Paper to be presented at the "Berlin Conference on the Human Dimensions of Global Environmental Change". 22-23 February 2008, Berlin

Looking for transitions: background, framework and application of transition monitoring for the Dutch energy transition

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Abstract

The specific nature of transitions towards sustainable development and transition management makes monitoring a challenging but essential task. Challenging because it relates local, short term interventions to large-scale and long term change processes and essential because monitoring is an important tool in making management adaptive and governance reflexive. This paper contributes to the development of transition monitoring as an instrument that helps transition managers improve their activities. Firstly, it investigates the implications of the worldview underlying transitions and transition management on using mainstream monitoring approaches. Research on transitions and transition management is based on complexity and a network-perspective. In some circumstances well-established monitoring approaches like the logical framework approach are inappropriate or even counterproductive from this perspective. These circumstances are described and demarcate an area in which improvement of existing monitoring practice is needed. Secondly, it presents a complexity-informed transition monitoring framework that deals with several issues: (1) formulating suggestions for intervention through monitoring, (2) the limited scope of transition management programmes in relation to the long time-frame and uncertain character of transitions, (3) the goal-seeking and adaptive nature of transition management, (4) the analysis of the coherence and synergies between individual projects and (5) the interaction between projects, the programme and societal developments. Thirdly, its application is illustrated for a programme in the Dutch energy system. Several indicators that address the relationship between the niche, regime and landscape-level developments and the coherence of the transition management portfolio are presented and discussed.

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1. Introduction

Sustainable development requires transitions in societal systems like the energy system. In these systems the current regime or dominant way of thinking, organizing and acting has to be replaced or transformed. Transitions are complex and long-term change processes that are to a large extent unpredictable and complex. They are influenced by a wide range of actors, trends and structures from local, individual activities to global developments. It is a question what policy instruments or governance arrangements can best stimulate fundamental change in societal systems. One of the possibilities is the transition management approach developed by (Loorbach 2007; Rotmans and Loorbach 2008).

Transition management does not consider complexity as a barrier but as a starting point for intervention. It is claimed that even though control over transitions is an illusion, influence can be exerted based on a reflexive process of searching, learning and experimenting. This process is carried out by shadow networks bringing together a wide range of so-called frontrunners that create room and opportunity for transition processes through a variety of activities. Based on a vision of long-term sustainable development and integrated systems analysis a variety of pathways is developed and experiments are carried out. This process of creating variation and novelty leads both to improved strategies and to change itself. Transition management creates knowledge on what route to take, while walking various pathways.

The success of transition management is in part dependent on continuing and up-to-date information on the transition dynamics, transition management activities and especially the relation between these two. Transition monitoring is therefore an important instrument (Loorbach 2007). We define transition monitoring as the process to observe both on-going dynamics of a transition and actions to influence this transition in order to gain insight on how to intervene more effectively. Transition monitoring in this paper is therefore not only useful for scientific purposes to make transition dynamics and management visible and increase our understanding of these processes but even more so for managerial purposes. One of the problems is that many existing monitoring approaches and indicators are based on a different worldview regarding societal change and management. This paper therefore attempts to highlight some of the features of a complexity-based monitoring approach to transitions in section 2. These insights are then applied to a generic monitoring approach that is believed to be appropriate for all transition-oriented change agents and transition processes in section 3. It would be a bit awkward however to leave the reader with a fairly abstract line of thought while monitoring has such a fact-and-figure and down-to-earth appeal. Therefore section 4 presents a thought experiment on how this transition monitoring approach can be worked out

in a large energy transition programme facilitated by the Dutch government. The paper wraps up with some concluding remarks in section 5.

2.Complexity-based monitoring

Transition management *"views society as a patchwork of complex societal systems. […] this is illustrated by three levels at which this complexity manifests itself: the level of society as a whole, of the problems facing our society and of dealing with these problems (governance)."* (Loorbach 2007). Such an explicit referral to complexity as a foundation for building theory on societal change and management has implications for the type of knowledge that can be generated for and used by management. Many monitoring approaches fall short in their ability to deal with complexity. This section gives some pointers on what complexity-based monitoring looks like and when it is appropriate. Complexity-based monitoring has implications for (1) the type of indicators, (2) the process of interpreting the indicators and (3) the relationship to management (Taanman 2007). To illustrate the shortcomings of some existing monitoring approaches, the indicators, interpretation and relationship to management of the logical framework approach (LFA) are taken as an example. This approach is widely used in project management.

Project monitoring is usually treated as a routine activity of tracking whether things proceed as anticipated (Miles and Cunningham 2006). Often the emphasis lies on goal attainment, especially deliverables. Monitoring goal attainment requires SMART (Specific, Measurable, Agreed, Realistic, Time-bound) formulation of these goals. But you will still need information on processes and outcomes or impacts as well, to find out *why* things are proceeding in a certain way. The LFA approach is already an important step forward and is described in box 1, because it monitors a (crude) theory of change or *project theory*, an explicit theory or model of how a project will, or has, brought about impact.

Box 1: the logical framework approach

The LFA method was developed USAID in 1969. It is also widely used in other projects. The Logical Framework is a table which relates *Activities*, *Outputs*, *Purpose* and *Goal*. Of each item several features need to be listed. The first column is used to provide a *Narrative* description of the event. The second column lists one or more *Objectively Verifiable Indicators* of these events taking place. The third column describes the *Means of Verification* and the fourth column lists the *Assumptions*. Assumptions are external factors that it is believed could influence (positively or negatively) the events described in the narrative column. The approach and the table are often criticized for not being able to deal with uncertainties and complexity or plain unskilful use (Gasper 2000).

2.1 Indicators

Things start to look differently from a complexity point of view. A complexity or network-based worldview understands dynamics from the interaction between elements at the same or across levels. These interactions can change and form emergent structures, processes and patterns. If society, a programme or project is seen as complex, Indicators should focus on these types of processes. A project is not understood as a single thing that inflicts change on a primarily static context, but as a system or network of stakeholders and other elements whose interaction 'inside' and 'outside' the project results in dynamics that include behavioral changes, establishing relations with other actors, exchange of resources, alignment of objectives, learning, etc. The project's workings are not separated from the context, but occur in interaction with this context.

The LFA is used to monitor a project theory, that in practice is often formulated as a theory of things and delvirables that emphasizes milestones instead of people. ("We will develop something, organize five meetings and therefore contribute to sustainable mobility"). These linear causal theories do not make explicit what factors and actors interact with the project and how these factors and actors are actually supposed to be influenced (apart from 'organizing a meeting'). Using networks or complex systems as the leading metaphor would stress the importance of people that embody information, have goals and are dependent on each other. According to Davies this resembles the day to day practice in projects much closer (Davies 2004; Davies 2005).

2.2 Interpretation of the monitored dynamics

Complex systems experience non-linear dynamics in which the relation between its elements changes. According to (Folke, Hahn et al. 2005): "*During such periods, experience tends to be incomplete for understanding, consequences of actions are ambiguous, and the future of system dynamics is often unclear and uncertain*". Interpretation of the dynamics based on existing knowledge can therefore lead to wrong conclusions. Dealing with this inherent uncertainty requires scrutinizing present theories, exploration of future options and promoting diversity and flexibility.

the LFA approach implies a detailed theory at the start of the project that does not change over time. This is appropriate for run-of-the-mill type of activities but not for highly innovative or open ended projects. Many innovative projects are undertaken for the *very reason* that it is not known beforehand what is realistic, what it exactly is that can be agreed upon and whether it is time-bound. Or as stated by (Duret, Martin et al. 1999), *innovations do not start from a state of knowing, but from a state of not knowing*. Using a predefined, fixed theory of change can lead to tunnel vision or simply display an image that is not representative of what actually goes on in the project.

2.3 The role of monitoring in management

As the main theory of change that requires scrutiny is the policy maker's (and not the monitoring expert's), arguments are made for bringing the policy maker and the monitoring expert in close contact in which the role of the monitoring expert and his relation to management includes helping managers think in systems, participatory approaches and more flexible monitoring instruments.

The monitoring information in the LFA is often used for accounting purposes only and little explicit attention is paid to the process in which the monitoring information can lead to improved strategies. Especially when it comes to developing indicators, collecting information and thinking what this information means for action, there can be little interaction with the management context in which the conclusions are to land.

2.4 Summary: when to use complexity-based monitoring?

The above can be translated into a heuristic when complexity-based monitoring is appropriate and to what extent (see figure 1). First, if change is thought to be dependent on complex interactions across scales, indicators should focus on (emergent) processes and patterns. Second, if also the programme theory is subject to change and/ or if interventions are hoped or feared to trigger uncertain, large-scale and irreversible effects. Interpretation of the indicators might become problematic. Third, if management desires monitoring to continuously scrutinize existing programme theories and develop new strategies, a different relation to management is in order.

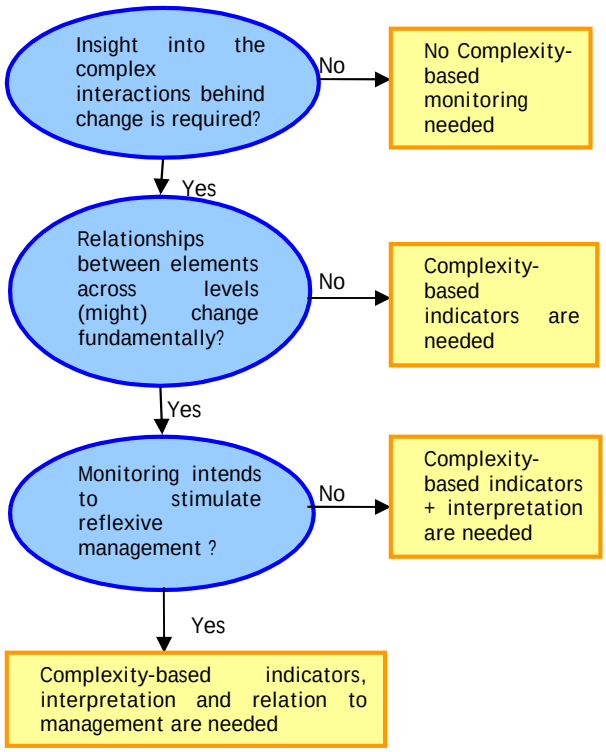

Figure 1: Heuristic for the application of complexity-based monitoring.

For transition management all three aspects are important: innovation and societal change are seen as complex, fundamental change is

anticipated and transition management is seen as a learning strategy in itself. A transition monitoring framework should therefore be based on the considerations presented in this section.

3. Framework for monitoring transitions

Transition monitoring is defined as an instrument for intervention and not as an exclusively descriptive activity. A first prerequisite is therefore that monitoring information can be used for formulating suggestions for intervention. This requires indicators that are based on three different domains of knowledge: descriptive knowledge on what topics are of interest, methodological knowledge of how these topics can be captured in reliable and valid indicators, and management knowledge of what kind of intervention is appropriate for what value of indicators.

Transition management programmes have a limited scope in relation to the long time-frame and uncertain character of transitions. Only monitoring the direct sustainability effects of a project is therefore insufficient. Ultimately it is the present societal system that is the source of unsustainability and the transition of this system that is of interest. This requires programme theories and scientific theories that in some way relate local, short term interventions to large-scale and long term change processes. Monitoring should therefore include both sustainability effects as well as change processes. But there is a third category as well.

Stimulating the goal-seeking and adaptive nature of management requires the continuous exploration and testing of programme strategies. This implies that monitoring should be based on the programme theories and focus on whether they have had the anticipated effect in the intended way in a certain context. Otherwise it is difficult to tell whether the interventions were successful by chance or because they were based on good theories. The monitoring process turns into a reflexive process (Grin and Weterings 2005). On the other hand, a strong focus on existing programme theories might *impede* reflexivity. As (van der Knaap 2004) argues "*it is difficult to underestimate the simplifying effect of a policy theory and the effect of measurability and monitoring. Where too much emphasis is placed on theoretical causality and measurability, this may lead to tunnel vision, rigidity and fear of innovation*". According to (de Bruijn 2002) such perverse effects might be counteracted by restricting the purposes and focus on monitoring, maintaining enough space for other information flows (especially face-to-face interaction) and opening up the process of meaning giving. An additional strategy is to include the theories in the monitoring. When refinement and change in the underlying theory is seen as a desirable effect of running the programme, the development of this theory, its congruence with on-going activities and its evidence-base are after all results. To differentiate

linear project or programme theories with more systemic notions, we use the concept of perspectives. These consist of an image of the present situation, a desired situation and a script on how to get from A to B (Diepenmaat 1997). We now have three categories of indicators: change process, sustainability performance and perspectives. Together, change processes, sustainable performance and creating perspectives form a theory of intentional behaviour (Diepenmaat 1997).

Programmes have a portfolio of projects and programme activities. Different transition management activities are connected and dependent on each other. Portfolio management therefore requires monitoring the coherence and synergies in the portfolio. Portfolio management has two levels of analysis (Cooper, Edgett et al. 1999): whether single projects contribute to the portfolio and whether the portfolio as a whole has some (emergent) qualities. These qualities include diversity in the portfolio, synergies between projects and flanking activities and coverage of the strategic goals.

Transition monitoring focuses on the interaction between projects, the programme and societal developments. A project needs to be relevant to the programme (portfolio), but it can also influence the programme through its failure or success, new insights and relations with other projects. In this sense the programme is a learning organization. You can repeat this argument for the relation between the programme and the societal transition. A transition programme should be meaningful in its societal context: reacting to societal development, aiming to remove the greatest barriers, etcetera. At the same time the programme as a whole might have an influence on the transition that is larger then the total influence of the individual projects or because programme management can influence other governance actors. The same argument can be made for the relation between the project and the societal transition. These three layers form a nested hierarchy where the lower levels should be relevant to higher levels that form the context, and at the same time influence these levels. When there is continuous interaction between these three layers, ie when the programme continuously develops itself through interaction between its environment and its projects, while at the same time it initiates and supports relevant projects and influences transition dynamics, in all likelihood the programme performs well.

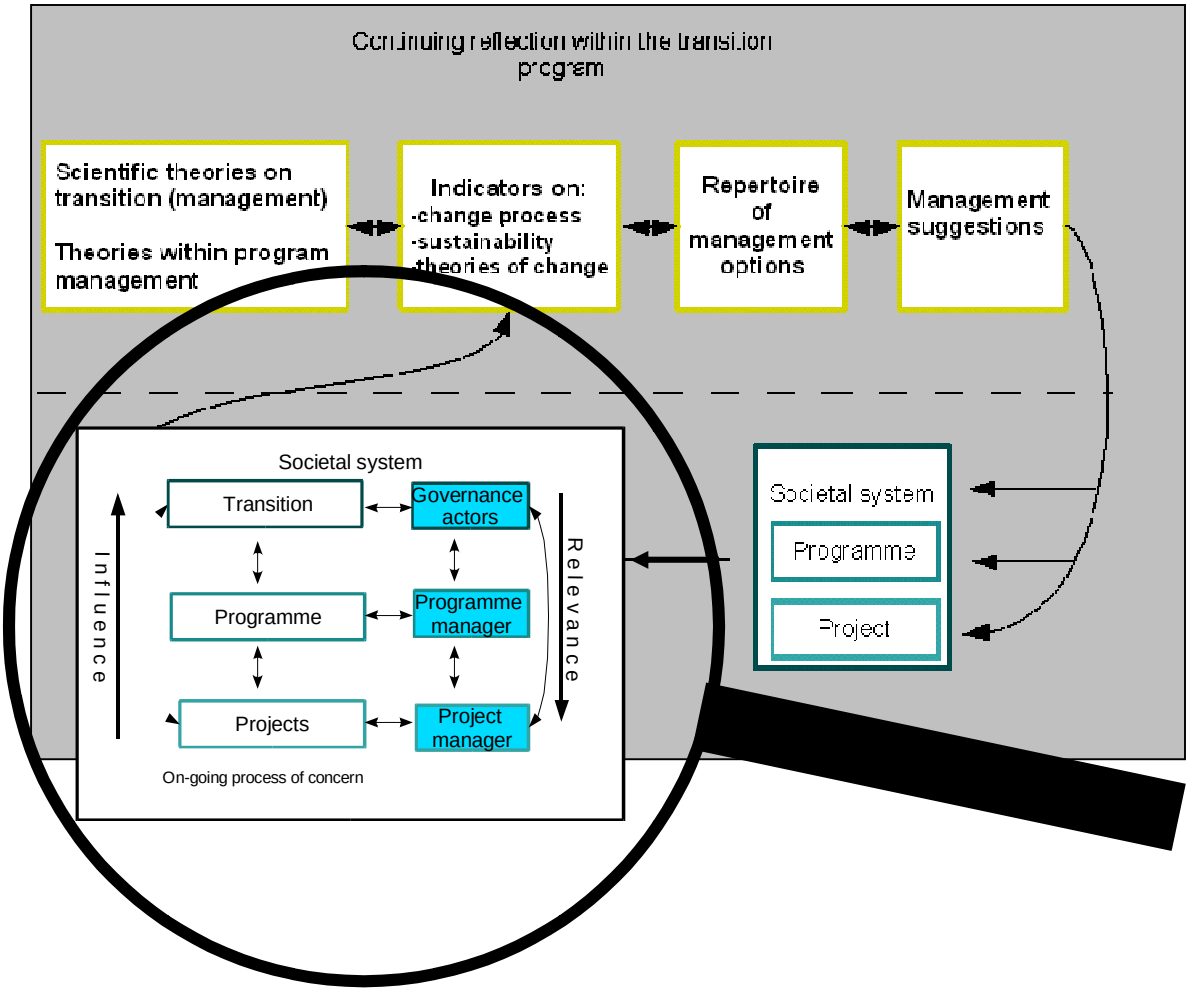

Figure 2: Framework fo transion monitoring

Based on the above, an approach for transition monitoring is developed[2]. This framework is presented in figure 2 and separates the monitoring process (top half) which takes place amid other reflective activities in a programme, from the objects of monitoring (lower half). A monitoring team consisting of managers and scientists in transition studies and, if needed, other actors, construct, measure and interpret the indicators. If needed, the indicators are qualitative. As a result of autonomous developments and management, projects, the programme and society change after which the whole monitoring process is repeated.

This framework is complexity-based. The indicators monitor the systemic relations between projects, the programme and the transition. Interpretation of the monitored dynamics requires reflection on the existing perspectives. Therefore the development of perspectives is monitored as well. Stimulating diversity (also in perspectives) and dialogue is thought to

[2] Currently further development takes place in practice in six different innovation and transition programmes.

enhance reflexivity. Transition monitoring is deliberately positioned amid other reflective processes in the programme and requires the participation of managers and possibly other stakeholders. This role of monitoring in management produces management information in a management context. As programme interests and the monitored areas of interest change, the indicators might be altered.

4.Monitoring the Dutch Energy Transition Programme (ETP)

In this part the application of the monitoring approach is illustrated for a programme in the Dutch energy system. Several indicators that address the relationship between the regime, niche and landscape-level developments and the coherence of the transition management portfolio are presented and discussed.

4.1 Background of the ETP

To get some grip on how the monitoring approach might be applied in practice, let's consider the Dutch Energy Transition Programme. The transition approach was adopted in the Dutch environmental policy plans in 2001 (AER and VROM-Raad 2004). The ministry of economic affairs then announced itself as transition manager on a transition towards a clean, affordable and secure Dutch energy system. Central to the programme are the platforms in which various stakeholders develop visions and transition pathways. Transition experiments started in 2004 (Kern and Smith 2007). Currently there are some 30 transition paths around 7 platforms (www.energietransitie.nl, see also table 1). A transition path is a roadmap for a part of the energy system. Next to the platforms, an interdepartmental platform energy transition (IPE) was set up to link the ETP to mainstream policy and a taskforce to give strategic directions and government advice. The programme has attracted some 200 MEuro private investments and public investments in the same order of magnitude until 2007 (Kern and Smith 2007). Currently the ETP is becoming part of a larger policy programme ("clean and efficient", (VROM)) and its budget is likely to increase substantially.

Table 1: platforms and transition pathways in the ETP

Platform	Transition pathways	
Sustainable mobility	Hydrogen-fueled vehicles Intelligent transport systems	Building hybrid car fleets Implementation of biofuels
Green resources	Sustainable production and development of biomass Sustainable import chains Co-productions of chemicals, transport fuels, electricit and heat	Syngas production for the NG infrastructure Biomass and improved sustainability in chemical industry
New gas	Energy saving in the existing built environment Micro CHP	NG-CCT Green gas
Chain efficiency	Industrial production chain Clearinghouse for commodities Process intensification Industrial CHP	Industrial ecology Paper industry Agricultural chains
Green electricity	Land-based wind energy Off-shore wind energy Bio-electricity	Central infrastructure Decentral infrastructure
Energy in the built environment	Existing buildings Innovation in Construction	Legislation
Energy producing greenhouse	Energy producing greenhouse	

Now the programme has been operational for several years, it has reached an appraisal phase (Thiry 2004) or evaluation phase (Loorbach 2007) in which the programme needs to take stock of what it has accomplished and whether existing strategies, including visions, pathways and experiments should be changed, replenished, discontinued, etc. Also the context of the programme has changed. In society and politics the attention for energy issues has increased. One striking example is that energy-saving was the third most quoted new years resolution in 2008. Secondly, the policy context is changing. The current government has announced to increase the budget and policy alignment involving the ETP. Apart from providing additional resources and improved access to policy, this might also threaten the flexibility and innovativeness of the programme though increased bureaucratization, dependencies and focus on control and accountability. Lastly, as in other countries, the transition itself is (slowly) taking shape.

A question from the IPE is what progress is seen in various transition pathways and how and whether the ETP can contribute to these pathways. The following subsections present a thought experiment on how the transition monitoring framework can be used to develop indicators for this programme.

4.2 Application of the monitoring framework

The monitoring process should be based on input of transition managers, scientists and monitoring experts. Describing the perspectives of the members of this monitoring team (especially those of the managers) would be a necessary first step. However, in this thought experiment we solely base ourselves on reports and web sites of the ETP and insights from studies on transitions.

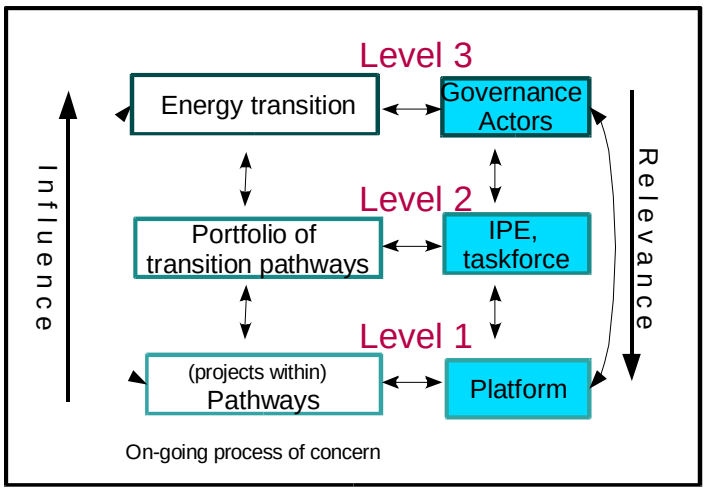

Figure 3: Transition monitoring framework for the ETP

For the ETP, the lower part of the monitoring framework can be described as in (fig. 3). The main target group for steering suggestions are the platforms, IPE, the taskforce and governance actors including the state government. We will focus on three different layers:

- Level 1: The pathways as formulated by the platforms and their various activities and projects.
- Level 2: The 'whole' ETP with its portfolio of pathways and of importance to the IPE and taskforce
- Level 3: The energy transition in which the ETP takes place. Of course there is a lot more happening on the various themes and pathways than within the ETP. It is therefore at this level that the unfolding of the transition pathways is analyzed (Level 3a) and also the relation between the various pathways and the energy transition at large (Level 3b).

The next paragraphs show how indicators can be developed that are based on theories on transitions and employ the transition monitoring approach described in the previous part. Each indicators is connected to certain concepts from studies on transitions and the three categories of transition monitoring (change process, sustainability performance, perspectives). Jumping up and down somewhat, first the projects within the individual pathways, then the

development of the pathways in general will be discussed followed by an assessment of the pathway portfolio and the energy transition at large.

4.3 Level 1: projects within individual pathways

The transition pathways themselves can be described as perspectives. After all, they are based on an image on the present situation, a desirable more sustainable situation and a way to get there. Different activities and projects contribute to these perspectives. An important element in transition management (or indeed many programmes) is that the projects and activities have some autonomy and room for maneuvering, but that the various activities do feed into each other.

Some projects (transition experiments) try out an innovation or system innovation in practice. Other activities and projects are 'flanking' in the sense that they concern research projects, investigations of possible legal barriers, influencing schooling curricula, etc. In a sense the latter activities create room for transition experiments. Refraining at this point to formulate indicators for individual projects we can now formulate three (qualitative) indicators:

Table 2: Activities with the ETP in the various transition pathways

Concept	Indicator or index	Nr	Categories
Coherence between projects and activities within a transition path	Interaction between flanking activities and transition experiments	1.1	Change process
	% experienced problems in transition experiments that are addressed in flanking activities	1.2	Development of perspectives/ change process
	Identification of central and loosely coupled activities	1.3	Change process

4.4 Level 2: portfolio of transition pathways

Selecting pathways on the basis of the development of individual pathways is too narrow a basis: also the (emergent) characteristics of the portfolio as a whole are important. Two of these characteristics spring to mind: the *diversity* of the portfolio (and as such the contribution of the portfolio to the diversity of the Dutch energy system) and the *coverage of the strategic vision* of the ETP.

Diversity has some positive connotations. Evolutionary approaches to innovation and management claim that "*the greater the genetic variability upon which selection for fitness may act, the greater the expected improvement in fitness*" (Fisher, 1930 in Bergh 2006). According to (Stirling 1997), diversity creates more possibilities for cross fertilization and

therefore innovation, it hedges against ignorance[3], prevents early lock-in and accommodate plural perspectives. Stirling distinguishes three dimensions of diversity: variety (the number of options), balance (the evenness of representations of the different options in the portfolio) and disparity (the degree to which the options are different). Next to the performance of individual pathways, an additional criterion from portfolio management is making the programme strategy operational (Cooper, Edgett et al. 1999), ie whether it covers the programme strategy. The scope of ETP strategy can be interpreted as follows (Taskforce-EnergyTransition 2006):

> To make the Dutch energy system clean, affordable, reliable and economically competitive, a transition is required that involves various sectors (industry, mobility, telecommunication and agriculture), a range of actors (businesses (both SME and large companies), government, civil society and knowledge institutes) and a variety of changes (consumer behavior, innovation, business start-ups, institutional). This process has an important international dimension.

Table 3: A portfolio of transition pathways

Concept	Indicator or index	Nr	Categories
Diversity, variety	# pathways	3.1	Change process
Diversity, balance	ETP investments (fte, #projects, subsidies)/ pathway	3.2	Change process
Diversity, disparity	Disparity index based on for example: - different transition patterns - different application context - different maturity	3.3	Change process
Diversity, strategy coverage	Sustainability issues	3.4-3.x	Sustainability performance
	Coverage of sectors		Change process
	Coverage of stakeholders		Change process
	Coverage of desired changes		Change process
	International dimension		Change process

4.5 Level 3a: unfolding of the transition pathway

Various relevant theoretical concepts and monitoring approaches have described the development of new niches (Levinthal 1998; Horbach 2005; Raven 2005). These niches can in time replace parts of the regime. In this paragraph we will use the Innovation Systems Analysis (ISA) as developed by (Jacobsson and Johnson 2000) and tested and adjusted by (Hekkert, Suurs

[3] Ignorance is the uncertitude when the chance of occurrence and possible effect of future developments cannot be assessed. This is opposed to risk (when both are known), uncertainty where the effects can be explored though for example scenario's but chances of occurrence are unknown and fuzziness, where outcomes are poorly understood but a basis for assessing probabilities exists.

et al. 2007) and connect it to the niche-regime interaction and transition patterns developed by (Rip and Kemp 1998; Van der Brugge, Rotmans et al. 2005; de Haan 2007; Geels and Schot 2007).

Every transition path requires the development of an innovation system. The ISA is "*developed to analyse all societal subsystems, actors, and institutions contributing in one way or the other, directly or indirectly, intentionally or not, to the emergence or production of innovation*." (Hekkert, Suurs et al. 2007). Because measures like diffusion and private investment are not easily applicable to very new and developing innovation systems and because they do not present a direct insight into the problems or drivers of development, (Hekkert, Suurs et al. 2007) monitor activities that hamper or foster the development of the innovation system. This ISA is based on 6-9 different processes that characterize a 'healthy' innovation system like providing guidance of the search and entrepreneurial activities. An ISA can identify which processes are lacking and whether there are virtuous patterns of activities that set of new activities.

Because identification of lacking innovation processes alone might be insufficient to produce management information, you need additional information. Information on what the problem entails, what intervention repertoire is available and whom to involve. This requires the introduction of some extra concepts, niches, regimes and transition patterns.

A working innovation system effectively builds a new system called a niche: a constellation with a different functioning from the existing regime and a different culture (eg paradigm, symbols) and structure (eg technology, infrastructure, laws) (de Haan 2007). The development of niches depends in part on the *context* in which an innovation is applied. Niches often fulfill a specific function in a specific market. Entering new markets is an impetus for new learning and development (Levinthal 1998; Nooteboom 1999). Also the *performance of the niche in terms of functioning* is important. Especially for a programme that supports sustainable development.

Niches are not isolated from the regime. Often they are add-ons to the existing system, make use of the same resources (ie infrastructure, labour market), etcetera. Identification of these *regime-barriers or drivers*, combined with the innovation processes present a clearer image of what is going on.

Last, it might be useful to employ a heuristic on what *transition pattern* the pathway is contributing to (de Haan 2007): is it the development of a new system, with largely new entrants, a new knowledge base, etc (called empowerment), the adjustment of the current regime, largely instigated by and based on the resources of the present regime (adaptation) or is it forcefully introduced by actors outside the niches and regime (reconstallation)? This last piece of information gives an idea what type of actors (incumbents or new entrants) and what type of policy instruments are appropriate.

It is also interesting to see how and to what extent the innovation pathway is being supported and talked about at the national level, regime players and within the niche. We will come back to that in the next section.

Table 4: Unfolding of the transition pathways

Concept	Indicator or index	Nr	Categories
Innovation processes	Lagging innovation functions	2.1	Change process
	Description of current application context	2.2	Change process
Niche-regime interaction	Conflicts with regime functioning	2.3	Change process/ development of perspectives
Transition patterns	Types of actors and resources involved	2.4	Change process
Sustainability performance	CO2/ energy unit or avoided CO2, costs of final energy/ avoided costs, Reliability, dependency on imports Volume of exported sustainable energy technologies and services	2.5-2.x	Sustainability performance

4.6 Level 3b: relation to the Dutch energy transition

According to (Verbong and Geels 2007) "*for a balanced assessment you should not only analyze 'pet technologies' and niche innovations but also broader regime developments*", because these regime dynamics influence changes to a high degree. Windows of opportunity in this regime can be used to embark on specific transition pathways.

Elements fit for monitoring transitions include heuristics on transition processes are that misalignment between the regime and its societal context, regime-internal misalignments named 'heating up' (Geels 2005; Geels and Schot 2007) or stress (de Haan 2007) and pressure from niches (including pathways, but not limited to the transition paths).

Table 5: The transition pathways in relation to the energy transition

Concept	Indicators	Nr	Categories
Pressure of landscape on regime	Oil price NG reserves	4.1	Change process
	Top 10 problems with the regime in the media and # times mentioned (eg # times global warming is mentioned in national newspapers)	4.2	Development of perspective
	Sustainability performance of regime	4.3	Sustainability
Stress within regime	Sense of urgency and problem perception on own functioning	4.4	Development of perspective
	Attention paid to societal tension in regime media + attention paid to transition pathways	4.5	Development of perspective
	Conflicts between regime players	4.6	Change process
Regime adaptation	Changes in specific cultural, structural and practice-based aspects of regime	4.7a - 4.7x	Change process, Development of perspective
Pressure from transition pathways	# of top 10 experienced societal problems that the pathway contributes to	4.8	Development of perspective
	Mentioning of specific innovation pathways as threats, options or opportunities in regime media	4.9	Development of perspective
	Diffusion percentages of various options	4.10	Change process , Development of perspective

4.7 Combining these indicators for improved steering options

The monitoring approach is systemic and the sets of indicators are interrelated. Combining various indicators can produce better insights and the most relevant management information. Examples include the question whether individual projects contribute to lacking processes in the unfolding transition pathways, how you might approach the trade-off between focusing on a single transition pathway and stimulating diversity and whether transition pathways might stimulate on-going changes in the culture and structure of the energy regime.

5. Conclusion and discussion

In transition programmes it is essential to develop insights in the complex change processes that characterize radical innovation and transitions. Radical innovation and transitions both imply processes where systems change fundamentally and with them the rules of the game, technologies, actors etc. These processes require not only complexity-based concepts and indicators, but also imply that current perspectives and lines of action change in the process. When programme managers want to deploy monitoring to help them become more reflexive, monitoring is better of using insights of complexity-based monitoring and evaluation, instead of assuming a non-complex situation. This has implications for the indicators used, the way to interpret them and the relation to management.

The transition monitoring framework presented in this paper incorporates these insights. The framework has a focus on the interaction between the programme, its projects and the societal context it is embedded in and the interaction between providing perspective, change processes and sustainability performance. Most monitoring approaches require closing down the perspective or programme theory *before* monitoring is thought possible. In this line of thought monitoring depends on the formulation of SMART goals. But for transition programmes these perspectives are inherently fuzzy, in development and often somewhat unclear. Perspective development might be better treated as a result worth monitoring. In the right circumstances this delivers additional process benefits by stimulating reflection on the perspectives by stakeholders. The monitoring process is characterized by co-construction by expert developers and users, application of scientific knowledge and management knowledge and continuous refinement of indicators based on previous experience.

The question is of course whether this approach lives up to its expectations and whether it actually results in a distinctive type of monitoring in practice. For the former I'd like to refer to (Taanman, 2008), the latter has been illustrated in this paper with a thought experiment of what indicators might look like in the Dutch Energy Transition Programme (ETP). This experiment shows that it is fairly straightforward to order information in various levels and how combining insights from various levels provides additional and more management oriented information. The set of indicators as presented here is thought to be fairly atypical even though individually many indicators are well-known.

On the other hand, many indicators are very qualitative and sometimes vague, depend on fairly elaborate information infrastructures within the programme and working out these indicators

into readily observable measures will require a substantive amount of work. It is also difficult to arrive at a limited number of indicators given the number of interactions and dimensions that are of concern. Last of all, it might still be difficult to base non-trivial steering suggestions on these indicators. Such trivial indicators are the inverse of a low performance on a certain indicator. Like the steering suggestion "do something on the problem perception within the sector" if the indicator shows that there is a lack of problem perception in the sector. In the writer's experience this is hardly perceived to be practical advice by programme managers. Part of this lies in the nature of transition management: it is not a routine, run-off-the-mill type of management process[4] where a set of if…, then … rules can be thought up that suffices. Steering will always depend on particular circumstances. Framed differently this is exactly one of the reasons why this approach to monitoring is interesting: it is poised right at the edge between practice and theory. A difficult yet exciting place to work.

Acknowledgements

The transition monitoring framework is developed with and by Henk Diepenmaat, Jan Rotmans and Rob Weterings. Many of the ideas presented here are part of the way of thinking and discussions within the Dutch Research Institute for Transitions (Drift) at the Erasmus Universiteit in Rotterdam. This research has been financed by the Knowledge network for System Innovations (KSI). Furthermore I would like to thank Eefje Cuppen for her valuable comments on an earlier version of this paper.

[4] One might even argue that the knowledge for action is even fundamentally of a different nature than more scientific indicator-based knowledge. See the discussion on Aristotles distinction between sofos and phronesis in for example Loeber, A. M. C. (2003). Practical wisdom in the risk society : methods and practice of interpretive analysis on questions of sustainable development. S.l., s.n.

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