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On the Role of Envisioned Futures in Sustainability Transitions

On the Role of Envisioned Futures in Sustainability Transitions

Alexandra Nikoleris



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DOCTORAL DISSERTATION

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Abstract <p>Different kinds of representations of the future are often asked for in order to motivate and inspire societal change. These envisioned futures can be based on political or behavioural change, or may visualize technical development which could help us solve complex societal problems. The latter type of representation is especially important if we aim for sustainable development, and even more so if we aim to live up to the Paris agreement and mitigate climate change. Such technical visions are the particular focus of this thesis.</p> <p>The importance of visions of and expectations on technology is also highlighted in the research field which focuses on socio-technical transitions towards sustainable production and consumption. Visions and positive expectations are claimed to have a coordinating effect, they attract resources and legitimise development of technologies which promise to enable the vision to be reached. Whether expectations and envisioned futures in general can really be claimed to have coordinating effects is however not generally agreed on. The aim with this thesis has been to develop analytical tools to help us explore the role of envisioned futures in sustainability transitions, so that we can acquire a better understanding of how they become efficacious.</p> <p>The thesis includes four research papers. Paper I and II focus on how a reconceptualisation of structure and agency is needed in sustainability transitions if explanatory theories are to be developed of what transitions are and how they come about. Based on critical realism, the groundwork for such theories is laid. Transitions are reconceptualised as transformations which result in systems with new emergent properties. This means that the study of transitions is really a study of how new structures that enable or constrain action come about. It is argued that to understand the importance of expectations we have to separate the act of expecting, which is part of human reflexivity, and that which motivates us to act in the world, from expectation statements. The latter is a causal narrative linking propositional statements of how the world works which can be used in different ways: to prepare for anticipated outcomes, to evoke emotional engagement or to learn by seeing things in a new light. Margaret Archer's work on morphogenesis of structure, human reflexivity, and our internal conversation has guided this work.</p> <p>Paper III and IV focus on different kinds of envisioned futures and the different ways in which they can create engagement in the recipient of these representations. The envisioned futures studied include literary fiction (climate fiction or 'cli-fi'), scientific climate scenarios, and expectations on technology for carbon capture and utilisation. Our understanding of the world relies on story-telling to a large extent. We engage in the world through practice but we also fit these experiences into encompassing stories of how the world works and relate them to our personal concerns. Both concerns and rationales acquired through sense-making are important when actors reflexively deliberate on how to act. Explorative scenarios and predictive statements on future technology capabilities can give us a better understanding of different possible futures and what means we have to reach them, while fictive stories are better at providing affective engagement. Different kinds of envisioned futures are therefore important in a debate on where we want to go and how we should get there.</p>	
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On the Role of Envisioned Futures in Sustainability Transitions

Alexandra Nikoleris



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A doctoral thesis at a university in Sweden takes either the form of a single, cohesive research study (monograph) or a summary of research papers (compilation thesis), which the doctoral student has written alone or together with one or several other author(s).

In the latter case the thesis consists of two parts. An introductory text puts the research work into context and summarizes the main points of the papers. Then, the research publications themselves are reproduced, together with a description of the individual contributions of the authors. The research papers may either have been already published or are manuscripts at various stages (in press, submitted, or in draft).

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To my beloved family and friends

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List of publications

This thesis is based on the following publications, referred to by their Roman numerals:

- I **Structure reconsidered: Towards new foundations of explanatory transitions theory**
Oscar Svensson, Alexandra Nikoleris
Research Policy (2018), 47(2), pp. 462–473

- II **The coordinating power of expectations**
Alexandra Nikoleris
Manuscript, draft

- III **Conflicting expectations on carbon dioxide utilisation**
Alexandra Nikoleris, Ellen Palm
Manuscript, submitted to Energy Research and Social Science, March 2018

- IV **Narrating climate futures: shared socioeconomic pathways and literary fiction**
Alexandra Nikoleris, Paul Tenngart, Johannes Strippel
Climatic Change (2017), 143, pp. 307–319

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Author contributions

Paper I: Structure reconsidered: Towards new foundations of explanatory transitions theory

This paper developed out of joint attempts and ideas on theorising sustainability transitions and radical change during several years. ‘Methodological implications’ was written by Oscar Svensson and commented by me. The rest of the parts were co-developed and co-written.

Paper II: The coordinating power of expectations

I conducted all the interviews and wrote this paper as single author.

Paper III: Conflicting expectations on carbon dioxide utilisation

The idea for this paper was developed in collaboration. I was responsible for the analytical framework and wrote most of the research approach. Ellen Palm wrote most of the introduction. The rest of the paper was written in collaboration.

Paper IV: Narrating climate futures: shared socioeconomic pathways and literary fiction

This paper was a truly shared effort in design and writing, the analysis conducted in collaboration.

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Oscar, that was a bumpy ride! Thank you for all the wonderfully confused discussions and struggles, and the moments of clarity. I look forward to reading your coming masterpieces!

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My greatest thanks to Sara Granér for the fantastic cover illustration. Your interpretation of my research could not have been better! To all of you who do not feel like reading the thesis: just stare at the cover. All will become clear.

Popular summary in English

Different kinds of representations of the future are often asked for in order to motivate and inspire societal change. These envisioned futures can be based on political or behavioural change, or may visualize technical development which would help us solve complex societal problems. The latter type of vision is specially important if we aim for sustainable development, and in particular if we aim to live up to the Paris agreement and mitigate climate change. Such technical visions are the particular focus of this thesis.

The importance of visions and expectations on technology is also highlighted in the research field which focuses on socio-technical transitions towards sustainable production and consumption. Visions and positive expectations are claimed to have a coordinating effect, they attract resources and legitimise development of technologies which promise to enable the vision to be reached. Whether expectations and envisioned futures in general can really be claimed to have coordinating effects is however not generally agreed on. The aim with this thesis has been to develop analytical tools to help us explore the role of envisioned futures in sustainability transitions so that we can acquire a better understanding of how they become efficacious. Based on the philosophy of science called *critical realism*, I have developed the basis for a framework to study the mechanisms by which envisioned futures may lead to transformative change. Margaret Archer's work on human reflexivity and our internal conversation has guided this work.

I have also studied different kinds of envisioned futures and the different ways in which they can create engagement in the recipient of these representations. The envisioned futures I have studied include literary fiction (climate fiction or 'cli-fi'), scientific climate scenarios, a demonstration project to introduce biogas as a fuel for heavy transport, and expectations on technology for carbon capture and utilisation. My analysis shows that different types of engagement can be important if we want to have a public debate on sustainability in which we are not only debating which solutions are most effective, but also which measures and goals are most desirable if we want to reach our visions.

Populärvetenskaplig sammanfattning på svenska

Visioner och framtidsbilder efterfrågas ofta för att motivera och inspirera till samhällsliga förändringar. Sådana visioner kan bygga på politisk förändring eller måla upp bilder av teknisk utveckling som hjälper oss att lösa svåra samhällsliga problem. Den typen av visioner är kanske speciellt viktiga när vi strävar efter en hållbar utveckling, och framför allt ifall vi vill motverka att jordens medeltemperatur höjs med mer än två grader med allvarliga klimatförändringar till följd.

Vikten av visioner och förväntningar på teknologi lyfts också fram i den forskning som studerar just samhällslig och teknisk omställning mot hållbara produktions- och konsumtionssystem. Visioner och positiva förväntningar sägs ha en koordinerande effekt, något som attraherar resurser och människor att jobba för att utveckla den teknik som behövs för att visionen ska nås. Men huruvida detta verkligen stämmer och hur effekterna av olika sorters framtidsbilder och förväntningar ska studeras är fortfarande oklar. Målet med den här avhandlingen har varit att ta fram analytiska verktyg som kan hjälpa oss att få en ökad förståelse av framtidsbilders roll i omställningen till mer hållbara system. Baserat på vetenskapsfilosofin *kritisk realism* har jag utvecklat grunden till en teori om de mekanismer med vilka framtidsbilder leder till förändring. Margaret Archers arbete om människors reflexivitet och den interna konversationen vi alla håller när vi skapar oss en förståelse av vår omvärld har varit vägledande för denna teorigrund.

Jag har också studerat olika typer av framtidsbilder och hur de på olika sätt kan väcka engagemang hos den som tar del av dessa bilder. De olika sätt att föreställa sig framtiden som har studerats är skönlitteratur (så kallad cli-fi eller climate fiction), vetenskapliga klimatscenarion, demonstrationsprojekt för att introducera biogas som bränsle för tunga transporter och förväntningar på teknologi som kan använda koldioxid som kolkälla till material och bränslen. Genom att studera och analysera dessa framtidsbilder visar jag att olika typer av engagemang kan vara viktiga för en samhällsdebatt där vi inte bara behöver diskutera vilka åtgärder som är mest effektiva, utan också vilka åtgärder som är mest önskvärda i förhållande till det slutmål, eller den vision, vi vill nå.

On the role of envisioned futures in sustainability transitions

We split time into three parts. The brain, it seems, splits it twice only: now, and not now. So in the not-now, I can say that I was set adrift in an open boat, and after a while learned how to make a rudder and oars, though I never mastered a sail and its wind. The wind blows where it will, and I have many times arrived at the unexpected.

— Billie in *The Stone Gods* by Jeanette Winterson

I Introduction

In a TEDx talk from 2013 called ‘Foresight in Hindsight’, Reinier de Graaf presents a matrix of predictions made by different people in different professions: prophets, politicians, artists, scientists and business. The predictions concern five different areas: the planet, humanity, culture, technology and economy. He then goes on to show how often these predictions turned out to be true. Most of them were of course false. But more interestingly, the majority of predictions that turned out to be true were made by someone who had no expertise in the area. Prophets were better at predicting the economy than economists, and artists better at predicting future technology than scientists.

Despite the long history of inaccurate predictions of the future which Reinier de Graaf illustrated, visions and plans constitute an important part of human activity and social planning, from making decisions in everyday life to forming political and organisational strategies. Instead of dismissing the practice of envisioning because of its inaccuracy, its importance as a democratic tool to discuss possible different futures should be acknowledged. While long-term predictions and visions seldom come true, anticipation is an inherent feature of human action because to be able to plan we need to know where we are going. In other

words, we need to anticipate possible outcomes and envision where we want to go and what to achieve (Patomäki, 2006). Furthermore, despite the inaccuracies of predictions, different ways of envisioning the future still have an impact on the projects we pursue and the values that we endorse. One important example is how technologies figure in these futures. The idea that technological progress can improve the human condition has put technologies and technological futures in the centre of anticipatory activities, from making visions and plans to exhibiting technology prototypes in fairs that showcase the wonders of the future (Goodman, 2008; Ganz, 2008).

There are multiple ways in which futures can be envisioned. The methods of future studies includes foresights, forecasting, strategic planning, technology assessment and backcasting, in order to prepare for, avoid, or discuss possible consequences and outcomes of present-day decisions and trends (Börjeson et al., 2006; Sardar, 2010; Bishop and Hines, 2012). While these methods are developed to enable the envisioning of credible and probable futures, human history is also full of futures which serve as inspiration or warning, with little claim of credibility. Fiction, in the form of novels, art or film, has provided many utopian or dystopian accounts of the fate of humanity.

In this thesis I engage with how these different envisioned futures are actually used and how we can explain when and how they contribute to socio-technical change. Based on the work on how expectations are fundamental in enabling coordinated change (van Lente and Rip, 1998), I develop analytical tools to enable identification of the mechanisms by which envisioned futures become efficacious in these processes of change. As an overarching term I will use ‘envisioned futures’ to denote all different ways in which futures are represented, from concrete and formalised representations like scenarios, visions, roadmaps, and goals, to less explicit representations such as prototypes, paintings, or poetry. The different kinds of envisioned futures potentially have different effects on what we do in transitions, and they may engage actors in different ways. This is the reason I have used this broad term rather than using concepts with more narrow meaning such as ‘visions’ or ‘imaginaries’ which often denote some kind of sharedness among actors, as well as desirability (Jasanoff, 2015).

1.1 Envisioned sustainable futures

Not just the idea of progress has spurred visionary practice. The risk of resource depletion, pollution, authoritative rule, or war has equally given rise to cautionary or dystopian representations of futures, from urban visions to literary fiction (Goodman, 2008). The idea of progress has been more strongly opposed in the late twentieth century, as a reaction to the implicit notion inherent in ‘progress’ that nature’s resources would never be depleted or destroyed (Nisbet, 1979). Technology, from this perspective, does not only bring goodness and prosperity but also environmental degradation and pollution. While issues of ecologi-

cal sustainability, i.e. the preservation of ecosystems' capacity to generate goods, have been discussed since at least antiquity, sustainable development emerged as a concept which reconciled sustainability (preservation) with development (progress) (Du Pisani, 2006). The vision of a sustainable development is a vision of a future process rather than a future state and thus seems to evade earlier warnings of the risks of utopias that they would inevitably lead to authoritarian rule and repression. Sustainable development is not a blueprint of what society should look like but rather sets very loose conditions for what good futures should focus on. Very different social visions of what a sustainable future looks like and what is desired exist. Visions of high-tech societies with 'smart' technology compete with envisioned communal simplicity and local economies (van den Bergh et al., 2011).

The double role of technology as both saviour and destroyer is particularly interesting in processes of change towards more environmental sustainability, what has become known as 'sustainability transitions.' Sustainability transitions and the prospects of sustainable development are encompassed in the large field of 'sustainability science'. This field covers the study of society's capacity to deal with environmental change as a result of economic activity as well as assessments of the impact that these activities have. A more specific focus on how socio-technical changes towards sustainable development come about is found in sustainability transitions research. In the sustainability transitions literature, transitions are generally defined as changes of socio-technical systems, with a focus on the process of change. Markard et al. (2012, p. 956) for example, define sustainability transitions as 'long-term, multi-dimensional transformation processes through which established socio-technical systems shift to more sustainable modes of production and consumption.' Four frameworks dominate this field of research: transition management, the multi-level perspective (MLP) on socio-technical transitions, strategic niche management (SNM) and technological innovation systems (TIS) (Markard et al., 2012).

All four frameworks highlight the importance of envisioned futures in different ways. Common to strategic niche management, transition management and the technological innovation systems framework is that envisioning is a practice that should be encouraged for successful innovation to take place. This applies especially to innovations for sustainability as they do not apply to 'normal' market conditions since they do not necessarily imply improved conditions or functions for the individual but for society at large, and therefore need strategic support (Raven et al., 2016). In strategic niche management, this strategic support is particularly highlighted through the concept of 'protective space' in which experimentation with new solutions should take place (Kemp et al., 1998). In the TIS framework, envisioned futures figure among the different 'functions' that have been identified as important for successful innovation. One of these is to 'guide the direction of search' (Hekkert et al., 2007) or 'influence on the direction of search' (Bergek et al., 2008). Stimulation of strategy building and envisioning is important to produce goals and legitimacy, not only to create new market preferences or government funding but to enable the exchange of ideas

between technology producers and users. In transition management visioning takes an even more prominent role than in TIS and SNM but is still connected to experimentation and learning. Visions are not only seen as representations of expectations on technologies but should have a social dimension, and be used explicitly to build transition objectives and goals (Rotmans et al., 2001). As in the other frameworks, the role of visions is to create societal consensus and support for experimental activities and policies.

The focus on the role of envisioned futures in these frameworks is prescriptive rather than descriptive or explanatory. Another feature they have in common is that their focus is mainly on how new technologies develop, and on how to foster successful development, rather than on how socio-technical systems as a whole change. The fourth framework, the MLP has a more explicit focus on multiple aligning or contradicting processes between new socio-technical solutions and incumbent ones, and on how these processes enable or hinder transitions. However, drawing on strategic niche management, the importance of visions and expectations in the building up of protective spaces for new niches, is stressed also in the MLP.

1.2 Research objective and questions

The emphasis on the importance of envisioned futures for successful creation of new innovation systems and the development of new technologies opens up questions on their role in the overall process of transitioning towards sustainability. How and when do envisioned futures spur action? How can we explain their relative success or failure in doing so? Fundamental to all processes of change are that there are constraints and enablements to the projects being pursued. Equally important is the motives actors have to pursue these projects and join together in order to achieve common goals. What I imply here is of course the importance of conceptualising *structure* and *agency* in a way that enables us to explain both the outcomes of sustainability transitions and, more specifically for this thesis, how envisioned futures can be situated among these different drivers of change.

Structure is a concept widely used in research on social systems, but there is no agreement as to what this concept actually means. A very broad understanding, a common ground, of what structure is, would be that it is a 'pattern or arrangement – as opposed to that which is "random" or "chaotic"' (López and Scott, 2000, p. 3). Agency is, in the widest sense of the term, understood as the acting of humans. The undervaluing of agency in sustainability transitions research have been criticised (Smith et al., 2005), and its presence defended (e.g. Geels (2011)). The critique has recently been evoked again, by de Haan and Rotmans (2018), who point out that even though agency may be taken into account in sustainability transitions research, the different frameworks 'do not rely on agency for their explanations of transformative change' (p. 276).

The overarching aim of this thesis can then be presented as *to better understand and explain how envisioned futures contribute to sustainability transitions*. This is approached through three research questions:

1. How can structure and agency be conceptualised so as to allow for explanation of how sustainability transitions come about?
2. How can such an understanding of structure and agency be used to explain the role of envisioned futures in transitions?
3. In what different ways do envisioned futures create engagement with sustainability issues and socio-technical change?

The research presented in papers I-IV has been conducted in an exploratory fashion in an attempt to answer these questions. With the starting point in sustainability transitions research, I wanted to find out if there was reason to believe in the maxim that we need a vision to change the present. The inability of the multi-level perspective to explain why some transitions fail and others succeed, which also makes it difficult to use for explaining what kind of effects envisioned futures might have in this process, lead to an immanent critique of the framework. In paper I, we identify the conceptualisation of structure and agency as the main culprit for this lack of explanatory power and suggest an alternative way, based on critical realism, to conceptualise structure, agency, and transitions, thus answering question 1.

In paper II, I engage with question 2 by building on the conceptualisation of structure and agency outlined in paper I, in order to situate envisioned futures in the processes of change that are enabled and constrained by structural and cultural contexts. I am using Archer's work on reflexivity as the main mechanism by which such constraining and enabling is turned into reasons for agents to act in the world. I outline a basis of an explanatory framework for how expectations form an important part of this process.

Question 3 is dealt with in papers III and IV and to some extent in paper II. The empirical examples of envisioned futures encompass four different ways in which futures are envisioned and deliberated: scientific discourses, scenarios, demonstration projects, and literary fiction. The main sustainability issue which has been of concern in these envisioned futures is climate change. For the research presented in paper IV, the focus on climate change was a deliberate choice; in the other cases this rather reflects the dominance that the problems of climate change has acquired in terms of sustainability challenges, and thus the focus of much of the technology development which is made in the name of sustainability.

1.3 Concepts used for different kinds of envisioned futures

As has already been stated in the previous sections, envisioned futures can take many different forms and can be called many different things, depending on how they have been produced and used. The difference in how they are being conceptualised also depend on what they are meant to conceptually say about what they are about, and the possible effects they have. Two concepts that are in focus in this thesis are scenarios and expectations.

Scenarios

A scenario is most often used as a way of telling us something about the future, to reduce uncertainty and to enable long-term planning. Scenarios are thus not only imagined futures but should be able to answer questions like ‘what is likely to happen’, ‘what different things could happen’, and ‘how can specific targets be reached’. Börjeson et al. (2006) differentiate between these three kinds of scenarios and denote them as predictive, exploratory, and normative, respectively. While scenarios do not aim to be true in every detail, they have a requirement of plausibility; they cannot be totally ‘made up’ (Bishop and Hines, 2012). The extent to which the truth claims of a scenario must be satisfied differs among authors. While Börjeson et al. (2006, p. 723) define scenarios as ‘descriptions of possible future states and descriptions of developments’, Bishop and Hines (2012) highlight the storytelling aspect of scenarios, claiming that it is more than just a description. A scenario, as a story, should be specific, with events, names, and dates. It should, however, still be plausible, and not only that; it needs to be relevant and to contain conflicts and unresolved issues. Internal cohesiveness is important; see also Grunwald (2011) on this point.

In this thesis, only climate scenarios are explicitly included in the empirical material. These scenarios, the newly developed ‘shared socio-economic pathways’, are of the explorative type according to the categorisation above, and are made to help to inform decisions regarding the mitigation of, and adaptation to, climate change (Nakicenovic et al., 2014). They are used as a scientific method to elicit possible futures of societal development and climate change and thus to reveal uncertainty and complexity in the outcomes of possible developments. The shared socio-economic pathways are developed as five narratives, or basic storylines, from which more specific scenarios can be built, using qualitative or quantitative data (O’Neill et al., 2017). These storylines are not rich in the sense that Bishop and Hines (2012) call for, and are not aimed at illustrating the consequences of specific courses of action. However, these scenarios are specifically developed as tools to enable a better understanding of possible futures, and it is in this way that the concept of ‘scenario’ will be used in this thesis: as envisioned futures aimed at providing knowledge of what can possibly happen.

Expectations

Expectations on technologies have been defined as ‘real-time representations of future technological situations and capabilities’ by Borup et al. (2006, p. 286). This definition shows the temporal relation between futures and the present but the same authors also point out that their definition overlaps with ‘visions’ and ‘promises’ which are more normative in character in the sense that they more explicitly demarcate between good and bad futures.

In paper II, I engage with the ‘sociology of expectations’ literature to understand if, and in what ways, expectations can be key mechanisms in understanding how envisioned futures lead to action in sustainability transitions. This literature is also used for the analytical framework in paper III. Rather than conceptualising expectations as representations, we use the term ‘expectation statements’ to cover all types of representations which may evoke expectations. These expectation statements include envisioned futures of different kinds but also descriptions of e.g. technological functions, fictive stories, and explanations.

Discourse

Like scenario and vision, the word ‘discourse’ is widely used in everyday language as well as denoting versions of a theoretical concept. At one end, discourse is used to denote the talk between two people, and at the other it is something that structures and renders meaning to the whole of society, constituting the social system (Howarth, 2000). The common ground of the concept is that it comprises how human interaction through language (sometimes incorporating action) creates meaning of social and physical phenomena (Hajer and Versteeg, 2005; Howarth, 2000; Winther Jørgensen and Phillips, 2000). The basic assumption behind all theories on discourse is that language shapes our view of the world, rather than simply mirroring it (Hajer and Versteeg, 2005). The differences between them can summarily be described as how they approach the ‘real’, i.e. the ontology and epistemology of the approaches. While discourse theory (developed by Laclau and Mouffe) does not distinguish between discursive and non-discursive practice (not denying that there is a reality out there, only that we cannot access it through any other practice than discourse), critical discourse theory distinguishes between discourse and other practices that are not as flexible, such as institutions, the economic system, or material practices. In the latter perspective discourses are shaped by and re-shape such non-discursive practices (Winther Jørgensen and Phillips, 2000).

Discourse is in this thesis understood as a specific way of representing things which can be identified with specific positions or perspectives, such as the discourse of ecomodernism (Fairclough, 2013). A discourse is thus a collection of representations which are semi-coherent and widely accessible. In this, a discourse differs from meaning-making in general (such as individual reflection or very local or transient representations). Meaning is made

and interpreted all the time, especially in individual experiences and encounters with reality. These more general ways of producing meaning, which are part of all social processes, are denoted by the concept of semiosis, which includes language, visuals, and body language.

1.4 Outline of the thesis

In the second section, I discuss the theoretical background to the research presented in this thesis. In the third section, I shortly describe and discuss the research approaches and methods used in papers I-IV in section three. In the fourth section I summarise the findings of the papers. The first chapter of the thesis ends with a concluding discussion section five, and an outlook with suggestions for further research in section seven. The second chapter contains the four papers.

2 Theoretical frameworks used and scrutinised

The research presented in this thesis is not based on a single theoretical framework or approach. My PhD education has been characterised by a search for theoretical frameworks suitable for explaining how and when envisioned futures matters for sustainability transitions. Such a search is always conditioned by the circumstances one finds oneself in as a researcher. In my case, the MLP was suggested as a suitable framework in the first two projects I took part in. However, experiencing a growing frustration with the way envisioned futures were mainly prescribed as being important in sustainability transitions research, I sought the roots of these claims. These were found in the literature on ‘sociology of expectations’ which transitions scholars refers to. The sociology of expectations literature does not deal with transitions as such, but offer a richer framework for understanding how expectations come about, why they are being held, and the effects they often have. These insights have been useful in my studies on how claims about future capabilities of technologies are being made and how such claims compete.

During the same period, I was increasingly frustrated by the lack of explanation that the MLP narratives provided. I had discussions with Oscar Svensson on the pros and cons of using the MLP as an analytical framework to study the processes we were interested in. When he presented an idea for a paper on the conceptualisation of radical change in the MLP, I immediately joined him. This led to our critique of the explanatory power of the MLP, presented in paper I. Having been introduced to critical realism during a PhD course, we were curious to see if that could help ameliorate our frustrations. Admittedly, we have also used critical realism and critique by authors influenced by critical realism, most notably Margaret Archer, in our own critique of the MLP. Of the many different philosophies of science, critical realism is the one I have found the most useful so far. It provides tools for how to explain phenomena and how change comes about in a world where multiple causes often interact to produce highly irregular outcomes.

Archer’s morphogenetic approach, and particularly her work on agency and reflexivity, was helpful in giving a better understanding of how expectations can lead to coordinated activity for socio-technical change and to re-conceptualise the meaning of ‘expectations’ and ‘expectation statements’.

Below, I will summarise the parts of these frameworks and approaches that I have engaged with in my research. How they have been used is described in section 3.

2.1 The multi-level perspective

The multi-level perspective is presently the most prominently used framework to study sustainability transitions. It is aimed at explaining transitions and how they occur, and

is developed as a heuristic to map and identify recurring patterns and actors which drive transitions. The primary idea of this framework is that there is an interplay between three levels of structure: the niche, the regime, and the landscape. Each level is characterised by its durability and dominance in the system (Rip and Kemp, 1998; Geels, 2002). The MLP describes socio-technical change as a process whereby the dominant *regime* is replaced by a *niche* when external (created by shifts in *the landscape*) or internal destabilising processes create room for niches to break through. The three levels of the MLP, the landscape, the regime, and the niche refer to different degrees of structuration, the levels should not be seen as separate spaces or systems but as structures which govern actors engaged in a certain socio-technical domain (food production or electricity generation for example) to different degrees.

As stated in the introduction, envisioned futures and expectations have not acquired a prominent role in the stories of transitions that the MLP presents. Still, based on the research on niche development, expectations and visions are recurrently claimed to be important for legitimising the new socio-technical configurations and for resource attraction. Legitimation and resources are important parts of what is needed for transitions to take place but it does not mean that visionary practices on their own can explain the success or failure of a specific technological concept (Raven et al., 2016). Expectations and visions are understood as a kind of structure, in the sense that they do provide cognitive rules for future behaviour, and provide direction for experimentation and development (Geels and Raven, 2006). Visions are part of discursive struggles to legitimise the existence of the new socio-technical concepts, to change institutions and challenge the current systems to open up the possibilities of supporting new innovations (Smith and Raven, 2012). Expectations are also used to explain both upswings and downswings in the interests of a new technology. ‘When learning processes produce outcomes that do not meet the expectations, this leads to a backlash in expectations that turns from the positive to the negative. When actors’ beliefs turn sour, networks fall apart and resources are reduced, leading to a decline in development’ (Geels and Raven, 2006, p. 389). In this account then, the importance of envisioned futures and visionary practice is important to reinforcing the niche, to enable its take over when the regime is destabilised.

Situating expectations as part of structure fits well with the overall conceptualisation of structure as rules which are instantiated in practices by actors. These rules are the grammar of socio-technical systems which actors creatively interpret and are guided by in practice (Geels, 2004). The structures, or rules, are thus connected to a system because they are what guides action in the system, although they are not *part of* the system. The MLP is thus founded on a distinction between structure (the regime) and the socio-technical system as such. ‘System’ should be used to refer to ‘tangible and measurable elements’ and regimes to the ‘underlying deep structures’ – socio-cognitive frames and rules, such as engineering heuristics and routines, which actors follow in action (Geels, 2011, p. 31).

2.2 Sociology of expectations

The research on how expectations influence technology development is diverse and no coherent theory or framework has been developed. Rather, it is a set of work which is about ‘exploring a range of questions about the role of expectations in shaping scientific and technological change’ (Borup et al., 2006, p. 285). It was introduced as a particular set of research by Brown and Michael (2003), who contrasted it with scenario-building research with the claim that while the latter is looking *into* the future, ‘sociology of expectations’ is looking *at* the future and how its representations affect action in the present. This focus on how representations of futures have effects in the shaping of technology and knowledge is what binds together this rather diverse set of research.

Expectations on technologies, or ‘technological expectations’ has been defined as ‘real-time representations of future technological situations and capabilities’ (Borup et al., 2006, p. 286) but more generic definitions such as ‘expressed ideas of future developments, including various beliefs and hopes in overall progress, visions, rhetoric marketing language, prototypes and political exclamations’ (Hultman and Nordlund, 2013, p. 33) are also used. Expectations defined in such a broad way, overlaps with how I use the term ‘envisioned futures’ in this theses.

Expectations are generally held to be *structuring*, something which governs behaviour. At the same time, the kinds of expectations that are studied in relation to technological development and socio-technical change are studied because they are believed to enable action which will *change* practices and systems. In this case, then, expectations are of interest because they have transformative potential. To capture this dual nature of expectations, van Lente and Rip (1998) introduced the concept of ‘prospective structures’. This way of conceptualising expectations stresses both their structuring effect as well as their futuricity, so that they need not be conformative to current structures and ideas.

But in what sense are expectations structures? The conceptualisation of expectations as prospective structures (van Lente and Rip, 1998) builds on the idea that the content of expectations designates roles for different actors. If these expectations become accepted by a large number of actors, these actors also have to live up to the roles that they were given. In that sense, expectations are rules for future behaviour. As rules guiding behaviour, expectations coordinate activities in the present and help make agendas. Deuten and Rip (2000) highlight the narrative character of expectations and how the roles of actors also fit into the storyline which expectations are made up of. Accepted narratives guide action because it constrains what is possible for actors to do without contradicting the script. Such contradicting requires extensive effort from actors as the narrative does not support their actions any longer. Not only are humans designated a role in these stories, technological artefacts are also given a specific role to play. Expectations therefore lead to promises which both human actors and technological artefacts need to live up to. These promises, through

assessment and testing, lead to specific requirements and roles to fill in which are further assessed in a promise-requirement cycle (van Lente and Rip, 1998). If these expectations are lived up to (generally by being actively pursued by advocates of the expectations), if the roles are enacted, structure has changed.

On the effects of expectations

The reason why expectations need to be situated in relation to structure and agency is of course that they are claimed to *do* things, they have effects. Apart from guiding activities by providing roles and requirements on actors who commit to the expectations, other effects of expectations have been studied. These effects include providing legitimization and attracting resources for a promising technology. Generally accepted promises and expectations do not provide legitimization for a specific technology alone; activities which align to these expectations do not need further legitimization (Borup et al., 2006).

One of the most oft-cited effects of expectations is that they, through their guidance, *coordinate* action (van Lente and Rip, 1998; Borup et al., 2006). This is also one of the main reasons why expectations and envisioned futures are claimed to be important for sustainability transitions – expectations provide directionality. The basic mechanism by which this happens is in the storylines of the envisioned future as was stated above. The coordination sometimes happens through self-fulfilling prophecies because actors believing in or desiring a certain future act to make it come true (van Lente and Rip, 1998). This is a reflexive process; actors do not blindly follow the expectation but strategically manoeuvre their situation. The coordinating effect of expectations, and the self-fulfilling prophecies, is also what leads to the much studied process of hype (and disappointment) cycles (Brown, 2003; Konrad, 2006; Bakker and Budde, 2012; Budde et al., 2015; Gardner et al., 2015). That self-fulfilling prophecies are followed in a coordinated manner does not depend upon a shared set of values, or the envisioning of desirable outcomes, but on the fact that the actors aligning to the expectations expect *the same outcome*. Despite the assurance of expectations not working deterministically, these described processes of the effects of expectations make it difficult to understand (and explain) when actors have enough freedom not to follow the expectations and ‘prospective structures’ and when they are obliged to do so. Statements like this one reinforce the appearance of deterministic effects: ‘Actors ... know the other actors, they know the stakes and the rules of the game. *And they act accordingly*’ (van Lente and Rip, 1998, p. 208, emphasis added).

2.3 Critical realism and Archer’s morphogenetic approach

The critical realist ontology distinguishes between three ontological domains of reality: the ‘empirical’, the ‘actual’ and the ‘real’ (Bhaskar, 1998). This distinction should not be un-

derstood as a claim of fictional existence of that which we observe, rather the opposite. There is an independent reality, with an existence independent from our perception of it and that which we do measure or experience (the empirical) is only a part of that which is real. In the same vein, events that actually occur do not exhaust all possible eventualities that *can* occur, and the actual is also a subset, but a larger one than the empirical, of the real. To cover also that which has not happened but still exists as a possible event, critical realists refer to causal powers of entities (such as systems) as potentialities which may, or may not, actualise. Matches, dry logs of wood and a human being capable of igniting the matches, together have the potential to produce a fire, but the outcome may still be that no fire was lit due to unfavourable conditions such as rain or wind. The powers, or mechanisms, of entities may therefore exist untriggered as well as triggered but counteracted, and thus without effect. These powers are emergent properties of the entity, which result from the parts of which the entity is made up, and the ways in which these parts are organised, or their relations. Social systems are generally full of contingent and complex interactions between many different mechanisms and the outcome of a series of actions are therefore seldom reproduced on a regular basis. In critical realist terms these are the characteristics of an 'open' system.

One important implication of this is that the structure of a system is an emergent property of the parts of that system and how these parts are internally related to each other. At any one time, this structure already exists. Human action (or any other type of event) can transform or reproduce this structure through their practice but structure is never created or made, as if without history (Bhaskar, 1998; Archer, 1995). Archer (1996, 1995, 2000) calls this process of transformation 'morphogenesis' and that of reproduction 'morphostasis', hence the naming of her overall approach as the morphogenetic approach. I will only outline what is important in this approach for the research that is presented in this thesis.

The morphogenetic approach is built on analytical dualism. This means that Archer takes structure to be analytically distinct from the practices of people. Similarly, culture is distinct from how people interact, using discourse and other semiotic elements like body language. Culture is a concept which denotes all existing intelligibilia, and it is a system with logical connections between its parts (the ideas themselves). This cultural system is the result of prior human socio-cultural interactions, it is always man-made, but the result is an emergent system with properties that make this system able to produce independent causal influence over further socio-cultural interactions. This autonomous capacity comes from how ideas are logically related. If the two ideas are necessarily related but contradictory, for example, it will cause trouble for anyone who advances one of these ideas but do not wish to endorse the other. This is however only a problem if the contradiction is recognised (by someone). The causal influence of the cultural system thus depend on the intention and recognition of people and is never determining. The cultural system is always reproduced or transformed, never created, through socio-cultural interaction and is always distinct from

the people holding the ideas which it consists of (Archer, 1996).

Agency, on the other hand, is the emergent capability to intentionally act in the world which all sentient beings possess. Archer admittedly focuses only on humans but whether or not other animals have agency is a discussion which has to take place in another text. As humans, our agency is a result of our bodily interaction with our environment, our engagement in practical activity, and discursive interaction. The primary of these practices is our bodily engagement in the world, and it is through these practices that we develop our sense of self. Subsequently, by engaging in the other domains we also become social beings. We are born into positions which might change during our life course due to structural changes or as a result of our own actions. All this engagement is what shapes our own personal concerns, that which we care about. This is possible because humans possess the capability of exercising reflexivity: the ability to think, deliberate, believe, intend, and love (Archer, 2000). These capabilities, our agency, is transformed or reproduced in the same way as culture and structure are transformed or reproduced through human practice.

So, culture, structure and people all have emergent properties which makes them capable of influencing the course of events in different ways. But structure and culture also motivates people in their action. This motivation is only conditional and never deterministic, people have to find them good or bad in relation to their concerns, which is why many agents do not act according to their objective interests given by the position in which they find themselves. The constraints and enablements of structure and culture must be activated, they do not act without anything to act on. Archer (2000) calls these actions 'projects', intended to capture that people choose to act in accordance with their concerns, they are not maximisers or satisfiers. What motivates people to act is thus a result of the reflexive capacity of people, which takes place in the internal conversation (Archer, 2003). One of the capacities that we possess is the ability to anticipate and imagine future events and worlds.

3 Research approaches and methods

Envisioned futures are created and voiced through a number of different techniques and proliferate through different kinds of spaces, from science fiction or science novels, to scenarios and forecasts, prototypes, demonstration projects and political visions. In my attempt to better understand how they matter for sustainability transitions, I have studied some of these different kinds of envisioned futures. As the aim is also to better conceptualise envisioned futures, and the effects they potentially have, in relation to structure and agency, the research approaches in the different papers are diverse.

The argument presented in paper I is built on an immanent critique of the multi-level perspective which seeks to show how the MLP produces problems which cannot be solved within the framework itself (Bhaskar, 2015; Harvey, 1990). Starting off from the conceptualisations, most notably on transitions, structure and agency, given in the early work on the MLP, we scrutinised the implications of the ontological assumptions which the MLP builds on to search for reasons for its lack of explanatory power. This task was at times tricky, not really because the MLP is continually being developed but because its different parts have quite often been inconsistently defined and most of all inconsistently used in empirical research. The pragmatic task of providing a heuristic framework (Geels and Schot, 2010) does not then always fit well with creating ‘causal narratives’ (Geels, 2011) or explaining outcomes (Geels and Schot, 2007). While defenders of the first project may easily sidestep almost all criticism by referring to the importance of rigorous research rather than elaborate theories, anyone endorsing the latter ambition will find it harder to avoid questions of ontology. In paper I, we also argue that *even if* we accept that the MLP is in fact mainly a heuristic framework, the concepts it builds on still refer to ontological assumptions, even if we cannot identify a solid ontological foundation for the framework as a whole.

Rather than building an explanatory theory on what we found to be solid in the MLP, we suggest that critical realist meta-theory can provide the basis for creating a new theoretical framework of transitions. This basis is used in paper II, and especially the work of Archer (1996, 1995, 2000, 2003), to reflect on the possibility of envisioned futures to be coordinating. The benefits of conceptualising structure, culture, and agency the way Archer does is used to discuss how we can understand what expectations are, and what they potentially do. This was done in dialogue with an empirical study of how futures were envisioned through, and by actors involved in, a demonstration project on biogas for heavy trucks. The project was selected from a database of publicly funded demonstration and pilot projects in the Nordic countries which was compiled in 2013 as part of the research project InnoDemo. The project *BiMe Trucks* was selected due to its reported successful collaboration and project outcome. During the spring of 2014, after the project had ended, I conducted interviews with representatives from the five official project partners. The analysis of the interviews

was complemented with analysis of the project webpage, flyers, the project application, and final report.

For paper III we conducted a discourse analysis on how expectations are argued for and evoked by other rhetorical means such as emotional language and metaphors. The different processes in the promise-requirement dynamics outlined by van Lente and Rip (1998) were used as an analytical framework to identify arguments and the way they were structured. This analysis was complemented with an analysis of naming the technological domain, or concept, of carbon dioxide utilisation, and how this concept is metaphorically connected to other concepts with positive connotations. The texts studied in paper III are papers published in scientific journals. They were selected from search results in Web of Science and ScienceDirect in October 2016. Based on cross-references, further papers were identified and a total of 59 papers were analysed. Carbon dioxide utilisation is approached as a potentially interesting concept from many different scientific communities, but the selected material here is delimited to texts with an explicit focus on the carbon dioxide as such. Other approaches, such as the literature on ‘power-to-gas’, see the utilisation of carbon dioxide as a part of what is required in future electrification but do not develop an overall agenda for carbon dioxide utilisation in its many forms.

In paper IV, a newly developed set of scenarios of future societal conditions, called Shared Socio-economic Pathways (SSPs) were compared to climate novels (climate fiction). The analysis conducted was mainly interpretive, reading the selected literary works as scenarios and then contrasting the two sets of narratives. The narrative structure of the SSPs proved suitable for such a comparison. The selection of novels was made from a large set of literature, identified through compilations of climate fiction novels, such as those made by Johns-Putra (2016) and internet communities like ‘goodreads’ and ‘eco-fiction.com’. We read and discussed these novels in a reading group, and from this larger set of novels five works were selected. The selection criteria were based on how well they could be compared to the SSPs. We thus selected novels based on their *closeness* to the SSPs, rather than focusing on contrasting futures. The five literary works therefore portray a world (future or present) which does not deviate too much from present day conditions; they are culturally narrow (they have been published by English-speaking authors from the UK and the USA), reflecting the predominantly Western outlook in the modelling community. The chosen literary works have been widely read and are written by established authors.

4 Summary of papers

In this section I will summarise the findings from the research presented in the papers.

4.1 Paper I: New theoretical foundations for transitions research

In paper I, new ways of theorising sustainability transitions that allow for explanation was sought. By explanation we mean being able to answer *why* phenomena happens by explicating what is necessary for that thing to happen and separating these necessary conditions from contingencies that might also be needed for the sum of causal factors to be sufficient for the phenomenon to occur. Based on a critique of the ontological assumptions on which the MLP (not always consistently) is constructed, reasons for the lack of explanatory capacity in this framework were explicated.

Immanent critique of the MLP

Three problems regarding how structure is conceptualised in the MLP were identified. The first problem follows from how the separation of systems and structures means that it is the cognitive, normative, and regulative rules established within a domain that enable and constrain action. The properties of the system, including material properties such as geographical scale, or technological characteristics, only influence the outcome of events by being interpreted by actors, through these rules, and thus need to be recognised to be effective. This follows from relying on Giddens' duality of structure, in which structure and agency are seen as inseparable. Whereas the socio-technical rules are 'stabilised' by being inscribed (or embedded) in material properties (such as spatial distances or artefacts) they only exert influence over action if perceived and translated by actors. But this disregards the fact that while the structure of a system needs to be (fallibly) perceived to motivate agents to act in certain ways, the outcome of a sequence of events may depend on factors unacknowledged by any of the agents participating in these events. Such disregard makes it a lot more difficult to explain why some systems are harder to change than others, despite the actors having similar intentions of change.

The separation of structure from system, and the conceptualisation of structure as rules governing behaviour, is also problematic in terms of explaining how different actors have different possibilities to take the same kind of (transformative) action in a domain. This stems from how the MLP differentiates between different structures only in terms of how mature and diffused they are, and thus are available and restrictive to all actors in the same way. So when the interpretative schema that rules are become shared among actors, these actors face the same kind of constraints and enablements. The only way different actors

can be differently affected by structures is then by way of how knowledgeable they are – how good their ‘discursive penetration’ is (Archer, 1995). Contrary to such an assertion, it has been suggested in sustainability transitions research that different actors are in fact constrained differently by way of difference in their ‘access to resources at different geographical levels’ (Coenen et al., 2012, p. 971). However, this difference cannot be explained using the MLP framework.

While the first two problems identified in the MLP’s conception of structure and agency stem from the conflation of these two properties, which does not allow the study of their interplay, the third problem relates to how change itself is conceptualised. Since transitions are conceptualised as shifts ‘of the underlying structure which regulates technical change’ (Schot and Geels, 2007, p. 617) this says little about the non-discursive changes beyond new regulative rules that follow from a transition. The subversiveness, or the transformative potential of a transition, is thus left un-analysed in MLP-based studies. A rule-based understanding of transitions does not necessarily say much about to what extent the system or domain studied has changed. As different systems might change in different ways with new sets of rules it is contingent whether or not, and how much and in what way, the system has been transformed during a transition. This contradicts the assertion that transitions research is about studies of radical or transformative change.

All three problems summarised above inhibit the explanatory power of the MLP. The way in which structure is conceptualised as existing only in processes of action leads to the equation of mechanisms with patterns and processes in the MLP. Rather than studying (multiple) causes and effects, the MLP guides the researcher to create narratives of ‘temporal sequences of events and the timing and conjunctures of event-chains’ (Geels and Schot, 2010, p. 93). The causality of the narratives that the researcher thus constructs is guided by the plot inscribed in the heuristic of the MLP, which provides a generalised transition story. Such an approach has little explanatory value when comparing failed with successful transitions since the plot gives us little guidance on how different causal factors interrelate or why the generalised story that the MLP provides is indeed suitable for all kinds of transitions in socio-technical systems.

Remedies to these problems: new conceptualisations

To remedy the shortcomings of the MLP summarised above, we further propose in paper I to base a theory of sustainability transitions on a critical realist philosophy.

The basic ideas of critical realism, outlined above, are useful for a different conception of structure and agency than that of MLP. Instead of conceptualising structure as the rules which govern practice in a domain or system, structure denotes the relational way in which an entity is constituted and this structure is what gives the entity its causal powers. A sys-

tem can therefore be said to *have* a structure which will enable and constrain the different activities pursued by actors. Not only material entities have powers emergent from their constitutive parts, but the same holds for cultural systems of thought (the discursive domain, or the domain of ideas) and for human agency (Archer, 1996, 1995, 2000). These different powers are distinct from each other but their transformation and reproduction are intertwined. Material properties of systems can thus exert causal influence on events, regardless of whether or not we recognise them or incorporate them into practices through rules. These emergent properties of actors (agency), ideas (culture), or systems (structure) interact in a contingent way to produce effects in open systems. This means that the way in which we as actors are constrained, enabled, and motivated in our activities depend on our positions in a structure as well as our capabilities as human beings.

From this alternative conception of structure and agency, transitions can be re-defined as qualitative shifts, by which the system is transformed into a different system with new emergent properties, which when activated have new types of causal powers. The constraints and enablements on the projects pursued by actors will have changed so that new projects are favoured or old projects are favoured in new ways. A simplistic example can illustrate the meaning of this:

Imagine two identical systems, systems A and B, where heating is provided by the burning of fossil fuels in oil or gas furnaces at home while electricity comes from a fossil power plant nearby. In one of these systems, system A, people decide to reduce their primary energy input and therefore build a district heating grid and rebuild the power plant into a combined heat and power plant so that they get both electricity and heat from it. Now, one could say that this new technical infrastructure is a stabilisation of the change in socio-cognitive rules which guide the people in system A, who now wants to reduce primary energy input. That is all well and good because it was this new focus which led them to take on the project of transforming their energy system, but this is not the point here. The point is that system A now has gotten new properties which will constrain new projects and enable others differently than it did before. These constraints and enablements cannot be explained by the shift in socio-cognitive rules but by the effects that subsequent actions had on the properties of the system.

If people of both systems now decide to 'go green' and lower the climate impact of their energy supply they will be differently favoured in these two systems. Equally constrained by an economic system which favours the lowest cost for the same end, in this case low climate impact, they will likely opt for different solutions. While the people in system A might swiftly start burning biomass instead of coal in their power plant, the people in system B might shut down their power plant altogether, build a wind farm and install heat pumps in their homes. As the properties of the systems do not *determine* what decisions the people will make, it is difficult, if not impossible, from the outset, to *predict* what will happen. What can be said, however, is that the people of system A meets different constraints and

enablements than do people in system B after system A first was transformed, and this is why we can identify its first shift as a transition. The second shift in system A, when they substituted coal for biomass, does not (in this limited example) constitute a transition as the technological infrastructure allows for easy switching between coal and biomass. In a more complex example, we would also have to take into account that other factors like ownership, access to resources, distribution of wealth, and so on, might also lead to new emergent properties after the second shift, which could justify it being called a transition.

4.2 Paper II: Expectations as reflexive practice

When first analysing the collected material for this study, the simple answer to the question ‘how do visions, scenarios and expectations coordinate demonstration projects?’ was that *‘they do not’*. From a larger number of interviews than the ones used for paper II, I concluded that there was no simple way in which I could claim that scenarios or visions had played a big role in coordinating the activities of the demonstration projects or in forming the groups as such. The futures that the different interviewees did envision were simply not shared in the group, except maybe for the project goals themselves, but even these, when specified, were contested. Neither could it be claimed that the different actors knew what to expect (van Lente and Rip, 1998), except for very specific things like ‘we should build five refuelling stations’ or ‘a pilot plant will be built’, things that they really had *agreed* on doing in carrying out the project.

Discouraged by this conclusion, I left the material on the drawing board for quite some time. In a second attempt to understand how and if envisioned futures can be efficacious in the context of a demonstration project, I scrutinised the basis on which van Lente and Rip (1998) propose that expectations are coordinative. Coordination, in this context, mean that agents are ‘somehow attuning their behaviors toward one another’ (Disco and van der Meulen, 1998, p. 7). The basic way by which this alignment is claimed to happen is through scripts – stories of how technologies will develop and the roles that different agents will have in making that development happen. Coordinating expectations are therefore basically ‘role expectations’, rules for what each agent is expected to do and fulfill and orient itself toward. Not only human agents are included in these role expectations – they also coordinate technologies.

I identified three problems with their conceptualisation which stem from how they are conceptualised as ‘prospective structures’. Expectations are called prospective structures because van Lente and Rip (1998) claim that actors are creating these structures ‘before them’. This implies that structures can somehow be creatively made through practice, restricted only by the ‘script’ or agenda, agreed on by the actors who share expectations. But this idea ignore the constraints and enablements provided by already existing structure and the cultural system. Bhaskar (2015) and Archer (1995) convincingly argued that structure

and culture cannot be created, only reproduced or transformed, as structure necessarily predates action. As Marx famously noted, we never make history under self-selected circumstances but under circumstances already existing. If expectations guide activities, they do so in conjuncture with other motivating forces, and never alone. This is the first problem with understanding expectations as ‘prospective structure’.

The second problem is that expectations need to be shared and taken up in agendas in order for them to coordinate action. But does this imply that actors expect the same things or does it mean that they are guided by the agenda and therefore deliberately align their activities? Because the agenda allows for reflexive interpretation but the actors act according to their expectations, it is unclear exactly what needs to be shared. In the demonstration project BiMe Trucks which I studied, the actors seemed to orient their activities towards each other, and allocate roles, based on an understanding of other actors’ interests rather than shared expectations. Because this was a collaborative demonstration project they had a shared agenda, but it was limited to the project goals itself and did not matter after the project itself had ended.

The sharedness and neglect of existing structure and the cultural system is related to the third problem identified. The expectations are claimed to coordinate through allocation of roles. But acceptance of such expectations cannot by itself explain alignment of activities. Role expectations for each position in a structure which an agent enact are overdetermined by the structural and cultural system. So the role designated to each agent cannot be determined by acceptance of the expectations alone. To explain why each agent is aligning its activities, the structural position of that agent needs to be taken into account – as well as the specific concerns that this agent has developed. This argument is well aligned to the suggestion by Bakker (2014) that the strategies developed by agents in a transition must be understood as an interplay between their interests and their expectations.

Technologies, being inanimate artefacts with no intentionality, cannot accept role expectations and cannot be constrained, nor enabled: this is something only the projects of intentional actors can be. But this does not mean that how new technologies are developed are caused by the intentions of actors alone. The projects that actors pursue will be an important factor in explaining the direction and pace with which a technology develop (without any projects they would not be developed at all). However, the causal powers of the technological artefacts, activated through experimentation, will be another important factor that explain the outcome of these projects. As agents are involved in such experimentation they will learn from their practical engagement with the technology which might lead to new projects being pursued.

By differentiating between culture, structures, and agency and their different properties, I propose to reconceptualise expectations in two ways. First, as an act, *to expect* is part of the reflexive practice, the internal conversation that actors engage in (Archer, 2003). It is

through this internal conversation that actors reflexively deliberate on their projects and strategies. Actors reach conclusions on which strategies to pursue based on their personal concerns and their perceived structural interests. The capability of expectations to coordinate transformative activity can therefore not be inferred from observed shared expectations or agendas alone.

Second, *expectation statements* are statements that explicitly tell us to believe in causal narratives, whether based on possibilities and probabilities or predictions. These can be used for different purposes: to attract attention and resources, and to legitimise projects but also to warn us of undesirable consequences of our actions. The success of them doing so depends on socio-cultural interaction between actors situated in a specific structure. In the paper, I exemplify expectation statements with scenarios, forecasts, predictions, and visions. An envisioned future with no truth-claims is not an expectation statement in this strict sense, but it may still be able to evoke expectations in the actor during her internal conversation. This is because imagination can make us understand the world anew, and so the propositional statements about causes and effects may be altered.

Rather than providing a causal narrative for how expectations come to coordinate transformative action (creating structure), I propose that we should search for the potential powers that expectations have, the mechanisms by which they become efficacious. This means that the effects of expectations cannot be predicted and that causal narratives with certain outcomes cannot be created. A simplified scheme containing the relevant factors for the process by which I propose that expectations are taken up by actors can still be sketched as an illustration:

- Initial possibility is represented in a story
- The story is reflexively interpreted by an actor in relation to other propositional statements, the actor's practical knowledge and concerns
- (In)action is taken based on this reflexive process
- Transformation or reproduction of existing structure.

The coordinative effects of envisioned futures, and expectations, and if they lead to transformative change, is concluded to be an open question.

4.3 Paper III: Expectations on carbon dioxide utilisation

In paper III we explored different ways in which expectation statements on technologies for the utilisation of carbon dioxide are presented in scientific discourse. We found that

while most of the papers advocate carbon dioxide utilisation, they express conflicting views on what this technological domain essentially ‘is’ – what should ‘count as’ carbon dioxide utilisation and what should not, and thus also what it should be able to contribute to. One of the reasons for these conflicting expectations is that the envisioned futures in which these technologies would be employed differ. Despite the differences in the envisioned futures, the importance of utilising carbon dioxide is supported by the claim that carbon dioxide is the *only* viable source of carbon in the future. In different ways, the futures envisioned invariably present a lack of sustainable carbon sources: due to climate change, a scarcity of biomass resources, or a decline in oil extraction. That carbon dioxide utilisation is *needed* can thus be supported by a variety of futures, as long as these depict a society with continued heavy reliance on hydrocarbons and other carbon-rich materials and fuels.

The necessity of supporting carbon dioxide utilisation technologies is the only expectation on which the envisioned futures depicted in the scientific papers converge. There is a broadly stated claim that carbon dioxide utilisation will contribute to climate change mitigation, but the extent of how and in what circumstances it can be promised to do so is debated. The divergence in expectations depends to a large degree on whether fossil fuels are envisioned to constitute a large part (or not) of the future energy system (worldwide or in parts of the world). Specific requirements are therefore also contested, as some authors argue forcefully for the utilisation of ‘green’ carbon from biomass or ambient air, connecting carbon dioxide utilisation to circles of life such as the carbon cycle and photosynthesis. Here, the envisioned futures are the extension of a circular economy, with enhanced resource effectivity and technologies that imitate nature.

These positive metaphors of naturalness and cyclic resource use are evoked across the different futures envisioned in relation to ‘rational’ arguments used to assess the limits and potentials of utilising carbon dioxide and its prospects in contributing to climate change mitigation. These metaphors thus seem to float above assessments and requirements as a common framing together with the necessity of utilising carbon dioxide as a source of carbon for future materials and fuels.

4.4 Paper IV: Affective engagement through literature

In paper IV we sought to enable a discussion between literary fiction and scientific scenarios on climate change, the shared socio-economic pathways (SSPs), by discussing the different ways in which they might engage the reader with climate change and how they affect the understanding of challenges to mitigation and adaptation.

The SSPs are scenarios of possible future worlds with varying challenges to mitigation of and adaptation to climate change (O’Neill et al., 2017). They are constructed as narratives from which factors can be translated to numerical values to be used in climate and economical

models for further scenario work. The SSP narratives are thus not fleshed out stories but rather narrative contexts or backgrounds which focus on objective factors relevant to the mitigation of and adaptation to climate change. Based on the SSP narratives more specific futures can be envisioned.

Literary fiction on climate change, however, brings climate change into its stories in different ways. It might serve as a backdrop to the story, in other cases it actively steers and contributes to story development. In contrast to the SSPs, literary fiction does not to a large extent systematically describe objective factors that are relevant to mitigation and adaptation. Instead, the world in which the story takes place is described through specific events and through the filtering of subjective perspectives of characters in the story.

By reading the novels as scenarios – looking for factors indicative of challenges to mitigation and adaptation and similarities to the five SSPs, we could directly relate the two different kinds of narratives to each other. In this way the general trends described in the SSPs could be compared to specific events unfolding in the novels, for example the rising inequality in SSP4 with the growing unrest and collapse of political legitimacy in Saci Lloyd's *The Carbon Diaries 2017*. This comparison shows the first difference between these two ways of envisioning futures. While the SSPs provide knowledge in general terms, often describing change as a process without actors, the unfolding of events is not always explained but *experienced* in novels. Novels give us insight into actors' desires, beliefs, and reactions to different circumstances. Whereas scientific scenarios provide knowledge as to how structures affect the ease by which climate change can be acted on, novels give us a glimpse of *why* specific actions are taken and what *motivates* actors in different contexts.

Four conclusions were drawn in the paper. First, that the two different kinds of narratives are comparable. Many different scenarios and stories can fit within the context that the SSPs provide. Second, that fiction tells somewhat different stories than scientific scenarios and sheds light on factors important to challenges to mitigation and adaptation that were not visible in the scenarios. Among these factors are actors' motivations and reasons for engaging with climate change. Third, novels have more room to elaborate on solutions that are not deemed plausible or credible in a scientific context, opening up space for a discussion on the desirability of different futures and solutions. Fourth, novels provide insight into how climate change is experienced differently by different actors and the dynamics that these different experiences create. The knowledge and concerns that the different kinds of narratives convey create different kinds of engagement – in simplistic terms it can be said that SSPs are more 'rational' and literary fiction more 'emotional'. These differences can also be summarised as the scenarios being about the objective (structure) while literary fiction is about the subjective (agency).

The 'rational' engagement that the SSPs create focuses on avoiding risks and managing opportunities. This comes as no surprise as the objective of constructing scenarios is to

enable better planning and prepare for possible outcomes. The 'affective' engagement in the novels is generated through relatable personal stories and emotional themes such as loss, trauma, accidents, murder, injustice, and poverty. An example is how Barbara Kingsolver's *Flight Behavior* portrays what poverty means, and how it affects the way in which actors engage with climate change.

5 Concluding discussion

This thesis has laid the groundwork for a realist theory of the role of envisioned futures in sustainability transitions. The importance of how we understand the relationship between structure and agency has been stressed and their separation into two distinct emergent properties advocated. Two different facets of reasoning that is needed to motivate transformative action have been explored: expectations, which provide rationales for taking certain kinds of action, and affective engagement, which emphasise the importance of taking action. This section contains some concluding remarks on how the research questions have been answered and how these answers matter.

5.1 The value of reconceptualising structure and agency to explain the role of envisioned futures in sustainability transitions

To be able to explain how transitions come about we need to know what it is that change, how it can change and what the driving forces are. A realist understanding allows for the study of the interplay between the different entities that influence the outcome of transition activity. The interacting powers are emergent from people, systems, and ideas. To be able to explain how they become effective in transforming existing contexts we need to establish the capacities of existing structures as well as what it is that motivates transformative action.

The separation I suggest, between the act of expecting and expectation statements, enables us to study how different kinds of expectations and ways of envisioning futures may potentially have different effects. Our expectations reflect our understanding of how the world works. This knowledge of the world is of fallible, but if it does not refer to that world at all, if it is not accurate enough, it might be revised if we act on it. This does not mean that our revised conception is true, but at least it must be of greater practical value if we are not to revise it again. These kinds of expectations are about possibilities and probabilities, what we expect to be the outcome of a certain course of events. They guide us towards means and ways of doing things if we want to reproduce or transform the socio-technical system.

But humans also have the capacity of imagination. Worlds other than the ones we inhabit can be envisioned and speculation on how things would be if we did A or B, or if circumstances changed, is part of decision-making in everyday life as well as strategic planning. If this practice of envisioning is not deemed ‘realistic’ or probable in any sense, it is not likely to generate any expectations but will be dismissed as unfeasible, utopian or mere daydreaming. This does not imply that imagination is not an important part of human reflexivity. An actor can most certainly report of ‘seeing things differently’ after having read a fictional story or daydreamed. To see things differently can lead to re-evaluation of the interests of that actor. But while imagination is an important part of reflexivity, it is not likely to lead

anyone to *expect* that this world will come about. Such utopias (or dystopias) rather serve as compasses – they provide direction of where to go. *How* to reach the imagined world is based on our knowledge of the world and our strategies are likely to be generated both from what we want to accomplish, and from how we think we will be able to do so. In formulating a strategy we thus express our expectations on what we think the outcomes of our practice will be, and what we think will be the right thing to do.

This is not to say that if a vision is produced, actors have the power to make it come true. Only some futures are possible, especially in the short run. Technological characteristics and properties are part of the social structure that influence the kind of futures that are possible to achieve. To enable future transitions we therefore need not only causal narratives of how transitions usually come about but plausible accounts for how specific ongoing transitions can possibly succeed. The best way forward for such an undertaking is an explanatory theory which takes into account both material, ideational, and agential powers.

5.2 Engagement with sustainability issues and transformative change

The third research question that I have been seeking to answer in this thesis was about the different ways in which envisioned futures may create engagement with sustainability issues and socio-technical change. To discuss the findings of papers III and IV, which address this question, I first have to clarify what I mean by engagement. In general terms the concept implies that to engage in is to partake in a certain action. But engagement does not simply imply doing something, but doing with it concern. It is how this concern may be generated through various types of narratives and propositional statements that I wish to discuss here.

In the scientific discourse on carbon dioxide utilisation, expectation statements were constructed in several different ways to provide *reasons* to support and develop technologies to capture and use carbon dioxide in different applications. The reasons provided mainly built on propositional statements, claims on how things will develop and the probable causal effects. The forms of propositional statements that we identified were based on the capacity of the technologies themselves and on probable socio-technical development. The truth claims of these statements can be assessed to some degree by the reader and the reasons provided by them can thus be categorised as cognitive-rational. The SSPs which we discuss in paper IV provide the same type of reasons.

In contradistinction, the literary fiction excels at providing affective reasons to engage in sustainability transitions. As emotions are the way by which we are affectively aware of our context, emerging from bodily, practical, and discursive practice they are resources that we use to deliberate on the worth of pursuing different projects (Archer, 2000). Such affective response depends on remembrance and identification of particular experiences. By providing stories with characters with agency identification, a kind of second-hand experience

can be created, to imagine not only what might happen, but also how that might feel. Narrative devices, such as focalisation, help the reader to identify with the characters and to make their stories meaningful in relatable personal stories. By being presented to situations which we might not recognise (we might not have experienced that particular situation) the process of identification and remembrance of similar kinds of experiences, *emotional anticipation* might emerge. These stories help the reader anticipate the fear of loss or the joy of success that might result from different kinds of action taken on sustainability issues. Emotional reasons are more difficult to generate through structural scenarios because a lot of imagination is needed to get a grasp of what these structural conditions imply, they do not tell us what it is like to live in the worlds they envision.

Of course, no text is ever only ‘emotional’ or ‘rational’; fictional stories are full of propositional statements whose potential truths can be deliberated, and their contextual truth-value assessed, be that in the real or the fictional world. Similarly, scientific discourse is full of symbolic and affective language, as our analysis of the papers on carbon dioxide utilisation showed. But as proxies of these two poles of different ways in which reasons for action are generated, the literary fiction and scientific discourse exemplify how both reasons and emotions are needed to create a concern (Archer, 2000). This is important in studying the role of envisioned futures in sustainability transitions as one of their main effects is to create concerns, and concerns are needed for commitment to transformative activities.

6 Envisioning futures of research

Much work remains if my aim of being able to explain and understand how envisioned futures contribute to sustainability transitions is to be reached. It is likely that many different kinds of envisioned futures are needed in a democratic discussion on what sustainability really means how we should move towards it and their respective role in motivating transformative action should therefore be explored. I suggest that two specific themes for further exploration on why envisioned futures are engaged with and how they come to have effect: credibility and the mechanisms of coordination.

That envisioned futures need to be ‘credible’ to have an effect is often taken to be true. But what does ‘credibility’ mean and in what situations does it matter? When is imagination and speculation – deliberate fiction – more important? Does it matter if we often get the future wrong? And which aspects are important to get right? To explore these questions, not only the study of how envisioned futures matters in different transformative practices but also the process by which we produce new representations of the future. It should be fruitful to link futures studies, and research on the role of envisioned futures, as already suggested by van Lente (2012) and implied by Patomäki (2017).

How and if credibility matters can not be answered in a satisfactory way if we do not understand how collaborative engagement with transformative change comes about. To explore the mechanisms by which collaborative engagement is established and maintained – what they depend upon and how transformative groups use envisioned futures in collective reflexivity – is therefore important. The work by Donati and Archer (2015) could be one source of inspiration to explain how collective engagement comes about and if this is pertinent in explaining the seemingly coordinating power of envisioned futures.

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