WHO IS THE WOLF?

A SYSTEMS VIEW OF ENERGY TRANSITION IN THE NETHERLANDS

WHO IS THE WOLF?[1]

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[1]**Disclaimer:**

The present document is a literal translation of a report originally published in 2015. It has not been updated to reflect recent developments such as the Dutch Climate Law (Feb 2019) and is intended to describe and illustrate the process that was followed. The views expressed in this document were those of the authors at the time of publication and do not necessarily reflect their views today, nor the official policy or position of any other agency, organisation, employer or company.

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FOREWORD

'In a complex, globalised market society, the advancement of various public interests will in certain circumstances also require the collective efforts of parties other than the government,' the Scientific Council for Government Policy [WRR] contends in its report 'Publieke zaken in de marktsamenleving' [Public affairs in the market society] (2012). It is self-evident that the transition to a sustainable energy system is a complex societal issue involving crucial public interests. In line with the referenced WRR report, this issue must be considered and discussed with various public and private parties.

The complexity perspective starts from the notion that society is a complex system, full of non-linear feedbacks and evolutionary dynamics, driven by a diversity of actors, linked in networks and embedded in social practices. However, the concept of complexity is still highly abstract and there remains a gap between theory, on the one hand, and empiricism and practice, on the other. At the same time, policy practice and the business community are experimenting with the governance of complex systems with a view to the future.

Yet it is clear that where the theme of complexity may have significant added value to thinking and acting towards a sustainable energy system, this notion should not obstruct the view of the special responsibilities for which public and private actors are and will remain accountable. On the contrary, the focus must be on honing in on these responsibilities and this accountability in the context of constructive and future-proof collaboration.

Uniting theory and practice may contribute to an improved empirical basis for the complexity approach, but above all to finding a set of tools that may augment policy practice. Given the importance of the issue and the discussion about it in public and private circles as well as from the perspectives of knowledge and policy, and because the theme concurs with the studies under the WRR project 'Handelingsperspectieven voor duurzaamheid' [Action perspectives for sustainability], experts of the Scientific Council for Government Policy (WRR) participated in two workshops initiated by Roland Kupers, co-author of 'Complexity and the Art of Public Policy'. During these two-day workshops, a wide variety of participants debated the added value of a complexity perspective for an energy transition in the Netherlands.

It is important to establish links between public, private and social parties in the societal debate and to communicate the findings of this field experiment in a transparent manner. To that end, Roland Kupers, et al. Wrote this reflection, based on the discussions during the workshops. This publication is not a report of the workshops, but outlines the ideas on complexity and energy transition that were put forward and provides an impetus for establishing the link between theory and practice.

The authors are responsible for the text of this publication and would like to thank the workshop participants for their rich and varied contributions to the discussions.

'Anyone allowing a complexity perspective to sink in will become aware that it opens a vessel of new opportunities, an entirely new perspective on control, change and transition,' the authors write in the epilogue. I hope readers will gain a lot of new and useful insights and ideas.

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In 1995, the wolf was reintroduced to Yellowstone National Park. The story of this reintroduction effectively illustrates how a cascade of unexpected effects can be explained on the basis of the complexity of ecosystems: when wolves took up their place in the ecosystem again after seventy years, this changed the grazing behaviour of deer, which in turn helped the ecosystem in the valleys to thrive in all its diversity. Ultimately, this even changed the course of rivers, as the recovered ecosystem counteracted erosion in riverbeds. In this context, the wolf is the driver of recovery of the ecosystem as a whole, including the riverbeds. This illustrative depiction of the dynamics in a networked ecosystem demonstrates how a relatively minor intervention can affect many parts of that system. The challenge for policy lies in looking for this type of effect, in the realisation that a high level of impact goes hand in hand with a low level of predictability.

Looking at the world around us from this perspective exposes similar patterns and processes at all levels of scale. Economies are connected across the globe, as a result of which developments at the other side of the world may have direct local effects: after the relatively small-scale Greek economy caught a cold, it infected much larger Europe. Insights into complex systems show how local effects trickle down to other systems. In essence, complex systems are about connectivity: plexus means to braid, and complexity is the science of braided or interconnected systems.

In this publication we will explore a systems perspective on the Dutch energy transition. We are looking for the wolf: policy interventions in or outside of the energy system that may help accelerate the energy transition. Phrased differently: we will explore how we can find wolves and how we can envisage the possible effects of their introduction.

The political debate on public policy is often characterised through the dual frames of state and market: societal issues are solved by means of direct government intervention or through the market mechanism. Based on what are often ideological considerations, this contrast suggests a limited set of strategic policy options. The question should be posed whether these are the only two flavours in the policy-makers' book of recipes.

In recent decades, science has witnessed a gradual revolution under the banner of 'complexity'. Like all fundamental developments in science, this will ultimately have consequences for the political debate. In this reflection we will investigate how a complexity perspective may help us look at strategic policy options for a transition to a more sustainable energy system through different eyes.

A new frame is most immediately visible in language. A key part of this narrative therefore comprises in the formulation or reformulation of existing and new solutions in a 'systems language'. This may on occasion be familiar, but often it will not. We will explore the systems language for complexity in Chapter 2.

But first, Chapter 1 provides an overview of what is meant by an energy transition, in which we find that this process is relatively slow in the Netherlands compared to other countries, that government control en market mechanisms play a role in the debate on energy transition, and that means and goals often overlap and intersect.

The energy transition is aimed primarily at factors that directly impact energy use and their related emissions. The energy system is defined as the sum of energy technologies, energy producers and energy consumers. Use of the term energy system serves to create a clear delineation between what does and what does not belong to that system. In practice, the natural boundaries that distinguish one system from the other are often elusive. The consequences of the reintroduction of the wolf in Yellowstone, for example, were not limited to the fauna in the area. And conversely, if the park rangers had wanted to reroute the riverbeds, would they have ever thought that reintroducing the wolf might be a solution? As such, it is impossible to determine in advance how narrowly or broadly the energy transition system must be described to be able to identify our wolf.

In Chapter 3, we will address energy policy from this perspective. Looking at the energy transition through the lens of complexity reveals different possibilities, resources and opportunities. This systems perspective offers a cognitive framework for looking at issues such as an Agreement on Energy not only in terms of target reach, but also as a means for establishing networks, accommodating stakeholder diversity or adaptation. We will argue that a complexity approach may help supplement and augment the traditional toolbox of policy instruments. In Chapter 4, we will zoom out from energy policy and consider the policy fields that become visible when looking at the system from a broader perspective. As indicated above, our description must be considered a search for the energy transition wolf. We explicitly do not intend to pass judgement on the policy fields discussed on the basis of this search. However, our search will provide a number of insights that we hope will be conducive to the development of policy aimed at the energy transition. And, more generally, these insights are relevant for thinking about how we can use a complexity frame for developing policy. This is discussed in Chapter 5.

In separate boxes throughout the text we describe examples of possible solutions in the language of systems. Of course we do not presume to present a full set of solutions within this brief scope, but we do want to place the issue in a different context. Any systems perspective comes with significant uncertainties, and predictions cannot be made. However, we can think about the complexity of the energy system, about identifying decisive transition factors, and about opportunities for creating smart policy to make adjustments at systems level. Perhaps specifically the Netherlands, wedged between the Anglo-Saxon and Rhineland approaches, can provide a new perspective on systems change and policy.

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THE HESITANT DUTCH TRANSITION

What is a Dutch energy transition?

The challenge for the European energy system is to be virtually CO_2-free by 2050. This is a clear target, driven from the desire to address climate change. For the Netherlands, this means a drastic change in its energy system. The clock is ticking, but a lot is possible in 35 years: in 1980, there was no internet yet, we programmed using punch cards, teletext was introduced as technological tour de force, and the public transportation stamping ticket was rolled out. A world of difference with the situation today. The main environmental problems at the time were soil pollution (Lekkerkerk), acid rain ('Waldsterben') and overfertilisation. Problems that could primarily be described as technical issues and that led to major improvements in the quality of the living environment in subsequent years. It was also the year in which unleaded petrol was introduced, celebrated as a significant advance in air quality improvement. This goes to show that a lot can change in a few decades.

The resources for a large-scale modification of the energy system are available: second to Luxembourg, the Netherlands is the most prosperous country in the European Union. The interest on Dutch government bonds in the capital markets is at a historic low (sometimes even negative) and the national debt is limited, particularly if, for a consistent comparison, the collective assets of pension accrual and housing corporations are included. The energy sector covers a limited part of the domestic economy, but does make a substantial contribution to export and has a significant impact on the national budget through the income from natural gas. So there also are potential resources along those lines. While the stakes are large, in principle the total investments do not seem excessive.

Technologically much is possible: many of the technologies necessary for a fossil-free energy system are already available in the market and sometimes also economically performing.[3] Neighbouring countries like Germany and Denmark preceded us in their choice for a sustainable energy transition; the Netherlands can benefit from the rapid cost reductions this entails.

By itself, an energy transition in the Netherlands would not appear to be that difficult. But why is it so hard to achieve in practice?

Piano, piano...

In a recent report[4] on energy policy in the Netherlands, the International Energy Agency (IEA) states that "Despite the significant progress in decoupling emissions from economic growth and industrial energy efficiency, the Netherlands remains one of the most fossil fuel- and CO_2-intensive economies among IEA member countries. The share of fossil fuels in the energy mix is above 90%." Besides the closure of 2.6 GW of coal capacity, the Netherlands adds 3.5 GW net: "Three additional coal plants with combined capacity of 3.5 GW are being developed. This development contrasts with wider European Union trends, where investment in new coal-fired power plants is scarce [...] and most countries are reducing their coal fired capacity."

Developments in making the Dutch energy system more sustainable are slow, especially compared to neighbouring countries. However steps are being taken: for ten years, the Netherlands explicitly pursued an 'energy transition policy' and in 2013 various social parties entered into the Agreement on Energy for Sustainable Growth. Yet the cumulative results seem modest.

It must be possible to do better.

The energy sector is not an isolated industry and connects to almost every other sectors of the economy. The energy system is a web that covers society as a whole. As a result, changes in the energy system are by definition societal transitions. Moreover, the energy system depends on other economic subsystems; change is not just about new technologies, but also concerns new market constructions, cultural factors of existing and new stakeholders, routines and challenging of accepted economic truths. All this has far-reaching consequences for any energy transition approach.

Countries also handle this is in different ways. Germany is committed to the *Energiewende*, a programme for an energy transition in which industrial policy is combined with the close involvement of citizens. The development and application of sustainable and often decentralised energy technologies has resulted in a major shift of the energy system over a fairly short period of time. The approach is strongly bottom-up, with the formation of flourishing energy cooperatives and the installation of the inevitable solar panels and wind turbines. There is a broad basis of support for the Energiewende, and the notion of a sustainable energy supply has almost become part of German identity.[5] On the other hand, Germany bears a large part of the initial expenses of technology development, which makes the Energiewende a costly programme. Moreover, what are by now relatively low-carbon gas-fired plants in the energy market are being outranked out by more polluting but cheaper coal-fired plants, which benefit from cheap imported coal and from a poorly functioning European emission-rights market.

Great Britain has a completely different approach. It focuses mainly on enhancing centralised generation capacity, and for its sustainable energy technology overwhelmingly looks to large-scale offshore wind parks. At the moment, this process plays out primarily through the development of what is known as a capacity market, in which major producers receive compensation for keeping capacity on stand-by. In practice, this usually means extending the economic life of coal-fired plants that would otherwise have been written off. Great Britain also invests – at exorbitant public cost – in additional nuclear capacity near the existing Hinkley Point plant.[6] Citizens are hardly involved in this – the political sympathy for shale gas even appears to diametrically oppose this. There are major differences in the approaches of the countries in Great Britain, with Scotland focusing on wind on land and a strongly bottom-up development of a strategy for sustainable development in Wales[7], while England devotes a relatively great deal of attention to maintaining (often aging) capacity.

The picture of the energy transition in these two nations is radically different: the Energiewende in Germany is a far-reaching systemic change of the German economy and the German society, while Great Britain follows a more top-down technological approach to reduce CO_2 emissions. Great Britain uses a combination of market mechanism and government intervention to renew the energy system, while the transformation in Germany is more far-reaching and also affects adjoining systems.[8]

However, there also are striking similarities, particularly the role of anchoring policy in law. German policy for making the energy supply more sustainable is based on the Erneuerbare Energien Gesetz, a statutory framework introduced in 2000 providing for, among others, feed-in tariffs for sustainable energy products. (The EU scheme was amended in 2014, to include modification of a number of the feed-in tariff principles. The significance of these modifications was not discussed during the workshop and not studied for this publication.) In 2008, Great Britain introduced the Climate Change Act, a roadmap for CO_2 emission reductions until 2050.[9] A major distinction is that Great Britain has tried to keep the statutory basis outside of politics with its Committee on Climate Change, while Germany keeps it close to politics. This may explain the difference in the breadth of societal support.

Cultural factors undoubtedly play a role in these differences between the British and German approaches. The importance of cultural factors has also been pointed out for the Netherlands. Ben Coates, author of the book Why the Dutch Are Different: A Journey into the Hidden Heart of the Netherlands, concludes in The Independent: "The Kingdom of Orange is not very green". He refers to the Dutch tendency to consider nature as something that must be protected against, rather than actively protected. Coates elaborates on this as the cultural context for the lag in the Dutch energy transition: "Holland has a dirty secret. To outsiders, it may seem a green idyll, where cycling and recycling are the norm. But scratch the surface [...] and you find a crowded, carbon-spewing, urban nation spectacularly addicted to fossil fuels."

Culturele factoren spelen ongetwijfeld een rol in deze verschillen tussen de Britse en Duitse aanpak. Ook voor Nederland is wel naar het belang van culturele factoren verwezen. Ben Coates, de auteur van het boek *Why the Dutch Are Different: A Journey into the Hidden Heart of the Netherlands*, concludeert in The Independent: "The Kingdom of Orange is not very green". Hierbij wordt verwezen naar de Nederlandse neiging om de natuur te zien als iets waartegen primair bescherming geboden moet worden, eerder dan iets om actief te beschermen. Dit wordt door Coates uitgewerkt als culturele context voor de achterstand in de Nederlandse energietransitie: "Holland has a dirty secret. To outsiders, it may seem a green idyll, where cycling and recycling are the norm. But scratch the surface [...] and you find a crowded, carbon-spewing, urban nation spectacularly addicted to fossil fuels."[10]

While the importance of cultural factors may be debatable, these considerations do beg the question: is a different perspective conceivable that would help us advance our conception of the energy transition in the Netherlands?

A traditional perspective

With a traditional perspective on policy issues such as the energy transition, there is always the risk that an approach is chosen that does not or not sufficiently accommodate the complexity of the system itself. That could make policy inefficient, ineffective or even counterproductive. That is a lesson that also can be learned from other policy fields. In development cooperation, for instance, we have seen wasteful examples from an overly simplistic approach justified on the basis of the idea that a system can be guided in the right direction from the top down.[11] And innovation policy, conversely, places excessive trust on the market to ultimately adopt the innovations invested in at any given time. Here, an overly linear perspective dominates on the chain from knowledge, through innovation, to economic growth. In both cases, policy theory (i.e. the ensemble of causal relations and other assumptions on which policy is based[12]) is insufficiently attuned to the complexity of the system.

In energy transition policy too, the change in the energy system itself is often considered a relatively straightforward issue. The energy system is then described as a simple system, i.e. a system intelligible through well-delineated, linear dynamics. This is a pre-eminently reductionist approach in which the features of the system are considered the sum of the individual parts. In this perspective, the energy system consists of right-minded, rationally operating actors who knowingly consider the pros and cons, without having to justify any relevant societal environment. The dynamics of such a system are entirely causal, which means that any action, such as a policy intervention, has a direct, proportional and predictable effect.[13]

Such a non-complex and static systems frame dominates in many policy fields, and certainly also in energy policy. An example of a static systems approach is the use of technological cost abatement curves.

In 2007, McKinsey & Co (a consultancy) introduced the 'carbon abatement curve', which provides a seemingly simple and transparent comparative overview of the cost effectiveness of different measures for reducing CO_2 emissions (Figure 1). This has the benefit that

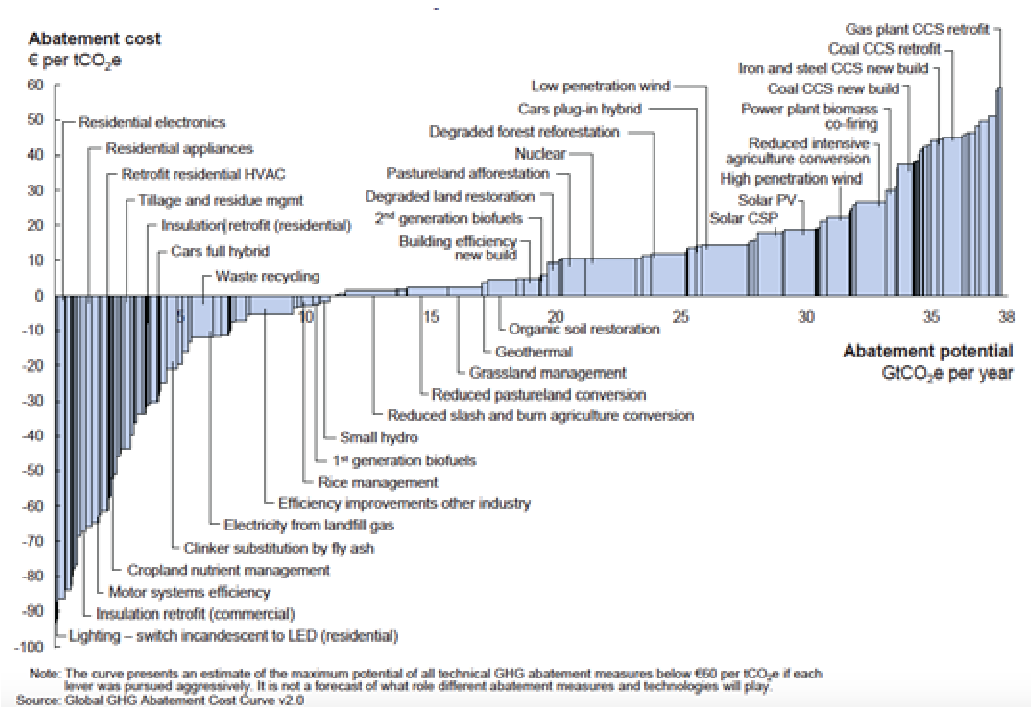

Figure 1
McKinsey abatement curve, in which the abatement potential (in Gt CO_2 per year) of a large number of energy technologies is plotted against the abatement cost or revenue (in euros per tonne of CO_2 avoided).

wide-ranging technological interventions can be readily compared, regardless of the sector in which they are used. That way measures in, for example agriculture, the energy sector, industry and built environment can be compared. A 2009 version of this curve describes how replacement of light bulbs by LED lighting is most cost-effective (in terms of yield per tonne of CO_2 avoided), while capturing CO_2 in existing gas-fired plants is only possible at exorbitant cost.[14] This data representation has proven very popular, and specific versions have been made for all kinds of countries, sectors and companies.[15]

This approach is an example of a simple, static systems approach. The implicit assumption is that different measures are independent of each other. However, that assumption is only reasonable in a stable and balanced market with relatively mature technologies. But the market for energy technologies has strong feedback mechanisms, not least because the learning curve of technologies depends on their application. This means that the prices for technologies decrease in relation to the installed capacity, sometimes spectacularly so for new technologies. The graph from 2009 shows that photovoltaic (PV) solar energy would be more expensive than Concentrated Solar Power (CSP), an assumption that was superseded only a few years later through the rapid cost reduction of PV. Cost reductions arise largely from learning by doing: it is during production and installation that lessons are learned that continue to decrease costs.16 Learning curves are of particular importance for new technologies, but there is no room for these dynamics in this kind of graph. The abatement curve is a description of the state of the art at a particular moment in time, independent of the rate of installation of investments in further innovation.

The abatement curve approach also disregards interdependencies between the technologies in the energy system. E.g. the climate benefits of heat pumps in an extremely well insulated home are much lower than in a house with a large heat demand. Interdependencies can also arise through social norms: someone who buys solar panels may also be more likely to buy a hybrid car. Technological development essentially consists of combining existing developments.[17] This results in a high level of interdependency between energy technologies. Interdependencies with systems outside the elements in the graph have not been considered, but cannot be ignored; consider for instance, the availability of biomass in competition with other forms of land use, or the production of energy in waste incineration plants, which in turn depends on the availability of waste.

All measures on the left-hand side of the graph are net positive. The question why they have not been implemented yet can be compared to the well-known joke about an economist who does not pick up a bank note lying in the street, because for a homo economicus it cannot be lying there. If they are so profitable, why were the measures on the left-hand side not implemented under the influence of market forces? These cost curves do not recognise barriers such as transaction costs, lock-ins, lack of trust, ignorance or market failure. However it is not meaningful to insist that a measure is profitable in principle, when either its costs have been underestimated or the returns are not a decisive factor.

A final objection is the lack of uncertainty margins in the cost estimates. A simple comparison of the graphs throughout the years demonstrates that large margins would have been appropriate – but such numbers are time and again presented to policy-makers as facts about the future. This dulls the incentive for formulating more adaptive policy, which will adjust to changing developments within the bounds of possibility.

While the above approach emphasises static calculations, we also know that dynamic developments resulting from innovations and learning processes are extremely important. The abatement curve approach creates a suggestion of 'certainty', while a complex system is characterised by uncertainty. A different perspective is urgently required, but the influence of traditional approaches appears to be undiminished.

The influence of economic models

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Market stability is trivial and not even an interesting question - M. Friedman

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Macro-economic models play a central role in the analysis, formulation and justification in many aspects of policy. There also is much modelling in the field of energy, see for example the computation of the consequences and feasibility of the Energy Agreement.[18] Such exercises are often used in policy and politics to justify statements on the costs and benefits of different policy proposals. But how applicable are these models to the energy transition?

The basic assumption of most macro-economic models is the idea that there is an optimum equilibrium. This idea was adopted from physics by the 19th-century economist Walras, shortly after formulation of the first law of thermodynamics, the law of conservation of energy. This economic model was increasingly refined in the 20th century, while physics was meanwhile exploring radically new paths, not least of which the second law of thermodynamics.[19]

The equilibrium model basically states that a system always returns to a situation of equilibrium and rest. This can be illustrated by a spacious, smooth bowl, in which a ball is rolling until it has found the stable optimum on the bottom. The equilibrium is the starting point for analysis: in a market, the price of goods is an expression of an equilibrium between supply and demand. In this perspective, the equilibrium is also stable: if demand increases, the adjusted price will immediately create a change in supply and therefore a new equilibrium. Many welfare economics models lack monetary variables: there is no capital, and therefore no financial sector, there is no division of capital (and therefore no inequality), and a suggestion (albeit unjustified) of financial stability in the long term. Time usually does not play a significant role either: after a disruption the system will always return to its equilibrium, regardless of, for instance, the social and physical developments that may have taken place in the meantime. Policy based on equilibrium models places a lot of emphasis on confidence in the stabilising effect of the market.

However, a complex system can be much better characterised through the topography of a rugged landscape than as a closed equilibrium system in a smooth bowl. There are multiple dynamic equilibria, temporary states of rest and stability, followed by rapid changes towards a new more or less stable situation. The dynamics in a complex system is characterised by cascade effects and tipping points; minor causes can have major effects. A complex system therefore does not lend itself readily to predictions about its future. Moreover, a complex system is not sharply demarcated, which means that external causes may sometimes unexpectedly play a major role; in practice no effects are completely external.

But modelling the interactions in and around the complex system is fiendishly difficult. The relatively simple characterisation through macro-economic equilibrium models no longer suffices. This is not a new idea, but its consequences are only accepted to a very limited degree. Equilibrium economics prefers quantifiable risks over elusive uncertainties. Equilibrium models are also used for the energy transition to make predictions about the economic consequences of measures (costs, benefits), but the predictive value of such calculations should be strongly challenged.

Does this mean that we should give up on modelling the economy? Certainly not. First of all, there are many other reasons for modelling in addition to prediction, such as getting to know and explain internal dynamics, exploring uncertainties and trade-offs, or recognising new questions.[20] In addition, we can learn to model complex systems with, for example, agent-based models or use micro-economic models to better understand the consequences of all kinds of variations.[21] Modelling complex systems may help to reconceptualise problems, in the case of the energy transition by means of, for example, elaborating concepts such as path dependency, lock-in, technological regimes, co-evolutionary dynamics, learning effects, and competition between technological systems.[22]

This provides room for a different assessment of the dynamics of the system. Equilibrium models have no *feedback* mechanisms or learning effects, leaving no room for positive *feedback*. As a result, the effects of specific policy measures are often underestimated. An alternative approach can be found in the study 'A new growth path for Europe'[23], which takes into account systemic effects such as learning by doing and expectations managements and, as such, provides a significantly more optimistic view of the potential of climate policy.

Conversely, there may also be negative *feedback*, which in turn renders a specific institutional or infrastructure lock-in more permanent. In that case, we can extract policy lessons about the competition between technological systems[24], or about the relationship between niche markets, competition and economic growth.[25]

Standard economic models are used both in the Netherlands and internationally to quantify and predict the economic consequences of climate policy. These conclusions have major consequences for the energy transition, but are in their essence misleading. The standard equilibrium models are applicable to other problems than the energy transition. The conclusions based on traditional equilibrium models must therefore be considered with a significant degree of restraint.

The influence of administrative models

Complexity is not a new concept in Dutch public administration.[26] Yet there are good reasons why it is difficult for policy-makers to apply insights to policy development from administrative variants of complexity theory. Culture, organisation and procedures in public administration are, after all, strongly grounded in a control philosophy that is at odds with the complexity perspective.

As in other countries, public administration in the Netherlands is in essence a bureaucracy. The idealised bureaucracy has been developed as a key pillar of the democratic constitutional rule of law. Bureaucracy has its origins in the pursuit of a government that protects its citizens against arbitrary administrative and political action. General principles of good governance, such as the legitimacy principle and the principle of equality before the law are deeply embedded in the organisation of government. Accountability mechanisms include, among others, the controlling power of Parliament, which is so important for a representative democracy.

In the eighties, public administration in the Netherlands was influenced strongly by the idea that bureaucracy could be much more efficient based on administrative principles from market organisations. The philosophy of governance of *New Public Management* put great emphasis on the efficiency of an organisation and on measuring performance and output indicators.[27] This emphasised quantifiable results, for which it had to be 'demonstrated' that they had been brought about by government efforts. And although the idea of accountability was consistent with the existing bureaucracy, this also resulted in a fairly limited view of responsibilities. From the point of view of New Public Management, the most efficient way to deal with complexity is through a clear deconstruction in tasks and responsibilities. As a philosophy of governance, New Public Management seems to be on the wane, but new conceptual frameworks such as a complexity perspective only trickle down to policy practice in dribs and drabs.

Towards a complexity perspective

We have ascertained that there are three challenges for the energy transition in the Netherlands:

1 - The energy transition in Netherlands is proceeding relatively slowly, particularly compared to neighbouring countries such as Germany and Denmark.
2 - The policy for energy transition appears to be solidly embedded in traditional conceptual frameworks, with an emphasis on technological, economic and administrative stability and control.
3 - There is little distinction and, therefore, confusion between government control and market mechanism, and between goals and means.

The next chapter will describes how the complexity frame can serve to respond to these challenges. It can help us develop a new approach, based on both the dynamics of complex systems and a fresh look at the core considerations of policy. The complexity frame is not a refinement of the existing perspective, but a fundamentally different framework.

02

THE TRANSITION THROUGH A COMPLEXITY LENS

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Our world is full of complex causality; causal loops and spirals, events with multiple contributing causes, chaotic oscillations in the weather, the stock market, the ecology. Understanding complex causal systems is fundamental to navigating the contemporary world, yet complex causality gets no more than an occasional nod under the label of systems thinking... ...Awakening learners to these more complex patterns is half the battle. The other half concerns how easily we can overlook what's going on. Drawn to salient events, we may, for instance, never ask what keeps systems constant, miss problematic patterns that play out only now and again, and neglect possible causal influences far away in time and space. - David Perkins[28]

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Complexity as a lens

Classic approaches in terms of 'market' and 'state' offer insufficient policy perspectives for complex systems. We will have to look for a different approach. We need a new frame, one that goes beyond the traditional duality of government activism and market thinking.[29] That is no easy feat; economist Herbert Simon already pointed out that in order to replace outdated paradigms, we first of all need an alternative, more accurate and more realistic approach.

In this publication, the energy transition is considered through a *complexity lens*, a perspective in terms of complexity and dynamics, feedbacks and networks, resilience and vulnerability. This is aimed not as much at the question of how a system can be organised optimally and efficiently, as at how we can think about the policy prerequisites that are in line with the dynamics and resilience of a system. In turn this would offer the foundation for more effective policy.

For this purpose, we can leverage insights from complexity science.

Our starting point is that the energy system as a societal system can be described as an open and *complex adaptive system*. A complex adaptive system can be defined as "a system in which large networks of components with no central control and simple rules of operation give rise to complex collective behaviour, sophisticated information processing, and adaptation via learning or evolution".[30] Complex systems are studied through multiple disciplines, including economics, ecology, psychology, physics and information technology. Stephen Hawking characterised complexity as the science of the 21st century.[31]

This does not mean that complexity in itself is new, but the way in which these systems are considered is new.[32] An important step is the realisation that more research does not necessarily lead to greater insight and better predictability. The 'classic' scientific approach emphasises reductionist analysis of separate components, based on the idea that a better understanding of these parts would also lead to a better understanding of the system as a whole, the sum of the parts. In complex systems, this line of reasoning has to be cast aside. The dynamics of a complex system is determined by the nature and structure of the connections within the system, rather than being based on an understanding of its separate parts. Complex systems cannot be understood from the separate components, as they are more than the sum of their parts. This means that a systems perspective is required to really understand the bigger picture.

In a complexity frame, the stability of a financial network is not the result of the sum of the health of individual banks, but mainly of the structure of the network of which they are part. Changes in a complex system are not the outcome of the addition of the separate actions, but of the interactions between the components of the complex system. That seems difficult, but there are familiar examples in daily practice: How do fashions and hypes come about? What causes sudden changes in the political landscape? How can we understand fluctuations on the stock markets?

Illustrations of looking through a complexity lens

Traffic engineer Hans Monderman (who invented the Dutch concept of 'Woonerf') contended that, under certain circumstances, the removal of all traffic signs and traffic lights would lead to faster and safer traffic flows. He described this idea through the concept of 'shared space', in which traffic lights and lines on the road are replaced with a form of self-organisation by traffic participants. Anyone familiar with Bangkok, Cairo or New Delhi knows that this does not necessarily lead to a smooth circulation of traffic, but careful design and intelligent top-down intervention can be used to unleash the dynamics of the complex traffic system. It is not the lack of rules but it is the existence of an ecosystem determined by common social norms, efficient administration of justice, technical inspections, driving licences, etc., that makes self-organisation possible. The shared space concept has already been successfully applied in towns such as Drachten en Linz.[33]

In recent years, the banking sector has amply demonstrated that its vulnerability lies not only in individual banks, but in the cohesiveness between banks in the financial system. Back in 2008, complexity scientists pointed out that this formed a veritable ecosystem of deeply interdependent banks.[34] This described the sector in terms of a complex system vulnerable to cascade effects: the interconnection was so strong that toppling of one or a few banks would affect the entire sector. There was a 'systemic risk'. From this perspective, central banks would have to be tasked to not merely look at individual banks but also take responsibility for the topology of financial networks.[35]

A third example concerns the persistence of conflict situations, which sometimes disrupt countries for decades on end. In principle, conflicts can occur anywhere, but in some situations there is a vicious circle of action and reaction that results in increasing escalation and ultimately perpetuation of the conflict itself. If external forces decide to intervene, for example through military action or sanctions, the underlying idea is usually that it concerns 'a problem that needs to be solved'. In practice, however, that is rarely the outcome. An analysis of protracted conflicts shows that it is much more productive to approach a conflict in terms of lock-in, with the underlying dynamics of a complex system. This requires an approach in the form of engagement: "Success doesn't mean that we've ended the conflict, it means we've engaged a system so that violence declines over time".[36]

The general lessons we can infer from these examples is that a different frame may have major added value for what policy should and can do. This brings about a major shift. From management based on detail or in terms of the regulatory market, to a form of systemic responsibility. Can the system work? What are its vulnerabilities? Which actors determine dynamics? And so forth. This not only requires a 'mental shift' from the managers and officials involved, but also from the 'recipients' of policy: governance is more about continuous interaction and adjustment than about one-way traffic emanating from an all-knowing government.

We can learn from examples in many policy domains, as they offer best practices or provide insight into how policy can be drafted by learning.

A view on complexity

A number of concepts and terms is relevant to understanding all complex systems. We list six elements that distinguish a complexity approach from other, more static and classic approaches.

DThe first three notions relate to the description of systems as complex adaptive systems. This concerns the *actors* in the system, the interconnections between these actors in *networks*, and the mutual influencing via these connections in the form of *social norms and practices*.

The next three notions relate to processes and dynamics in complex adaptive systems. *Evolution* and *path dependency* describe processes resulting from dynamics at population level. *Emergence* and self-organisation describe developments in network structures. *Non-linear dynamics* describes the dynamic effects of these mechanisms for the complex system as a whole.

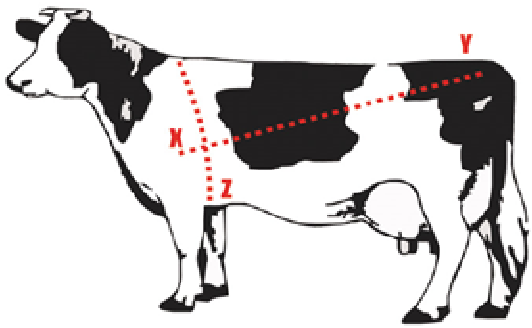
Actors

Complex systems do not have a homogeneous population of rational actors, but exhibit diversity and differences. Actors (individuals, institutions) have different motivations for their actions; they often act on the basis of routines and habits. For a classic economist this means the actor is not rational, but everyone, you and me, acts (often unconsciously) in accordance with a spectrum that is much broader than just costs and benefits. Moreover, we have the ability to learn and modify our considerations. In the field of behavioural economics, a lot of research is being carried out into the possibilities of influencing the behaviour of these boundedly rational actors.[37]

In complex adaptive systems, bounded rationality is only one of the relevant characteristics of actors. Diversity and heterogeneity of actors are important and often even decisive factors for the dynamics of complex systems. This is clear, for example, from the ability that a social group has to solve new problems. Social groups have the ability to explore a wide range of possibilities and adjust to new circumstances, provided there is room for diverse contributions, such as 'the wisdom of the crowds'.[38] This ability is not as large if there is a rigid form of leadership based on 'knowing how things are done' or in homogeneous groups affected by 'groupthink'. It is usually not the averages, but the exceptions that determine the course and social rhythm – the history of arts has been written by *mavericks*. Moreover, diversity is often not a normal distribution, but involves a high proportion of 'average' and a large number of exceptions.[39] This also means that policy based on averages rather than the spectrum of differences leaves out something essential.

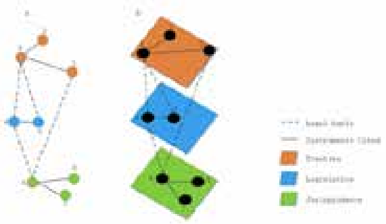
Networks on multiple levels

Social structures, the internet, the structure of (organically grown) cities or the structures of markets and trade flows are complex systems that can be described in terms of relations and interactions between different components of a network. These are not highly structured, hierarchical networks, but neither are they organised entirely arbitrarily. These more or less organically formed networks are characterised by a structure in which some components in the network have more connections than others and specifically to components that are relatively more distant than their immediate neighbours. Such networks are called 'small world networks', because information spreads much more rapidly through such networks than through other types of networks. Their structure and properties are fundamentally different from those of homogeneous networks, in which all nodes have approximately



In The *Wisdom of Crowds* Surowiecki describes how, under specific circumstances, a diverse group of people can make a better estimate than individual experts. He quotes the famous example of Francis Galton, Darwin's half-cousin, who observed how the crowd at a county fair assessed the weight of an ox more accurately than an experienced cattle farmer. Other studies showed how crucial the diversity of participants is for this kind of collective knowledge.[38]

the same number of connections. They are also fundamentally different from 'star networks', in which some nodes have a great many connections, while most nodes have only one or a few connections. In small world networks, a minor variation in the number of connections has a major impact on the speed of information propagation.[40]
Policy-makers must first and foremost understand the type of network they are dealing with, as the typology is key to the dynamics within that network. When dealing with a social network, it is important to account for the network centrality of the specific hubs, which can act as key accelerator (or conversely as counterforce!). At the same time, a network is also vulnerable if a hub has an overly dominant role in a network. Loss of such a component could cause the entire network to collapse.[41] Networks with relatively few connections are also vulnerable, because they buckle easily. But overly dense networks, with large numbers of connections, run the risk of short-circuiting. Finally, it is also important to consider the cohesion of networks. In principle, a social network has no boundaries and has the same *small world* characteristics at all levels of scale. As such, *small world* dynamics is independent of scale.



The type of network structure is not always visible, but it does determine to a great extent how a system behaves. Researchers at Cornell University describe how European legislation is a network of rules with a 'small world' structure. This type of network can also be found in nature and the internet. While very resilient, they are also vulnerable to attacks on the nodes.[42]

Social norms and practices
Social norms and structures usually do not play any role of significance in standard economic models. Economic considerations are a matter of individual rationality. However, in practice, human behaviour appears to be influenced strongly by its social environment.[43] Habits are often transferred by means of social norms; this not only applies to – often explicitly designated – rules of behaviour, but also to more unconscious norms, routines and practices based on observation of others and the notion of what is considered 'normal' or 'suitable'. This may have far-reaching consequences. A phenomenon such as obesity is not just a result of heredity or individual behaviour, but is also determined by social norms. Habits are passed on within social networks, as a result of which obesity can be considered a contagious phenomenon.[44]

Social norms also play a key role in the energy transition, for instance in the adoption of new products such as hybrid cars or LED lights. Specifically Dutch norms may play a role in a more cultural interpretation of the energy transition. The Netherlands' relation with nature is utilitarian to a significant extent. The landscape is man-made and its location in the delta requires the control of natural forces. Nature exists for the Dutch, instead of being an exterior wilderness, without people.[45] WWF Netherlands was the first NGO to apply itself to the *development* of new nature instead of focusing primarily on the conservation of existing nature – a useful approach in itself, but at the same time also uniquely Dutch.

In a complexity frame, there is a continuous interaction between social norms, unconscious routines and practices, individual decisions and policy. It exhibits a complicated co-evolution. Social norms are determined by the set of individual decision and policy measures, but policy measures are themselves also embedded in social norms and political-cultural preferences. Moreover, social norms are not a stable given and continuously subject to change, even if these changes often go virtually unnoticed.

Evolution and path dependency
Dynamics in a complex system can be understood as an evolutionary process of differentiation, selection and retention. Differentiation comprises processes such as mutation (biology) or innovation (economics)

that result in new ways of functioning in a given environment. Selection is the process in which poorly adjusted ways of functioning are removed through competition in favour of well-adjusted ways of functioning (*survival of the fittest*, or survival of the most adapted life form). Successful versions can thrive through growth and development. In this perspective, the market is not as much the mechanism driving supply and demand towards an optimum price, as it is a selection mechanism, a test for the success or failure of new innovations and ideas. Such processes are also not unfamiliar in a capitalist economy: "In dealing with capitalism we are dealing with an evolutionary process. (...) Capitalism, then, is by nature a form of economic change and not only never is but never can be stationary".[47] A key consequence of an evolutionary perspective is that decisions or other developments can never be isolated in time: they always build on preceding developments. Every decision is historically embedded and in essence the result

In the wake of all convictions after the financial crisis, it was studied whether bankers are perhaps less honest than the average human being. The surprising result is that, in an experiment, bankers were only significantly less honest within the context of the financial world, but not outside that context. The social norms in the financial sector appear to be contagious and embedded in the organisation rather than in individuals.[46]

of an accumulative process. This is known as *path dependency*. Technological developments always build on previous innovations. This process is strengthened by the formation of embedding structures in the form of institutions, infrastructures or culturally determined routines.[48] The best-known example is perhaps the car, which is not only the preferred option for many people in terms of cost, but also because a sophisticated infrastructure has been developed for it over the past century, forcing competing technologies to start from that same architecture (see case about driverless cars, p.25). Path dependency shields the position of existing technologies and makes it difficult for new technologies to break-through.

Path dependency and lock-in not only follow from the physical infrastructure and economic embeddedness, but also from cultural and social dimensions. The formulation of future perspectives or the narration of stories may open the door to a new path and break the dependency on the old path. History matters. New paths will only open up if they can be imagined: 'Ah, so that's another possibility!' This is a subtle process that may have major consequences: With 'Room for the River', Dutch water management took a new course, building on a radically different discourse on dealing with water. This centred on the influence and uncertainties of the surrounding systems; water management as part of a complex network of systems.[49]

Emergence and self-organisation

In a complex system, the dynamic interaction between actors at micro-level results in structures and self-organisation at macro-level. It may appear as if macro-structures emerge 'automatically', but they are, in fact, the result of an aggregation effect. Such an effect is more than the sum of its parts: the flight of one starling cannot predict how a cloud of starlings is formed. Macro-structures (such as institutions) can be understood as resulting from bottom-up dynamics, but at the same time, structures in turn provide direction for dynamics at macro-level.[50]

Emergence is a concept we know from our own environment: traffic jams are not seldom the result of deviant behaviour of a few drivers, with a long chain of effect on the drivers behind them; the 'phantom traffic jam'. A lot of physical and social structures are a result of emergence: they are macro-structures that follow from interactions between a large number of actors. With an occasional exception, cities are generally not planned and organised from the top down, but rather an outcome of a continuous process of development and innovation. The electricity infrastructure as we know it is the outcome of over 125 years of development of small-scale local networks that have ultimately become today's intertwined transnational networks.[51]

Desire paths is the name of the paths that arise spontaneously in parks, the result of all kinds of individual decisions to take a short-cut. The paths on university campuses are especially difficult to plan in advance. Some physical planners allow the paths to develop by laying plots of grass first. The park is not landscaped until the preferred pattern resulting from interactions of the walkers has become clear.

Non-linear dynamics

As a result of the many feedbacks, the dynamic of complex systems is usually non-linear. There are no equilibria in the classic, static sense, but at best *dynamic* stable states. A complex system is continuously subject to minor fluctuations. The system sometimes returns to a stable condition (the 'attractor'); this is referred to as 'resilience'. This need not be desirable: an organisation such as the Mafia is extremely resilient, and in the case of the energy transition, one can consider this as a locked-in system of fossil fuels.[53]

Under the influence of specific disruptions, the system can also reach a tipping point and switch to a different state. This is often the result of cascade effects, as we see with large-scale power cuts. There is usually no way back, or only with great effort ('hysteresis').[54]

On balance … uncertainty

On balance, these characteristics always result in irreducible, fundamental uncertainty. This is a conclusion with major consequences. First of all, it calls on managers and citizens to accepts the fact that providing or expecting certainties is impossible in principle. This requires a fundamentally different attitude, an in-depth understanding as well as an acceptance of the fact that we do not and cannot know everything. But that is, at the same time, the motivation for scientific progress, for administrative adaptation and for everyone to lead a curious and meaningful life.[56]

In his much-discussed book, Thomas Piketty [52] describes how income inequality is the result of historic choices and accidents. Without this having ever been an explicit objective, equality has changed enormously: it is an emergent property of the socio-economic system, something that exists at systems level without it being clear how it relates to the underlying elements.

On 15 July 1907, an unusually silent bus collected its first passengers from Victoria Station in London. This started the largest test with electrical public transport in the world, in which a total of twenty buses were used. The London Electrobus Company hoped it would be able to replace the 230 unpopular, noisy and smelly combustion-engine buses. But despite its popularity with the passengers, the company went belly-up in 1909, because the owners had used the company assets to live the good life on the French Riviera.

England was a superpower and events in the British Empire often determined developments elsewhere in the world. Given this status, the owners of the Electrobus accidentally clinched a lock-in of the combustion engine for public transport for up to a century.[55]

03

ENERGY POLICY THROUGH A SYSTEMS LENS

Instruments such as the Agreement on Energy for Sustainable Growth or the Brandstofvisie (i.e. fuels vision) aim to effect change in the energy system from within. A systems perspective can apply a complexity lens and through it a cognitive framework for reinforcing, enhancing and supplementing these methods, instead of merely tolerating them between the dominant state and market narratives. In a complex system, objectives provide direction. The Urgenda ruling, for instance, can be considered a *fitness criterion* that may provide a new impulse and direction for the energy transition. An expression of ambition and direction instead of an externally imposed political objective: a wolf in this ecosystem.

We can look at existing policy through a complexity lens. Although 'state' and 'market' thinking are dominant in the current policy approach, we are also seeing that policy-makers take the behaviour of various actors into account, as well as their mutual relations in the energy system. Policy development itself can be described as an emergent outcome of the dynamics in a complex system. Policy usually builds on preceding policy, offers a compromise of various interests and visions, and takes a variety of actors, long-standing patterns and previous experiences with what works and what does not into account. The literature on public administration has, for some time now, been focused on the complexity of policy-making (see references under endnote 32). However, it is more difficult in policy practice to look at the system to be directed through a complexity lens; specific policy often refers to 'the consumer' or 'the car driver', as if these groups of actors are homogeneous..

Applying the concepts from the previous chapter, we can take an explicit look at current policy through a complexity lens.

Diversity of actors and strategies: the Energy Agreement

In September 2013, over 40 societal parties concluded the Agreement on Energy for Sustainable Growth with the government, coordinated by the Economic and Social Council (SER).[57] After months of negotiations, the parties reached agreement on a range of aspects concerning energy savings, clean technology, employment and climate ambitions, specified in ten 'pillars'. The Agreement on Energy also represents large-scale involvement from a broad basis of support in the business community, social organisations, financial institutions and government agencies. No limit was set for participation in advance, and in practice it turned out that mostly representative organisations such as VNO-NCW, Aedes, Duurzame Energiekoepel and Bouwend Nederland joined, supplemented with a number of specific interest groups, such as Greenpeace, Natuur & Milieu and the Fietsersbond. Following the Agreement on Energy, an assurance committee headed by Ed Nijpels was set up to keep the implementation of the agreement going. From a complexity perspective, a number of aspects of this approach stand out. Most remarkable is the wide diversity and involvement of actors. This initially made the negotiation process difficult, but a key benefit was perhaps the formation of new social networks, with at the very least some insight in and understanding of each other's points of view.

This benefit should not be underestimated, following over a decade of strife and polarisation between the parties. This is not to say that all parties were involved. Many of the negotiators had a representative role for a collective; organisations such as MKB-NL and VNO-NCW by definition represent an average position. As such, they cannot focus on innovative frontrunners alone, as this would alienate their other members. And because of the representative role of many negotiators, the diversity at the negotiating table was not as great as it would have been if all individual frontrunners (and laggards) had been around the table. Innovation in complex systems comes about by leveraging the diversity of actors. A structure in which solutions result from averages will never do full justice to the entire range of diversity. In this perspective it would be better to look for ways to integrate a broader range of differences and use that to spread more widely the desired modifications. A challenge for the Agreement on Energy is that both the means and the goal are outcomes of the 'complex' process. While this creates a basis of support for the means, the outcome cannot avoid being a compromise. Similarlty viewed through the complexity lens, the Urgenda ruling could be interpreted as breaking open a well-defined, consensus-oriented consultative structure through the inclusion of new parties. [58]

A second noteworthy aspect is the way in which the Agreement on Energy deals with coal. One of the elements of the Agreement on Energy is that the old coal-fired plants are closed, in exchange for the abolition of an existing coal tax. This exchange also brings about a shift from a market perspective to a top-down approach. A coal tax is a measure that keeps pressure on reducing the use of coal in the system across the board; in a complexity frame, a shift toward a CO_2 tax would be more suitable, as it is more result-oriented, and independent of the way in which it is realised.

In a complexity frame, parties could also have considered taking things one step further and closing all coal-fired plants to trigger a systems transition, similarly to the way in which the German decision on nuclear plants can be interpreted. In principle, it is conceivable that closure of five plants could act as a catalyst for a more drastic phasing-out of coal capacity; a first step in a cascade of closures. However, with the more or less simultaneous opening of a number of new (and more efficient) coal-fired plants, this perspective is unlikely to shift any time soon. There has been no fundamental shift in policy on coal-fired plants, as a result of which the energy system does not really escape from the fossil lock-in.

A third notable aspect is that the Agreement on Energy does not loose itself in the search for a silver bullet. A broad set of measures based on ten pillars is presented. The Agreement on Energy is aimed at 2020 (with a look ahead to 2023) and lists measures that can contribute to this goal. There are measures on all kinds of levels: direct technology control (coal, wind at sea), establishing a low-CO_2 context (via an emissions trading system), and flanking measures (training, job market). This yields a mix of bottom-up market control and top-down government interventions, with one of the key pitfalls being that these measures are too loosely connected to put any pressure on an energy transition at systems level. On the one hand, this shows that there is no hierarchy in the measures.[59] On the other hand, there is too little systematic cohesion in them, because they are not grounded on objectives or in a long term vision. A long-term objective is an essential ingredient for a complex system to enable deployment of its adaptive capacity for self-organisation. It provides direction to numerous minor interactions which, together, can contribute to an effect at systems level. An investor who has a choice between a more green-field and a more brown-field investment, for instance, will find it easier to make a choice in light of a visible and shared collective goal.

CASE

NEW COAL-FIRED PLANTS FULLY DEPRECIATED?

The closure of coal-fired plants, as agreed in the Agreement on Energy, may seem surprising, as the plants are still a long way from being fully depreciated. We can look at this differently from a systems frame.

The considerations of the Balkenende II government that permitted the existing generation of coal-fired plants had been justified through the diversification of energy sources. At the time, there were major concerns about a one-sided dependence on natural gas and the risk of sharply increasing oil and gas prices. An investor would call such a decision a *hedge*, the creation of option value to protect against potential undesirable consequences. When the consequences do not occur, the hedge has basically become worthless, but the investor will be happy to write it off. After all, the hedge has done what it was supposed to do.

From the perspective of the energy system as a whole, the 3500 MW in new coal plant capacity can be considered such a hedge. Oil and gas prices are low, demand in OECD countries is decreasing structurally, and where necessary there are alternative sources in the form of LNG or shale gas. The hedge has performed its societal duty and can therefore be considered written off.

Of course this does not hold for the balance sheets of the power companies that built the plants, where the value of the hedge was realised. The energy companies do get some of the value in the form of fiscal benefits, the longer operational life of 2800 MW of old plants, and through lower costs of gas and renewable energy production. But a major part has been realised diffusely in society and should be expressed there by means of the collective government balance sheet.

The financial status of the new plants depends on the system in which they are considered. This offers room for a broader policy perspective.

Central control and direction: Warmtevisie [Heat vision]

The Warmtevisie — a vision document for the centralised provision of industrial and urban heat[60] (April 2015) — of the Dutch Government is aimed at the transition of heating of homes and companies by means of natural gas, to renewable heat and residual heat in order to save energy and reduce CO_2 emissions. In a complexity frame, one might ask whether this is too limited a focus on natural gas and heat. What are the interconnections between the heat system and other systems?

Warmtevisie includes a mix of market approaches and government interventions. It underscores that markets could not have come into being until after socialisation of the costs of existing infrastructure, such as the gas distribution network. This will also have to happen for heat, which, according to the report, will require a high degree of government control.

The question is whether the government must be the only actor; it is instructive to look back at how the Netherlands climbed up from virtually the bottom to become a frontrunner in industrial heat recovery in Europe between 1980 and 2000. After 2000, performance in the Netherlands strongly fell (Figure 2). A growing reliance on market dynamics can be considered a central reason for this retraction.61 Viewed through a complexity lens however, this appears to be a story of a adaptive, incremental collaboration between parties that were able to discover new solutions based on growing mutual trust, in a way that a market system couldn't.

The Warmtevisie is formulated mainly in terms of government control. The question that arises in a complexity frame is whether there are options to facilitate bottom-up cooperation between actors, as happened successfully in industrial heat recovery.

Experience has also been gained in other fields with a similarly adaptive cooperation between different parties. The construction industry, for instance, used to be driven by an economic model in which parties joined on a project basis in order to provide acceptable quality at the lowest possible cost. In addition, the sector was (and still is) characterised by a high degree of fragmentation. The cost model in combination with sectoral fragmentation blocks the way for the organisation of learning processes and large-scale investments in innovation and sustainability. This does not mean that the necessity was not recognised, but the systematic coalescing of different parties required a degree of intervention that could not be mustered.62 In the meantime, a number of different initiatives have been developed that could act as a connecting fabric for parties to connect, such as the 'nul-op-de-meter' zero-energy homes and the Energiesprong programme. Government is not always the initiator, but government can significantly direct an increase in scale of promising initiatives, for example by institutionalising experimentation as a method for linking up bottom-up initiatives with top-down direction.[63]

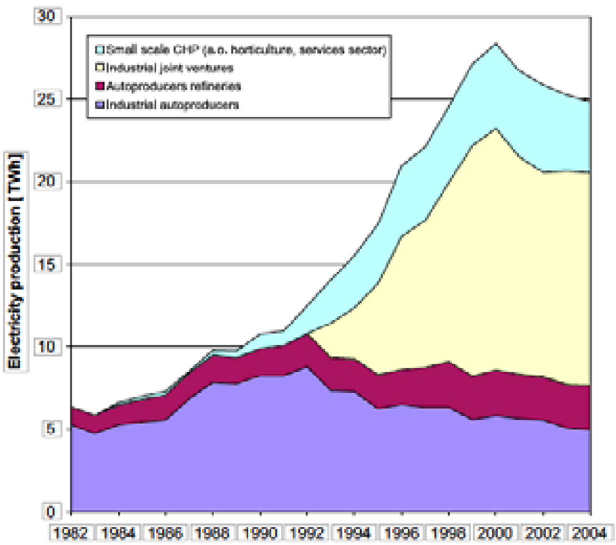


Figure 2
Electricity production from decentralised cogeneration (1982-2004), excluding district heating (Source: Statistics Netherlands).

Networks on multiple levels: the Brandstofvisie [fuels vision]

In June 2014, the SER presented the outcome of a process for the development of a sustainable vision for transport fuels.[64] This shows how Dutch emissions of 38 Mtonnes of CO_2 equivalents in 2013 might be reduced to 12.2 Mtonnes of CO_2 equivalents in 2050 (Figure 3).

The Brandstofvisie primarily concerns transport. Also studied were the relations with non-fuel- and transport-related measures, such as behavioural change, logistics efficiency and more efficient use of infrastructure. It is worth noting that the Brandstofvisie was based on the 'Adaptive Programming' method. This method, which was first used in relation to water management in the Delta Programme, explicitly includes uncertainty as part of decision-making. Uncertainty is turned into looking for and valuing flexibility, working with development paths instead of fixed final situations, linking short-term decisions with long-term tasks, and connecting investment agendas. These are aspects that also play a role in the common sustainable Brandstofvisie for the Netherlands.

The Brandstofvisie accounts for networks on multiple levels, albeit that the systems perspective is delineated within the limits of the system of fuels. The mix of six distinctive 'fuel tables', such as electric, liquid, etc. are considered from an adaptive and flexible perspective, taking optionality into account.

However, the interaction between the fuel system and other systems in the Netherlands or abroad is only considered to a very limited degree. One of the reasons is the choice of 'tank to wheel' instead of 'well to wheel'. How will trade flows in fuels (such as in the Port of Rotterdam) adapt to the new mix? Will the market deliver this, or will supplementary policy be required? Other external factors may also play a key role. If, for example, the increasing concern about the mediocre air quality in the Netherlands were to become a more substantial factor, this might put significant pressure on the fuel system. Paris is increasingly banning diesel engines from the city. In the Netherlands, Utrecht has set up a low-emissions zone for old diesel cars and Rotterdam will follow shortly.

The Brandstofvisie is focused mainly on the fuel system itself. It would be interesting to extend the analysis with perspectives from other transport modalities. The interaction with local conditions may also result in various solutions for cities, nature conservation areas or even social systems. What opportunities exist to further strengthen the Brandstofvisie by considering interlinked systems?

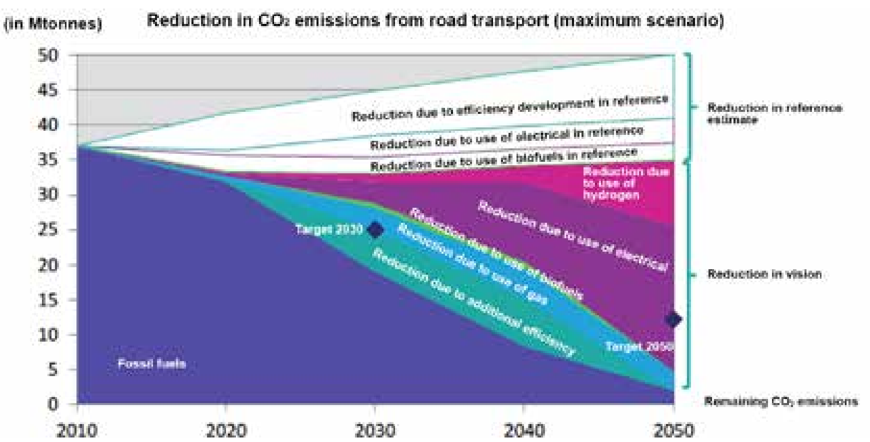


Figure 3
Maximum scenario for reduction of CO2 emissions in road transport

CASE

DRIVERLESS CAR

The driverless car could contribute to a virtuous cycle of safer, fewer (as a result of collective use), more efficient (lighter because safety provisions are no longer necessary), more modern (as a result of shorter life cycle) and less polluting (because electrical) cars.

They are used less than 5% of the time, which means they have a product cycle of 25 years and can therefore only benefit from technological developments with a significant time lag. Driverless cars can contribute to the creation of a fundamentally different transport system in an emergent manner, which in turn may change social norms and practices in other systems by means of network effects.

Today's manufacturers are focusing primarily on 'driver assist', gradual computer assistance in existing systems. This could act as 'stepping stone' toward a system of driverless cars. Provided they are developed further, driverless cars are also safer, because they are less vulnerable to human failure (they caused 570 fatalities and 20,000 casualties in 2014). Cars may also become more lightweight; the high weight of modern cars is intended primarily to improve protection of passengers, but this also means they use more fuel.

The combination of an efficient infrastructure, high population density, poor air quality and high degree of prosperity puts the Netherlands in a unique position to experiment with scaling up rapidly. As Germany is doing with PV, the Netherlands could make a significant contribution that others can leverage. Local experiments, such as in Milton Keynes, Singapore and Michigan, have already been carried out, but nowhere on a national scale.

This could have major consequences for the energy transition, through shifts in social norms, infrastructure, support from citizens, and demand for fossil fuels. It is characteristic of complex systems that these consequences cannot be predicted precisely.

The importance of story-telling: natural gas and the energy transition

The societal mandate for the role of (natural) gas in the Dutch energy system is under pressure as a result of the earthquakes in Groningen and societal concern about the potential production of natural gas from shale. Gas production from the Groningen field has meanwhile been reduced from 42 billion m3 in 2014 to 30 billion m^3 for 2015.[65]

In principle, there is great diversity in the sources of natural gas, but each of these has its own specific problems. A reorientation towards gas imports will put a significant burden on the balance of payment. While replacing current coal production by gas does accelerate reduction of CO_2 emissions (provided the associated methane leakages are below a stringent threshold), it is also butting up against societal boundaries.[66] Moreover, the Netherlands has an extensive and finely branched infrastructure for the distribution of gas; a key asset that is in dire need of renewal, which may create the space for new trade-offs. And of course there also is a robust electricity infrastructure. Other energy options, including renewable sources, are also struggling to gather sufficient societal support. Dutch gas is part of an extensive ecosystem of infrastructure, knowledge, and market parties. This ecosystem is an important source of income for the state as well as the national balance of payment, partly because other energy imports are avoided.

The impact of fossil fuels on the Dutch treasury is significant. Moreover, numerous activities, such as the Port of Rotterdam, strongly depend on fossil fuel activities. However, an energy transition will lead to new industries and activities, as happened with the IT revolution, and as we are witnessing in Germany, Sweden and Denmark through their energy transitions. Innovation of existing systems is an inevitable part of an energy transition. The fact that there are major tax and industrial consequences is inescapable; certain parts of the energy-intensive industry may have to pursue other options.

The energy transition in other countries is accompanied by a solid industrial policy, such as the photovoltaic chain in Germany and China, or shale gas in the United States. The Netherlands has developed an instinctive reluctance for government intervention in industries. This reluctance is quite understandable in a market frame, but in a systems frame there may be circumstances in which a lock-in must be overcome through the means of a more activist policy.

The current narratives on gas offer few opportunities for unravelling the current lock-in of the energy system. On the one hand, gas can be considered a key element of an energy system based on fossil fuels ('Gasrotonde'), but in connection with renewable energy sources gas (with CO_2 storage) could also have an explicit role in the transition of the energy system.[67]

This appears indistinguishable from a traditional state frame: after all, income from gas accrues to the public treasury, which can be used for the energy transition no matter what. In a complexity frame, the narratives on policy are of crucial importance, as they are central to mobilising new bottom-up initiatives, which through the narratives themselves, are given direction and motivation. It is essential to distinguish whether companies like NAM and Gasunie, merely defend vested interests in natural gas or whether they might play a role in generating the means for realising the energy transition. This perspective may result in new decisions that can ultimately contribute to acceleration of the transition. This does, however, require a new vision of the future of gas in the Netherlands, with a new societal foundation and space for sustainability.

04

AROUND THE ENERGY SYSTEM

The ability to zoom out is of key importance to get a picture of the transition of the energy system. Other factors are important as well, such as social norms and practices, barriers in other policy fields, or key technological developments in other sectors. In other words: the specific topics in policy are not always in line with the broader societal issues, such as the energy transition. Without presuming to be exhaustive, we will explore a number of themes that also contribute to the energy transition.

Social norms and practices in the built environment

The built environment represents approximately one third of Dutch energy consumption. While new housing is increasingly required to be energy-neutral from 2020, the large majority of the current housing stock will also still be around in 2050. As such, an energy transition requires a drastic intervention in existing buildings. That is not a simple task. All kinds of technical measures can bring about a gradual decrease in energy consumption per individual home, but their actual adoption is often thwarted by social norms and practices.

People are very much attached to routines in their direct living environment; owners and residents usually only take small steps towards energy saving in their homes.[68] As a result, technical interventions that leave behavioural practices untouched generally lend themselves well for implementation, such as water-efficient showers or energy-efficient equipment. More fundamental technical interventions that require an active investment in terms of cost or breaking daily routines are more difficult, for example renovation or rebuilding. Energy consumption considerations usually do not play a leading role in this. Nevertheless, there are many initiatives in this space, such as the 'Nul op de meter' programme, which funds deep renovation based on lower energy bills.[69] The United Kingdom has green deals aimed at cleaning up attics, as an excuse to insulate the roof – this connects to peoples' routines and is seen as an attractive incentive.

Measures that directly affect human behaviour are usually notoriously difficult to implement. These include lowering the thermostat, turning off the lights, putting on a warm sweater, etc. Nevertheless, there are sometimes interesting hypes as a reaction to shifting social norms. A textbook case from outside the energy sector is smoking. This used to be consistent with the behaviour of opinion leaders, but continuing to smoke has increasingly become unacceptable within the social order. So it may be difficult but not impossible to put pressure on social norms and subsequently on social practices and routines. A lot of initiatives contribute to that pressure, but it is not possible to predict precisely which straw will break the camel's back. The challenge for the energy transition is to offer such initiatives the space to put pressure on traditional, energy-wasting routines. Three examples illustrate this:

- 'Eco-logisch' is an Amsterdam DYI store selling all the usual building materials, but specifically focused on sustainable construction. During a workshop on the potential of sustainable economy for the Amsterdam Region, the passionate entrepreneur who set up this store explained his biggest hurdle: "most contractors in the Amsterdam region have no idea how to handle these materials and they prefer to go back to the tried and trusted building methods, as they learned them during their training."

- Various inhabitants of the Amersfoort town centre are inspired by sustainable energy initiatives and aspire to making their own energy supply more sustainable by investing in solar panels on their roofs. However, the town centre is an urban conservation area and strict regulations prohibit the installation of solar panels on listed buildings. This constitutes a lock-in of legislation that offers no space for well-thought-out innovation for a more sustainable city.
- Tilburg is a town with sustainability ambitions. It was therefore only logical that the construction of a new school building considered optimising energy efficiency. Having stumbled in earlier projects, the responsible civil servant convened the architect and the builder at an early stage, and nothing appears to stand in the way of a school building with an extremely low heat demand and an efficient energy supply. But unfortunately, the funds for the new construction and those for the energy costs of the building once completed come from different sources. As a consequence it was impossible to fund the additional costs of this school building, even if the costs were to be earned back within a few years as a result of the energy savings. The gap between the two funding sources could not be closed.

The success of an energy transition hinges on changing and reducing the demand for energy, with an important contribution from the built environment. Strict EU regulations enforce a new order for all new buildings. But modifications of existing buildings form the largest challenge. How can social norms surrounding the energy transition be made more contagious in the built environment? For one example of such contagion, recall the apparent influence of wide adoption of solar panels in Germany on citizens' support of the Energiewende. What influence do related policy issues such as education, preservation of historic buildings and municipal finances have?

The organisation of capital

The energy transition also requires a shift from variable cost into investments. This is due to the fact that many innovations convert variable into fixed costs. A gas-fired plant has fuel costs for life, while a wind park is an up-front investment; an energy-efficient house has much lower ongoing heating costs, but higher initial investments; an LED light is more expensive to buy, but cheaper to use, etc. As a result, capital intensity will increase at first, while resources will be released later because of lower variable costs. This literally requires spending money to make money.

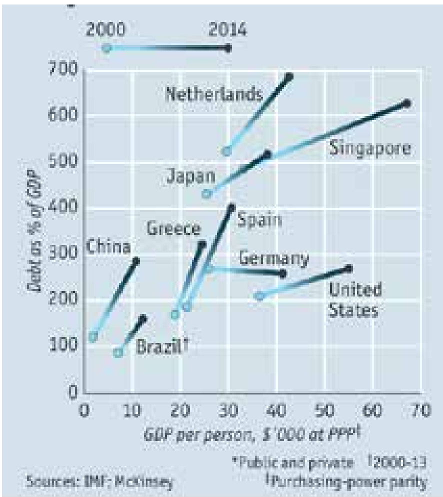


Figure 4:
Change in level of national private and public debt between 2000 and 2014, as a percentage of GDP. (Source: *The Economist*).

CASE

FINE PARTICLES AS CATALYST

A key for obstacle broad involvement in the energy transition is the relatively abstract nature of the climate issue. Despite the Netherlands' front-line position in sea level rise, the global nature of an invisible issue constitutes a major obstacle.

This is true for other countries as well. In China, for instance, the air quality measurements that were reported via the internet from the detector on the roof of the American Embassy in Beijing on a daily basis, became a key catalyst for forcing the government to act. The approach to air quality included measures aimed at reducing the use of coal, a step that also put up the energy system itself up for debate and paved the way for an enormous upscaling of solar and wind capacity.

While the Netherlands also has major problems with air quality – albeit of a different order than in the major cities in China – in Europe the Netherlands is a laggard. Poor air quality directly affects people's health, which may make it an important factor in turning public opinion in favour of changes in the energy and transport system. Measures for combating particulate matter are closely related to the energy transition. In this way, local themes can be linked to global issues. A high degree of public support like in Germany is essential for sustaining a policy of change.

In a systems frame, the approach to air quality offers the opportunity to activate indirect forces and trigger new emergent effects, which may ultimately accelerate the energy transition.

This could include integration of fine particle maps in weather apps, such as Buienradar, or information on motorway overhead signs, as with the BOB drunk-driving campaigns.

The implication is that the structure of the system of financing can have a significant influence on the energy transition. In the Netherlands, this system has a number of quite extreme properties. As a result of the tax-subsidised mortgages, the Netherlands has the highest domestic debt in the world, as a percentage of the GDP. However, this is balanced by high amounts of savings in the form of pension funds. The banking sector is highly concentrated: the market share of the five largest banks is 85%, over twice that in Germany and just below frontrunner Greece. The Netherlands also has the smallest share of foreign banks, similar to Spain.[70] Until the turn of the century, the savings surplus was provided mainly by households, but afterwards almost entirely by companies.[71] The government only has access to a small part of that capital. In short: an idiosyncratic system with a very ample capital surplus but at the same time a very high degree of concentration of financial decision-making and governance.

Governance of capital is, of course, not the only consideration. Also important are the expected returns - and the question of whether existing investments will be displaced or new ones added. These considerations are generic and also apply to the Netherlands. The governance issue, however, is typically Dutch, and therefore specifically relevant for the course of its energy transition.

There is enough capital in the Netherlands to address the increasing capital intensity, but governance is overly centralised compared to other systems. Suitable governance for a complex system is polycentric, with different actors at different levels of scale. More diversity in the financial sector, both in nature and in scale, seems a key prerequisite for an energy transition that is not primarily driven by the government. The question should be posed what else would have to change in the financial system in the Netherlands to bring about the required shift from variable costs to higher capital intensity for the energy transition?

Non-linear dynamics in innovation

In The Nature of Technology[17] complexity economist Brian Arthur describes the basic principles of innovation processes. He describes how innovation is less the result of new ideas, but primarily consists of the recombination of existing ideas. To encourage innovation, it is important to be able to generate a multitude of ideas in various disciplines, to offer the opportunity to connect these, and to allow creative spirits to identify new combinations. Arthur moreover suggests that too narrow a focus on a small number of sectors may limit the room for true innovation. Insight into the underlying mechanism of innovation will help direct policy towards what is needed: relatively gradual progress in existing fields or a non-linear recombination of various ideas into step-change innovation.

Innovation takes place within an ecosystem with a broad diversity of players. Such an *innovation system* is defined through those interrelated functions and mechanisms that enable or help accelerate innovation.[72] A systems view of innovation processes recognises all kinds of feedback mechanisms, such as the way in which users deal with new technologies, by incorporating learning processes or recognising the cohesion between technological developments and societal issues. A policy perspective in terms of an innovation system is aimed at tackling systemic obstacles, instead of mere market failures. An innovation system consists of co-evolutionary processes of change, for instance because regulations move in sync with technological developments, and vice versa. Phrased differently: in an innovation system, innovation itself is embedded in society. What are the options for shaping the innovation system in the Netherlands in such a way that it supports the energy transition?

05

ENERGY TRANSITION IN COMPLEXITY

Strategic incrementalism between *top-down* and *bottom-up*

Any consideration of a 'transition of the energy system' almost automatically leads to a top-down perspective: the system itself is the object of change, and the policy-maker exogenously stipulates the conditions for that change. However, such a perspective wrongfully assumes that there are sufficient starting points for a controlled and targeted transition strategy. In policy practice, such a possibility for control is lacking. Many actors play a role in the design and dynamics of the energy system, all guided by their own perspectives and driving forces. A logical conclusion could be to drive the energy transition through market mechanisms, by invoking the economic rationality of producers and consumers by means of, for example, a CO_2 price. But in that case an adequate sense of direction, an actual *incentive* for transformation of the energy system, would be missing and strong lock-ins and path dependencies might well thwart market forces.

The complexity frame is an approach that is intended to bypass the pitfalls of both approaches. A state-driven *top-down* approach would require more than a state is capable of. It is difficult for a government to formulate social norms, introduce innovation drivers, or make specific technology choices on its own. The complexity-inspired policy-maker, on the other hand, is capable of establishing the conditions for the playing field, of articulating innovation and renewal, of breaking through lock-ins at systems level.

In doing so, it is important to realise that controlled changes in complex systems are always incremental and rarely take the form of a large-scale transition programme.[73] This requires an approach of *strategic incrementalism*: based on a good sense of direction, the government uses regulation as the guiderails to 'push the energy system in the right direction'.[74] Strategic incrementalism offers space for a step-by-step yet ambitious approach, establishing the conditions for the playing field and providing a push in the right direction. Moreover, this provides space for a more decentralised strategy, in the sense that many different solutions can be integrated in the formation of a more sustainable energy system. The energy transition is not a technocratic issue for the government alone or in consultation with a few large parties; it is a societal issue that requires involvement, ideas and social innovations.

CASE

A FOCUS ON THE CITIZEN

In recent years, the energy transition was mainly tackled by the government, knowledge institutions and societal organisations, and the business community. The 2011 Agreement on Energy, for instance, was drafted in consultation with a number of major players, without any deep societal grounding.

However, energy is not a daily theme for average citizens, even though growing numbers of citizens are increasingly aware of the influence they (can) exercise on the energy system. These interested and informed citizens join in new networks, sometimes local, sometimes virtual. The number of energy cooperatives is gradually increasing, as are new forms of organisation (associations and foundations) to meet the energy demand. These new networks usually provide a more direct link between the energy provider and the consumer.

Within these networks, new social norms often apply - such as the awareness of the energy system and conscious choices for independence or sustainability. These new social norms become apparent when actors from these networks come together, such as at the annual event organised by 'Hier Opgewekt', a knowledge platform for local sustainable energy initiatives. However, the choices of these citizens and consumers are often limited by the lock-ins of existing infrastructure and the small scale at which modifications can be financed.

A broader understanding of network topologies may contribute to the acceleration of innovation and to the dispersion of social norms on which these initiatives are founded. This also applies to increased appreciation for the importance of the diversity of initiatives in order to be able to innovate more quickly. Well-defined boundary conditions can help provide direction, cohesion and embeding for these experiments.

Clear distinction between means and goals

Why do we want to accelerate the energy transition? Is making the energy system sustainable a goal in itself or a means to contribute to combating climate change? This question is more fundamental and more difficult to answer than would appear at first glance. The need for a significant CO_2 reduction is a starting point that is hardly under debate. It is also clear that techniques such as wind turbines, solar panels or geothermal installations can make a significant contribution towards achieving this. But what about CO_2 capture and storage, or the future role of gas in heating, or the acceptance of biomass? Each of these may considerably contribute towards the climate mitigation, but each of these is also subject to societal debate.

In considering the energy transition, goals and means are often intertwined. An energy transition as a means to contribute to CO_2 reduction could also comprise the above-mentioned techniques, but should also question their acceptance in society: which changes in norms and values do they entail? What opportunities are there to improve the quality of life? What are the risks? What are the economic opportunities for the Netherlands? Who bears the costs and who benefits? Is it knowable whether the benefits will exceed the costs, or vice versa?

If we see the energy transition as a goal in itself, it is important to consider the justification of this goal. This will of course be found in the contribution towards combating climate change, but could also be expressed in terms of economic opportunities. Energy transition then becomes an economic issue, related to current societal issues. This may recalibrate Dutch industrial policy, which is currently laid down primarily in the so-called 'top-sector policy'. Not the strength of sectoral R&D then becomes the starting point, but rather the extent to which companies can contribute to tackling societal issues. Specifically the Netherlands has a lot of opportunities for this, and at the same time great challenges. Challenges from its CO_2-intensive economic structure, its central position in European logistics, and from the high density of people, cars and cattle.[75]

However, if we consider the energy transition in the broader context of the societal, social and economic developments that will take place within the next few decades anyway, we see an enormous acceleration of investments, which could act as a catalyst for the required innovation. There is no reason to assume that we currently live in the best of all possible worlds, and the energy transition is a society-wide project that, when looking through a complexity lens, could show the connection with other changes. Considering the connection between the energy system and the rest of society leads to a less utilitarian and more inspiring perspective. The challenge lies in offering space to dynamics, innovations and experiments on the one hand, and in offering structure and assurance to enable promising ideas to drive the transition on the other. Here, the government links major societal challenges with an incremental approach in organisation and process.[76]

Looking for the wolf

At the start of this document, we referred to the wolf in Yellowstone Park. In this example, the wolf is presented as an 'organising principle', a force that has an in-depth effect on the system and ultimately contributes to the transition of a degraded ecosystem into a flourishing and diverse park. The question in respect of the energy transition could be posed as: who is the wolf?

In order to be able to answer this question, we must first consider what it is that the wolf actually does. In complexity terms, we could argue that the wolf changes the *fitness metrics* of the system: where previously the supply of food was the only fitness metric for the deer, after the introduction of the wolf it becomes important also to be vigilent, to be able to flee quickly or to defend themselves. Those who can't do these things, lose out. By analogy, we are looking for a new 'fitness metric' for the energy system, based on low-CO_2 energy production. In this context, high CO_2 emissions will be penalised, to the benefit of alternatives with no or far fewer CO_2 emissions.

In this approach, an energy transition may benefit from a price on CO_2, which will shift the boundary conditions of the energy system. But already today a very high CO_2 price is included through taxes in the prices of diesel and petrol, but the actual behavioural effect is minimal. A CO_2 tax in itself will never be sufficient, as it does not do enough justice to differences in the time horizon (see for instance the difference between expenditure and investments) or to considerations of bounded economic rationality. A price for CO_2 is an important environmental variable, but a true energy transition also requires a broad approach, with a toolkit full of strategies and policy instruments, and involving consumers, citizens, companies and communities. That toolkit also contains a strategy for infrastructure, for innovation and for system-oriented industrial policy[77], through which to do justice to a longer time horizon, to diversity and variation, to niches in new innovations, and to space for experimentation.

In the example of Yosemite Park, the wolf removes elements unable to hold their own; the wolf presents itself as *fitness factor* in relation to the deer. But the question is not merely: 'who is the wolf?', but also 'who is the weak deer?'. In an energy transition, these are the parties that are unable to adjust to functioning in a low-CO_2 energy supply. In Germany, this has become a topical issue, and a legacy company like E.On is radically changing course by hiving off its entire fossil business.[78] Moreover, there will also be parties that will experiment and innovate on a large scale but that will inevitably fail now and again. It is important, therefore, to incorporate a degree of tolerance for failure. For the government this problem translates into what could be termed 'the art of exit', the ability to let go without causing the entire system to collapse. That is not a simple task: protecting an immature industry will often result in frustration about failed experiments, such as the specific downfall of American solar cell producer Solyndra, despite a positive balance in the overall government support programme.[79]

Ability to adjust and smart navigation in networks

The government has many instruments at its disposal, but it does not have the monopoly on wisdom when it comes to determining societal goals or the best way to achieve these goals. Both the goals and the road towards them will change 'along the way'.[80] This requires policy to be adaptive to a certain degree, capable of responding to changing circumstances and to new insights. In that process, new ideas, perspectives, techniques and action plans will tumble over each other in rapid succession. The government must have a sense of direction and urgency in order to request commitment from other parties to contribute to the realisation of an energy transition. Defining the direction is not a *top-down* activity, but the outcome of a process in which it leverages society's learning capacity. This is a continuous process of interaction, 'a stream of actions involving both intentions and emergence', switching between 'umbrella strategies' and more specific process strategies.[81] Steering towards an energy transition is not a matter of management and control, but a process of navigation and setting direction.

Also of essential importance is the awareness that an energy transition is not just a matter for the government alone, but for the entire network of many different actors. This begs the question: which parties in that network are the central hubs, who are the accelerators and who are the impediments? It may be important in this respect to share the path together – from that perspective the Agreement on Energy is an investment in sharing the challenge of taking joint steps towards an energy transition. In such a context, specific social norms may be up for discussion as outdated, for instance the predominant form of mobility in cities. Education may play a role in developing and learning how to cope with different perspectives on sustainability in general or creating a more sustainable energy system in particular.

Sometimes, key actors may appear to come from outside the energy system to drive change. In the German Energiewende, citizens and local companies come together in energy cooperatives at an extensive scale, creating a new player in the system. In the Netherlands, it would not be inconceivable that cash-rich parties such as banks or pension funds invest in promising sustainability initiatives. The extent to which initiatives are promising depends on the ambitions and stability of the underlying transition policy, in which the government can clearly assume a guiding role.

CASE

DESIGNING A NETWORK STRUCTURE

The adoption of solar panels is clearly contagious: in neighbourhoods where a resident introduces solar panels, more panels are bound to follow. These infections are viral - depending on the strength of the idea, and on the underlying network structure that is infected; as such networks are important for the energy transition. The question is how can we make these networks more effective? We can distinguish between local networks and connecting networks.

Compact local networks: Bottom-up initiatives can easily be connected via social networks. Residents in Almere living in a new housing estate of their own design soon established a Facebook group where they could share experiences. An app like Peerby connects residents to borrow tools from each other. Residents in a neighbourhood in Utrecht set up a WhatsApp group to connect the informal supply and demand for healthcare. Such initiatives have the potential of being transformative in the social dynamics of communities or entire cities; the basic notion of the sharing economy.

Connecting networks: Compact local networks are not sufficient to spread ideas on a large scale. This also requires hubs and lateral connections. One option for this would be a national competition for the lowest accumulated energy consumption of all parents of a class or school. The reward could consist of something for the school. That way, relatively local but less compact networks are joined at a national level through an annual award. The possibilities for such ideas are basically endless, provided that they result in the creating of effective networks.

EPILOGUE

BEYOND THE *SILVER BULLET*

Major transitions cannot be solved with the same approach as for the Manhattan or Apollo project, and the energy transition or more generally climate mitigation is no exception.[82] In a complexity frame, *silver bullet* solutions are inconceivable and undesirable, firstly because the outcome of an intervention always comprises a (significant) element of uncertainty and as such always requires adjustment (immediately or in due course), and secondly because the context of complexity always requires a broader approach. Or, as complexity researcher Robert Geyer put it: "Complexity emphasizes the range of strategies necessary to deal with situations, rather than a hierarchy of strategies."[83]

This initially appears unsatisfactory, a drag on the impetus to get on with it, a disappointment to those who are looking for a direct action. But anyone allowing the complexity frame to sink in, will become aware that it opens a host of new opportunities, an entirely new perspective on control, change and transition.

It is important, however, to realise that complexity science is a discipline that is still being developed. It is a young discipline and, according to renowned biologist Stephen Jay Gould, "replete with cascades of nonsense, but also imbued with vital, perhaps revolutionary insights".[84] Some insights have a scientific basis, but others are fairly intuitive. 'Complexity science' is 'a science in the making'. This does not mean that we can sit back and wait until the discipline develops into a mature and technologically founded discipline. On the contrary: the discipline develops best in experimentation with (policy) practice, by testing concepts, by learning what works and what does not, by developing practical and verifiable concepts. Phrased differently: "The ultimate proof of any new intellectual approach, of course, is in the putting into use".[85]

Based on this consideration, two workshops were organised with players from various sectors to look at the upcoming Dutch energy transition as a complex system. The study of the value and value-added of concepts from complexity science was a key objective for the workshops.[86] This had a dual effect. First of all, we see that the theoretical framework is continuing to develop and crystallise, but also that it often remains fairly abstract, at some distance from empiricism and practice. Secondly, we see that in policy[87] and in the business community[88], based on the well-considered intuition that 'classic' governance models are inadequate, a lot of experimentation is already happening in the governance of complex systems. So while the theory is hampered by a shortage of empirical substantiation, interesting and often intuitive projects frequently lack the language to allow proper deep reflection. By organising the workshops, we had the ambition to contribute to closing this gap in the area of the energy transition.

A key observation concerns the remarkable motivation and openness of the participants during the workshops. This is in line with the experience of other meetings in which issues were addressed collectively and systemically. The encouragement to look through a complexity lens, perhaps even the permission, acts as an incentive to the participants, because they are allowed to look at broader connections and greater relevance. Whether this will result in breakthroughs is an open question, but it does contribute to the quality of the discussion.

ACCOUNTABILITY

The organisation of the workshops and the realisation of this publication are the result of public and private efforts.
Initiator was Roland Kupers, co-author of 'Complexity and the Art of Public Policy', who is affiliated with Oxford University and Singapore Management University, with the support of Royal Dutch Shell. Shell also acted as the host for the workshops.
Other authors who are employed at the Scientific Council for Government Policy have contributed to the specifications of the workshops and drafting of this publication.
Participation of the workshops was based on invitation of persons involved in energy transition policy or interested in the theme of complexity from other policy fields. Invitations were sent to persons working for the national government, the business community, research institutes and NGOs. Discussions were held under Chatham House Rules.
The text in this publication is the authors' responsibility. A draft version of the text was submitted to the participants in the workshops and a number of WRR colleagues for comment.
The following persons attended the workshops in a personal capacity:

A. van Gijssel, Aedes – association of housing corporations
A. M. Schwencke, AS I-Search
P. de Boer, DNV GL
R. Grimbergen, DSM
L. Ouillet, Eneco
P. Koutstaal
R. Ybema, Energy Research Centre of the Netherlands (ECN)
C. Beijnen, W. de Groot, Gasunie
J. Hugtenburg, H+N+S Landschapsarchitecten
A. Castelein, Rotterdam Port Authority
B. Geurts, Ministry of General Affairs
G. Roest, Ministry of the Interior
J. Wiers, Ministry of Foreign Affairs
A. Dekkers, Ministry of Economic Affairs
W. van Goudoever, Ministry of Finance
P. Wouters, Ministry of Infrastructure and the Environment
F. Landstra, P. Verhagen, Ministry of Justice and Security
K. Wilkeshuis, Netbeheer NL
P. Boot, Netherlands Environmental Assessment Agency (PBL)
C. van der Linde, Council for Environment and Infrastructure (RLI)
M. Böggemann, E. Breunesse, D. Bosman, Royal Dutch Shell
J. Bolhuis, Siemens
R. Weterings, Social Economic Council (SER)
M. Weijnen, Scientific Council for Government Policy (WRR)

The authors bear full accountability for the content of this publication.

NOTES

1
How wolves change rivers: www. youtube. com/watch?v=ysa5OBhXz-Q. The presentation in this video is not undisputed. In the New York Times of 2014/03/10, Marion Fayolle writes a critical note entitled “Is the Wolf a Real American Hero?” about the potential romanticisation of the role of the wolf in Yellowstone. The wolf is part of a complex system, not a simple solution to an ecological problem. In our story, the wolf is an illustration of that complexity.

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IEA (2014). *Energy Policies of IEA Countries: The Netherlands, 2014 review. OECD/IEA, Paris.* Quotes op p.10 en op p.165.

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7
See http://thewaleswewant.co.uk/.

8
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By way of comparison to understand these amounts: the price of one tonne of CO2 on the European emissions trading market is approximately 8 euros(zie https://www.eex.com/en/market-data/emission-allowances/spot-market/european-emission-allowances). According to the Ministry of Finance, the tax benefit of energy-efficient cars (a scheme that is currently subject to review) increased to 1,000 euros per tonne of CO2 avoided (see http://verantwoordingsonderzoek.rekenkamer.nl/2013/ienm/beleidsinformatie/hoge-prijs-voor-tegenvallende-milieuwinst-zuinige-autos).

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