Key Enablers and Barriers for a Climate Neutral Energy System in the Netherlands in 2050

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Abstract

The Netherlands aims to have a climate neutral energy system in 2050. This is challenging because abundant low-cost natural gas has led to a relatively high energy intensity of its economy as well as vast accumulation of fossil assets. Earlier studies showed that an energy system cannot be seen independently from other systems including finance, innovation, politics, policies, law, and behavior. To explore key enablers and barriers for the Dutch energy system, this study therefore adopted a participative modelling approach with participants with expertise in these different systems. We found that understanding the interrelations between the systems is crucial for avoiding policy resistance and other unintended consequences of policies. We show how public engagement proves to be crucial when considering the energy transition from a holistic perspective and provide recommendations for achieving effective climate policies.

Introduction

Countries need to decarbonize their energy systems to meet the Paris goal of ensuring that the increase in global mean temperature stays well below 2 °C above pre-industrial levels, while aiming to limit warming to less than 1.5 °C. The implications for the Netherlands are substantial (Van Vuuren et al., 2017). For about half a century, the Dutch energy system relied heavily on the Groningen natural gas reservoir, one of the largest natural gas reservoirs that has ever been found (Kern and Smith, 2008; Loorbach et al., 2008). The abundance of low-cost natural gas attracted energy intensive industry, with the result that the Dutch economy has a relatively high energy intensity compared with other European countries (Eurostat, 2020, p. 19). Because of the high energy intensity and the urgency to lower emissions, decarbonizing the Dutch energy system requires more than incremental changes, it requires *system change*: fundamental changes across domains at a pace that is unprecedented (De Coninck, 2022; de Gooyert et al., 2016).

It is acknowledged that decarbonizing an energy system cannot be seen separately from other systems in the society in which the energy system is embedded (Markard, 2018; Otto et al., 2020). The energy system is fundamentally intertwined with those other systems, including the financial system (Monasterolo, 2020; van Tilburg et al., 2022), innovation systems (Jacobsson and Bergek, 2011), politics (Avelino et al., 2016; Hajer and Pelzer, 2018), policies (Bergquist et al., 2022; Drews and van den Bergh, 2016), law (Heldeweg, 2017), and behavior (Steg and Vlek, 2009). These systems mutually influence each other, developments in one system enable and restrict the developments in other systems and vice versa. These interconnections are relevant, because overlooking them in the governance of the transition gives rise to policy resistance and other unintended consequences (Forrester, 1971; Sterman, 1994). However, despite the existence and relevance of interrelations between systems being widely acknowledged, the *nature* of the interrelations is still largely unknown. To achieve smooth decarbonization, more knowledge is needed on *how* the different systems are interrelated. Identifying this type of insights on the interrelations between systems is hard because research typically takes places *within* the boundaries of a single system. This study aims to fill this research gap by applying a participative modelling approach where experts from the different systems work together to discuss the interrelations relevant for the energy transition. This study aims to contribute to a smooth decarbonization through answering the research question: What are the key enablers and barriers for a climate neutral energy system in the Netherlands in 2050? Identifying key enablers and barriers requires identifying interrelations between the various systems that shape the energy transition. In this paper we report on the interrelations that we found through participative modelling and discuss the implications of these interrelations for how decarbonization may be governed.

Method

Identifying enablers and barriers for decarbonizing the Dutch energy system requires a multidisciplinary approach because of the interrelations between the energy system and other systems as finance, innovation, politics, policies, law, and behavior. This study reports on a project that revolved around collaboration between disciplinary experts that each provide knowledge from their domain. To synthesize their viewpoints, we adopted a participative modelling approach, using the guidelines as put forward in the group model building tradition (Vennix, 1999). By iteratively discussing the insights from respective domains, we arrived at a more holistic, integrated understanding. We used causal loop diagrams as a boundary object to discuss where the elements of one domain touch those from other domains and vice versa (Black and Andersen, 2012; Luna-Reyes et al., 2019). Because of the explorative nature of this study, we used qualitative diagrams to structure the complexity of the system. The resulting model can be seen as a scoping model: it helps to identify the nature of interrelations between systems on a high level of aggregation (Costanza and Ruth, 1998).

The Dutch minister for climate and energy constituted a team of experts from different disciplines of science and industry and gave them the assignment to develop guidelines on how to reach a climate neutral energy system in the Netherlands in 2050 (https://www.etes2050.nl/, accessed on 20 March 2023). One of the members of this 'Expert Team Energy System 2050' invited the author of this paper to help synthesize their disciplinary knowledge through participative modelling workshops. A team from the ministry of economic affairs and climate helped prepare and organize these workshops. A preparatory workshop with the organizing team was held on 2 June 2022. The main workshop lasted three hours and took place face-to-face on 10 June 2022. A two-hour follow-up workshop was held online on 30 August 2022. The results of the workshops were summarized in a report and shared with the participants. The author of this study used the results from the participative modelling workshops and related literature on energy transitions to develop smaller diagrams that aim to capture the main feedback mechanisms that followed from the workshops and related literature. These smaller diagrams are presented below. The full diagrams as developed during the workshops are available from the author upon request.

Results

This section describes the highlights of the discussions that emerged during the participative modelling workshops.

Greening the society through lower energy consumption and renewable energy production.

The discussion about a climate neutral energy system in the Netherlands in 2050 started with distinguishing between two main avenues for lowering the carbon intensity of the society: lowering energy consumption and producing the energy that is still used renewably. The Netherlands has for its energy use historically relied a lot on the natural gas reservoir in Groningen, a province in the north-east of the country. The discovery of the reservoir in the 60s of last century resulted in a large volume of low-cost fossil energy supply that attracted a lot of energy-intensive industries, including steel, aluminum, refineries, and basic chemicals. A more sustainable economy will need to rely on different sources of earning power. The Netherlands is a river delta, providing both access to deep sea shipping and inland shipping, and over time this has led to the Netherlands functioning as a hub between north-western Europe and the rest of the world, amongst others through Port of Rotterdam, one of the largest ports in the world. In addition, the North Sea is increasingly seen as a sustainable source of earning power because the shallow sea allows for large quantities of wind turbines, and the many empty oil and gas reservoirs hold potential for storing CO_2 and potentially hydrogen. One way to achieve a climate neutral energy system in the Netherlands, would be through energy intensive industries leaving for other countries, for example because other countries have more access to low-cost renewable energy. However, because of its role as a hub and the potential of the North Sea for large scale renewable energy production, it seems that replacing the fossil energy-intensive industries by sustainable industries is preferable over de-industrialization. Climate policies, like pricing climate externalities through taxation, came up as an important way to help shift from an economy that is based on fossil energy to an economy that builds up sustainable energy-intensive industries. Climate policies help through favoring renewable energy production over fossil energy production, through favoring sustainable economic activities over fossil economic activities, and indirectly through encouraging innovation that helps to develop new more sustainable economic activities that can outcompete fossil economic activities. The above is summarized in Figure 1 below.

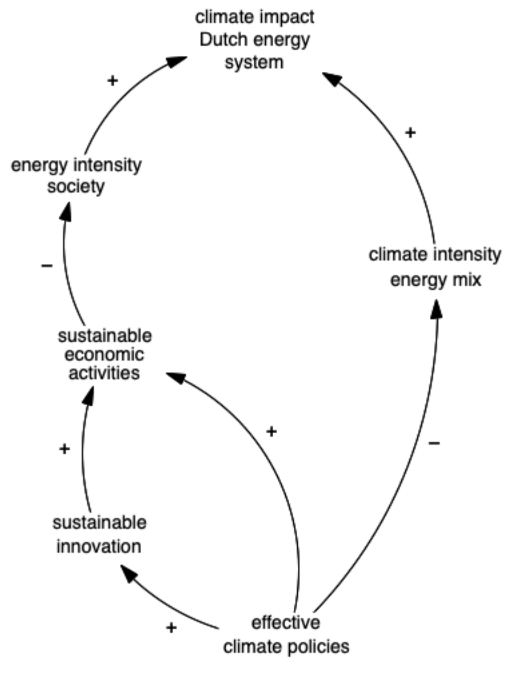

Figure 1: Climate neutrality through lowering energy consumption and renewable energy production

The energy transition requires capacity to change and societal support.

The next step in the discussion revolved around the question which factors determine whether effective climate policies will be put in place or not. Two important factors identified were the capacity to change, and the societal support for effective climate policies. Capacity to change is connected to the value of fossil assets. Currently, the Dutch society depends to a large extent on fossil activities. The history of abundant natural gas and energy-intensive industry resulted in an accumulation of fossil assets. These fossil assets influence the capacity to change negatively, intentionally through fossil stakeholders that promote their interests, but also because moving away from a fossil economy will mean that these fossil assets need to be written off at a higher pace, with vast economic consequences. The more the Dutch economy is founded on sustainable economic activities, the lower the value of these fossil assets. This results in reinforcing feedback where effective climate policies will make future effective climate policies easier to achieve, but currently, with still substantial fossil assets underpinning Dutch economy, this seems a chicken and egg problem where dependence on fossil assets hinders effective climate policies, which are necessary to reduce dependence on fossil assets (loop R1 in Figure 2). Along similar lines, firms will become more agile when they rely less on fossil assets, making the shift to sustainable activities easier (loop R2 in Figure 2).

Effective climate policies also depend on societal support. Climate policies affect citizens in all facets of their live because they affect how citizens live, dress, eat, move, and consume. Because of these far-reaching consequences, climate policies are not always popular. If climate policies lack support, politicians are likely not to impose them, as that would likely cost voters in the next phase of the election cycle. In addition to perceived urgency, support is also influenced by the extent to which citizens perceive the transition to a climate neutral society as fair. This includes whether citizens find that the benefits and the burdens of the transition are shared fairly, and whether the process that led up to the selection of climate policies is perceived as fair. This also relies on trust citizens have in the government. One way in which government obtains trust, is by showing that it is indeed capable of imposing effective climate policies through a fair process and with fair consequences. This leads to reinforcing feedback, where effective climate policies, again, make future effective climate policies easier to achieve, because they increase the trust that is necessary for the perceived fairness and hence societal support (loop R3 in Figure 2). The above is summarized in Figure 1 below.

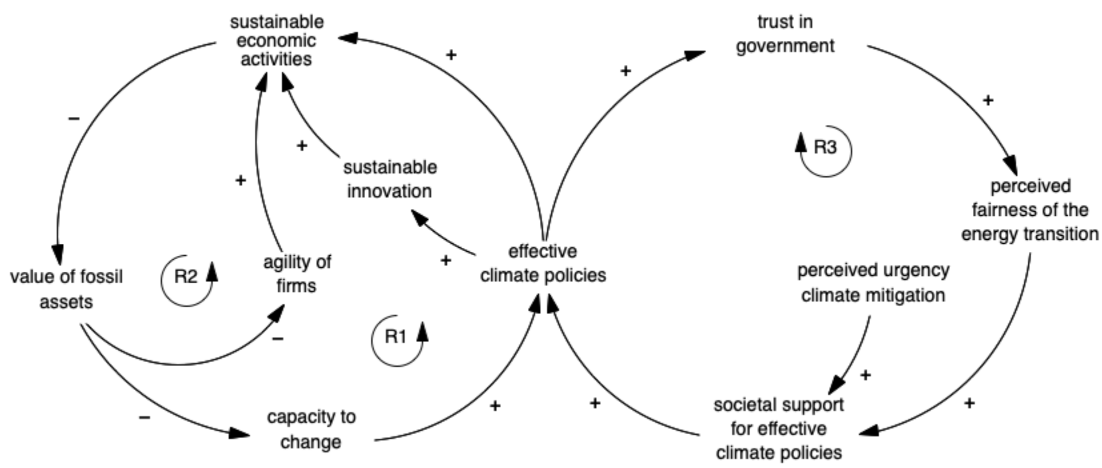

Figure 2: Effective climate policies requires capacity to change and societal support

Sustainable behavior and resistance to change.
The discussion in the participative modelling workshops finally also revolved around the role of consumer behavior. Lowering the energy intensity of society can be achieved by lowering the energy intensity of consumption and by lowering consumption. Effective climate policies help nudge citizens towards more sustainable behavior, both lowering consumption and shifting to more sustainable consumption. Over time, this sustainable behavior will become the new standard, and norms will shift towards more sustainability. These shifting norms lead to even more sustainable behavior, reinforcing feedback in the form of a contagion effect (loop R5 in Figure 3).

The sustainable norms, together with the perceived fairness of the energy transition, influence the resistance towards renewable electricity and green industry. Especially for onshore wind power, solar farms and sustainable heavy industry, the resistance of citizens can substantially delay projects or even lead to cancelling them altogether. The less resistance, the easier it is to realize sustainable economic activities, and to shift the energy mix towards more renewable energy, lowering the climate intensity of the energy mix. These relations are included in Figure 3 below.

Finally, a balancing feedback loop is identified where achieving the goals of decarbonizing the Dutch energy system will over time lead to less urgency to put additional effort to decarbonize the energy system (loop B1 in Figure 3).

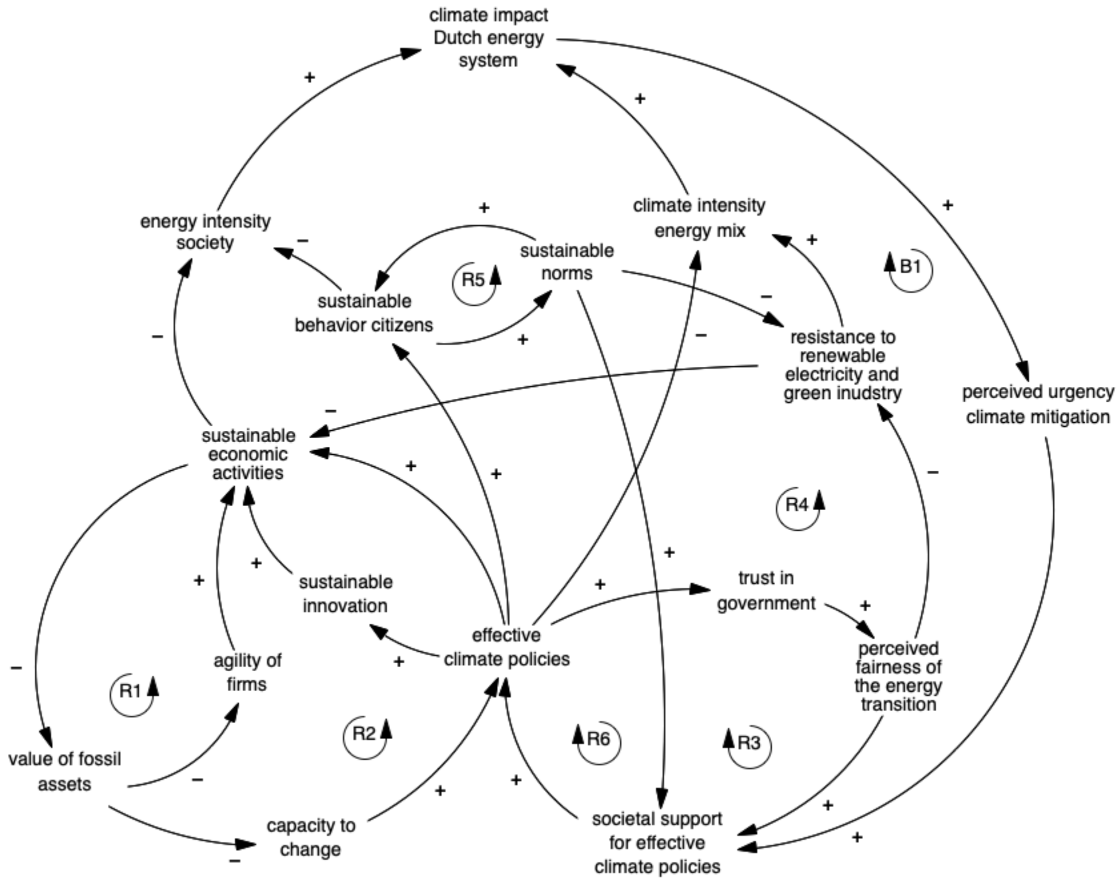

Figure 3: Factors that shape the transition towards a climate neutral energy system in the Netherlands in 2050

Conclusion and discussion

This study set out to identify key enablers and barriers for achieving a climate neutral energy system in The Netherlands in 2050. We adopted a multidisciplinary approach through participative modelling with experts from different domains that all shape the energy system. We concluded that indeed the energy transition relies heavily on how other systems codevelop, including finance, innovation, politics, policies, law, and behavior. In addition, we conclude that if you follow a multidisciplinary systems approach as we did in this paper, you arrive at different policy recommendations compared to when you follow an approach that is confined to the energy system in isolation. We identified 7 key feedback mechanisms. To reach the unprecedented systems change necessary to decarbonize the Dutch energy system, policies will have to intervene in these key feedback mechanisms to overcome inertia and to set in motion the reinforcing change towards sustainability. Below we discuss the implications of our findings and our recommendations.

We found a variety of reinforcing feedback loops that will make it easier to make progress on decarbonizing the energy system when activated, but that currently do not yet form the dominant mechanisms steering the transition. This is analogue to other chicken and egg problems where different aspects of a reinforcing feedback loop require changes in other variables in the loop to be set in motion. The implication is that it is clear that more effort should be taken to get these reinforcing mechanisms out of the gridlock situation that they are currently in. This holds for two large parts of the system: the part where the *accumulated fossil assets* make it hard to take effective climate action (R1 and R2 in Figure 3), and the part where societal support and effective climate action are intertwined (R3 and R6 in Figure 3). This reiterates earlier studies that also pointed out the importance of vested interest and public engagement (Kern and Smith, 2008; Loorbach et al., 2008, Markard, 2016), but goes further by emphasizing the relevance of the fact that those two factors not only shape climate action but are also to a large extent shaped by it.

We propose policies to intervene in the feedback mechanisms around fossil assets and societal support. We recommend increasing the role of citizens in developing policy to decarbonize the Dutch energy system, for example through establishing citizen assemblies. On the one hand, increased citizen involvement may help to decrease the extent to which the climate policy process is influenced by the accumulated fossil assets in the Dutch energy system (Avelino et al., 2016). The Netherlands will need to develop new economic activities to form new sources of earning power (Jacobsson and Bergek, 2011). However, traditionally, incumbent actors have a substantial role in the policy process (Heldeweg, 2017). This leads to fossil assets influencing the climate policy process in various ways, through actors that rely on fossil assets for their profitability defending their interest (Monasterolo, 2020), but also through less visible mechanisms where current norms and standards are more favorable for fossil activities (Avelino et al., 2016). Involving citizens in developing policies can provide the counterweight that is needed to lower the extent to which the policy process leads to policies that, intentionally or unintentionally, favor current modes of production and consumption, at a time where a radical shift in such modes is required. On the other hand, increased citizen involvement helps to increase the societal support that is crucial for a swift implementation of climate measures (Bergquist et al., 2022; Drews and van den Bergh, 2016). Even for citizens not directly involved in measures like citizen assemblies, it is likely to increase support because it contributes to procedural justice: if citizens perceive the process that was used to develop policies as fair, they are more likely to support the policies that have been proposed in that process, even if those polices have negative consequences for themselves. Another way to increase citizen involvement is by engaging the public in a series of press conferences by the Dutch prime minister. By discussing the status quo, the plans, and the efforts that are already taken, such press conferences would show the commitment of the national government to the required transition, the dilemmas that are inherently part of the fundamental changes required, thereby contributing to the trust in government that is essential for progress (Steg and Vlek, 2009). An additional approach to increase the perceived fairness of the energy transition is through measures that help alleviate energy poverty, addressing concerns that citizens that already are disadvantaged will have to bear disproportional burdens of the energy transition. Although others have proposed similar measures before, our analysis provides a more holistic understanding of why these measures are so relevant, by explicitly showing how they address the interrelatedness of the energy system and other systems with which it coevolves. Some of these measures, like citizen involvement, are often presented as a way of dealing with one aspect of the energy transition, like the extent to which it adheres to democratic principles. We show that the relevance of such measures goes much further and cannot be seen independently from effective action and the progress that we make in decarbonization the energy system.

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