non-binding commitment rather than a legal demand (Interviewee A-1). A recent study found that there are still barriers to effective implementation of the 50% local ownership (Schaar, 2022).

Role of energy cooperations and communities

The significance of energy cooperations and communities in the energy transition was highlighted during the interviews, emphasising their social function in involving people more directly (Interviewee T-2). If people are more engaged or could even directly benefit from new opportunities, this could both accelerate the energy transition in the built environment and increase public willingness to participate and accept the new constellations that come with the transition. A critical aspect here is the need to approach or treat non-members – i.e., people that are not part of those cooperations and communities – fairly, such as in terms of energy prices, to ensure social equality (Interviewee T-2).

Public acceptance

In this study, *public acceptance* refers to the general approval, support, or tolerance of a new technology, policy, or change by a society or community. In the context of the energy transition, public acceptance pertains to how receptive or resistant populations are to the changes proposed or implemented in the energy sector. High public acceptance can lead to faster policy implementation, easier rollout of new technologies, and increased investor confidence in the renewable sector. Low public acceptance, on the other hand, can lead to resistance, protests, legal challenges, and delays in project implementations. This can significantly slow down the pace of the transition. Policies that are perceived as inclusive and beneficial to the broader population tend to garner more support, while those viewed as exclusive or benefiting only a few can be met with scepticism or opposition, as elaborated upon earlier.

The Netherlands has been undergoing a transition in its electricity system, moving from fossil-based energy sources, particularly coal and natural gas, to renewables like wind and solar energy. Challenges related to public acceptance in the context of these new energy sources are multifaceted. The most prominent challenges are described in **Table 5**.

Table 5. Challenges pertaining to public acceptance of renewable energy integration in the Netherlands.

Challenge	Description
Wind energy	
Visual and noise pollution	Large wind turbines, especially in onshore locations, can be seen from considerable distances, leading some locals to perceive them as visually obtrusive. Moreover, turbines produce a consistent hum or whooshing sound, which can be bothersome for residents living nearby.
Impact on wildlife	Birds are particularly vulnerable to flying into wind turbine blades. While modern turbines are designed to minimise such impacts, there remain concerns about local wildlife populations, especially if the wind farm is near migratory paths or habitats.
Effects on property values	There's a perception (sometimes supported by studies and sometimes refuted) that the presence of wind turbines can decrease property values because of the aforementioned noise and visual impacts.
Shipping and navigation	For offshore wind farms, local communities involved in fishing, shipping, or recreational boating might be concerned about navigational hazards.
Ecological impacts	Environmental groups and some sections of the public might be concerned about the ecological impacts on marine environments.
Communication	Clear communication about the benefits of wind energy, the precautions taken to minimise environmental impact, and its role in combating climate change can help sway public opinion. Involving local stakeholders in decision-making processes and providing compensatory measures, such as community funds or reduced energy bills, can also enhance acceptance.
Solar energy	

Land use	Large solar farms require significant areas of land. This can lead to debates over the best use of land resources, especially in densely populated countries like the Netherlands. In some cases, agricultural land or natural habitats may be disrupted.
Aesthetics	Just like wind turbines, large arrays of solar panels can be considered visually unappealing, particularly in scenic or historically significant areas.
Profitability	Financial attractiveness of solar panels is currently widely debated as energy prices are rising, owners now often have to pay fees to return electricity to the network, and the feed-in scheme is being ceased.
Communication	Solar farms can be designed to integrate with the environment, for instance by allowing sheep grazing between panels. Also, the dual-use approach, where agriculture and solar generation coexist, is a possibility. Again, involving local communities in planning and highlighting the long-term benefits can lead to greater acceptance.
Grid infrastructure	
Physical infrastructure	Transitioning to renewables might require new substations, power lines, or other infrastructural components. These can face opposition due to concerns about visual impacts, land acquisition, and potential health concerns related to electromagnetic fields.
Distributed generation	As homes and businesses produce their own power and feed it back into the grid, there might be concerns about grid stability, safety, and potential changes to energy pricing.
Economic factors	If transitioning to a more modern grid leads to increased energy prices or is perceived as economically burdensome to the community, it can face resistance.
Communication	Proper communication is key. Educating the public about why these changes are necessary, the precautions being taken, and the benefits can lead to better acceptance. Allowing communities a voice in the planning and decision-making process ensures that their concerns are addressed and that they feel ownership of the transition.

In each of these challenges, the underlying theme is the importance of clear communication, community involvement, and ensuring that the broader public understands the benefits and reasons behind the energy transition, a view that was widely supported by various interviewees (Interviewee G-1, G-2, A-1, I-3, T-1, T-5). Given the Netherlands' commitment to reducing greenhouse gas emissions and transitioning away from fossil fuels, finding ways to address these concerns and integrate renewables in a way that is acceptable to the public is essential. The multi-faceted nature of this topic alone underscores the need for a systematic and holistic approach.

One of the interviewees elaborated upon the value of a systems approach, especially at the local level, when fostering social acceptance (Interviewee I-3). By taking the instance of municipalities shifting to heat pumps, for instance, the requisite network connection must be ensured by a net operator. Failure to do so would lead to inoperative heat pumps, causing public frustration. The interviewee further elaborated on the imperative to decide between the myriad energy options available (such as all-electric, green gas, hydrogen, etc.), contingent on numerous factors, ranging from sustainability, financial implications, to the frequency of infrastructure installations. With regard to the latter, the interviewee drew explicit attention to the local environment of public citizens: the need to repeatedly open roads for infrastructural updates poses significant inconvenience to locals, necessitating robust planning; for instance, if a local neighbourhood transitions to a heat network, locals will not appreciate it if the roads were opened fairly quickly again for new electricity cables (Interviewee I-3).

Interviewee T-1 posited that social acceptance predominantly concerns the built environment, pointing to examples of large-scaled solar and wind farms that are built near households. The interviewee mentioned that the success and exponential growth of offshore wind can be attributed to diminished direct impact on citizens and fewer instances of appeal against development plans, which they said is more likely to happen for inland projects. In the early stages of offshore wind, visual pollution from the parks posed concerns. However, new innovations and technology development has made it possible to build these parks farther from the shore and, as such, concerns have been mitigated to a large extent (Interviewee T-1). The view that offshore wind has been successful as a result of inland opposition to projects is contested by Interviewee A-1, who strongly argued that the development of offshore and onshore wind is not connected in that sense and that both sectors have developed independently; in other words, they argue that the success of offshore wind cannot be attributed to public resistance to onshore wind (Interviewee A-1).

Interviewee A-1 delves further into the evolution of energy projects with relation to public acceptance. Modified designs, such as smaller wind turbines and alterations in decision-making processes, have emerged as a result of public resistance. Several drivers of resistance were enumerated and ranged from apprehension to environmental change, perceived unfairness in decision-making, cost-benefit imbalances, to larger global concerns like the limited impact of single-nation initiatives, especially when juxtaposed against nations expanding their coal industries, like China (Interviewee A-1). While democracy and public participation remain pivotal, the interviewee also emphasises the implications of legal mandates enforcing climate action due to potential human rights violations, such as the Urgenda case.

If new technological solutions on the demand side, such as electric cars and solar panels, aren't accepted by the public, they might not gain traction and limit solutions on the supply side. Considering that Mission A is fully focused on production of renewable energy, it depends on other missions to work on solutions that stimulate the uptake of the newly generated energy, such as Mission C for the electrification of industry and Mission D for the adoption of electric vehicles and renewable energy in mobility. One of the interviewees therefore argues for a ‘market pull’ strategy by the central government, which goes beyond promoting a new technology and additionally considers its actual use and integration into daily life (Interviewee G-1). In case incentives prove insufficient, implementing normative policy might be necessary to create the envisioned ‘market pull’. Normative policy works best if pursued at the level of the European Union to ensure a consistent framework across the member states, avoiding competition and considering that citizens generally opt for the most economical choices (Interviewee G-1). Another interviewee highlights the initiatives that EZK has made in recent years, notably through communication departments and citizen forums, to involve the public in the energy transition (Interviewee G-2). While the interviewee stresses the urgency of the transition, they also advocate for a collective understanding and acceptance before taking rigorous actions, referring to the recent events with natural gas in Groningen (Tweede Kamer der Staten-Generaal, 2023a). The interviewee recognises the challenge of addressing everyone's concerns and the need for balancing prompt action with community involvement, acknowledging the political nature of the challenge. This was further underscored by Interviewee T-1, who reflected on the importance of net balancing during the phase-out of fossil energy: they drew explicit attention to a potential plummet in public acceptance for the energy transition if energy supply was to get disrupted significantly as a result of *dunkelflaute* when there are no options such as coal, oil, and natural gas available.

An interviewee pinpointed two central issues within their programme: the influence of behaviour on technology uptake and the implications of automation and care relief (Interviewee T-5). The interviewee emphasised the crucial role of societal adaptability in a flexible energy system. While aspects of automation, such as smart energy services, can be beneficial, they may also be perceived as daunting by users. For example, the interviewee cited concerns about electric vehicle charging rates in smart charging scenarios (also elaborated upon by Interviewee G-5). If charging is scheduled during peak energy supply times, users might worry about not having their vehicles ready when needed. To address this, some projects introduced an 'override' button, letting users opt for full-speed charging. Initially, this feature was frequently used, but over time, many became more receptive to the idea of smart charging (Interviewee T-5). The rationale behind smart charging is to address the electricity net's supply-demand disparity. Notably, since most users return home between 5 and 6 PM and need their cars the following morning, there's ample opportunity to charge vehicles overnight in sync with the grid's load (Interviewee G-5). Incorporating features like the 'override' button showcases the advantages – and possibly the necessity – of granting users more control, and thus comfort, over such technologies to foster broader acceptance. Interviewee T-5 further underscores the idea of 'public value', stressing the importance of an energy system that is equitable, inclusive, and subject to democratic oversight. They reference the Club of Wageningen, a Dutch collective focused on issues like cybersecurity and data protection. In the case of smart devices, for instance, they aim to safeguard users from potential data surveillance by corporations, using devices such as smart meters.

Environmental movements also influence public acceptance. Interviewee A-1 stated that the public discourse is marked by division: groups such as Extinction Rebellion contend that actions are insufficient, whereas others believe that the policy measures are excessive. The reality lies midway: while the Dutch government has been proactive since 2015, it is evident that further steps are required to achieve the 2030 objectives. Interviewee A-2 expressed scepticism towards the strategies and claims put forth by environmental movement Extinction Rebellion: they found the group's assertions to be unrealistic and naive, referring to demands to eliminate all emissions in just a few years and questioning how such goals can be achieved through citizen forums.

Summary

The trajectory of the Netherlands' ambitious pursuit of a carbon-free electricity system is inextricably linked to the degree of public endorsement and active participation. The public's perception and consequent responsiveness have the capacity to influence the transition from conventional fossil fuels to more sustainable alternatives, such as wind and solar energy. When there is public understanding and subsequent support for these transformative measures, the rate of policy and technological implementation can be substantially accelerated. Efficacious communication, active community engagement in decision-making processes, and transparency with regard to the advantages are considered critical. Conversely, a lack of involvement or information may result in resistance, manifesting in protests, legal procedures, and substantial delays. Tangible manifestations of resistance are likely to occur at the local level. For instance, frequent infrastructure disruptions or wind turbine installations that are built nearby neighbourhoods can give rise to dissatisfaction by local citizens. If feasible, offering residents agency, be it in determining their electric vehicle charging schedules or influencing the placement of new energy infrastructures, can amend this resistance.

Recent events, notably the natural gas debacle in Groningen, serve as a reminder of the repercussions that may emerge if concerns of (local) citizens are not taken into consideration appropriately and timely. Moreover, the polarisation of the public debate surrounding the Dutch energy transition can significantly influence public acceptance. While certain societal groups may advocate for increased urgency, others may perceive the transitory measures as overly radical. For a smooth transition towards a carbon-free electricity system, it's imperative to bridge these divides, foster open dialogue, and ensure that policies and initiatives are both transparent and inclusive. Engaging all segments of society in constructive conversation and ensuring that their concerns and aspirations are addressed can mitigate the challenges posed by polarisation.

In summation, for the Netherlands to efficiently navigate its trajectory towards a more sustainable energy paradigm, it's imperative for policymakers and stakeholders to prioritise public sentiments and engage in consistent, transparent dialogue. Establishing trust and fostering public engagement will be essential for a successful energy transition.

5.7. Mobilising relevant policy domains

The directionality challenge of mobilising relevant policy domains relates to identifying and coordinating different policy sectors towards achieving a specified policy goal (Bergek et al., 2023). These include policy domains related to technology, innovation, energy, municipal and regional governance, environmental policy, and fiscal policy. These domains collectively address various challenges such as stimulating knowledge development, funding large-scale plants, managing environmental permitting processes, and implementing fiscal incentives. Collectively, they are intended to work in tandem in addressing societal challenges, such as the climate goals.

The challenge is multilayered. Firstly, it includes identifying the most appropriate policy domains, which can effectively address systemic weaknesses and realise various transition pathways. This process is complicated because it requires determining which sector is best equipped to tackle transformational failures, destabilisation needs within a particular industry, and other sector-specific issues. This is often done by identifying problems and intervention points, taking into account the varied expertise and jurisdictional power of each policy domain. Secondly, the challenge extends to coordinating the identified policy domains to ensure that each domain understands their role in achieving the policy objectives. It involves developing domain-specific goals and action plans that align with the overall policy objective. These actions must be coordinated in time, necessitating a thorough understanding of the available pathways, their respective weaknesses, and potential solutions. A significant hurdle in this coordination is the handling of conflicting values or targets. For instance, while the permitting process for new constructions represents democratic principles and environmental protection, it can also be time-consuming, thus creating a conflict between different policy domains. The challenge for policymakers is to reconcile these conflicting values, make timely decisions, and manage the various levels of governance involved in achieving the climate goals.

In summary, the 'mobilising relevant policy domains' directionality challenge emphasises the need for effective identification, enrolment, and coordination of different policy domains. This involves understanding and resolving potential conflicts while aligning various policy sectors to meet an overarching goal.

Topical integration within the Top Sectors

Considering that the Top Sectors are at the forefront of stimulating and releasing the mission at hand, and have historically been made responsible for facilitating innovation in their respective sectors, the Top Sectors are a primary structure to mobilise relevant policy domains for the interdisciplinary challenges at hand and as such, interviewees were asked to what extent and how topics are integrated within and between Top Sectors.

Topic sharing across TKIs and innovation programmes

First and foremost, during the research study, one of the Top Sector Energy's TKIs adopted a new name: TKI Wind op Zee ('offshore wind') changed its name to TKI Offshore Energy (Interviewee T-1). The organisation felt that their name no longer fitted its mission; while originally primarily focused on offshore wind energy, the range of sustainable offshore energy sources has expanded throughout the years and now also includes hydrogen, and wave and solar energy. The TKI believes it is crucial to expand its scope as developing the different technologies apart from each other may lead to poor harmonisation and integration in the energy system. The new name aligns with the evolving needs of the energy landscape in the Netherlands, offering a more comprehensive set of solutions that can contribute to achieving the country's climate and energy goals (Interviewee T-1). Hydrogen also has its own TKI and cross-sectional innovation programme within the Top Sector Energy, namely the TKI New Gas; TKI Offshore Energy primarily focuses on the offshore applications of the hydrogen technology, whereas projects related to the development of the hydrogen technology or the production side (e.g., the development of electrolysers) falls under the scope of TKI New Gas, and sometimes under the scope of TKI Energy & Industry, for its purpose of the electrification of industry (Interviewee T-1, T-3, T-4). The purpose of cross-sectional programmes is to integrate knowledge and specialised experience to benefit the applications in other programmes, as integrating too much into one programme may result in programmes that are so broadly defined that they become directionless and unmanageable; there is always a search for optimal demarcation of TKIs and their innovation programmes, though the demarcation is not rigid and cooperation is encouraged (Interviewee T-1, T-5). Systems integration also has its own cross-sectional programme, namely MMIP 13, which focuses on topics such as overall regulation and innovative approaches to integration technologies including holons and the opportunities of a 'holarchy' to shape the future of our energy system; systems integration is also a point of interest for TKI Energy & Industry, considering that the industry is one of the largest consumers of energy in the Netherlands and are therefore a key player in establishing a good balance between supply and demand in the future electricity and energy system (Interviewee T-1, T-4; van Bracht, 2020). In addition to the topical integration, the TKI's former name was in Dutch, and while the Top Sectors have traditionally focused on the geographic region of the Netherlands, the TKI believes an international name represents the scope of its innovation programme better (Interviewee T-1). In a similar fashion, TKI Energy & Industry, has transitioned from focusing on energy efficiency and more efficient existing processes, towards the electrification of industry. The interviewee noted that this involves both existing and developing technologies and that it has the potential to significantly increase electricity demand, which has implications for other sectors, such as the offshore wind energy sector, to supply the required electricity (Interviewee T-3). By shifting to supply-oriented directionality, as opposed to the long-standing demand-driven approach, the transition can be guided more effectively. While the production sector seems ready to transition rapidly, the demand side remains less prepared. Thus, for effective balancing of supply and demand, strategic directionality is required, with network and grid operators positioned to spearhead this change (Interviewee G-5). Interviewee T-3 pointed out that renewable energy sources like solar and wind are dependent on weather conditions, and therefore, their supply is not constant. They suggest that there's a debate over whether the responsibility to adapt should fall on the supply side (needing to work harder to meet constant demand) or the demand side (needing to adapt to fluctuating supply). They agree that a shift is occurring, but the direction of that shift is still a matter of discussion (Interviewee T-3).

Topics can also be shared across programmes while being demarcated by sector or domain. For instance, TKI Offshore Energy (through MMIP 1) is primarily focused on the supply side in the offshore energy sector, i.e., the generation of renewable energy, and works with interim goals that aim for specific capacities by 2030. TKI Urban Energy (through e.g., MMIP 2), on the other hand, focuses on the generation of renewable energy on land and in the built environment. One example of how these two TKIs/MMIPs integrate topics is the technology of floating solar PV (Interviewee T-1; (Top Sector Energy, 2021). While both TKIs work with solar PV technologies, floating solar PV on inland waters falls under the scope of MMIP 2 whereas floating solar PV at sea falls under the scope of MMIP 1. In addition, similar to the previous example of hydrogen, the knowledge and R&D related to solar panels are generally covered by the TKI Urban Energy, while TKI Offshore Energy focuses on its offshore applications (Interviewee T-1). With relation to wind energy, knowledge generated by the rapid development of offshore wind is shared with MMIP 2 for onshore wind farms (Interviewee T-1; Top Sector Energy, 2021) Interviewee T-5 acknowledges topic sharing across programmes as well, and highlights a different issue, namely topics that may 'fall between two stools'. They point to an example of electric mobility: if trucks are supposed to go all-electric, there will be a demand for charging stations at or near industrial parks, which falls in the domain of the built environment while the goals of sustainable mobility fall under the scope of MMIPs 9 and 10 of Mission D (Interviewee T-5). Each programme and domain have its own finance streams; this thus raises the question how investments and topics are demarcated between the various programmes and domains, and part of that may be addressed by the mission teams (Interviewee T-5). It also requires the varying teams to speak each other's language and use common vocabulary, as people in logistics may use the abbreviation 'DC' for 'distribution centres' while people in the electricity system may use that same abbreviation for 'direct current'; collaboration and mobilising domains are thus not limited to technological consideration, but also come with practical challenges (Interviewee T-5).

Interviewee T-3 acknowledged that the various missions are coming closer to each other in terms of collaboration; there have already been joint innovation tenders between Mission A ("an entirely carbon-free electricity system by 2050") and Mission C ("carbon-neutral industry with reuse of raw materials and products by 2050"), for instance. The approach is becoming increasingly more strategic, aligning aspects such as supply and demand within innovation tenders. The interviewee also notes that this development aligns with changes in the market. Four years ago, market participants were preoccupied with their own problems and strategies. However, as the need for interconnection becomes more urgent and challenges become so complex that they cannot be resolved one-dimensionally anymore, sectors are evolving and starting to find each other out of mere necessity (Interviewee G-3, T-3). For instance, to stimulate offshore wind energy development, the demand side may need to be stimulated to ensure that the offshore wind business does not fail. Within industry, actors are realising the urgency of implementing new solutions, which are partly driven by stricter legislation. Hence, the shift from independent efforts towards more cooperative projects is, to an extent, driven by necessity (Interviewee T-3). Moreover, different sectors initially focused on their individual needs, such as an initial 'sprint' to realise the first gigawatts of offshore wind energy, while further development now faces integration challenges and thus increasingly requires a more concerted effort to harmonise activities across the lifecycle of energy; in other words, the level of required policy layering and integration of plans may be (partly) phase-dependent. This shift has consequences for the market and the feasibility of new wind parks' business cases. On the industry side, a similar trend is observable. Replacing one technology or another is no longer an isolated activity that leaves the rest of the system unaffected. This situation coincides with an increased urgency at the policy level. Four years ago, when the missions were introduced, it would have been challenging to enforce the same level of coordination purely from a policy standpoint. The transition can only be partially directed and is also adaptive. It was necessary first to scale the technology, and then to focus on its integration (Interviewee T-3).

Within the domain of sustainable electricity supply (such as the wind and solar PV sectors), the current strategy implemented is deemed coherent and is supported by the relative homogeneity of the field. The coherence is said to be generated from the bottom-up, as opposed to top-down governance (Interviewee A-4). The process of linking distinct sectors, also called 'sector coupling', is considered of critical importance for the mission. For instance, the interviewee underscores the necessity of harmonising the electricity supply through its integration with the mobility sector, e.g. through the adoption of smart electric vehicle charging. While the interviewee acknowledges that such coupling does take place, they also expressed concerns that it is not always the case and that it may require institutional entrepreneurs to fill that gap (Interviewee A-4). The interviewee also points to MMIP 13, one of the Top Sector's innovation programmes that specifically focuses on system integration: while the interviewee states that it is positive that there is a dedicated programme for system integration, its annual budget is limited to 3 million Euros and there is an absence of clarity regarding the needs for 2030, and thus its impact might be limited (Interviewee A-4). The interviewee also points out that

TNO has an independent programme on system integration, however, that the programme lacks specificity.

To meet transition goals, the mission-oriented innovation policy must address the multifaceted nature of innovations. One of the interviewees provided the example of electric vehicles: while the development and uptake of these vehicles are important factors, associated elements like diverse charging stations, differing wattage requirements, cost comparisons with other fuels, and potentially more effective policies in neighbouring regions (to achieve a levelled playing field) also play a crucial role. These collective factors influence a consumer's willingness to invest in such innovations. Orchestrating these various elements and aligning them cohesively is central to a mission-oriented innovation policy, necessitating a comprehensive approach (Interviewee G-1).

Topic themes are shifting from economic factors to others

For MMIP1, the emphasis was initially on cost reduction, as this was seen as a crucial element for the development of a self-sustaining market. This focus was particularly relevant during the early stages when the first subsidy-free tenders were being introduced. The efforts in cost reduction have proven successful and have exceeded the expectations as to how quickly costs would come down, and this has allowed attention to shift towards other vital aspects like systems and spatial integration, ecology, human capital, and circularity (Interviewee T-1). The goals of achieving 21 GW by 2030 and 50-70 GW by 2050 for offshore wind energy are ambitious and require a well-balanced system, and this makes systems integration a paramount concern at this stage of the transition. Systems integration has its own separate programme within the Top Sectors, namely MMIP13, indicating its current importance. While cost reduction remains vital to the MMIP1 programme, the industry is likely to continue progressing in this area without intervention or explicit attention anyway, according to the interviewee. However, systems integration will require collaborative efforts, as it is a complex issue that goes beyond mere cost considerations (Interviewee T-1).

Topics such as ecology and circularity are also gaining attention. Innovations in ecology are critical given evolving legislations, especially at the EU level. The industry needs to ensure that wind turbines are ecologically benign or even beneficial to the immediate environment, e.g., of the environment of wildlife. Similar considerations apply to circularity, which aims to make the entire lifecycle of wind turbines more sustainable (Interviewee T-1). Furthermore, social acceptance is another aspect that is being tackled, although this is rather relevant with regard to the built environment, and not so much for offshore energy. Offshore energy projects were said to have endured resistance as well, however, as wind farms are being built farther away from the shore, this has become much less of an issue (Interviewee T-1). In summary, while cost reduction was initially the driving force for offshore wind energy in the Netherlands, the rapid achievements in this area have allowed for an expanded focus. Systems integration, ecology, circularity, and human capital are now receiving increased attention to prevent them from becoming future bottlenecks. While the industry can handle cost reduction autonomously, collaborative efforts are crucial for addressing more complex, multifaceted issues like systems integration (Interviewee T-1).

The prioritisation of social and behavioural factors in the transition was coined as the paradigm shift from ‘technology push’ to ‘policy pull’ (Interviewee G-1). In other words, the shift is being made away from merely developing new technologies to a more holistic approach where policies actively shape market conditions for innovation. The interviewee termed this as 'market creation', in line with the views of Mazzucato (2016). They also highlighted that technology is not often the failing point in transitions; rather, the bottlenecks are more likely to be legal, economic, fiscal, or behavioural. The interviewee provided an example of the heat pump, where the focus by engineers was solely on efficiency, but noise pollution was neglected and eventually resulted in low adoption rates. This instance illustrates the need for a more integral approach that includes not just technological factors but also social and behavioural aspects (Interviewee G-1). Interviewee G-2 similarly recognised the growing importance of non-technological factors in successful innovation. These factors include digitisation, systems integration, human capital, and socially responsible innovation; with regard to the latter, the interviewee noted that this term and the corresponding programme are somewhat vague at this moment (Interviewee G-2). Both interviewees stressed the need for a more inclusive approach to innovation that goes beyond pure technology. They pointed to the importance of policy, behaviour, and other non-technical factors in realising successful transitions. This is evident in programmes like MMIPs under the circular economy theme, which have started to include social science and humanities in their design, as well as in an increased focus on *market creation* through policy mechanisms (Interviewee G-1, G-2).

Tender criteria for e.g., offshore wind farms are evolving as well. Interviewee I-2 provided an example of a wind farm area with two lots, each 2 gigawatts in size: one focusing on ecology and the other on system integration. These are important areas of concern in the current energy transition landscape. However, a financial component also plays a role in the tender process. If a bidder scores full points on the quality criteria, they can then channel the rest of their resources into a financial bid. The party that offers the most resources financially would win the tender. The interviewee, however, raised concerns about this financial aspect. They argue that the focus on high-stakes financial bidding could potentially lead to a "race to the bottom" in terms of cost, undermining the qualitative goals of the project. They suggested that this financial component might be better eliminated or reduced, but regardless, they find the qualitative aspects of the tenders – ecology and system integration – to be well-conceived (Interviewee I-2). Interviewee I-1 agreed with the concern about financial aspects, but took it a step further. They noted that this model allows a party to essentially "buy" a project if they invest a large amount of money into it. While this could lead to lower costs for green energy in the Netherlands in the short term, it may not be sustainable in the long run. Such an approach would intensify competition among parties and could result in an industry that lacks a sustainable business model (Interviewee I-1). Both interviewees question the sustainability of the current financial aspects of the tendering process, suggesting that while it may lead to lower costs in the short term, it may not support the long-term goals of creating a sustainable and robust green energy sector. They both argued for a re-evaluation of the tender criteria to better align with broader objectives (Interviewee I-1, I-2).

Interviewee T-3 also confirmed a noticeable shift in innovation policy from a ‘technology push’ to a more systemic perspective focused on the implementation of technology and cross-sectoral integration. The interviewee provided the example of industrial heat pumps to illustrate this point: instead of solely focusing on the creation of a high-performing heat pump, the new approach looks at the broader industrial heat system in which the heat pump operates. Another example includes electric naphtha crackers, which are large-scale industrial processes consuming 1 to 2 gigawatts of energy. They highlighted the importance of considering systemic aspects such as infrastructure, electricity supply, flexibility, and backup provisions. The shift in focus represents a more nuanced understanding of how innovations fit into a broader system, which, in turn, shapes technology development to be more aligned with these systemic considerations (Interviewee T-3). The interviewee further acknowledges the societal, legal, and political complexities involved in a large-scale transition to green energy. They mentioned an ongoing programme within the Top Sector Energy called "Socially Responsible Innovation" (*maatschappelijk verantwoord innoveren*) aimed at integrating societal conditions into technical projects. Efforts to consider these factors are made at various levels, including industry clusters and regional areas, and include discussions with environmental organisations and local government representatives. However, securing funding for these activities remains a challenge (Interviewee T-3). The interviewee underlines the evolving landscape of innovation policy that now includes a broader, more inclusive perspective. This shift is not just technical but also involves societal, legal, and political aspects, although integrating these dimensions can be financially and administratively challenging.

Governmental preparedness and influence

Within the Netherlands Enterprise Agency (RVO), dedicated teams are in place and focus on aspects such as production, electric vehicle infrastructure, industry electrification, smart energy systems, and other topics; however, a comprehensive approach to multidisciplinary issues remains absent, and this is not limited to the RVO alone (Interviewee G-3). According to the interviewee, this fragmentation across sectors is a consequence of the market liberation, which led to individual entities that each optimise their own operations. This now poses a significant hurdle towards realising an alternative energy system, considering that an alternative system necessitates the business cases of those individual entities to alter as well throughout the process. To facilitate a cross-linkage among these domains, the interviewee argues that a new organisational framework would likely be required. They outline two potential solutions: regional governance (more decision-making power and directional capabilities for municipalities and provinces, as issues such as net congestion require local solutions) or national institutional entrepreneurship to reimagine the approach to the multifaceted challenge of the energy transition. The RES could assume responsibility for the regional context, however, Interviewee G-3 noted that the RESs currently only oversee the production aspects, and thus are the demand or distribution aspects. Additionally, ongoing debates persist over the responsibilities of RESs and CESs and how they relate to each other. As such, the interviewee suggests that the best viable solution could be addressing the challenge within the context of the National Environment and Planning Strategy (NOVI). The interviewee further elaborates that the transformation of the system does not merely entail cooperation between actors, domains, sectors, and so on, but that it also requires a shared understanding, new work methodologies, and a reconfiguration of risk distributions (Interviewee G-3). They cited a recent study that provided a network construction of the Top Sectors, both before and after missions were introduced, which illustrated the evolving and increasingly interdisciplinary nature of these networks, thus demonstrating collaboration.

EZK acknowledges the essential role of decision-making, often influenced by considerations of strategic autonomy and the perceived urgency of the energy transition (Interviewee G-1, G-2). Nonetheless, the versatile strengths of the Netherlands cross a diverse range of areas, which complicates the prioritisation process. In November 2022, EZK therefore unveiled the National Technology Strategy ('*Nationale Technologiestrategie*'), a strategic framework designed to identify the key technologies and to identify ten main areas that the Netherlands should concentrate on, considering the prevailing societal challenges (Interviewee G-1; Ministry of Economic Affairs and Climate Policy, 2018a). This strategy was initiated in response to the 'KIA Key Enabling Technologies', which initially listed 56 technologies and have since been revised to 44 in 2023 (TNO et al., 2023). The strategy primarily forms the basis for the deployment of public resources and EU co-financing within the Top Sectors, National Growth Fund, and NWO calls. Moreover, this strategic framework equips EZK with a proactive tool in the event of an Important Projects of Common European Interest (IPCEI) call from the European Union (Interviewee G-1). As Interviewee G-1 explained, EZK found itself unexpectedly confronted with IPCEI calls in the near past, thus compelled to make *ad hoc* decisions; in other words, the tool should allow the Netherlands to be better prepared for future calls. It is important to note that decision-making in this context does not equate to determining which sectors to sustain or exclude from the Netherlands. Rather, EZK focuses on defining the conditions applicable to various sectors, leaving it to the stakeholders within these sectors to ascertain their potential involvement. However, the strategic importance of certain sectors for the Netherlands, as well as the necessity to mitigate dependency on other countries, may compel the necessity of decisions in these areas (Interviewee G-1).

Partly as a result of the commitment of the Paris Agreement in 2015, the European Union has been actively engaging in the development of legislative frameworks to substantiate green claims and more stringent sustainability regulations, thereby promoting the authenticity and reliability of green investments (Interviewee A-1). It aims to mitigate carbon footprints and associated human rights infringements. This includes mapping the entire value chain, including what products nations import and what effects that has on other countries. It is acknowledged that effective policy and legislation are crucial to achieving set goals, a perspective shift from the less strict goals that were adopted around the 2010s (Interviewee A-1). The Paris Agreement serves as a foundation for various EU objectives, but is not legally binding (Interviewee A-1). Interviewee A-4 disagrees with that statement and argues that the Agreement is in fact binding, as well as the nationally determined contributions (NDCs), which are long-term emission reduction goals of nation states and part of the signed Agreement. In reality it is a mix of both legally-binding and non-binding provisions: while member states are obligated to set and communicate their NDCs, pursue mitigation measures, and provide transparent progress information, "parties do not have an obligation to achieve their NDCs" (Bodansky, 2021, p. 1). This was echoed by Interviewee A-1, considering that international platforms such as the United Nations lack the legal mechanisms to enforce agreement. The EU, on the other hand, does possess sovereignty, a judicial system, and tools for the enforcement of agreements that nation states commit to (Interviewee A-1). Consequently, for nations like the Netherlands, EU-level decisions are particularly pertinent. If EU member states fall short of set objectives, administrative solutions, as allowed by EU legislation, are typically employed. However, with the approach of the 2030 deadline, these solutions may not suffice in the long term (Interviewee A-1).

International cooperation presents challenges, as evidenced by the Netherlands' experiences with 'innovation missions', in which the Netherlands cooperates with other governing bodies to develop joint programmes, as nation states tend to pursue individual energy autonomy which may complicate collaboration. Despite considerable collaboration and participation in multiple forums, achieving robust international cooperation remains difficult (Interviewee G-2). The interviewee further explains that it turns out to be difficult to motivate Dutch firms to engage in IPCEI calls because of the relatively low success rates of those calls. There are developments in international collaboration, however, which is exemplified by an ongoing cooperative endeavour at the North Seas to establish a green energy hub with infrastructure that connects countries at the North Seas; the Netherlands aspires to become an international trading hub for offshore wind energy, as will be outlined in the forthcoming NPE (Interviewee G-2). Apart from international collaboration, the local context is important for consideration as well. Overall directions are to be provided by higher levels of government, but ultimately it is up to local governments to realise energy projects into practice and integrate them within the local contexts (Interviewee I-3).

In advancing towards an efficient operational system, an integrated approach incorporating multiple policy sectors, such as business environment, industrial strategy, and climate policy, is necessitated. Indeed, EZK is making efforts towards unified strategies in areas such as energy and spatial planning, and BZK is exploring similar strategies to align larger themes like new residential area development, energy transition, and agricultural sector evolution (Interviewee G-2, I-3). Although progress has been made to integrate aspects within the energy sector, significant room for enhancement remains at the ministerial level (Interviewee G-2, I-3). For instance, the current ongoing issues concerning the Heat

Act (*Warmtewet*) demonstrate this need for improvement: there appears to be reluctance of local council members to communicate the fiscal implications to their citizens and, instead, seem to advocate for the nationalisation of e.g., heat networks (Interviewee I-3): "[..] *if I then see how complicated it is made, for example, now with the Heat Act, I think 'yes, that is ruled by fear'; there are a few aldermen who said 'we don't want to stand in a room to tell that it will all become more expensive, so let it be in public hands so we can at least say that it is public, and then they trust us and we don't have resistance.' Of course, that is not... something you can build a system upon.*"

The interviewee emphasises that the focus should be on adopting a practical stance to improve conditions for citizens, and that unnecessary policy barriers should be avoided (Interviewee I-3). At the ministerial level, one of the interviewees acknowledged a degree of departmental divergence as well as interdepartmental conflicts between directions (such as between business & innovation and climate & energy), which may complicate collaboration and integration of various policies (Interviewee G-2). Despite this, they strive to maintain regular communication, engage in thematic teams, and strive to foster connections and collaborations. The interviewee underscores a strong alignment at policy levels, particularly in relation to the decarbonisation of the industry.

National plans to provide directionality across domains

The Netherlands is currently working on the NPE, which is supposed to be finalised in 2023, along with an Energy Main Infrastructure Programme (Rijksoverheid, 2023d, 2023a). The Outlook Energy System 2050 (Expertteam Energiesysteem 2050, 2023b) served as a preparing document for the NPE (Interviewee G-4, T-2). These plans aim to outline the strategy and key decisions for the future energy system. This is necessary as each sector develops their own plans (e.g., electricity, mobility, built environment, industry), while they all make use of the same infrastructure. It is considered crucial that all sectors, and all energy sources and carriers, are integrally approached when it comes to energy planning and financing – in this context particularly energy in the form of electricity – which was also the aim of the recently conducted and published Integral Energy System Outlook 2030–2050 (Netbeheer Nederland, 2023d;Interviewee G-3, G-4).

The NPE charts the future energy system and the requirements to achieve it. The government emphasises a more regulatory role in energy supply and infrastructure, space, distribution, and conservation. The Dutch government commits to making choices to provide guidance for the development of the future energy system (Rijksoverheid, 2023a). The first choice that the government makes is to maximise the supply of energy, by stimulating as much domestic production, import, and building the necessary infrastructure as quickly as possible. Therefore, moving forward, the government will base its policies and investments on the scenarios with the highest demand and infrastructure expansion should no longer be delayed until when there is sufficient demand, but expanded systematically based on expected demand in the future (Rijksoverheid, 2023a). With the Energy Main Structure Program (PEH), the government specifically maps out how much space is needed for the future energy system, where specific components such as electrolysers and batteries could be placed, and how this can be arranged intelligently (Rijksoverheid, 2023d). This includes searching and reserving space for large-scale energy projects after 2030 based on the vision of the future energy system, i.e., taking into account that more infrastructure will certainly be needed in 2050. As a result, construction should be able to be accelerated through time, as opposed to going through the process of e.g., spatial planning when demand is already present – leading to delayed actions. Part of the future demand for infrastructure will be provided through the reuse of existing infrastructure, such as gas pipelines for the transport of hydrogen, locations that are designated to power plants – such as the existing coal plants, which are planned to be closed this decade – will be repurposed for sustainable energy plants, and it has already been mapped out where more high-voltage lines and high-voltage stations will be needed in the future (Rijksoverheid, 2023a).

Infrastructure that plays an important role for the entire energy system, such as the hydrogen backbone, gets priority in construction and permitting. The Netherlands has high ambitions for the production of hydrogen with electrolysis. The government is therefore now designating the places where electrolysers may be located in the future, namely at places where power cables from offshore wind farms come ashore as this would require fewer high-voltage lines to the hinterland. In addition, the national government makes agreements with provinces and grid operators about the desired distribution of large batteries (Rijksoverheid, 2023a). These will be included in the Multi-year Programme for Energy & Climate Infrastructure (*Meerjarenprogramma Infrastructuur Energie en Klimaat*, or MIEK in short; Rijksoverheid, 2022c; Interviewee G-2). **Figure 3** includes a spatial plan as part of the current MIEK. As the required infrastructure requires time to be developed, the government also acknowledges that demand and supply will not always run parallel. This will require other solutions in the meantime to bridge the gaps in demand and supply, particularly in the case of (energy-intensive) industry (Interviewee T-1). One of the mitigation strategies that the Dutch government chooses to continue to strongly focus on is energy saving and as of July 1st 2023, the energy saving obligation has been tightened for organisations (Rijksoverheid, 2023f) and energy saving targets are being developed per sector (Rijksoverheid, 2023a).

Figure 3. Dutch spatial plan (MIEK) that integrates current and proposed future infrastructure for e.g., electricity, CO2, hydrogen, and gas. Adopted from Rijksoverheid (2022c).

The NPE also recognises international collaboration and opportunities. As a transit country with large ports and as a major producer of wind energy in the North Sea, the Netherlands is committed to maintain the potential to remain an important energy hub for Europe (Rijksoverheid, 2023a). In the energy system of the future, international cooperation and international connection of our energy systems become more important and the government wants to make agreements with other North Sea countries about the development of energy hubs in the North Sea so that multiple national energy systems are interconnected. The Esbjerg and Ostend Declarations (Rijksoverheid, 2022g, 2023e) are examples of international agreements to pursue that objective.

Reception of the NPE

Synchronising the different elements of the energy transition, such as scaling the production of renewable energy while ensuring that the electricity infrastructure is capable of handling this increase, as well as managing the adoption of electrification in domains such as industry and the built environment, requires collective action and coordination, and cannot be strictly approached by domain-specific policy; the NPE provides a roadmap for such collective action, and the Dutch Minister for Climate and Energy Policy was recently made politically responsible for the execution of that plan (Interviewee G-2). The Dutch efforts to develop a national plan, the NPE, were received positively as interviewees indicated a need for a long-term, integral and holistic approach that combines the many varying facets that make up the energy system, as it requires a central point of reference to guide the necessary and timely decision-making processes (Interviewee G-2, G-3, G-4, T-2).

They bring up the forthcoming National Energy System Plan (NPE), which is a comprehensive blueprint that incorporates input from a variety of stakeholders. This plan depicts the route towards accomplishing a climate-neutral energy system by 2050 and addresses a range of challenges, encompassing innovation and network management. It isn't about allocating specific duties to different departments, but more about presenting a roadmap for collective action. The plan has been coordinated with the minister (Rob Jetten) and his input has been taken into account.

Summary

Overall, there was consensus that there is a need for collaboration between various stakeholders to realise the energy transition. Within the Top Sector Energy, innovation programmes are already working together to avoid both working on the same things. For instance, while the focal mission distinguishes between two innovation programmes, namely one for onshore energy and one for offshore energy, the programmes combine forces on for example the technological level. For instance, both may make use of wind turbine technologies and recent innovations, while their applications are different. Particularly in the context of network congestion and the growing importance of systems integration as the transition proceeds, many stakeholders advocated for more collaboration and integrated programmes (rather than sectoral ones; although these still remain import as well). The NPE was mentioned to have potential to realise this in practice.

5.8. Identifying target groups

The Dutch energy transition is a monumental task and complex process that cannot be resolved by one or a few actors. Rather, it requires the involvement of a multitude of target groups. Collaboration is therefore a crucial element in this endeavour. Depending on the system boundaries that are considered to be part of the scope of the mission, e.g., from energy production and distribution to consumption, target groups can either be included or excluded. In this study, various target groups that pertain to the mission towards a carbon-free electricity system are highlighted.

Top Sectors, NWO, and RVO

Top Sectors

The Dutch Top Sectors are considered a fundamental component of the Dutch innovation ecosystems by fostering cooperation and networking within TKIs, through actions such as hosting events and workshops, or providing support to industrial actors, and facilitating connections between different parties within and across sectors as well as aiding the formation of public-private partnerships and consortia (Interviewee T-4). When building consortia, the Top Sectors can offer help by sharing contacts and expertise, thus creating a flexible and collaborative environment. The ultimate goal is to foster innovation and apply knowledge in the field, with market players playing a crucial role. The interviewee stresses that their role could be described as 'servant leadership', as they aim to mobilise and assist the sector to support the goals of the mission (Interviewee T-5). Companies can make use of the platform that the Top Sectors provide by identifying and establishing synergistic relationships with, for instance, start-ups that offer potential innovations and require market knowledge or capital, and offer a means to publicise the innovations or other initiatives through the platform’s reach (Interviewee I-1). Top Sectors have the ability to play a role in connecting various parties and sectors as they are positioned between the government, knowledge institutes, and industry. They have a strategic role in directing the innovation agenda, supporting innovators through various means such as financing, subsidies, and networking opportunities, and promoting the innovation activities within the Netherlands (Interviewee T-1; T-4). New promising technologies that are not yet supported by the government can be advocated for by the Top Sectors, and policy-making and the regulatory environment can be influenced to shape the right directions for optimal support of innovation. For instance, Interviewee T-1 explained how floating wind was frowned upon by the RVO and EZK, as that the Dutch sections of the North Sea were considered too shallow and therefore unfit for the technology; as such, supporting it with national capital would only benefit the development of the technology, but not contribute to the Dutch energy transition. The role of the Top Sectors thereby also extends by stimulating the actors within their respective sectors to highlight barriers to innovation, such as technological, social, and legal challenges, which the Top Sectors can then share with the government and indirectly contribute to government plans (Interviewee T-1; T-2). The Top Sectors can execute this function as part of ministry advisory bodies (Interviewee T-2). For instance, during the research period, the Dutch government was looking into revising the Energy Act (*Energiewet*). Interviewee T-2 mentioned that various actors criticised the first draft of the new Energy Act as it was rather conservative concerning the topic of energy sharing, which they believe impedes innovations such as ‘collective self-consumption’ (i.e., the collective generation and consumption of renewable energy). While it is up to the government, including the political arena, to finally decide what the Act entails, Interviewee T-2 recognised it as their task to advocate for such topics to be included in the next draft. While the Top Sectors are indeed considered facilitators in the innovation ecosystems of their respective sectors, Interviewee G-3 noted a certain level of ambiguity with relation to the mandate that Top Sectors actually have. According to Interviewee G-3, the Top Sectors sometimes appear to feel responsible for the implementation phase in the transition, although they typically operate at lower TRLs, such as development, pilot, and demonstration projects.

The role of the Top Sectors has evolved over time, from an initial focus on purely economic development to a broader, more encompassing goal that includes tackling societal challenges (Interviewee T-2). This shift indicates a more holistic approach, recognising that economic development and societal well-being are intertwined and that innovations must serve multiple ends. In that sense, the Top Sectors now act as a bridge between sectoral innovation and public policy, fostering a two-way flow of ideas, needs, and solutions (Interviewee T-2). Interviewee A-2 offered a more nuanced view, particularly in the context of the electricity system overhaul. While they acknowledged that the Top Sectors do contribute to innovation, the most transformative changes occur elsewhere, implicating a broader array of stakeholders and systems outside of the *ecosystem* of the Top Sectors. The interviewee pointed out the pressing challenge of reducing emissions to zero, emphasising the need for rapid advancements in solar and wind energy. However, these advancements also introduce logistical and infrastructural difficulties, particularly in terms of electricity distribution and grid enhancement. This suggests that while the Top Sectors can drive innovation, they are just one piece of a much larger puzzle that involves regulatory frameworks, infrastructural developments, and public engagement (Interviewee A-2). Both these perspectives reveal the multifaceted nature of the challenges involved in transitioning to a more sustainable and equitable future. While the Top Sectors can act as catalysts for innovation, solving the broader societal and environmental challenges requires a multi-pronged approach involving various actors and institutions, both within and outside the Top Sectors structure.

NWO

The NWO operates in close proximity to the Top Sectors via a dedicated track to finance (mission-oriented) innovation through the Top Sectors and beyond. The organisations are connected to each other via the KIC programme. The NWO, as explained by Interviewee A-5, frequently communicates with the Top Sectors to exchange information regarding the research topics that require more attention and how the NWO can assist in fulfilling those needs. The primary contribution of the NWO to the energy transition is fundamental research, focused on projects at lower TRLs. The NWO does not solely determine the programming of projects. Instead, the programming is significantly influenced by the topics outlined in the Knowledge and Innovation Agendas (KIAs) and based on the needs of the Top Sectors. The NWO exercises more influence in the 'how' than the 'what'; in other words, the NWO typically has a last say which topics are indeed funded and then organises the ‘calls’ that project teams can apply for. This particularly pertains to the ‘Mission’ track of the KIC, which annually consists of 55 million Euros (out of the 100 million Euros allocated to the KIC-NWO programmes), while other tracks and long-term programmes allow more input from the research fields (Interviewee A-5). Additionally, the NWO facilitates a '*Vraag voor Partners*' track, where large companies or consortia can propose research programmes. These companies provide ideas and funding, and the NWO assists in organising the call for proposals within the scientific field. The NWO also recently launched its own ‘climate institute’, the Dutch Climate Research Initiative, which aims to “make a substantial contribution to accelerating the transformations needed to achieve a sustainable, climate-neutral society by 2050” (NWO, n.d.), and which will have its own budget separate from the KIC. The NWO aims to develop their programmes thematically, i.e., in line with the societal challenges at hand (Interviewee A-5). The NWO strongly stimulates collaboration between a variety of actors, such as in structures like consortia, to stimulate both interdisciplinarity within the research team – which the NWO believes is critical to address modern day challenges – and ensure the valorisation of the outcomes of the results, e.g., by a company that co-finances or otherwise participates in the study (Interviewee A-5).

RVO

The RVO primarily contributes to the mission-oriented innovation policy and energy transition at the financial level, namely through the execution of innovation schemes and subsidies at the national level, such as the SDE(++) (*Stimulering Duurzame Energieproductie en Klimaattransitie*) and ISDE

(*Investeringssubsidie duurzame energie en energiebesparing*). The RVO plays a key role in enabling the financial aspects of green initiatives (Interviewee G-3).

Net and grid operators

The transformation of the energy system will shift a large focus on the electricity system in the future. The networks and grids are rapidly evolving, which necessitates a shift in the roles of net and grid operators. Traditionally, these operators have held a facilitative function, to ensure that all demand can be met. The changing landscape, however, now demands a more proactive stance from them. In fact, net operators are looking to be co-creators of the future energy system, as the networks and grids make up a vital position in that system. While net operators maintain close relationships with government departments, such as EZK, BZK, and I&W (Interviewee G-4), the position of the network (and its operators) has reportedly been overlooked, which according to one interviewee is one of the reasons why we are currently facing net congestion (Interviewee G-5). Interviewee A-4 criticised this attitude of the net operators in this and argues that they should have been more proactive already, given that the ambitious objective of e.g., "achieving 90% electricity production from solar and wind energy by 2030" was established many years ago; in other words, the net operators should have been more foresightful as to what was bound to happen in the near future (Interviewee A-4). According to Netbeheer Nederland, this is a common critique, which they believe is understandable but also unduly, as the net operators are certainly aware of what is needed, but that they are not capable of doing everything they may want as a result of "inappropriate (legal) frameworks, procedures, and financing by the government" (Netbeheer Nederland, 2022a). While it is the government's responsibility to instruct net operators what they can or cannot proactively invest in (Interviewee A-4), net operators can take a leading role by advocating what they feel is necessary from an infrastructural perspective. Net operators therefore currently collaborate with municipalities and provinces in the integral programming of the environment (Interviewee G-5). Net operators also aim to collaborate within (innovation) programmes to jointly perform research and to indicate what insights and experience they have from practice (Interviewee G-4). Moreover, partnerships with local governments could be explored to regulate permits for energy parks to ensure that their locations align with the conditions of the spatial area and network (Interviewee G-5); this already occurs to an extent on the demand side, considering that applicants of the SDE++ subsidy must provide a positive transmission capacity indication of their regional grid operator (RVO, 2023b).

Government

The Dutch government is widely perceived to play a critical role in directing, incentivising, and shaping innovation within the energy transition. The government (in this context mainly the political cabinets of Rutte, along with EZK) put sustainability on the agenda of the energy sector, which caused a major directional push in the sector; at first, the approach was mainly to scale up renewable energy as part of the energy mix, later the topic of sustainability became more important as well (Interviewee G-5). During this time, the government became more actively involved in shaping directions. In 2013, the Dutch government worked with the sectors via the Energy Agreement (*Energieakkoord*). The Climate Agreement was later published in 2019, wherein agreements on (sectoral) targets are made and which the sectors will have to resolve on their own. Since then, the realisation has come that the government should be more directive through coordination as to how the targets should be met. This shows that policy goals become less without obligation, which is why reciprocity and enforcement are becoming more important discussion topics; this also includes a component of accountability for governments, so they can demonstrate that e.g., tax money is well spent (Interviewee A-1).

Particularly in relation to projects of national interest, the Dutch central government plays a key role through so-called government coordination schemes (*Rijkscoördinatieregelingen*) (Interviewee A-1), which automatically apply to for example power plant with a capacity of 500 of more MW, wind farms with a capacity of 100 or more MW, and the expansion of the national high voltage grid (≥220 kV). Some of those projects are also part of the MIEK (RVO, 2019). Apart from these standard coordination measures, one interviewee also argued that the directionality in relation to the mission must come from the government in a top-down manner; input for this directionality should, nonetheless, be provided by actors within the system (Interviewee G-4).

Whether or not the government is capable of providing the required directionality was questioned during the interviews. The government tends to be slow in taking action, considering that decision-making typically takes time (Interviewee T-2). This view was echoed by another interviewee, who drew on the example of the currently attempted tailor-made agreement with large industry actors, which appear to take a lot of time to translate plans and intents to concrete actions (Interviewee G-4). On the regional level, clear directions and certainty tend to be lacking as well. For grid operators, it would be beneficial if local policy-makers would be clearer about their plans, such as whether they will go full electrification of a neighbourhood or also make use of a heat network, as well as concrete timelines as to when and where; this would allow grid operators to adapt their own plans and agendas to meet regional demands (Interviewee G-4). Interviewee A-4 also agreed that it is the central government's duty to provide directionality. They believe the transition of the electricity system is currently going well, however, that this transition has been initiated rather late in the Netherlands; they recognise a different approach towards hydrogen now, which has gained a lot of attention in recent years (Interviewee A-4). Another aspect when it comes to capabilities is the traditional stance towards providing directions. The Dutch government tends to favour the liberal idea of providing incentives and subsidies and leaving innovation and directions of change up to industries (interviewee A-3). Furthermore, as a consequence of this stance, ministries may lack the required expertise and knowledge to provide directions, which would imply that it could be practically infeasible or at least difficult to pursue a more normative role, even if they would desire to do so. Besides, ministries may be incentivised to avoid having to deal with resistance from industries that would be impacted by normative policy (Interviewee A-3). A recent example of a normative policy that caused public outrage is the Dutch nitrogen policy. Hence, the government is required to build up and maintain field-specific knowledge, and act more powerful and courageous than now if it is expected to take on a more active role and provide directionality (Interviewee A-3), which is a new role for policymakers (Interviewee G-1). According to a policymaker at EZK, there are signs that Dutch policymakers are slowly shifting towards steering the transition through policy, which was illustrated by an anecdote of colleagues from BZK that recently stated they would look into legislative changes to support innovation (Interviewee G-1). Another interviewee commended the government's receptiveness to collaboration and partnership with the market (Interviewee T-4). They expressed optimism about the joint efforts and the understanding that the transition requires the government to create the right conditions and pursue collaboration. Regarding expert knowledge, particularly in the context of local government, they did not directly identify issues, considering that there are various organisations that can provide the required knowledge and advice when required; such as the Hydrogen Valley in the north of the Netherlands or the Innovation Quarter in Rotterdam. The interviewee therefore does not believe it is necessarily required for (local) government actors to possess in-depth knowledge about everything, however, it depends on the context and what level of understanding is expected from policymakers (Interviewee T-4). The Netherlands should also not want to do everything on their own, but rather collaborate internationally as well, e.g., within the European Union (Interviewee G-1).

The clarity of the role of the Renewable Energy Strategies (RES), particularly regarding the inclusion of both incentives and penalties (i.e., the 'carrot and the stick'), is uncertain (Interviewee I-3). It is also unclear whether the RES is a formal entity (Interviewee T-2) and whether the responsibilities of the RESs go beyond the production side of the energy transition (Interviewee G-3), which adds further confusion about its role and institutions in the energy transition; similar thoughts were shared regarding the CESs, the Cluster Energy Strategies, which focus on the cluster industries (Interviewee

G-3). Furthermore, municipalities bear the responsibility for large-scale energy production on land, making the execution of RES plans dependent on their actions and requiring municipalities to be up-to-date with those. However, not all municipalities have the necessary resources to fulfil this role. Currently, there is also a discussion about the potential involvement of provinces in certain aspects of the RES. Broader approaches to energy planning include the National Strategy on Spatial Planning and the Environment (Interviewee G-3) In general, there is a continuous assessment of which level of government should be responsible for implementing plans on a local scale (Interviewee T-2, I-3). Increased collaboration between system actors – especially in addressing net congestion – indicates a recent critical turning point (Interviewee I-3). The realisation that no single actor can resolve the issues at hand alone has spurred more cooperative efforts, especially since the Climate Agreement of 2019. However, this has not been without its challenges as the interviewee noted that organisations like VNG (Association of Netherlands Municipalities) and IPO (Interprovincial Council) were initially hesitant to fully commit to the collaborative efforts due to concerns about citizen resistance (Interviewee I-3). This friction underscores the complexity of navigating multiple stakeholders in the transition process.

The interviewee acknowledges the potential for subsidies in the energy sector but argues that regulation should also facilitate experimentation. This calls for innovation in market regulation, a responsibility the interviewee attributes to the government. By adopting such an approach, the government could potentially accelerate innovations and address lingering issues like grid congestion (Interviewee I-4).

Environmental movements and financial actors

Within the domain of financial actors, the management of (subsidy) instruments is often predominantly approached from a national perspective with an economic bias, favouring the least costly projects (Interviewee G-3). Interviewee G-3 therefore argues for a more regional approach to tackle those issues. The primary implication of this perspective is that financial actors and developers of governmental schemes need to incorporate regional activities into their assessments and prioritise non-economic factors. For example, funding may be justified for a comparatively expensive project with significant long-term potential, rather than opting for a cheaper alternative with short-term benefits. This requires a paradigm shift, which may be difficult to achieve, but it is one that Interviewee G-3 views as necessary.

In parallel, the environmental movements add a social dimension to the transition. The criticism aimed at companies like Tata Steel exemplifies societal demands for rapid changes, despite the inherent difficulties in transforming operations instantaneously. Companies have the technical and financial capabilities to transition, but societal impatience and an increasingly polarised public debate could potentially compel large shareholders to relocate their operations to countries with less pressure for immediate transformation (Interviewee T-3). This would imply that the Netherlands would miss out on economic and societal benefits (such as employment) and that it would be unable to transform the industry to a sustainable one. The optimal path, as suggested by Interviewee T-3, involves companies assuming responsibility, investing in newer technologies, and helping them in transitioning their older, polluting operations, all while remaining within their home countries.

Energy cooperatives, communities, hubs, and clusters

Various concepts exist for organising and managing energy resources, including energy cooperatives, communities, hubs, and clusters. Each has its own characteristics, albeit they all emphasise collaboration and shared goals, and they can all play a role in promoting and realising the energy transition. An *energy cooperative* is a not-for-profit organisation that is owned and operated by its members. These members are typically consumers who collaborate to produce, purchase, and distribute energy. The main goal of an energy cooperative is to provide its members with reliable and affordable energy and to channel the profits derived from these activities back into the cooperation (Interviewee T-2). In the context of the energy transition, many energy cooperatives focus on renewable energy sources, such as wind and solar power. They allow individuals to participate directly in the energy transition by producing their own renewable energy. *Energy communities* are groups of individuals, households, businesses, or other entities that collaborate on energy-related projects. These projects can include the production of renewable energy, energy efficiency initiatives, or the development of local energy grids. For instance, they can aspire to pioneer smarter energy utilisation strategies and might delve into the feasibility of local energy markets, or orchestrate a balance between energy supply and demand (Interviewee T-2). Energy communities are often driven by shared environmental goals, and they allow participants to have a more active role in their energy use. They can be particularly beneficial in areas where traditional energy infrastructure is lacking or inadequate. An *energy hub* is a centralised location where multiple forms of energy are produced, converted, stored, and distributed. This can include electricity, heat, and fuels. Energy hubs are designed to optimise energy use and reduce waste, often through the use of smart grid technologies. They can play a key role in the energy transition by integrating renewable energy sources and improving energy efficiency. *Energy clusters* are geographic concentrations of interconnected companies, specialised suppliers, service providers, and associated institutions in a particular field that are present in a nation or region. Clusters are a driving force for economic development within regions, promoting innovation, fostering knowledge transfer, and creating jobs. In the energy sector, clusters might include companies involved in renewable energy, energy efficiency, grid technologies, and other related fields.

One of the options to realise the energy transition in the Netherlands is to transform industrial parks into energy communities. To this end, policymakers are required to think about what the goals are for industrial parks, as the goals will lay the foundation of the policy conditions that apply to those parks (Interviewee I-3). A long-term vision is required to avoid inefficiency that could be caused by sequentially examining various options such as heat, hydrogen, and all-electric. Taking a step further from energy communities, energy clusters can play a role in realising the transition within industry. Interviewee G-4 highlights the geographical dichotomy in onshore and offshore energy cluster formation. While the North Sea region sees the emergence of large energy clusters, inland areas are characterised by more decentralised industries. The consolidation of inland industries could potentially enhance energy management efficiency, for instance, through the interconnection of these clusters via a hydrogen backbone (Interviewee G-4). The historic decentralisation of industries, such as stone factories located adjacent to water for transport reasons, underscores the difficulty that comes with centralising decentralised industries. Additionally, the concept of collective energy usage in e.g., an energy hub necessitates negotiations of guarantees, rights, obligations, and risks. Several questions arise in this context, including mechanisms for dealing with excess energy usage by a member, cost and investment distribution, and issues of exclusivity and inclusivity in collective membership. These questions are pertinent to collective energy services, which are currently a significant area of research and innovation (Interviewee T-5).

There were more than 700 energy cooperations in the Netherlands in 2022 (HIER, 2023), underscoring their relative success (Interviewee A-1). As they currently encounter legal barriers, however, their effectiveness in contributing to the energy transition is hindered (Interviewee A-1). Energy communities have also been challenged with legal barriers. The Dutch energy legislation, in its present form, conceptualises these entities based on their 'activities', which means that energy communities are legally classified in the same role as major market actors such as Eneco and Vattenfall (Interviewee T-2). The new Energy Act is ought to change this (REScoopEU, n.d.). While it will exempt energy cooperations from the obligation of becoming formal energy suppliers, their functional 'activities' would largely align with those of established energy suppliers. An added complexity arises from the legislative viewpoint which categorises energy sharing within communities as a distinct form of energy supply. Given these stipulations, energy communities often struggle with challenges in adhering to standards typically set for conventional energy suppliers (Interviewee T-2). Despite these legal obstacles, energy cooperations (and communities alike) have gained increased attention since 2015 in the European Union, as a greater focus is placed on consumers in the energy sector, and could potentially facilitate public participation and social acceptance by organising financial participation in local energy projects (Interviewee A-1). Furthermore, some cooperations have successfully met the legal conditions and may offer support to other cooperations as well through licensing (Interviewee A-1). Nonetheless, energy cooperations and communities may be characterised by early adopters, while the energy transition requires the entire society to succeed. To this extent, concerns were voiced during the interviews regarding the perceived lack of urgency of the energy transition among the Dutch population (Interviewee G-2). There is thus also a perceived need for increased public awareness and education on the critical nature of the energy transition, e.g., through collaborative structures such as cooperations, communities, hubs, and clusters.

Firms and trade associations

The process of (sectoral) plan formulation requires appropriate involvement of individual firms, according to Interviewee I-3. The interviewee argued that often trade associations are involved in the development of such plans, and that there are risks that policy is based on reports and desk research rather than practical insights. Whether or not to include individual firms in this process, Interviewee G-5 argues that this depends on the topic at hand and may also differ by trade association. Netbeheer Nederland, for instance, represents the net and grid operators; these members are more or less homogeneous and consistent, which eases collaboration and representativeness. Trade associations that have a diverse member base, such as VEMW (who represent various groups including large-scale industrial users, commercial businesses, and non-profit organisations), are more likely to experience representative difficulties and may be prone to internal friction (Interviewee G-5). Civil servants from EZK stated in the interviews that involving more parties doesn't necessarily lead to better plans, but may instead result in more challenging plan formation due to the overwhelming number of stakeholders (Interviewee G-1, G-2). Therefore, the EZK also stresses the need to manage (and thus, limit) the number of participants to formulate a plan effectively and timely.

While the Top Sectors (and their TKIs) provide productive and facilitative ecosystems for sectors, some interviewees also pointed to the leadership roles that they claim they have (Interviewee I-1; I-3; I-4). This varies from engaging in advisory panels to exchange knowledge, information, and insights to influence policy, to searching for collaborations with e.g., start-ups and scaling-up innovations – both nationally (which is the operational field of the Top Sectors) and beyond. The commitment of individual companies to sustainability is exemplified in the case of Eneco, a company that has set itself an ambitious target of achieving a carbon-neutral electricity system by 2035 (Eneco, n.d.). This target includes a pledge to carbon neutrality across all scopes (1, 2, and 3), thus embodying a full commitment to expedite the energy transition. To this end, Eneco focuses heavily on wind energy, both onshore and offshore (Interviewee I-4). Furthermore, the firm aims to cover various lifecycle stages, from production to transmission to consumer usage profiles. The interviewee recounts the difficulties that the company’s then-CEO faced in promoting the sustainable strategy internally because only few believed in it. However, as the company has persisted, there is now a long-standing commitment to sustainability which has since been embedded in their ‘DNA’ and corporate culture (Interviewee I-4). While acknowledging the importance of government frameworks in accelerating sustainability efforts, the interviewee reiterates Eneco's inherent drive to pursue such objectives. This view resonates with the views of Interviewee I-1, whose ambition it is to take responsibility in developing the right technologies in the offshore wind sector; according to the interviewee, it would be best if corporations would take on a leading role in what needs to happen (Interviewee I-1, I-4). For instance, emerging start-ups are able to provide new technologies but may lack the required market knowledge or capital to implement it. Financially strong firms, such as Eneco and Ørsted, are capable of supporting such start-ups and select the most promising options for implementation (Interviewee I-1, I-4).

Interviewee A-4 supports the notion of firms taking responsibility and taking on a leadership role. They noted that major actors are not necessarily the ones taking on a front-runner position (such as in the market of smart charging stations for electric vehicles), and thus identified the need of institutional entrepreneurs to fill those gaps (interviewee A-4). This aspect was further highlighted by another interviewee, who argued that – on the mobility side of the energy transition – industry innovation and global dynamics have a more profound influence on directions than national policies (Interviewee A-2). The entry of non-traditional automobile manufacturers, such as Tesla, spurred a significant shift in the market, leading to technological simplification of car manufacturing and opening the market up to new players. Without the success of Tesla, Interviewee A-2 argues that the automobile market would have probably opted for hybrid vehicles rather than electric vehicles, as the former are much more complex to manufacture. This global transformation, driven by market dynamics and technological innovation, underscores the critical role of institutional entrepreneurs in steering change within a traditionally oligopolistic market (Interviewee A-2).

The crucial role of clear communication and mutual understanding in promoting efficient coordination among the different players within the energy system was highlighted (Interviewee I-4). They admit there can sometimes be obstacles, such as reluctance from others to adapt or assertions that certain tasks cannot be achieved. Nonetheless, the interviewee suggests that if all involved parties are willing to openly discuss their goals and how these align with the goals of others, many possibilities for effective collaboration can arise. Moreover, if one party's new approach can address a problem for another, there's generally willingness to adjust and work together within the limits of their resources and capabilities. Despite potential challenges, the interviewee believes that the overall level of coordination within the electricity system is quite good and they generally have positive experiences with this aspect of their work (Interviewee I-4).

Innovation ecosystems

Innovation ecosystems consist of a network of interconnected organisations, individuals, resources, and processes that stimulate, foster, and manage innovation within a particular industry, region or thematic area. The entities within an innovation ecosystem can include businesses of all sizes (from startups to large corporations), universities, research institutions, investors, government bodies, and other stakeholders. In an effective innovation ecosystem, these different components interact and collaborate in ways that accelerate the development and diffusion of new technologies, products, and services. Each component brings its own unique strengths and capabilities to the system, contributing to an environment that encourages experimentation, learning, and adaptation. The flow of ideas, knowledge, skills, and resources between entities is an essential part of this process. For instance, a tech startup might rely on research from a local university, funding from venture capitalists, guidance from an incubator or accelerator, market access facilitated by government policies, and collaboration with other businesses to develop and launch its product. Each of these relationships contributes to the startup's success, and the success of the ecosystem as a whole. The innovation ecosystem concept highlights the importance of collaboration and interdependence in the innovation process. It suggests that successful innovation is not just about individual genius or the resources of a single organisation, but also about the connections and interactions between diverse entities within a larger system. This perspective has important implications for how organisations manage their innovation activities, and how policymakers and other stakeholders support innovation at a regional, national, or global level.

The increasing complexity and interdependence of societal challenges have led to a recognition among companies that collaboration is essential, particularly in areas where companies often specialise.

Interviewees noted that the necessity for systems integration often prompts collaboration, and could be helpful in illuminating overlooked aspects (Interviewee G-1, T-2). For instance, employers' associations such as VNO-NCW could highlight policies that are too heavily focused on large firms and thereby require more attention for small and medium enterprises (Interviewee G-1). There is a high propensity for companies to identify non-competitive partners across the value chain for joint efforts as these entities typically have complementary skills and often rely on each other for successful project completion (Interviewee T-2).

During the interviews, firms were asked how they engage in collaborations and touch upon the concept of innovation ecosystems. While the Top Sectors are widely recognised as providing ecosystems for the respective sectors, firms also scope on their own to identify potential collaborations. Eneco does this as a member of various innovation platforms and collaborations with universities, incubators, accelerators, the RVO, and the Top Sectors and its TKIs – which are primarily nationally oriented, while Eneco also scouts globally (Interviewee I-4). Eneco is also part of various advisory councils and has its own venturing portfolios for start-up development within Eneco's value chain. Moreover, Eneco maintains an internal culture of keeping each other updated with the latest developments through internal information and knowledge sharing; besides that, the interviewee also collaborates with external organisations to scope the latest developments. It's pertinent that the organisations align with Eneco's value chain and/or business; in some cases, experimentation occurs outside of the value chain. The interviewee identifies several potential roadblocks or challenges in scouting and collaborating with other parties. Before investment, they assess the quality of the company's management, the TRL, and whether the service aligns with Eneco's vision. Comparisons are made among different companies working in a particular area to determine who is furthest along, who performs best, and who has the most expertise. However, even when an innovation seems promising, there can be internal barriers to its implementation. These might include system technical or IT difficulties or high capital intensity. It is important to note here that the company does not view itself as a technology company or manufacturer, but rather as a distributor of energy; they are therefore more interested in providing testing opportunities, pilots and demonstration projects, and sharing market information, rather than being involved in the development of new technologies (Interviewee I-4). Additionally, intellectual property considerations can present challenges in collaborative engagements. It was noted that, while some companies are apprehensive about sharing information due to intellectual property concerns, many are open and cooperative. It was suggested that clear agreements on intellectual property rights can facilitate collaboration by specifying ownership and rights of usage. Nevertheless, in case firms are hesitant about sharing information, it may be impossible to collaborate. Overall, it was reported that a majority of companies within the energy sector are willing to collaborate, provided that appropriate agreements are set and legally documented (Interviewee I-4).

Ørsted predominantly works with start-ups through 'technology pulls,' using the innovation funnel concept, i.e., they review 100 startups, consider ten, and then proceed with the two that have the best chance of success in the long term (Interviewee I-1). Ørsted recognises its responsibility to develop the right technologies and receives a lot of interest from other actors, which the interviewee believes is because of the positive brand image of Ørsted; major key and capital-rich entities like Ørsted should therefore take a leading role, according to Interviewee I-1. Organisations like Ørsted have a deep understanding of the market, the present challenges, and can use this knowledge to assist start-ups and attract capital (Interviewee I-2). Interestingly, current consortia often seem to be formed *ad hoc*, with whoever crosses the organisation's path, an approach that needs more deliberate planning (Interviewee I-1). The interviewee cites an example of a consortium that was looking for a participant for which only Ørsted and Vattenfall would have been suitable partners, but neither was asked until a few days before the deadline of the call that the consortium was aiming to apply for, leading to missed opportunities (Interviewee I-1); this exemplifies the need for a more organised approach. A potential way to accomplish this is through the performance of systems scan to identify potential actors to collaborate with.

Offshore energy and cooperation at the North Seas

Offshore wind is an emerging domain that has attracted significant interest from large entities like Shell, Ørsted, and Eneco, that were traditionally associated with fossil energy investments. The entry of these actors into the offshore wind business reflects their ability to adapt to changing market conditions and new institutions (Interviewee T-1). These actors are considered critical for the development of offshore wind parks, given the significant investment required and the organisational capabilities needed. Furthermore, TKI Offshore Energy engages with various ports and regional stakeholders, emphasising the role of ports in the installation and exploitation of offshore wind parks, and recognising the importance of human capital and education. The offshore wind sector also experiences active engagement from serious consortia, with each tender attracting five to seven capable consortia for the realisation of offshore wind parks (Interviewee T-1).

The concept of international collaboration and entrepreneurial initiative underpins the recent Esbjerg Declaration, which aims to set collective ambitious targets for offshore wind towards 2030 and 2050 between Denmark, Belgium, Germany, and the Netherlands (Rijksoverheid, 2022g), which was followed up by the Ostend Declaration (Rijksoverheid, 2023e), and underscores the intentions to create a shared energy infrastructure (Interviewee G-2). In the Ostend Declaration, the Netherlands commits to "establish about 21 GW offshore wind capacity around 2030 and [studying the feasibility of reaching] 50 GW in 2040 and 72 GW in 2050" (Rijksoverheid, 2023e, p. 2). In addition, the Netherlands will cooperate with a variety of European countries on establishing the "first interconnected system of energy islands and clusters in the North Seas by the mid-2030s" (Rijksoverheid, 2023e, p. 2) and will work on an "Offshore Energy Infrastructure Plan which includes the areas where wind farms are located, where energy hubs and (hybrid) interconnectors are build, and how many electricity and renewable hydrogen should be produced between 2030-2050" as well as facilitate the demonstration of two offshore hydrogen production projects (Rijksoverheid, 2023e), p. 4). This international commitment is considered a positive development, provides more confidence and certainty for firms, and could stimulate a 'flywheel effect', potentially driving large-scale applications to lower costs, enabling crucial solutions such as hydrogen, and shifting the focus of offshore energy to encompass the North Seas as a whole and not limit development to just the Dutch territorial waters (Interviewee T-1, I-1). Others view the Esbjerg Declaration as more of a position statement, a form of public relations that formalises goals that already existed before rather than introducing new ones (Interviewee I-2). Indeed, the Esbjerg Declaration was signed in 2022, while the Dutch cabinet already decided to increase the target capacity for offshore wind by 2030 to 21 GW in 2021 (Rijksoverheid, n.d.-b). Regardless, it still helps and is a good development in the right direction as it provides more legitimacy to the market and could result in the allocation of subsidiary funds (Interviewee I-2).

Summary

The mission towards a carbon-free electricity system involves a large number of varying stakeholders. This report listed a few of them – mainly those that were involved in the interviews – and aimed to explore their perspectives and roles when it comes to directionality. It is important to note that this list was not based on a functional analysis (as is typically the case in assessing mission-oriented innovation systems) and is thus not exhaustive. Nevertheless, it provides some insights with regard to managing directionality.

5.9. Governance

Missions can consist of multiple governance structures depending on the aim and context. In the case of the focal mission (and thus the overall climate goal), the governance structures can largely be broken down into two streams: those that work on the implementation of the Climate Agreement and those that work on the Integrated Knowledge and Innovation Agenda (IKIA), which resulted in the 13 MMIPs that are managed by the Top Sectors. In this study, the focus was on the latter governance structure – the new structure that combined the existing Top Sectors with the new mission-oriented approach – although this chapter also provides a broader perspective that includes various governance-related insights from e.g., the Climate Agreement in relation to the 'innovation' governance. The main end point of this analysis was to investigate how this new governance structure has been perceived by those in the field.

Top Sectors: how it started

To provide a simplified explanation, the interviewee describes the "Top Team," consisting of four individuals representing a figurehead of the sector and the three *triple helix* parties: industry, academia, and the government. This Top Team serves as a sort of executive board for the mission-driven approach. Additionally, there is a larger theme team that convenes several times a year, comprising stakeholders from various sectors, including universities, research institutions, businesses, and mission leaders. This theme team functions as a shareholders' meeting. In terms of execution, a wide range of individuals and organisations are involved in implementing the missions. EZK is responsible for policy coordination and ensuring everything proceeds smoothly. They receive advice and guidance from the theme team and Top Team regarding strategic direction and decisions. EZK heavily relies on the feedback received from these teams to inform their actions, as they may not have all the necessary expertise or insights internally (Interviewee G-2). As for the individual missions, each mission has a representation from the same three parties: government, industry, and knowledge institutions. The mission teams are responsible for determining the activities within the MMIPs. One or several individuals, along with their respective stakeholders, develop these programs. The mission teams, comprising representatives from the sector, review and approve these plans. Afterward, EZK also assesses and approves them, resulting in the final version of the program. The mission teams convene multiple times a year to discuss the progress of the innovation agenda, plan future programming, and address any existing challenges or issues. They may raise concerns or questions with EZK for further consideration. The interviewer notes that the role described by the interviewee seems similar to the functions of the TKI and programme managers involved in the MMIPs. The interviewee further stated that there is sometimes an overlap between teams and that stakeholders can participate in multiple teams, e.g., both the Top Team and mission team (Interviewee G-2). These structures, while difficult to navigate for some, serve as a means to include a wide range of stakeholders in the planning and execution of national missions.

The Top Sectors used to work with advisory and evaluation teams (AETs) that assessed the work of the Top Sector teams (Interviewee T-4). The programme managers would meet with the AET once or twice a year to discuss their activities and receive feedback. This was then discussed in a broader Top Team, which included the AET members along with other stakeholders. The interviewee argued that the mission teams appear to have built upon this structure but with some additional aspects. According to the interviewee, the mission teams have a stronger focus on integrality and are more responsible for the actions within the missions compared to the previous advisory and evaluation teams. While the AETs provided advice on the programmes, the mission teams have a greater level of responsibility and ownership over their specific missions. Some programmes have a Programme Advisory Committee (PACs), which reportedly have a similar responsibility as the former AETs. However, the interviewee also suggested that the mission teams themselves have become a kind of PAC in practice, as they take on similar roles and responsibilities. The overall sentiment regarding the new governance structure appears to be that there is still some searching and exploration happening in terms of how to optimise and organise these teams effectively (Interviewee T-4). Additionally, the interviewee mentions that the workload associated with these teams is substantial. They provided an example of individuals that participate in various committees, juries, expert groups, and assessment committees, which – together – require a significant amount of time. Therefore, the interviewee raised the question of whether the current expectations placed on the mission teams could be too high given the amount of work involved. There is still a need to clarify the precise roles, the degree of involvement, and the scope of responsibilities for each team (Interviewee T-4).

Towards the new 'mission-oriented' Top Sectors

In 2019, in the light of the new missions in response to the societal challenges, the Dutch government was asked how they wanted to proceed with the missions: through the Top Sectors, a theme team, mission team, or other approaches (Interviewee G-2). The response was to pursue all of these options, which resulted in a complex and challenging hybrid governance structure that built upon the existing Top Sectors (**Figure 4**). **Figure 5** displays the governance for the whole ET&S theme. During the interviews, it became clear that many people find it difficult to fully grasp the intricacies of this structure, as the lines of responsibility are not always clear (Interviewee T-1, T-3, T-5). The exact structures and combination of teams can differ per programme and TKI (Interviewee T-1). It brought up that the new governance structure, particularly the explicit roles and responsibilities of each team, is currently unclear and not well integrated into the existing Top Sectors model (Interviewee T-1). Some mission teams were even considered a formality, considering that the Top Sector teams already designed their programmes in line with the missions (Interviewee T-1). This unclarity might lead to inefficiencies and confusion among stakeholders, diluting the effectiveness of these mechanisms for fostering innovation and tackling complex challenges like the energy transition. This view was shared among various interviewees and highlights a critical concern, considering that if even insiders find the governance structure to be confusing, it raises questions about the system's effectiveness and the potential for bottlenecks and missed opportunities. Governance issues can have implications such as slowing down the pace of innovation and impeding the country's ability to meet its goals.

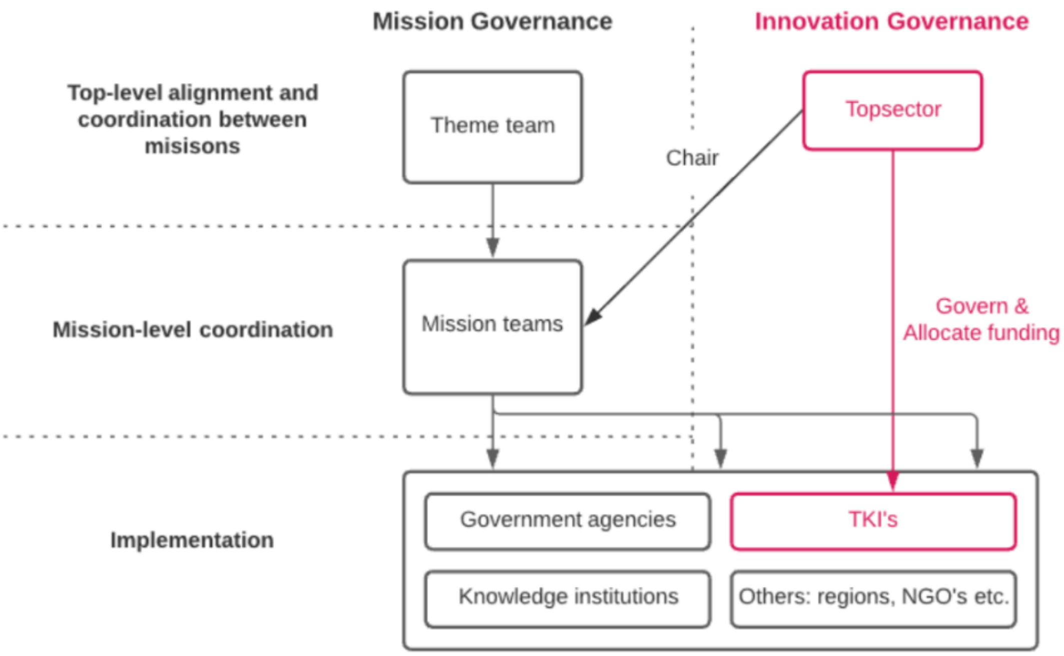

Figure 4. Illustration of the Top Sectors governance structure. The legacy structure is highlighted in pink. *Adopted from Baarslag (2021); personal communication.*

Mission teams

Mission teams were introduced to represent societal values and to ensure innovation programmes are embedded in the missions (Interviewee G-2, T-5). It provides a kind of 'check' to ensure that all perspectives are involved and the innovation is being driven in the right direction (i.e., providing the right directionality). Many of the boards of the TKIs, which originally shaped the programmes, have been slimmed down and now focus more on organisational issues. Some members of these boards transitioned to the mission teams to provide content-based input. The mission teams consist of a mix of familiar faces and new people. The TKI Urban Energy, for instance, has taken a fairly autonomous approach to the transition to mission-driven innovation policy (Interviewee T-5). They actively involve new parties in their innovation programmes without needing input from a committee. To better facilitate this work, they have established a programme advisory board to bring different perspectives from the sector into their programmes. This is their way to seek advice and ensure they remain updated with the latest developments. The role of mission teams and top teams is still being defined (Interviewee T-5). While the mission teams can provide content-based advice, they do not control the funding, which is in the hands of the top team. Thus, their influence is somewhat limited, and their exact role is a subject of ongoing exploration. Although the mission teams perform checks if the programmes are 'doing the right things', they are not seen as a decision-making body (Interviewee T-5). Instead, the interviewee views them more as advisory bodies.

A different perspective was provided by a different TKI. There the mission team oversees and coordinates all elements of the mission, including the various interests and needs, and budget streams. Various stakeholders make up the mission team, including the NWO, EZK, TKIs representatives, industry representatives, and knowledge institutions (Interviewee T-3). The interviewee further explained that the role of the mission team is to review the various budget allocation proposals from stakeholders and assess if they sufficiently cover all necessary themes. The programme managers, for example, are responsible for bringing forth proposals for their respective programmes. If well-substantiated, the mission team typically approves these proposals. The interviewee described a recent example where the mission team discussed the distribution of budget between different MMIPs. They felt that the MMIP on circularity had received a relatively high budget through the DEI+ (Demonstration Energy and Climate Innovation) scheme, and they proposed to shift more towards electrification, seeing its importance in the energy field. However, the mission team does not typically intervene in specific technology inquiries, which would be proposed by the programme managers (Interviewee T-3).

Theme teams

The theme team stands at a greater distance from the innovation programmes and focuses more on coordination between the different missions (Interviewee T-1, T-3, T-5). It is responsible for managing financial flows between missions and ensuring the alignment of different mission objectives. For instance, if two missions – say mission A (e.g., upscaling renewable electricity) and mission C (e.g., sustainable mobility) – are not aligning well, the theme team could intervene to improve coordination. The theme team also has a role in determining the distribution of budget and attention between different missions (Interviewee T-3). The interviewee explained that the structures are not the same across all TKIs, but there are common elements.

The theme teams are seen as responsible for the KIAs (Interviewee G-1). These theme teams are expected to advise organisations like NWO on their annual mission-driven calls (Interviewee G-1, A-5). The interviewee noted that there have been issues in the past where the theme teams' advice did not align with a mission-driven approach due to either a heavy public perspective (e.g., the 'public goods' perspective) or a lack of ownership over a mission or theme. The aim is therefore to improve this process. Ideally, the theme teams would determine how they approach the missions from multiple disciplines and coordinate their activities to avoid duplication and ensure complementarity. For instance, if there is a Growth Fund proposal on a particular topic, it would be inefficient for NWO to also issue a call on the same topic. Better coordination would help prevent such overlaps and enhance synergies.

Top Sectors: then versus now

To what extent the new governance structure is effective compared to the old Top Sector structure depends on what one considers 'good'; in addition, this study did not intend to evaluate the effectiveness of the mission governance. However, it was highlighted during the interviews that things used to be simpler when the mission and theme teams did not exist yet (Interviewee T-5). At the same time, it was pointed out that simplicity can lead to tunnel vision. It was therefore argued that, from the perspective of avoiding tunnel vision and aligning with the shift towards mission-driven innovation, it makes sense to include mission and themes teams. Indeed, as the government is investing in innovation substantially, there was also understanding that there is a need for formal bodies – other than the Top Sectors – to ensure that publicly funded programmes are focusing on the right things (Interviewee T-5).

Interviewees G-1 and G-2 provided a different perspective with regard to the complexity, arguing that it is not inherently problematic to have a layered governance structure as long as roles and responsibilities are clearly defined. In an ongoing review for the upcoming 2024–2027 innovation policy period, the mandate of the whole structure might be revised for these reasons. Nonetheless, the interviewee was also surprised that the governance structure is apparently unclear, considering that the structures have been designed by the KIA teams and directly involved stakeholders themselves (Interviewee G-1). Apart from that, the interviewee stated that governance structures evolve over time and emphasised that the past four years was the first period in which this structure was set up; the primary objective is to have a sound strategy and structure should follow accordingly, i.e., first determine *what* you need and *where* to go, and then determine *who* you will need and what their roles will be (Interviewee G-1). Furthermore, the rationale for having multiple governance layers is the multifaceted nature of the transition. While the existing Top Sectors structure had been established to represent and assemble the stakeholders in the major sectors in the Netherlands, the new 'mission-oriented' governance structure that was added on top of the Top Sectors structure was meant to focus on the missions; in other words, the current layered governance structure is a blend between sectoral and societal perspectives and interests (Interviewee G-2). Although acknowledging the complexity of the current governance structure, the interviewee suggested that with clear roles, strategic alignment, and coordination, these structures can function effectively to support both mission-oriented and broader innovation goals. These insights may serve as valuable considerations for the ongoing review of the next iteration of 2024–2027.

One of the interviewees highlighted an inherent tension in the transition from the Top Sectors approach to a mission-oriented one: while the mission-oriented approach aims to align innovation and industrial capabilities with broader societal goals, Interviewee G-3 warned against the risk of overestimating what businesses and knowledge institutions alone can achieve, and that some stakeholders appear to assume responsibilities that are too ambitious. For instance, the interviewee pointed out that the Top Sectors sometimes appear to feel responsible for the entire transition, while their formal responsibility is facilitating innovation within the sectors (e.g., Interviewee T-4 called themselves *innovation brokers*: bringing parties within and across sectors together to facilitate innovation). Achieving carbon neutrality of the Dutch electricity system is not just a technical or industrial challenge; it is a complex socio-technical transition that requires concerted effort from multiple stakeholders, including the general public and policymakers (Interviewee G-3). While private sector innovation is crucial, it is *just* one piece of the puzzle, and achieving complex societal missions will require a more integrated and comprehensive approach that goes beyond what any single sector can provide. The issue of 'overreach' may also hint at the need for more effective governance mechanisms that can help manage expectations and responsibilities across different sectors and stakeholders. This could be particularly relevant for aligning activities and objectives between the Top Sectors, which are innovation-driven, and the mission-oriented governance bodies related to the Climate Agreement (Interviewee G-3).

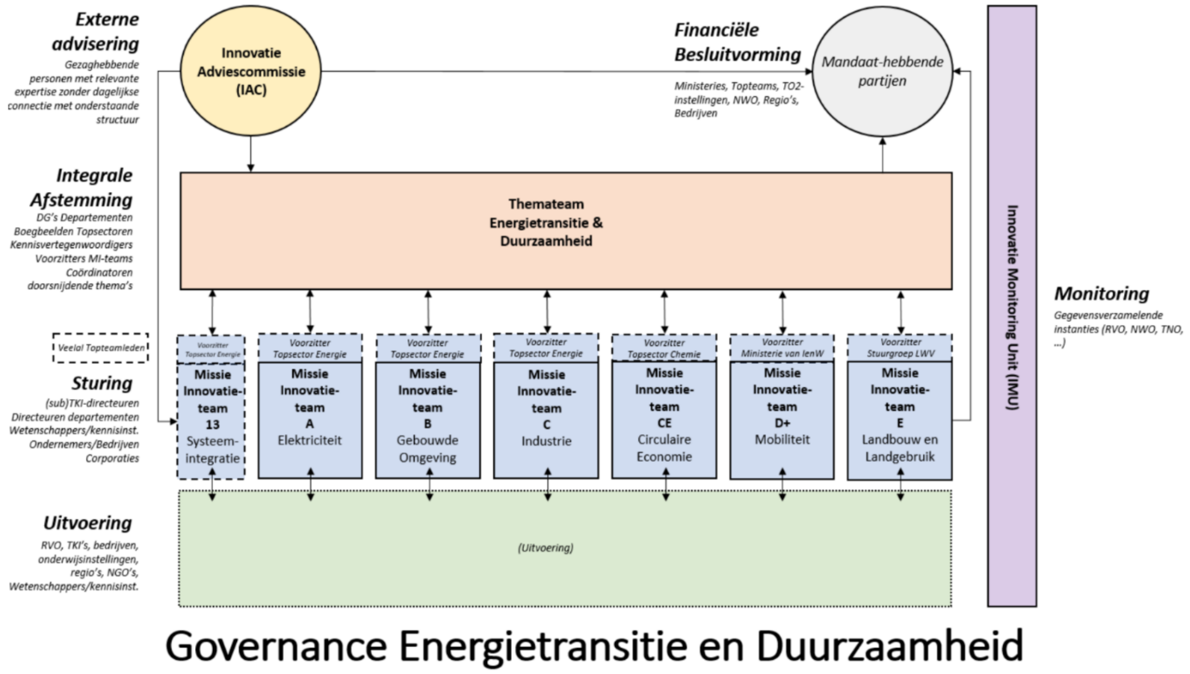

Figure 5. Illustration of the governance structure of the Energy Transition & Sustainability theme within the Mission-oriented Innovation & Topsector Policy.
Adopted from Baarslag (2021); personal communication.

Dutch governance: the Polder model

The concept of the 'polder model' is an integral aspect of Dutch governance and decision-making (Interviewee A-1, I-3). Rooted in the historical practice, 'poldering' emphasises consensus-based, multi-stakeholder discussions. While this model provides a foundational basis for building awareness around complex issues like energy transition and plays a prevalent role in Dutch governance structures, interviewees questioned whether it will be effective for the transition in the long term. The interviewee pointed to a phrase in the Climate Agreement that said 'parties would re-engage in discussions' if they would not be able to meet particular goals, suggesting that without a certain degree of normativity, freeriding behaviour could be induced that results in a lot of discourse but few actions (Interviewee A-1, I-3). By setting concrete, enforceable goals and imposing penalties like fines for non-compliance, for example, organisations can be held accountable for meeting sustainability objectives (Interviewee A-1). This kind of mixed governance approach could thereby be more effective at inducing organisations to act promptly and could serve as a vital tool in accelerating the transition. Overall, the Dutch tendency for 'poldering' or engaging in comprehensive, multi-stakeholder dialogue is both a strength and a challenge in the energy transition.

Governance: Innovation Policy versus Climate Agreement

The MTIP and Climate Agreement were formed in parallel in 2019 and are comparable in content (Interviewee G-2, G-3). Though designed separately, the Climate Agreement and MTIP are working on the same end goals (Interviewee G-2). The identified pathways – for instance, the explicit goals for electricity production from wind and solar PV – originated from the Climate Agreement and gave rise to the objectives as outlined in the innovation policy (Interviewee G-3).

The Regional Energy Strategies (RES) are aimed at decentralised planning for renewable energy and stem from the Climate Agreement. While the objective to achieve 35 TWh of renewable energy on land by 2030 is clear, the effectiveness of the RES remains uncertain (Interviewee A-1). This is in part due to the RES not being a governing body but rather a collaborative structure involving various stakeholders, from municipalities to societal organisations. It is currently unknown how effective RES truly is; their (informal) plans, which should eventually be covered by the OVIs, and progress are regularly monitored by PBL (Interviewee A-1). The OVIs are the frameworks for spatial planning in the Netherlands, such as the National Environmental Vision (NOVI), Provincial Environmental Visions (POVI), and Municipal Environmental Visions (GOVI). These frameworks indicate a multi-level approach to organising various aspects of infrastructure and land use, including transportation and housing. The OVI structure captures the regional context of the energy transition, indicating a coordinated approach to managing the multiple facets of sustainability and energy policy (Interviewee A-1). Overall, these points emphasise the complexity of governance, law, and strategy in climate and energy policy in the Netherlands.

The Netherlands used to work with a committee (*Uitvoeringsoverleg*) that played a role in monitoring of the whole climate policy and reporting about what was going well and identify potential bottlenecks (Interviewee G-3). This committee could bring together visions from different parties such as RVO, TenneT, and Netbeheer Nederland, integrate them, and provide advice based on common denominators. However, the committee was recently discontinued and the responsibility has shifted from a collaborative effort among various parties to the government; the Minister for Climate and Energy Policy bears political responsibility. This responsibility has also been adopted in the Dutch Climate Act, which specifies that it is a governmental matter. Every year, the progress is reported in the Climate Policy Monitor (*Monitor Klimaatbeleid*) and the Climate Note (*Klimaatnota*) translates the policy, i.e., interprets what is seen and what needs to be done differently. This pair of documents, together with the Environmental and Energy Exploration (*Klimaat- en energieverkenning*; KEV), serves as the primary steering instrument for the national government (Interviewee G-3).

Summary

The governance structure of the Top Sectors has been maintained in the new 'mission' Top Sectors governance structure. The most significant change implemented is the inclusion of new teams, specifically mission and theme teams, which operate at the level of the missions and the sustainability and energy transition theme. This new structure leverages the successes that have been achieved with the Top Sectors since 2011 and also ensures that societal issues, such as the energy transition, play a prominent role in innovation. Innovation is indeed necessary to achieve the ambitious climate goals set forth in the Climate Agreement.

A commonly heard statement during the interviews is that the current governance structure is unclear. Apart from the fact that the structure varies by mission, program, or TKI (Top Consortia for Knowledge and Innovation), not everyone can clearly explain the roles played by the different parties. This calls for a revision of the current governance structure to provide that clarity. Such a revision is not about redesigning the governance structure from scratch. On the contrary, the importance of the mission and theme teams is indeed recognized; they are responsible for ensuring that, for example, the innovation programs (MMIPs) serve not only sectoral interests but also the societal interests of the mission. An obvious strategy here is to provide clarity on who does what: the Top Sectors are responsible for organizing the innovation programs and facilitating (innovation) ecosystems, the mission teams for representing interests within the context of the mission (for example, what is currently needed in terms of innovation within the sector), and the theme team ensures an optimal balance between individual missions (for example, is the scaling up of renewable electricity in line with demand in industry and mobility).

6. Stakeholder experiences after four years MTIP

In addition to identifying directionality challenges and examining how the governance structure of the Top Sectors is currently perceived, it is also relevant to briefly consider the merits of the 'mission-driven' nature of the innovation programmes. This year marks the end of the first period of the Mission-oriented Innovation and Top Sector Policy (MITP), and programmes for the next four years are being prepared. It is therefore good to briefly take stock based on the experiences of those directly involved. This is not an extensive evaluation in any way, but serves to provide insight into how people have experienced the programs so far. A comprehensive evaluation is reportedly in the pipeline through the Advisory Council for Science, Technology, and Innovation (AWTI) (Interviewee G-2).

The impact that the MITP made

Stakeholders were asked what impact the MITP has made compared to previous innovation programmes. The actual impact of the mission-oriented approach on policy making remains unclear to some, especially in the energy sector where many factors come into play and influence the directions of policy (Interviewee G-4, G-5). Network operators have not seen a significant shift due to these missions. Rather, the issues plaguing the electricity network (such as net congestion) may divert attention from the mission-oriented innovation policy, causing other organisations like TSO/DSOs, EZK, or ACM to set the agenda to focus on those issues (Interviewee G-4, G-5). In order to overcome the challenges that are faced, many different actors need to work together and share insights with one another. Mission-oriented innovation programmes may play a role in that, although it is difficult to say whether they are causally related (Interviewee G-4). Nevertheless, ever since the government assumed ownership and political responsibility (ministers became responsible for the climate targets in their respective sectors and the Minister for Climate and Energy became the coordinator) for the implementation of the missions, there has been a noticeable acceleration focus (e.g., on hydrogen). This suggests that leadership changes have influenced the direction of energy policy (Interviewee G-2). However, it is important to note that this change regards climate policy in general and not just innovation policy.

The impact of the transition from a Top Sectors approach, aimed at driving innovation after the financial crisis in 2008, to a mission-driven approach aimed at tackling societal issues varies across sectors (Interviewee G-1). In Life Sciences and Health, for example, the mission-driven approach can create tension with business models, such as the development of new but expensive medicines. Conversely, sectors like Water and Energy have seen improved collaboration and alignment with national objectives through this approach. These sectors have traditionally been composed of separated ecosystems, referred to as "the three shades of blue" (Interviewee G-1). The interviewee also shared insights from a 2021 interim survey among all KIC partners, identifying three main areas for improvement: deepening, simplification, and expansion. 'Deepening' refers to going beyond just R&D and might include behavioural aspects. 'Expansion' is about integrating with other programs like the NWO and the National Growth Fund. 'Simplification' calls for streamlining governance structures, which have grown complex with the overlay of mission-driven approaches atop existing top-sector governance (Interviewee G-1). There has been a shift in the role of KIC partners as well. Initially, organisations joined KIC with the expectation of what they could gain or influence. Now, the focus is on what these partners can contribute to the mission. This change aims to avoid "Poolse landdag," a situation where too many diverse actors make consensus difficult to reach. As a remedy, key stakeholders will be involved in more focused, small-scale meetings, with broader consultations occurring on a quarterly or semi-annual basis (Interviewee G-1). Whether or not to include individual firms in policy design, a call made by Interviewee I-3, would not be ideal according to the interviewee, as it could create an unmanageable situation with too many parties at the table, making consensus hard to achieve (Interviewee G-1).

The introduction of mission-oriented policies has also shifted the focus from international competition and exports towards national societal challenges. While economic goals remain crucial, they are no longer the exclusive objectives. The focus is now also on the sectors and companies' potential contributions to addressing domestic societal challenges. Although the policy has not directly contributed to existing climate transition pathways, it has recentered innovation around societal issues, without losing sight of economic competitiveness (Interviewee G-3). Interviewee T-5 echoed these sentiments and additionally stated that several other changes have occurred: a more active government role, increased stakeholder diversity including civil society and cooperatives, and changes in subsidy and assessment criteria to align with sustainability goals. The approach is still evolving, with a greater emphasis on scaling up innovations rather than just developing them. There is also an ongoing effort to adjust regulations and make room for social innovation (Interviewee T-5).

Interviewee G-1 raised concerns about the complex language and abundance of jargon and abbreviations in mission-oriented innovation policy. According to them, this complexity not only confused the stakeholders directly involved but also made the policy less accessible to the general public. As a solution, they propose simplifying the existing array of missions (currently 25 missions, 6 KIAs, etc.) to a more manageable set of five primary missions, which has since been implemented. These five missions would still encapsulate the objectives of all the original missions while also aligning with the priorities of the Coalition Agreement. The idea is to make the policy easier to understand and communicate, thereby preventing people from getting lost in the details (Interviewee G-1). The interviewee further explained that the Climate Agreement acted as a catalyst in formulating the missions. These missions were defined by the responsible ministries and then incorporated into the innovation objectives of the MTIP. Periodic revisions (e.g., biannual or at the end of each term) are made to the MMIPs to ensure alignment with the latest insights and understandings (Interviewee G-1).

Is policy really mission-oriented or is it just new terminology?

Not everyone is convinced that the current mission-oriented innovation policy is actually 'mission-oriented'. Interviewee A-2, for example, argued that the current innovation policy is not actually oriented towards missions but merely a repackaging of existing approaches with updated terminology. Interviewee A-4 echoed this sentiment and also argued that it is more of a label than a practice. They believed that there is a lack of targeted or coordinated execution towards achieving missions, and criticised the absence of actual long-term projects that last, for instance, 10 years or more. They also pointed out that successful projects, such as WarmingUp and Integrated Approaches for the Energy Transition in Existing Buildings (IEBB), are terminated too early. The duration of such projects is typically up to four years, which is too short for projects that require more time to develop. 'Missions', in the Interviewee's vision, are intended to have a long-term vision and should therefore offer enough opportunities for such long-term projects. They further criticised the MOOI (Mission-driven Research, Development and Innovation) subsidy scheme, stating that its project selection criteria and priorities are flawed and favour the wrong projects. Relatively cheap projects that explore a new technology were, for example, favoured over projects that were more costly but more beneficial in the long term. As an example, the interviewee mentioned the Brains for Buildings project, which almost failed to get selected despite being a coherent and targeted program (Interviewee A-4). Interestingly, Dialogic found that especially the MOOI scheme provided opportunities for projects with a longer duration.

Impact on the Top Sectors

Interviewee T-4 pointed out the transformative impact of the mission-driven policy on top sectors, particularly in terms of a more integrated and strategic focus. While the previous emphasis was on specific technologies, such as hydrogen production, the new approach concentrates on holistic solutions towards achieving climate neutrality by 2050. This shift has also affected industry practices.

For instance, Tata Steel has evolved from considering temporary solutions like CCS to exploring long-term sustainability methods such as direct electrification and hydrogen (Interviewee T-4). They also highlighted the cross-sectoral operational nature of the TKIs, promoting integrated solutions to complex challenges. Whereas earlier each TKI and mission focused on their specific objectives, there is now greater inter-sectoral collaboration. This involves coordinated efforts to explore various aspects of energy transition, like flexibility, storage, and system integration. The goal is to approach issues in a more comprehensive manner, benefiting from different specialised focal points within the collaboration. For instance, one programme can be concentrated on system integration related to hydrogen, while the systems integration programme (MMIP13) focuses on other aspects such as regulation and innovative system integration methods like holons (Interviewee T-4).

Interviewee T-3 also acknowledged that the introduction of mission-driven policy has placed societal challenges at the centre. Initially, the programmatic shift towards a mission-driven approach was subtle, using the existing building blocks. The Top Sector Energy programmes for 2019–2023 was not fundamentally different from the earlier approaches. However, for the 2024–2027 period, there has been a reassessment to ensure alignment with key missions like climate neutrality and circular industry. Instruments such as the Electrification Roadmap have been developed in the meantime to offer more concrete measures, enhancing the focus and direction of the innovation efforts. The interviewee noted that this change is still recent, and it is not clear whether it applies across all missions or is specific to Mission C, focused on industry (Interviewee T-3).

The role of the NWO

The NWO has a longstanding relationship with the Top Sectors since their creation in 2011 (Interviewee A-5). Every year, €275 million is invested in research topics tied to the Top Sectors' agenda, with €100 million specifically for public-private collaborations. The introduction of the MITP in 2019 led to a reorganisation in investment. The KIC now includes a special "Mission" track that receives €55 million out of the €100 million designated for public-private collaborations. The NWO validates research topics from the KIAs for feasibility and appropriateness before announcing thematic calls for research, which typically have a budget of €5 million (Interviewee A-5). The NWO underwent an organisational change around 2017, which was shortly before the introduction of MITP. Initially organised by individual scientific disciplines, the NWO restructured its operations into broader domains, like science, social, humanities, medical, technical, etc. Since 2020, the organisation has adopted a more centralised and directed approach to topics, which is different from its earlier, more ad hoc, and flexible structuring. The shift to working with missions has provided clearer direction for organising and funding research programmes (Interviewee A-4). The NWO experienced a learning curve in adapting to this new way of working, and its current position is to provide more precise guidance on the topics that will be included in scientific research programmes (as opposed to being solely a 'facilitator'). The upcoming KIC program for 2024–2027 will largely maintain the current structure, but the NWO would like to assume more guidance of the programmes (Interviewee A-4). The introduction of the National Growth Fund, a fund with a budget in the billions, has led the NWO to reconsider the relevance of its €100 million KIC track. Specifically, the NWO is contemplating the value of its Strategy track, which funds long-term projects with €10 to €30 million each. Given that the Growth Fund may also fund similar types of projects (though not necessarily research-focused), the NWO has introduced *additionality* as a new criterion for project funding. This ensures that the NWO will not finance projects that are also being funded by the Growth Fund (Interviewee A-4). Reflecting on the KIC program for 2020–2023 and looking towards the next term for 2024–2027, the NWO has identified two key lessons: firstly, *additionality* will become a new criterion, requiring projects to demonstrate unique value if financed by the NWO and confirming that they are not financed by another entity like the Growth Fund. Secondly, operational changes have been made to improve the programmes' efficiency. The KIAs are now asked to submit research topics for intended calls by early fall to allow sufficient preparation time (during the first term of 2020–2023, there was a lead time to get used to the new way of working, and so research calls were initiated relatively late). This operational change aims to prevent delays, similar to those experienced in the current KIC program, and allows for immediate continuation into the next program cycle (Interviewee A-4).

Mission formulation

It was suggested that the missions could benefit from more specific formulation to guide the Netherlands in clear directions, implying that the current mission statements might be too vague or ambiguous (Interviewee A-3). Some interviewees pointed out that the mission formulation has been a source of confusion (Interviewee G-3, G-4). They noted that the focus is on the electricity system, whereas some stakeholders argue that the transition should encompass the broader energy system, an approach that the governing body of the sector electricity in the Climate Agreement (*Uitvoeringsoverleg Elektriciteit*) has taken since 2022: they will now focus on the energy system as a whole, rather than just the electricity component. The interviewees also raised questions about how mission-oriented innovation programs adapt to significant changes, such as the Outlook for the energy system of 2050 to decarbonise the electricity system by 2035 instead of 2050 – which has since been adopted as a target by the anticipated NPE – or the new EU targets spurred by events like the war in Ukraine (such as the REPowerEU initiative). Ideally, the mission would be reformulated accordingly (Interviewee G-2), however, this has not happened so far. In fact, the revised missions for the mission-oriented innovation policy maintained the mission towards a carbon-free electricity system in 2050.

Interviewee A-4 argued that overarching missions like reducing emissions or achieving a carbon-free electricity system are too general to effectively guide innovation. They suggested more specific sub-missions (e.g., developing heat pumps that are compact, silent, and efficient) to direct research and development more effectively. The interviewee also criticised the current sub-missions, such as the wind and solar production goals for 2030 and 2050 in MMIP 1. They argued that those interim goals are too vaguely formulated to provide actionable direction for research policy, as they only target capacity targets rather than objectives for innovation specifically (Interviewee A-4). Interviewee A-2 acknowledged that while breaking down a large system into smaller, more manageable missions has its advantages, it also presents challenges in terms of integration and coordination. It is always a search for the most optimal balance (Interviewee A-2).

7. Discussion

The objective of this study was to delineate the challenges associated with directionality encountered in translating the societal mission for a carbon-free electricity system into practice through concrete and actionable policy agendas. To this end, the illustrative model of Bergek et al. (2023) was employed.

The specific directionality challenges faced differ according to the mission, as the mission sets the playing field within which policymakers and other stakeholders must operate, as well as the policy domains that are implicated by the mission. This is also contingent upon the framing of the mission: if a mission is broadly framed, it can become an encompassing construct, whereas a mission that is too specifically formulated may overlook relevant intersections.

The formulation and time scope of the mission

The mission towards a fully carbon-free electricity system is broadly framed, as it aims for a system change without specifically prescribing how or with which technologies such change should be achieved. During the interviews, several individuals pointed to the mission formulation as a potential area for improvement to better direct the required changes (Interviewee G-3, A-3). This raises the question to what extent the mission should be refined or kept deliberately broad (for instance, to keep a wide range of options open). Fragmenting a complex mission into smaller components may lead to integration or coordination problems (Interviewee A-2). A middle-ground option might be working with overarching missions and more specific sub-missions (Interviewee A-4). In this case, the overarching mission would act more as a long-term vision, while the sub-missions would direct concrete actions (akin to the interim goals established in the MMIPs for 2030). Although these interim goals do not stem from innovation policy but rather climate policy, they are used in the MMIPs as a starting point. During the interviews, however, it was noted that the MMIPs – or, more broadly, the Top Sectors – are not actually responsible for these interim goals, as they focus on the implementation of solutions for the mission, whereas the Top Sectors and MMIPs are primarily responsible for driving innovations that could lead to such solutions (Interviewee G-3, A-4).

Moreover, the mission has a timeline up to 2050. This timeline was reaffirmed in the recent recalibration (May 2023) of the missions for mission-driven innovation policy (Ministry of Economic Affairs and Climate Policy, 2023c) and will serve as the basis for the recalibration of MMIP 1 in the upcoming four years (Interviewee T-1). A working group of the Climate Agreement recently indicated that, given the heightened goals set by the (now caretaker) government, **the aim for a carbon-free electricity system should be advanced to 2035 to achieve the broader energy system goals by 2050** (Expertteam Energiesysteem 2050, 2023b; Uitvoeringsoverleg Elektriciteit, 2022; Interviewee G-3, G-4). **This aim was adopted by the government in the draft of the NPE in July 2023** (Rijksoverheid, 2023a). As the intention is thus to advance the mission timeline from 2050 to 2035, this needs to be reflected in the mission formulation; otherwise, potential solutions might be postponed, leading to a lack of timely action. Decisions taken under the Climate Agreement should be integrated into the mission-driven innovation policy (Interviewee G-2).

From a political standpoint, there is increased tension surrounding the fixation on specific years, partly due to the current issues related to nitrogen policy. While a previous focus was on 2030 as a target year, some political parties have backtracked due to societal unrest and opposition; a new political party vehemently opposing the policy, the BoerBurgerBeweging, won the Provincial States elections in March 2023. It became evident in September 2023 that the target year of 2035 will not be implemented, even though a report from August 2023 called for stricter policy (WUR, 2023). This sequence of events underscores the political nature of grand societal challenges, especially when they impact citizens' living environment. While a specific year can serve as a motivator, it can also be perceived as a 'Sword of Damocles,' detrimentally affecting public debate. Even though a similar discussion concerning the energy transition mission has not yet arisen, it remains crucial to aim for the same goals to avoid policy incoherence. As climate policy is now making strides to have a carbon-free electricity system by 2035, innovation policy is still focused on 2050 as the target date. Given that the innovation agenda is based on the requirements for effective climate policy, aligning these objectives is therefore imperative.

Multi-layer innovation policy governance

Given that some coordination issues also touch on what is defined as directionality in the context of this study, the interviews also focused on the governance of the mission. This specifically concerns the governance of the mission within the mission-driven innovation policy, not the governance of the Climate Agreement and climate policy, and it aims to answer the following sub-question:

Sub-question 1: How is the focal mission currently governed in the Dutch MTIP?

The governance structure related to the innovation policy builds on the existing structure of the Top Sectors, which have existed since 2011 to drive innovations within the sectors. Interviews revealed that the existing Top Sector governance structure has remained in place, and an additional governance structure has been added to safeguard the mission's interests. **The focus is mainly on the addition of two types of teams: theme teams and mission teams.** The theme team mainly focuses on safeguarding the five missions under the Sustainability and Energy Transition theme and how the available funds should be allocated. If it turns out, for example, that a certain component is disproportionately heavily subsidised compared to other components, the theme team can decide to adjust the balance. The mission teams work on individual missions. While the Top Sectors themselves organise and shape the MMIPs, the mission teams act as advisory committees that ensure the mission is adequately represented within the programmes. The exact structure, existing teams, and responsibilities vary per TKI. Not every programme directly falls under a mission (such as the innovation programme on hydrogen or MMIP 13 'system integration'), so they do not have a mission team. **Almost all participants from the Top Sectors who were interviewed for this study indicated that the current governance structure is unclear, and it is not clear who is responsible for what.** Although there have been no signs that this lack of clarity leads to problems within the programmes or collaboration between parties, it is important that the governance is in order to work effectively and to avoid confusion. It is therefore advisable to re-examine the governance of mission-driven innovation policy and improve it where necessary. A specific point for improvement is to map out and communicate the roles and responsibilities of all bodies within the governance structure with the relevant stakeholders. By clearly stating who does what and making clear agreements, the right groups will be given the mandate, and it should also become clear why certain teams exist and what they are responsible for. It is recommended to find a good balance between sectoral interests (for which the Top Sectors were originally established) and the societal interests of the mission (for which the mission teams and, in a broader sense, the theme teams are responsible); this should be a good reflection of what is needed on an innovative level to achieve the mission on the one hand, and what is needed within the sector to get there on the other hand (cf. handling goal conflicts).

Although this study did not specifically look at the governance of climate policy, some developments have taken place in the context of directionality, which are good to highlight briefly. Previously, governance was mainly at the Progress Consultation (*Voortgangsoverleg*; VGO) and Implementation Consultations and Structures (*Uitvoeringsoverleggen en -structuren*; PBL, 2022). **Since the end of 2022, the VGO has been abolished, and the coordinating minister for Climate Policy has taken over central control and other ministers have been made responsible for the implementation of climate policy in their respective sectors.** Although the Dutch government has traditionally left the tasks to the market, it now understands its role within the transition and therefore takes the lead to better steer where necessary, although the missions are still being filled in through collective processes (cf.

Parks, 2022) in which a wide range of parties participate (the knowledge and innovation covenant and agendas; KIC and KIA). **A new role for the government was also acknowledged during the interviews: there is a need for a government that has the right knowledge in-house and can act quickly based on new insights.** This requires a culture change among policymakers (Braams et al., 2022, Interviewee G-1) and the development of dynamic capabilities (Kattel & Mazzucato, 2018) to be able to translate the challenges one faces into concrete policy forms.

Considering that governance ultimately has an effect on both setting directions and coordinating them across sectors and policy domains relevant to the mission, it was recognised as a directionality challenge (DC10) on its own, in addition to the other identified directionality challenges (which will be elaborated upon in the next section). Without effective governance, policy aims can be designed but not implemented (Wesseling & Meijerhof, 2023).

Key points of identified directionality challenges

To achieve successful implementation of the mission and the ensuing (innovation) policy, it is important for stakeholders to take into account the identified directionality challenges (Bergek et al., 2023). In this section, we will highlight the main points emerging from the empirical data. This section was guided by the following sub-question:

> ***Sub-question 2: What directionality challenges do policy makers face in the Dutch energy transition?***

First, the mission confirms the importance of handling different types of goal conflicts (DC1). **At present, there appear to be no conflicts over the overarching climate goal.** This goal is supported by a wide range of parties through the Climate Agreement, and its direction was partly set as early as 2013 through the Energy Agreement. This implies that policymakers no longer need to proactively search for parties who are ultimately needed to implement the policy (cf. identifying target groups (DC8)). In fact, when formulating the mission, explicit consideration has already been given to involving a 'critical mass' (Schlaile et al., 2017) that collectively commits to the set goals and has the strength to bring about system change – a method in line with the Dutch Polder model, where a wide range of parties sit down at the table to negotiate and reach consensus. In this respect, the condition that divergent interests and perspectives of stakeholders must be considered when formulating the overarching vision and subsequent missions (Wanzenböck et al., 2020) has been met. While such stability can have positive effects, scientific literature also indicates that there should be enough room for new actors to profile themselves and space to experiment outside the regime (Schot & Steinmueller, 2018). Although the Parliamentary letter announcing the new innovation policy explicitly stated that space would be made for newcomers to participate (Ministry of Economic Affairs and Climate Policy, 2019c), the missions were primarily formulated by major parties and industry organisations within the sectors (Rijksoverheid, 2018). While the climate goal is widely supported and no conflict seems to exist in this regard, public debate occasionally shows that not everyone in society – and the political arena – is convinced of the necessity of having climate goals and policies at all (Interviewee A-1). **More specific conflicts can arise between policies focused on one or a few policy areas.** Currently, the target date is being moved from 2050 to 2035 in climate policy, while the mission remains unchanged in the recent re-evaluation of the missions for innovation policy. If people are expected to focus on 2035 as the starting point for a CO2-free electricity system, that goal will also be formulated as such in the objectives for the innovation policy, as otherwise the (perceived) urgency for certain solutions may decrease – especially if one assumes a longer period to take specific actions and maintains an overly inclusive vision for an extended time, without converging to a specific set of solutions (Wanzenböck et al., 2020).

In addition to clearly stating an end date by which the mission should be realised, the mission itself does not specify the exact objectives that should be served (it only provides the end product of the mission). **However, various policy documents do describe a wide range of objectives** (see handling goal conflicts (DC1)). This shows that mission-driven policy in the Netherlands should not only give direction to the mission itself – making the electricity system CO2-free – but should also contribute to economic prosperity, the business climate, and potential export products; thus, the Netherlands aims to position itself as an international leader in new technologies. In particular, the combination of renewable electricity through offshore wind and its integration into direct electrification of industry and the development of green hydrogen are recognized as important elements of the transition. Also, due to the Netherlands' strategic position in Europe, its large ports, and existing gas infrastructure, it aims to be a key player in the international trade of renewable energy. **However, it remains unclear to what extent all these goals relate to each other and how priorities are set among these goals.** Interviews revealed that over the past four years, focus has primarily been on economic factors – which ultimately determine to a large extent whether the energy transition can be feasible, affordable, and socially supported – and that gradually more attention is being given to other factors such as ecological and spatial implementation of solutions.

Some economic objectives also stem from the Top Sector Policy, which has been in operation since 2011 and has been merged with the current mission-driven policy. **A significant part of these factors also has a local component.** There are many ways to implement the mission (see e.g., formulating strategies (DC4)), and what works in one region may not work in another – or conflicts may arise between regions (Jakobsen et al., 2022). A specific form of strategy, 'realising destabilisation' (DC5), is also recognised in the model. This encompasses phasing out the old and stimulating the new, and policymakers will have to consider how to dismantle structures of the old system in such a way that its transformative capacity is not destroyed. Within Bergek et al. (2023)'s model, this is considered part of directionality, although it was categorised as a coordination problem in previous literature (M. J. Janssen et al., 2021; K. M. Weber & Rohracher, 2012). In this case, it concerns the phasing out of fossil fuels. Although the Netherlands has legislated that no electricity will be produced through coal burning by 2030 (a direction set in 2013 through the Energy Agreement), there is much criticism on the lack of decisive action to phase out 'subsidies' (tax benefits) for fossil fuels (Milieudefensie et al., 2023). **The Dutch government claims to be phasing out these benefits, but argues that it can't be done too quickly to keep the transition manageable for companies** (Tweede Kamer der Staten-Generaal, 2023b).

In the context of achieving destabilisation, there is also a call to consider no longer maintaining certain industries in the Netherlands. Interviews indicated that it's not expected that the Dutch government will make such choices, partly due to its historical approach of leaving such developments to the market itself. The Netherlands has a responsibility to manage the situation within its borders, but it's not necessarily negative if certain industries disappear as a result of policies. Although some argue that this may lead to the relocation of 'polluting' production to other regions or countries – thereby shifting the problem rather than solving it – several interviewees emphasised that this argument is somewhat of a non-starter because it would also lead to employment elsewhere, and companies would still have to adhere to the same rules (especially within the European Union). Most industries tend to adapt to new systems, so this risk is not as high as one might expect.

For the translation of the national mission to the regional context, the Regional Energy Strategies (RES) and Cluster Energy Strategies (CES) have been established within the framework of the Climate Agreement. Interviews showed that although progress is being made with these structures, there are still doubts about their mandate (PBL, 2022b) and the fact that the RES is mainly responsible for realising 35 TWh of electricity production through solar and wind energy on land, but not how this should be integrated into the environment. Urgent issues like grid congestion are also playing a very important role in realising such plans, as no guarantees can be given that projects can be connected to the electricity grid (supply congestion) or that companies can connect to electrify (demand congestion).

Additionally, there is a continuous quest to define system boundaries and align various policy areas with each other and coordinate them (cf. defining system boundaries (DC2) and mobilising relevant policy domains (DC7) and Weber & Rohracher (2012). Although the mission itself is formulated so broadly that it does not define specific boundaries other than reducing CO2 emissions within the electricity system, the policy is explicitly focused on developing and scaling up renewable electricity – particularly in the form of solar and wind energy. Depending on what one includes under the concept of the electricity system (for example, besides production, one could also include the distribution and consumption of electricity), the boundaries of the system targeted by the mission could be larger. Within the literature of mission-driven innovation, strong emphasis is placed on the fact that missions targeting complex societal issues like energy transition are not limited to sectors and policy domains, but rather go beyond those boundaries (Mazzucato, 2018a). Matters other than production is currently safeguarded by other missions, such as mission C (stimulation of the electrification of industry) and mission D (stimulation of the purchase of electric vehicles). Although these latter issues do not fall within the system boundaries of mission A, they are considered very relevant for the policy surrounding mission A. Over the past years, many plans have been made and possible paths for change have been mapped out through scenarios (see identifying realistic pathways (DC3)). This planning has mainly taken place from the sectors. In other words, plans have been made for the sustainability of the electricity sector, the mobility sector, the industry, and the built environment. On the one hand, it is relevant to include the sectoral perspectives and meet the needs and latest developments within the sectors; however, the current phase of the energy transition requires a more integrated approach that is not limited to sectoral planning, but rather looks beyond the sectors so that the plans within the sectors can be optimally coordinated with each other. Accordingly, the focus should not solely be on scaling up electric vehicles (mobility sector) or solar panels (built environment sector) and solar and wind farms (electricity sector), but there is a need for—a holistic perspective where the demand for electric vehicles and solar panels is linked to the production of renewable electricity. Particularly from the point of view of the pressing grid congestion, which is causing many companies in the Netherlands to experience delays in their pursuit of electrification, there is a strong need to provide better guidance to the tasks of linking sectoral planning for the sake of the mission. The Dutch government is currently working on the NPE, which for the first time should address these issues; the final version of the NPE is due to be delivered at the end of 2023. **The findings from this research underscore the need for a document like the NPE and therefore support the initiative.** Evaluations will have to assess in due course whether an integrated approach does indeed contribute to solving complex issues like the Dutch energy transition. A comprehensive evaluation is reportedly in the pipeline through the Advisory Council for Science, Technology, and Innovation (AWTI) (Interviewee G-2).

It's important to note that not all potential solutions are feasible. Whereas system boundaries (DC2) partially determine which options are achievable within the context of the mission in relevant policy domains (DC7), not all options that are possible within that context are within the reach of policymakers (cf. accessing relevant intervention points (DC9)). Some options may, for instance, fall outside jurisdictions (Binz & Truffer, 2017; Fuenfschilling & Binz, 2018). In the case of the Dutch mission, the focus is explicitly on the Dutch electricity system. However, the broader context of the mission encompasses much more than just the Dutch context. For example, the Dutch electricity grid is connected to the German grid; although the grids are not dependent on each other, the interconnectedness does bring challenges in terms of coordination in the event of grid stability and balancing supply and demand flows. Moreover, the Netherlands operates within the context of the European Union and partly the United Nations: the climate goals and goals for electricity production through renewable energy are more or less handed down by the ambitions and applicable legislation of the EU and UN – for instance, through the Paris Agreement and the EU Green Deal (see handling goal conflicts (DC1)). Although the Netherlands as a nation can offer input into such initiatives, they lie outside the jurisdiction of many national policymakers and must subsequently adjust the policy at the local and national level accordingly. During the interviews, criticism was also expressed towards the Dutch authorities that projects are sometimes not honoured because they do not (sufficiently) contribute to the Dutch energy transition, for example, offshore projects that would be carried out outside territorial waters. Although there has been little room for that in recent years, various agreements and declarations of intent have been concluded in the meantime to encourage collaborations between nations on the North Sea. It will therefore be interesting to keep an eye on how this will be further shaped, as this implies that eventually various projects will be carried out outside territorial waters; the question then is to what extent Dutch policymakers can still exert direct influence on the policy in that international context.

Intervention points can also evolve depending on interim experiences and may lie relatively easily within the reach of policymakers, as opposed to what may be important for the transition. In 1995, the Dutch government set the goal to produce at least 10% renewable electricity by 2020, in response to depleting fossil fuels and emerging concerns about climate change (Wanzenböck et al., 2020). The focus was mainly on onshore energy; offshore energy was considered too expensive at the time. However, after it became clear that there was significant resistance to land-based energy projects and plans were delayed, the decision was made to invest more heavily in offshore energy; the really major commitment to offshore energy only came with the Energy Agreement in 2013 (Ministry of Economic Affairs and Climate Policy, 2013). What needs to be taken into account is that long-term goals should not come at the expense of short-term goals. When a date is agreed upon (especially if it is legally established), but cannot be adhered to due to practical circumstances, this can lead to hasty compensatory measures that contribute little to the transition in the long term – just to achieve a goal on paper. **Especially when an issue has a political component, drastic decisions can be postponed, leading to problems later on if sudden, drastic measures then need to be taken. This happened with nitrogen policy in the Netherlands**; while the government had been aware for decades of the effects of nitrogen on nature and that measures would come at the EU level, the necessary measures have been put off for years, resulting in many projects currently being halted (including projects for the electrical infrastructure) due to strict nitrogen regulations. During the interviews, **it was emphasised that choices must be made within a few years to prevent a similar problem in the electricity sector; especially since such projects require a relatively long lead time**.

The previous paragraph also **raises the question of the extent to which *political stability* is an independent directionality challenge**. We have seen what can happen when a political arena postpones complex or sensitive issues to subsequent cabinets, such as the current problems around nitrogen policy. While postponing difficult decisions may avoid electoral risk in the short term, it does not contribute to the effectiveness of a mission in the long term. In the case of the mission towards a CO2-free electricity system, politics are expected to make choices and focus on cross-sectoral long-term plans at the national level (cf. identifying realistic pathways (DC3)). As part of the increased climate goals for 2030 of the Rutte IV cabinet, a recent package of additional measures was introduced (Rijksoverheid, 2023b); since the package is going to cost more than 28 billion euros, there has been a public debate about the extent to which such investments are effective and responsible and outweigh other societal problems and themes. The same applies to the distribution of subsidies; this is a purely political choice (Interviewee G-3), so political instability could theoretically have an impact on the direction of a mission. Political stability as a directionality challenge is probably primarily important for complex societal issues involving many different actors, such as in the energy transition. This research has not specifically focused on this challenge, and the hypothesis has not been empirically tested; this is a possible starting point for future research.

Finally, involving and prioritising citizens is a very important prerequisite for a societal mission like this, as the transformation of the electricity system has implications for the entire society. Nurturing public engagement (DC6) is therefore of great importance and has been added as a separate directionality challenge to the model. Social involvement is high on the mission's agenda, as the transition will not succeed without sufficient support from society (NWO, 2019). This ensures not only that citizens feel heard and involved, but also that they can exert influence on the democratic process that concerns everyone in a democratic constitutional state. During the interviews, it became clear that not everyone is convinced of the importance of social involvement; some characterised it more as a side issue that does not add much to the energy transition. Nevertheless, social acceptance is one of the six focus points for the process that the Regional Energy Strategy (RES) goes through. While engineers sometimes want to act quickly because a particular project is technically the best, policymakers do well to also take steps back when resistance arises; this will ultimately lead to a more widely supported outcome (EMMA, 2020; SPA Sustainability, 2022) Interviewee A-1).

The findings are in line with recent studies and the NPE

Various insights that were acquired through this study were in line with the insights acquired through a recent case study from PBL (PBL & VU, 2023). As part of the Learning Evaluation Climate Policy (*Lerende Evaluatie Klimaatbeleid*), PBL conducted a case study that focused on the network capacity due to the urgent and pressing issue of net congestion in combination with the ambitious objectives to at least double the electricity capacity in the Netherlands by 2040. The case study acquired insights from government officials from the relevant ministries, including EZK, BZK, LNV, and IenW. They identified six themes that require more attention in policy making and implementation: (1) a shared vision for the future electricity network; (2) culture change in the government: from sectoral thinking to systems thinking; (3) enhanced knowledge sharing between departments; (4) courageous policy implementation based on reflexivity; (5) promoting flexible use of energy; and (6) creating local ownership, and thereby public participation and acceptance (source). These themes can largely be compared to themes that were identified in this case study. In **Table 6**, the themes were matched with one another based on the findings from both case studies. Note that this table includes a new directionality challenge: *managing political stability* (DC11). PBL identified the need for courageous policy decisions, as currently many difficult policy choices are not made out of fear of having to readjust at a later point of time and out of fear of (political) reckoning (PBL & VU, 2023). As such, there is a need for a cultural shift in which concerns about (political) careers do not outweigh effective policy. While similar sentiments were found during this case study (the need for making difficult choices, the culture shift in which that should be embedded, and the need for less pressure on difficult political choices), however, the extent of those findings were not substantial enough to report as a separate directionality challenge. Besides the PBL study, the findings also largely correspond with the observations and aims of the NPE that is currently in the works and is supposed to be finalised by the end of 2023 (Rijksoverheid, 2023a). Furthermore, the Quickscan of what is necessary to realise the future energy system in the Netherlands by Netbeheer Nederland published complementary findings (Netbeheer Nederland, 2022b). Any of the documents advocate for more directionality by the government.

Table 6. Matching of the case study (*PBL, 2023*) and the corresponding directionality challenges in the mission towards a carbon-free electricity system.

Transformative capacity (net capacity)	*Directionality challenges (mission A)*
1: Shared vision future electricity network	DC1: handling goal conflicts
2: Culture change government	DC8: identifying target groups
3: Intergovernmental knowledge sharing	DC7: mobilising relevant policy domains
4: Courageous policy implementation	DC1: handling goal conflicts DC4: formulating strategies *(DC11: managing political stability)*
5: Promoting energy use flexibility	DC4: formulating strategies *(Mission B)*
6: Creating local ownership	DC4: formulating strategies *(Climate Agreement)*

Towards improving the directionality of the mission

The identification of directionality challenges contributes to the scientific discussion on how directionality manifests itself in practice. This study has attempted to map out the directionality challenges encountered in translating the mission into practice. The individual chapters in this report provide insight into the challenges experienced and the various thoughts on potentially resolving those challenges. To take it a step further, efforts have also been made to arrive at concrete recommendations that people – particularly policymakers – should pay attention to when developing policy around a societal mission (see **Table 7**). This aims to answer the following sub-question:

Sub-question 3: How can the mission directionality be improved?

These recommendations are based on a synthesis of the findings and proposals from the interviewees. Similar insights were recently obtained from the ongoing evaluation of Dutch climate policy (PBL & VU, 2023).

Table 7. Summary of the directionality challenges and recommendations in the Dutch mission towards a carbon-free electricity system.

Directionality challenge	*Context*	*Recommendations*
DC1: Handling goal conflicts	Goals and priorities may conflict. For instance, the Netherlands strives for various goals simultaneously, such as providing a good business climate, distinguishing between key enabling technologies, trading-off fiscal regulations and R&D subsidies, and driving sustainability in the Dutch economy. Explicit aim of mission-oriented innovation is targeted policy rather than the conventional generic R&D policies. Furthermore, infrastructural projects to expand the electricity grid were halted due to restrictive nitrogen policy, and the construction and operation of energy parks require directionality with regard to their locations.	Establish a cross-sectoral task force involving policy makers, business leaders, academics, and environmental experts to harmonise conflicting objectives. Implement adaptive regulations that can be adjusted as conditions evolve. Clearly communicate what goals take priority over others (as opposed to vague and directionless ambitions). Prioritise projects that may have trade-offs in the short term, but offer benefits in the long term, such as electricity infrastructure projects.
DC2: Defining system boundaries	The mission focuses primarily on the production of carbon-free electricity with the intent to become the largest source of energy by 2050, both on- and offshore but with particular attention for offshore wind. Demand and the use stage of the electricity are targeted by other missions and programmes and therefore fall out of the scope of this mission. More integral approaches to connecting these dimensions are becoming more important over time.	Maintain the boundaries of the system to explicitly focus on the challenges of the electricity system. However, also pursue plans in a cross-sectoral manner to match the outcomes of various missions that address the energy transition. Consider the integration of all available and applicable energy sources and carriers, within the context of electricity infrastructure and consumption patterns, decarbonisation potential, affordability, and reliability.
DC3: Identifying realistic pathways	The Netherlands has put emphasis on the rapid upscaling of wind and solar energy, both onshore and offshore, which shall be coupled with hydrogen to balance fluctuations in supply and demand, act as a storage option, and facilitate energy-intensive industry. At the same time, the government has communicated a commitment to investigate the potential of nuclear energy.	Continually assess the range of feasible transition options that can be realised within the given timeframe and context of the focal mission. Establish national plans that are broadly supported by relevant stakeholders, actionable and, to an extent, enforceable to drive commitment. The anticipated National Plan Energy System is a promising first step in this direction.
DC4: Formulating strategies	Stakeholders identified a variety of factors that currently halt certain innovations, such as challenging market conditions and unsuitable financial and regulatory frameworks. Moreover, there is demand for a clear vision and incentives that should provide more clarity, legitimacy, and certainty to system stakeholders as to what directions are to be pursued. Providing directions through (tender) criteria appears as	Perform periodic innovation system analyses (preferably every four years, in line with the MTIP innovation programmes) in the context of the focal mission or selected technologies of the future energy system, to continually assess the enabling and blocking factors of the available pathways and to aid evidence-based directional strategies. Provide a clear long-term vision (cf. DC4) and establish both stimulative and normative

	effective. Long-term paradigms such as the Dutch 'copper plate' were challenged.	incentives to get there. Rethink conventional systemic paradigms that may need adaptation to support the transition.
DC5: Realising destabilisation	The Dutch phase-out of coal and – to an extent – natural gas is widely considered a positive and necessary avenue to accelerate the transition. However, renewable energy sources such as wind and solar energy have an intermittent pattern, and alternative options should be integrated additionally to cover periods in which renewable energy is not available (e.g., during *dunkelflaute*). Furthermore, destabilisation policies should motivate change rather than dismantle the transformative capacity, and should safeguard energy supply security.	Continually assess whether the destabilisation policies are in line with the upscaling of renewable energy solutions and their integration within the electricity and energy systems (e.g., the *Monitoring Leveringszekerheid* from TSO TenneT should provide a solid basis). Ensure a realistic approach to the transition to avoid dismantling the transformative capacity. Advocate for the destabilisation in an international context to ensure a level playing field.
DC6: Nurturing public engagement	A vital aspect of the energy transition is public participation and social acceptance of solutions and pathways. Without it, the transition could suffer delays from e.g., low legitimacy and legal procedures against energy projects. Participation is not limited to brainstorming and contributing to decision-making, but it is also about becoming a part of the energy system. This could be achieved through initiatives such as collective self-consumption, local ownership, and bottom-up solutions by which citizens may determine for themselves how they can contribute to the transition.	Involve citizens (boards) in the planning of local solutions for the energy transition, take resistance seriously, and ensure that the democratic process is warranted. Clearly communicate the plans that are being discussed with citizens, explain the rationale behind the plans and what it contributes to the local environment and the energy transition as a whole, and communicate clearly what is expected from participants to ensure a common knowledge base.
DC7: Mobilising relevant policy domains	The transition towards renewable energy sources requires the coordination of a multitude of policy domains and actors at various governance levels and with varying jurisdictions to address weaknesses and transformational failures (cf. DC4) and destabilisation needs (cf. DC5).	Conduct an elaborate scan of the relevant policy domains in the context of the mission to identify any bottlenecks and conflicts that halt the transition. Such scans should provide a basis for national plans, such as the anticipated National Plan Energy System.
DC8: Identifying target groups	In order to successfully effectuate a transition, relevant actors that can act upon the identified pathways (cf. DC3) and that can be targeted by strategies (cf. DC4) should be identified. A multitude of target groups exist and may be expanded upon depending on the system boundaries (cf. DC2). Particularly important in the context of the mission are the government, Top Sectors, industrial actors, and local energy initiatives.	The government is recommended to assume a leadership role in setting directions and providing the required clarity and certainty that other stakeholders need to execute plans in a timely manner. Furthermore, take position in (innovation) ecosystems for optimal market sensing and act swiftly on perceived bottlenecks that halt innovation. Governance structures such as RES and CES may need a broader mandate to be fully functional. Industrial actors that are committed are welcomed in the transition, but require degrees of certainty to fully underscore their

		commitment. Local energy initiatives offer great potential in a future decentralised energy system, but the required legal frameworks makes their application complex.
DC9: Accessing intervention points	There is demand for a national strategy, however, one that is embedded in international (e.g., within the EU Green Deal and EU ETS) and local (e.g., RES/CES) contexts. Pressing issues that were highlighted within the context of the mission were net congestion and the need for a holistic vision.	Implement national solutions that contribute to the Dutch energy transition, however, aim for European integration at the same time (e.g., to provide a level playing field). The local context of these solutions should be leading. Furthermore, continually assess regulatory bottlenecks.
DC10: Governance	With the introduction of the missions in 2019, a new governance layer was added on top of the existing Top Sectors governance structure. This 'missions' governance structure (that e.g., consists of Mission team and Theme teams) and the responsibilities of each body is considered unclear.	Revise the governance structure of the Top Sectors and missions. Involve all relevant stakeholders to redefine the various teams and their roles. The following roles are recommended: Top Team (leading the TKI), TKI (innovation broker and sectoral needs), Mission Team (warrant the mission/societal needs), Theme Team (warrant a good balance between the programmes).

Key challenges

The interviewees were additionally asked what they perceive as the most urgent or important challenges when it comes to directionality. The overarching themes and corresponding topics are listed in **Table 8**.

What became clear from these challenges is that there is a need for a **vision and more long-term clarity** as to what the desired pathways are. The outcome is known, a carbon-free electricity system, (although there is currently a conflict when this goal needs to be achieved, 2035 or 2050), but the pathways to get there have not been delineated yet. While the focal mission is aimed at upscaling the production capacity of renewable electricity (to this extent, there is a clear directionality for what is needed in the context of the mission), stakeholders recognise **interconnectedness between missions and policy domains**, which will need to be **approached from a systems thinking approach** rather than exclusively within sectors. For instance, synergy with e.g., offshore hydrogen in combination with electrification needs from large industrial clusters is currently being investigated as well. Such synergies go beyond just the electricity system and thus require system boundaries to be expanded to combine efforts across sectors, missions, and innovation programmes. The NPE, which is currently in the works, is intended to address these boundary crossing challenges.

In line with the vision and long-term clarity, the government needs to **address its rigid stance to policymaking and become more flexible and agile**, allowing more space for experimentation beyond current legislative frameworks and addressing regulatory bottlenecks such as permitting procedures and the legal mandates that key players (such as network operators) have in the transition of the electricity system. This may require a transition of public administration traditions to adopt this new role (Braams et al., 2021), which will likely prove to be difficult (Interviewee G-1). Central in everything the government does for the transition should be **public participation**, considering that the transition affects the entire society and without public support, it is unlikely that energy projects can be realised within the time frame of the mission.

Table 8. Key directionality challenges as perceived by the interviewees.

Theme	*Topics*
Vision and long-term planning	- Develop a vision that is clear yet flexible - The vision should provide long-term certainty - Balance the focus on short- and long-term goals - Focus on full decarbonisation of the electricity system by 2035 - Approach the mission from the perspective of the energy system
Policy and governance	- Political responsibility for communicating solutions - Develop appropriate legislation in a timely manner - Demonstrate national leadership and do not avoid difficult choices - Approach policymaking from a systems thinking perspective - Adopt a more agile approach to policy-making and regulation - Adopt flexibility to adapt to fluctuating market dynamics
Collaboration and integration	- Establish effective collaboration between departments - Recognise non-economic factors (such as ecology and systems integration) as decisive criteria for projects - While making sectoral sprints, prioritise systems integration - Coordinate stakeholders via e.g. (innovation) ecosystems

	- Support collaborations between established firms and startups
Resources	- Accelerate the pace of the transition to meet the new goals - Provide incentives or normative policy to stimulate pathways - Enable greater valorisation of research programmes - Provide more opportunities for pilot and demonstration projects
Public support	- Address the lack of sufficient urgency across society - Initiate a meaningful public debate, away from extremities - Account for the importance and feasibility of human capital - Ensure public participation is a key element in the transition

Reflecting on the directionality challenges framework

The directionality challenges described by Bergek et al. (2023) were, according to their own admission, not a complete list that would be relevant for all cases. In the case of the mission for a carbon-free electricity system in the Netherlands, all listed directionality challenges could be identified, and two new challenges were added, namely that of nurturing public engagement (DC6) and governance (DC10). DC6 involves maintaining public participation and acceptance of solutions contributing to the energy transition and DC10 involves establishing effective governance structures that contain the ability to both manage the mission and steer it in the right direction. *Accessing intervention points* (DC9) was, however, not elaborated upon in this study report, as it was blended within the other challenges. For instance, the problems and solutions with regard to net congestion were elaborated upon in *formulating strategies* (DC4) and *identifying target groups* (DC8): a possible intervention includes institutional changes to the role and mandate of the TSO/DSOs to give them a more prominent role in the spatial planning and decision-making with regard to energy projects. Considering that the possible intervention points were thus already listed and included in the texts directly, it would result in unnecessary repetition if listed again in a separate chapter, or – vice-versa – would result in fragmented text elements. Nevertheless, the *meaning* behind the challenge remains important and the challenge was thus included in this discussion and in **Table 7**; it is important for policy makers to realise that not every potential intervention point may be within reach of their jurisdiction.

Given that every transition and individual mission brings its own unique context and playing field, it is obvious that not every challenge is relevant for each case. Nevertheless, I would argue that most challenges are indeed applicable to every case. Every mission has to deal with goals; although theoretically it is possible for a mission to have only one goal, I find that unrealistic in the context of grand challenges like the energy transition. In that respect, choices will always have to be made between various goals (DC1) and priorities set among them. In addition, every mission will bring certain system boundaries (DC2) — broadly the scope — and relevant policy domains (DC7). A mission would also not be a mission without pathways (DC3) that can be taken to realise the mission, as well as the strategies (DC4) that underlie them. The mission will also, in all cases, be relevant to certain target groups (DC8). On the other hand, achieving destabilisation (DC5) and mapping out intervention points (DC9) are not necessarily components in every case. A mission within the theme of health, for example, may be aimed at reducing cancer; in that case, there may not be a need for a systemic change in which the new situation must replace the old regime, but there is instead a certain outcome that is desired. It is also possible that a mission is formulated and positioned in a context where policymakers have complete freedom of action, making it pointless to mention all options already identified via realistic pathways (DC3). Lastly, mapping intervention points may not always be relevant in the case of practical assessments (as is the case in this study), considering that intervention points may be directly listed in the realistic pathways (DC3) or strategies (DC4) and account for any factors that could hinder its accessibility. In that sense, accessing intervention points (DC9) could be interpreted primarily as a conceptual challenge that is not separately accounted for in practice. Considering that the framework by Bergek et al. (2023) aims to aid with the translation of innovation policy into policy practice (by identifying any challenges that policymakers could face in setting directions of innovations and transition processes), it could be argued for not to fragment those elements. Nevertheless, the conceptual value – increasing understanding of the challenges that policymakers may face – remained uncontested in this study.

Lastly, the framework is mainly conceptual in nature and while it can provide understanding and aid policymakers in identifying directionality challenges when trying to translate missions into policy practice, it can be fairly difficult for practical applications as there is no grounded methodology as to how the challenges should be studied. For instance, in order to formulate strategies, Bergek et al. (2023) recommends conducting an innovation systems analysis (e.g., a technological, national, or mission-oriented innovation system analysis), however, this requires a substantial amount of time and effort to pursue. Moreover, while the challenges are well defined and described, there is sometimes overlap between challenges and thus they are not entirely mutually exclusive; this could lead to interpretative issues, although its effect is arguably minimised by the fact that the challenges are not assessed in seclusion but rather as part of the sum of challenges (also because they logically lead to one another, hence the 'translation steps' rationale on which the framework is based). Furthermore, while the framework allows for the qualitative identification of directionality challenges, it does currently not allow for prioritisation between those challenges. Prioritisation may be of interest to policymakers that aim to use the framework in developing strategies to address those challenges, and thus may be a possible avenue for future research (see below).

Theoretical implications and avenues for future research

The main theoretical implication this case study has is contributing to the theory by empirically applying the framework of Bergek et al. (2023). Considering that it is a novel framework, which takes a new approach to mission-oriented innovation policy and places *directionality* at its core, it allows for assessing the means necessary to steer innovation in particular directions rather than stimulating innovation generically (Schot and Steinmueller, 2018). Throughout the course of the study, it became clear that the directionality challenges framework is not complete, or at least not standardised, as the particular challenges that are perceived depend on the focal missions, the context in which it is embedded, and which stakeholders are involved in the assessment of the challenges. Furthermore, the study contributes to the literature by departing from directionality as one of the core elements in mission-oriented innovation policy, which has primarily been addressed conceptually in the literature (Haddad et al., 2022). It thus provides empirical knowledge about how directionality is implemented in practice and a broader understanding of what key challenges are that need to be taken into account when pursuing working with missions (Parks, 2022).

The following avenues for future research were identified.

Applying the Mission-oriented Innovation Systems framework to the case

While the framework contributes to the scientific discussion about directionality and can help policymakers and other relevant stakeholders map the directionality challenges of their mission – especially when one is specifically interested in setting direction for a mission. Nevertheless, it is good to briefly mention the concept of mission-oriented innovation systems (MIS) (Hekkert et al., 2020). MIS is a more concrete framework where the innovation system is thoroughly mapped by extensively analysing its structural and functional components. Subsequently, supporting factors and barriers can be identified (Wesseling & Meijerhof, 2023). Given the broad interpretation of *directionality* in the framework of Bergek et al. (2023), it is expected that at least part of the barriers that would be identified via the MIS analysis, the MIS goes beyond those factors and, instead, provides a better understanding of the *structuring* and *functioning* of the innovation system in the context of the focal mission. Such an analysis was conducted in 2021 (Baarslag, 2021; offline report), however, was based on propositions rather than an innovation systems framework that has since been developed (Wesseling & Meijerhof, 2023). It is highly recommended to apply the MIS framework to the mission towards a carbon-free electricity system as it allows for an assessment and refinement of the framework, a thorough analysis of the innovation system surrounding the mission, and possibly result in valuable insights into what is necessary towards and beyond the goals for 2030, which could be utilised for the next revision of the mission-oriented innovation policy and programmes.

Delineating the concepts of *directionality* in transformative innovation policy

Furthermore, as outlined in Chapter 2, the framework of Bergek et al. (2023) and thus this study as well, defined *directionality* broader than other previous studies. One of the seminal contributions to innovation policy literature includes Weber and Rohracher (2012), who defined four *transformational system failures*': directionality, demand articulation, policy coordination, and reflexivity. Policy coordination includes, among other failure mechanisms, "the lack of multi-level policy coordination across different [governance] levels or between [..] sectoral systems (Weber and Rohracher, 2012, p. 1045). In this study, that failure mechanism is captured through *mobilising relevant policy domains* (DC7). Another failure mechanism includes "the lack of [..] coordination between [..] innovation policies [..] and sectoral policies" (Weber and Rohracher, 2012, p. 1045), which in this study is referred to *handling goal conflicts* (DC1). Furthermore, reflexivity was identified as a standalone failure that hinders transformation systems change by Weber and Rohracher (2012), while the mission-oriented innovation system framework by Wesseling and Meijerhof (2023) considers reflexivity as a dimension of directionality (Wesseling & Meijerhof, 2023). This shows there is a wide variety of definitions and interpretations of what *directionality* entails, particularly between various literature streams. The new generation of mission-oriented innovation policy integrates insights from the transitions literature (Schot and Steinmueller, 2018) and identifies directionality as a core element to address societal challenges (Diercks et al., 2019). However, the concepts are still in development and a recent systematic review embedded both literature streams in what they termed *transformative innovation policy* (Haddad et al., 2022); they indeed also found that there is no consensus as to how *directionality* should be defined and interpreted. In this light, given the importance of directionality in the new innovation policy streams, it is recommended to further delineate the concept and find consensus to allow effective frameworks to be built upon that understanding.

How could reflexivity be incorporated in innovation policy to provide directionality?

In this study, reflexivity was not investigated in detail and was therefore not included in this report. However, it has been reported to be an important element for directionality, both in mission-oriented innovation systems (Wesseling & Meijerhof, 2023) and in governance (Lindner et al., 2016). One important delineation that was made during the interviews (Interviewee A-1) was that it depends what you are reflexive about: "*Are you reflexive regarding how you want to achieve the targets or the targets itself? You could realise that the target is no longer what it needs to be and adjust it along the way. Alternatively, if you stick to the target but acknowledge that the pathway that you utilise to get there is not working, then you can adapt to a different pathway.*" Changing mission objectives is an inherently political process. During the interviews, the recent results of the 2023 Dutch provincial elections were briefly discussed, as the elections were a victory for the Farmer-Citizen Movement (*BoerBurgerBeweging*), who strongly argued against the more stringent Dutch nitrogen policy, which was supposed to come into effect in 2030. During and following the elections, various political parties changed their standpoints with regard to the nitrogen policy, and suddenly ceased their support for 2030 as a deadline. The interviewee argued that this is not an example of reflexive governance, however: "*Those parties suddenly adjusted the deadline date, but given the nitrogen crisis in the Netherlands that may not be so responsible, nor reflexive. Rather, it is reflective; responsive. [..] It is,* *however, part of the democratic process*" (Interviewee A-1). A possible avenue could be investigating how reflexivity could be incorporated in (mission-oriented) innovation policy to provide the necessary directionality.

Towards a hands-on prioritisation framework to address directionality challenges

As highlighted in the previous section, while the framework of Bergek et al. (2023) allows for the qualitative identification of directionality challenges, it does not currently allow for prioritisation between those challenges. Prioritisation may be of interest to policymakers that aim to use the framework in developing strategies to address those challenges. The MIS framework does make use of rating the distinct functional elements of the innovation system; a similar strategy could be applied to the directionality challenges. In this way, the directionality challenges could be scored by relevant stakeholders on a 5-point Likert scale; dimensions that can be scored could include *importance* and *urgency*. The challenges could then be plotted in a prioritisation matrix based on the two values and be ranked in terms of priority handling. This could lead to a hands-on prioritisation framework that could aid policymakers in setting priorities for dealing with directionality challenges in the context of transformative innovation policy. A possibly interesting research avenue could thus include developing a framework by defining the scales of importance and urgency. Moreover, it could include an investigation into the interconnectedness of the individual directionality challenges, as this could provide further insights into potential spillovers that may occur (e.g., when addressing one directionality challenge, it may also have an effect on another, related directionality challenge).

Managerial or policy implications

The findings of this study are of great relevance for practitioners that are currently or aim to utilise the concept of missions to address grand societal challenges, as mission-oriented innovation policy goes beyond supporting generic innovations and rather aims to set directions of desirable outcomes. Both when designing a mission as well as implementing it following its formulation, practitioners may be faced with challenges that have an impact on the directionality of the mission. The challenges identified provide hands-on insights as to how they are interpreted, what effect they may have on policy and the progress of the mission, and a set of recommendations derived from the involved stakeholders was provided – which allows for brainstorming and comparison with other missions, particularly in the energy field.

Limitations

While case studies offer valuable insights into specific cases and phenomena, they also come with various limitations that need to be taken into consideration when interpreting the findings.

First, case studies have limited generalisability. As each case study is embedded in a unique context, the findings that were acquired may not be generalisable to other cases. Even missions within the Energy Transition and Sustainability theme of the MITP, although embedded within the same overarching mission of reducing carbon emissions, may differ considerably given their unique characteristics and contexts. Second, considering that this case study was performed by one researcher, the interpretation of the observations as well as data collection may have involved subjective judgements, although activities were undertaken to limit these risks (see Methodology section). In addition to that, interviewees may have provided biased perspectives or may not have shared everything they know about the discussed subjects. Third, sampling bias may have occurred during the invitation phase for the interviews. While purposive sampling was used and participants were screened for their relevance for this study, there may have been stakeholders that would have been a better fit but were overlooked. Nevertheless, saturation was reached and all interviewees were able to be categorised in the relevant stakeholder groups (see Methodology). Fourth, while the focus of this study was on innovation policy, insights with regard to the Climate Agreement and climate policy were sometimes also included when deemed relevant to put things into perspective. While this may have clouded some of the findings, the intention was to enrich the information and provide *thick descriptions* as to what has been shared by the involved stakeholders.

8. Conclusions

Mission-oriented and transformative innovation policy is increasingly implemented in practice by policymakers in response to *wicked* societal challenges, such as climate change. The Netherlands introduced five missions in 2019 within the theme of sustainability and energy transition with the overarching aim to reduce carbon emissions and reach carbon neutrality by 2050. One of the missions is to achieve an entirely carbon-free electricity system by 2050.

In mission-oriented and transformative innovation policy, *directionality* is recognised as one of the key elements to steer the mission in the right direction. The purpose of this case study was to identify the directionality challenges – as described by Bergek et al. (2023) – in the context of the Dutch mission towards a carbon-free electricity system. Additionally, the governance structure of the Top Sector Energy was assessed as the 'mission governance' (with a societal perspective) built upon the existing 'Top Sector governance' (with a sectoral perspective). Finally, since this study applied the novel framework of Bergek et al. (2023), its practical applicability for policymakers and its contribution to science was briefly assessed.

In order to answer the first sub-question, "*how is the focal mission currently governed in the Dutch MTIP*", the governance structure of the blended mission and Top Sector governance structure was assessed. During the interviews, it became clear that the current structure is unclear to many and needs clarification as to who is responsible for what. More specifically, the 'mission governance' that was added on top of the existing 'Top Sector governance' included new teams such as the mission teams and the overarching theme team. While the Top Sectors still manage the innovation programmes (MMIPs), the mission teams exist to evaluate the programmes and ensure that they address the innovation needs that help the mission forward. The theme teams operate at a more abstract level and exist to balance the efforts between the individual missions. It is recommended to delineate and communicate the roles and responsibilities of each team within the Top Sectors to ensure good governance.

The second sub-question, "*what directionality challenges do policy makers face in the Dutch energy transition*", applied the directionality challenges framework by Bergek et al. (2023). The existing literature has overlooked directionality challenges that are explicitly relevant to innovation policy and this case study confirmed the accuracy of the challenges as described by the framework. In addition to that, new directionality challenges were identified, namely *nurturing public engagement* and *managing political stability*. The former was included in this study, as the involvement and participation of public citizens is considered a pivotal cornerstone in achieving the energy transition. The latter was not, however, as it was not studied in such a detail that it deserved to be included. Nonetheless, the focal mission has a political component as the Dutch government is politically responsible for the implementation of the mission. In 2023, an electoral shift during the elections for the provinces resulted in an abrupt revision of the mission related to nitrogen policy. While policy related to the energy transition is more broadly supported – for example, via the Climate Agreement – it is less likely that a similar situation will occur for the mission that was studied. Nonetheless, it is a challenge that policy makers may need to account for, especially when a mission involves making difficult choices that are of political nature.

Table 9. Summary of the identified directionality challenges. Adjusted from Bergek et al. (2023).

Directionality Challenge (DC)	Definition	Translation step
1. Handling goal conflicts	Prioritise between different and sometimes conflicting aspects of an overarching goal as well as between this goal and already existing ones.	Policy objective
2. Defining system boundaries	Define the problem and the focal system so that a wide enough set of alternative solutions is included while considering sectoral specificities.	Policy objective
3. Identifying realistic pathways	Identify and prioritise a wide enough range of feasible transition options and pathways that can be realized within the given timeframe.	Policy logic
4. Formulating strategies	Analyse system strengths and weaknesses for multiple pathways, formulating appropriate measures and strategies.	Policy logic
5. Realising destabilisation	Implement policies that motivate change rather than dismantle the transformative capacity.	Policy logic
6. Nurturing public engagement	Actively foster and encourage involvement, participation, and interaction of the general public in matter of societal importance.	Policy logic
7. Mobilising relevant policy domains	Identify, enrol, and coordinate relevant policy domain actors at different governance levels and with different jurisdictions.	Policy domain
8. Identifying target groups	Find relevant actors, which by different means can act upon the identified pathways and adjust strategies to these target groups.	Policy leverage
9. Accessing intervention points	Identify (industry-specific) supply- and demand-side points of entry within reach for various interventions.	Policy leverage
10. Implement effective governance	Establish and maintain systems and practices that enable efficient and accountable decision-making and administration within an organisation.	Policy leverage

A total of ten directionality challenges were identified in this case study (**see Table 1**), namely: handling goal conflicts (DC1), defining system boundaries (DC2), identifying realistic pathways (DC3), formulating strategies (DC4), realising destabilisation (DC5), public engagement (DC6), mobilising relevant policy domains (DC7), identifying target groups (DC8), accessing intervention points (DC9), and governance (DC10). Following the analysis, it is hypothesised that DC1–5 and DC7–8 are standard directionality challenges that apply to any mission, regardless of its topic and context; whether this is indeed the case remains to be seen in future case studies in which the framework is applied. There are many factors that contribute to the directionality of a mission (see **Table 7** and **Table 8**), however, some of the most common factors that were shared by the involved stakeholders was that there is a need for a long-term vision and innovation programmes, and a need for systems integration and national plans that cross boundaries and policy domains for optimal coupling. In such a plan, the sectoral plans as well as plans related to the electricity (and energy) systems would come together and ideally lead to a synergistic view of what is needed, when it is needed, and how it will be implemented – as opposed to the sectoral plans that the Climate Agreement was based on. The Netherlands is currently working on the National Plan Energy System (NPE), which is supposed to be completed by the end of 2023. The NPE implements exactly what many stakeholders asked for, and the findings of this case study thus supports the development of the NPE. It is promising that the recommendation that emerged from these findings is already being implemented.

The third sub-question, "*how can the mission directionality be improved*", has been addressed in tandem with the second sub-question. Based on the directionality challenges that emerged, actionable recommendations were formulated to directly or indirectly address the challenges (and thereby improve directionality). These recommendations were derived from the insights that were shared by the interviewees. Summarised recommendations on how the mission directionality could be improved have been provided for each identified theme and challenge in **Table 7** and **Table 8**.

The central research question was "*how can mission-oriented innovation policy be improved by learning from the directionality of the mission towards a carbon-free electricity system*". The sub-questions, through the case study, have provided insights into the directionality challenges that are at play in the Dutch mission towards a carbon-free electricity system and how these challenges can be addressed to enhance directionality. The findings confirm the conclusions of Wanzenböck et al. (2020) that new innovation policies need new governance modes due to the wide variety of stakeholders and policy domains involved in a societal mission, and to generate the desired legitimacy. This study, however, also highlights the question of what *directionality* entails, considering the lack of consensus in the literature (Haddad et al., 2022). What can be learned from this case study is that it is evident a mission needs a clear long-term vision to combat uncertainty, incentives and normative instruments to get there, the involvement of a large variety of stakeholders to share insights and build legitimacy and support, and good governance and coordination to direct the mission to the desired pathways and outcomes (Janssen, 2020). In order to achieve missions, particularly those that address grand societal challenges and span various policy domains, benefit from higher degrees of directionality to steer the mission activities and relevant sectors in the right direction.

This study has a societal relevance as the findings contribute to more understanding of one way to interpret directionality, providing directions to societal missions. Considering that 'missions thinking' has only been adopted relatively recently, and that increasingly more governments around the world are adopting the concept, the findings of this study can provide practitioners with insights from practice. To this extent, it is also noteworthy that PBL has initiated a *learning evaluation* with regards to climate policy, to allow policymakers and other relevant stakeholders to learn from e.g. transformative capabilities in the context of working with missions. The insights from this study could aid in acquiring a broader understanding of what directionality challenges are, what they entail, who they are relevant to, and how they possibly could be addressed.

Furthermore, it is noteworthy that directionality challenges are dynamic in nature, and assessments of challenges offer insights into what challenges are perceived at this moment; hence, they can be different after some time has passed or could result in a different set of challenges depending on the selected stakeholders that are involved in the study. Different stakeholders may perceive different challenges, as well as perceive challenges differently.

Finally, when pursuing missions to address societal challenges, it is important for practitioners to be aware of the directionality challenges that may emerge both during the mission design as well as mission implementation phases. Directionality challenges determine how effective a mission will be in practice. A directionless mission will not be able to steer the mission activities in the right direction and may thus not lead to the desired outcomes. Until now, directionality has mainly been a conceptual term in the innovation policy literature, and there is a demand for empirical insights into the extent and manner in which directionality manifests itself in practice. In this case study, the directionality challenges surrounding the Dutch mission for an entirely carbon-free electricity system were mapped and provided actionable insights to increase understanding and work towards solutions.

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Appendices

Appendix A: interview guide – policy makers/advisors (in Dutch)

Beleidsmakers en -adviseurs (Nederlands)

Allereerst veel dank dat u tijd wilt vrijmaken om uw kennis en expertise met mij te delen; dit wordt zeer gewaardeerd en het is van grote waarde voor mijn scriptieonderzoek. Laat ik mijzelf eerst kort introduceren. Mijn naam is Jeroen van der Teems en ik zit in de laatste fase van mijn master Innovation Sciences aan de Universiteit Utrecht. Dit interview is onderdeel van mijn scriptieonderzoek, dat ik uitvoer om mijn master af te ronden.

Sinds 2019 werkt Nederland met 25 missies om maatschappelijke uitdagingen te addresseren. Eén van die missies behelst het CO2-vrij maken van het elektriciteitssysteem tegen 2050 (hierna 'de missie'). Om de missie ook concreet aan te pakken werkt Nederland momenteel met een missiegedreven innovatiebeleid. Missiegedreven innovatiebeleid gaat verder dan generiek innovatiebeleid, wat vaak enkel gericht is op economische peilers en het aanjagen van algemene R&D, in de zin dat maatschappelijke thema's (zoals klimaatverandering) centraal staan. Binnen dergelijk beleid is sturing ('*directionality*') een cruciaal element om niet meer enkel innovaties in het algemeen aan te jagen, maar ook om expliciet richting te geven aan welke innovaties benodigd zijn om de missie te kunnen realiseren; tevens staat economische groei niet per se meer centraal, maar worden ook niet-economische factoren meegewogen. In dit interview proberen we inzichtelijk te krijgen hoe de sturing van de missie zich manifesteert in de praktijk en hoe verschillende partijen dit vanuit hun perspectief zien. Aangezien missiegedreven innovatiebeleid nog relatief nieuw is, is er nog weinig empirische data hoe men hiermee omgaat. Ook trachten we knelpunten en blokkers in het beleid in kaart te brengen om mogelijke verbeterpunten te identificeren.

Het interview zal naar verwachtingen maximaal één uur duren. Interviews worden strikt vertrouwelijk behandeld en worden volledig geanonimiseerd verwerkt in de scriptie. Met uw toestemming zou ik graag de audio van het interview op willen nemen om het interview te kunnen transcriberen; dit zal het analyseren van de resultaten vergemakkelijken en kwalitatief verbeteren.

Voordat we van start gaan, hebt u vooraf nog enkele vragen of opmerkingen?

Vragen		**Mogelijke vervolgvragen**
	Positionering	
1	Op welke manier is uw organisatie verbonden met de missie?	
2	Op welke manier draagt uw organisatie bij aan de missie?	
3	Tot in hoeverre bent u het eens met hoe de missie geformuleerd is ("Een volledig CO2-vrij elektriciteitssysteem in 2050")? Waarom?	• Tot in hoeverre biedt de missie zelf sturing (los van het beleid omtrent de missie)?
	Beleidsdoelen	
4	Tot in hoeverre wordt de missie gesteund door relevante stakeholders?	• Zijn er bepaalde afwijkende visies en/of belangen aanwezig onder relevante stakeholders?
5	Tot in hoeverre worden de maatschappelijke problemen, waar de missie zich op richt, geprioriteerd ten opzichte van andere maatschappelijke thema's?	• Zijn er in de context van de missie conflicten met andere doelen (zoals vestigingsklimaat of het stimuleren van economische groei)? Wat kan men doen om die op te lossen? • Tot in hoeverre worden beleid en wet- en regelgeving op elkaar afgestemd ten behoeve van de missie?

6	Wat zijn de systeemgrenzen van de missie (beperkt de missie zich bijvoorbeeld enkel tot opschaling van productie of valt ook de vraagkant van hernieuwbare energie hieronder)?	• Zijn de huidige grenzen afdoende om de missie te kunnen realiseren? • Hoe hangen missies binnen het duurzaamheids- en energietransitie-thema met elkaar samen?
	Beleidsrationale	
7	Wat is momenteel de koers van de oplossingen om de missie te realiseren? Dit kan zowel technolisch als niet-technologisch van aard zijn.	• Wordt deze koers gesteund door een doorslaggevende groep actoren? • Tot in hoeverre is de huidige koers tevens legitiem en maatschappelijk geaccepteerd? • Ontstaat er een (nieuwe) set aan dominante oplossingen?
8	Tot in hoeverre functioneert het systeem/de markt om de missie te realiseren? Indien u knelpunten of moeilijkheden herkent, wat zijn deze?	• Heeft u een idee hoe die knelpunten of moeilijkheden opgelost zouden kunnen worden? • Voldoet de huidige set beleidsinstrumenten om innovaties in de juiste richting aan te jagen? • Waar komt mogelijk verzet/intertie (of juist steun) vandaan? Hoe manifesteert dit zich in de praktijk?
9	Middels de Klimaatwet wordt de emissiereductiedoelen ook bij wet vastgelegd. Tevens wordt via een andere wet de energieproductie van kolen richting 2030 uitgefaseerd en woningen worden via regeling van het aardgas ontkoppeld. Tot in hoeverre zijn deze uitfaseringen in uw opzicht legitiem en maatschappelijk verantwoord, en sociaal geaccepteerd?	• Zijn er andere aspecten binnen het elektriciteitssysteem waarvan u van mening bent dat die gedestabiliseerd zouden moeten worden? • Zijn we momenteel afhankelijk van onwenselijke socio-technische configuraties (zoals niet-duurzame energiebronnen)?
	Beleidsdomeinen	
10	Tot in hoeverre zijn de governance structuren, die ten behoeve van de missie zijn opgezet, geïntegreerd in – en hebben zij een invloed op – de missie arena? Zijn de juiste actoren en diens belangen ook voldoende meegewogen om uiteindelijk tot een goede sturing te komen? Wat kan hierin verbeterd worden?	• Is er sprake van een 'inside/political' of een 'outside/managerial' governance approach? • Tot in hoeverre is de governance van de missie effectief? • Welke rol en verantwoordelijken draagt uw organisatie binnen deze missie?
11	Hoe kan de coördinatie van deze missie naast andere missies (zoals emissieloze mobiliteit of een circulaire economie) omschreven worden? En hoe worden verscheidene beleidsdomeinen die gerelateerd zijn aan de missie gecoördineerd, en is die coördinatie effectief (denk bijvoorbeeld aan fiscaal, innovatie-, bedrijven- en milieubeleid)?	• Welke moeilijkheden worden er ervaren met betrekking tot coördinatie? Wat zouden mogelijke oplossingen kunnen zijn? • Tot in hoeverre is hier sprake van een geïntegreerde en gecoördineerde samenwerking tussen (semi)-overheden (cf. 'whole-of-government approach')? • Hoe worden onderlinge afhankelijkheden van oplossingen gecoördineerd (denk bijvoorbeeld aan het koppelen van opschaling van grootschalige productie van hernieuwbare energie en het realiseren van de benodigde infrastructuur en voldoende vraag om die productie te legitimeren)?
	Beleidsinvloed	

12	Tot in hoeverre worden de ambities van de missie en de tussentijdse doelen gerealiseerd in de praktijk?	• Wat moet er gebeuren om de effectiviteit van de missie te bevorderen? • Wat zijn mogelijke interventiepunten die de uitvoerbaarheid van de missie kunnen verbeteren?
13	Tot in hoeverre zijn beleidsmakers in staat om effectief sturend beleid te maken voor de missie (bijvoorbeeld met betrekking tot jurisdicties en de geografische reikwijdte van beleid)?	
14	Hoe wordt het beleid op verschillende niveaus (gemeentelijk, provinciaal, Europees, internationaal) gecoördineerd en is die coördinatie effectief?	• Hoe kan de coördinatie verbetert worden?
15	Hoe dragen (waarde)netwerken, coalities en (innovatie) ecosystemen bij aan het faciliteren en realiseren van innovaties?	• Tot in hoeverre hebben dergelijke samenwerkingsverbanden invloed op de richting/sturing van het innovatiebeleid?
	Reflexief beleid	
16	Wordt de voortgang van de missie transparent gemonitord (bijvoorbeeld door een speciale werkgroep) en is de missie op koers om de gestelde doelen te behalen?	• Zo niet, wat moet er gebeuren om toch de doelen te kunnen halen – of zou de missie herzien moeten worden? • Wordt de impact en relevantie van de missie governance regelmatig geëvalueerd en, indien nodig, adequaat herontworpen?
17	Vindt er regelmatig multi-stakeholderoverleg plaats om te beoordelen of de missie nog steeds adequaat geformuleerd is en om de belangen van relevante stakeholders opnieuw te wegen?	• Zijn dergelijke overleggen adequaat om de koers van de missie, indien dat nodig blijkt, bij te sturen?
	Concluderend	
18	Zijn er andere uitdagingen die uw organisatie ervaart met betrekking tot de sturing van de missie?	• Hoe zouden die uitdagingen geaddresseerd kunnen worden?
19	Samevattend, wat zijn – in uw opzicht – momenteel de **belangrijkste uitdagingen** met betrekking tot het adequaat sturing geven aan de missie?	• Wat moet er volgens u gebeuren om die uitdagingen te addresseren?

Appendix B: interview guide – academia (in Dutch)

Interview topics | Experts (Nederlands)

Allereerst veel dank dat u tijd wilt vrijmaken om uw kennis en expertise met mij te delen; dit wordt zeer gewaardeerd en het is van grote waarde voor mijn scriptieonderzoek. Laat ik mijzelf eerst kort introduceren. Mijn naam is Jeroen van der Teems en ik zit in de laatste fase van mijn master Innovation Sciences aan de Universiteit Utrecht. Dit interview is onderdeel van mijn scriptieonderzoek, dat ik uitvoer om mijn master af te ronden.

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Het interview zal naar verwachtingen maximaal één uur duren. Interviews worden strikt vertrouwelijk behandeld en worden volledig geanonimiseerd verwerkt in de scriptie. Met uw toestemming zou ik graag de audio van het interview op willen nemen om het interview te kunnen transcriberen; dit zal het analyseren van de resultaten vergemakkelijken en kwalitatief verbeteren.

Voordat we van start gaan, hebt u vooraf nog enkele vragen of opmerkingen?

Vragen		**Mogelijke vervolgvragen**
	Positionering	
1	Wat weet u van de huidige energietransitie in Nederland?	
2	Op welke manier bent u (direct of indirect) betrokken (geweest) bij de doelstellingen van de missie?	
	Beleidsdoelen	
3	Tot in hoeverre wordt de energietransitie, waar de missie zich op richt, geprioriteerd ten opzichte van andere maatschappelijke thema's zoals landbouw, gezondheid en veiligheid?	
4	Zijn er in de context van de missie conflicten met andere doelen (zoals vestigingsklimaat of het stimuleren van economische groei)? Wat kan men doen om die op te lossen?	• Tot in hoeverre worden beleid en wet- en regelgeving op elkaar afgestemd ten behoeve van de missie?
5	Er wordt tegenwoordig veel gesproken over het versnellen van de transitie en het Expertteam Energiesysteem 2050 spreekt zelfs al over 2035 in plaats van 2050. Wat zijn in uw optiek realistische transitiepaden?	• Tot in hoeverre worden ook niet-technologische aspecten, waaronder energie-efficiëntie, participatie en sociale rechtvaardigheid, hierin meegenomen?
	Beleidsrationale	
6	Wat vind u van de huidige koers van de oplossingen om de missie te realiseren? Hebt u een andere visie voor het elektriciteitssysteem van 2050? Dit kunnen zowel technologische als niet-technologische elementen zijn.	• Wordt deze koers gesteund door een doorslaggevende groep actoren? • Tot in hoeverre is de huidige koers tevens legitiem en maatschappelijk geaccepteerd?

7	Tot in hoeverre functioneert het systeem/de markt om de missie te realiseren? Indien u knelpunten of moeilijkheden herkent, wat zijn deze?	• Hoe zouden die aandachtspunten opgelost kunnen worden? • Voldoet de huidige set beleidsinstrumenten? • Waar komt mogelijk verzet/intertie (of juist steun) vandaan? Hoe manifesteert dit zich in de praktijk?
8	Is er voldoende aandacht voor niet-technologische aspecten van de energietransitie?	• Zo niet, wat ontbreekt er en hoe kan men dit addresseren?
9	Middels de Klimaatwet wordt de emissiereductiedoelen ook bij wet vastgelegd. Tevens wordt via een andere wet de energieproductie van kolen richting 2030 uitgefaseerd en woningen worden via regeling van het aardgas ontkoppeld. Tot in hoeverre zijn deze uitfaseringen in uw opzicht legitiem en maatschappelijk verantwoord, en sociaal geaccepteerd?	• Zijn er andere aspecten binnen het elektriciteitssysteem waarvan u van mening bent dat die gedestabiliseerd zouden moeten worden? • Tot in hoeverre zijn we afhankelijk van onwenselijke elementen, zoals fossiele brandstoffen? Hoe ziet u het verband tussen het uitfaseren van regelbaar vermogen en de leverings-zekerheid van energie?
	Beleidsdomeinen	
10	Tot in hoeverre zijn de governance structuren, die ten behoeve van de missie zijn opgezet, geïntegreerd in – en hebben zij een invloed op – de missie arena? Zijn de juiste actoren en diens belangen ook voldoende meegewogen om uiteindelijk tot een goede sturing te komen? Wat kan hierin verbeterd worden?	• Tot in hoeverre is de governance van de missie effectief?
	Beleidsinvloed	
11	Tot in hoeverre worden de ambities van de missie en de tussentijdse doelen gerealiseerd in de praktijk?	• Wat moet er gebeuren om de effectiviteit van de missie te bevorderen? • Worden sectoren voldoende zekerheid geboden om te investeren op de lange termijn? • Wat zijn mogelijke interventiepunten die de uitvoerbaarheid van de missie kunnen verbeteren?
12	Hoe wordt het beleid op verschillende niveaus (gemeente, provincie, Europa, internationaal) gecoördineerd en is die coördinatie effectief?	• Hoe kan de coördinatie verbetert worden?
13	Hoe draagt samenwerking bij aan het faciliteren en realiseren van innovaties?	• Tot in hoeverre hebben dergelijke samenwerkingsverbanden invloed op de richting/sturing van het innovatiebeleid?
	Reflexief beleid	
14	Wordt de voortgang van de missie transparent gemonitord (bijvoorbeeld door een speciale werkgroep) en is de missie op koers om de gestelde doelen te behalen?	• Zo niet, wat moet er gebeuren om toch de doelen te kunnen halen – of zou de missie herzien moeten worden? • Wordt de impact en relevantie van de missie governance regelmatig geëvalueerd en, indien nodig, adequaat herontworpen?
	Concluderend	
15	Samevattend, wat zijn – in uw opzicht – momenteel de **belangrijkste uitdagingen** met betrekking tot het adequaat sturing geven aan de missie?	• Wat moet er volgens u gebeuren om die uitdagingen te addresseren?

Appendix C: interview guide – enterprises/industry (in English)

Interview topics | Enterprises (English)

Thank you for allocating some of your time to share your knowledge and expertise with me; I highly appreciate it and it is valuable to my study. Let me first briefly introduce myself. I am Jeroen van der Teems, an Innovation Sciences master's student at Utrecht University. The research I am conducting is part of my master's thesis.

This interview contributes to the analysis of directionality challenges in the Dutch mission towards a carbon-free electricity system by 2050. Directionality challenges are important to be addressed for innovation policy to realise its aims. This interview aims to capture a number of aspects to contribute to those challenges from the perspective of enterprises. It is crucial to gather the views of firms considering that firms are one of the relevant stakeholders that need to implement the solutions that contribute to the realisation of the mission. In addition to the views of firms in this, the views from other stakeholders within the mission arena will be gathered as well – allowing for the analysis from multiple perspectives.

This interview is expected to take up to approximately 45 minutes. Interviews will be handled in a confidential manner and completely anonymised processed in my thesis. With your consent, I would also like to record the audio of this session to allow myself to write a qualitative transcript of what we discuss today and to analyse the findings thoroughly. Do you provide consent for this?

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

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?	
	Problem and solution pathways	
3	What (un)certanties do you experience with regard to reducing CO2-emissions within the electricity system?	• What can be done to reduce uncertainties?
4	How does your organisation envision the electricity system by 2050?	• To what extent is the mission on its way to realise that vision? • What solutions can be regarded as promising? • How do you reflect on the intermediary goals for 2030 (i.e., the rapid upscaling of production from wind and solar energy)?
5	What conflicts or difficulties does your organisation experience in executing the mission?	• What could be a potential solution to these conflicts or difficulties?
	Governance of the mission	
6	Who carries what responsibilities to achieve the mission? What role does your organisation play?	• Is your organisation familiar with Topsector Energy and its TKIs (Offshore Energy and Urban Energy)? If so, what role do they play?
7	How are the actions and actors within the electricity system coordinated for the purpose of the mission?	• What sources of resistance (or support) influence the mission direction / governance? • Are there are any difficulties in relation to destabilisation (such as the phasing-out of coal and gas)? • How can the governance/coordination be improved?

	Guidance of the search for solutions	
8	To what extent does the mission and the available instruments provide certainty and enable your organisation to invest in projects that contribute to the mission?	• What is the balance between stimulative (e.g., subsidies) and normative (e.g., regulations) instruments? • What could be done to improve certainty and enable organisations?
9	How does your organisation leverage the mission? For example, is it utilised as a tool to fund R&D of existing business activities or does it serve as an incentive to explore new activities?	• To what extent is your organisation's strategic focus aligned with the mission? • To what extent are there business models to support the current trajectories (such as wind and solar)?
	Formation and leverage of markets and value networks	
10	How does your organisation stay updated with the latest knowledge, technical developments, and trends?	
11	To what extent is there a market for the solutions that contribute to the mission?	• If low: what are the underlying problems? • What can be done to create new markets? Which parties play an important role in that?
12	What role does collaboration with other organisations play in the context of the mission?	• What difficulties does your organisation experience with regard to participating in networks and/or ecosystems? What are potential solutions to resolve those? • To what extent does your organisation involve itself in collaboration within the sector/the system? How does your organisation scope which parties can be collaborated with to create value?
13	To what extent is your organisation willing to engage in knowledge and capabilities sharing with other organisations?	• What role does intellectual property play in this?
	Concluding	
14	Are there any other challenges, that have not been touched upon in this interview, that your organisation experiences with regard to the directionality of the mission?	• How could these challenges be addressed?
15	In summary, what are in your opinion the current **most important challenges** with regard to adequately steering the mission?	• What do you believe must happen to address these challenges?

Appendix C: interview guide – enterprises/industry (in Dutch)

Interview topics | Bedrijven (Nederlands)

Allereerst veel dank dat u tijd wilt vrijmaken om uw kennis en expertise met mij te delen; dit wordt zeer gewaardeerd en het is van grote waarde voor mijn scriptieonderzoek. Laat ik mijzelf eerst kort introduceren. Mijn naam is Jeroen van der Teems en ik zit in de laatste fase van mijn master Innovation Sciences aan de Universiteit Utrecht. Dit interview is onderdeel van mijn scriptieonderzoek, dat ik uitvoer om mijn master af te ronden.

Sinds 2019 werkt Nederland met 25 missies om maatschappelijke uitdagingen te addresseren. Eén van die missies behelst het CO2-vrij maken van het elektriciteitssysteem tegen 2050 (hierna 'de missie'). Om de missie ook concreet aan te pakken werkt Nederland momenteel met een missiegedreven innovatiebeleid. Missiegedreven innovatiebeleid gaat verder dan generiek innovatiebeleid, wat vaak enkel gericht is op economische peilers en het aanjagen van algemene R&D, in de zin dat maatschappelijke thema's (zoals klimaatverandering) centraal staan. Binnen dergelijk beleid is sturing ('directionality') een cruciaal element om niet meer enkel innovaties in het algemeen aan te jagen, maar ook om expliciet richting te geven aan welke innovaties benodigd zijn om de missie te kunnen realiseren; tevens staat economische groei niet per se meer centraal, maar worden ook niet-economische factoren meegewogen. In dit interview proberen we inzichtelijk te krijgen hoe de sturing van de missie zich manifesteert in de praktijk en hoe dat vanuit het perspectief van bedrijven wordt ervaren. Ook trachten we knelpunten en blokkers in het beleid in kaart te brengen om mogelijke verbeterpunten te identificeren.

Het interview zal naar verwachtingen maximaal 45 minuten duren. Interviews worden strikt vertrouwelijk behandeld en worden geanonimiseerd verwerkt in de scriptie. Met uw goedkeuring zou ik de audio van het interview op willen nemen om het interview achteraf te kunnen transcriberen; dit zal het analyseren van de resultaten vergemakkelijken en kwalitatief verbeteren.

Voordat we van start gaan, hebt u nog vragen of opmerkingen?

Vragen		**Mogelijke vervolgvragen**
	Algemeen	
1	Hoe is uw organisatie betrokken bij de missie naar een CO2-vrij elektriciteitssysteem?	
2	Hoe draagt uw organisatie bij aan de missie?	
	Probleem- en oplossingroutes	
3	Welke (on)zekerheden ervaart u bij het terugbrengen van CO2-emissies binnen het elektriciteitssysteem?	• Wat kan er gedaan worden om onzekerheden te verminderen?
4	Hoe voorziet uw organisatie het elektriciteitssysteem van 2050?	• Tot in hoeverre is de missie onderweg om die visie te realiseren? • Welke oplossingen kunnen als veelbelovend worden geacht? • Hoe reflecteert u op de tussentijdse doelen voor 2030 (met andere woorden, de grote opschaling van productie uit wind- en zonneenergie)
5	Welke conflicten of moeilijkheden ervaart uw organisatie bij het uitvoeren van de transitie?	• Wat zouden mogelijke oplossingen kunnen zijn voor deze conflicten of moeilijkheden?
	Governance van de missie	
6	Wie draagt welke verantwoordelijkheden om de missie te halen? Welke rol speelt uw organisatie?	• Is uw organisatie bekend met de Topsector Energie and haar TKIs (Offshore Energy en Urban Energy)? Zo ja, wat voor rol spelen zij?

7	Hoe worden de acties en spelers binnen het elektriciteitssysteem gecoördineerd ten behoeve van de missie?	• Welke bronnen van verzet (of steun) hebben invloed op de richting of governance van de missie? • Zijn er conflicten met betrekking tot destabilisatie (zoals het uitfaseren van kolen en gas)? • Hoe kan de governance/coördinatie van de missie bevordert worden?
	Sturing in de zoektocht naar oplossingen	
8	Tot in hoeverre bieden de missie en de beschikbare instrumenten zekerheid en stellen deze uw organisatie in staat om te investeren in projecten die bijdragen aan de missie?	• Wat is de balans tussen stimulatieve (zoals subsidies) en normatieve (zoals reguleringen) instrumenten? • Wat kan er gedaan worden om bedrijven meer zekerheid te bieden?
9	Hoe gebruikt uw organisatie de missie? Kan het bijvoorbeeld gezien worden als een middel om bestaande activiteiten te financieren of is het een prikkel om nieuwe activiteiten te onderzoeken?	• Tot in hoeverre is de strategische focus van uw organisatie in lijn met het doel van de missie? • Tot in hoeverre zijn er business-modellen om de huidige koers te ondersteunen (zoals wind en zonne)?
	Vorming en toepassing van markten en waardenetwerken	
10	Hoe blijft uw organisatie op de hoogte van de laatste kennis, technische ontwikkelingen en trends?	
11	Tot in hoeverre is er een markt voor de oplossingen die bijdragen aan de missie?	• Indien weinig: wat zijn de onderliggende problemen daarvoor? • Wat kan er gedaan worden om nieuwe markten te creëeren? Wie spelen daarbij een belangrijke rol?
12	Welke rol speelt samenwerking met andere organisaties in de context van de missie?	• Wat voor moeilijkheden ervaart uw organisatie met betrekking tot het deelnemen aan netwerken en/of ecosystemen? Wat zou er mogelijk gedaan kunnen worden om die moeilijkheden op te lossen? • Tot in hoeverre zet uw organisatie in op samenwerking binnen de sector/het systeem? Hoe brengt uw organisatie in kaart met welke partijen u een samenwerking kunt aangaan om waarde te creëeren?
13	Tot in hoeverre is uw organisatie bereid om kennis en kunde te delen met andere organisaties?	• Welke rol speelt intellectueel eigendom hierin?
	Concluderend	
14	Zijn er andere uitdagingen, die nog niet aan bod zijn gekomen in dit interview, die uw organisatie ervaart met betrekking tot de sturing van de missie?	• Hoe zouden deze uitdagingen geaddresseerd moeten worden?
15	Samenvattend, wat zijn in uw opzicht momenteel de **belangrijkste uitdagingen** met betrekking tot het adequaat struing geven aan de missie?	• Wat moet er volgens u gebeuren om die uitdagingen te addresseren?