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Experiences with Socrobust at ECN

Micro combined heat and power generators and fuel cell vehicles

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Abstract

The Socrobust methodology has been designed in the European Socrobust project to assess the potential for socio economic success of a particular set of projects defined as radical or architectural innovations involving technological discontinuities and breakthrough products or services. This type of innovation can in general not be managed as continuous 'conventional' innovations. In evaluation literature e.g. (Cooper, 2000) three core principles for the management of architectural innovations are highlighted. These core principles are the need for anticipating the future world, the need for consistency with the present situation as so to define a development path and the requirement of dynamic adaptation. From these core principles Socrobust has been derived. This study reports the experiences with the application of Socrobust to two possible breakthrough innovations of the ECN unit Clean Fossil Fuels: micro combined heat and power generators (micro-CHPs) and fuel cell vehicles.

The following aspects of the development of the micro combined heat and power generator and fuel cell vehicles R&D programmes have been assessed by means of the Socrobust methodology:

- The developments in and around the R&D programme in the past and in the present situation.
- The position of the critical actors for the present situation.
- The image of the future world on which technology development is based: what does the world look like when technology to be developed has been implemented on a large scale?
- The key changes that are needed to bring about this desired future world.
- The position of the R&D programme related to the position of possible alternatives.
- Actions that can be undertaken to strengthen the position of the R&D programme.
- Possible niches that could lead to the breakthrough of the innovation.

The project had a double objective. The first objective was to assess the technology development in order to increase the chance of success of micro-CHPs and fuel cell vehicles while the second objective was to improve and adapt the Socrobust methodology to the needs of the ECN unit Policy Studies. This unit wants to use Socrobust as a tool to effectively assess and to improve the chance for technological breakthrough of radical innovations.

Both technologies have undergone the Socrobust process twice. The outcomes of the first round have been evaluated and the Socrobust methodology has been slightly adapted for the second Socrobust round. The second round has been introduced to improve and adapt the Socrobust methodology. The methodology applied in the two Socrobust rounds and, to some extent, merely with the aim to improve the methodology, the outcomes of these rounds are described in this report. The detailed outcomes of the methodology are described in two separate internal ECN reports. The study ends with conclusions and learning points concerning the double application of Socrobust to both R&D programmes.

CONTENTS

SUMMARY

The Dutch Ministry of Environment and Spatial Planning stressed the need for a transition towards a sustainable energy supply system in the fourth National Environmental Policy Plan (NMP4). A transition is a gradual and lengthy process (25-50 years) of change in which a system changes fundamentally. The change concerns changes in various areas: technological and institutional changes, changes in behaviour, culture and intentions. The overall change encompasses changes in socio cultural, techno economical and environmental aspects.

Transitions often co-evolve with the breakthrough of several radical or architectural innovations. These innovations challenge existing technological conventions, regulatory frameworks, and established relations between consumers and producers. The Socrobust methodology[1] is used to assess the potential societal robustness of the development of two possible radical innovations at ECN in this project: micro combined heat and power generators (micro-CHPs) and fuel cell vehicles.

The Socrobust methodology was designed in the European Socrobust project as a management framework to deal with the potential for socio-economic embedding of a set of projects defined as radical or architectural innovations involving technological discontinuities and breakthrough products and/or services. Socrobust can be used to increase the chances for 'success' (the chances of a technological breakthrough) of radical innovations by rendering visible the developments that have to take place before the innovation can be embedded in society (Laredo et al., 2002).

The objectives pursued in the project were twofold. The first objective was to assess the technology development within the unit Clean Fossils in order to increase the chance of success of two of their R&D programmes. The second objective was to improve and adapt the Socrobust methodology to the needs of the ECN unit Policy Studies. In order to reach the second objective Socrobust was applied twice to both R&D programmes.

The following aspects of the development of the micro-CHP and fuel cell vehicles R&D programme have been assessed twice by means of the Socrobust methodology:

- The developments in and around the programme in the past and in the present situation.
- The position of the critical actors in the present situation.
- The image of the future world on which technology development is based: what does the world look like when technology to be developed is implemented on a large scale?
- The key changes that are needed to bring about this desired future world.
- The position of the R&D programme related to the position of possible alternatives.
- Actions that can be undertaken to strengthen the position of the R&D programme.
- Possible niches that could lead to the breakthrough of the innovation.[2]

The outcomes of the Socrobust process were evaluated after the first Socrobust round. The application of the Socrobust method to both R&D programmes led to different kinds of outcomes. The present and future image of the micro-CHP R&D programme after the first round were broad, many actors and functions were involved in both situations, while the present and future image of the fuel cell vehicles R&D programme were much more technically orientated.

[1] Socrobust: Management tools and a management framework for assessing the potential long-term science and technology options to become embedded in society. The project was financed within the TSER Programme of the European Commission. The outcomes are described in Laredo et al. (2002).

[2] This aspect has only been assessed once during the first Socrobust round.

These differences and the time period between the two Socrobust rounds led to a different approach for the two second Socrobust rounds. The methodology was slightly altered in both cases but the focus of the two rounds differed. The second round of the micro-CHP R&D programme was focussed on the differences that 'spontaneously' occur after a certain time period. The purpose of this was to assess after how much time the application of Socrobust should best be repeated. The second fuel cell vehicles round focused on broadening the outcomes of the various Socrobust tools.

The following important learning points could be discerned from the outcomes of the two Socrobust rounds.

- The differences between the two R&D programmes heavily influence the outcomes of the Socrobust methodology. We believe that the following differences caused different outcomes of the two times two Socrobust rounds: The fuel cell vehicles programme and the micro-CHP programme differ in the kind of activities that are performed at ECN within the development of the two technologies. The activities of the fuel cell vehicles programme are orientated towards research and development while some activities related to micro-CHPs are closer to market diffusion. Furthermore the relative importance of the programmes in the technology development differ. The fuel cell vehicles R&D programme is relatively a small actor in the fuel cell vehicles network, this in contrast with the micro-CHP programme. We also believe that the differences between the flexibility in the technology development[3] and differences between the programme managers' attitude on the usefulness of evaluation tools led to some differences in the kind of outcomes between the two R&D programmes.
- The repeated application of Socrobust to the micro-CHP R&D programme after six months led to some small but interesting differences. No explicit conclusions on after how much time Socrobust could best be repeated could be drawn from this one example. We believe that the ideal time period between two Socrobust rounds is strongly technology or R&D programme dependent. Repetition of Socrobust after a few months may be useful for a R&D programme with rapidly changing internal and external circumstances. For R&D programmes which internal or external circumstances do not really change only a repetition after a few years may be of use. We like to mention a period of one year as an indication of a possible 'standard repetition' time.

Also some less important learning points about the application of the Socrobust tools could be discerned.

[3] The fuel cell vehicles R&D programme is still very flexible, while most choices are already made for the technology development within the micro CHP R&D programme.

1. INTRODUCTION

The Dutch Ministry of Environment and Spatial Planning stressed the need for a transition towards a sustainable energy supply system in the fourth National Environmental Policy Plan (NMP4). A transition is a gradual and lengthy process (25-50 years) of change in which a system changes fundamentally. The change concerns changes in various areas: technological and institutional changes, changes in behaviour, culture and intentions. The overall change encompasses changes in socio cultural, techno economical and environmental aspects. Further information about transitions can be found in Appendix A.

Transitions often coincide with the breakthrough of several radical or architectural innovations. These innovations are innovations which nature challenges existing technological conventions, regulatory frameworks, and established relations between consumers and producers[4] (Laredo et al., 2002). In this project the Socrobust methodology[5] is used to assess the societal robustness of the development of two possible radical innovations at ECN: micro combined heat and power generators (micro-CHPs) and fuel cell vehicles.

The Socrobust methodology was designed to assess the potential for socio economic success of a set of projects defined as radical or architectural innovations involving technological discontinuities and breakthrough products and/or services. Socrobust can be used to increase the chances for 'success' (the chances of a technological breakthrough) of radical innovations by rendering visible the developments that have to take place before the innovation can be embedded in society.

In the project 'Pathways to a clean fossil society' the Socrobust methodology has been applied to Micro-CHP and Fuel cell vehicles, two different R&D programmes within the ECN business unit Clean Fossil. The project had a double objective. The first objective is to assess the technology development in order to increase the chance of success of micro-CHPs and fuel cell vehicles while the second objective was to improve and adapt the Socrobust methodology to the needs of the ECN business unit Policy Studies. This unit wants to use Socrobust as a tool to improve and effectively assess the chance for technological breakthrough of radical innovations.

[4] Radical innovations are innovations which breakthrough from niche to regime level presupposes significant changes on regime level. A transition to a more sustainable energy system consists of the breakthrough of radical sustainable and energy saving innovations together with necessary changes on regime level.

[5] Socrobust: Management tools and a management framework for assessing the potential long-term science and technology options to become embedded in society. The project was financed within the TSER Programme of the European Commission. The outcomes are described in Laredo et al. (2002).

2. PROJECT METHODOLOGY

In the project 'Pathways to a clean fossil society' the Socrobust methodology was applied to Micro-CHP and Fuel cell vehicles, two different R&D programmes within the unit Clean Fossil.

The objectives pursued in the project were twofold. The first objective was to assess the technology development within the unit Clean Fossils in order to increase the chances of success of micro-CHPs and fuel cell vehicles. The second objective was to improve and adapt the Socrobust methodology to the needs of the ECN business unit Policy Studies. In order to reach the second objective Socrobust was applied twice to the two R&D programmes. After the first application the outcomes were evaluated and the methodology was (partly) adapted. After these adaptations the second 'round' of Socrobust was held and the outcomes were evaluated again. In this report the Socrobust process (how did we apply Socrobust and which adaptations did we make to the methodology), bottlenecks and other interesting points that occurred during the application of Socrobust to the R&D programmes are discussed. The outcomes of the actual application of Socrobust to the micro-CHP and fuel cell vehicles programmes are described in two separate ECN reports.[6]

The project methodology is sketched in **Error! Reference source not found.** below. The Socrobust methodology is applied to the two R&D programmes depicted by C1 and C2 in the figure. The outcomes, the methodology and the Socrobust process are evaluated after the first round. The outcomes of these informal evaluations are used to if necessary adapt the methodology for the second round. The (altered) Socrobust methodology is applied to the two R&D programmes once again. The outcomes of this second round are evaluated again.

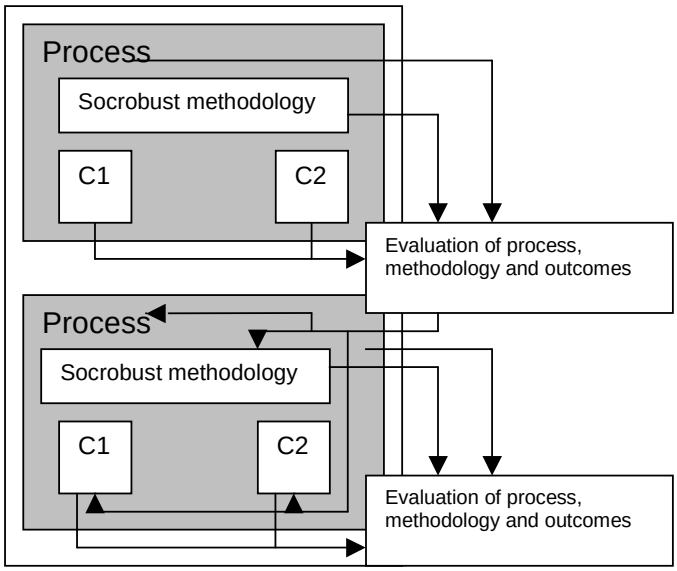

Figure 2.1 *Project methodology. With C1 and C2 the R&D programmes micro-CHP and fuel cell vehicles are depicted*

The Socrobust methodology as applied to both the micro-CHP as fuel cell vehicles R&D programme in the first Socrobust round is described in the sections below. Often descriptions by Laredo et al. (2002) are used for this description.

[6] Still to be published.

2.1 Socrobust methodology

The Socrobust methodology has been developed in the European Socrobust project. The aim of this project was to prepare and equip project managers or technology developers with a methodology, which would help them to assess the project's potential to become embedded in society. In evaluation studies e.g. (Cooper, 2000) that are quoted by Laredo et al. (2002) three core principles of a management framework to manage architectural innovations are highlighted. These core principles are (1) the need for anticipating the future world, (2) the need for consistency with the present situation as so to define a development path and (3) the requirement of dynamic adaptation.

From these core principles Socrobust was developed. The Socrobust process involves two distinct phases, one of 'description' and one of 'assessment'. The description phase consists of an exploration of the internal world of the R&D programme. Socrobust seeks to unfold and reveal the 'future world' already embedded in the project, and in the implicit assumptions about users, values, rules and infrastructure that it already embodies. Socrobust uses the concept of the 'future working world' (De Laat, 1996) to define the situation in which the innovation can be embedded in society. The concept of the future working world supposes that the necessities for an innovation to be embedded in society are already inscribed in the technology. The method uses the image of the future working world to identify the key changes needed to come from the present situation to the 'ideal' future working world.

The second phase within the process is to assess the character and nature of prevailing uncertainty. This means focusing on the next steps and trials that will help stabilise aspects as being both relevant and uncertain. Here reference is made to the external world. The external check aims to assess the feasibility of realising key changes necessary to the project's success and - as part of this - to identify elements, groups and projects which either share the same views (and thus enhance the robustness of the project) or on the contrary develop alternative views of the world. An analysis of the positioning of the project and its room for manoeuvre can be made after this check. Judgements are passed and decisions about the next round of actions can be made. The Socrobust methodology has been expanded by an extra step during the first Socrobust rounds. To strengthen the exploration of the possible pathways the technologies could follow on their road to implementation a workshop on possible niches is added.

Information was gathered during the project by means of various consulting interactions between the R&D programme manager or expert and two or three interviewers or consultants. The process consisted of three interviews, an Internet search and a small workshop. During the process the methodology, tools, outcomes and process were evaluated. We ('the interviewers') used these evaluations to adapt the Socrobust methodology for the second round.

The interviews

The interviews were conducted as follows: two or three 'consultants' interviewed the expert. One consultant conducted the interview and asked most of the questions. The second consultant took notes during the interview while the third observer had the role of observer. When there was no third interviewer present, the second interviewer took over the role of observer.

The Internet search

The Internet search was done by the second interviewer who also recorded the outcomes of the external check.

The workshop

The workshop was added to the original Socrobust methodology in the first Socrobust rounds. The workshop was held to gather information on possible pathways on how the technology could possibly break out from niche to regime level.

In the following section an overview of the Socrobust steps ('Which accumulation of steps forms the Socrobust method?'), a short description of the Socrobust tools ('How is gathered information portrayed?'), and an overview of the place of the Socrobust tools within the Socrobust steps and Socrobust process is given. For this description often descriptions by Laredo et al. (2002) are used.

2.2 Socrobust process

The two phases in the Socrobust process, the 'description' and the 'assessment' phase inform the design of five steps and twelve tools, see Figure 2.2 below. The grouping of the tools in the Figure is different from the grouping as used by Laredo et al. (2002). A fifth step and some tools that are missing in the Figure from Laredo et al. (2002) have been added. The objectives of the five Socrobust steps and matching tools are described below. For this description often descriptions by Laredo et al. (2002) are used. We here describe the *planned* use of the Socrobust tools. During the Socrobust process due to time and information constraints some adaptations were made. Some of the tools belong to two Socrobust steps. This is the case for the present and future network and the critical actors table. These tools are described with the first step they belong to, in this case the description step. A further description on how the tools have been completed during the first Socrobust round can be found in Chapter 3.

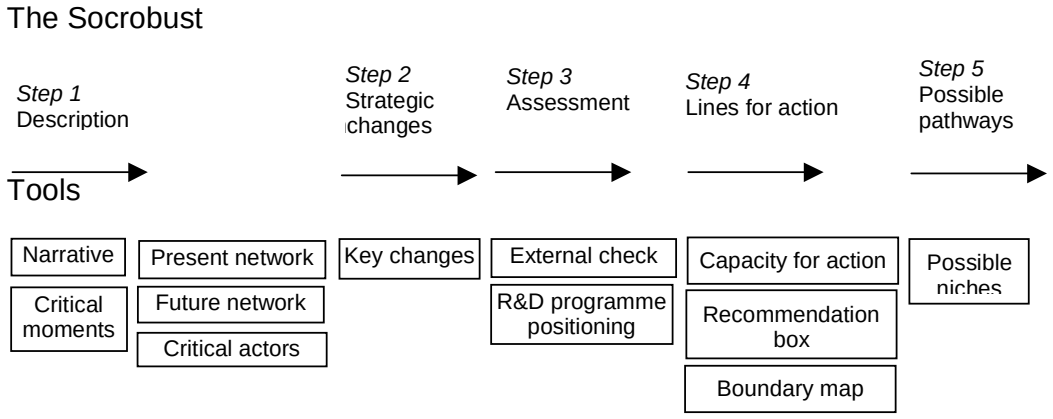

Figure 2.2 *The Socrobust process*

2.2.1 Description

No conventional figures and models can be used to assess the status and potential of an architectural technology: there is just too much uncertainty. When conventional calculations are not possible, technology developers have to describe their project in the hope that such a description will provide a sufficient basis for dialogue and exchange. The objective of such a description is to reach agreement on what the technology development is all about, who and what is (or should be) involved and which future the project is trying to build. In a good description (i.e. one fit for its purpose), technology developers should be able to offer a clear account of:

- the project rationale (main goal and origin, the global strategy),
- the project trajectory (main critical moments or turning points, and alternatives faced and choices made),

- the project's societal dimension (networks of actors mobilised, level of commitment, competing views and anti programmes (e.g. strategies of producers of competitive technologies)),
- the future world as it will look as the technology is implemented in society (embedded networks of actors routinely producing, improving and consuming the new product/service, necessary infrastructure).

The description step consists of two tools: the narrative and the critical moments table. The present and future network, and the critical actors table belong to both the description and the strategic changes step in the Socrobust methodology. These tools are also described below.

Narrative

The interviewers compile the narrative after the first interview. The R&D programme manager is asked to tell the story of the R&D programme: how did it all start, which actors have been involved, and which important choices were made?

The objective of this tool is to produce a narrative of the R&D programme. This narrative is used as a basic reference that ensures that both interviewers and managers and any other actor involved in the interaction are talking about the same thing.

The narrative as such is a short description of the past, the present and the anticipated future of the R&D programme. This first description might include references to:

- the origin of the research subject (within the organisation),
- the very idea and the needs it is addressing,
- the main lines of choices and the difficulties or uncertainties experienced,
- the artefact designed and it basic principles,
- the expected future of the research subject.

Critical moments table

The interviews compile the critical moments table after the first interview. While telling the story needed to write the narrative, the expert describes important moments within the course of the R&D programme. Hoe did these moments come about, which important decisions were made and what were the consequences of these moments for the R&D programme?

The interviewers compile a list of the R&D programme's key events and critical moments from which they consequently fill in a table form. In the second interview the table is briefly introduced and the list of events is discussed with the R&D programme manager for validation. The table is then developed together during the second interview. A revised version of the table is produced after the second interview.

The objective of this tool is to foster a strategic reading of the narrative. Project or R&D programme dynamics are conditioned by proactive or reactive choices of the team. Re-tracing the innovation journey to date makes it possible to identify the web of constraints that avenues the roads open to the R&D programme.

Each critical moment is characterised in the following terms:

- the date of the event,
- the description of the event,
- the source of the event,
- the implication of the event,
- the solution envisioned by the R&D programme,
- degree of irreversibility of the change,
- the nature of the alteration introduced in the R&D programme,
- stage reached by the R&D programme in the innovation journey.

Present network
The interviewers compile the present network after the first interview. The interviewers construct a TEN (techno economic network) map of the current relations of actors with the R&D programme from the R&D programme's story as described in the first interview. In such a map the positions of the R&D programme and other important actors are described in relation to four different poles: the regulation pool, the science pool, the industry pole and the user pole. In the second interview the concept of the TEN map is introduced to the R&D programme manager. The concept of actors, intermediates and networks is discussed and the R&D programme manager is asked to improve the network.

The objective of this tool is to provide the project manager with a visualisation of the innovation in terms of the heterogeneous web of linkages that construct and surround it. In representing the complete picture, the map provides its readers with an immediate overview of the key items and relations to be considered. Equipped with the TEN map the R&D programme manager will find himself/herself in a position to assess the current state of the societal situation regarding their innovation (Laredo et al., 2002).

The present network is a societal map. The map visualises the current societal situation of the R&D programme. The map used, called TEN, visualises the four poles described earlier.

Future network
The interviewers compile the future network after the first interview. In this interview the R&D programme manager is asked to describe an image of the future in which the technology is completely embedded in society.[7] How would the world look like? What would be the role of users, producers and the government? Which organisations and market structures will have to exist in such a future?

The future world, a picture of the world as it would look like if the technology would be completely embedded in society is represented in a societal map. This map is discussed with the R&D programme manager during the second interview.

The objective of this tool is to provide the R&D programme manager with a visualisation of the future of the technology as he or she pictures it. The TEN map of the future world elicits the ideal situation of the proposed innovation. Such an overview facilitates discussions about the bets, the scenario, the uncertain zones and the future because it highlights key but currently fragile elements on which the success of the technology depends. The future network can easily be compared with the present network as they are both depicted in the same format (Laredo et al., 2002).

The future network just like the present network is a societal map. The map describes the people and things at stake and the linkages between them in a situation in which the technology is completely embedded in society.

Critical actors table
The interviewers prepare a draft critical actors table after the first interview. The table is discussed with the R&D programme manager in the second interview.

The objective of this tool is to clarify the role of the actors involved with the R&D programme. Some of the involved actors are very important to the R&D programme while others are less important. By defining the actors in terms of importance and involvement discrepancies between an actor's involvement and importance can surface. Possible discrepancies can have significant effects on the chances of further involvement of these actors in the (near) future.

[7] Behind this tool the concept of the future working world can be seen (De Laat, 1996).

The critical actors table is complementary to and a product of the present network. It summarises further details about the key items represented in the TEN map. Actors are characterised in terms of their importance and involvement with R&D programme.[8]

Importance is characterised by:
- the actor's centrality within the network,
- the actor's representativity and centrality within the pole,
- the actor's substitutability.

Involvement is characterised by:
- the actor's motivation to join the development,
- the actors objective in contributing to the development,
- the actor's global strategy,
- an estimation of the actor's alignment,
- the irreversibility of the actor's commitment.

2.2.2 Strategic changes

The objective of the second step in the Socrobust process is to identify the key changes that are necessary to close the gap between the present state of affairs and the desired future world. To identify these key changes the technology developer needs to:
- Articulate the future world inscribed in their projects (as is done in the future network).
- Articulate the assumptions they are making about the evolution of the societal context (technology, regulation market) and how it might be in the future.
- Make clear what role they intend to play in this evolution and the assumptions they make about their own capacity to affect the world of their programmes.
- Backcast scenario's to identify the steps to be taken if the technology development is to move to a new stage.
- Reflect on the coherence of the desired future world and the assumptions they are making about the evolution of the world.

The strategic changes step consists of the key changes table, the present and future network and critical actors tables. These last three tools also form a part of the description step. For this reason these tools have already been described above.

Key changes table

The programme manager, supported by the interviewers, completes the key changes table during the second interview.

The objective of this tool is to focus attention on the few crucial assumptions which the R&D programme manager makes about the present situation and about the future. The tool connects the present and future network and articulates the changes that should occur in order to arrive from the present network to the future network

Each key change will be described in terms of the following characteristics:
- The name of the key change.
- How can the change be described?
- What has been taken for granted?
- What practises have disappeared?
- Which actors are most affected?

[8] This is a slightly adapted version of the critical actors table as described by Laredo et al. (2002). These adaptations were made before the first Socrobust rounds to improve the tool's clarity.

- What is the extent of the change?
- What is the rate/timing of it?
- What is necessary for the change to come about?
- Which related changes can be distinguished?
- What are the most appropriate points of entry, i.e. points to initiate the change?
- What opposition is expected?

2.2.3 Assessment

The objective of this step is to expose the convergence (or difference) between the technology developer's vision of the future and the visions of such a future circulating in the external world. Convergence is not a measure of a certain success, but it is an approximation of the effort which the technology developer (or others interested in such a breakthrough of the technology) will have to invest to bring about such a change and to build the necessary networks of relevant allies. Instead of scanning the world at large, in the assessment step the main assumptions underlying the project's vision of the future world are tested. The following questions should be answered in such an assessment: 'What are the main areas of uncertainty?', 'What are the main alternative views and controversies about these areas?', 'Where are those alternative views of the future expressed and debated?', 'How well established is the technology developer's position within these fora?', 'Who are the R&D programme's potential allies and who are potential opponents?' The answers of these questions give an indication of the societal robustness of the R&D programme. The number of potential allies and proponents, the nature of the main alternative views and the accessibility of the relevant fora give an indication of the position of the R&D programme in the external world. This position of the R&D programme in the external world can be used to indicate the R&D programme's influencing possibilities in the next Socrobust step.

The assessment step consists of the external check and the R&D programme positioning table.

External check

The external check, a search on the Internet in the original Socrobust methodology, is performed by one of the interviewers after the second interview. No direct involvement of the R&D programme manager is required. The results of the external check are discussed during the third interview.

The objective of the external check is to put the project's assumptions about the future world into perspective and to specify alternative views and ideas of the future world as shared by other actors. The assumptions behind the future network and the key changes table are checked during the external check. This way the external check provides material that programme managers can use to learn more about the actors involved in the connected projects and about a range of alternative strategies that they might adopt.

The assessment step involves standing back from the research and testing the societal robustness of its main assumptions. The external check is a web search. In this web search the main assumptions and bets on how the desired future could be reached are checked. Most of these assumptions and bets were formulated by the R&D programme manager while completing the key changes table. The web search transforms these bets and assumptions into a set of questions, which require clarification, and identifies the principal positions taken on these questions in the world beyond the R&D programme. The result of the external check is a description of the viewpoints of various relevant actors outside the project on the key changes and underlying assumptions.

R&D programme positioning table
The interviewers compile the R&D programme positioning table after the external check. The programme positioning table is discussed with the programme manager during the third interview.

The objective of the R&D programme positioning table is to give an overview of the programme's position in three important 'landscapes': (1) the technological landscape, (2) the legal, administrative and regulatory environment and (3) the landscape of demand, of users and of markets.

The positioning table formalises the insights required from the external check to produce a diagnosis of the robustness of the innovation. A radical innovation's robustness is defined in the quality of its anchorage in three public spaces mentioned above. In each of these three spaces, the quality of the embedment or anchorage of the innovation is evaluated to an analysis of four main criteria:

- the focus of the R&D programme,
- potential allies and existing alignments,
- potential opponents and existing alignments,
- main challenging alternatives/positions.

2.2.4 Lines for action

The identification of the technology's strengths and weaknesses, as can be derived from the assessment step, form a necessary basis for discussions on what can be done to improve the technology's chances of success. The discussion focuses on the strategic question of what can be done next either to adapt the innovation to the societal world in which it must exist, or to adapt the social world to the innovation. The fourth step helps technology developers to:

- identify desirable changes in order to increase the chances of success,
- recognise key actors and locations from which to trigger these changes,
- recognise what is within and without the scope of action,
- identify alternative modes of actions (entering the debate, constructing the forum, enrolling a key player in the controversy, changing the innovation specifications…).

The lines for action step consist of the capacity for action table, the recommendation box and the boundary map.

Capacity for action table
The interviewers compile the capacity for action table after the external check. The capacity for action table is discussed with the R&D programme manager in the third interview. The objective of the capacity for action table is to make a statement about the desired actions in each of the three main dimensions or landscapes in the positioning tables and to describe the project's team possibilities for effective action. The capacity for action table completes the programme positioning table by identifying plausible courses for action and practical options for improvement.

The capacity for action table allows for the identification of the R&D programme's weaknesses and the kind of actions needed. From this identification, the abilities of the R&D programme to implement relevant actions in the desired direction are recognised.

The capacity for action table provides an estimation of the possibilities of the R&D programme to lessen the uncertainties in the three landscapes. The uncertainties and threats for each landscape are treated in the tables. The fora of debate in which the uncertainties are articulated are given for each uncertainty, and possibilities for the R&D programme manager to influence the outcome of the debates are mentioned.

Recommendation box
The interviewers formulate the recommendations (for the recommendation box) before the third interview. In drafting the recommendations they take into account the information from all preceding steps. The interviewers discuss the recommendations with the programme manager during the third interview.

The objective of the recommendation box is to provide the programme manager with realistic actions that he or she can perform to influence the R&D programme's chances of success. The actions described in the recommendation box are fitted to the R&D programme's ambitions and possibilities.

Recommendations to improve the R&D programme's changes of success are given in the recommendation box. These recommendations are given by means of an action vocabulary: each action is introduced by means of a verb. An example hereof is the use of the verb 'monitor' for actions directed towards circumstances that are relevant but can't be changed by the R&D programme manager.

Boundary map
The interviewers compile the boundary map after the external check.

The objective of the boundary map is to give additional information to the R&D programme manager on his influencing possibilities now and in the near future. The R&D programme manager can increase his influencing possibilities: by involving actors the programme manager can widen his scope for actions.

The boundary map gives additional information on which actors could probably be influenced by the programme manager. In the boundary map a division is made between actors and circumstances on which can be acted upon today, actors that are likely to be involved in the future[9] and actors or circumstances which are relevant and recognised but which can't be changed.

2.2.5 Possible pathways

This last step has been added to the original Socrobust methodology as described by Laredo et al. (2002). Apart from formulating recommendations on how the innovation process can best be adapted to the developments in the external world, it is also useful to generate ideas on possible pathways on how the technology, when technically developed, could break out from niche to regime level. To generate these ideas a workshop on possible niches and niche trajectories is held. In such a workshop the following questions should be brought up:

- Which possible niche applications could exist for the innovation?
- What could be learned in these niches?
- Could the niches be arranged in such a way that they form a niche trajectory that could lead to the large-scale implementation of the innovation?
- What strategic actions could be derived from the possible existence of the various niches or niche trajectories?

Description of possible niches
'Description of possible niches and niche trajectories' are formulated by means of a workshop. For this workshop both people from Policy studies as well as people from Clean Fossil Fuels are invited.

[9] Or actors that can probably be influenced in the future.

The objective of the description of the possible niche and niche trajectories is to introduce the idea of niche management to the programme manager and give him an idea on possible niches, niche trajectories and actions he or she can take to stimulate niche formulation.

The tool 'the description of possible niches and niche trajectories' gives information on the outcome of the niche discussions during the workshop. The description consists of information on possible niches and niche trajectories, possible learning points that can occur during the niche trajectories and possible strategic actions to stimulate niche trajectories.

The tools described above are applied to both R&D programmes during the first Socrobust rounds in May/June and June/August 2002 respectively. The interviews were planned to be held during a two-week period. The time between the first and second interview was approximately three working days while the time between the second and third interview was approximately one week. Between the second and third interview the external check was planned. All activities, apart from the external check, were planned to last three hours. For the external check a time period of approximately two days was planned. The experiences with Socrobust during these first rounds are described in the following chapter.

3. SOCROBUST EXPERIENCES

The Socrobust methodology was first applied to the micro-CHP and fuel cell vehicle R&D programme in May/June and June/August 2002 respectively. This chapter discusses the bottlenecks that emerged during the first application of Socrobust and experiences with the methodology. After this first round of Socrobust the Socrobust methodology has been slightly altered. The resulting adaptations in methodology are discussed in Chapter 4.

3.1 Experiences with Socrobust process

3.1.1 Timing

The first Socrobust round consisted of three interviews and a small workshop. All activities were planned to last three hours. This estimation proved to be too optimistic. The tight planning gave rise to adaptations regarding the content of the interviews, shifting of the application of the Socrobust tools between the interviews and extra interviewing time.

The most important experience occurred during the application of the Socrobust method to micro-CHP. Instead of discussing all micro-CHP technologies within the micro-CHP programme (Stirling micro-CHPs, PEM and SOFC micro-CHPs) it was chosen only to discuss Stirling driven micro-CHPs. It was necessary to shift tools between interviews and to use extra interviewing time even with this adaptation.

The first interview could be held within three hours. The second interview however was far too fully planned for this. The interviewers completed several tools (the narrative, the critical moments table, the present and future network) before the interview. These tools had to be discussed in the second interview while also new tools (key changes, critical actors table) had to be completed during the interview. A second ‘second’ interview was necessary in the micro-CHP case. The external check was held after this double second interview. The Internet search necessary for the external check could be held within the planned two days. Due to the extra ‘second interview’ the interviewers had no time to complete the recommendation box after the external check. For this reason in this interview only the external check and the programme positioning table was discussed with the programme manager. The recommendation box and for fuel cell vehicles the capacity for action table had to be shown to the R&D programme manager during the workshop.

The interviews were planned to be held during a two-week period. The time between the first and second interview was approximately three working days while the time between the second and third interview was approximately one week. Between the second and third interview also the external check was planned. Due to the full interviewing program and the extra interviews the time period between the interviews was considered to be too short. The time period between the second and third interview was considerably longer in one case because the R&D programme manager planned his holidays between the two interviews. This unexpected delay caused many discussions and some time loss during the third interview.

In the workshop, in both cases, the Socrobust methodology, the outcomes of the Socrobust process and the brainstorm on possible niches was treated within three hours. In the evaluation of the workshop it became clear that although the program was very full adaptations were not possible. All planned activities proved to be necessary while lengthening of the workshop was not possible.

3.1.2 The division of labour between interviewers

Each series of interviews was done by the same interviewers. Each interviewer kept the same task in a series. When one series of interviews was finished the interviewers and the division of labour between them changed. One of the interviewers of the first series of interviews asked the questions in the second series of interviews. We thought this approach to be effective for knowledge dissemination, which indeed occurred. This approach has as side effect that the programme managers were confronted with relatively inexperienced interviewers, which may have been detrimental for the outcomes of the methodology.

3.1.3 Protective strategies

During an assessment like the Socrobust method, numerous factors influence the relationship between the evaluator, the participants and their superiors. The relationship between the participants and their superiors can become strained when the results are not what the latter had expected. This makes participants vulnerable (Guba and Lincoln, 1989). To strengthen his position, although wanting the assessment to be beneficial for all parties, the participants can have the urge to give a 'safe' picture of the project. Having already been evaluated in recent history, which turned out to have significant consequences for available budgets, one programme manager indeed seemed somewhat reluctant to share all the uncertainties and risks he had in mind.

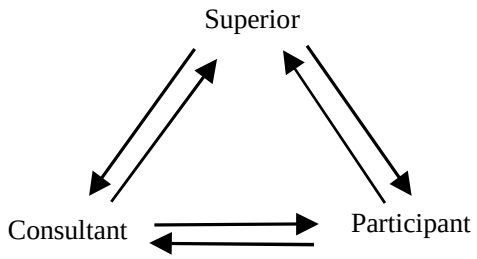

Figure 3.1 *Relationships between superiors, participants an consultants during an evaluation program*

3.1.4 Positive attitudes

This points to the importance of the mindset of the participants. The Socrobust method is designed to deal, at least partly, with the matter of protective strategies that participants may use. By drawing present and future networks, participants are forced to map out what strategies are necessary to make the links between present day work and future success. The programme positioning tables are designed to force the participants in thinking about (possible) opponents. This surely makes them more aware of their relative position and their strategies to improve it.

Yet in some cases some times the programme manager stayed close to his envisioned way to success. So the Socrobust method is not guaranteed to uncover all implicit uncertainties. Socrobust is a reflexive method, it is true that 'what comes in, comes out'. Having a positive attitude towards the Socrobust methodology from the start is crucial for carrying out a successful Socrobust.

3.1.5 The attitude of the programme manager about the relative size of the R&D programme and the stage of the technology development

The programme manager of the fuel cell vehicles programme had the strong preposition that he could rely on important actors in the technology's network. These actors have a far better view on user needs and demands than actors within the fuel cells R&D programme according to the programme manager. The reasoning behind this attitude was twofold. Actors within the fuel cell

programme were less influential than other actors within the technology's network while the technology was also still far away from market diffusion in the programme manager's opinion. This attitude could have been the cause of the quite 'narrow' outcomes of the Socrobust tools. The R&D programme manager deemed for instance user aspects as less important because he is convinced that he will hear about these aspects from other larger actors in the network.

3.1.6 The importance of mutual understanding

Building up a good relationship between the evaluators and the participants is very important. The first preparatory phase of the process should be used to do just this. In the first contacts, the foundations for future co-operation are build. If these foundations are strong, constructed by mutual respect, openness and clarity, the basic conditions for a good method are being met. This also refers to the importance of agreements about the confidentiality of the results. Due to lack of meetings, it seemed that these foundations were not as strong as they could be in the case of the fuel cell technology.

Building up a good relationship is not only necessary to take away as much risks on protective strategies. It is also needed to develop a common understanding about the Socrobust vocabulary. Of course, the tools of Socrobust are not unambiguous in their interpretations. For instance, the many different columns in the different tables all have a specific meaning. Another good example is the focus on one technology as described in the original Socrobust methodology. The programme manager judged this focus as too narrow, while the interviewers judged such as focus necessary in order to properly apply the methodology. These and some other small misunderstandings had to be solved during the application of Socrobust. It is crucial that the participants and the consultants share a common understanding of this meaning of the Socrobust tools and their objectives.

It is not obvious that this common understanding is there from the start. Both parties have different vocabularies. Above all, the consultants are the most used to the crucial elements of the theoretical underpinning of Socrobust, and the language in which they are expressed. Although it seemed that the parties had a good mutual understanding, it is not always clear to which extend there existed a common understanding of the meaning of all the terms used in the method. It is possible that from the interviewer's side, the change in interview teams did not benefit the clarity of their vocabulary.

3.2 Experiences with the Socrobust steps

Below we shortly describe the experiences we had with the Socrobust tools in the first Socrobust round. The outcomes and our experiences with the Socrobust tools and/or process are described below per Socrobust step. Examples of the tools that are mentioned in the following sections are given in Appendix B. Here excerpts of the outcomes of the Socrobust tools are given.

3.2.1 Experiences with the 'Description' step

During the first interview the R&D programme manager was asked tell the story of the technology development within the R&D programme. This narrative was the input of the narrative, the critical moments table and the present network. Information needed to complete the future network was also gained during the first interview. After relating the programme's present and past situation the programme managers were asked to look at the future: they were asked to describe a future world in which the technology is embedded in society. After the first interview the consultants made drafts of the present and future networks. The networks were discussed and adapted during the second interview. The critical actors table was completed by the R&D programme managers during the second interview.

Outcomes
Almost all tools within the description step lead to interesting outcomes. The cluster narrative and the critical moments tool show the importance of a choice the micro-CHP programme made about 8 years ago: a one kWh Stirling driven micro-CHP was to be developed for the Dutch or European market. The reasoning behind this firm and almost irreversible choice proved to be unclear during the interview. This choice however has important implications on possible implementation strategies for micro-CHPs. The cluster narrative and the critical moments table of the fuel cell vehicles programme showed a to and fro change within in the R&D programme.

The stage of technology development can be discerned from the present network of the two technologies. The present network of the micro-CHP programme is directed towards the demonstration and implementation of micro-CHPs. The present network around the fuel cell vehicle R&D programme is a network we think of as a research institute network. For the most part other research institutes and producers (future and present users of the technology) are involved in this network. The R&D programme has no links with user representatives and only limited links with actors from the regulation pole. When asked about this technological orientation the programme manager explained that the R&D programme was only a small actor compared with other actors in the fuel cell vehicle field. Other actors as energy companies and car manufactures have far more possibilities to influence future developments. According to the programme manager these actors also have a far better view on user needs and demands.

The future working world of the micro-CHP programme is focussed around ESCOs (energy service companies). These companies should lease the micro-CHPs to consumers. The user aspects of micro-CHP are characterised in the future network. The future working world of the fuel cell vehicles R&D programme is focussed around decentralised fuelling at home or at the working place. In this future image only a few small prepositions about the future user context were made. In both cases the programme managers were asked to make a distinct choice for one possible future for the technology for the future working world. In practice more future possibilities are open to the R&D programme. This will further be explained in the next section.

In both cases some small discrepancies between an actor's involvement and importance emerged from the critical actors table. No major conclusions could be drawn from the critical actors tables.

Experiences with tools/the Socrobust process during the description step
Drafting the narrative was very straightforward. The narrative is just a written down version the R&D programme managers' interpretation of the R&D programmes trajectory till the time of the interview. The idea behind the critical moments table was straightforward as well. In this table important moments within the R&D programmes trajectory had to be summarised and characterised. The actual completion of the critical moments table formed the basis of a discussion on how the critical moments table should be completed such that the changes could effectively be characterised.

The discussion focussed on the 'implication/choice', 'envisioned solution' and 'what changed' column in the table. The outcome of the discussion was that in the implication/choice column the direct implications of the described events had to be placed. The consequences for the R&D programme or the envisioned solution of the programme are described in the envisioned solution column. The originating change is described in the 'What change' column. For some events the change had to be split over two columns; the 'consultants' felt that only this way the occurring changes could be described correctly. An example of such a split is shown in Appendix B.

While filling in the critical moments table the interviewers deemed the 'stage reached column' as not very useful. More often than not the interviewers didn't complete this column.

The interviewers made draft versions of the present and future network before the second interview, which proved to be effective. The R&D programme managers were able to quickly adapt to the idea of present and future techno economic networks.

Both programme managers had to choose between several 'futures' while drafting the future image of their technologies. In especially the fuel cell vehicles programme manager's opinion the likeliness of the futures is strongly dependent on future technical developments. A technical breakthrough, like solving of the on-board Hydrogen storage problem, will change the odds for each technical option. Because so many options were open to the fuel cell vehicles programme manager, the interviewers decided to guide the choice of the programme manager and ask the manager to opt for a future image without on board reforming. This alternative seemed to lead to further reaching consequences than the fuel vehicles without on board reforming alternative. A discussion about the breadth of the future network emerged during the second interview in the fuel cell vehicles case. Mostly technical actors seemed to be involved in the technology's future network unlike in the micro-CHP case.

The interviewers have chosen to describe and characterise the *present* critical actors in the critical actors table. The interviewers also decided to use slightly different terms to characterise the importance and involvement of the various actors. In the slightly adapted critical actors table the actor's importance was characterised by the following terms: the actor's centrality within the network, the actor's representativity and centrality within the pole, the actor's substitutability. The actor's involvement was characterised by the actor's motivation to join the development, the actor's objective in contributing to the development, the actor's global strategy, an estimation of the actor's alignment (see below) and the irreversibility of the actor's commitment.

Even with these adaptations some of the terms used in the critical actors table were unclear to the consultants. The discussion focussed on an actor's alignment, and the completion of the 'centrality of the actor within the network' and the 'representativity and centrality within the pole' column. During the discussion the interviewers came up with a workable definition of an actor's alignment. According to use an actor's alignment is determined by the extent in which an actor *is* aligned ('in one line with') to the R&D programme and by the extent to which an actor *could be* aligned to the R&D programme. An interesting outcome was that discrepancies between the two aspects of an actor's alignment could exist.

The place of the actor within the network should be characterised in the 'centrality of an actor within the network' column. How central is a certain actor within the network? Does the actor form a node that connects certain other actors or does it seem to be a dead branch on the technology development tree? The outcome of 'representativity and centrality within the pole' discussion was that the positioning of an actor in relation to the four poles and its relative strength in the pole has to be characterised in the column.

3.2.2 Experiences with the 'Strategic changes' step

The strategic changes step consists of completing the key changes table.

Outcome

The outcomes from the key changes table were interesting. The programme manager from the micro-CHP programme supposed mostly non technical changes that had to be brought about before micro-CHPs could be embedded in society. Some of these changes were quite radical. A conclusion of the key changes table that some actor groups that are likely to support the development of micro-CHPs could also be opposed to this development.

The programme manager of the fuel cell vehicles R&D programme supposed that for the most part technical changes have to be brought about before fuel cell vehicles can be embedded in

society. Some of these changes were quite radical. The cluster manager states that not all changes that are described in the key changes table are vital for the technology's embedment in society.

Experiences with tools/the Socrobust process during the strategic changes step
The completion of the key changes table was relatively straightforward. Some discussion emerged about the completion of the 'what is the rate of change/timing of it' column. In this column both the necessary rate of change to bring about the desired future was well as the expected rate of change should be filled in.

3.2.3 Experiences with the 'Assessment' step

The assessment step involves standing back from the R&D programme and testing the societal robustness of its main assumptions. This requires two sub steps: the external check, in which information is gathered about the state of the art and knowledge relating to each key change identified, and the positioning table which assesses the programme's robustness in respect to each key change.

Outcome
In the external check both direct and underlying prepositions of the R&D programme managers have been checked on the Internet. The external check for the micro-CHP R&D programme was focussed on the technology's future working world. Most of the programme manager's prepositions could be affirmed by means of the external check.

The strongest preposition of the R&D programme manager of the fuel cell vehicles R&D programme was that the R&D programme could rely on other strong and important actors like car manufactures and energy companies. According to the programme manager these actors have a far better view on user needs and demands than the R&D programme. The interviewers deemed that this preposition couldn't be efficiently checked and choose to focus on the underlying prepositions. The outcome of the external check of these underlying prepositions was a bit ambiguous. The remainder of the external check for the fuel cell vehicles R&D programme was focussed on the technology's future working world. The external check didn't affirm all the prepositions but it must be remarked that these affirmations doesn't have to be essential for the R&D programme's success due to the programme's flexibility.

The R&D programme positioning table summarises the evaluation of the R&D programme's societal robustness along three dimensions of the future market. The table describes the state of the R&D programme in terms of two criteria: (a) prevailing uncertainty and the (b) the relative strength of the programme's position (compared to alternatives). The micro-CHP position table showed that within organisations that are aligned with the R&D programme some opposition against micro-CHPs could be found. The conclusion of the fuel cell vehicles programme positioning table was that the future positions of all alternatives within the tables were uncertain: everything can happen. Some actors could support as well as oppose the development of fuel cell vehicles or the necessary infrastructure, while with some actors synergy might exist. The R&D programme manager felt that these uncertainties pose no threat to the technology development, as the R&D programme is still very flexible.

Experience with the tools/Socrobust process during the assessment step
The interviewers have had some difficulties while performing the external check. One important aspect of the external check is that one has to choose which assumptions should be checked. In some cases this choice was a hard one. The external check should be concentrated on the R&D programme's specific areas of uncertainty according to Laredo et al. (2002). This was only partly possible for the fuel cell vehicle R&D programme; according to the programme manager all technical and thus also all societal options are still open to the R&D programme. Another

problem was that some prepositions could not be effectively checked on the Internet. An example hereof was the preposition the R&D programme could trust other actors to provide them with important user information. The interviewers have checked underlying prepositions in this case.

The first remark that can be made about the R&D programme positioning tables is that these tables urged the interviewers to make choices. The interviewers could only describe certain aspects of the positioning of the R&D programme in the three landscapes. Only the more important outcomes from the external check could be placed in one of the three positioning tables. This may not be completely clear to the programme managers. The second remark concerns the Socrobust assessment part of the tables, it is possible that a reader will only read the Socrobust assessment, it is therefore important to give a deliberate assessment about the R&D programme's position in this assessment part.

3.2.4 Experiences with the 'Lines for action' step

The external check and the R&D programme positioning tables form the input of the lines for action step of the Socrobust methodology. The lines for action step consists of the capacity for action table, the recommendation box and the boundary map. The last two tools are complementary.

Outcome

The outcome of the capacity for action table is a list of possible threats and uncertainties, a list of fora in which the uncertainties are debated and the actions the R&D programme manager can take to influence the outcome of the debates. The programme managers' room for action was limited as could be expected. The interviewers deemed that by involving and influencing actors the programme manager could have some influence on the outcomes of the debates. Due to time constraints the capacity for action table was not completed for the micro-CHP programme.

The recommendations for the micro-CHP programme have been focussed on the technology's future image and on the embedment of the technology. The recommendations for the fuel cell vehicles R&D programme have been focussed on the similarities and differences between the possible future images of the fuel cell vehicles R&D programmes.

A boundary maps accompanied the recommendation box. The boundary map gives additional information to the R&D programme manager on his influencing possibilities now and in the future. The outcomes of the boundary maps of both R&D programmes weren't shocking.

Experience with the tools/Socrobust process during the lines for action step

The capacity for action table was only filled in for the fuel cell vehicles R&D programme. The interviewers felt a bit ambiguous about the usefulness of the capacity for action table. On the one side the table was very useful for the preparation of the recommendation box, on the other side the interviewers felt that their influence on the actual completion of the table was too large. While the uncertainties that were treated in the capacity for action table followed from the external check and the R&D programme positioning tables, the fora of debate and the room for action were completely open for the interviewers' interpretation.

The interviewers used an action vocabulary to formulate the recommendations for the recommendation box. The action vocabulary consisted of various verbs such as to monitor (developments that can't be influenced), reflect upon (the routes not taken), to think about, to explore, to build (a forum), to prepare, to contribute to, to discuss, and to enrol (other actors). The interviewers deemed this action vocabulary as very useful in preparing the recommendations. The verbs structured the discussion.

The original Socrobust methodology describes that the recommendations should mainly be focussed on the R&D programme's future working world. This was only possible for the micro-CHP case. The interviewers had to draft more general recommendations for the fuel cell vehicles R&D programme because for this R&D programme too many technical possibilities were still open. A less positive point of the recommendation box was that due to the way the box was compiled the programme managers had no influence on the content of the recommendations. In one case this caused the programme manager to be suspicious of the recommendations, he would have liked to have more influence of the realisation and the content of the recommendations.

All recommendations were given at once to the micro-CHP programme manager independent of when the recommendations could best be implemented. For the fuel cell vehicles programme the interviewers choose to discriminate between possible long-term and short-term actions. This distinction seemed to work well.

The interviewers considered the boundary map as a very useful instrument although the outcomes of the map weren't shocking. The boundary map consists of a series of nested boxes of frames. The smallest frame indicated the actors that could be acted upon today while the middle frame indicated the actor that might be influenced in the near future. The largest (outer) frame indicated the circumstances and actors that probably can't be influenced now or in the near future. The map explains by its form that the boundaries between the boxes can be shifted; by involving actors the programme manager can widen his scope for actions.

The interviewers have chosen to use the boundary map in the lines for action step. Another choice would be to use the boundary map in the description of the present situation. The interviewers recommend from their experiences that the boundary map should be used in the lines of action step in any case. Apart from this the map could also be used to describe the position of actors in the present situation.

3.2.5 Experiences with the 'Possible pathways' step

The possible pathways step is new to the methodology and consisted of a workshop. Both people from Policy studies as well as people from Clean Fossil Fuels were invited for this workshop. The interviewers used the outcomes of the Socrobust methodology and some information about niche trajectories to generate a discussion on possible niches, niche trajectories and strategic actions the programme managers could take to stimulate niche formulation.

Outcome

The niche discussion led to completely different conclusions in both cases. The participants of the fuel cell vehicles workshop came up with numerous niches and some niche trajectories while in the micro-CHP case only a few possible niches emerged. The participants of the fuel fell vehicles workshop came up with functional (modes of transport) geographical, as well as functional geographical niches (harbours). The participants also described possible niche trajectories and learning points during the trajectories. The workshop ended with a discussion about the strategic implications of strategic niche management and the existence of the possible niches and trajectories. The danger of lock in was often mentioned during the discussion, especially in relation to the choice for a storage medium for the necessary Hydrogen. An important outcome of the discussion was that the Hydrogen infrastructure most probably would emerge independent of the efforts of the fuel cell vehicle R&D programme. It should be noted that the niches mentioned by the fuel cell vehicle workshop people by itself did not emerge form the Socrobust procedure. The people involved were already aware of potential niches and of the importance of niches.

Experience with the tools/Socrobust process during the possible pathways step
The idea of a possible pathways workshop lead to an interesting discussion among the interviewers about the name of the workshop. The workshop was described as a workshop about possible transition paths in the project plan. Transition paths are however much more all embracing than the breakthrough of one or more technologies. For this reason it was chosen to alter the name of the workshop in breakthrough pathways.

The workshops had a double objective, the distribution of knowledge about the outcomes of the Socrobust methodology and the introduction of the idea of niche management. The workshops lasted three to four hours which meant that the workshops fully planned. Both workshops consisted of the following steps:

- an explanation of the Socrobust methodology,
- the outcomes of the methodology (the present network, future network, recommendations, etceteras) in the respective cases,
- a discussion about the recommendations,
- a presentation about possible breakthrough mechanisms such as niche accumulation,
- a short repetition of the important outcomes of the methodology,
- and a brainstorm about possible niches, niche trajectories and their strategic implications.

The last step was planned to last about half of the workshop time. The workshop program was discussed after the micro-CHP workshop. The conclusion of the discussion was that although the workshop was fully planned all steps of the workshop were necessary to reach the two objectives. The only option to decrease the time pressure during the workshop was not possible in the next fuel cell vehicles workshop: the workshop couldn't be lengthened.

4. ADAPTATIONS FOR THE SECOND ROUND AND EXPERIENCES WITH THE ADAPTED METHODOLOGY

The application of the Socrobust method to the micro-CHP R&D programme and the fuel cell vehicles R&D programme resulted in different kinds of outcomes: different bottlenecks emerged for both technologies. These differences and the bottlenecks are discussed in Section 4.1 below. These differences and bottlenecks led to various alterations in the Socrobust methodology. The alterations in the Socrobust process and tools are discussed in Section 4.2 and 4.3 below. The chapter ends with an evaluation of which alterations concerning the content of outcomes spontaneously occurred between the two Socrobust rounds.

4.1 Discussion of emerging bottlenecks and resulting adaptations

An almost similar application of the Socrobust methodology to the two R&D programmes resulted in different kind of outcomes. The image depicted by the micro-CHP programme leader is more concise and as a logical consequence, more complete. This can be seen, among other things, when looking at the various kinds of actors who have been represented in the future situation. The CHP programme manager describes the technological product and its market. The described situation is one in which micro-CHPs are leased to consumers. The present and future image of the fuel cell vehicles R&D programme is more technologically orientated, especially in the present network where, indeed, not all poles are (yet) developed. The interviewers believe that they can explain the differences in the kind of outcomes by:

- The difference in flexibility between the two technology developments. The fuel cell vehicles R&D programme is still very flexible and will adapt most of the possible future options, while most choices are already made for the technology development within the micro-CHP R&D programme.
- The different kind of activities of the two technology R&D programmes. The activities in the fuel cell vehicles R&D programme are still more focused on research and development while activities in the micro-CHP R&D programme are more related to market demonstration and the formation of consortium etcetera.
- And possibly by differences between the (personality of the) two programme managers. Note that they did not differ in their active participation and their contribution.

The second round of Socrobust has been introduced to improve and adapt the Socrobust methodology to the needs of the ECN business unit Policy Studies. One of the questions the unit wants to be answered is in how much time the application of Socrobust to a particular technology should be repeated, if it should at all. Considering the given differences between outcomes and the time period between the two rounds for the two cases (one month in the fuel cell vehicles case versus six months in the micro-CHP case), the interviewers felt that the approach for both cases should differ. The obtained results for both cases also differ much as to their completeness and their consistence. The interviewers merely wanted to repeat the Socrobust process in the micro-CHP case while they wanted to focus on the (supposed missing) breadth of the networks and consistence of the assumptions ‘behind the future world’ in the fuel cell vehicles case. The additional time given in the second round would allow for this.

The interviewers adapted the methodology of the second round in order to broaden the outcomes of the fuel cell vehicles case. As the adaptations seemed to be useful, some of these modifications were repeated in the micro-CHP case.

The following important alterations were made during the second Socrobust rounds:

- It was tried to discuss the irreversibilities arising from the fuel cell programme's critical moments table. It is possible that such a discussion may cause the programme manager to think differently about the programme's flexibility. Some irreversible choices might have been made during the R&D programme's history. The discussion could sharpen the discussion about the R&D programme's key changes table and external check.
- The present and future network and the key changes were stronger linked together. It is possible that by this approach the breadth of the networks and the resulting key changes could be broadened. Also a smoother transition between the four poles used for the networks and the three landscapes used for the cluster positioning tables after the external check can taken care of by the combining of these tools.
- The external check was broadened by means of interviews. Not all issues could be checked by means of a web search during the first Socrobust rounds. The interviewers of the second Socrobust round tried to check these and other issues by using interviews next to searching the Internet.
- The R&D programme positioning tables were changed. The interviewers made it clearer that only certain aspects of the R&D programme's position in the three landscapes could be checked and deleted the Socrobust assessment part of the tables. This to avoid hasty conclusions from readers who decide to speed-read the tables.
- The interviewers planned to discuss the lack of possible niches in the micro-CHP case during the second Socrobust round.

Apart from these changes some other minor alterations were put through in order to sharpen the outcome of other Socrobust tools. The alterations in the Socrobust process, tools and outcomes are discussed in the following sections.

4.2 Alternations in the Socrobust process

The second round consisted of two interviews instead of three interviews and a workshop. In the interviewers' initial opinion, this time period would have been sufficient for merely repeating the first Socrobust rounds. The interviewers however decided to change some of the Socrobust tools to ascertain more consistency during the second Socrobust round, which to some extent meant that more time was required. The interviewers would have needed three times two hours instead of twice two hours. The practice has been two times three hours, and an additional third interview of almost two hours for the fuel cell vehicles case.

The persons who conducted the first series of interviews (the first round) didn't conduct the second series of interviews but one person. This interviewer had the role of observer during the first series of the fuel cell vehicles interviews. The main thing to notice about this interviewer is that he knew more of the technological issues than any of the other interviewers, while he also felt comfortable with the Socrobust methodology. This conscious choice (the continuation of the sequence as used in the first Socrobust rounds) led on the one side to some waste of time (the programme manager had to explain some issues again) while on the other side the new interviewer generated new input while asking about the same issues in another way. This way, more people from Policy Studies could gain some experience with the Socrobust methodology and the continuity within the project was still guaranteed.

4.3 Alternations in the Socrobust tools

4.3.1 Narrative

The interviewers of the second round chose not to repeat the narratives of the two R&D programmes due to time constraints, and to the fact that the outcomes were clear enough. The circumstances around and within the fuel cell vehicles R&D programme didn't alter much in the six weeks between the two Socrobust rounds. On the contrary, the changes that occurred in the six months between the two micro-CHP Socrobust rounds have been for some aspects rather important, and were described by means of the critical moments table, the next Socrobust tool.

4.3.2 The critical moments table

The way the critical moments table was completed didn't change during the second series of interviews. New critical moments reflecting the recent changes in and around the R&D programme were added to the micro-CHP critical moments table. This resulted in an extension of the critical moments table by a full page. The altered circumstances that gave rise to the extended critical moments table also caused alterations/additions in the outcomes of the other Socrobust tools. The interviewers tried to shorten the critical moments table for the fuel cell vehicles R&D programme and to better discuss the R&D programme's irreversibilities and choices that were reflected in the critical moments table. The interviewers shortened the critical moments table in the fuel cell vehicles case from three to two full pages. This way, important choices were better reflected in the critical moments table. The objective to better discuss the irreversibilities that occurred within the R&D programme's development has not be fully reached as, to the programme manager's opinion, all technological roads and future societal choices were still open to the R&D programme.

4.3.3 The present network, the future network and the key changes table

The interviewers explicitly explained the programme manager how the future network is actually combined with the future network and how the key changes table is a direct result of their 'confrontation'. The interviewers introduced a time path and hierarchy in the events that should occur to bring about the desired future working world. Obviously, not all assumptions were as important and not all events that were assumed needed to occur at once for the R&D programme to go further in the direction of the future network.

The interviewers used the following methodology for the fuel cell vehicles case:

- The programme manager was asked to sketch the present network of the transportation sector. This network should be focussed on all functions that conventional cars fulfil in the present network. This way the programme manager became more conscious about the various functions that conventional cars fulfil in the present situation.
- The interviewers asked the programme manager to sketch the future network based on the functions depicted in the present functional network for the original end year of the technology development.[10]
- The interviewers were planning to ask the programme manager to depict (in an additional picture) the future network in a year between now and the original end year of the technology development. This year will be called the 'year in between' in this report.

[10] The same year as the programme managers used while sketching the future network during the first series of interviews (2030 in the fuel cell vehicles case).

- The interviewers, in co-operation with the programme manager, then formulated a list of events or changes that should come about before the situation desired for the end year and the year in between could be reached. The list merely focused on the technological option central in both networks. This way, the assumptions were placed in time perspective and relevant assumptions were separated from less relevant assumptions.
- The interviewers wrote down the long list of assumptions and grouped the assumptions according to the three landscapes later to be used in the programme positioning tables. This, because of the expected difficulties to switch from the four Socrobust poles to the three Socrobust landscapes.
- The interviewers validated the assumptions list with the programme manager to ascertain that the list corresponded with his view.
- The list of assumptions formed the basis of the external check, the programme positioning tables and the capacity for action tables.

The new methodology altered the outcomes of the present and future networks and the list of key changes or assumptions of the fuel cell vehicles R&D programme. The present network of the fuel cell vehicles R&D programme did not alter much in the second round. The future network did alter from the network sketched in the first round. The interviewers asked the programme manager to sketch the future network and underlying assumptions in 2030 and 2015. The future network has been sketched only for the situation in 2030 due to time constraints, the assumptions have been formulated for both situations. The underlying assumptions differed for both situations. The resulting list of key changes was more extensive than the original key changes table and they were leading to two consistent future worlds. As the 'year in between future world' is halfway between the present situation and the end year future world, this tends to reinforce the consistency of both worlds.

For the micro-CHP programme a similar approach was followed. The present network and future network of the micro-CHP R&D programme did not alter much. This is important to note because, obviously the many additional critical moments could have led to changes in the present network and in the R&D programme manager's view of the future network. The interviewer, in co-operation with the programme manager, completed two instead of one future network. The desired situation in 2012 was sketched in the first new future network, while in the second network the situation in 2025 was depicted. The assumptions between the two future networks seemed to be different, while the programme manager also stressed different roles of different actors in the two situations. The step in 2012 should be seen as a good preparation for the step in 2025. This reinforces the consistency of the future world. The programme manager in co-operation with the interviewers formulated (following the three landscapes) three lists of assumptions that had to be brought about before the situation 2012 and 2025 could exist.

The interviewers of the second round found that most of the worked out well. They thought that the methodology ascertains a more fluent transition between the R&D programme networks, the external check and the R&D programme positioning tables. The extra steps caused the programme managers to be conscious of the difference between the four poles in the future and present network and the four landscapes in the R&D programme positioning tables. This greatens in turn their participation during the subsequent steps. In the process, much attention was given to the formation of concise and coherent future-working worlds. An argument to work with two future worlds accompanied with several dates is that it eases the task of giving concise information on the future world. Often, managers do already have an idea about a path toward their final future-working world. It is important to note that some discussion occurred when one of the programme managers was asked to select one concise technological option. To 'draw' one or more options about how the future world would or should look like, is quite a big step for a R&D programme manager who daily copes with the full basket of options. Additional prudence is required when only one option has to be chosen. One ought not to work further and further with one selected technological option, and forget that there are assuredly also other future working worlds.

4.3.4 Critical actors

The critical actors tables were checked during the second Socrobust rounds. Some minor alterations were made. As the present networks did not change a lot during the second rounds, the absence of changes in the critical actor table is not surprising.

4.3.5 External check

The methodology of the external check was changed after the first Socrobust round. The interviewers checked the assumptions by means of interviews with actors in the field instead of by an Internet search. Two external actors that both the interviewers as the programme managers deemed as relevant actors were interviewed for both R&D programmes. The external check was more focussed on the specific assumptions behind the R&D programmes' future networks than the external checks in the first Socrobust rounds. The outcomes of the external check have been convincing. Some of the assumptions were confirmed by means of the interviews, while some were not. Both the interviewers and the managers seem to have learned from these insights. The way these insights have been embedded in the Socrobust methodology makes them more interesting. It generates the possibility to use them in the subsequent steps, and it gives new possibilities to sharpen the view of the managers (or just to better understand this view).

The use of interviews also had a disadvantage. An external check by means of interviews meant that the opinion of fewer actors could be placed into perspective. The interviewers therefore recommend that the external check should consist of a web search as well as one or two interviews (per case).

4.3.6 R&D programme positioning table

The structure and the content of the R&D programme positioning tables of the fuel cell vehicles were altered. The interviewers of the second series of interviews initially felt that the structure of the original R&D programme positioning tables was unclear. By altering the structure of the table, the problem with the Socrobust assessment part of the table could be overcome. The interviewers of the first series of interviews felt that the possibility that a reader would only read the Socrobust assessment part of the table, could lead to misunderstandings.

The interviewers used the following methodology for completing the R&D programme positioning tables: the new R&D programme positioning table consisted of four columns and a certain number of rows. The rows indicated the alternatives for the fuel cell vehicles. The name of the alternative and a short description of the alternative are given in the first two columns of the table. The third column indicates the circumstances in which the future alternative will probably exist ('the key assumptions' in the table). The fourth and last column indicates which actors will probably be in favour of the development, e.g. which actors will be in favour of the development of fuel cell vehicles.

The interviewers emphasised the choices they made while completing the R&D programme positioning tables. They explicitly said to the programme manager that they would concentrate on certain developments instead of concentrating on all developments within the three landscapes.

Only some minor adaptations were made to the R&D programme positioning tables in the micro-CHP case. The programme manager could still identify these positions after six months.

4.3.7 Capacity for action table

The capacity for action table for the fuel cell vehicles R&D programme wasn't altered during the second round due to time constraints. In fact, the old table did correspond with the outcomes of the first Socrobust round, which, with the vision of hindsight, were quite different from the outcomes of the second round. If the interviewers would have liked to, if they had the time, adapt the outcome of the capacity for action table to the altered external check and R&D programme positioning tables. This was however not possible.

The interviewers in the second round decided to complete the capacity for action for the micro-CHP programme. This table wasn't completed during the first micro-CHP Socrobust round. They felt that the completion of the capacity for action table was necessary for the formulation of the recommendation box. The interviewers of the second round used the same methodology as the interviewers of the first round did for the fuel cell vehicles programme. The results have been written down systematically. The interviewers felt that the table formed a constructive contribution to the recommendations.

4.3.8 Recommendation box

The alterations within the external check and the R&D programme positioning tables automatically led to changes in the content of the conclusions and recommendations. The interviewers of the second round tried to summarise first what the conclusions were for the present case, and to play along with some of the proposed 'conclusions'. The resulting 'recommendations' are not written with the intention to bestow the basket of ingredients necessary to reach the chosen technological option at the specified date in the future. They might function as a warning (for threats) and as an agenda for actions to bring a more robust technology in the future society. Due to the modesty of the given recommendations, it appears less important to review all issues discussed in the research.

This is quite a big difference with the first Socrobust round were the interviewers used the action verb vocabulary. The interviewers of the second round felt that they could not really use the action verb vocabulary in this way. They felt that it was too difficult to explain the given 'verbs-recommendations'. Instead, they chose to go through the whole report and come to a number of subjects that were worth to take up to this last step.

The case of the fuel cells begins with an overview of the learning points acquired during the Socrobust process, which set the scene to elaborate recommendations. These recommendations ultimately led to five verb-recommendations.

In the case of the micro-CHP, the interviewers decided to start with putting down what has been learned regarding the R&D programme's stakeholders and their interests. The interviewers continued with putting down the central issues for a research institute and the programme manager. This ultimately led to eight verb-recommendations.

4.3.9 Boundary map

The way the boundary maps was completed and the outcomes of the boundary maps didn't alter much during the second series of interviews. The maps were checked and some minor alterations were made. Each time, this step was completed before the step of the recommendations.

4.3.10 Possible niches

The niche discussion was not repeated during the second Socrobust round. The interviewers planned to discuss the cause of the lack of possible niches in the micro-CHP niche discussion and the strategic implications of this development during the second micro-CHP round. Due to time constraints, this was not possible. The discussion about niches in the fuel cell case was considered to be completed, with interesting outcomes.

4.4 Spontaneous alterations between the two Socrobust rounds

One of the objectives of the second round was to assess which changes concerning a R&D programme could occur within a certain time period, and thus to assess after how much time Socrobust could thus best be repeated. Changes that occur could have various causes. The changes could be caused by changing circumstances over time but also by the increase in the programme manager's reflexibility[11] or by the changes in methodology as applied during the second round. The assessment could only be done for the micro-CHP programme. The time period between the two micro-CHP Socrobust rounds amounted to six months, which is an interesting period of time for a technology that will probably be introduced in the market within four years. Some interesting changes occurred between the two micro-CHP Socrobust rounds. These developments somewhat altered the outcomes of the Socrobust tools. All changes were directed towards a move towards the implementation of the innovative technology in the (Dutch) market. No explicit conclusion on after how much time Socrobust should best be repeated for a technology could be drawn from this one example. The interviewers think that the ideal repetition time is strongly technology or R&D programme dependent. Repetition of Socrobust after a few months may be useful for a R&D programme with rapidly changing internal and external circumstances. For R&D programmes which internal or external circumstances do not really change only a repetition after a few years may be of use. A period of one year could be an indication of a possible 'standard repetition' time.

[11] The first Socrobust probably caused the programme manager to be more reflective on his own technology development. The programme manager is more or less trained in the application of the Socrobust methodology to his technology after the first Socrobust round.

5. CONCLUSIONS

This study described the methodological issues of the application of the Socrobust methodology to the micro-CHP and fuel cell vehicles R&D programme. The Socrobust methodology has been applied twice to both R&D programmes. The following paragraphs discuss the learning points.

An important leaning point was the influence of the differences between the two R&D programmes on the outcomes of the Socrobust methodology. The kind of outcomes differed for both R&D programmes. One of the R&D programmes had a market orientated present network while the other programme's network was more technically orientated. The future network of the first programme was broad and included user aspects while the other programme's future network was more technically orientated. The differences between both key changes tables and other tools reflected the differences between the R&D programmes' networks.

The R&D programmes differed from each other. The most important differences between the two R&D programmes are the kind of activities (research, demonstration, market introduction etc) deployed within the two programmes and the relative importance of the programmes in the overall technology development. The activities deployed in the fuel cell vehicles R&D programme are focused on research and development while the micro-CHP programme is more involved in market demonstration. The fuel cell vehicles R&D programme is a relatively small actor in the fuel cell vehicles network. This in contrast to the position of the micro-CHP programme's position in their technology development. This R&D programme is a relatively large actor within the technology development. Other differences between the R&D programmes are: a difference between the flexibility in the technology development (the developments within the fuel cell vehicles cluster are still very flexible, while in the micro-CHP case clearly some choices have been made), and possibly a difference in the programme managers' attitude on the use of evaluation tools.

The differences between the R&D programmes are also reflected by the different kinds of outcomes of the various Socrobust tools. For instance: the micro-CHP programme manager feels that the programme should play a important role in the implementation of the technology. This in contrast of the attitude of the fuel cell vehicle programme manager: he (rightly) assumes a more modest role for his R&D programme. This difference could probably be caused by the difference in relative size between the two R&D programmes.

Another important learning point concerns the time period after which the application of the Socrobust methodology to a project or R&D programme should best be repeated. We repeated the application of Socrobust to the micro-CHP cluster after six months and in this period some interesting but not shocking alterations occurred. This repetition and some internal discussions on this subject lead us to believe that the ideal time period between two Socrobust rounds is strongly technology or R&D programme dependent. Repetition of Socrobust after a few months may be useful for a R&D programme with rapidly changing internal and external circumstances. For R&D programmes which internal or external circumstances do not really change only a repetition after a few years may be of use. A period of one year could be an indication of a possible 'standard repetition' time.

From the experiences with the tools during the first and second Socrobust rounds the following secondary learning points can be distinguished:

- The application of Socrobust to a R&D programme takes quite some time. At least three interviews of three hours and a workshop of three hours are needed. It is very well possible that the second interview will take longer than the planned three hours. The time planning of a possible second Socrobust round is dependent on which tools or aspects of Socrobust are planned to be treated in such a second round.
- The sequence of interviewers of successive Socrobust rounds is of importance. The persons who conducted a series of interviews didn't conduct a second series of interviews but one person. We, as interviewers, found this sequence of interviewers very useful as more people could gain some experience with the Socrobust methodology while the continuity within the project was still guaranteed. It is probably better though that all interviews will be done by the same two or three persons from the customer's or technology developer point of view.
- The initial preparatory phase in the project is of importance. This phase is crucial for developing a good relationship and consequently the conditions for proper mutual understanding of the method. Also, a good relationship between evaluators (interviewers) and participants (programme managers), resulting in a positive attitude towards the Socrobust method, can safeguard the process from protective strategies.
- The interviewers can broaden the future network by combining the formulation of the present and future network during a second Socrobust round. It still has to be tested of such an alteration will be at use for a first Socrobust application.
- The external check can be broadened by means of interviews. The interviewers considered the outcomes of the interviews as useful but they also think that some assumptions still have to checked by means of a web search.
- A time path in key changes or underlying assumptions can be introduced by using two networks instead of one future network. The introduction of such a time path in the second Socrobust rounds led to different outcomes in both cases. The interviewers considered this time path as useful. It still has to be tested of such an alteration will be at use for a first Socrobust application.
- Combining the key assumptions to three groups before the external check can facilitate the change over from the four poles in the networks to the three technological landscapes in the R&D programme positioning tables.
- The action vocabulary to be used while formulating the recommendations was considered as useful.
- A time path can be introduced in the recommendations as well. The interviewers of the first round considered this as very useful.

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APPENDIX A TRANSITIONS

In the National Environmental Policy Plan 4 (NMP4) the Dutch Ministry of Environment and Spatial Planning stressed the need for a transition towards a sustainable energy supply system. A transition is a gradual and lengthy process (25-50 years) of change in which a system changes fundamentally. The change concerns changes in various areas: technological and institutional changes, changes in behaviour, culture and intentions. The overall change encompasses changes in socio cultural, techno economical and environmental aspects.

To describe transitions often a multi level perspective is used. In such a perspective three levels are distinguished, notably (technological) niches, regimes and landscapes. The three levels can be characterised as follows (Elzen, 2001):

- Technological niche or just niche: denotes a protected space where technologies or concepts are developed that cannot economically survive in their present state. They are protected by various actors who believe in their long-term prospects and/or profits and who are willing to invest time, effort and/or money. A technological nice is different from a market niche. The latter denotes a subsection of a larger market that can survive economically while a technological niche cannot and needs protection.
- Socio technical regime: The regime is the whole of rules, regulations, assumptions and theories, division of labour etceteras that are embedded in material and social practices. It is characteristic for regimes that technological developments within the regime are mostly incremental, in other words are aimed at optimisation. Examples of regimes are the regime of energy supply, the regime of agriculture and the regime of transport by ship.
- Socio technical landscape: this denotes the wider context of a regime in the form of socio cultural and economic factors and processes. Events and process on the landscape level influence events and processes on niche and regime level. An example of an event on landscape level is the nuclear disaster in Chernobyl. The processes of liberalisation and individualisation can be seen as processes on landscape level.

A transition can be seen as a regime and landscape transformation. Innovations can only outgrow niches when they are able to couple with developments on landscape and regime level. When innovations outgrow niches the regime changes. The introduction of Hydrogen fuelled cars for instance will have impacts on infrastructure, assumptions on regular conventional driving and governmental regulations.

Although transitions are characterised by non-linear behaviour, the process itself is a gradual one. Four phases can be distinguished (adapted from Kemp and Rotmans, 2001):

- The predevelopment phase: there is very little visible change, but there is a lot of experimentation in this phase.
- The take off phase: the process of change gets underway and the state of the system begins to shift.
- The acceleration phase: structural changes take place in a visible way through an accumulation of socio-cultural, economic, ecological and institutional changes that react with each other; in this phase collective learning, diffusion and embedding processes occur.
- The stabilisation phase: the speed of social change decreases and a new dynamic equilibrium or regime is reached.

The transition towards a more sustainable energy supply seems to be between the take off phase and the acceleration phase. More sustainable technologies such as wind turbines are emerging in the present ‘fossil’ regime of energy supply and institutional changes like laws concerning green electricity are beginning to occur. In this phase it is important to examine images of the future and ways in which these images can possibly be reached.

Within most images of the future sustainable technologies to be used to supply energy or energy saving technologies play an important role. Many of these technologies are radical, architectural or system innovations which technological breakthrough presupposes important changes on regime and landscape level. Examples of those presupposed changes can be changes in infrastructure or far-reaching changes within the regulation system.

APPENDIX B THE SOCROBUST TOOLS

Socrobust consists of the following tools:

- the narrative
- the critical moments table
- the present network
- the future network
- the critical actors table
- the key changes table
- the external check
- the R&D programme positioning table
- the capacity for action table
- the recommendation box
- the boundary map
- the possible niches.

The sections below show examples of the various Socrobust tools. For these examples excerpts of the various tables and tools that have been filled in during the two Socrobust rounds are given.

B.1 The narrative

The narrative is a short description of the past, the present and the anticipated future of the R&D programme. The completion of this tool is quite obvious, therefore no example is given.

B.2 The critical moments table

The table below shows an example of a critical moments table.

Table B.1 *Excerpt of the critical moments table of the fuel cell vehicles R&D programme after the first series of interviews*

Date	Description	Source	Implication/choice	Envisioned solution	Irreversibility	What change	Stage reached
1990	Ronald Mallant meets PEM fuel cell technology at an H_2 conference in Hawaii	Passive	Interest in PEM fuel cells	Discussion within ECN SF: research on PEM FC in stead of ICE hydrogen bus?	Low	Consider alternatives for ICE	Start-up
1990	Selection of PEMFC as drive	Pro-active	Change from ICE to PEM	Select technology in which ECN can contribute	Medium	Change of subject of research	Start-up

B.3 The present network

The present network of the micro-CHP programme after the second round. The network is in Dutch. The poles are:

- Wet- en regelgeving: the regulation pole.
- Producenten: the producer pole.
- Gebruikers: the user pole.
- Technologie en wetenschap: the science pole.

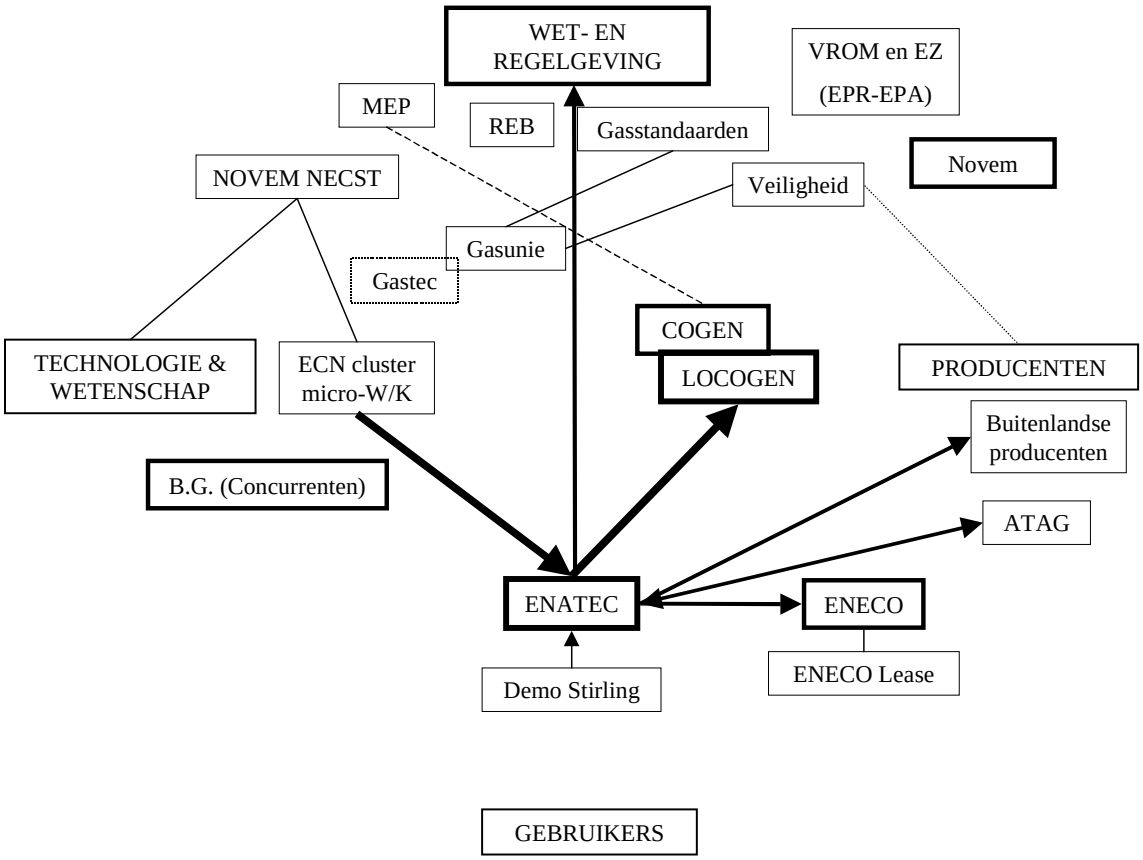

Figure B.1 *The present network of the micro-CHP R&D programme after the second series of interviews*

B.4 The future network

Important actors or attributes of important actors for the situation in which the technology is completely embedded in society are depicted in the future network. An example of a future network could not be given due to confidentially reasons.

In the network the same poles as in the present network are used:

- the regulation pole
- the producer pole
- the user pole
- the science pole.

B.5 The critical actors table

The tables below show an excerpt of the critical actors table of the fuel cell vehicles case. The critical actors table consists of two separate tables: the actor importance table and the actor involvement table.

Table B.2 *Actor importance*

Actor	Centrality within the network	Representativity and centrality within the pole	Substitutability	Estimated importance
Actor X	Central	Producers: high Users: quite high	Very low	High

Table B.3 *Actor involvement*

Actor	Motivation to join	Objective in contributing to the development	Global strategy	Estimated alignment	Irreversibility	Estimated involvement
Actor X	Business opportunity	Future market leader fuel processing	Entrepreneur	Alignment: high Possibility to influence the actor: low	Average/high	High

B.6 Key changes table

The following example is an excerpt of the key changes table as completed during the first round for the fuel cell vehicles programme.

Table B.4 *The key changes table of the fuel cell vehicles R&D programme after the first round*

Key change	Description	What has been taken for granted?	What practices have disappeared?	Which actors are most affected?	What is the extent of the change?	What is the rate of change/timing of it?	Key critical factor	Related changes	Entry points	Oppositions
Education; courses	Metamorphosis in refresher courses on motor technology	Education on electrotechnics	Education with regard to mechanical skills	Education of mechanics; mechanics	Little change with regard to education; rather profound for mechanics	Refresher course; mechanics have to be versatile	Refresher courses at specialised institutes	Status of profession	Contacts with technical education	Technical education; mechanics needing refresher courses

B.7 External check

The outcome of the external check consists of a synthesis of the main positions identified, of the arguments mobilised and of the most interesting material revealed by the search relating to each key change. No example of the outcomes of the external check will be given.

B.8 R&D programme positioning table

The table shows the position of the micro-CHP R&D programme in the technological landscape (first round). The R&D programme positioning table is strongly altered after the first series of interviews for the fuel cell vehicles case. The altered R&D programme positioning table is shown in Table B.6 below.

Table B.5 *The R&D programme positioning table. The table shows the position of the micro-CHP R&D programme in the technological landscape after the first series of interviews*

	Description	Type of main activities	The programme's position
Programme Focus	Stirling motor	research	Mainly to be used in already existing buildings
Alternative (1)	Existing gas motor	The gas motor has been introduced on the market	confidential
	Fuel cells	The fuel cell is still in the research/demonstration phase of its development	confidential
Alternative (2)	Grid electricity/more efficient boilers	Common in most places	Present situation
	Grid electricity and district heating	Common in some areas	confidential
	Conventional boiler and gas driven heat pump	Energy saving future possibility	confidential
Potential Allies	Manufactures of low temperature heating systems	Research and development	confidential
	Stirling manufactures	Research and development	confidential
	Innovative boiler manufactures	Research and development	confidential
	Material developers	confidential	confidential
Potential opponents	Conventional producers of electricity	Established companies that should comform themselves to the new situation	R&D programme informs the producers of new developments
	Conservative boiler manufactures	confidential	confidential
	Other Stirling builders	They have their own concepts	confidential
Socrobust Assessment	Confidential		

Table B.6 *The R&D programme positioning table. The excerpt of the table shows the position of the fuel cell vehicles R&D programme in the technological landscape after the second series of interviews*

Position of the R&D programme in the technological landscape (with emphasis on possible future vehicles)			
Alternative.	Description alternative.	Key assumptions.	Proponents.
• Fuel cell vehicles.	Attributes of the alternative	Circumstances in which the alternative probably will foster such as: Stringent local emissions policies. Stringent climate policies.	Actors that probably will support the emergence of the alternative and the situation in which they will probably support the alternative. Examples are: Countries with a CH4 infrastructure. Car manufactures (when pro H2).
• Alternative.	Attributes of the alternative.	Weak local emissions policies. Weak climate policies.	Actors that probably will support the emergence of the alternative and the situation in which they probably will support the alternative.
• Etcetera.	Etcetera.	Etcetera.	Etcetera.

B.9 Capacity for action table

The table shows a shortened version of the capacity for action table for the fuel cell vehicles R&D programme (after the first round).

Table B.7 *The capacity for action table of the micro-CHP R&D programme after the first series of interviews*

Dimension	Threats/uncertainty	Debate loci	Room for action
Technological landscape	Threats as they emerged from the external check (e.g. The environmental image of fuel cell vehicles)	Actors and places that are relevant for each specified threat of change (e.g. a debate about the environmental pros and cons of various transportation options)	Margins for manoeuvring (e.g. try to involve environmental organisations)
Legal, administrative and regulatory environment	e.g. Which route does the government choose to fulfil its CO_2 reduction targets in the transportation sector?	Study groups on EU and national level	Clean fossil fuels can only indirectly influence the outcomes of the debates by involving other actors (other research institutes, environmental organisations, user representatives)
Positioning of demand, users and markets	Will the government stimulate the use of Hydrogen fuel cell vehicles?	Debate between various Dutch ministries (Environment, Transportation, Economic Affairs)	Clean fossil fuels can only indirectly influence the outcomes of the debates by involving other actors (other research institutes, environmental organisations, user representatives)

B.10 Recommendation box

The recommendations given to both programme managers revolved around actions which reflected the programme's position within the space of debate. An action vocabulary was used during the first Socrobust round for both technologies.

Due to confidentially reasons no example of the recommendation box will be given. The following verbs were among other verbs used during the first Socrobust round:

- monitor and discuss (developments),
- strengthen (your knowledge on),
- think about,
- take care of a discussion about,
- explore the possibility of engaging (another actor),
- build a discussion platform about (including information on which organisations could form a part of the discussion platform),
- strengthen the position of (an actor),
- develop new field test (including information on the kind of field test that could be developed).

In the fuel cell vehicles example the recommendations were placed in time perspective. An example hereof is shown below:

Try to influence the national government to stimulate the development of fuel cell vehicles and/or to choose for a hydrogen transition route

Background
A description of why the recommendation could be of importance for the fuel cell vehicle R&D programme.

Short-term actions:

- Contribute to the discussion about possible transition routes.
- Develop hydrogen demonstration projects (fuel cell vehicles can also be used with a limited infrastructure).

Long-term actions

- Strengthen the relationship between actors advocating the Hydrogen transition route.
- Try to stimulate research on CO_2 capture techniques.

B.11 Boundary map

Below an example of an empty boundary map is shown.

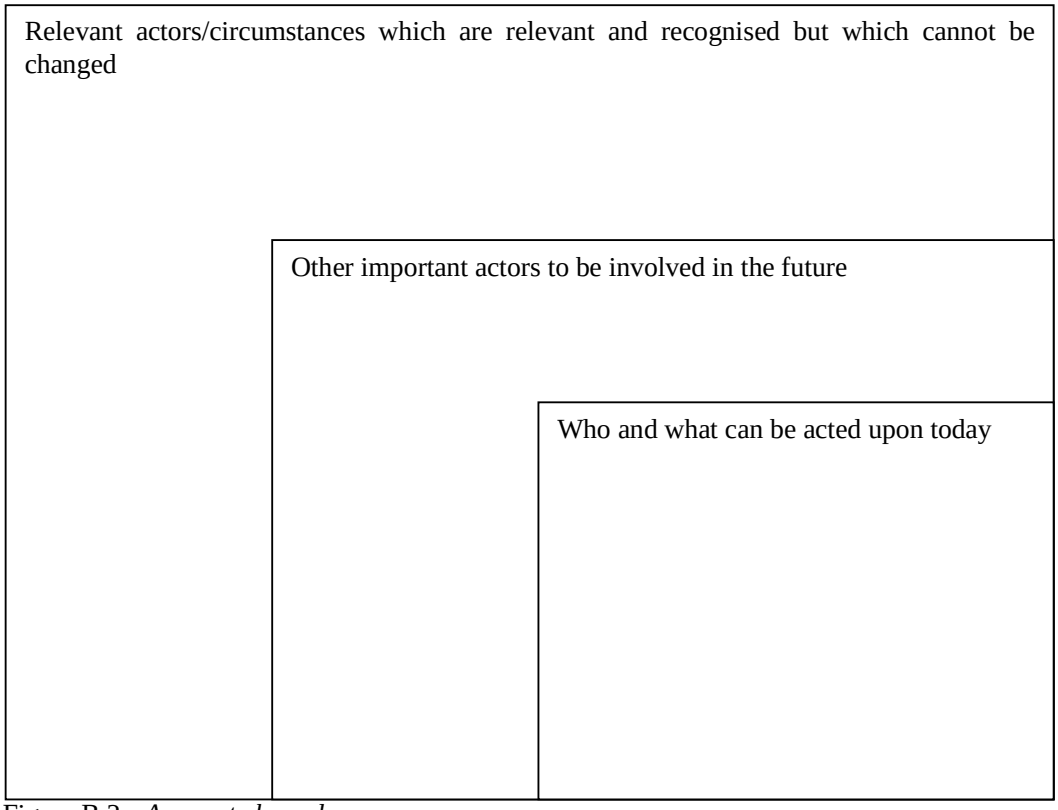

Figure B.2 *An empty boundary map*

B.12 Possible pathways

The possible pathways tool is a description of possible niches, niche trajectories and their strategic implications. The learning points of each niche trajectory are described per niche trajectory. No example is shown.