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Improving Information for Policy Makers**

Managing Societal Transitions: Dilemmas and Uncertainties: The Dutch energy case-study

by

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FOREWORD

This paper was prepared for an OECD Workshop on the *Benefits of Climate Policy: Improving Information for Policy Makers*, held 12-13 December 2002. The aim of the Workshop and the underlying Project is to outline a conceptual framework to estimate the benefits of climate change policies, and to help organise information on this topic for policy makers. The Workshop covered both adaptation and mitigation policies, and related to different spatial and temporal scales for decision-making. However, particular emphasis was placed on understanding global benefits at different levels of mitigation -- in other words, on the incremental benefit of going from one level of climate change to another. Participants were also asked to identify gaps in existing information and to recommend areas for improvement, including topics requiring further policy-related research and testing. The Workshop brought representatives from governments together with researchers from a range of disciplines to address these issues. Further background on the workshop, its agenda and participants, can be found on the internet at: www.oecd.org/env/cc

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This paper is issued as an authored "working paper" -- one of a series emerging from the Project. The ideas expressed in the paper are those of the author alone and do not necessarily represent the views of the OECD or its Member Countries.

As a working paper, this document has received only limited peer review. Some authors will be further refining their papers, either to eventually appear in the peer-reviewed academic literature, or to become part of a forthcoming OECD publication on this Project. The objective of placing these papers on the internet at this stage is to widely disseminate the ideas contained in them, with a view toward facilitating the review process.

Any comments on the paper may be sent directly to the authors Jan Rotmans* and René Kemp** at: J.Rotmans@icis.unimaas.nl

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EXECUTIVE SUMMARY

System innovation offers a route for achieving sustainability benefits. This requires the management of processes of evolution and orientation of private and public actors to transition goals. Ideas about how to manage transition processes are worked out into a model for governance, called transition management. Transition management tries to orient existing dynamics towards transition goals chosen by society. Through its focus on long term goals of sustainability and its attention to dynamics it aims to overcome the conflict between long-term ambition and short-term concerns. Key elements are the formulation of a transition goal and the use of process management based on a philosophy of learning- by-doing and doing-by-learning. Actual policies and goals are evaluated in development rounds. Dutch environmental policy makers have adopted the model of transition management, developed by the authors, as a model for working towards a transition in energy, agriculture and transport. In this paper, the model of transition management is described and worked out for the case of a low-emission energy supply system.

1. INTRODUCTION

Environmental problems of pollution have been countered quite successfully through the use of control technology and cleaner processes at the production side. At the consumer side little has changed. People still engage in the individual use of motorised transport and energy-intensive life styles. The common explanation for this is that people *want* automobility, cheap energy and cheap food. Such an explanation assumes that people preferences are fixed and that the system is geared toward satisfying these. It fails to see that people want many things; that consumer choices are restricted by supply choices, and that user benefits may conflict with societal benefits. Supply and demand not only interact but also interlock. Their interaction gives rise to particular trajectories, which are sustained by industrial interests vested in it, assumptions about user needs and high costs of making a system change, both for the actors concerned and society of large. The above helps to understand why most change is incremental, aimed at exploitation rather than exploration (March, 1991).

Environmental policy has been unsuccessful in changing behaviour and bringing about societal transformations, involving a change in both technology and behaviour. There is a consensus that the existing trajectories in transport, energy, and agriculture are not sustainable, but the alternatives are not clear or deemed unsatisfactory by experts. There is a conflict between short-term goals of policy and the long-term change needed for sustainability. Whilst the goal of sustainable development has been accepted there is a paucity of concepts and tools to work towards it. This paper offers an approach to further sustainability goals. We have called this approach transition management because it aims at managing the processes of co-evolution that make up a transition. Transition management consists of the management of phases of a transition in a reflexive, iterative and stepwise manner. Dutch policy makers in the new national environmental policy plan *Een wereld en een wil* (A world and a willing) have embraced it and made it official policy. The plan uses 2030 as a time horizon. In this paper we explain the notion of transition management and explain why it is a useful model for managing processes of co-evolution and transitions.

2. THE NEED FOR TRANSITIONS AND SYSTEM INNOVATIONS

Nowadays our society faces structural problems which cannot be solved by incremental policies leading to incremental change. These problems are complex, persistent, ill-structured, and surrounded by uncertainties. Examples of these problems are the agricultural sector with its many symptoms of unsustainability, visible through diseases like BSE and Foot & Mouth; the water sector with symptoms like floods, droughts and water quality problems; the energy sector with its one-sided and environmentally-detrimental energy supply system; the transport sector with its pollution and congestion; and the health care sector with its exorbitant costs and the ageing perspective. These problems may seem different in scope and nature, but they have certain commonalities. They are complex because they are not easy to solve, and ready-made solutions are absent. They are also deeply rooted in our societal structures and institutions, and are closely interwoven with multiple societal processes, so that they cannot be isolated and solved in isolation. Another commonality is that they are difficult to steer, because many actors are involved as stakeholders, because they have a stake in these problems, and they all try to influence each other in the underlying steering process. In general, we call these problems with large complexity, great uncertainty, high stakes and steering problems, wicked problems. So the increasing societal complexity forces us to think and act in a different manner, to look at the nature of these wicked problems, and coming up with new, structural solutions, paving the way for a more sustainable society.

In order to solve the signalled persistent or wicked problems our society faces fundamental innovations are necessary. Still these kinds of problems are often approached through a short-term financial-economic perspective, which leads to ad-hoc solutions exacerbate the problems rather than solving them. This culminates in a so-called boomerang-effect: with the passage of time these problems return on the policy agenda in a magnified form.

Radical societal changes require innovation on all sorts of fields at all kinds of levels: innovation of production and consumption processes, technological innovation, institutional innovation and political-governmental innovation. We refer to these kinds of integral innovation with a long time-horizon as system innovation. The word integral points to the fact that system innovation does not only involve ‘hard’ innovations such as technologies and machineries, but also ‘soft’ innovations such as principles, rules and organisational forms (Dirven et al., 2002). From the innovation literature it follows that the more complex an innovation is, the more important the soft innovations are. Thus system innovations are organisation-exceeding, qualitative innovations which are realised by a variety of participants within the system, and which fundamentally changes both the structure of the system and the relations between the participants. Within these system innovations in turn innovations at the individual level, in terms of product, process and project innovations.

At a higher aggregation level we could cluster system innovations into transitions, broad societal themes and problems. Thus transitions involve a set of system innovations, as will be further explored below in section 3.

In the environmental field we have seen quite a few examples of structural, persistent problems, such as climate change, loss of biodiversity but also toxic chemical pollution. The accumulation of stock pollutants and ever-increasing scale of economic activity, undoing environmental improvements per unit of output, call for system innovation. End-of-pipe solutions and other types of changes at the supply side will not suffice. We need more comprehensive responses, involving a change in production chains, in product-

service systems, and the ways in which we consume and live (Kemp and Soete, 1992; Kemp 1995; Weterings et al., 1997; Weaver et al., 1999, Vellinga and Herb, 1999, Ashford et al., 2001). In the vocabulary of innovation studies, we need system innovation besides system improvement. System innovation in the sociotechnical realm involves changes in sociotechnical systems beyond a change in (technical) components. It is associated with new linkages, new knowledge, different rules and roles, a new 'logic of appropriateness', and sometimes new organisations.[1] System innovation usually consists of a combination of new and old components and may even consist of a novel combination of old components, as in the case of industrial ecology—the closing of material streams through the use of waste output from one company by another.

Two other examples of system innovation offering environmental benefits are: the hydrogen economy (with the hydrogen generated in clean ways, for instance through the use of renewables); and integrated mobility (or chain mobility). In the latter case, people are using different transport modes (collective ones and individual ones such as a car and bicycle) using information services from mobility agencies that offer them travel plans and make reservations. Chain mobility involves a wide range of changes, in infrastructure (in the form of P+R stations and special bus lanes), in technology (such as light rail in conurbations) but also an array of social and organisational changes: the collective ownership and use of cars (car-sharing and riding), the creation of mobility agencies offering and selling intermodal transport services, the integration of collective transport schemes, and the introduction of transport management system for employees by companies.[2]

System innovation transcends a single country or a single continent and goes beyond the use of more efficient manufacturing processes and green products. The transformation may be beyond those that the dominant industries and firms are capable of developing easily, at least by themselves (Ashford et al., 2001, p.3). The time scale for system innovation, one generation or more, is long from a policy point of view. System innovation may consist of the development of a new system (such as the development of the grid-based electric system) and the transformation of an existing system, such as the emergence of a regime of chain mobility out of the existing regimes of individual and public transport. The distinction between system innovation and system optimisation is useful because it forces one to think about the long-term consequences of innovations: whether they give rise to or contribute to system innovation or do not alter the current path of development.

[1] A related distinction is that between sustaining innovations and disrupting innovation (Christensen, 2000).

[2] Three other examples, described in Ashford et al. (2001) are: biomass-based chemistry, multiple sustainable land-use (the integration of the agricultural function with other functions in rural areas) and flexible, modular manufactured construction.

3. TRANSITIONS

The sociological concept of transition has its roots in biology and population dynamics (Davis, 1945). Most widely known is the demographic transition, a highly non-linear shift from a dynamic equilibrium, which consists of high death rates and high birth rates, to a new dynamic equilibrium with low birth rates and death rates. As of the end of last century, the demographic transition has become a historical fact in approximately 30 countries all over the world, including all the larger industrialised countries of Europe and Japan (UN, 1997).

The economic concept of transition was put forward by Rostow (1960) and Boulding (1970), who even made a sort of typology of transitions. In this economic context, the notion of transition is mostly used as the multi-staged development from a controlled economy to a market economy, accompanied by the evolution of new political and social institutions. Rostow suggested that countries passed through five stages of economic development: (i) *traditional society*, where the economy is dominated by subsistence activity and output is consumed by producers rather than traded; (ii*) transitional stage*, with increased specialisation that generates surpluses for trading; (iii) *take off stage*, where industrialisation increases and workers switch from the agricultural sector to the manufacturing sector; (iv) *drive to maturity stage*, where the economy is diversifying into new areas, producing a range of goods and services; and (iv) *high mass consumption stage*, in which the economy is geared towards mass consumption and the service sector becomes increasingly dominant. Many development-economists have pointed out the limitations of this economic concept, arguing that it does not address the issue of development in a wider context, and that it is mainly applicable to Western economies rather than economies in developing countries.

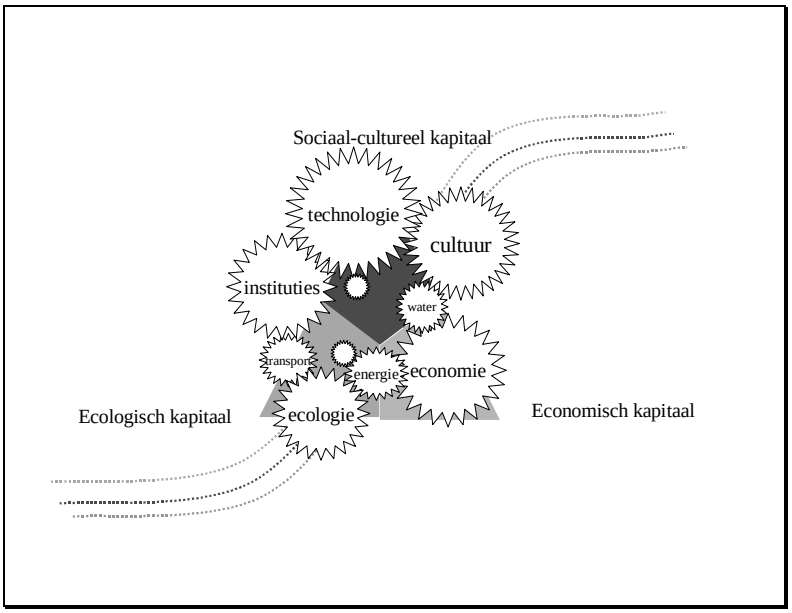
From a complex systems theory point of view, transitions could be considered as system transformations from slow equilibrium dynamics to quick development and instability, reverting to relative stability (Rotmans, 1994). The new equilibrium is a dynamic equilibrium, i.e. there is no status quo, because a lot is changing under the surface. This can be represented as an s-shaped curve, marking the speed of change, the size of change and the time period of change, as denoted in Figure 2. In principle, it is possible to have different paths to the same equilibrium level. It is also possible for the same transition pattern to be realized in different ways.

The integrated systems approach implies thinking in terms of stocks and flows. Stocks are properties of a complex system that change relatively slowly (with regard to the total volume) over a long period of time. Stocks are described in terms of quantity, quality, functionality and space-use. Flows are aspects that change relatively quickly in the short-term and reveal the relationship between stocks. A transition is therefore the result of long-term developments in stocks and short-term developments in flows. Every domain has thereby its own dynamics. Cultures only change slowly, just like ecological systems. Economic changes, however, can take place suddenly and are usually determined by the lifespan of capital goods. Institutional and technological changes are somewhere in between. The whole picture, therefore, is a mélange of fast and slow dynamics, the tempo and direction of which are ultimately constrained by the slowest processes, i.e. development in stocks.

In general, a transition can be defined as a long-term, continuous process of change during which a society or a subsystem of society fundamentally changes. A transition can be described as a set of interconnected changes, which reinforce each other but take place in different areas, such as technology, the economy, institutions, ecology, culture, behaviour and belief systems. A successful transition is a spiral that

reinforces itself, driven by multiple causalities and co-evolution. A pre-requisite for transitions to happen, is that several developments in different domains at different scale-levels come together to reinforce each other. To use a mechanical metaphor, all social phenomena have an impulse value for transitions, but only some provide a flywheel force. To stay with this mechanical metaphor, the complex set of cogwheels that engage one another (see Figure 1), could easily lead to an interlock, but once in a while they reinforce each other.

Figure 1. Transition as a complex set of societal cogwheels that engage each other.



Integrated Assessment is an interdisciplinary science that attempts to synthesize concepts from different scientific fields in order to support complex decision-making. An Integrated Assessment approach towards the notion of transition unfolds the contours of a transition theory. The transition theory holds that the dynamics underlying a structural long-term change of societal subsystems can be described and explained using the concept of transitions. The theory is based on two underlying conceptual pillars: the multi-stage concept, and the multi-level concept.

The multi-stage concept describes a transition at the conceptual level in terms of four stages or phases (Rotmans e.a., 2000), (see Figure 2).

i. a *pre-development* phase of dynamic equilibrium where the status quo does not visibly change;

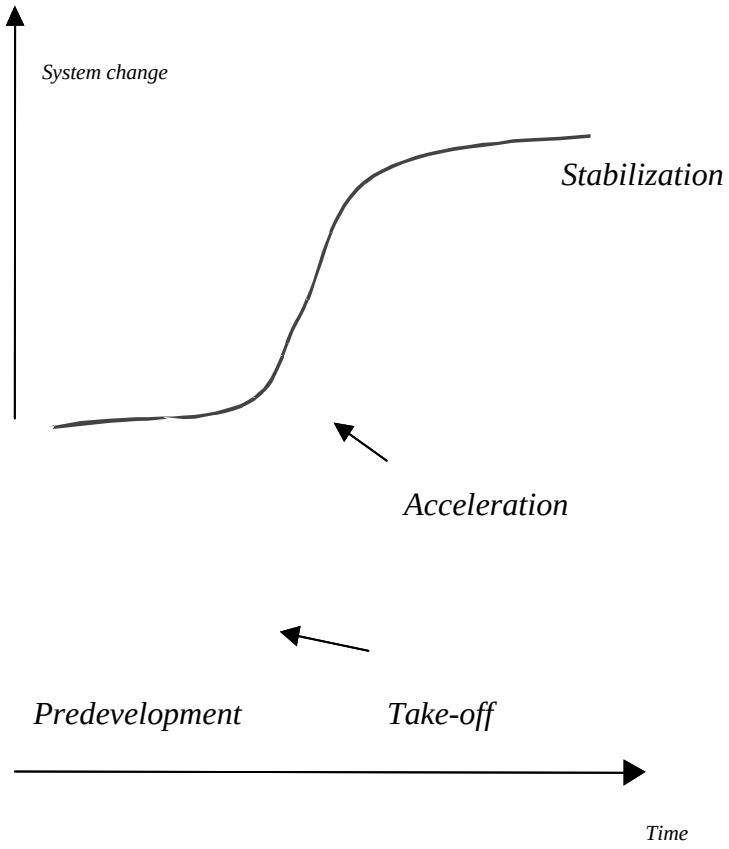
ii. a *take-off* phase where the process of change gets underway because the state of the system begins to shift;

iii. an *acceleration* phase where visible structural changes take place through an accumulation of socio-cultural, economic, ecological and institutional changes that reflect to each other;

iv. a *stabilization* phase where the speed of social change decreases and a new dynamic equilibrium is reached.

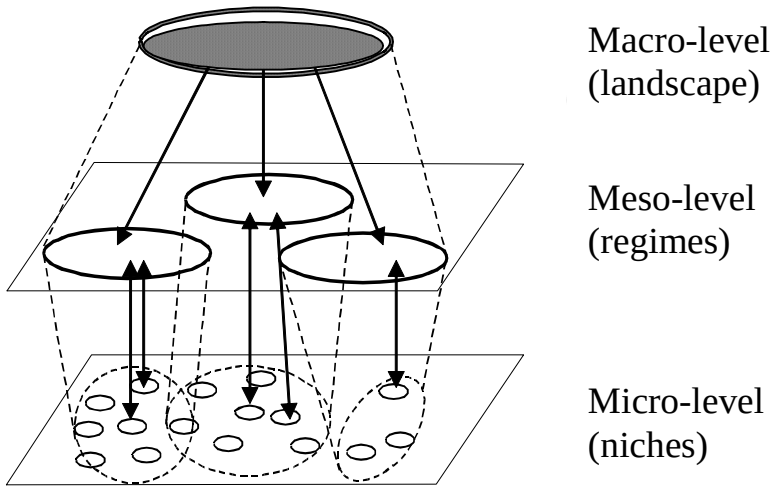
Different societal processes come into play during the various phases. It is also important to realize that fundamental changes do not necessarily occur in all domains at the same time. It should be noted that the concepts of speed and acceleration are relative: all transitions contain periods of slow and fast development. Nor is a transition usually a quick change, but a gradual, continuous process typically spanning at least one generation (25-50 years).

Figure 2. The different phases of a transition



The multi-level concept is based on the division of micro-, meso- and macro-levels fits closely with the classifications used by Geels and Kemp to describe changes in socio-technical systems, namely the division into niches, regimes and socio-technical landscapes (Geels and Kemp, 2000). Although this taxonomy originates from changes in function-oriented systems related to energy and food production, it also appears useful for the analysis of broad societal changes (see Figure 3).

Figure 3. Interaction between different scale-levels



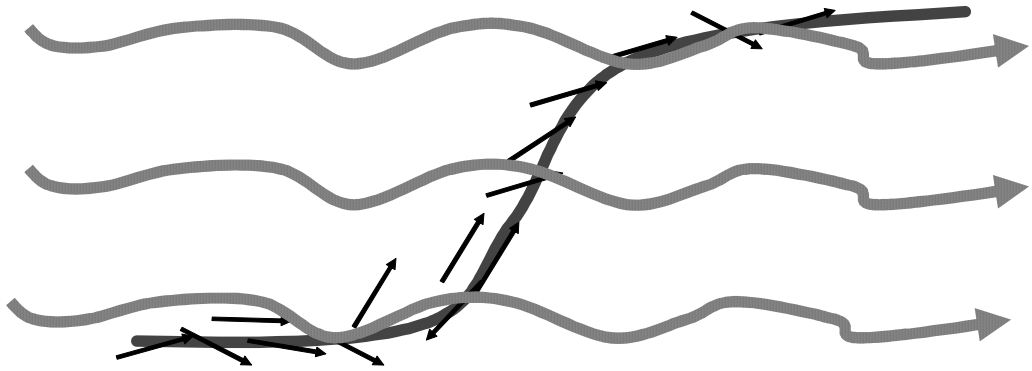
At the *macro-level* the societal landscape is determined by changes in: the macro economy, political culture, demography, natural environment, and worldviews and paradigms. This level responds to relatively slow trends and developments. Its seismic undercurrents can play an important role in speeding up or slowing down a transition, but its geology is for the most part unyielding. At the *meso-level* operate the social norms, interests, rules and belief systems that underlie strategies of companies, organisations and institutions and policies of political institutions. At this level the dynamics is determined by dominant practices, rules and shared assumptions which are most geared towards optimising rather than transforming systems. At the *micro-level (niche-level)* act individual actors, technologies and local practices. At this level, variations to and deviations from the status quo can occur as a result from new ideas and new initiatives, such as new techniques, alternative technologies and social practices.

Interlinking the two transition concepts of multi-level and multi-stage yields the following pattern. In the pre-development phase of a transition the regime often acts as an inhibiting factor. Typically it will seek to maintain social norms and belief systems, and to improve existing technologies. The strategy is aimed at fighting off new, threatening developments. The take-off phase is reached when a modulation of developments takes place at the micro- and macro-level. This means that certain innovations at the micro-level, e.g. in terms of behaviour, policy or technology can be reinforced by changes at the macro-level, e.g. changes in worldviews or macro policies. It can go either way: breakouts at the micro-level find fertile soil at the macro-level, or a break through at the macro-level can be accompanied by suitable initiatives at the micro-level. In the acceleration phase, the regime has an enabling role, through the application of large amounts of capital and innovation. The regime changes as a result of self-examination, or in response to bottom-up pressures from the micro-level, or to top-down pressures from the macro-level. Through the reinforcement of modulated developments at the three different levels, things change rapidly and irreversibly. In the stabilization phase the acceleration slows down, due to a new regime that has been built up, again resisting new developments. The stabilization phase is no end-point; on the contrary, it represents a dynamic equilibrium, which could accommodate the seeds of change for another transition.

The multi-stage and multi-level aspects of transitions imply that change only breaks through if developments one level gel with developments in other domains. This fundamental change in the take-off and acceleration phase is the result of many attempts in the pre-development phase to change the system. In most cases these attempts are doomed to fail: only in exceptionally few cases the modulation at different scale levels culminates in a take-off phase. The stabilization phase is not an end-point but reflects a new dynamic equilibrium, which contains the seeds of change for a new transition.

A transition is the result of long-term developments in stocks and short-term developments in flows (Figure 4). Since stocks change slowly, the dynamic pathway of a transition is characterized by an S curve (for example a logistic curve). The developments occur in various domains: technology, economy, social life, culture, nature. Every domain has its own dynamics. Cultures only change slowly, just like ecological systems. Economic changes, may occur very rapidly, price fluctuation being an example. Institutional and technological changes are somewhere in between. The whole picture, therefore, forms a hybrid mixture of fast and slow dynamics. The various time axes shift over each other and constantly influence each other. The slowest processes to a great extent, determine the tempo and the direction of the entire dynamics, i.e. by the developments in stocks.

Figure 4. A transition is the result of long-term developments in stocks and short-term developments in flows

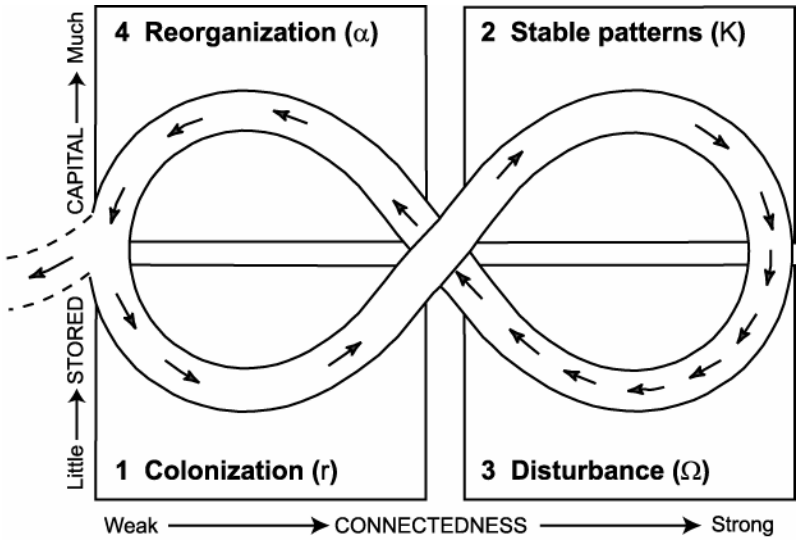


Source: from Rotmans, et al., 2000 and 2001

A prerequisite for the realisation of a transition is a fundamental change of ideas, perceptions and assumptions, denoted here as a change in worldview. According to Schwartz and Thompson (1990), a worldview is the whole set of notions, perceptions, norms and values through which people look at the world. Worldviews usually change only slowly and gradually, due to increasing knowledge, empirical facts, new insights, or through articulation and confrontation of divergent visions. But worldviews can also change suddenly, through calamities, disasters of surprises, e.g. Chernobyl, an oil crisis or the terrorist attack on the WTC on 11 September 2001. Often, however, there is a combination of a long-term under-currence and a calamity that reinforce each other, and lead to an accelerated conversion of the worldview.

So far, we have treated two different system aspects of transitions: we have covered the temporal dimension (speed, size and time period) and the level dimension (micro-meso-macro) dimension. What we have not discussed yet, is the nature of the transition, in terms of the change in characteristics of the system under concern. An interesting parallel here could be drawn between the 'lemniscate' or 'eight-curve' of Holling (Gunderson and Holling, 2002) and the transition curve. Holling describes four different phases in the development of ecosystems, eg. exploitation, conservation, release and reorganization, see Figure 5. As he argues these phases could be distinguished as well in socio-ecosystems. The slow period is the stage from exploitation to conservation, during which capital is built up, whereas the relatively fast period is the stage from release to reorganization, during which innovation and restructuring take place. Transitions could be described in the same terms of 'degradation' and 'breakdown' versus 'build up' and 'innovation'.

Figure 5. 'lemniscate' adaptive cycle



Source: Gunderson and Holling

Transitions are characterized by processes of variation and selection, by a variety of new ideas and techniques of which many 'die', and only a few will 'survive' and grow out into large-scale developments. This implies that the stage from exploitation to conservation could be regarded as the transition stage from pre-development to take-off (slow process during which different sorts of capital are built up). The stage from release to reorganization could be considered as the transition stage from acceleration to stabilization (fast process during which destruction takes place on the one hand, and system innovation on the other hand). For the sake of brevity we won't go into further detail, but we will explore this further in upcoming publications.

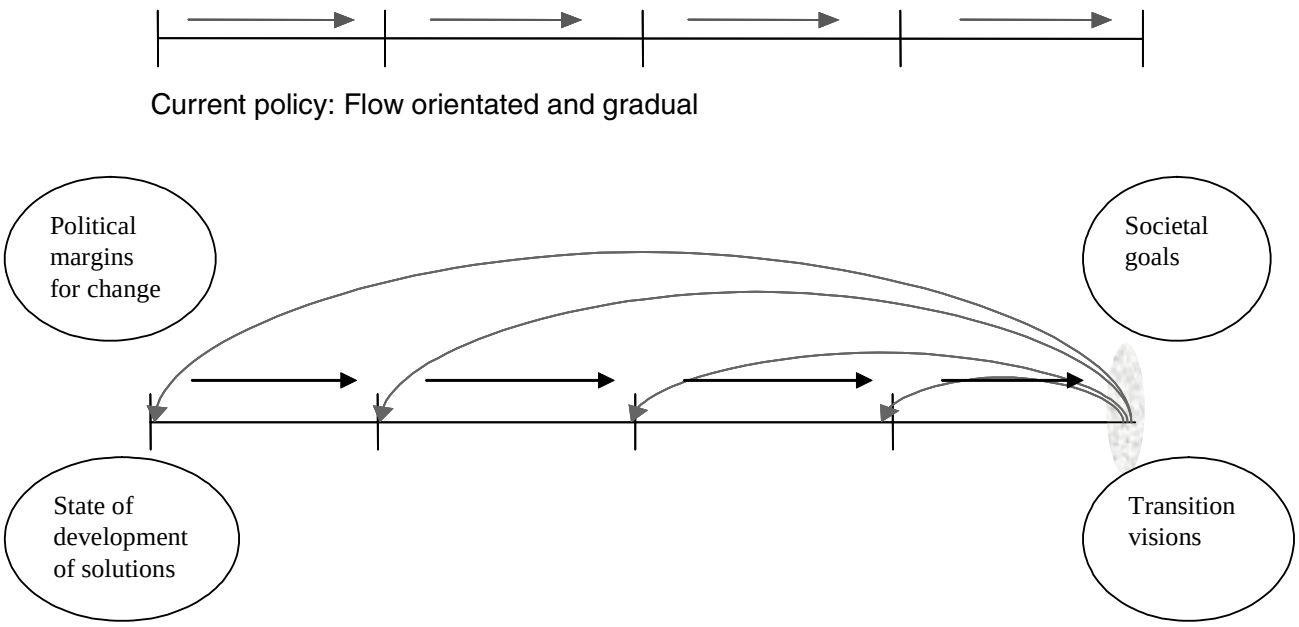
4. TRANSITION MANAGEMENT

The question arises to what extent and in what manner these broad societal innovation processes such as transitions can be managed or steered. After all, transitions are no blueprints that determine systematically what will happen. On the contrary, transitions are evolutionary processes that mark possible development pathways, of which the direction and pace could be influenced by specific policies. In other words, transitions cannot be managed in the classical manner of full control and supervision, due to the fundamental uncertainties and many surprises on a transitional pathway. However, transitions can be managed in terms of influencing and adjusting: a more subtle, evolutionary way of steering. In other words, the direction and pace of transitions can indeed be influenced. In concrete terms this means steering through creating a climate in which societal innovation can flourish and through the initiation of the right initiatives at the right moment. A sound and transparent communication among all parties involved is of crucial importance in this process. But if so, in which way could transitions than be managed or steered? First of all there is no generic recipe for the management of transitions and system innovations. The management of this kind of complex societal processes is comparable with a common search travel, for which, however, there is not yet a common compass available, and this still has to be developed.

Transition management consists of a deliberate attempt to bring about structural change in a stepwise manner. It does not attempt to achieve a particular transition goal at all cost but tries to utilise existing dynamics and orient these dynamics to transition goals that are chosen by society. The goals and policies to further the goals are not set into stone but constantly assessed and periodically adjusted in development rounds. Existing and possible policy actions are evaluated against two criteria: first, the immediate contribution to policy goals (for example in terms of kilotons of CO2 reduction and reduced vulnerability through climate change adaptation measures), and second, the contribution of the policies to the overall transition process. Policies thus have a *content goal* and a *process goal*. Learning, maintaining variety and institutional change are important policy aims and policy goals are used as means. The use of development rounds brings flexibility to the process, without losing a long-term focus.

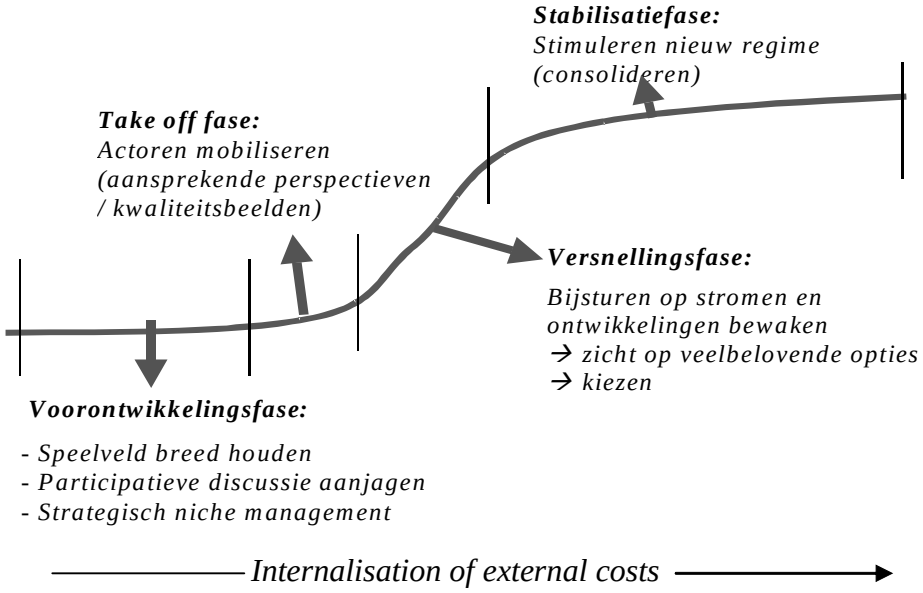
A schematic view of transition management is given in figure 6.

Figure 6. Short-term versus long-term policy



Transition management is based on a two-pronged strategy. It is oriented towards both system improvement (improvement of an existing trajectory) and system innovation (representing a new trajectory of development or transformation). The role of government differs per transition phase. For example, in the predevelopment stages there is a need for social experimentation and creating support for a transition programme, the details of which should evolve with experience. In the acceleration phase there is a special need for controlling the side effects of large-scale application of new technologies. Throughout the entire transition the external costs of technologies should be reflected in prices. The changing nature of policy is shown in Figure 7.

Figure 7. Role of the government in various phases of a transition process



Strategic niche management is the creation and management of a niche for an innovation with the aim of promoting processes of co-evolution. The innovation is used by real users. This helps to promote interactive learning (between suppliers and users) and helps to build product constituencies (which include policy actors). The approach of SNM is described in Kemp et al. (1998a), Kemp et al. (1998b), Kemp et al. (2001) and Hoogma et al. (2001).

Transition management breaks with the planning and implementation model and policies aimed at achieving particular outcomes. It is based on a different, more process-oriented philosophy. This helps to deal with complexity and uncertainty in a constructive way. Transition management is a form of process management against a set of goals set by society whose problem solving capabilities are mobilised and translated into a transition programme, which is legitimised through the political process.

Key elements of transition management are:

- Long-term thinking (at least 25 years) as a framework for shaping short-term policy
- Thinking in terms of more than one domain (multi-domain) and different actors (multi-actor) at different scale levels (multi-level); how developments at one level with one type of actors gel with developments in other domains
- A focus on learning and a special learning philosophy (learning-by-doing and doing-by-learning)
- An orientation towards system innovation
- Learning about a variety of options (which requires a wide playing field).

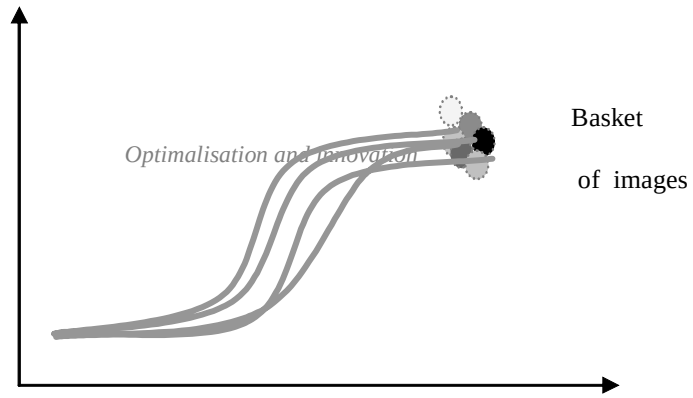
Transition management does not aim to realize a particular path. It may be enough to improve existing systems, it may also be that the problems turn out to be less severe than at first thought.

Transition management is not an instrumental activity. The actual policies are the outcome of political negotiations and processes of co-evolution which inform further steps, but the basis steps are:

The transition goal

This consists of a basket of images, not a societal blueprint. The transition goal is multi-dimensional and should not be defined in a narrowly technological sense. The goals should be democratically chosen and based on integrated risk analysis.

Figure 8. Transition goals: basket of images



This will constitute a radical break with current practice in environmental policy where quantitative standards are set on the basis of studies of social risk, and adjusted for political expediency. Risk-based target setting is doomed to fail when many issues are at stake and when the associated risks cannot easily be expressed in fixed, purely quantitative objectives. This holds true for climate change but also for sustainable transport.

Transition management relies on integrated risk analysis and the setting of minimum levels for certain stocks (e.g. health, ecosystem diversity and capital) and aspiration levels. The estimates of various types of risk are subjective, since the risks are surrounded by structural uncertainties, legitimating the incorporation of various perspectives (van Asselt, 2000). The net result is a policy corridor for key variables, indicating the margins within which the risks are considered acceptable.[3]

The use of transition visions

Transition management is based on long-term visions that function as a framework and a frame for formulating short-term and long-term objectives and evaluating existing policy. To adumbrate transitional pathways, these visions must be appealing and imaginative and be supported by a broad range of actors. Inspiring final visions are useful for mobilizing social actors (such as 'underground transport' and 'multifunctional land use'), although they should also be realistic about innovation levels within the social subsystem in question.

The 'basket' of visions (see Figure 8) can be adjusted as a result of what has been learned by the players in the various transition experiments. The participatory transition process is thus a goal-seeking process, where both the transition goals and visions change over time. This differs from so-called 'blueprint' thinking, which operates from a fixed notion of final goals and corresponding visions.

[3] The idea of a policy corridor is described and applied in Rotmans and den Elzen (1993).

Interim objectives

Figure 6 shows the similarities and differences between current policy-making and transition management. In each case, interim objectives are used. However, in transition management these are derived from the long-term objectives (through so-called 'backcasting'), and contain qualitative as well as semi-quantitative measures. In other words, the interim transition objectives contain *content* objectives (which at the start can look like the current policy objectives, but later will increasing appear to be different), *process* objectives (quality of the transition process, perspectives and behaviour of the actors concerned, unexpected developments) and *learning* objectives (what has been learned from the experiments carried out, have more options been kept open, re-adjusting options and learning objectives).

Evaluating and learning

Transition management involves the use of so-called 'development rounds', where what has been achieved in terms of content, process dynamics and knowledge is evaluated. The actors who take part in the transition process evaluate in each interim round the set interim transition objectives, the transition process itself and the transition experiments.

The set interim objectives are evaluated to see whether they have been achieved; if this is not the case, they are analysed to see why not. Have there been any unexpected social developments or external factors that were not taken into account? Have the actors involved not complied with the agreements that were made?

The second aspect of the evaluation concerns the transition process itself. The set-up and implementation of the transition process is put under the microscope. How do the actors concerned experience the participation process? Is it dominated by certain parties (vested interests)? Is it too consensual (too cosy), or is there too little commitment? Are there other actors who should be involved in the transition process? Are there other forms of participation that must be tried out?

The final issue for evaluation is the amount of learning or 'enrichment' that has taken place in the previous period. A special point of attention is what has been learned from the experiments carried out to stimulate the transition. What have been the most important learning moments and experiences? Have these led to new knowledge and new circumstances? And what does this means for future policies?

Creating public support

A continuing concern is the creation and maintenance of public support. This is important for the process to keep going and preventing a backlash, which may occur when quick results do not materialize and setbacks are encountered. One way to achieve this is through participatory decision-making and the societal choice of goals. But societal support can also be created in a bottom-up manner, by engaging in experiences with technologies in areas in which there is local support. The experience may take away fears elsewhere and give proponents a weapon. With time solutions may be found for the problems that limit wider application. Education too can allay fears but real experience is probably a more effective strategy. Through the prudent use of new technologies in niches, societal opposition may be circumvented.

5. TRANSITION MANAGEMENT IN RELATION TO CURRENT POLICY

Transition management should be seen as complementing rather than conflicting with current policy. The concept of transition places short-term policy within a time frame of one, two or three generations (50-100 years) rather than the maximum of 5-10 years, which is typical of current policy. It is also oriented towards system innovation. Unfortunately, the fruits of technical fixes will contribute more quickly to policy objectives in the short term. An example of this is CO2 collection and storage. Another example is the catalytic converter which helped to achieve reductions in automobile NOx emissions but increased energy use and that did not deal with the many social and economic problems related to car use. Technical fixes are no solution for complex social problems.

This does not mean that transition management rejects the improvement of existing systems as a route towards sustainability. It says that you must aim for both system optimisation and system innovation instead of one of the two. The two strategies are not necessary mutually exclusive: cleaner cars can go hand-in-hand with innovative public transport systems. System improvements may thus act as a stepping-stone for system innovation. Another example is organized car sharing, which facilitates intermodal travel.

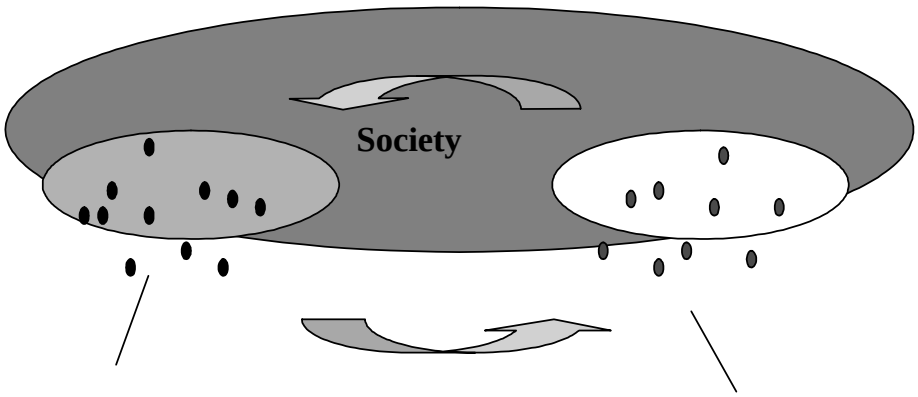
A characteristic of transition management when successful is that structural change is achieved in gradually, without too much destructive friction in the form of social resistance or high costs. This is done through the use of hybrid technologies and two-world technologies and exploitation of niches, attractive domains of application. You do not need centralised planning for the creation of a new system. It can also be achieved through in a gradual way, by adding for example new elements to an existing system, which facilitate further change.

Transition management tries to utilize the opportunities for transformation that are present in an existing system. It joins in with ongoing dynamics instead of forcing changes. Transition management also implies refraining from large-scale investment in improvement options that only fit into the existing system and which, as a result, stimulate a ‘lock-in’ situation.

The role of government in transition management is a plural one: facilitator-stimulator-controller-director, depending on the stage of the transition. The most effective (but least visible) is the guidance in the pre-development phase, and to a lesser extent, in the take-off phase. Much more difficult is the guidance in the acceleration phase, because the direction of development in this phase is mainly determined by reactions which reinforce (or weaken) each other and cause autonomous dynamics. It is still possible at this stage to adjust the direction of development, but it is almost impossible to reverse it.

Transition management is thus a combined search- and learning process, which requires an ingenious manner of steering. The search process is a process of envisioning that is organized by an independent organization in combination with transition teams in the home-bases, which continuously create suitable conditions for innovation. The learning process has three components: learning-by-doing (developing theoretical knowledge and testing that by practical experience), doing-by-learning (developing empirical knowledge and testing that against the theory) and learning-by-learning (developing learning strategies, applying and evaluating them). The joint search- and learning process takes place in the transition-arena, which operates on a distance from the political arena (arena of current policy), see Figure 9.

Figure 9. Communicating arenas



Current policy arena
- *Short term*
- *Peloton*
- *Incremental improvements*
- Problem and goal oriented

Transition arena
- *Long term*
- *Frontrunners*
- *System innovation*
- *Problem- and goalsearching*

The political arena aims at the short-term (at most 5-10 years), at incremental improvement with regular players and regular steering mechanisms. The transition- arena, however, aims at system innovation in the long run (25-50 years), with forerunners, making use of innovative steering mechanisms. This is illustrated in the box below.

Table 1. Current versus transition-policy

Current Policy	Transition 'Policy'
Short time horizon (5-10 years)	Long time horizon (25-50 years)
Facet approach	Integrated approach
- limited number of actors	- multi-actor
- one scale-level	- multi-level
- one domain	- multi-domain
Aimed at incremental change	Aimed at innovation for sustainable development
Regular steering mechanisms	New steering mechanisms
Political arena	Transition-arena
Linear knowledge development and dissemination	Learning-by-doing and doing-by- learning

At a certain point in time, a number of innovation experiments executed turns out to be successful and break through. In this break-through stage, the take-off phase, the successful innovations at micro-level will work through at the meso-level and grow into system innovations. At the same time, more and more actors outside the transition-arena will in this take-off phase get the feeling that they miss the boat. If these outsiders will hook on to the transition activities and experiments, the arena will spread steadily. In this stage there will be increasing interaction between the transition-arena and the current policy arena. The increasing interference will put the short-term policy into a longer-term perspective, with more and more overlap between the current and longer-term agendas. In this process of divergence and convergence between both arenas the government plays a facilitating rather than a leading role.

6. THE TRANSITION TO A LOW-EMISSION ENERGY INFRASTRUCTURE: DUTCH CASE-STUDY

This section applies the idea of transition management to energy supply. It examines the possibilities for managing the transition to a low-emission energy supply system. The development of a low-emission energy supply in the Netherlands makes a good case for transition management. The production, transport and distribution of energy represents an important societal sub-system, of which the services extend into social life. As with any transition, a number of important boundary conditions are set by other domains, which can either slow down or strengthen the transition. The economic domain demands affordability and sufficient economic returns; the socio-cultural domain values health, safety and asks for reliability of delivery; while from the ecological point of view, the risks for nature and the environment are important. Global and European 'landscape' developments have a major influence on the Netherlands' future energy supply.

From a transitional perspective, the transition in energy is still in its pre-development phase. The main unsustainability aspects are: the CO2 emissions contributing to climate change causing rivers overflows and increased sea levels, and the dependence on fossil fuels, making it vulnerable to price changes, which may cause economic problem but political problems, as was demonstrated by last year's unrest over high diesel prices. Alternatives are expensive at their current level of development and seen as longterm options. But deferment of the transition to new energy sources only shifts the problems to later generations, because future options for the energy supply are, to a large extent, determined by current investment in R&D (IIASA-WEC). The SER, an influential advisory board in the Netherlands has stated that the energy infrastructure must change fundamentally in the long-term.

The perceived unsustainability of the existing energy system by all the policy actors and the Dutch commitment to the Kyoto protocol are drivers for change, but there are many obstacles to an actual transition. One important hindrance is the overproduction of fossil fuels, leading to low energy prices. A second obstacle are the interests of the oil companies, an important policy actor. Although they claim to be investing in alternative sources of energy, they fear a lock-in, and are scared of placing all their eggs in one basket (i.e. choosing the 'wrong' energy technology). As a result, the current energy producers and users causing the CO2 emissions, have no real incentive for change. Finally, there is no groundswell of popular support for a change in sources of energy. In these circumstances, how can a low-emission energy system be developed through transition management, what kind of difference does it make?

Energy transition management

An essential element of transition management is the selection of a collective transition objective. This objective needs to be multi-dimensional, and not only quantitative. From the socio-cultural viewpoint, safety and reliability of delivery are important requirements. The ecological risks might be specified in CO2 concentrations. A low-emission energy supply is often translated in terms of CO2 reductions, of the order of 50% of 1990 levels, to be realized over a period of 50 to 100 years.

The second step concerns final visions of energy transition. A recent study by the Dutch Energy Centre, ECN, articulated three visions for the future of the Dutch energy supply:

1. Status quo

In this vision the current energy infrastructure remains intact, but final energy fuels are made from renewable energy resources (solar, wind and biomass). Oil, methane and electricity remain the final energy fuels. There will be more conversion steps, particularly for biomass and coal, where the primary energy fuels are both renewable and 'clean' fossil fuels (use of fossil fuels, with storage of CO2 in empty natural gas fields or coastal seas).

2. The hydrogen economy.

In this vision, hydrogen is the dominant final energy fuel, particularly for industry, transport and built-up areas. This requires a thorough adaptation of the current natural gas network, so that, for example, cars are able to run on hydrogen.

3. The all-electric society

Here, the role of electricity as the final energy fuel is dominant in all sectors of society. This requires a fundamental transformation of the current energy infrastructure, including a large-scale electricity network in order to allow cars to run on electricity, for example.

These three final energy visions are not mutually exclusive, and each combines centralized with local systems of power generation. They are, however, purely technological in their perspective. Real transition final visions must have a social dimension. The social, cultural, institutional and environmental contexts of a transition must be considered carefully if the process is to attract the support of actors involved.

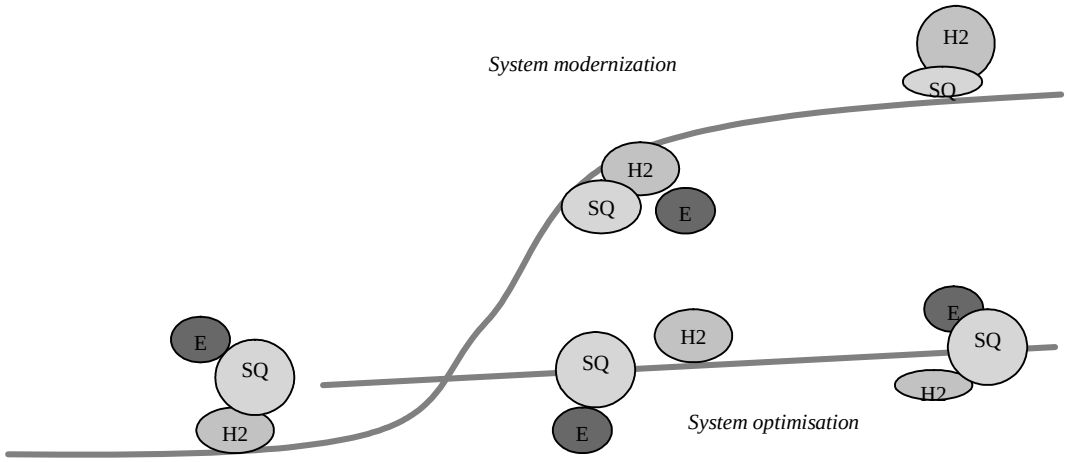
The ECN analysis suggests that all three final energy visions may lead to the desired 50% reduction in CO2 emissions, but only if they are followed scrupulously. The roles of renewable energy sources (solar, wind and biomass) and clean fossil fuel energy in each final vision are clear; what is not so obvious is how much all the visions continue to rely on nuclear power and the parallel development of energy-saving technology. One thing that is clear is that the biomass for energy cannot be produced in the Netherlands. To produce the biomass alone for the first vision would require the entire land of the Netherlands to be used for growing energy crops.

It is difficult to make judgements about the viability of the various options, as costs were not estimated. At first sight, the status quo final vision offers a lot of advantages, since the existing infrastructure can be preserved, although an exorbitant quantity of biomass is required. The hydrogen society final vision has the advantage that it can be entirely CO2-free. Furthermore, there is considerable enthusiasm for such advanced technology. On the other hand, such a fundamental changeover would require a great deal of time and effort. The electrical society final vision opens up the prospect of a gradual transfer to low CO2 emissions, or possibly even a CO2-free energy supply in the long-term. There is, however, not a great deal of enthusiasm for this, partly as a result of the risks (breakdowns, disasters) and the way in which it could sideline a number of innovative technologies presently in development.

Formulating interim objectives is the third step of transition management. This allows us to describe the various transition paths behind the final energy visions. Linking the chosen final energy visions to the various transition paths can outline a transition management strategy. If we look at the characteristics of an energy path, a couple of things catch the eye. Firstly, there is no one-to-one relationship between the transition path and the final transition vision. Secondly, the energy transition is not a series of jumps, but a process of gradual development.

Given the present uncertainty about which option is best, all final visions must be kept open, at least for the time being. It may take decades for a technology winner to emerge (see Figure 10). The other options then gradually disappear from the picture, although a hybrid always remains possible. Though the rise and fall of options is evolutionary and largely autonomous, it is not outside the control of government. Even within a continuously changing economic, technological, environmental and institutional context, a strategic policy towards system innovation can refocus or redirect the transition.

Figure 10. Keeping open transition images in the course of time



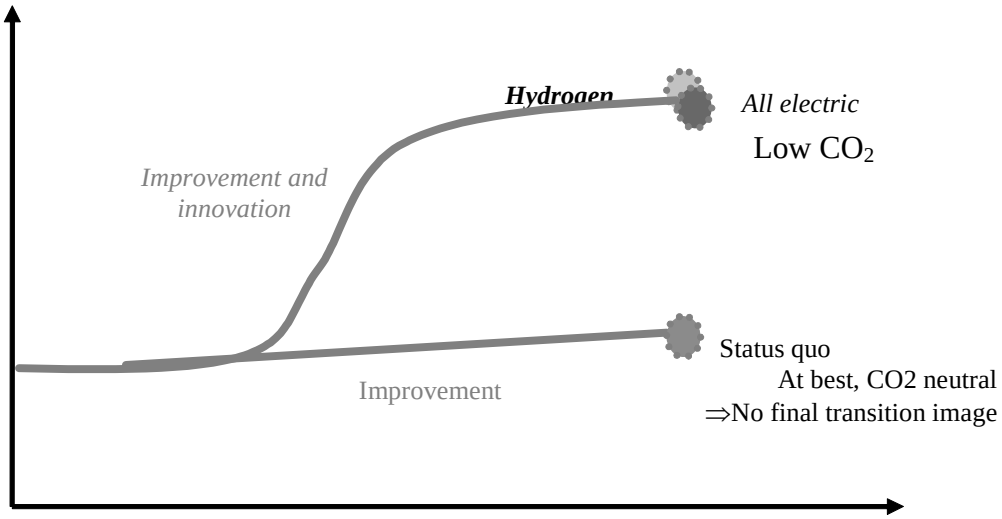
Source: Rotmans et al., 2000 and 2001

The Netherlands' current policy is orientated towards observing agreements such as the Kyoto Protocol in 2010. But neither the Kyoto policy nor the proposed, tighter Kyoto+ policy is an example of energy transition management. A great deal of the CO2 reductions will be achieved abroad through low-cost options that do not contribute to system innovation.

The Netherlands could achieve CO2 reductions of approximately 13% in the period 2010-2020, according to the ECN report (making final CO2 emissions in 2020 approximately 6% lower than in 1998), but only by a Herculean effort. Unless accompanied by structural change in the energy infrastructure, it would require massive use of renewable energy and enormous investment in energy saving. Yet this seems to be the way the country is headed. With the focus on the medium term (reaching no further than 2020), there is little sign of change to the current energy infrastructure, based on oil, gas and electricity.

Not only does this reduce the time available to real change from 50 to 30 years, it effectively locks out two of the three transition visions: the hydrogen and electricity societies (see Figure 11). Nothing is turned upside down, there is no forced change to the energy infrastructure. Promising alternative energy options are locked out. A transition may still be possible but one does not really prepare for it.

Figure 11. Kyoto process and the process of system innovation



Source: Rotmans et al., 2000 and 2001

The value of transition management is that it does not choose for one solution and also does not let time choose. Transition management does not attempt to choice the best path but attempts to learn about various options and to modulate dynamics towards societal goals. An energy transition policy contains the current climate policy, but adds three things to it: a long-term vision, an impulse for system innovation, and a framework for aligning short-term goals and policies to long-term goals.

However, our analysis also shows that it won't be easy to realise such an energy transition. Apart from the overall frame conditions that should change, it requires a double role of the government. In process terms the government has to facilitate the transition process, whereas in terms of contents, the government has to inspire the other social actors, by giving direction. The guidance for the process of a transition will require a different form of participation, however, with new actors. Via a process of so-called *niche participation*, new players who are as yet insignificant but who may become important in the future should become involved in the process. These actors may be brokers for renewable energy, communities for sustainable energy lifestyles, or producers of new energy technologies. In organizing the transition process, the government can form an interdepartmental body or create an external entity of private and public decision makers responsible for transition management. The details of this need to be further worked out.

7. SUMMARY AND CONCLUDING REMARKS

There is a convergent view that several of the present trajectories of development are not sustainable and require fundamental change. This paper has described a method for managing the change process. We have called this method transition management because the challenge of sustainability involves the management of transition problems: the costs of adaptation, resistance of vested interests, and uncertainty about the best option. Through transitions environmental benefits may be achieved, through the development of new systems that are inherently more environmental benign, but transitions may also produce wider sustainability benefits in the form of preservation of natural capital, health protection and social well-being.

Although transitions cannot be managed, one can work towards them. This is what transition management attempts to do. Transition management consists of a deliberate attempt to bring about structural change in a stepwise manner. It tries to utilise existing dynamics and orient these dynamics to transition goals that are chosen by society. The goals and policies to further the goals are constantly assessed and periodically adjusted in development round. Through its focus on long term ambition and its attention to dynamics it aims to overcome the conflict between long-term ambition and short-term concerns.

Transition management

… is a collective, cooperative effort to work towards a transition in a flexible, stepwide manner, utilising dynamics and visions

… involves a wide range of policies with their choice and timing gauged to the particular circumstances of a transition

… involves system innovation and system improvement

Transition management is based on a two-pronged strategy. It is oriented towards stimulating system improvement and system innovation to meet the transition goals. The role of government in transition management is a plural one: facilitator-stimulator-controller-director, depending on the stage of the transition.

The value added of transitions management is that it orients myopic actors to the future and to societal goals, that it creates societal support for a transition (resulting in a transition programme which is politically legitimised) and commits societal actors to change. It provides a basis for coordination of public and private action. It does not fix a path but explores various options.

In our view, transition management offers a promising alternative for a planning and control approach and the use of economic incentives that both suffer from serious problems: economic incentives are likely to be too weak and probably too general to promote system innovation whereas a planning and implementation approach is likely to be disruptive, by failing to include the multitude of microconcerns at the decentralized level. It is a different type of governance model, not an instrument.

Transition management involves a change in policy making, which is oriented toward long-term goals of sustainability (instead of short-term goals), to system innovation and to new actors. Transition management is not something consensual. Transition management does not exclude the use of control policies, such as the use of standards and emission trading. We need corrective policies besides push policies. The policies can be chosen and legitimised as part of the transition endeavour or independently from it. For example the

use of CO2 taxes and other types of economic incentives can be legitimised by the economic principle that one should internalise external costs. The introduction of corrective policies will not be easy. Perhaps the commitment to a transition facilitates their introduction. We don't know. Perhaps it will forestall the introduction of taxes. We have to see. Transition management is not a panacea but a promising perspective. It may be used to achieve a greater coherence in policy and in societal actions for sustainability. It also is *do-able* at least in a country such as the Netherlands, which is another important aspect in favour of its use.

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