32nd International Conference of the System Dynamics Society, Delft, 2014

Energy Transition Dynamics; Understanding Policy Resistance in the Dutch Energy System

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Abstract

Various countries seek to establish an energy transition, a structural change towards a more sustainable energy system. Countries implement a combination of energy policies aimed at establishing an energy transition, but these policies frequently result in unintended negative consequences. This study provides an attempt to unravel the complexity of the Dutch energy transition. We present a model of the Dutch energy transition, showing its various components and their interrelations. The model is based on eight group model building workshops in which a total of 96 stakeholders in the Dutch energy transition participated. In each workshop, a variety of stakeholders engaged in the collaborative construction of a model that explains the current progress of the energy transition. In this paper, we aggregate these eight models into one overarching model, which we lay out step by step. The model shows how technological, ecological, social, economic, and political aspects of the energy transition influence each other either directly or indirectly. We discuss several policy implications, with a focus on reducing unintended negative consequences.

Keywords: energy transition, complexity, group model building

Word count: 4.978

Introduction

Various countries seek to establish an energy transition: a transition towards a more sustainable energy system by improving energy savings and increasing the share of renewable energy production (Smil, 2010). The Netherlands is one of these countries and stands out because of the discrepancy between its goals and the current state of its energy system (Verbong and Geels, 2007). Following European aims, the Dutch government recently set a goal of 16% renewable energy production by 2023 (SER, 2013). With a current share of 4,7% renewable energy production, substantial change is necessary in order to achieve this goal (PBL, 2012).

Several approaches have been used to study transitions, alternatively focusing on the diffusion of technology trough innovation systems (Hekkert et al., 2007), on governing networks and decision-making processes to bring about a transition

(Loorbach, 2010), and on the alignment of technology niches and broader economic and social regimes (Kemp, 1994). Although each approach has its own focus, the approaches share the importance they attach to the complexity of transitions. This complexity explains why energy transition policies often result in unintended negative consequences (Greening and Jefferson, 2013a). In this study, we use a system dynamics approach in an attempt to unravel this complexity (Forrester, 1961; Sterman, 1982). Our approach is aimed at constructing a model that endogenously explains the development of the Dutch energy transition. To make sure that all important aspects are covered, we have a total of 96 stakeholders with different viewpoints participating in the construction of the model through group model building workshops (Vennix, 1996). By incorporating these views, we answer the call for studies that provide an 'integrative framework', bringing together a variety of issues including technological and behavioral components (Greening and Jefferson, 2013b).

The Dutch Energy Transition

At present, more than 85% of the Dutch energy consumption is covered by oil and natural gas (primary energy consumption in 2012, BP, 2013). The Port of Rotterdam, the largest port in Europe, provides the Netherlands with easy access to oil. What distinguishes the Netherlands the most from other European countries however, is its reliance on natural gas. This stems from the fact that the Netherlands has a large reserve of natural gas in the province of Groningen (with a proven reserve of 1.0 trillion m3 at the end of 2012, BP, 2013). In cooperation with private parties, the Dutch government has been extracting natural gas for several decades (Verbong and Geels, 2007).

Since the energy crisis in the early 1970s, the Dutch government has been developing energy policies that include increasing the energy system's sustainability (Van Rooijen and Van Wees, 2006). Over time, a range of policies has been implemented but the effectiveness of these policies remains limited: a large gap between desired and current situation remains. Policies aimed at renewable electricity for example ranged consecutively from voluntary agreements, to the promotion of demand, as well as the promotion of supply (Van Rooijen and Van Wees, 2006). By frequently changing policies, the government has not been able to reduce market uncertainties and to instill confidence in market parties (Van Rooijen and Van Wees, 2006). While sustainability became more and more prominent in policy rhetoric, the changes that did occur in the Dutch energy system were mainly driven by broader trends such as Europeanization and liberalization, with environmental aspects remaining in the periphery (Verbong and Geels, 2007).

Since the early 2000s the Dutch policies are explicitly aimed at bringing about an energy transition, including the appointment of a 'transition manager' that is responsible for managing the 'energy transition project' in 2001, and the appointment of a 'task force energy transition' with 17 members from both private and public parties in 2005 (Kern and Smith, 2008). The taskforce and its transition management however, had no substantial impact on the energy policy (Kern and Smith, 2008). While the transition efforts were explicitly aimed at incorporating various organizations in identifying policies, the partnerships soon became dominated by elites from the government and the fossil industry (Hendriks, 2008). The 'transition storyline' referred to 'niche innovations' that lead to 'system changes', but as incumbents captured the governance of the transition, the potential for change diminished (Smith and Kern, 2009). Established players played a too great role, standing in the way of effective transition management (Kemp et al., 2007).

The most recent energy policies were formed in 2013. Following a request from the Dutch government, the Dutch Social and Economic Council (SER) facilitated a process in which a wide variety of parties negotiated how the national objectives are to be met. One of these objectives is the goal of 16% renewable energy production by 2023 (SER, 2013), compared to a current share of 4,7% (PBL, 2012). A total of 40 organizations signed the so-called 'Energy Agreement' that was the result of this process, including "central, regional and local government, employers and unions, nature conservation and environmental organizations, and other civil-society organizations and financial institutions" (SER, 2013).

The description of Dutch energy policies above scratches the surface of the complexity that constitutes the Dutch energy system and shows several examples of policy resistance. In the end of the next section therefore, we turn to a method that is specifically aimed at unraveling system complexity and coping with unintended negative consequences (Sterman, 1994). But first, we provide more background on previous studies on transitions and how these studies conceptualized complexity.

Transitions and Complexity

This section provides an overview of earlier studies on transitions and complexity. We discuss how our approach relates to these earlier studies. Transitions in general, and sustainability transitions like energy transitions specifically, are gaining increasingly attention (Markard et al., 2012; Schreuer et al., 2010; Van den Bergh et al., 2011). Within this stream of research, scholars apply several conceptual frameworks that focus on different aspects of transitions. All of the dominant approaches recognize the importance of the complexity of transitions. Below we discuss these dominant perspectives and how they conceptualize complexity. After that, we discuss the system dynamics approach that we adopt in this study and how this approach deals with complexity.

The 'technological innovation systems' approach focuses on several functions that innovation systems should perform before a certain technology can bring about a transition (Bergek et al., 2008; Hekkert et al., 2007; Hekkert and Negro, 2009; Jacobsson and Bergek, 2011). This approach focuses on the development, use, and diffusion of technology (Bergek et al., 2008). It conceptualizes innovation systems as consisting of actors, networks, and institutions, and argues that system failure is caused by the failure in one of seven key functions of an innovation system (Bergek et al., 2008; Hekkert et al., 2007). The approach helps with explaining the (lack of) success of a certain technology (Hekkert and Negro, 2009; Negro et al., 2006). A transition perspective however is technology indifferent, in the sense that it focuses on changes in the outcome of a system (in terms of GHG emissions, for example), independent from the type of technology that brings about such changes.

The 'transition management' approach focuses on the governance of transitions in networks and decision-making processes (Avelino, 2009; Loorbach, 2010; Rotmans et al., 2001). This approach focuses on the interaction among societal actors to increase the support for policy decisions (Loorbach, 2010). Problems are considered to be persistent because the underlying systems are highly complex. Complexity arises because problems occur across several societal domains with several interactions between these domains (Loorbach, 2010). The transition management approach is explicit with regard to the strategies that governments should adopt in order to bring about a transition. The authors provide a stepwise program that governments should follow consisting of problem structuring, networking, and conducting and evaluating experiments (Loorbach, 2010; Rotmans et al., 2001).

The 'multi level perspective' focuses on the interfaces between new technologies and existing regimes (Elzen and Weiczorek; 2005; Geels, 2002; 2004; 2010; Geels and Schot, 2007; Kemp, 1994; Smith, Voß, and Grin, 2010). Complexity is conceptualized by three levels that together form a system: niches in which new technology evolves, regimes that function on the basis of shared rules, and landscapes that consist of broader structural trends (Geels, 2002). In this approach system failure is caused by incompatibilities between the three levels. Although several pathways to alignment are possible (Geels and Schot, 2007), technological transitions only come about when these are sufficiently embedded in the surrounding economic and social systems (Kemp, 1994). To prevent misalignment, technology should evolve in a protected space until the three levels are compatible (Smith and Raven, 2012).

In our study we adopt the system dynamics approach (Forrester, 1961; Richardson, 1991; Senge, 1990; Sterman, 2000; Vennix, 1996). In this approach, systems are conceptualized as causal relations between both physical and behavioral components that together provide an endogenous explanation for the behavior of the system as a whole (Forrester, 1961). This approach argues that closed circles of causal relations (feedback loops) are the main determinants of system behavior and as such provide the strongest leverage points for interventions (Richardson, 1991; Senge, 1990). Within system dynamics there is a school that focuses on developing expert models (Sterman, 2000; see for an application on sustainability transitions Papachristos, 2011), and there is a school called 'group model building' that focuses on bringing together stakeholders to construct a model *collaboratively* (Rouwette et al., 2011; Vennix, 1996; 1999; see for an application on energy efficiency in New Zealand Elias, 2008). This study adopts the group model building approach.

The system dynamics approach adopts a systems perspective that is broad enough to endogenously explain behavior over time (Forrester, 1961). As such, it takes a broader perspective than the technological innovation system that focuses on a single technology Hekkert and Negro, 2006). Like the transition management approach, system dynamics focuses on the interrelations of various subsystems (Loorbach, 2010). The system dynamics approach however lacks a general recipe for bringing about transitions such as that from the transition management approach and the multi level perspective (Loorbach, 2010; Kemp, 1994). While the other approaches explicitly seek patterns between transitions, our approach in this study does not presuppose such a pattern. Rather, we focus on bringing together stakeholders in the energy transition to find a robust endogenous explanation for the development of the Dutch energy transition. Because of the similarities in the conceptualization of complexity we expect the system dynamics approach to be complementary to the technological innovation system approach, the transition management approach, and the multi level perspective.

Method

To unravel the complexity of the Dutch energy transition we construct a system dynamics model describing the mechanisms that endogenously explain the development of the transition (Forrester, 1961; Sterman, 1982). Involving a wide variety of stakeholders with various viewpoints in constructing the model helps to construct a robust model of the energy transition (Vennix, 1996). To ensure a fruitful dialogue between the stakeholders we organize several workshops according to the format as put forward in group model building literature (Andersen and Richardson, 1997; Rouwette et al., 2002; Vennix 1996; 1999). Group model building is specifically suited to structure a dialogue where various stakeholders try to persuade each other on the importance of the various aspects of a complex issue (Rouwette et al., 2011).

A model building process consists of stakeholders participating in workshops in which they construct a model that is the representation of that part of reality that is relevant for a certain issue (Franco and Montibeller, 2010), in our case the energy transition. The model is built step by step and to ensure that the model accurately captures the viewpoints of the participants, with each step the question is asked whether all participants agree with the extension of the model. In our study, the model takes the form of a causal loop diagram: a diagram showing the relevant variables and the causal relations that link them (Vennix, 1996).

To ensure that there is enough room for interaction we aim to keep the number of participants in a single workshop low. It is this interaction that facilitates the exchanging of arguments and the building of the model. On the other hand, we want to incorporate a wide diversity of viewpoints, which is served by including more participants. Therefore, we chose to organize eight different workshops that are exactly the same in their design, except for the stakeholders that participated. As a result, we get eight different models of the Dutch energy transition. By looking at the similarities and differences between these eight models, we aggregate them in a single overarching model, which we present in the next section.

We invited stakeholders in collaboration with the Dutch Distribution System Operator Alliander. Various employees of Alliander helped by pointing out relevant stakeholders in their networks. The starting point for these invitations was the desire to include the widest variety of viewpoints as possible. Ultimately, 96 stakeholders participated in our workshops, drawn from different stakeholder groups such as managers from large corporations, civil servants, researchers, bankers, lawyers, and entrepreneurs. A list with all participating stakeholders is available from the authors.

Each workshop was lead by two facilitators that were familiar with the group model building method. The first two authors of this paper are amongst these facilitators. The workshops took about five hours each and took place in September and October of 2013.

Results

In eight workshops, stakeholders with a wide variety of viewpoints engaged in a dialogue on the energy transition. In each workshop the following question was guiding: “How can we explain the current development of the Dutch energy transition?” Despite substantial differences between the workshops, the different groups shared several lines of thought. The description of these shared lines of thought below are therefore not a complete representation of the eight dialogues, but they do represent the consensus between the various viewpoints. We support the description with a causal loop diagram that we build up step by step. This diagram as well is an extraction of the eight causal loop diagrams that were constructed in the workshops. As a result the diagram is not a complete representation of the workshops, but it does provide an overview of the elements that were similar for the eight workshops.

The causal loop diagram may be read as follows. If two variables are connected by an arrow with a plus sign, this means: if variable A increases variable B increases as well, and if variable A decreases variable B decreases as well. If two variables are connected by an arrow with a minus sign this means: if variable A increases variable B decreases, and if variable A decreases variable B increases. A closed loop of causal links is called a 'feedback loop'. These loops are characterized by the fact that each variable, via a chain of causal relations, influences itself. We distinguish between two types of feedback loops. A positive feedback loop, which has a reinforcing effect, indicated by a snowball sign. For each variable in this loops it holds: if variable A increases this leads via a chain of causal relations to a further increase of variable A. Alternatively, if variable A decreases this leads via a chain of causal relations to a further decrease of variable A. A negative feedback loop, which has a balancing effect, indicated by a balance sign. For each variable in this loop it holds: if variable A increases this leads via a chain of causal relations to a decrease of variable A. Alternatively if variable A decreases this leads via a chain of causal relations to an increase of variable A.

The energy transition is a transition towards a more sustainable energy system. An energy system consists of two sides: the side of energy *demand*, and the side of energy *supply*. On both sides the sustainability of an energy system may be improved. The demand side consists of energy consumption by for example households, industry, and mobility. Sustainability on the demand side may be improved by energy conservation. Energy conservation may consist of decreasing the consumption of energy, or increasing the efficiency of energy consumption (decreasing the units of energy consumed per unit of output). The supply side of energy consists of the various ways of energy production, for example by combustion engines, central electricity plants and decentralized electricity production. Sustainability on the supply side may be improved by increasing the share of renewable energy production, for example by installing wind mills, solar panels, and so on. In terms of our model we represent this as follows: investments in renewable energy production and energy conservation lead to a higher sustainability of the energy system, see Figure 1.

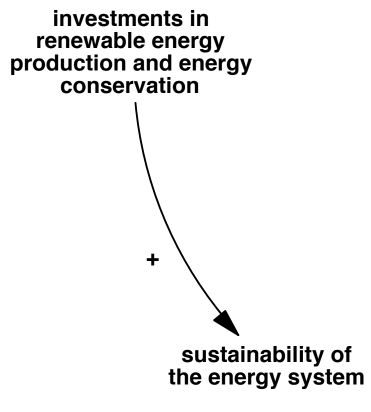

Figure 1: Renewable energy production and energy conservation increase sustainability

When substantial investments are made in renewable energy production and energy conservation this leads to more than the intended increase of sustainability. An important side effect that was mentioned in the workshops is the intermittency that comes as a consequence of a higher share of renewable energy production. Windmills and solar panels for example only produce energy when the circumstances are right (enough wind but not too much, enough solar radiation). This intermittency has as a consequence that the demand and supply of energy are less aligned compared to fossil energy. To ensure the reliability of the energy system despite this intermittency, considerable investments are necessary. Investments in energy infrastructures may help to spread out the regional discrepancy between demand and supply, by transporting energy over larger distances. By transporting energy, local shortages and surpluses can be balanced. Besides, investments in energy storage may help to spread out the temporal discrepancy between demand and supply, by forming a buffer.

Investments in renewable energy production lead to intermittency and to counter this, additional investments are necessary. These additional investments add to the total costs of renewable energy production increase. These higher costs have as a consequence that the attractiveness of new investments decrease. The costly side effects of renewable energy production in this way form a balancing feedback loop, as is shown in Figure 2.

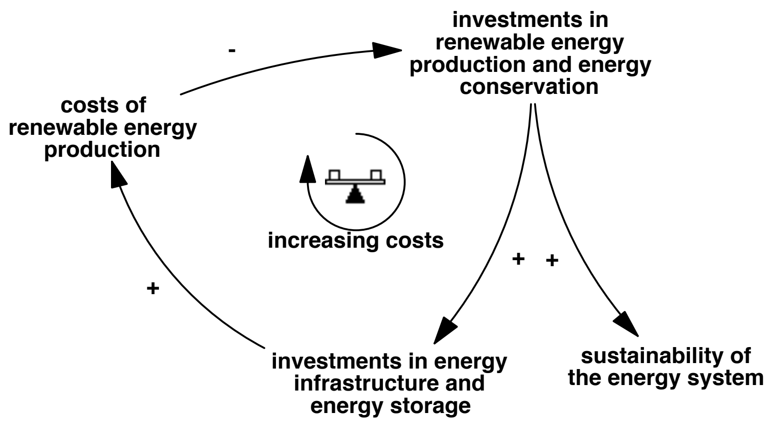

Figure 2: Investments in renewable energy production have costly side effects

The lower the sustainability of the energy system, the higher the chance that this receives publicity. Examples are oil disasters or the negative environmental impact of shale gas that receives attention by environmental action groups and newspapers. This publicity leads to more visibility of the environmental impact of the energy system. This increased visibility fuels civil unrest on environmental impact. This unrest consequently can incite investments in renewable energy production and energy conservation.

Because investments in renewable energy production and energy conservation increase the sustainability of the energy system, the causal chain via visibility of the impact and civil unrest has a balancing effect, see Figure 3.

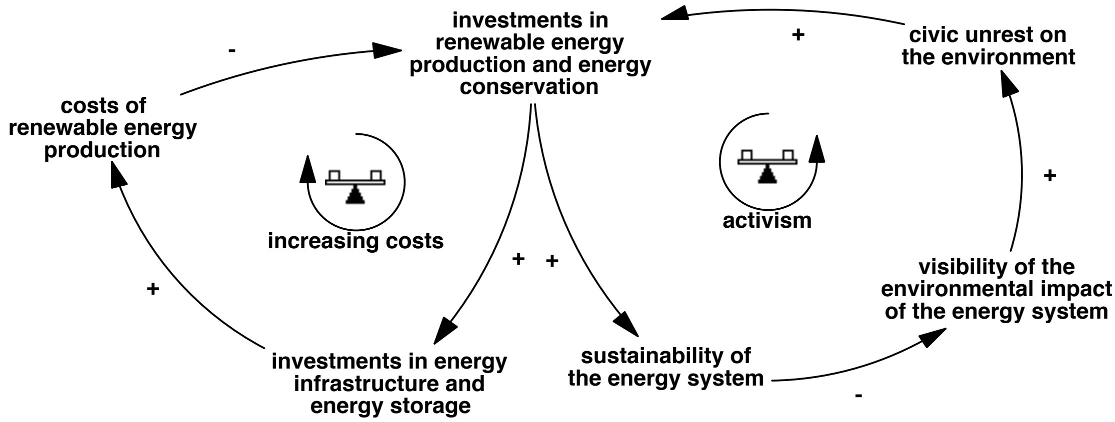

Figure 3: Unrest over environmental impact incites investments in sustainability

The cost structure of renewable energy production differs form fossil energy production. What characterizes for example windmills and solar panels are the high initial costs (purchase and installment), and the low variable costs. Maintenance costs keep coming back but the wind and solar radiation that are converted into energy are free. Fossil energy production like coal and gas plants have much higher variable costs, the plants have to buy fuel for as long as they produce energy. When capacity for renewable energy production gets installed, this has a decreasing effect on the market price of energy. When windmills and solar panels are installed, they increase the availability of energy on the market, causing a decrease of the market price of energy. During the workshops several participants brought up the cases of Denmark and Germany, where the energy market price was even negative occasionally.

A high energy market price is an incentive for energy consumers to decrease their dependency on energy from the market. By investments in their own renewable energy production and by investments in energy conservation, consumers need to buy less energy from the market. The lower market price counteracts this incentive. Therefore, the feedback loop along energy market price has a balancing effect, see Figure 4.

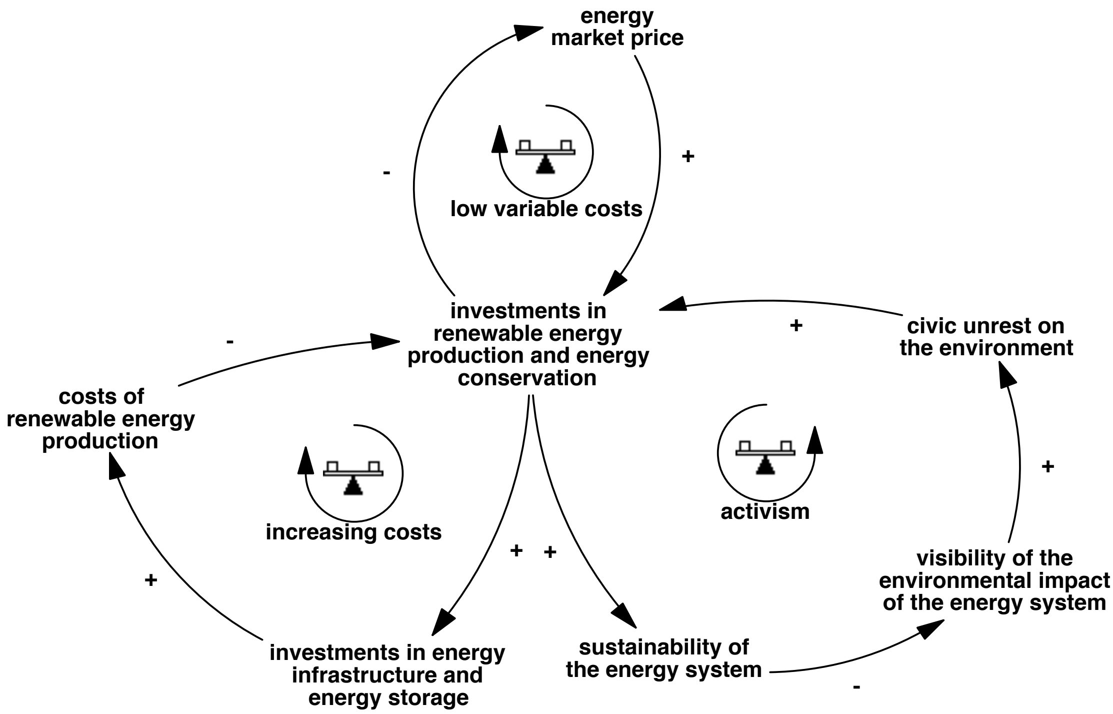

Figure 4: A lower energy market price decreases the incentive for investments in sustainability

The strong position of the fossil industry was mentioned in most workshops. The exploitation of the Dutch gas reservoir and the historically grown position of fossil multinationals have as a consequence high vested interests, and these interests are seen as conflicting with a transition towards more sustainability. Two expressions of these interests are the following. First, the energy system is designed towards fossil energy, which allows for large economies of scale for fossil energy and making adaptions is costly. This translates into a negative relation between the power of vested interests and the market price of energy. Second, the Dutch policy is geared towards fossil energy. The government depends on the gas exploitation for a substantial part of its income and the fossil industry has a large voice in setting policy. This translates into a negative relation between the power of vested interests and the extent to which the policy is geared towards energy transition.

Through investments in renewable energy production and energy conservation, the power of vested interests will decrease. When an increasing share of the system is adapted to renewable energy the economies of scale will appear in the renewable sector as well. Because of renewable alternatives the government will decrease its income based on fossil fuels and the new parties will gain a larger voice in stipulating new policy. Both mechanisms result in reinforcing effects. We label these processes creative destruction in the market for energy and overturning the policy, see Figure 5.

There are two relations that relate the variables described earlier with the feedback loops we just described. The additional costs of investing in energy infrastructure and energy storage to meet the intermittency of renewable energy mentioned earlier strengthen the power of the vested interest. During the workshops it was said that the fossil industry uses the negative side effects of renewable energy to feed anxiety for negative effects of the energy transition, protecting their interest in this way. The civic unrest mentioned earlier that may follow from publicity on environmental problems increases the pressure on the government to adapt policies to facilitate the energy transition. Both relations are included in Figure 5. With these additions we finished the model that represents the core of the eight workshops.

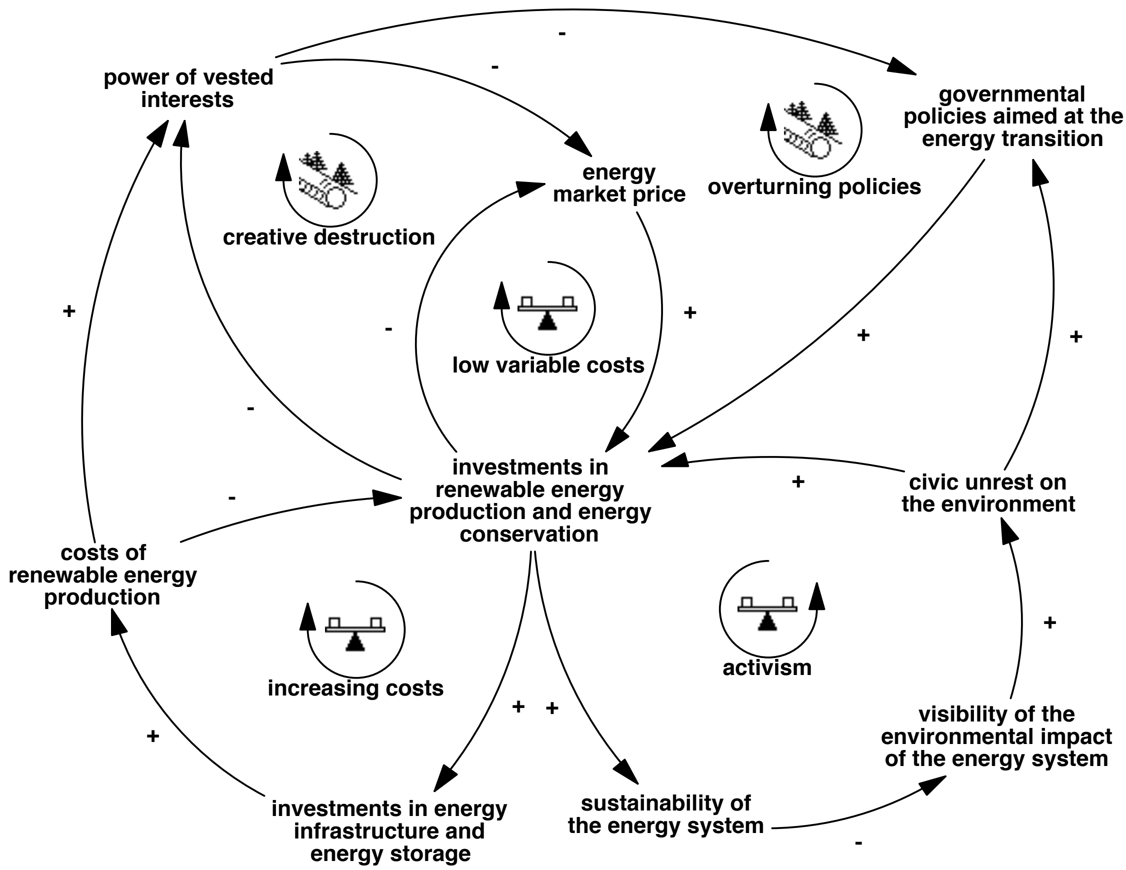

Figure 5: Relation technological, ecological, social, economic, and political factors

In the stepwise construction of the model, different types of variables were integrated. We started by looking at technological consequences of renewable energy production. Solar and wind energy are both suffering from intermittency and therefore bring along additional costs. After that, we saw the relation with ecological and social factors. When environmental concerns get wide publicity, this leads to civic unrest. What followed was the inclusion of economic factors. Investments in renewable energy production and energy conservation influence both the demand and supply side of the energy market. Finally, we saw the role of political factors. If the vested interest loose power this initiates a reinforcing mechanism with even less power as a result.

Discussion

For this study a total of 96 stakeholders with widely varying viewpoints participated in workshops, in which they collectively constructed models that explain the current development of the Dutch energy transition. This group of participants consisted of civil servants, researchers, consultants, bankers, lawyers, and entrepreneurs, representing the public and the private domain. Despite the diversity in backgrounds the participants succeeded in building models that they felt represented all of their views. They all acknowledged that they could recognize their own view in the shared models. This result is in line with earlier research in which group model building facilitated the construction of a shared model (Rouwette et al., 2011; Vennix, 1996; 1999), and provides confidence in the validity of the resulting model. At the same time, this result nuances earlier research that focused on the differences between the various stakeholders in the energy transition (Negro et al., 2012). While the model is not complete, in the sense that it does not include all details relevant to energy transition, it does provide insight into its main mechanisms. The model describes physical components as well as behavioral elements. In that sense the research answers the critique on earlier studies on transitions that too much emphasis is put on the technological aspects of innovations (Lachman, 2013).

By providing an integrative view of the Dutch energy transition, the system dynamics model complements previous approaches in conceptualizing transitions. The technological innovation system approach (Hekkert et al., 2007) has been used for in-depth studies of single technologies (Hekkert and Negro, 2009; Negro et al., 2007). An integrative model such as the one presented here can be used to unravel the interrelations between several innovation systems and the non-technological systems in which they are embedded. Our model provided an attempt to unravel the complexity of the Dutch energy transition and as such may play a role in the 'problem structuring' phase of the transition management cycle (Loorbach, 2010). The multi level perspective focuses on the interface of technology niches and existing regimes (Kemp, 1994). Our model shows how investments in renewable energy and energy conservation are driven by and impact broader communities, politics and markets. It may as such be seen as an analysis of where technology and existing regimes meet, which is an important element of the multi level perspective. We focused on an endogenous explanation of the Dutch energy transition. This complements the focus of the transition management approach and the multi level perspective that seek patterns *between* various transitions (Geels and Schot, 2007; Rotmans et al., 2001).

Conclusion and Policy Implications

In this study we made an attempt to unravel the complexity of the Dutch energy transition. We conclude that the energy transition consists of several subsystems. The model as provided in Figure 5 shows how technological, ecological, social, economic, and political factors influence each other either directly or indirectly. The results have several policy implications, which we discuss below.

The energy transition asks for an integrated approach

Interventions that aim to improve only one of the subsystems of the energy transition will result in unintended side effects in subsystems that are either directly or indirectly related. One example of such an effect is the following. Imagine that the Dutch government would invest heavily in both energy conservation and renewable energy production. It follows from the model in Figure 5 that these investments would have a positive effect on the sustainability of the energy system, thereby lowering environmental concerns of citizens. This will lead to lower grassroots investments in energy conservation and renewable energy production. In this way, there is a 'crowding out effect' of community-based investments by government spending (Menges, 2003; Popp, 2006; Van den Bergh et al., 2011). In general, it can be recommended to design combinations of interventions that affect the different subsystems, so that unintended effects in related subsystems are counteracted. For example, one might envision government programs that do not crowd out private investments, for instance by combining conventional investments in energy conservation and renewable energy production with providing funds to support grassroots activities (Seyfang and Haxeltine, 2012; Walker et al., 2007).

Installing renewable energy production capacity lowers the incentive to invest in renewable energy production

Besides the crowding out effect discussed above, investments in renewable energy production have a more direct unintended consequence. A counterintuitive insight that followed from the model is that subsidizing renewable energy production as a consequence lowers the incentive to invest in additional renewable energy production. Renewable energy production is characterized by high up-front costs and low variable costs. Once the renewable energy production capacity is installed, the energy market is supplied with energy that has low costs during times of high solar and wind energy (Sáenz de Miera et al., 2008; Sensfuß et al., 2008). Fossil energy production is faced with substantially higher marginal costs because generators continue to run on fuel. Several participants in the workshops mentioned the low, and on occasion even negative, spot prices on the German and Danish electricity market as an example of this effect. High electricity prices may be one of the reasons for energy consumers to decide to build their own renewable electricity production. In doing so, they lower their sensitivity to energy market price volatility. The decrease in energy market price due to the lowering effect of renewable energy production lowers the motivation for energy consumers to build their own capacity. To mitigate this effect, we recommend combining support for renewable energy production with other policies, like CO_2 pricing (Hirth and Ueckert, 2013).

The energy transition asks for an explicit exit strategy for the fossil industry

Given a certain demand for energy, new energy production capacity is only necessary in the pace that old energy production capacity is decommissioned. Fossil power plants typically have a lifetime of several decades, and in the Netherlands several new fossil power plants have recently been built (Graus and Worrell, 2009). This makes the Dutch energy transition substantially different form the transitions in countries that either do not currently have a large number of fossil power plants such as Denmark (Lund and Mathiesen, 2009), or countries that explicitly chose to close down nuclear power plants because of safety reasons such as Germany (Smith Stegen and Seel, 2013). If the Dutch energy transition objectives are to be met this asks not just for building renewable energy production capacity in addition to fossil capacity, but this asks for the *replacement* of fossil production capacity by renewable energy production capacity. Moreover, the model in Figure 5 shows that the two reinforcing mechanisms that speed up the energy transition both include the ‘creative destruction’ (Schumpeter, 1942) of the fossil industry. Policies aimed at supporting this ‘creative destruction’ may consist of shifting investments from fossil industries and of reducing the threats that accompany such a shift by compensating financial losses for fossil companies (Arbuthnott and Dolter, 2013).

Acknowledgements

Funding for this project was provided by Next Generation Infrastructures and Alliander. We are grateful to all stakeholders that participated in the workshops that provided the input for this study. We thank our Alliander colleagues Eltjo Beretty, Marisca Zweistra, and Pieter van der Ploeg for their help with inviting stakeholders and organizing the workshops, and our Radboud University colleagues Brigit Fokkinga, Marleen McCardle, Inge Bleijenbergh, and Hubert Korzilius for their help with facilitating the group model building workshops. We thank Tjerk Wagenaar, Annemieke Traag, Behzad Rezaei, Peter Molengraaf, and Jan Jonker for their keynote presentations, which formed wonderful contributions to the conference in which we informed the participants of the workshops on the results.

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