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Governing the Energy Transition

Reality, Illusion or Necessity?

Edited by
Geert Verbong and Derk Loorbach

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Contents

Figures

1 Introduction

Geert Verbong and Derk Loorbach

1.1 SOCIETAL CHALLENGES OF THE ENERGY TRANSITION

On 14 August 2003, a blackout occurred in the Northeastern part of the US and in Lower Canada, causing, among other things, the normal flow of life to come to an abrupt standstill in New York City. Lots of people got stuck in elevators, the subway system halted and millions of New Yorkers came out into the streets, many of whom were forced to stay there for the night. Engineers managed to trace the origin of this blackout to Ohio: apparently, operators did not know how to deal with local disturbances and this caused several lines to get overloaded, which subsequently were switched off. The instability spread from one region to the next, resulting in the large-scale blackout (Schewe, 2007). Only a few weeks later, a major storm knocked down power lines near the Italian-Swiss border. Due to excessive loads on the remaining lines, officials decided to remove Italy from the European grid. Less than two minutes after this decision's implementation, frequency instabilities caused a complete collapse of the Italian electricity system, virtually throwing Italy into darkness. In Rome, where the annual Notte Bianca festival was taking place, the power outage created chaos after the subway system stopped functioning, leaving thousands of festival visitors stranded. The death of at least four people was directly attributed to the power outage (Lagendijk, 2008).

Blackouts effectively demonstrate that without electricity the fabric of modern life immediately starts to disintegrate. Our modern society has become highly dependent on energy supply systems. We have become so used to a continuous and uninterrupted flow of electricity and other energy carriers that we only become aware of our dependency when a major disturbance occurs or becomes imaginable. In 2005 a controversy arose between Russia and Ukraine about natural gas and transit prices. When Russia cut off the gas supply to Ukraine on the first of January 2006, many West-European countries started to worry. Russia is one of the main suppliers of natural gas to this part of Europe, the Ukrainian pipelines serving as the main transport arteries. Although this particular controversy was settled within a couple of days, European governments had become painfully aware of

this new dependency. That their concerns were justified became clear once again in January 2009, when a new dispute would cause a severe reduction of the supply of Russian gas (Pirani et al., 2010). Of course, the industrialized world has had to face disruptions of the energy supply before, the 1956 Suez crisis and the 1973 oil crisis being the best-known cases. Clearly, the uneven geographic distribution of energy resources has made energy supply systems vulnerable to political instability and turmoil, as well as to the strategic use of energy resources as a political weapon. Such events also have had a major impact on energy prices.

Another major challenge involves the finite nature of the earth's fossil fuel reserves. At the same time when the control over oil fields was used as a strategic weapon in the early 1970s, the Limits to Growth report introduced the notion of the scarcity of fossil fuel resources and their future depletion to a large audience (Meadows, 1972). This report induced a frantic search for alternatives and ways to increase energy efficiency. The falling energy prices in the late 1980s temporarily eased the urgency of these policy goals, but the growing demand and the increasing efforts needed to maintain existing production fields or to find and develop new fields have put the scarcity of fossil fuels on top of the political agenda again. The output of many old fields is steadily declining. Some scientists argue that we have already passed the peak in oil production, whereas others, notably those with interests in the oil industry, tend to present more optimistic predictions (Bardi, 2009; Verbruggen, Marchobi, 2010). If this so-called Peak Oil debate will not be decided in the short term, all experts agree on the need for a transition to a different system of energy supply. The question is, however, which alternative pathways should be pursued and at which speed. That we are exploiting the earth's limited resources in a highly unsustainable way has been generally acknowledged since the first oil crisis, but this awareness has become more prominent during the first decade of the twenty-first century, due to the growing concerns about climate change but also because of a steep rise of oil prices. From about the turn of the century, energy prices began to rise to levels above $140 per barrel (2008), followed by a rapid decline and a new, more gradual rise in the next year. Although energy rates are highly unpredictable, experts expect oil prices to be much more volatile in the nearby future (Jesse and Van der Linde, 2008).

The effects of higher energy prices have been highly illustrative for the interrelatedness of the divergent domains in society: higher fuel prices have put pressure on the transport system and contributed to a greatly intensified search for alternatives. One option, the substitution of oil and natural gas by biofuels, has meanwhile attracted a lot of negative attention, because the production of biofuels directly competes with the production of food. Although some organizations and politicians have argued that the production of biofuels has led to food shortages and high prices for basic staples, causing severe political disturbances in several regions (Rosegrant, 2008),

the situation seems rather much more complex. For one thing, the demand for agricultural feedstock—largely used to feed cattle, pigs and chicken—has also increased substantially. The meat goes in particular to consumers in emerging markets such as China and India. In many ways these countries have adopted to the Western model of industrialization, based as it is on extensive use of fossil fuels, and a food pattern that includes daily consumption of meat as a major ingredient. Moreover, in the past few years, harvests in several countries were poor, which is to be attributed at least in part to shifts in regional climates that cause droughts and desertification in some parts of the world and flooding and destruction due to excessive rainfall in other parts. Increased agricultural production on a global scale has made this sector much more energy-intensive, both directly, through the use of machinery, and indirectly, due to the massive use of fertilizers. Fertilizers are produced from fossil fuels in an energy-intensive production process. Higher demand, higher energy prices and lower output inadvertently have led to higher food prices. Moreover, agricultural policies, such as those of the EU, tend to protect local farmers and markets. Closed markets in turn have made it very difficult for rural farmers in developing countries to sustain or improve their production, contributing to the massive urbanization that has occurred worldwide. This example underscores that processes of production and consumption have grown intricately linked on a global scale. There is at least one important lesson to be drawn from this story: we need an integral solution that takes the interconnections between the various social domains into account. Put differently: we need a systemic perspective on both the various problems involved and their solutions.

The rising pressure on our system of energy supply also follows from another effect of the way we have organized our system of energy supply. Evidence is mounting—even though it does not go uncontested—that the increasing levels of greenhouse gases (CO_2) contribute to climate changes worldwide. The International Panel on Climate Change (IPCC) has published extensive studies on the changes in the earth's atmosphere and the consequences for the earth's climates. The impacts will be dramatic, in particular for vulnerable regions in less developed countries, such as densely populated delta areas or small Pacific islands. Levels of CO_2 in the atmosphere have been rising since the late eighteenth century, with a marked acceleration after the Second World War. To most experts, the cause of this rise is quite obvious: the Industrial Revolution, which started in England and subsequently spread across the world, marked a dramatic change in human production and consumption patterns. Instead of relying on organic sources of energy (wood, wastes, horsepower), manufacturing began to rely increasingly on energy produced from coal and, later on, oil and gas. The same was true of professional activities in the sphere of farming, crafts and office work (electrical rather than manual devices), as well as in the sphere of mobility and domestic consumption (such as energy for heating houses). The ensuing increase of the concentrations of greenhouse gases in

the atmosphere is inherently linked to our system of energy supply, as the combustion of fossil fuels not only produces useful energy but also CO_2. Energy use accounts for about 75 percent of all emissions, or, in the words of David Mackay: "The climate change problem is principally an energy problem" (2009: 16).

Finally, although the energy crisis and the economic crisis of the 1970s produced a temporary slowdown, a new phase of exponential growth in energy consumption set in during the 1990s, now fueled by rapid economic growth in China, India and other emerging economies. This has in fact launched a new global race for securing strategic reserves of oil and natural gas—but also other natural resources, such as particular precious metals—in which both old and new players participate.

The conclusion to be drawn from the challenges we face in relation to our dependency on our energy supply system—its vulnerability to political instabilities and wars, its highly undesirable side-effects because of climate change, its ultimate unsustainability on account of resources depletion—seems inevitable: we need to change drastically the way we generate and consume energy. In the updated version of the EU Energy strategy, the European Commission has stressed that "Energy is the life blood of our society" (European Commission, 2010). Our energy supply system is a critical infrastructure indeed, because all sectors in our society—including transport and mobility, housing, food production and healthcare—depend on a reliable and affordable system of energy supply. Furthermore, access to energy is also a condition for human development. Many people do not have access to reliable and affordable energy; in India over 400 million people still depend on traditional biomass. Such a transition, therefore, implies a task that is even more daunting: "The energy challenge is one of the greatest tests our society has to face. It will take decades to steer our energy systems onto a more secure and sustainable path" (European Commission, 2010). This also calls for huge investments in energy generation and infrastructure. Still, the European Commission is not very positive on the progress made so far: the existing strategy seems inadequate for reaching the long-term goals (European Commission, 2010).

For several decades now we know that somehow we need to change our system of energy supply and consumption. But despite the many efforts and resources aimed at reducing our energy consumption, diversifying our energy sources and developing alternative energy technologies, we are still highly dependent on fossil fuels. Even worse, the general expectation is that energy demand will increase substantially and that we have to rely on the use of fossil fuels to meet this demand until way into the twenty-first century. Why, then, is it so difficult to change this system?

In this respect, many would immediately refer to the convenience of fossil fuels. Coal, oil and gas contain energy in a quite condensed form. Generation of the same amount of energy based on wind energy, biomass,

or solar energy (PV or CSP) requires large surface areas because of the much lower energy density of the energy flows. As a result, we have become highly addicted to the continuous supply of (relatively) inexpensive fossil fuels. This also explains that the need and the options for change are highly contested almost by definition. Because there is a multiplicity of problems related to our current energy system, as outlined above, while each problem comes with a variety of proposed alternatives, it is impossible to address the whole issue from a single perspective or from the angle of one actor.

The debate on CO_2 emissions—and the need to reduce them—offers a case in point. If the media debate on climate change has become polarized by contributions of the climate skeptics, this also applies to the discussion on alternatives. Some experts have argued that we need to implement a radical shift toward full-scale renewables, but other experts argue that we can sustain fossil fuel production if we successfully implement Carbon Capture and Storage (CCS). Again others have claimed that the diffusion of renewables will involve too slow a process and that they will not be able to meet the energy demand, implying that we need to invest in nuclear power to bridge the time needed for switching to fully sustainable systems of energy supply. Basically, these different pathways, proposed by highly heterogeneous actor groups and backed by different interests and lobby groups, are mutually exclusive. Changing our prevailing energy systems also involves the challenge of dealing with a society in which power and politics do not always follow a scientific logic and/or adopt the best alternatives available.

A significant obstacle, too, is that our current systems of energy supply have co-evolved with modern society. Our society has fully adapted to the fossil fuel-based energy system, which in turn is deeply entrenched in all social domains and practices. The vested interests are enormous, ranging from those of the oil producing countries and the giant oil companies to those of consumers filling their cars with gasoline or turning on the air-conditioning of their home to regulate the indoor climate. Changing the ways in which we provide and organize the supply and usage of energy therefore presents a host of major challenges: we have become completely locked-in in our current fossil fuel-based and centralized systems. Because energy systems are critical to all domains of society, this adds greatly to the complexity of the challenge. There are no simple solutions because every major intervention in the energy domain may produce a chain of unexpected and potentially unwanted reactions in other domains.

1.2 UNDERSTANDING THE ENERGY TRANSITION

Our current energy systems are deeply entrenched in our economy, consumption patterns, regulations and infrastructure. The diverse and

various problems described above, in combination with the increasing vulnerability of our energy systems, could possibly lead to more fundamental and non-linear changes. In the dynamics involved new alternatives may start to compete, dominant options may begin to experience pressures, and tensions may increase between different actor strategies, powers and institutions. The uncertainties around many of these developments are high, which is one of the reasons for different actors to make different assessments regarding the urgency of the problem and the desired direction. Understanding the past, present and possible future dynamics requires a perspective covering a sustained, long-term period; considering interactions at and between different levels of scale, actors and domains; and enabling multi- and interdisciplinary research. The transition approach, as the central point of departure in this book, in fact provides such perspective.

Scholars from several disciplines have studied transitions as a phenomenon. Originally, the term "transition" was used to describe the "phase transitions" of substances going from solid to liquid to gas, but since then the concept has been applied to a wide variety of different types of systems to describe shifts between qualitatively different states. The shift is not a linear one but a chaotic and non-linear process of change. This model is called "punctuated equilibrium" (Eldredge and Gould, 1972; Gould and Eldredge, 1977), and it has been applied in ecology, psychology, technology studies, economics and demography (Gersick, 1991). The sociological concept of transition has its roots in population dynamics. Davis (Davis, 1945) describes the demographic transition in which initially both birth rates and death rates are relatively high. Via a non-linear drop in these rates, a new stable situation is reached with relatively low birth and death rates.

During the 1990s, this concept found its way into research of socio-technical innovation and sustainability (Rip and Kemp, 1998; Schot, Geels, Rotmans, Kemp, Schot et al., 1998; Rotmans, 2000; Rotmans, Kemp et al., 2001). The coupling of the socio-technical research perspective on transitions with the governance and sustainability perspective on non-linear systemic societal change laid the foundation for the new field of Transition Studies (Rotmans, Grin et al., 2004). This new field of research investigates transition processes from a variety of system-perspectives: socio-technical systems (Kemp, Schot et al., 1998; Geels, 2002; Berkhout, 2004), innovation systems (Smits, 2004) and complex, adaptive systems (Rotmans, Kemp et al., 2001; Loorbach, 2004; De Haan, 2006; Van der Brugge, 2009).

In the field of transition studies, transitions refer to large-scale transformations within society or important subsystems during which the structure of the societal system fundamentally changes. Examples are the demographic transition and the transitions from an industrial to

a service economy, from extensive to intensive agriculture, and from horse-and-carriage to individual car-mobility (Geels, 2002). Transitions comprise the shift of a relative stable system (dynamic equilibrium) that undergoes a period of relatively rapid change, during which the system reorganizes irreversibly into a new (stable) system again (Rotmans, 1994). Transitions have the following main characteristics (Grin, Rotmans and Schot, 2010):

- Transitions are co-evolutionary processes that require multiple changes in socio-technical configurations.
- Transitions are multi-actor processes, involving a large variety of social groups.
- Transitions are radical shifts (in scope) from one configuration to another.
- Transitions are long-term processes on a macro-level.

A transition is a complex process with a huge number of driving factors and impacts that involves co-evolving markets, networks, institutions, technologies, policies, individual behavior and autonomous trends.

From a scientific perspective, the concept of transition integrates views, approaches and methodologies from an array of different sub-disciplines. In the past, scholars from different disciplines—such as climate change research, innovation studies, sustainability science, technology studies and policy sciences—have often run up against quite similar problems. All these disciplines, for example, deal with issues of multi-level dynamics, multi-actor networks, radical innovation and uncertainty, and the impossibility of full control. In this sense, the transition concept does not only fit very well in the new emerging scientific discourse around complex societal change processes; it also provides focus and direction for this debate by bringing these different schools of thought together. The transition concept thus provides a framework for scientific integration, but it also offers a common language for interdisciplinary debate. It triggers discussions and new thoughts about the dynamics of transitions and their governance as much as it evokes ideas and experiments regarding their implementation.

Smith, Voss and Grin (2010) argue that innovation in the context of sustainable development calls for a re-assessment of the process of technological change. To understand the challenge of innovation processes that can bring about transformations in socio-technical systems in favor of sustainable development, a broader analytical perspective is needed. The Multi-Level Perspective on socio-technical transitions (MLP) offers such a framework (Rip and Kemp, 1998; Geels, 2002; Geels and Schot, 2007; Markard and Truffer, 2008). The MLP, which has been proposed and developed by several scholars in Transition Studies, is one of the central notions in this book (along with transition management).

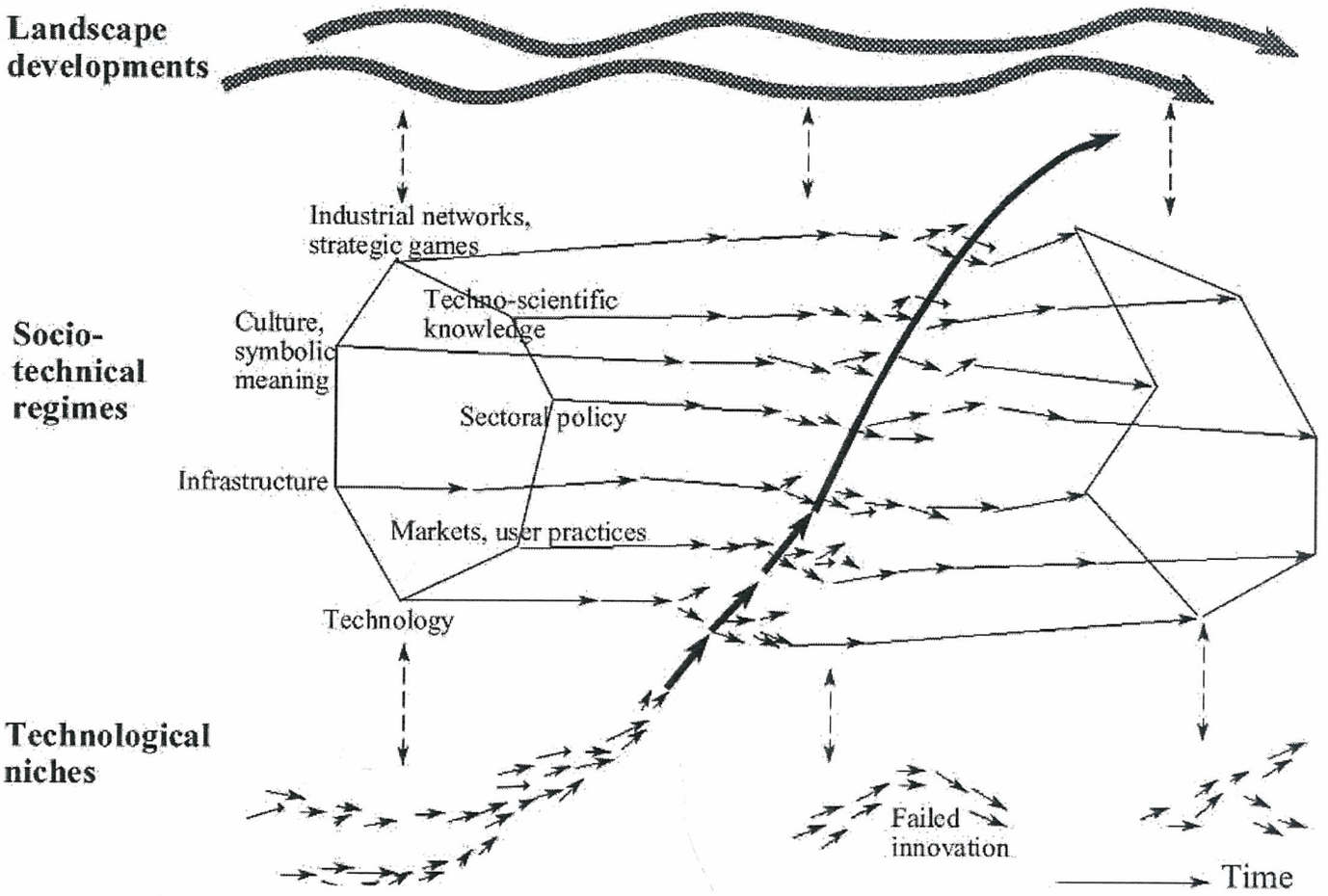

Figure 1.1 A dynamic multi-level perspective on system innovations (Geels, 2002: 1263).

The MLP (see Figure 1.1) conceptualizes transformations as the result of processes occurring at and between three interrelated levels: niches, regimes and landscape. Socio-technical regimes are the dominant rule-sets supported by incumbent social networks and, as such, embedded in dominant artifacts and prevailing infrastructures. They are considered dynamically stable: regime change is of an incremental nature and aimed at strengthening the regime, rather than challenging it. The socio-technical landscape is considered exogenous and provides the environment in which regimes evolve. It consists of features such as the geographical position of the land, climate and available resources, as well as *softer* features such as political constellations, economic cycles and broad societal trends. Landscape factors serve as a major source of selection pressure on dominant regimes. Radical innovation originates in niches: small protected spaces, in which new socio-technical practice can develop, protected from harsh selection criteria and resistance from prevailing regimes. Socio-technical transitions—changes from one stable regime to another—are conceptualized in the model as occurring when landscape pressures destabilize prevailing regimes, providing breakthrough opportunities for promising niches.

Several authors have commented on the virtues and the shortcomings of the MLP (Markard and Truffer, 2008; Genus, 2008; see also Smith, Voss and Grin, 2010). For a detailed theoretical discussion, we refer to Volume One of this series (Grin, Rotmans and Schot, 2010) and to the literature. We are interested in how a multi-level analysis of the energy domain can provide us with lessons on how to tackle the challenge of energy transitions. Several authors in this book use the MLP, they comment and criticize the framework, propose adaptations or are offering an alternative perspective.

1.3 GOVERNING THE ENERGY TRANSITION

We have defined transitions as non-linear regime-shifts. Regimes are defined in a number of ways, but commonly they refer to the dominant structures, institutions, practices, paradigms and economics around a specific technology (socio-technical), ecosystem (social-ecological) or societal function. Underlying these perspectives is the complex adaptive systems perspective in which basic mechanisms and dynamics drive systemic change and produce certain patterns. Complex adaptive systems are in open exchange with their environment, but build on an incumbent structure optimized to adapt to external changes, as well to internal innovation. The energy system as a complex adaptive societal system can be defined as all those actors and artifacts that together produce the societal function energy. It is an open and nested system, that is, it is interconnected with other societal systems (like mobility, food provision, construction) and embedded within the broader fabric of society. Without aiming to define the components and their

interrelations, framing energy in terms of complex adaptive systems opens up analytical possibilities for identifying crucial dynamics and change patterns, which ultimately could provide the basis for governance. For this, the MLP is put in a dynamic perspective using the so-called multi-phase model (Rotmans et al., 2001), which provides the opportunities for identifying patterns and mechanisms of transitional change. The multi-phase concept describes the systemic change of a dominant regime in four main phases following an S-shaped pattern. In the *predevelopment*, a regime is relatively stable but increasingly unable to adapt to landscape changes and emerging niches. Under sufficient pressure, the regime might open up or crack (called *take-off*) and enter a *reconfiguration* or *acceleration* phase, in which elements of the old regime and novel elements are combined to form a new dominant regime that enters a *stabilization* phase. Basically, this captures a non-linear systemic shift, whose key message is that large-scale fundamental change needs a long time to build up, suggesting that it may be emergent below the surface.

From the multi-level and multi-phase perspective, we argue that in the longer term, transitions in the energy domain are inevitable due to emerging alternatives combined with increasing landscape pressures. However, it is uncertain when they will take place, in what form and at what speed, where they will lead us to, and what their impact will be. The basic idea underlying transition governance is that, while it is impossible to predict or direct transitions, it should be possible to influence ongoing transition dynamics in terms of speed and direction. In other words, analyses in terms of transitions could help to identify dynamics (e.g., emerging innovations, niche-clustering, increasing landscape pressures, regime crises, lock-in or modulation) that can be influenced.

Importantly, the history of energy regimes determines to a large extent the possibilities for shaping and governing desired transitions to sustainable energy systems. As argued in Chapters 2 and 4 in this volume, we need to consider much longer timeframes than those normally used in the policy domain, and search for ways to mediate between gradual change in existing regimes and rapid diffusion of successful alternatives. This means developing anticipatory and adaptive capacity way beyond the existing ways in which policies and strategies are developed and implemented from within the context of the existing regimes. It implies that new kinds of governance are needed that are able to develop coherent alternative technologies, institutions, practices and cultures anticipating possible systemic shocks parallel to improving and adapting existing regimes to changing circumstances and to the successful alternatives. In other words, governance strategies that are able to break open the lock-in pathway in which current energy systems are trapped.

From a governance perspective, dealing with a locked-in system possibly moving toward take-off has been labeled as a "persistent problem" (Rotmans et al., 2001). The possibility of systemic failure combined with the

desire for more sustainable performance of the system and the impossibility of centrally governing this process poses an enormous long-term challenge to policy and governance. Persistent problems are complex because they are deeply embedded in our societal structures, uncertain due to the hardly reducible structural uncertainty they include, difficult to manage with a variety of actors with diverse interests involved, as well as hard to grasp in the sense that they are difficult to interpret and ill-structured (Dirven, Rotmans and Verkaik, 2002). Persistent problems are the governance equivalent of what Rittel and Webber (1973) refer to as "wicked problems" usually associated with policy-making. Persistent problems cannot be solved using only current policies alone but require innovative societal governance approaches. Persistent problems are related to the system structures that have evolved over decades and cannot be corrected by the market or current policies alone. System failures are locked-in flaws in our societal structures, such as technological fixation, weak networks or dominant networks, institutional barriers and path dependencies.

In this view, the proverb suggesting that the stone age did not end because of a lack of rock could be very true for the fossil-based energy regimes. From a complex adaptive systems perspective, a lock-in combined with increasing landscape and niche pressures is inevitably leading to a non-linear and relatively rapid fundamental systemic change or transition. The most used depiction of a systemic shift is the multi-phase model described above, which suggests a rather smooth process in four phases towards a new equilibrium. The work on transition patterns (Schot and Geels, 2008; Van der Brugge, 2009; De Haan, 2010) seeks to conceptualize the underlying dynamics that cause such non-linear systemic shifts in terms of threshold behavior and non/linear cause-effect mechanisms (see also Grin, Schot and Rotmans, 2010). This work argues that transitions are far from unidimensional or predictable: there are multiple systemic pathways that might evolve and that can only be assessed as they emerge. In other words, from a transition perspective there are a number of possible pathways emerging for the energy system that are currently competing (see, e.g., Chapters 5 and 9, this volume).

As energy systems move closer to take-off, this might open up the pathway towards a full reform into another dynamic equilibrium, one based on, for example, decentralized and renewable energy. However, other pathways are far from unlikely. A lock-in into suboptimal pathways, for example, could involve a shift to a fossil/nuclear-based system with CO_2 storage, possibly slowing down alternative routes and implying another transition to be necessary in a few decades. Although CO_2 storage could also facilitate desirable transitions, it is currently primarily promoted by fossil fuel energy producers that seek to sustain their production this way (see also Chapter 5, this volume). Or such lock-in could even lead to a backlash or system breakdown in which the dependence on outside provision is not dealt with and energy systems start facing shortage

or even power failures. Events such as the recent meltdown in Fukushima illustrate the vulnerability of our current energy systems and the contingency of events that influence the dynamics between such emerging pathways. Not only did this crisis strike the Japanese energy supply system; immediately it also fed back into debates on energy transitions all over the world. In some cases opening up space for more aggressive renewable based strategies, in others creating support for CCS and in others increased polarization about nuclear energy strategies. Whereas the future is unknown, all indicators seem to suggest that more fundamental changes are likely and probably necessary in the near future. As different emerging pathways can be observed, there is increasing debate and contestation around different options and possibilities, about who owns energy production and who has access to energy, and about how to ensure social equality and how to sustain ecological systems.

This argument states the need for developing governance strategies that deal with the energy system as a whole: the ongoing dynamics from a transition perspective are moving towards either one of the pathways. From the perspective of sustainability, the question is not so much how specific solutions can be promoted or how specific barriers can be removed, but rather how the dynamic process of energy transition as a whole can be guided into a desired direction as rapidly as possible. Regarding dominant policy, the fundamental uncertainties, unpredictability and ambiguities involved in future transition pathways furthermore require a fundamentally different way of thinking about and implementing strategy well beyond traditional planning, innovation policy or process management. They call for transition governance strategies developed initially perhaps as *shadow track*, an alternative governance process in parallel to the existing dominant policy processes, to increase the speed and direction of emerging sustainability transitions.

The broad philosophy of transition governance is captured by the basic tenets for complexity governance (Loorbach, 2007; Rotmans and Loorbach, 2009) that evolved from the limited set of principles initially formulated (including "keeping options open," "dealing with uncertainties," "multi-level-approach" and "multi-actor strategy" [Rotmans et al., 2001]). These principles have been derived from interrelated insights concerning the behavior of complex societal systems to insights from recent debates on innovations in governance (such as network governance, process management, interactive policymaking and so on). Over the past decade, scholars further developed these principles theoretically and translated them into governance experiments that have helped to test these principles, as well as further refine them. It is possible to summarize the basic assumptions for such a governance strategy as follows:

1. The dynamics of the system create feasible and non-feasible means for governance: this implies that substance and process are inseparable. Process management on its own is not sufficient: insight into

how the system works is an essential precondition for effective management. Systems-thinking—in terms of more than one domain (multi-domain) and different actors (multi-actor) at different scale levels (multi-level), analyzing how developments in one domain or at one level interact with developments in other domains or at other levels—is necessary to be able to take into account such possible means and levers for governance.

2. Long-term thinking (at least 25 years) serves as a framework for shaping short-term policy in the context of persistent societal problems. Because societal transformations require a long time and long-term system dynamics are more important for understanding the nature and direction of transitions, the link between long-term and short-term is inevitable. This implies processes of back- and fore-casting: the setting of short-term goals based on long-term goals and the reflection on future developments through the use of scenarios.
3. Objectives should be flexible and adjustable at the system level. The complexity of the system is at odds with the formulation of specific objectives. With flexible evolving objectives one is in a better position to react to changes from inside and outside the system. While being directed, the structure and order of the system are changing, and so the objectives set should change as well.
4. Creating space for niches in transition arenas and transition experiments. A niche is a new structure, a small core of agents, that emerges within the system and that aligns itself with a new configuration. Often, the new alignment is the emergent property of the system. An emergent structure is formed around niches to stimulate the further development of these niches and the emergence of niche-regimes.
5. A focus on frontrunners. In this context, frontrunners are agents with peculiar competencies and qualities: creative minds, strategists and visionaries. They are active at different levels of scale and in very different areas, be it within business, government, science, societal organizations or in everyday life. Frontrunners are able to generate dissipative structures in complex systems terms and operate within these deviant structures. They can only do so without being (directly) dependent on the regime's structure, culture and practices.
6. Guided variation and selection. Diversity is required to avoid rigidity within the system. Rigidity here means reduced diversity due to selection mechanisms, which means that the system cannot respond flexibly to changes in its environment. Rather than selecting innovative options in a too early stage, options are kept open in order to learn about the pros and cons of available options before making a selection. Collective choices are made "along the way," based on learning experiences at different levels. Through experimenting we can reduce some aspects of the high level of uncertainty, leading to better-informed decisions.

7. Radical change in incremental steps. Radical, structural change is needed to erode the existing deep structure (incumbent regime) of a system and ultimately dismantle it. Immediate radical change, however, would lead to maximal resistance from the deep structure, which cannot adjust to a too rapid, radical change. Abrupt forcing of the system would disrupt it and create a backlash in the system because of its resilience. Incremental change allows the system to adjust to the new circumstances and to build up new structures that align to the new configuration. Radical change in incremental steps thus implies that the system heads for a new direction towards new attractors, albeit in small steps. To reconcile these seemingly incompatible aspects of radical versus incremental change is at the core of transition management.
8. Learning-by-doing and doing-by-learning. Social learning (Social Learning Group, 2001; Brown and Vergragt, 2008) is a pivotal aspect of societal transition processes, aimed at *reframing*, changing the perspective of actors involved. Two important components are learning-by-doing (developing theoretical knowledge and testing that by practical experience) and doing-by-learning (developing empirical knowledge and testing that against the theory). Social learning in transition processes stimulates the development of visions, pathways and experiments that form a new selection environment.
9. Anticipation and adaptation. Anticipating future trends and developments, taking account of weak signals and seeds of change acting as the harbingers of the future, is a key element of a pro-active, long-term strategy as transition management. This future orientation is accompanied by a strategy of adaptation, which means adjusting while the structure of the system is changing.

1.4 TRANSITION MANAGEMENT

Researchers and policymakers have taken up this general idea from around 2000, when a national program started in the Netherlands to influence developments in the energy domain toward a sustainable energy supply. This marked the beginning of a quickly expanding network of practitioners and researchers that further developed the idea of actually influencing transitions in various domains, regions and cities. This network built on previous innovation programs in the Netherlands focusing on technological innovation, societal contexts and sustainability largely driven by research such as Sustainable Technological Development (STD) (Vergragt and Van Grootveld, 1994; Weaver et al., 2000). The Dutch Energy Transition Program has become one of the prime cases of transition management; it has been widely discussed in the scientific literature on transitions (See also Chapters 10 and 12, this volume). This program, however, only represents

part of the wide array of efforts and activities influencing developments in the energy domain. They have revealed that implementing transition governance can take many forms and that significant impact on the speed and direction of transitions in the energy domain is subject to future assessment only. These efforts and activities, however, have provided a fruitful testing ground for the development of a more specific and operational framework for transition management, along with a large number of other application domains (Loorbach and Rotmans, 2010).

The main conceptual challenge of transition management is to translate the relatively abstract steering principles derived from the dynamics of complex systems and transitions into a practical management framework. In order not to lose too much of the complexity involved and without becoming too prescriptive, transition management has been developed as a cyclical process of development phases at various scale levels (Loorbach, 2007). In effect transition management comes down to creating space for frontrunners (niche-players and regime-players) in transition arenas, forming new coalitions around these arenas, driving the activities in a shared and desired direction and develop coalitions and networks into a movement that puts societal pressure on regular policy. Within the transition management framework, activities related to structuring the debate involved (such as systems analysis, envisioning, agenda building and experiments) are linked to process-related activities (network and coalition building, executing experiments and process structuring). The preferred actors to be involved (based on the necessary competencies) and instruments (scenarios, transition-agendas, monitoring instruments, etc.) could be derived from this framework.

In each of the activity clusters, coalition and network formation is of vital importance combined with the systemic structuring and synthesizing of discussions. The transition arena is meant to stimulate the formation of new coalitions, partnerships and networks that together create a new way of thinking. Mostly, coalitions emerge around transition pathways or experiments, or around specific sub-themes, where sub-arenas arise. The very idea behind transition management is to create a societal movement through new coalitions, partnerships and networks around arenas that allow for building up continuous pressure on the political and market arena to safeguard the long-term orientation and goals of the transition process.

It is clear that there is no panacea for societal unsustainability: sustainability cannot be defined in general, nor can it be enforced in a traditional sense. In a modern network society there is a huge diversity of problems, solutions, perspectives, interests and knowledge. Likewise, it is no longer possible or desirable to enforce social changes top-down, so that modern society is in need of new mechanisms to simultaneously foster and stimulate diversity, and provide a flexible selection environment based on collective demands and desires. The only way to develop a more sustainable society is through a process of fundamental reflection on our current values

and societal regimes, whereas on a local level experiments are simultaneously used to explore alternative futures (see also Verheul and Vergragt, 1995). This societal model of learning-by-doing and doing-by-learning can be directed and structured by using the transition concepts.

A key insight derived from experiences with transition management over the past few years is that by specifically engaging societal actors in debate about ongoing transitions in their respective sectors, new discourse will emerge. Actors develop with each other a systemic understanding of the complex problems in their area, which enables them to reflect upon the sustainability challenges in terms of *transition*. Without ever actually being able to determine whether a transition is actually going on, or in which specific phase of transition a sector finds itself, it at least provides actors with a shared language and focus to guide their actions. Based on the idea that self-organization (in the context of transitions, "self-innovation" is perhaps a better term) will become increasingly dominant in our society, transition management tries to develop arenas, processes and strategic agendas that facilitate, stimulate and guide action.

1.5 AIM AND STRUCTURE OF THIS BOOK

With this in mind, the aim of this book is twofold. First, we want to provide new scientific insights into the nature of the challenge we face, based on research on transitions and transition dynamics of the last decade. Second, we will assess the efforts to put this knowledge into practice, into new forms of policy and policy tools, focusing in particular on a new policy approach, Transition Management. Our central concern is: how can we understand ongoing dynamics in our energy systems based on the transition perspective, and following from this, what are the possibilities for influencing these dynamics?

Transitions research operates in between science and society. On the one hand, it seeks to conceptualize, analyze and describe transitions as empirical phenomena based on scientific methods. On the other hand, it seeks to use this understanding to actively engage with the transitions under study so as to experiment with the insights derived from the analysis. The experiments and implementations of notions such as strategic niche management, transition management, transition monitoring and innovation systems in turn inform scientific debate about the possibilities for understanding and influencing transitions. These experiments raise questions and prompt debate in the scientific arena (for example related to normative orientation of researchers, legitimacy of interventions and lack of attention to power and politics), and in turn lead to adapted and new strategies. In this book, we have tried to capture this exchange between transitions and governance, between empirical and action research, between inside and outside. If this volume has one key message, it is that the iterative dialogue and cooperation

between different disciplines, as well as between science, policy and society, has led to a process of learning-by-doing and doing-by-learning that in itself has already shaped the energy transition and produced a diverse community of actors engaged in this process.

In emerging transition and sustainability networks, complexity is rather the rule than the exception, boundaries between disciplines become blurred, and a changing society seems a given. However, sustainability and transition research and governance in particular, even if making their mark, still represent a niche only. The existing regimes—in which control, specialization, predictability and objectivity are still dominant—are driving societal change and progress through regulations and liberalization. These regimes increasingly seem to be in conflict with emerging niches comprising local contexts, different worldviews and inherent uncertainties. This conflict becomes especially apparent in public officials who struggle with their role, scholarly debate about the value of integrated analyses and a normative choice for sustainability as frame, and societal debate about the need to enforce sustainability. This volume addresses these emerging tensions by framing them as indicators for an imminent take-off phase. Not only are alternative cultures, structures and practices growing stronger (technologically, scientifically, socially and economically); there also is an increasing variation of solutions at the regime level that seeks to sustain and prolong the existing regimes. This possibly brings with it conflict, polarization, conservatism, increasing uncertainties and turbulence. In this context, the essays collected in this volume provide an overview from a sustainable energy transition perspective of what is changing, what these dynamics might imply and in which ways actors seek to consciously influence these transitions.

The structure of the book tries to capture this intimate relationship between analysis, experimental implementation, reflection and theory building as interrelated elements of transition research. We have brought together leading transition scholars and practitioners in the field of energy transitions from both sides: more analysis driven and more governance oriented. The different chapters each have their own starting-point and follow their own logic, but they also aim to connect the insights derived to a better understanding or governance of transitions. We adopted a transition logic throughout the book. Starting from research focusing on understanding and analyzing patterns and dynamics of transitions, we will move to understanding the role of governance, via experimental applications of transition governance. At the end, we reflect on the particular merits of transition analysis and the feasibility of transition governance.

We use the term "transition research" to describe research on transitions and transition management as currently conducted within different scientific disciplines. Research on energy transitions and transition management seems almost impossible from a traditional, single disciplinary perspective. Transitions are defined as all-encompassing transformation processes that

can be properly analyzed only in hindsight. And although we can identify elements of governance and agency in historical transitions, and hypothesize upon what transition management could be and how we could actually apply it, it seems impossible to formulate straightforward hypotheses to be tested through case studies or literature research alone. The nature of this research is to explore and underpin a new governance approach theoretically and simultaneously develop an operational model. This automatically required an interdisciplinary, participative and applied research process. The contributions in this book also reflect this inter- and transdisciplinary journey in the domain of the energy transition over the last decades. It comprises a large number of different disciplinary perspectives, includes contributions of transition practitioners and reflects in different ways upon the underlying theoretical assumptions and evolution therein. In other words, this volume seeks to capture glimpses of the dialogue between different disciplines, as well as between science and practice, based on the transition frameworks.

After sketching the broader landscape for energy transitions from a more systemic and social practice perspective, we concentrate on energy regimes: how to understand them analytically and how actors embedded within these regimes seek to prolong their lifetime. Next, we zoom in on the niche level of innovations with two chapters dealing with the role of niches and innovation processes. From the system analytical perspectives, we shift our focus to questions of agency and expectations, starting out with the role of civil society and the potential influence of the different pathways and scenarios envisaged on agency. Subsequently, two chapters address the practices of energy transition management in the Netherlands from the inside out, raising questions with regard to the manageability of energy transitions. This discussion is continued with a chapter devoted to the analysis of the transition management efforts in the Netherlands from an international perspective and a chapter that explores the necessity and possibilities for transition governance strategies in a European context. In the conclusions, then, we reflect on the advances made in energy transitions research and practice over the last decade and look ahead to identify the main challenges involved, both theoretically and in society.

In Chapter 2, this volume, Vincent Lagendijk and Geert Verbong provide a brief survey of historical transitions in fuel usage by humans: from a society that relies on organic resources and energy supplied by animals and human beings to an industrialized society based on fossil fuels, initially coal and, as the twentieth progressed, more and more oil and natural gas. The fossil fuels constituted the basis of the expanding energy supply networks, the electrical grids, gas networks and, to a lesser degree, heating systems. The authors illustrate several main landscape developments that have a major impact on the development of our energy systems after the Second World War and the responses of governments in general, and the EU in particular, to the challenges of energy crisis, volatile energy prices, political dependencies and, increasingly, the unsustainable character of our current energy systems.

As such, this chapter sets the stage for Chapter 3 of this volume, in which Elisabeth Shove concentrates on a very important point that is often overlooked in debates on the need to green our energy systems and to fight climate change: the origin of our continuously increasing demand for energy. Shove argues that we need to understand that energy, rather than being consumed directly, is mediated through systems of provision. For example, energy enables the provision of services such as lighting, mobility and cooking. To understand the development of energy consumption, she stresses that it is necessary to focus on the social practices that require energy. Shove uses the development of air-conditioning as a very striking example, while also investigating the appropriateness of the MLP for dealing with transitions in social practices. One of her conclusions is that we need to pay more attention to issues of social and spatial scale. Also, despite the general perception that social behavior is difficult to change, her story of the global diffusion of air-conditioning as an integral part of current configurations of comfort, shows that these seemingly non-negotiable societal needs actually are very recent and arbitrary constructions.

In Chapter 4 of this volume, Erik van der Vleuten and Per Högselius investigate the long-term dynamics of European energy regimes. They describe and analyze the historical shaping of incumbent European electricity and natural gas supply regimes. Until the 1980s, these regimes were quite stable, but in recent decades these regimes have had to deal with a variety of social, political and environmental challenges. The authors demonstrate that the oft-articulated assumption that incumbent regimes only strive for stability and resist change is too simple or even incorrect. Regime actors can be actively involved in change processes. Based on their historical analysis, they propose three additions to transition theory. First, regime stability and regime change should be scrutinized in a symmetrical way, not prioritizing resistance to change. Second, they argue that a transnational perspective allows bringing into view the geographical dimension of energy transitions. Transition researchers commonly use a national perspective on regimes, but a considerable part of the regime dynamics transcends national boundaries and are played out in the transnational arena. Finally, Van der Vleuten and Högselius argue that regime-landscape interactions are an important yet underdeveloped site for regime dynamics. Often, landscape developments are used as an exogenous driver of regime (and niche) change, but a co-evolutionary perspective on the regime-landscape interaction could be much more productive in providing insights into transition processes.

Next, in Chapter 5 of this volume, Philip Vergragt assesses the potential contribution to an energy transition of Carbon Capture and Storage (CCS). Regime actors and the government have pointed to CCS as a transitional technology for tackling the problem of the emission of greenhouse gases in the short term. However, large-scale adoption of CCS could result in

reinforced lock-in into fossil fuels. Vergragt uses a set of criteria to assess the possibility of reinforced lock-in, and he explores various transition pathways for the introduction of CCS. Concluding that this danger is very real, he proposes a prudent policy approach to CCS and to prevent any rush to implement CCS. Large-scale experimentation, testing and learning should make clear what the real long-term impact of CCS will be; more time is needed to settle public debates on safety and acceptability. He also suggests we should pay more attention to linking CCS to the use of pure bio-energy, for this could result in negative emissions of CO_2. In this way the reinforced lock-in into fossil fuels could be mitigated or even prevented, but more research and testing is needed to investigate the feasibility of this option.

Focusing on experimentation and niches of renewable energy technologies in Europe in Chapter 6, this volume, Rob Raven claims that despite successes the development and introduction of renewable energy have been slow and complicated, due to its lock-in in the incumbent energy regimes. Raven introduces the approach of Strategic Niche Management (SNM). Its central idea is that promising technologies such as renewable energy technologies need protection from the harsh selection environment to be able to develop into viable options for a sustainable energy system. A survey of the field leads to the conclusion that SNM has been quite useful in explaining the dynamics of niche processes, but that it has not lived up to its management promise yet. More research on the conditions creating incentives for key niche processes is needed. Also, more attention has to be paid to the politics of experimentation and niche building to understand how protection should be created, maintained and withdrawn. This should include the cultural struggles, media debates and social resistance triggered by the large-scale application of, for example, wind energy or biofuels. Understanding the role of civil society organizations in shaping social acceptance is an important new theme of research and action.

In Chapter 7 of this volume, Roald Suurs and Marko Hekkert look at innovation from the Technological Innovation Systems (TIS) perspective. They draw attention to the role of context in creating successful innovation journeys and focus in particular on the role of so-called "motors of innovation." They argue that successful development and diffusion of (technological) innovations depends on the functioning of frame-conditions such as entrepreneurial activity, market-development and support of science and technology. In this chapter the authors provide an alternative framing and analytical perspective to the SNM perspective and make the argument that the TIS perspective addresses a "missing link" between the niche level addressed by SNM and the regime level which is more the primary focus of transition management. The use of the TIS perspective, they argue, offers concrete insights for policymakers to develop innovation policies, which they illustrate with the TIS-based evaluation of the energy transition program in the Netherlands.

As argued by Adrian Smith in Chapter 8, this volume, we ought to pay more attention to the role of civil society in transitions. Smith defines civil society as "an arena that encompasses the collective activities by which associations of people develop and assert shared values, identities and interests, without direct recourse to market transactions or the authority of the state." Because of the sheer enormity of the challenge we face, the active involvement of civil society is inevitable. In many cases, civil society organizations are actively involved already, yet there seems to be a consistent pattern to these activities. Although there is a long history of environmental activism, civil society support of energy transitions should not be taken for granted. Smith regards civil society as a source of innovative activities that either advocate alternative pathways by nurturing alternatives or contest the incumbent ones by unsettling and delegitimizing regimes. For the analysis and understanding of such activities social movement theory can be very useful. This applies in particular to the processes of scaling-up and extending the impacts of experiments and niche activities outside their direct sphere of influence. But whereas civil society can be instrumental in achieving a transition to more sustainable energy systems, Smith also cautions against too much optimism, because civil society will never be "a singular, manageable presence."

Next, in Chapter 9 of this volume, Geert Verbong and Frank Geels use the transition pathway typology proposed by Geels and Schot to explore a set of possible futures for the electricity system. These range from the emergence of a Super grid that links large-scale renewable power plants all over Europe and North Africa to the turn to local and regional autarkic electricity systems. This exploration shows that there is not one but there are many roads to a more sustainable electricity system. Although the debate on transitions in the energy domain usually focuses on technological innovation, technological feasibility is not the main issue; a future transition will be determined by economic, socio-cultural and institutional dynamics. An environmental concern such as climate change serves as just one of the criteria that drive the development of energy systems, next to cost efficiency, reliability, reduction of dependency and social control. For this reason, we should not take for granted that we are actually moving towards a more sustainable future. Moreover, global developments like the emergence of the BRIC nations, but also particular social practices, continue to raise our energy demand. Every solution for our current problems should therefore start with a careful consideration of the constantly expanding set of services our energy systems supply.

Chapter 10 of this volume, written by Frans van der Loo and Derk Loorbach, describes and analyzes the well-known energy transition process in the Netherlands as coordinated by the Dutch Ministry of Economic Affairs. Asking to what extent this ministry has actually been capable of developing energy transition management, this chapter provides a rich empirical description of the emergence, evolution and diffusion of such management

by this ministry and interrelated actors. Van der Loo and Loorbach identify a number of positive and negative aspects of the energy transition process. On the one hand, it developed a major network, a well-financed innovation agenda and several institutional changes and innovations, but, on the other hand, the energy transition process seemingly replaced previous energy innovation policies and was integrated into the existing energy (policy) regime without actually affecting it. Although dominant and vested interests if not the government itself limited the space for more radical development and major impact, a coherent, transition-oriented innovation space was created. Pointing to several indicators of a more fundamental shift in the societal dynamics, the authors argue for a more fundamental reorientation of the energy transition process.

Subsequently, Chapter 11 in this volume, by Mattijs Taanman, deals with the role of monitoring and evaluation in transitions, focusing on transition monitoring in the context of the energy transition process. Because radical uncertainties are a key feature of transitions and learning and experimentation are a core element of transition management, evaluation and monitoring are crucial. Essentially, however, transition (or reflexive) monitoring is not based on quantitative indicators, such as regular policy monitoring, but seeks to use transition patterns and analytical concepts to structure participatory evaluation processes and collectively frame and interpret the dynamics of transitions and relative progress. This approach, then, engages actors involved in experiments, policymaking and agenda-building to collectively reflect upon these processes. Taanman illustrates his monitoring framework through its application in the context of the Platform New Gas, one of the platforms of the energy transition process. Next, he reflects more in general on the notion of reflexive monitoring and the difficulties to implement it in the context of a relatively pragmatic and action-oriented policy context.

In Chapter 12, this volume, Florian Kern reflects on the energy transition process from an outsider perspective. Kern both synthesizes the international debate on the energy transition process and reflects on the possibilities for international application of transition management in general. The energy transition process has served as a key reference case for debate on the feasibility of transition management. Illustrating that the scientific debate has directly led to changes and improvements in the policy practices, Kern also points out that there are a number of fundamental issues and questions that remain unresolved. He argues that the debate should more clearly make the distinction between the theoretical ideas underlying transition management and the actual implementation in the context of the energy transition. Based on this distinction, he reflects on the possibilities for application of the basic transitions approach and the need for context-specific methods and instruments that should go along with this. One crucial factor in both successful implementation as well as potential diffusion is the way in which energy transitions and their

governance are framed or within which discourse energy transition policies are developed. If the transitions discourse is evolving internationally, Kern cautions us, it can easily be hijacked to serve already existing policy paradigms, such as liberalization.

In Chapter 13 of this volume, Måns Nilsson explores the challenges and opportunities for energy transition at the level of the EU. Although there are many major policy areas in Europe about which the EU has a dominant say, energy policy is not one of them. However, as Nilsson shows, the transition perspective may contribute to systematic analysis of the tensions and dynamics between national energy regimes, regional and local niches, and the broader strategic debate on the position of Europe in a global context. Accordingly, transition management is used to conceptualize and explore possibilities for influencing a sustainable energy transition. Nilsson identifies a number of strategies that might create the conditions for an accelerated up-scaling of alternatives, convergence of energy policy agendas and more refined and underpinned ambitions at the European level. Within this context, he focuses on the question to what extent existing EU policies in the areas related to energy are on course to support such a transition. His provoking conclusion is that most policies seem to support improvements of the existing regime, but that it is yet unclear whether a sustainable energy transition at the European level is actually contingent on regime stabilization. Given that the EU has gradually evolved out of multiple national regimes, it might as well be a matter of constructing a novel regime altogether.

Finally, in the concluding chapter, Derk Loorbach and Geert Verbong synthesize the insights compiled in this volume and they outline the major challenges for advancing energy transitions toward sustainability as well as for transition (management) research. They conclude that the various contributions to this volume suggest we are currently entering a phase in which more fundamental changes in energy systems are likely than in the last decades. The vulnerability and criticality of energy systems combined with a broadening, yet fragmented, advocacy for fundamental changes and maturing alternatives provide the ingredients for transition. But the pathways we are to follow in the future, the authors argue, are highly uncertain and in some cases mutually exclusive. This implies societies will increasingly experience conflicts, problems and tensions around changes in energy systems. The proper understanding of these dynamics and the need to govern these dynamics effectively pose enormous yet inspiring challenges for research and governance alike.