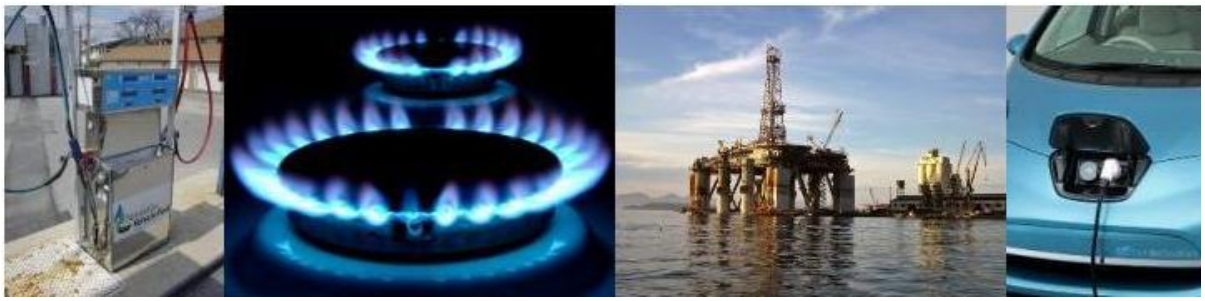
Master thesis

Discourses on the desirability of sustainable transport alternatives

Reinier van der Wees



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Discourses on the desirability of sustainable transport alternatives

Reinier van der Wees (0492418)

R.J.vanderWees@students.uu.nl

Supervisors:
Dr. R.A.A. Suurs
Dr. S.O. Negro

Faculty of Geosciences, Department of Innovation and Environmental Sciences, Science and Innovation Management, Utrecht University, the Netherlands

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Abstract

The widespread use of fossil fuels for road transport is resulting in environmental pollution, risks for energy security and economic risks due to increasing oil scarcity. The development and implementation of sustainable alternatives for road transport could provide a solution for these problems. However, this development of sustainable alternatives has proven to be difficult. Many processes have to be built up before an alternative can compete with the incumbent technologies. This research focuses on one of these processes, namely acquiring legitimacy. In this process, actors try to get their technology accepted as a desirable and realistic alternative. When different actor groups try to acquire legitimacy for different alternatives, they get into conflict with each other and discourses emerge.

The aim of this research is to provide theoretical and practical insights into these discourses and their effects on technological innovation systems. The Technology Specific Coalitions Framework has been used to provide detailed insights into discourses between coalitions of actors. In general, it is likely that three or four coalitions are involved in discourses on sustainable alternatives. These coalitions comprise of a coalition of strong supporters of a specific technology, one that criticizes this alternative, possibly a coalition that supports a competing alternative and a group of actors that supports a broad range of alternatives. The conflicts between these coalitions seem to focus mainly on technological factors such as CO_2 reduction potential, cost effectiveness and production potential.

Additionally, the behavior of the individual actors and the cooperation between actors within coalitions has been investigated. The results of this research suggest that the goals and interests of individual actors significantly determine their positions within the discourses. Moreover, the results show that there is not much cooperation between actors to form broad coalitions to support an alternative. Instead, many actors pursue a lobby together with similar firms and organizations to reach their shared goals and defend their interests. In general, these lobby activities hamper the development of sustainable alternatives. However, one example shows that the cooperation between a broad range of actors can be effective to stimulate important activities in the development of sustainable alternatives.

Contents

1. Introduction

1.1. Background

The widespread use of fossil fuels for road transport is resulting in a number of large problems in our society. First of all, the resulting CO_2, NO_x and PM emissions cause environmental pollution. CO_2 is the largest contributor to global warming, which causes climate change on a global scale. This climate change results in more severe droughts and sea level rise, which can have devastating effects on ecosystems, food security, water availability and economies in coastal areas [1,2]. The NO_x causes local pollution in the form of acid rain, which can harm ecosystems. Particulate matter (PM) are another form of local air pollution, which causes serious health problems [2].

Second, oil reserves are increasingly concentrated in politically instable countries: 64 percent of the global oil reserves can be found in the Middle-East [3]. The growing use of fossil fuels for transportation creates a growing dependence on these countries, resulting in risks for energy security.

Third, the recent surge of oil prices has resulted in growing attention for the problem of global oil scarcity. The increasing economic welfare of countries outside the OECD, especially China and India, is causing a considerable growth of demand for fossil fuels on the medium and long term. On the other hand, oil companies increasingly have trouble to produce oil, because the easily accessible sources are depleting [4]. These developments could produce considerable scarcity resulting in high prices of fossil fuels in the future, which can harm the economy.

One of the solutions to these problems is using sustainable alternatives for road transport. These sustainable alternatives produce much less or even no CO_2, NO_x or PM. Furthermore, the growth of sustainable road transport would lower the risks for energy security and the demand for oil. For these reasons, it is important that sustainable transport alternatives are supported in society. However, this has proven to be difficult in the last decades. The incumbent energy system is still developing into a direction that worsens the large societal problems caused by fossil fuels. At present, markets in the transport sector do not account for the societal costs of carbon technologies and the possible benefits of sustainable transportation [5]. Furthermore, sometimes even governments are worsening the problem by subsidizing the oil industry instead of supporting sustainable alternatives [6,7].

According to Unruh (2000;2002), these developments are caused by the “carbon lock-in” [7,8]. His contention is that “industrial economies have become locked into fossil fuel-based technological systems through a path-dependent process driven by technological and institutional increasing returns to scale” (p. 817) [7]. The carbon lock-in condition arises through the combined interactions between technological systems and governing institutions. Through these interactions, a strong and inert complex of interrelated technologies and institutions emerges [7]. The transportation system is an example of such a complex, in which

the internal combustion engine and fossil fuels have been dominant and have profited from increasing returns for a century.

A related phenomenon is early lock-in. Early lock-in occurs when society selects suboptimal technologies. Famous examples are the QWERTY keyboard [9] and the Windows operating system [10]. The early lock-in phenomenon can also emerge in the development of sustainable transportation. Different technologies for sustainable transportation compete with the incumbent system based on fossil fuels to break through the carbon lock-in. If the system becomes locked into one of the alternatives and this alternative turns out to be undesirable or even unsustainable, the technology can keep developing into this lock-in situation [5]. A possible undesirable consequence is that the development of other promising technologies is hampered in an early phase [10].

The risk of early lock-in into suboptimal technology has a central role in environmental policy making, because the actors involved have to reach emission goals on the short term and develop a long term energy transition at the same time. A technology with many short term benefits can have limited potential for the long term. Long term and large scale development of such technologies can result in a lock-in, because the development of other alternatives with more long term potential can be hampered. However, because there are many uncertainties, we can only determine in retrospect whether technologies have been optimal or suboptimal. Furthermore, actors in society will have different perceptions of optimal and suboptimal technologies. Criteria such as emissions, costs and safety can be determined objectively, but to be able to choose between alternatives, these criteria have to be weighed. The weighing of different criteria is inevitably subjective. As a consequence, determining the importance of criteria is a political process and the resulting technological choices are also political. This research will focus on this political process, in which conflicts between coalitions of actors shape the choices between sustainable transport alternatives.

1.2. Discourses on sustainable transport alternatives

In the political process, fierce conflicts between involved actors emerge, because these actors value criteria differently and often try to gain legitimacy for a specific technology. These different conflicts together form a discourse around a specific technology.
This discourse is necessary, because it can help policy makers and investors to reduce uncertainty on which alternative is the best choice for their investments. However, discourses often are not as constructive as intended. The discourses can even increase uncertainty for policy makers, because different actor groups come up with contrary statements and it is hard to determine who to support. Moreover, there are many ways to frame the potential of a technology and actors will often emphasize the criteria that suit best to their own (political) goals. Often even misinformation is used by actors to legitimize or delegitimize a technology [11].

Hopefully, this research can help policy makers in two ways. First of all, an overview of the variety of standpoints and arguments can make the causes of conflicts more transparent.

Policy makers can use this information to make discourses more constructive and to find solutions for the conflicts. Second, an analysis of goals and interests of individual actors can provide an explanation for their supporting or opposing behavior. This information can help policy makers in assessing attempts to shape the legitimacy of technologies. Subsequently, it becomes easier to develop a detailed and independent vision on different technologies.

Discourses on the desirability of sustainable transport alternatives are also interesting from a theoretical point of view. In the last decade, considerable research has been done on the development and use of these sustainable technologies [12,13,14]. These studies have often analyzed the development of sustainable technologies in Technological Innovation Systems (TIS), in terms of structures and processes. This research focuses on one of these processes, namely the political discourse between different actors on a specific technology. An analysis of discourses can provide three theoretical contributions. First of all, it can provide more detailed insights in the formation of political networks, which has often been indicated as a crucial process for the formation of a TIS [5,6,11,12]. Second, it can provide insights in the cooperation between actors within these networks. This cooperation is important in counteracting the political power of the incumbent industries and it can result in the start of important activities within a TIS [5,12]. Third, this research can provide more insights on the influence of individual goals and interests within political networks. The goals and interests of the incumbent actors are especially important, because these incumbents can be an important blocking factor for the development of a TIS.

1.3. Research questions

I will use the theoretical background on technology specific coalitions and beliefs as a starting point for analyzing discourses on the desirability of different alternatives for sustainable transport. In the policy making process, advocates of different technologies will compete to influence policy. In this competition, technology specific coalitions are formed, which consist of different actors in the TIS who share technology specific beliefs [12,15]. As a consequence, it is likely that coalitions get into conflict with each other, because they differ in their technology specific beliefs. An example of a conflict between coalitions is the recent discourse on biofuels, in which the advocates of first and second generation biofuels have fierce discussions on which generation to support. The first research question is as follows:

RQ1: Which differences in beliefs cause the conflicts between technology specific coalitions on the desirability of different alternatives for sustainable transport in Dutch environmental policy?

The analysis of the conflicts between technology specific coalitions can help policy makers to obtain an overview of the variety of arguments and interpretations. However, this analysis does not help in understanding the behavior of the actors within the coalitions. The second research question is as follows:

RQ2: Which specific goals or interests can explain the positions of individual actors within the discourses?

After studying the conflicts between coalitions and the behavior of individual actors in depth, it is important to investigate the effects of cooperation within broader coalitions on the TIS. As argued, cooperation between actors within political networks has been indicated as a crucial process for the formation of a TIS in the literature. An investigation of important activities within the TIS can show whether this cooperation between actors actually results in development of the TIS. Additionally, the lobby activities of individual actors will be investigated. As a consequence, this research can provide insights on the usefulness of cooperation between a broad range of actors in political networks. The third research question is as follows:

RQ3: How does cooperation between actors within the coalitions influence the development of technological innovation systems?

1.4. Research design

In order to answer the research questions, two case studies have been performed. Two cases of conflict between technology specific coalitions have been selected in the field of sustainable mobility. The starting point for the selection of the cases has been whether there is discussion on the desirability of specific technologies. Early lock-in is especially important within these discussions, because the actors disagree on whether specific technologies have the potential to contribute to a long term transition.

As a result, the following cases have been selected:

1. The Biofuels case, in which conflicts have risen on the desirability of first and second generation biofuels. An important issue within this discourse is whether implementing first generation is useful for accomplishing the transition towards second generation biofuels.
2. The Automotive Natural Gas case, in which conflicts have risen on whether natural gas can be a transition fuel towards a sustainable transport system.

1.5. Outline of the thesis

Chapter 2 will elaborate on the theoretical background of the research. In Chapter 3, the method that will be used to acquire and analyze the data will be presented. In Chapter 4 and 5, the analyses of the two cases will be presented. In Chapter 6, a synthesis of both cases will be presented, in which the most important lessons that can be learned from the cases will be summarized. In Chapter 7, the results of the research will be discussed and the conclusions will follow in Chapter 8.

2. Theory

2.1 Introduction

This chapter elaborates on the theoretical concepts that will be used for the research. First of all, the Technological Innovation Systems concept will be introduced as a theoretical background for this research. Second, the focus of this research is on technology specific coalitions, groups of actors that try to gain legitimacy for a specific technology. To conceptualise the discourse between these coalitions, the Technology Specific Coalitions Framework will be used, which is based on the Advocacy Coalitions Framework [15,16]. Finally, the theoretical background of the analysis of the actor behaviour within the coalitions will be given.

2.2. Technological Innovation Systems

As argued in the introduction, much research has been done on the development of sustainable technologies within Technological Innovation Systems (TIS), in terms of structures and processes. As a theoretical background, this section will elaborate on the structure of a TIS.

A TIS is defined by Carlsson & Stankiewicz (1991) as "a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion and utilisation of technology" (p. 111) [17]. According to this definition, the structure of a TIS is made up by three main elements: actors, networks and institutions [12].

Actors and especially networks are important for this research, because actors form technology specific coalitions. All kinds of actors can play a role in a TIS: entrepreneurs, multinationals, consumers, suppliers, government agencies, knowledge institutes, non-governmental organisations and intermediaries. Institutions are the "rules of the game" [18], the norms and rules that regulate the interactions between actors [12]. Additionally, the techno-economic aspects of technological artefacts (e.g. cost structures, safety, reliability) are very important in the analysis of technological change [5]. For sustainable transport innovations, technological factors are especially important, because a TIS may stop developing if it turns out that a technology is too expensive or environmental effects are negative.

2.3. Discourse between Technology Specific Coalitions

In previous research on the development and diffusion of renewable technologies, acquiring legitimacy has been emphasized as an important process within the formative phase of development of a TIS [5,6,11,12,13,14]. In this formative phase, acquiring legitimacy means getting a renewable technology accepted as a desirable and realistic alternative of the existing incumbent options. When the technology has become accepted, its legitimacy can increase further when more actors and especially more powerful actors support the technology [11]. To

acquire legitimacy, technology specific coalitions need to be formed, which can engage in political debates to get the technology accepted and to involve more actors in the coalition [6,11,12]. Firms and industry associations are especially important for the strength of the coalition, but a large variety of actors can be part of it. Examples are universities, private and non-commercial associations, media and politicians [12].

As argued, a technology specific coalition tries to get its technology accepted as a desirable and realistic alternative. Often, several technology specific coalitions try to convince policy makers and politicians that their specific technology is the best choice. As a result, these coalitions get into conflicts with each other. The focus of this research will be on these conflicts. Two discourses will be analyzed using the Technology Specific Coalitions Framework, which is based on the Advocacy Coalitions Framework introduced by Sabatier (1988;1998). Additionally, the behaviour of individual actors will be analyzed, in which the focus will be on their specific interests and goals and the cooperation between the actors.

2.4. The Advocacy Coalitions Framework

2.4.1. Introduction

The Advocacy Coalitions Framework was introduced in political science by Paul Sabatier (1988). The conceptual framework is based on the ideas of Heclo (1974), who saw policy change as the product of (1) large social, economic and political changes and (2) interaction between different actors within a policy community involving both competition for power and efforts to address policy problems in a more sensible way [19].

The Advocacy Coalitions (AC) Framework has three basic premises [15]:

1. Understanding policy change and the role of policy-oriented learning in this process requires a timeframe of at least a decade.
2. The most useful aggregate unit of analysis for understanding policy change is the policy subsystem, which is defined as “a set of actors who are involved in dealing with a policy problem” (p. 138) [15].
3. Public policies incorporate implicit theories about how to achieve objectives and therefore they can be conceptualised as belief systems. These belief systems consist of value priorities and perceptions of problems, causal relationships, world states etc. Although every individual has unique beliefs, the framework is based on the assumption that the actors within a coalition share a set of normative and causal beliefs.

In 1998, Sabatier revised his framework, in which he added two basic premises:

1. Theories of the policy process need to address the role of technical information in the process, because this is the topic of the majority of discussions in policy domains.
2. In virtually all domains, policy subsystems will involve actors from several levels of national and international government.

The transition to the use of sustainable transport technologies will likely be a process which requires several decades, in fact it already has taken three decades [5]. This makes the AC framework suitable for analyzing policy change in this domain. The analysis will focus on the sustainable transport subsystem in environmental policy.

2.4.2. General overview of the framework

The AC Framework consists of two parts, namely the internal structure of policy subsystems and external factors that affect policy change within subsystems. The AC Framework is shown in Figure 2.1. The rest of this chapter will focus on the internal structure of the policy subsystem. After all, the focus of this research is on the conflicts between coalitions and these conflicts occur within the internal structure. However, external factors will be taken into account in the data collection and analysis, because they can have a large influence on discourses. External factors can be a necessary background to be able to understand the discourses. For example, the large increase of food prices in 2008 had a significant influence on the biofuels discourse and the positions of actors within the discourse.

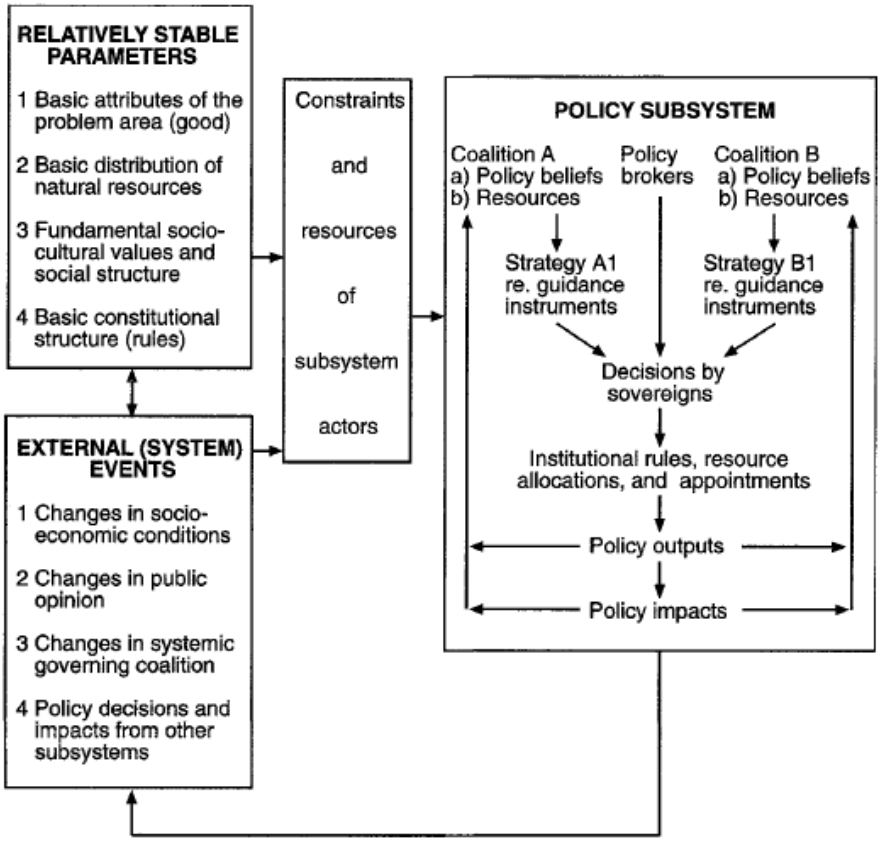

Figure 2.1: General model of policy change in which advocacy coalitions compete within policy subsystems [16]

2.4.3. Internal structure of policy subsystems

According to Sabatier (1988), it is most likely that new subsystems emerge because a group of actors is dissatisfied enough with the neglect of a problem in existing subsystems to form their own subsystem. In a subsystem, many actors are active. As argued, every actor has unique beliefs, but it is an enormously complex task to consider these beliefs in detail.

Therefore, Sabatier (1988) has introduced the notion of advocacy coalitions, which are defined as "people from a variety of positions who share a particular belief system and who show a non-trivial degree of coordinated activity over time" (p. 139) [15]. In most subsystems, there will be two, three or four important coalitions, because many factors push actors to cooperate to form effective coalitions. The sharing of values and beliefs within a coalition contributes to group cohesion [16]. On the other hand, it also results in competition between coalitions. In this research, the focus will be on this competition. Since coalitions consist of actors with similar beliefs, the conflicts between coalitions are caused by differences in beliefs. Hence, this research will focus on these differences. For the analysis of the conflicts, coalitions are formed by actors with shared beliefs, without taking coordinated activity into account. After the analysis of the conflicts, the coordination between actors will be investigated.

Finally, two remarks on the internal structure of policy subsystems are important for the analysis. First of all, not every actor will share one of the major belief systems. Researchers for example can participate because they have important skills, while they are indifferent to the beliefs of different coalitions. Second, it is important that there is at least one actor or category of actors that is concerned with keeping the level of conflict between limits and reaching a solution to the problem. These actors are called "policy brokers" [15,16]. Traditionally, civil servants have been known to function as policy brokers. However, in reality the dichotomy between advocates and brokers does not exist. Every actor is to some extent concerned with both advocating its beliefs and searching for solutions and consensus [15].

2.5 Technology Specific Coalitions Framework

The AC Framework is intended for analysis of all kinds of policy change, so it does not have to involve technology in the analysis. However, for this research on competing advocates of specific technologies, the framework has to be used in a technology specific manner. A schematic representation of one conflict between two technology specific coalitions is given in Figure 2.2. It is important to emphasize that Figure 2.2 is a simplification. As argued, it is likely that a discourse consists of different conflicts between multiple coalitions.

In the process, the policy subsystem of sustainable transport is an arena in which advocates of different technologies compete for legitimacy. In the model, the advocates of technologies share technology specific beliefs. Through the sharing of beliefs, coalitions are formed. Due to the differences in beliefs, coalitions get into conflict with each other.

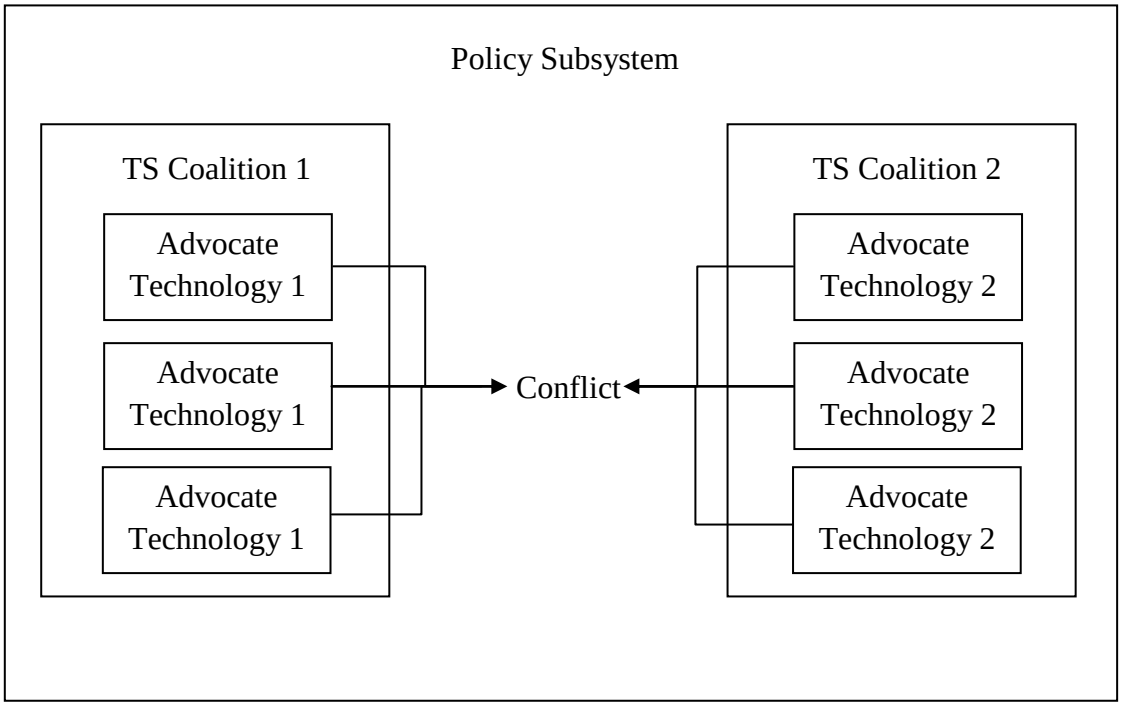

Figure 2.2: Schematic representation of the discourse between technology specific coalitions

2.6. Actors

While the AC Framework is helpful to conceptualise the competition for legitimacy that occurs in the formative phase, it can only be used to analyse actor beliefs and their positions on an issue. Such analyses result in coalitions of shared beliefs, but the framework cannot help us in finding out why individual actors take a certain stance in the debate. In other words, the framework is much less useful for explaining actions, interests and motives. In fact, Sabatier himself admits that he has large difficulties with taking interests into account (1988, p. 142). However, as argued in the introduction, the goals and interests of individual actors do play an important role. They can provide an explanation for the support for or resistance against a technology by a specific actor. An analysis of the behaviour of the incumbents is also interesting, since their opposing behaviour has been indicated as an important blocking factor in previous research [11,12].

Finally, the cooperation within the coalitions will be investigated and whether cooperation has resulted in activities within the TIS. According to Jacobsson & Bergek (2004), technology specific coalitions need to engage in political debates in order to gain influence over institutions and to secure alignment of institutions to a specific technology. This alignment of institutions is reflected in activities within a TIS that result from the discourse. When the political discourses have been analyzed, it is interesting to investigate whether activities have started within the TIS as a result of cooperation between coalitions. Examples of these activities are subsidies or low tax rates for a specific technology, investments in infrastructure and changes in laws and regulation [5,11].

3. Method

3.1. Introduction

For this research, two case studies have been performed. Section 3.2 will shortly elaborate on the case study method. The remaining sections will explain the steps that have been taken for each case: constructing a social map (3.3), data collection and data analysis (3.4).

3.2. Case study method

For this research, two cases were studied, in which discourses between technology specific coalitions have been investigated empirically. According to Yin (2003), the case study is "an empirical enquiry that investigates a contemporary phenomenon within its real-life context, especially when the boundaries between phenomenon and context are not clearly evident" (p. 13) [20]. From this definition, three conditions for the use of the case study method can be derived:

1. The context of the phenomenon under study is important for answering the research questions, especially when the boundaries between phenomenon and context are not clear.
2. The focus of the study is on real-life contemporary events.
3. The behavioral events under study are hard or even impossible to control.

Considering these conditions, the case study method is suitable for this research. The events in a TIS happen in a real life societal context, which makes them impossible to control. Furthermore, the distinction between the events under study and the context are not always clear.

3.3. Constructing a social map

Technology specific coalitions consist of a range of actors sharing a set of beliefs on which technologies should be supported in policy. Therefore, the first step in analyzing these coalitions in the sustainable transport subsystem was to determine which actors are part of the subsystem. A social map gives an overview of the actors that are active in the system. Social maps have been constructed for every case study by doing a literature search. The work of Suurs (2009), the GAVE and EOS databases of SenterNovem and other internet sources were a starting point for the literature search. After this global search, the resulting list of actors has been discussed with innovation researchers at Utrecht University and the secretaries of the Sustainable Mobility Platform at SenterNovem. The resulting overview of the involved actors for both cases, based on Ros & Montfoort (2006) and Suurs (2009), can be found in Appendix A.

3.4. Data collection and analysis

The first part of this section elaborates on the data collection method, namely interviews. The second part will deal with the operationalisation of the theoretical concepts to interview

questions. The third and fourth part will elaborate on the analysis of the data and the synthesis.

3.4.1. Interviews

After constructing the social map, sixteen interviews have been conducted. Interviews are targeted on the specific research topic and consequently, the results can give much insight in this specific topic [20]. For this research, interviews are especially important, because the research focus is on beliefs, resulting coalitions and the conflicts between those coalitions. A literature search is likely to result in statements from actor groups, but the underlying beliefs will not always be clear. It is crucial that these beliefs are investigated more specifically, because the differences in beliefs are the source of the conflicts between coalitions. In interviews, the beliefs and conflicts can be targeted more specifically.

The actors that have been interviewed for this research are shown in Figure 3.1. An overview of the interviewed actors for each case specifically is given in Appendix A.

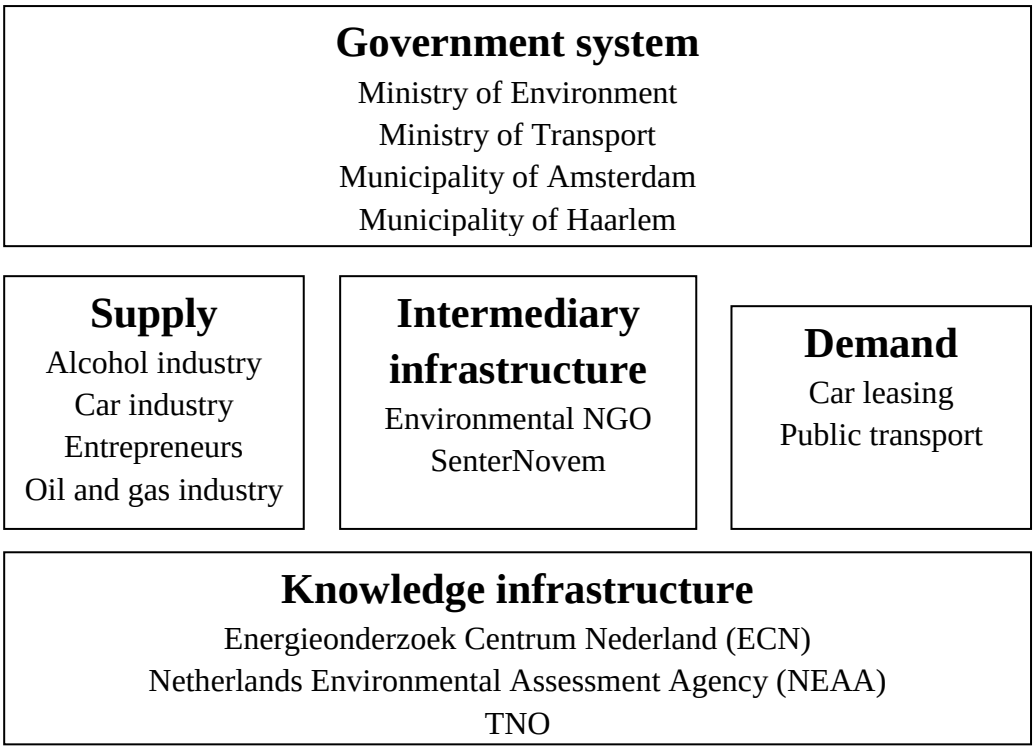

Figure 3.1. Overview of the interviewed actors

3.4.2. Operationalisation

This section will elaborate on the measurement of the theoretical concepts that have been introduced in Chapter 2. Since the data will be collected with interviews, the interview questions will be the indicators for the measurement of the concepts. The format for the interview questions can be found in Appendix B.2. In Table 3.1, the operationalisation of the theoretical concepts is shown. Each of the dimensions is linked to one or more interview questions. The operationalisation with the corresponding interview questions can be found in Appendix B.1.

Table 3.1. Operationalisation of the theoretical concepts

Research question	Concept	Dimension
RQ1	Events	N/A
	Beliefs	General
		Long term potential
		Niche/Large scale
		Lock-in
	Coalition	Shared beliefs
	Competing coalitions	N/A
	Conflicts	N/A
RQ2	Specific goals/Interests	Directly/not directly involved in development
		Specific goals
		Specific interests
		Support for other technologies
RQ3	Cooperation between actors	N/A
	Conflict outcomes	N/A
	Activities within TIS	N/A

First of all, the interview respondents have indicated the important events in the discourses studied. These events have been used to construct a short history of the development of the technology which serves as an introduction of the discourse.

Second, several interview questions deal with the beliefs of the actors. These beliefs are the basis of the analysis, because similarities in beliefs determine the coalitions. On the other hand, the differences in beliefs determine the conflicts. The interview questions deal with general beliefs on the technology and a couple of specific beliefs. These specific beliefs are beliefs on the long term potential of a technology, the desirable scale of implementation and whether the technology will result in a lock-in. The respondents have been questioned about these specific beliefs because these technological aspects play an important role in conflicts between coalitions within the discourses studied.

As argued, the coalitions can be derived from the shared beliefs of different actors. Additionally, two interview questions deal with the actors that agree and disagree with the interviewed actor. These questions give more insight in the division of actors over the different coalitions and the competing lobby activities.

Beside the conflicts between coalitions of actors, the interviewees have been asked specific questions about their own organization. First of all, the respondents were asked directly for the specific goals and interests of their organization. Second, they were asked whether the organization is directly involved in the implementation of the technology. Third, the

respondents were asked whether they supported other technologies beside the technology under study. By asking these specific questions, an overview of the important goals and interests of the involved actors could be obtained.

Finally, three additional interview questions deal with the cooperation with other actors and resulting specific lobby activities. To measure the impact of the cooperation, the respondents were questioned about the outcomes of the conflicts and whether activities have started in the technological innovation systems as a result of the cooperation. Examples of these activities are government policy, investments in infrastructure and changes in the market.

3.4.3. Data analysis

The analysis of conflicts consisted of three steps. First of all, the arguments for supporting or opposing the specific technology have been labeled within the interview results. These arguments form the beliefs of the actors on the specific technology. Second, these labeled parts of the interviews have been gathered in groups of similarity. From these groups of similar beliefs, the coalitions could be derived. For example, several car manufacturers, filling station entrepreneurs and the municipality of Haarlem form the Automotive Natural Gas coalition, because all three actors strongly support automotive natural gas as a cost effective solution for environmental problems. As argued, the cooperation between actors does not play a role in determining the composition of the coalitions. Finally, the differences in beliefs between the coalitions provided an explanation for several conflicts. For example, the conflict on the effects of biofuel production has resulted from a difference in beliefs on the impacts of biofuel production on food markets.

Additionally, the specific interests and goals of individual actors have been labeled within the interviews. Often, these goals and interests not only resulted from the direct interview questions, but also from the actor beliefs that were not shared with other actors. These actor specific beliefs often also indicate the interests of an individual actor. For example, the oil industry was the only actor who argued that automotive natural gas has no environmental benefits compared to LPG. Apparently, this argument is only important for this industry and therefore, it also gives information about the interests of this industry.

Finally, the cooperation between actors within a coalition and the effects on the TIS have also been measured with the interviews. The cooperation has been measured by asking whether the interviewed actor pursues a lobby with other actors. For this research, a distinction between two types of cooperation is made. On the one hand, actors can cooperate with similar actors to defend the interests of an industry or to reach a common goal. On the other hand, actors can cooperate with other actors to form a broader political lobby. This second type of cooperation is especially important, because cooperation of a broad range of actors within political networks is often indicated as a crucial process for the formation of a TIS.

3.4.4. Synthesis

After the two case studies have been conducted, the synthesis will provide the lessons with respect to theory and the lessons for policy makers. The comparison of both cases provides

information about the general patterns that can be found in political discourses. These general patterns result in the theoretical lessons. The causes of the conflicts, the interests of the actors involved and especially the role of the government in the discourse result in lessons for policy makers.

4. Case 1: Biofuels

This chapter will elaborate on the first case of the research, the biofuels case. First of all, the basics of the technologies will be given. Second, the biofuels discourse will be introduced. Third, an overview of the most important conflicts between coalitions that form the biofuels discourse will be given. The fourth section will elaborate on the specific goals and interests of individual actors and the cooperation between the actors within the coalitions.

4.1 Introduction of biofuel technologies

In this research, the common distinction between first and second generation biofuels is used. Moreover, biofuels can be used in two ways for transport: they can be blended with fossil fuels or they can be used in their pure form [21]. It is possible to use petrol or diesel with small biofuel percentages in modern cars and infrastructure. In current policy, blending is the main route: the Dutch government has set a target of 4 percent biofuels in 2010 through blending [22]. The use of pure biofuels results in more CO_2 reduction, but this option also requires car and infrastructure adaptation [21]. The rest of this section will elaborate on first and second generation biofuel technologies. For this research, the two most important biofuels are bioethanol and biodiesel, both for first and second generation.

4.1.1. First generation biofuels

In general, first generation biofuels are based on agricultural food crops [21]. First generation biofuels are produced and used as follows.

Bioethanol is produced through the fermentation of sugars. For the first generation, these sugars are obtained directly from sugar beet or sugar cane. Another possibility is to use potatoes and various sorts of grains, but then the large molecules have to be broken down to smaller sugar molecules first [23]. Each of these crops is also used for food production. Bioethanol can be blended up to 20 percent with petrol in current petrol engines [23,24].

Biodiesel is produced by mechanically pressing pure vegetable oil from agricultural crops, for example rapeseed. It is possible to use the oil product in diesel engines, but engine adaptations are required. The pure oil cannot be blended with diesel, because the molecule structures are large and branched. Therefore, it is necessary to break these structures down to smaller straight chained molecules to be able to blend the product with diesel [23]. Without significant adaptations to the diesel engine, blending up to 20 percent is possible [24].

4.1.2. Second generation biofuels

Second generation biofuels are generally based on woody energy crops (for example willow, popular or miscanthus), agricultural and forest residues or waste woods [23]. The most important second generation biofuels are cellulosic ethanol and Fisher-Tropsch diesel.

Cellulosic ethanol is also ethanol from fermentable sugars, but cellulosic biomass is converted to these sugars first. This is done by breaking down the complex molecular structures of this biomass through hydrolysis or the use of enzymes [23]. Because the bioethanol product is

roughly equal to first generation bioethanol, it can only be blended with petrol up to 20 percent without adaptations to petrol engines.

In the Fischer Tropsch process, the biomass is converted to syngas by gasification. The resulting syngas is a mixture of combustible gases, consisting mainly of CO, CO_2, hydrogen, methane, water and nitrogen. After removing nitrogen and tars as much as possible in gas cleaning, the hydrocarbons are converted to hydrogen. In the next step, a part of the CO reacts with water to produce hydrogen and CO_2 (the water-gas shift). A certain ratio of CO and H_2 remains for the synthesis, in which the syngas can be converted to a broad range of hydrocarbons. Through this process, Fischer-Tropsch diesel is produced, which can be used in conventional diesel engines. When the engine is modified to exploit the qualities of the fuel, it is possible to achieve more CO_2 reduction [23].

4.2. Introduction to the discourse on biofuels

4.2.1. Historical background of biofuels (1990-2003)

In the early 90s, the most important driver for the development of biofuels was not mitigating climate change, but the decline of the agricultural sector. France and Germany, countries with a large agricultural sector, were starting a lobby in the EU for the support of biofuels as a new market opportunity for farmers [5,33,36,37,40,41,43]. Therefore, the main driver for biofuels in this period was economic and there was no urgency for sustainable transport.

At the end of the 90s, the climate change issue became more important. The pressure to reduce CO_2 increased for the EU and its member states [5]. Biofuels were still primarily presented as an economic opportunity for the agricultural sector, but with the additional benefit that they were CO_2 neutral [40]. At the beginning of this century and especially since 9/11, the security of supply issue became more important [5,40]. Since then, economic opportunities for agriculture, CO_2 mitigation and security of supply have always been the main arguments for supporting biofuels [40,41,43]. The result was an European Directive in 2003, which obliged member states to meet goals for sustainable transport [5,36,41]. This Directive included all renewable alternatives in transport. However, biofuels were perceived as the most significant option on the short term, so this Directive more or less became known as the Biofuel Directive [33,40].

4.2.2. The formation of a countermovement

Until the publication of the European Directive, there was a generally positive perception of economic gain for agriculture combined with mitigating climate change and security of supply [36,37,40,41]. However, after the publication of the Directive, a serious countermovement took off, initiated mainly by environmental NGO's [5,37]. These NGO's had criticized biofuels since the end of the 90s [5,33], but this time they were joined by the oil industry and academia [30,34,40]. The cost effectiveness and environmental gains of biofuels were criticized in several scientific papers [41,43]. An important argument was that it is much more efficient to produce electricity from biomass when the whole production chain is considered [34,40,41]. The EU and the national government have reacted to this movement by

saying that every sector has to reduce CO_2 and there was no exception for the transport sector [41].

Through time, an increasing amount of scientific reports on low CO_2 reduction potentials and indirect land use effects were emerging [40]. An important event in the discussion was the use of palm oil for producing electricity by a Dutch energy company in 2006 [36,41]. Several environmental NGO's were criticizing this company and also the government for subsidizing this project, because they saw alarming signals of land conversion in developing countries, which would lead to the loss of rain forests and its biodiversity [34]. Meanwhile, these NGO's were also starting the debate on the effects of biofuels on the food market [43]. As a consequence, the national government started to realize that production of biofuels has to be sustainable and that total environmental gains could be much lower than expected [36].

4.2.3. Discussion on first and second generation

Through time, the contrast between first and second generation biofuels became increasingly important in the debate. Second generation has always been embraced by politicians, because land use is much lower and no food crops are used, so competition with food markets is avoided. However, the industry and academics saw that second generation would not become technologically mature and cost effective on the short term [43]. Consequently, the government faced a difficult dilemma: first generation biofuels were considered as the only feasible option to meet the EU goals, but they were also controversial [34]. During the implementation of the EU Directive in the Netherlands, a political discussion started on the choice between first and second generation biofuels and whether investing in the first generation is necessary to implement the second generation [34,43].

4.2.4. Food-fuel discussion

In 2008, a large increase in food prices occurred. This increase led to food riots in developing countries, which generated much publicity [34]. Therefore, the biofuels discourse transformed from a political discussion towards a broader societal discussion [30,31,32,37,42]. Not only NGO's, academia and the government were involved in this discussion, but also several industries and the media. The central issue in this discussion became whether food crops should be used for biofuel production [30,37,40]. Various actors have argued that food crops should never be used for the biofuel production again [33]. A discourse between these actors, the government and industry still continues, in which different beliefs are underlying the positions of the different coalitions and many interests play a role. In the next sections, I will elaborate on these coalitions, beliefs and interests in detail.

4.3 Overview of the biofuels discourse

4.3.1. Introduction

Before the most important conflicts within the biofuels discourse are presented, the coalitions within this discourse have to be introduced. The following coalitions play a role within the discourse.

1. The **Biofuels Critics** are skeptic about the potential of biofuels in general in the transport sector. Furthermore, they argue that both first and second generation biofuels should be implemented very carefully, because the direct and indirect effects of the production of biofuels are unclear.
2. The **Second Generation Coalition** believes that first generation biofuels are not necessary to accomplish the transition towards second generation biofuels. Therefore, this coalition proposes to skip the first generation and invest mainly in the second generation.
3. The **Step up Coalition** stresses that development of first generation biofuels on the short term is a necessary stepping stone towards large scale production and use of second generation biofuels on the long term.
4. The **Sustainable Biofuels Coalition** believes that biofuels are a promising alternative for fossil fuels on the short term, regardless of their generation. However, this coalition also stresses that it is imperative that the production of the biofuels is sustainable. Unsustainable biofuels should not be used in the Dutch transport sector.

In 4.3.2 to 4.3.4, the most important conflicts that form the biofuels discourse are presented. The overview of the conflicts is given by focusing on the specific differences in beliefs that cause the conflicts between coalitions.

4.3.2. Discussion on the use of biofuels in the transport sector

First of all, there is a discussion between the coalitions on whether biofuels should be used at all in the transport sector. The conflict between the coalitions is shown in Figure 4.1.

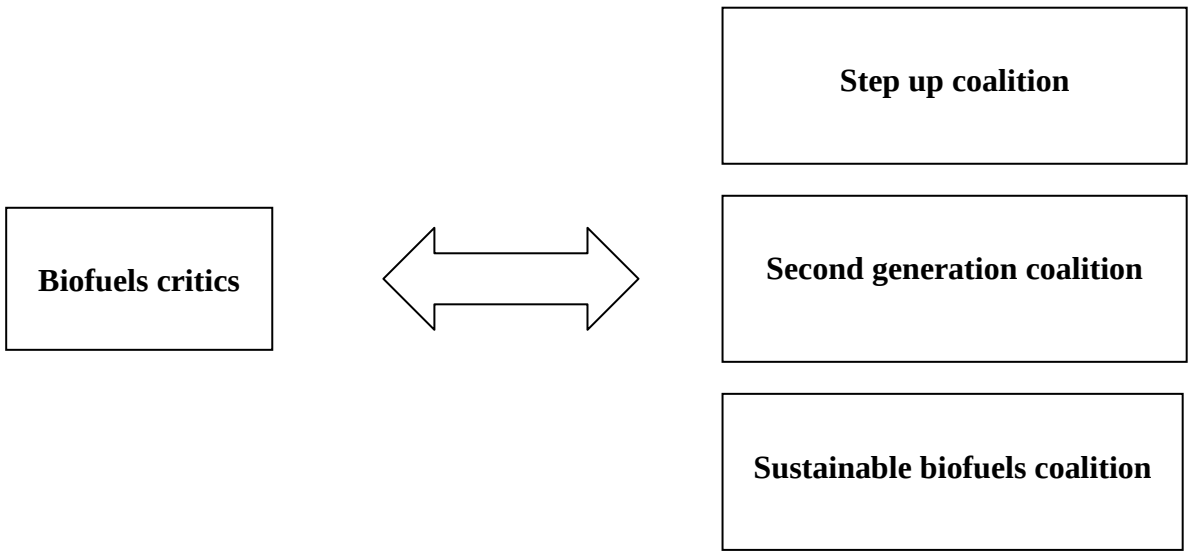

Figure 4.1: Schematic representation of the discussion on the use of biofuels

On the one hand, the biofuels critics doubt whether biofuels should be used in the transport sector. Biofuels are energy intensive and as a consequence, the CO_2 reduction potential is too small [34,40]. First of all, an internal combustion engine is still used, which is relatively inefficient. It would make more sense to produce electricity from the biomass and use this electricity in electric cars, which are much more efficient [34,40]. Second, the production of first generation biofuels results in considerable greenhouse gas emissions. Since there are also other environmental problems with biofuels production, the total environmental gains are not significant [34]. Finally, second generation biofuels are more promising, but the production potential seems to be limited when certified biomass and residues are used as feedstocks [34,40].

The other coalitions in the biofuels discourse do believe in the potential of biofuels in the transport sector. Because fuel cell cars and electric cars are not available on the short term, biofuels is one of the few alternatives that can provide CO_2 reduction in the transport sector on the short term [36,43]. Furthermore, the necessary changes to the infrastructure and cars are minor compared to electric or fuel cell cars [33,37,42,45]. With the right feedstocks and production processes, considerable CO_2 reductions can be achieved with biofuels [30,37,41].

4.3.3. Discussion on the effects of biofuel production

The discussion on the effects of biofuel production has been a central issue in the biofuels discourse. The conflict between the different coalitions is shown in Figure 4.2.

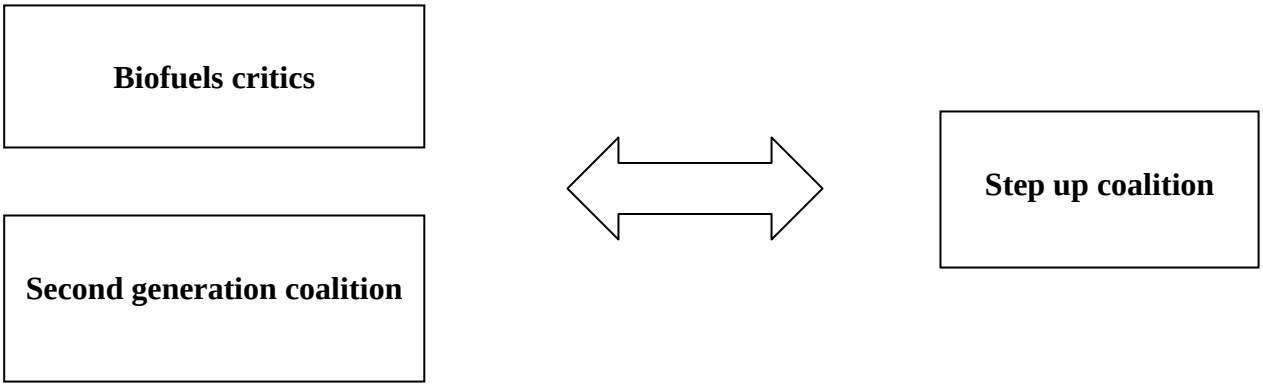

Figure 4.2: Schematic representation of the discussion on the effects of biofuel production

On the one hand, the biofuel critics and the second generation coalition believe that the production of biofuels will have serious effects on food production and biodiversity. These effects result from the changes in land use that are caused by biofuels production. The biofuels critics believe that the production of biofuels will result in rising food prices, because food crops are used for biofuels production and consequently, the demand for these crops will rise rapidly [34,40]. Furthermore, more arable land will be necessary for producing large amounts of biofuels, which will be devastating for local biodiversity, especially rain forests [34]. Because it is possible that structural land use effects will also occur for second generation biofuels, the biofuel critics believe second generation should also be used with caution [34,40]. The second generation coalition is also worried about the land use effects, but

they believe second generation biofuels will solve the problems, because these biofuels are not produced from food crops and land use is much lower [31,33,42].

The competing coalition in this discussion is the step up coalition. This coalition believes that land use effects will not occur when first generation biofuels will be used on a relatively small scale [30,41]. The recent food price increases have mainly been caused by decreasing food surpluses and low yields [41]. The influence of biofuels on food markets was very small [41] and the land use effects are very uncertain [30]. However, these actors recognize that large scale first generation production will lead to undesirable effects in food markets [41]. Fortunately, this problem is much smaller for second generation biofuels. As long as first generation production capacity does not become too large and the future growth will be covered by second generation, significant land use effects will not occur [30,41].

The sustainable biofuels coalition consisting of government actors has to find a compromise between both sides in the discussion. While this coalition believes in biofuels as a significant option for reducing CO_2 on the short term, it also stresses that the production of biofuels should be sustainable [36,37,43]. Furthermore, the distinction between first and second generation is not very useful, because first generation is not always worse on CO_2 reduction and indirect effects than second generation. Therefore, it is more useful to evaluate biofuels on their effects. To this end, the government has developed sustainability criteria for biofuels. The most important criteria are CO_2 reduction, land use and innovativeness [36,37,43]. In the beginning of June 2009, the Renewable Energy Directive (RED) has been published, in which the sustainability criteria have been determined on a European level [36,41,43]. Furthermore, the government also subsidizes innovative biofuels with high CO_2 reductions and low land use through the Innovative Biofuels Program [36,37,43]. With these measures, this coalition of government actors tries to induce selection in the market, in which the biofuels that use much land for production are excluded [37,43].

4.3.4. First generation lock-in discussion

The third important discussion within the biofuels discourse is whether first generation is a necessary step towards second generation. The conflict between the different coalitions is shown in Figure 4.3.

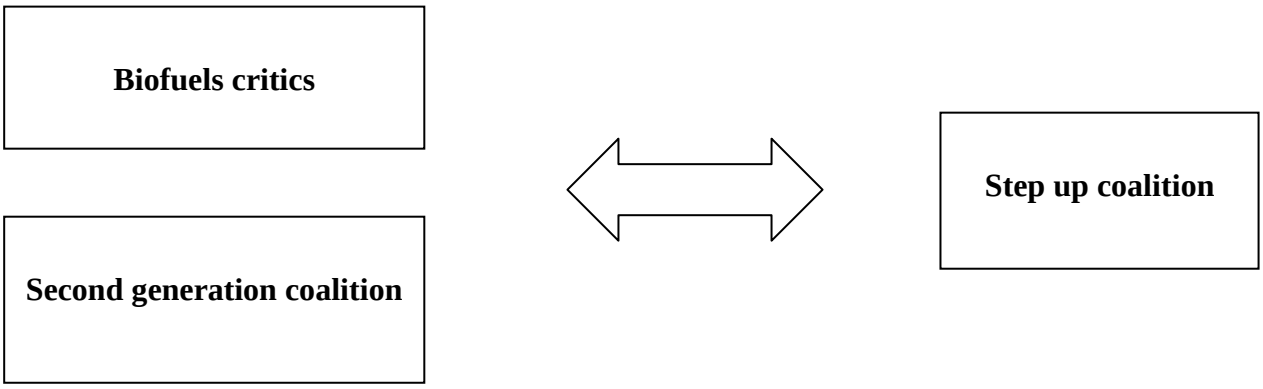

Figure 4.3: Schematic representation of the first generation lock-in discussion

On the one hand, the second generation coalition and biofuel critics believe this step up effect of first generation is small [31,33,34,40]. The biofuel critics generally think the learning effect of first generation is small, because different knowhow and processes are needed for second generation biofuels [34,40]. Moreover, an industry with its own economic interests is created around first generation, which is not desirable for the long term. When first generation production becomes too large, an undesirable lock-in has been created [34].

The second generation coalition believes that the first generation is not necessary to accomplish the transition towards second generation, especially for biodiesel. Therefore, it proposes to skip first generation and invest mainly in second generation [31,33,42]. When first generation bioethanol would be produced in a sustainable way and the fuel would be competitive in the Netherlands, it would be a step towards second generation, because both processes do not differ much [31]. On the other hand, the fundamental barrier is the technology for converting wood to sugars, which is still very expensive. Therefore, it is also questionable whether it is helpful to invest in first generation production capacity, which is not innovative at all [33]. Second generation biodiesel is completely different from first generation [31,33] and the industry that is emerging around first generation creates undesirable lock-in effects [31]. Especially the car manufacturers and oil industry are involved in a large discussion with this industry, because they argue that the fuel quality is too low, which causes technical problems [31,41]. The quality of second generation biodiesel is much higher, possibly even higher than the quality of fossil diesel [33]. Therefore, these industries are not interested in first generation biodiesel and focus on the second generation.

The competing coalition is the step up coalition. The actors in this coalition are convinced that the only way to acquire the necessary preconditions for second generation is to start with first generation at present [30,41]. Second generation is currently too expensive and not technologically mature yet. To make the transition towards second generation biofuels economically feasible, it is imperative that a market, production capacity and distribution infrastructure already exist for biofuels [30,41]. Otherwise the investments and entrepreneurial risks of building a second generation plant are too large and consequently no second generation plants will be built [30]. As argued, there are also technological reasons to start with first generation bioethanol, because a second generation plant is largely identical to a first generation plant. Therefore, investing in first generation can lower the investment barrier of second generation bioethanol. For biodiesel, first and second generation processes are completely different, but a market and infrastructure are still necessary [30].

Finally, the sustainable biofuels coalition is less involved in this discussion, because this coalition evaluates biofuels on their effects instead of using the distinction between first and second generation. However, this coalition does provide a compromise with the sustainability criteria, because they prevent a lock-in into undesirable biofuels. These biofuels with low CO_2 reduction potentials and high land use are not allowed on the market [37,43].

4.4. Actors

This section elaborates on the specific goals and interests of actors within the coalitions and whether there is cooperation between actors. An overview of the actors within the coalitions is shown below in Figure 4.4.

Biofuels critics (4.4.1) Environmental NGO's Netherlands Environmental Assessment Agency Food industry	**Second generation coalition (4.4.2)** Public transport ECN Car industry
Step up coalition (4.4.3) Alcohol industry Oil industry	**Sustainable biofuels coalition (4.4.4)** Ministry of Transport Ministry of Environment SenterNovem

Figure 4.4: Overview of the actors within the coalitions

4.4.1. Biofuels critics

As mentioned in 4.3, the biofuel critics argue that the potential of biofuels is limited and implementation of biofuels should be done very carefully. In general, the actors within this coalition do not engage in coordinated activity to influence policy. Instead, they act independently, although they have similar beliefs on biofuels. This section will elaborate the specific goals and interests of the actors within the coalition.

As argued, the **environmental NGO's** have criticized biofuels since the end of the 90s. They generally pursue this lobby without cooperating with other actors [34]. One of their main goals is to prevent the possibly catastrophic effects of climate change. Therefore, CO_2 reduction is a very important criterion in their assessment of technologies. As a consequence, the NGO's give more support to radical alternatives such as electric cars than to biofuels, because these radical alternatives have the largest CO_2 reduction potential. Additionally, environmental NGO's strongly emphasize that CO_2 reductions should not be realized at the expense of food production or biodiversity. Due to the combination of limited CO_2 potential and risks for undesirable effects, the NGO's criticize the use of biofuels in the transport sector and entirely reject first generation biofuels [34].

The **Netherlands Environmental Assessment Agency (NEAA)** aims to evaluate Dutch environmental policy in an objective and independent way. It tries to provide as much information as possible to politicians and to assess alternatives objectively on CO_2 reduction potential and the effects on local air quality and biodiversity [40]. In its independent role, this institute does not intend to cooperate in lobby activities with other actors. Based on its evaluations, the agency believes that implementation of both first and second generation

biofuels should be done very carefully. It is technically possible to grow second generation woody crops on degraded land, but the local effects on water availability and the economic feasibility are uncertain. Furthermore, the potential of sustainable biomass is limited, so the most important issue is where this biomass needs to be applied. Since transport is a relatively energy intensive activity and other sectors also need renewable energy, the transport sector might not be the best choice for implementing biofuels [40].

Finally, the **food industry** has played an important role in the discourse. When the food prices rose to a maximum in 2008, the food industry has pursued a lobby against biofuels. Many food commodities are an input to their production process and therefore the food industry was directly affected by the price increases. As a consequence, it was mainly due to commercial interests that the food industry has pursued this lobby against biofuels [30,33].

4.4.2. Second generation coalition

As argued in 4.4, the second generation coalition believes that first generation biofuels are not a necessary step for implementing second generation biofuels. In general, the actors within this coalition do not cooperate within the discourse, even though they have similar beliefs on biofuels. This section will elaborate on the specific goals and interests of the actors within the coalition.

Public transport often functions as an early market for sustainable transport alternatives. Public transport companies evaluate all alternatives on costs, emissions, other environmental characteristics and reliability [42]. Reliability is important for public transport because the fines for cancelling buses in the timetable are very high. Due to this economic risk, a public transport company cannot experiment with unproven technology. The consequences for maintenance are also important, but that is essentially also part of the costs [42]. When these interests are taken into account, biofuels are a significant option for decreasing emissions, since not many significant changes have to be made to current practice. Consequently, relatively low investments are necessary and risks for reliability are lower since the firms are familiar with using liquids. For bioethanol specifically, the high costs are the most important reason to reject the technology at present. However, the high costs are caused by the tax regime in the Netherlands. Bioethanol becomes an economically feasible option when it is exempted from taxes.

Although biofuels are considered as a promising option, first generation biofuels have been rejected by public transport. The most important reason has been the societal debate on the effects of the production of first generation biofuels. This debate has been especially important for biodiesel. Public transport firms do not wish to get involved in this debate. They comply to the political sentiment because they have a corporate social responsibility. Therefore, public transport believes first generation biofuels should not be used and the focus should be on development of the second generation, especially for biodiesel [42].

Energieonderzoek Centrum Nederland (ECN) is an independent advisor on energy and environment in the Netherlands. Its most important task is to determine the impact of

technological developments on the energy system and the environment. ECN often writes policy packages for the government in which it shows which policies the government has to implement depending on its political choices [33]. Since ECN has this objective and independent role, it does not cooperate with other actors within the coalition. For biofuels, the important evaluation criteria are CO_2 reduction potential, land use, innovativeness and security of supply. When ECN performs an analysis of biofuels in the Dutch transport system, second generation biofuels have positive results on all criteria. Therefore, ECN has advised that commercialization of second generation biofuels must be a goal of the government [33].

The **car industry** evaluates biofuels on costs, energy efficiency, emissions and fuel quality. When biofuels are considered by this industry, the general conclusion is that first generation is not a desirable path at the moment. Second generation is much more promising [31]. Bioethanol, especially second generation, is a promising transition path, because ethanol with the right feedstocks can have large CO_2 reductions without unsustainable effects on land use and without competition with food markets. However, the most important problem that stops the use of bioethanol in the Netherlands is that it is far too expensive. As long as the price of bioethanol is not competitive with the price of petrol, flexfuel cars will not be attractive for the consumer and as a consequence, bioethanol is not a feasible option for the car industry [31]. First generation biodiesel has generally been rejected by the car industry, due to the societal debate on the effects of biofuel production and the relatively low fuel quality. On the other hand, second generation biodiesel has the potential to meet the demands of car manufacturers in costs, emissions and fuel quality [31].

4.4.3. Step up coalition

As argued in 4.3, the step up coalition believes that first generation biofuels are a necessary step to realize large scale use of second generation biofuels. This coalition consists of the alcohol industry and the oil industry. These are two large industries who have many resources to pursue their own lobby. As a consequence, these industries do not cooperate within this coalition. This section will elaborate on the specific goals and interests of the actors within the coalition.

The **alcohol industry** believes biofuels are a market opportunity. There were plans for a first generation plant in the Netherlands, but this project has been cancelled, because it is not possible to compete with imported ethanol in the Netherlands. This is caused by too much tax and too low subsidies and import tariffs on bioethanol [30]. In the alcohol industry, cheap feedstocks are important to make a profit, so second generation is very promising for the future, both for traditional markets and the biofuels market. Consequently, the industry works on R&D for second generation. The societal debate on biofuels has not influenced the decision to focus on second generation, this was a purely economic decision [30]. However, the discussion did have a strong influence on the market for biofuels, because important early markets such as public transport and lease firms have rejected first generation biofuels when they became too controversial [31,32,42]. The alcohol industry has been involved in the discourse to look after its commercial interests, because the debate was very one-sided, mainly dealing with the negative impacts of biofuels. As argued, this industry is convinced

that the implementation of first generation biofuels is necessary to provide a stepping stone for second generation. On the other hand, the alcohol industry does believe it is important to use second generation biofuels for large scale implementation on the long term, because land use effects are much less severe [30].

At present, the **oil industry** is blending a few percents of biofuels into petrol and diesel. The oil industry selects alternatives on costs, environmental performance, fuel quality, the fit to the current infrastructure and consumer preferences. Especially the last two criteria are important for the oil industry specifically, because it has a commercial interest in the current infrastructure and consumers are used to liquid fuels. Biofuels will become more important for the oil industry in the future, because as oil becomes more expensive, liquid biofuels are a promising alternative [41]. Most R&D of the oil industry itself is focused on advanced second generation biofuels technology, because this industry also believes that biofuels should not compete with food products and the CO_2 reduction has to be much higher than first generation. Second generation is also an important goal because the quality of the fuel is better, especially for biodiesel [41]. However, at the same time the oil industry believes first generation biofuels is a necessary step towards implementation of the second generation. The industry will have to learn much about organization, logistics and safety of biofuels production and exploitation before the more advanced biofuels can be commercialized. Furthermore, the use of biofuels has to be tested because it differs from fossil fuels.

4.4.4. Sustainable biofuels coalition

The actors in the sustainable biofuels coalition believe biofuels should be evaluated on their effects instead of using the first and second generation distinction. The coalition consists of government actors, which have similar beliefs and cooperate in implementing biofuels. On the one hand, this coalition believes biofuels are an important option to reach the short term CO_2 reduction goals that have been set by the EU. On the other hand, the national government believes biofuels production has to be sustainable. The criticism of the environmental NGO's and academia on the sustainability of biofuels has played an important role in the process. As a consequence, the coalition has changed its policy in two ways.

First of all, it has lowered the national goals for biofuels for 2010 from 5,75 percent to 4 percent [30,37,40]. While the pressure of the environmental NGO's led to this decision, the market players perceived it as a lack of support. The probable result is that they will invest less in biofuel production [30,33,37]. Second, the coalition has developed sustainability criteria. The most important criteria are innovativeness, CO_2 reduction and land use. These Cramer criteria have been adopted to exclude unsustainable biofuels from the national market [30,34,36,37,41,43]. Additionally, the criticism has led to a constant pressure to work on the development of second generation biofuels [33,43]. This pressure has led to the Innovative Biofuels subsidy program, in which more innovative biofuels that reduce large amounts of CO_2 and use small amounts of land are supported [43].

After the development of the Cramer criteria, the Netherlands was one of the countries that has taken the initiative to develop sustainability criteria on EU level, resulting in the

Renewable Energy Directive [36,41,43]. This Directive is crucial, because as a result, the large European market asks for sustainable biofuel production [36]. The intended effect is that firms will start investing in high quality biofuel products which bring more CO_2 reduction and are produced in a sustainable way [33,37,43].

5. Case 2: Automotive Natural Gas

This chapter will elaborate on the second case of this research, the automotive natural gas case. First of all, the basics of the technologies will be given. Second, the discourse on automotive natural gas in the Netherlands will be introduced. Third, an overview of the most important conflicts between technology specific coalitions will be given. The fourth section will elaborate on the specific goals and interests of individual actors and the cooperation between the actors within the coalitions.

5.1. Introduction of technologies

Although the focus of this research is on automotive natural gas (ANG), several other technologies are also important. Actors can introduce other technologies in the interviews, because they believe that these technologies are more promising than ANG for the short or long term. Therefore, this introduction also has to elaborate on the (plug-in) hybrid vehicle, the electric vehicle and the fuel cell vehicle.

5.1.1. Automotive Natural Gas (ANG)

Automotive natural gas is identical to the natural gas that has been used for producing heat and power for decades. Natural gas can be used in internal combustion engines in quite the same way as petrol. For using natural gas in diesel engines, the dual fuel concept can be used, in which a small amount of diesel ignites the natural gas mixture [25]. Automotive natural gas can be distributed as compressed natural gas (CNG) or liquid natural gas (LNG). CNG is gaseous and has to be stored at high pressures. LNG is stored in liquid form at very low temperatures [25]. When a biological feedstock is used, for example waste streams or residues, ANG can be obtained in the form of biogas.

5.1.2. Hybrid Electric Vehicle (HEV)

A hybrid electric vehicle (HEV) is a car with a conventional petrol or diesel engine complemented by an electric motor and a battery pack. With a HEV, it is possible to reduce fuel consumption with 15 to 25 percent [25]. These fuel savings are possible due to the more efficient electric motor, which can provide a part of the power. When the car is at higher speeds and the engine is more efficient, the batteries are charged. The energy stored in those batteries can be used by the electric motor to provide a part of the power at lower speeds in urban areas, where the internal combustion engine is the least efficient. When the electric motor provides a larger part of the power, the engine can be downsized, which results in a higher overall efficiency and as a result, lower fuel consumption and CO_2 emissions [26]. However, a larger electric motor and more batteries are required to achieve equal performance. The next step is to drive fully electric without using the internal combustion engine. Using a plug-in hybrid, which can be charged at home, can reduce fuel consumption further. In the end, the plug-in hybrid can be converted to an electric vehicle (EV) by removing the internal combustion engine [26].

5.1.3. Fuel Cell Vehicle (FCV)

The fuel cell vehicle is quite similar to the electric car, the only difference is that it has a fuel cell instead of batteries. The fuel cell delivers electricity and heat through an electrochemical reaction, in which hydrogen and oxygen produce water [5,27]. In this process, the hydrogen gas moves into the fuel cell towards the anode. At the anode, the protons and electrons of the hydrogen gas are split into hydrogen ions and electrons. The hydrogen ions move through the electrolyte to the cathode, while the electrons have to move through an external electric circuit [5]. It is this electric current which can be used for producing power for driving vehicles or other purposes. However, one single fuel cell delivers a small amount of power, so a large stack of fuel cells is needed to provide enough power to meet the power demand of a passenger car [5]. A single fuel cell and a fuel cell stack are shown in Figure 5.1.

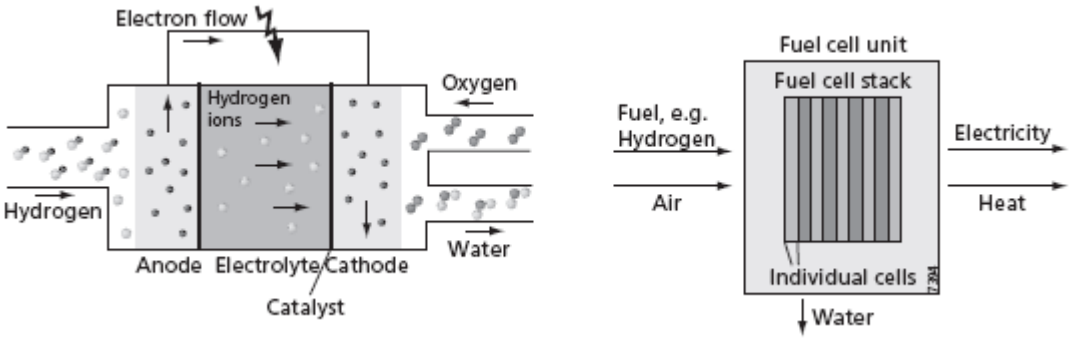

Figure 5.1. Schematic representation of a fuel cell and a fuel cell unit [5]

A fuel cell is more efficient than an internal combustion engine: about 60 percent against 20 to 25 percent [28]. On the other hand, hydrogen has to be produced first, which costs a considerable amount of energy. Therefore, most energy is lost in the production of the fuel, while the end use is relatively efficient. Moreover, a completely new infrastructure has to be built for the distribution of the fuel. Subsequently, the hydrogen has to be stored in compressed or liquid form before it can be used in the fuel cell. It is also possible to use methanol, gasoline or natural gas as a fuel. These fuels are reformed on-board to hydrogen, which is in turn supplied to the fuel cell.

5.2. Introduction to the discourse on automotive natural gas

5.2.1. The take-off of automotive natural gas

While the development of automotive natural gas already began in the 1970s as a reaction to the oil crisis [5], the first significant driver for the use of ANG in the Netherlands emerged in the beginning of this century, when the EU sharpened the air quality norms for cities [34,38,42]. These norms have been implemented in Dutch law in 2001 [5]. As these norms started to press on the economic activities within municipalities, especially in construction, serious economic consequences of these norms were visible for the first time [34,37,38]. As a consequence, ANG became interesting for municipalities, because natural gas vehicles had much lower NO_x and PM emissions, which are responsible for worsening air quality and the resulting health problems [5,31,35,44].

5.2.2. The start of the implementation of automotive natural gas

From 2004, public transport buses have been a suitable market to enforce lower emissions, because the municipalities have relatively large influence on this market through the concessions [31,37,42]. Municipalities can more or less demand the type of bus in these concessions [5]. The municipality of Haarlem has been a front runner in the development of ANG, since it was the first municipality which implemented natural gas buses [39,44]. When these buses were implemented, the large incumbent industries were resisting ANG for the first time [35,37,39,44]. This resistance originated mainly in the oil industry and the car industry, because several firms in these industries perceived natural gas buses as a threat to their market shares [35,39,44]. On the other hand, natural gas companies, filling station entrepreneurs and several car manufacturers started investing in ANG [5,31,35].

5.2.3. The ANG lobby and government support

Resistance against ANG also came from within the government, because the Ministry of Environment was not willing to support ANG with fiscal measures [37,44]. The Transition Platform for Sustainable Mobility, a public private partnership, has been pushing for these supporting measures [5,33,37,44]. This platform and ANG market actors started to develop a business case for a lower tax rate on natural gas [35,37,38]. The basic idea was that lower tax revenues are compensated by lower health costs [35,38]. At the end of 2006, their efforts finally resulted in the setting of a low excise rate by the government [35,37,39,41].

The government support triggers more initiatives within municipalities and as a result, more municipalities are implementing ANG buses [35,44]. Market parties were also starting to invest in a national filling station network for ANG [35,37,44]. The absence of this network is widely perceived as the largest obstacle in the implementation of ANG on a larger scale, because the value of such a network is high for private investors and individual consumers [32,35,37,41].

5.2.4. Emergence of the ANG discourse

As a consequence of the governmental support of ANG, a discourse on the desirability of ANG had started. One of the most important elements of this discourse became whether it is worthwhile on the long term to do these large investments in a filling station network [31,40,41,42]. The short term air quality advantages were clear, but whether ANG fitted within a long term transition towards sustainable mobility was much more debated. This debate intensified when the climate change issue was increasingly gaining attention in 2006, pushing the air quality issue to the background [37,39]. Moreover, manufacturers that exclusively produce diesel vehicles have been working on lowering the emissions of their buses and have pursued a large lobby towards the government, especially since 2007 [37,38,39,44]. These actors basically argue that it is unnecessary to invest in ANG technology, because diesel can have the same emissions, for both CO_2 and air quality [38,39]. The combination of this lobby and the increasing attention for climate change in society has resulted in more criticism on ANG, while the general opinion was generally positive before [31,37]. As a consequence, the discourse on automotive natural gas has intensified, in which the most important issue is whether it is worthwhile to pursue the parallel ANG transition

path. The competition between ANG and diesel supporters plays a central role in this discourse. The next sections will elaborate on the conflicts that form the discourse and the specific beliefs and interests of the individual actors.

5.3. Overview of the ANG discourse

5.3.1. Introduction

Before the most important conflicts between the coalitions are presented, the coalitions have to be introduced. The following coalitions are important within the ANG discourse.

1. The **ANG Coalition** believes it is imperative that investments are done in ANG infrastructure and biogas production at present. On the short term, ANG is the only cost effective sustainable solution for the environmental and political problems that are associated with the use of fossil fuels.
2. The **ANG Critics** do not believe in ANG as a preferable alternative for petrol and diesel on the long term. They believe ANG is only appropriate for niche applications with central fuelling stations in urban areas, for example buses.
3. The **EV Coalition** has a strong belief in electric cars as the solution for environmental problems, because these cars have no direct emissions. This coalition believes that, considering the enormous potential of the electric car, it is important to invest in this technology instead of ANG.

Finally, several actors consider ANG as one of the promising options for sustainable mobility. These actors believe it is important to develop all promising options, because it is impossible to choose between the alternatives in this early stage. Ultimately, economic feasibility and the suitability to different markets will determine which alternative is the best choice for each market.

In 5.3.2 to 5.3.5, the most important conflicts within the ANG discourse are presented. Again, the overview of the conflicts is given by focusing on the specific differences in beliefs that cause the conflicts between coalitions.

5.3.2. Short term discussion on air quality

First of all, there has been a fierce debate on the emissions of ANG vehicles and diesel vehicles, especially in the last two years. In fact, this is a discussion between two lobby groups, which are both trying to convince the governmental actors that their technology has lower emissions. As a consequence, this discussion is dominated by industrial players and the focus is on the short term effects on air quality [35,37,44]. This discussion is shown in Figure 5.2.

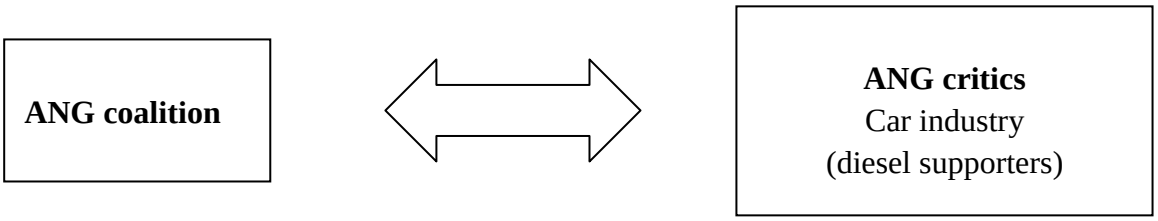

Figure 5.2: Schematic representation of the short term discussion on air quality

On the one hand, the ANG coalition strongly lobbies in favor of ANG. This coalition argues that ANG vehicles have much lower NO_x and PM emissions than diesel. Therefore, this coalition believes ANG is much more suitable for improving air quality [31,35,39]. The competing lobby comes mainly from the diesel supporters from the car industry, who argue that there will be no difference between diesel and ANG when the EURO6 norms are implemented in 2014 [33,42,44,45]. Furthermore, PM emissions have already declined much due to the use of filters in new diesel vehicles [33]. Since CO_2 emissions do not differ much, this coalition argues that investments in ANG are unnecessary [31,39,44]. As a result of the two lobby movements, governments make different choices in their support for the two technologies. Consequently, a division emerges between municipalities that choose to support ANG and municipalities that choose to support diesel [39,44].

5.3.3. Discussion on long term perspective

Despite the intense discussion on short term effects on air quality, most actors agree that natural gas vehicles have positive effects on air quality, due to their low NO_x and PM emissions. However, there is much more discussion on the long term perspective of automotive natural gas. This conflict is shown in Figure 5.3. The first part of this section will elaborate on the discussion on the long term perspective of ANG. Second, the discussion on the potential of biogas will be explained.

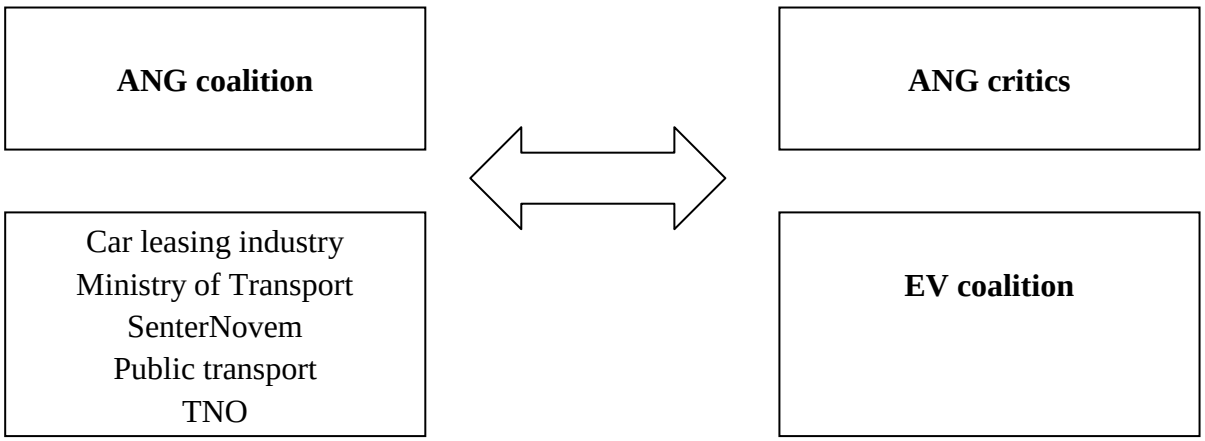

Figure 5.3: Schematic representation of the discussion on long term perspective of ANG

In the discussion on ANG, the ANG coalition and several individual actors believe that ANG can be a solution for air quality problems on the short term and that it has potential for increasing security of supply and mitigating climate change on the long term. First of all, as argued, ANG has much lower NO_x and PM emissions, which is beneficial for air quality

[35,37,39,44,45]. Second, in contrast with second generation biofuels, fuel cell cars and electric cars, ANG is already cost effective for firms and consumers [35,38,39]. Third, ANG also increases security of supply, because it is less scarce than oil and its sources are less concentrated in politically instable countries. Consequently, ANG is expected to be more price stable than petrol and diesel [32,35,44]. Fourth, the well-to-wheel efficiency of natural gas is higher, because refining and road transport are not necessary [35].

On the other hand, the ANG critics and EV coalition see much less potential for ANG on the long term. When the EURO6 norms will be implemented in 2014, ANG and diesel will have equal NO_x and PM emissions [33,42,44,45]. While large investments in ANG filling stations are necessary, the contribution of ANG to long term CO_2 reduction goals is relatively small [33,40]. Second, ANG vehicles have a lower driving range, which is caused by the lower energy density of natural gas. Therefore, ANG is less suitable for the consumer market [41]. Natural gas is a fossil fuel and not much improvements are expected for internal combustion engines in general. Therefore, the CO_2 reduction and cost reduction potentials are small. However, large investments must be done in ANG filling stations, which makes ANG a cost ineffective option with relatively low potential [33,40].

For the ANG coalition and several individual actors, the most important reason to invest in ANG is that it can be a stepping stone towards biogas [31,32,35,37,39,42,44]. This transition to biogas is crucial for the long term perspective of ANG. As argued, diesel vehicles and ANG vehicles will have equal NO_x and PM emissions in 2014, so there is not much perspective for ANG on the long term. However, the ANG infrastructure can be used to implement biogas, which is CO_2 neutral [31,32,35,37,39,42,44]. As a consequence, biogas can contribute to long term CO_2 reduction goals, which is an important reason to invest in the ANG infrastructure at present [31,32,42,44]. A second advantage of biogas is that it can be produced locally from waste [31,42]. As a consequence, it resolves security of supply issues [35] and creates additional economic activity [42]. Third, biogas has a high well-to-wheel efficiency and does not have the indirect effects and technical problems of other biofuels [31]. Finally, the ANG coalition also believes biogas can be a stepping stone towards hydrogen based transport, because decentralized production of hydrogen from biogas is very efficient [35].

According to the ANG critics and the EV coalition, biogas is a promising option, but it is uncertain whether the transition towards biogas will succeed. First of all, the future costs of biogas with natural gas quality are uncertain. It is imperative that biogas with natural gas quality will become cheaper than ANG, because otherwise users will continue using ANG [33,37]. Second, the availability of sustainable biomass is also uncertain [33]. Furthermore, the production potential of biogas is limited. Since households, industry and electricity production also need biogas in the future, it is doubtful whether it is sensible to implement biogas in the transport sector [33,40,41]. Finally, biogas is not a stepping stone to hydrogen, because hydrogen technologies are much more specific [33,41]. Altogether, these uncertainties bring a considerable risk of lock-in into ANG for the long term, which is a very undesirable development [33].

5.3.4. Discussion on government policy: norms or means?

The discussion on the most appropriate government policy for stimulating sustainable transport is strongly interlinked with the discussion on automotive natural gas. This discussion on government policy is known as the norms versus means discussion. Norms versus means is mainly an issue in public transport buses, so the focus will be on this market.

To support sustainable alternatives in the bus market, the government has two possibilities. The first possibility is setting norms: the government stimulates firms to reach a level of emissions at a certain point in time. Which technology is used for reaching the norms is not important. The second possibility is to stimulate firms to use a specific technology. Several municipalities have chosen to ask for ANG buses in their concessions [39]. These decisions have led to the norms versus means debate. This conflict is shown in Figure 5.4.

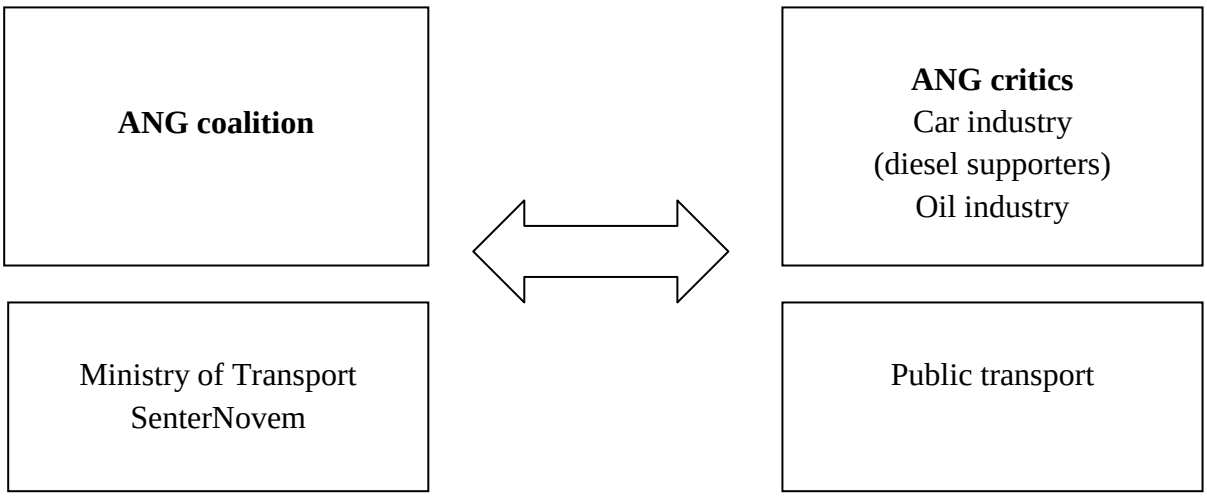

Figure 5.4: Schematic representation of the discussion on government policy

The oil industry, public transport and the diesel manufacturers from the car industry have been protesting the most against the means policies. These firms believe that stringent norms can have the same result as obliging the use of specific technologies. In their vision, the role of governments is to set norms and then firms will find the best economically viable alternative [37,41,42,44]. On the other hand, the ANG coalition and two government actors believe it is important to implement ANG at present [39,44]. When the government sets a norm, it is likely that the market will keep choosing diesel, because the costs are equal and the market actors are used to diesel [31]. Therefore, these coalitions believe the government should stimulate the development of the ANG and biogas path, because it can be an alternative for fossil fuels on the long term [44].

5.3.5. Discussion on the short term potential of electric cars

Since the summer of 2008, there has been a large renewed interest in electric cars. This renewed interest has led to many initiatives and much support for electric cars [31,38]. As a consequence, a discussion on the short term potential of electric cars has emerged. In this discussion, the ANG coalition and EV coalition differ considerably in their beliefs on electric cars. The resulting conflict is shown in Figure 5.5.

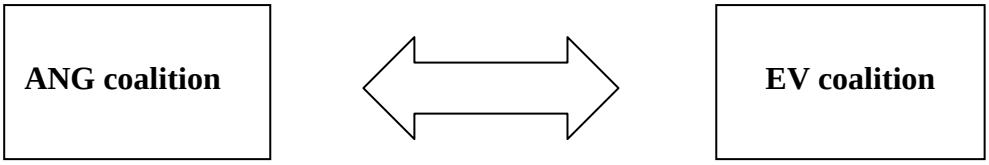

Figure 5.5: Schematic representation of the discussion on the short term potential of electric cars

The EV coalition is convinced that a part of the enormous potential of electric cars can be realized on the short term. Because electric cars have large emission reduction and cost reduction potentials and they can bring much economic development, the EV coalition believes this technology can also have better results on the short term compared to ANG technology [34]. On the contrary, the ANG coalition believes that electric cars are too expensive, polluting and unsafe for the short term [31,35]. Electric cars with a reasonable driving range need many batteries and these batteries are very expensive at present [31,37,45]. Electric cars have no emissions, but when the electricity is produced in a coal plant, the net emissions are higher than the net emissions of an ANG vehicle [31,35]. Finally, there are no full-fledged electric cars on the market yet. Until these cars are available, the safety of electric cars cannot be guaranteed [31].

5.4. Actors

This section elaborates on the specific goals and interests of actors within the coalitions and whether the actors cooperate within coalitions. An overview of the actors within the coalitions is shown below in Figure 5.6.

ANG coalition (5.4.1) Car industry Entrepreneur filling stations Municipality Haarlem	**ANG critics (5.4.2)** Car industry (diesel supporters) Ministry of Environment Oil industry Netherlands Environmental Assessment Agency
EV coalition (5.4.3) Environmental NGO's Municipality Amsterdam	Car leasing industry Ministry of Transport Public transport SenterNovem TNO

Figure 5.6: Overview of coalitions in the automotive natural gas discourse

5.4.1 ANG coalition

As argued in 5.4, the ANG coalition has a strong belief in ANG as a cost effective and sustainable solution for the environmental and political problems associated with the use of fossil fuels. Moreover, this coalition argues that ANG is the only feasible solution on the short term. This section will elaborate on the specific interests of the actors within the coalition and the cooperation between those actors.

Within this coalition, the **car industry** and **filling station entrepreneurs** are cooperating in the Aardgas Mobiel organization to lobby for ANG and biogas in the Netherlands [31,32,35,44]. Both actors believe ANG can become a competitor of petrol and diesel on the mainstream consumer market. Several car manufacturers already deliver cars that use ANG, because they believe there is a market for these cars on the short term, unlike second generation biofuels or electric cars [31]. The filling station entrepreneurs are working on the realization of a national network, because the value of the network will grow when the amount of filling stations grows and more consumers are switching to ANG vehicles [35].

The car manufacturers and filling station entrepreneurs have pursued a strong lobby for automotive natural gas, because it provides short term advantages for air quality. This lobby has resulted in a low excise rate for ANG, which has been a large stimulus for ANG initiatives, because the extra costs of the ANG technology could be compensated by lower fuel costs [31,38,39]. Another result of the lobby has been the establishment of a subsidy program for filling stations of alternative fuels. This subsidy program has been an important driver for the implementation of a national ANG filling station network [37]. The lobby of Aardgas Mobiel is currently shifting from promoting ANG towards promoting biogas. This shift is caused by the counter movement of the diesel lobby and the increasing interest for climate mitigation [31]. As argued, biogas is CO_2 neutral, resolves security of supply issues and can create new economic activity. It can be used without technical problems in ANG vehicles. Biogas can only cover ten percent of the demand, but it can be implemented on the short term, while second generation biofuels and electric cars still have large drawbacks and problems [31].

Finally, the political sentiment is currently very positive towards electric cars, which results in much fiscal support and subsidy for this alternative [31,35,38]. As a consequence, it becomes increasingly uncertain for entrepreneurs whether they should invest in ANG vehicles or wait for electric cars [35,38]. The car manufacturers and filling station entrepreneurs within Aardgas Mobiel believe the recent government support for electric cars is unfair, because ANG and biogas are more environmentally friendly on the short term. After all, the largest part of the electricity for electric cars is produced in coal plants [31,35]. Furthermore, communication towards the consumer is not honest, because he gets the impression that electric cars are a feasible alternative, while they are expensive, polluting and unsafe on the short term. Therefore, the government should implement fair and consistent policies that reward alternatives on their environmental characteristics instead of favoring one alternative [31].

The **municipality of Haarlem** is also a strong supporter of ANG. It was the first municipality that implemented ANG buses. This implementation of ANG has been quite successful, because air quality has improved considerably and there have been no technical problems. Several other municipalities have also started with the implementation of ANG, except for the four largest municipalities in the Netherlands, who generally do not choose for ANG [39]. The most important reason for municipalities to implement ANG is that it is the only option that can solve air quality problems in cities on the short term. ANG vehicles are currently available and automotive natural gas is cost effective. Promising alternatives such as electric and fuel cell cars are not cost effective yet, while the municipalities have to solve an air quality problem on the short term. Moreover, the budget of a municipality is limited, so supporting multiple alternatives simultaneously is not feasible. Because ANG is cost effective, the financial support of the municipality of Haarlem is focused on the implementation of biogas. The municipality plans to provide a CO_2 neutral alternative by producing biogas from waste and using this biogas in its buses [39].

5.4.2. ANG critics

The actors within the ANG critics coalition believe ANG is only suitable for niches in cities. These actors criticize ANG based on similar beliefs, but they do not cooperate within the ANG discourse. This section will elaborate on the specific goals and interests of the actors within the coalition.

The **manufacturers that exclusively produce diesel vehicles** have formed an important counter movement against ANG in the Netherlands. This group of manufacturers chooses to keep developing diesel technology on the short term, because they do not believe it is worthwhile to invest in automotive natural gas, which requires large investments and has limited potential [31,39]. Diesel technology will have equal emissions on the short term. On the long term, the combination of second generation biodiesel and hybrid technology can accomplish better results against lower costs [37]. Biodiesel and hybrid technology are especially more suitable for the consumer market, because the driving range of these alternatives is much better [32,41]. As a consequence of this counter movement, less municipalities and entrepreneurs are willing to invest in ANG, because they believe there is no incentive to use ANG instead of diesel.

As argued in the biofuels case, **Energieonderzoek Centrum Nederland (ECN)** is an independent advisor that objectively evaluates alternatives on their costs, innovativeness and their environmental characteristics. From this independent and objective standpoint, ECN has evaluated automotive natural gas quite negatively. ECN evaluates ANG as an option with limited potential and believes the transition to biogas is uncertain. Due to this uncertainty, there is a considerable risk for lock-in into ANG. Therefore, ANG can contribute to improving air quality on the short term, but on the long term, it can block other alternatives with much more potential [29].

In its measures, the **Ministry of Environment** supports ANG only for niches in cities to improve air quality, because it has never been convinced that large scale investments in ANG are worthwhile. The most important reason is that it does not believe that ANG is a stepping stone towards hydrogen. Therefore, this ministry argues that all the investments for ANG do not contribute to the long term transition towards hydrogen [37,44]. Consequently, the Ministry of Environment has been in disagreement with the Ministry of Transport and SenterNovem, who believe that ANG can be a promising option for the transport sector in general and translate this belief into their measures [44]. Recently, biogas is seen as a more promising transition path, but support for ANG is still small within the Ministry of Environment [44].

The **oil industry** believes that automotive natural gas and biogas can have advantages for small niches in cities, but there is no market for ANG as a substitute for petrol and diesel on the large scale. Two specific beliefs are underlying this standpoint. First of all, automotive natural gas does not have environmental benefits compared to LPG, which has been on the market for decades. Second, the driving range of ANG vehicles is limited compared to the range of petrol and diesel cars. Moreover, there is not much room for technological improvement, because ANG is existing technology. Second generation biofuels and hybrid cars have more potential and therefore these technologies are more promising for the consumer market [41]. Once again, the fit to current infrastructure turns out to be an important criterion for the oil industry. Since this industry has a commercial interest in the infrastructure for liquids, ANG is not a technology that fits within the activities of this industry. However, synthetic diesel produced from natural gas can be used in current infrastructure and therefore, this technology is supported. This synthetic diesel can also function as a stepping stone towards Fischer Tropsch diesel with a biological feedstock [35,41,44]. Again, the overall result of this lobby against ANG is that municipalities and firms will keep using diesel, because they believe there is no incentive to start using ANG. This lobby from the oil industry results in less municipalities who are willing to implement ANG [38] and it also slows down the implementation of national network of ANG filling stations [35].

As an objective and independent advisor, the **Netherlands Environmental Assessment Agency (NEAA)** does not believe automotive natural gas is a promising alternative for the future. CO_2 reduction potential and biomass production potential are too limited and the step up effect towards hydrogen is not clear. Therefore, the government should be very careful with large investments in a national network of filling stations. It seems more sensible to invest in the start of an electric infrastructure, because on the long term, electric vehicles will play a role, either using batteries or a fuel cell. It is not clear whether an ANG infrastructure is useful on the long term, so ANG and biogas are only suitable for small niches in cities [40].

5.4.3. EV Coalition

In the Netherlands, a group of actors with a strong belief in electric cars has started a lobby for this alternative. A broad range of actors is involved in this lobby movement at present, for example environmental NGO's, municipalities, banks and energy companies. In general, the

actors within this coalition believe that ANG can have advantages in niches, but the investments for the mainstream consumer market should be focused on electric cars. In this section, I will focus on the specific goals and interests of environmental NGO's and the municipality of Amsterdam.

Environmental NGO's support electric cars, because they believe that a drastic change in cars and infrastructure is needed to achieve the CO_2 reductions that are necessary for preventing catastrophic climate change. Electric cars are the most promising alternative, because they have the largest CO_2 reduction potential. Moreover, electric cars can also be a strong driver for renewable energy, because electricity producers have to fulfill a larger demand with the same amount of CO_2 emissions. This will be a large incentive for electricity producers to build more capacity of solar and wind energy. Additionally, lower amounts of money have to be spent on the import of fossil fuels [34].

In contrast with electric cars, ANG has no long term perspective for the larger scale, due to its limited CO_2 reduction potential. Moreover, the well-to-wheel efficiency of producing fossil fuels will not improve, because it becomes more energy intensive to produce them. Biogas is often presented as the long term perspective for natural gas, but there are two problems with biogas. First of all, different kinds of undesirable emissions are produced in biogas production. Second, the production potential of biogas from waste streams is limited [34].

The **municipality of Amsterdam** has made the choice to financially support electric cars. The most important reason for this choice is to improve air quality. Once again, this municipality had to choose one alternative, because its budget is limited. Unlike the municipality of Haarlem, Amsterdam has chosen for zero emission. Amsterdam believes that zero emission alternatives such as electric and fuel cell cars need extra financial support, since they are not cost effective yet. As a consequence, automotive natural gas is facilitated, but not financially supported, because it is assumed to be cost effective [38]. However, since only five percent will be covered by electric cars in 2015, the municipality believes there are enough possibilities for other alternatives such as ANG to develop. So, there is a preference for electric cars, but if they cannot be used, other clean alternatives can also be implemented [38].

5.4.4. Other involved actors

The other involved actors believe that there are several promising sustainable alternatives, including ANG. However, there are too many uncertainties to exclude alternatives in this early stage. Due to this neutral standpoint, these actors do not form a coalition, because a group of actors has to prefer specific alternatives to become a coalition. However, these actors have nonetheless been taken into account, because they play an important role in the discourses. This section will elaborate on their specific goals and interests.

For **car lease companies**, ANG is one of the promising alternatives, because it could be a stepping stone to biogas, which is a CO_2 neutral alternative. However, there are a few problems that currently hamper the growth of ANG in the car lease industry. It has a limited

driving range and there is no national network of filling stations yet. These are two essential preconditions for an alternative to become successful in the mainstream market. Whether the production potential of biogas will be large enough is also an important uncertainty. Moreover, electric cars have become an important competing alternative, because they have a large potential for the mainstream car market. Despite the large technological and economic obstacles, there is much development in electric cars. However, a clear choice between alternatives has not been made at this stage [32]. Finally, it is imperative for this industry that the firms are able to sell cars on the used cars market after a leasing period of three years. They need to be certain that the residual value of sustainable alternatives after the leasing period is high enough. While the government is using many fiscal instruments to provide an incentive for sustainable alternatives, for example hybrid or ANG cars, a buyer on the used cars market has less incentive to buy these cars. This lack of incentives can become a serious problem for the car lease industry and therefore it is important that this residual value is guaranteed [32].

The most important task of the **Ministry of Transport** is to regulate the mobility sector. The ministry, and the government in general, should find an appropriate balance between stimulating promising alternatives for sustainable transport through subsidies and leaving the choice between the alternatives to the market. For an alternative to become successful, it has to have low emissions and it has to be cost-effective. The main strategy is to develop different alternatives in public transport niches and work towards the large scale from this starting point. Through this strategy, a competition between alternatives is facilitated, which in turn provides an incentive to innovate for the developers of the technologies [37]. Automotive natural gas is one of the promising alternatives for sustainable mobility, because it is cost effective and could be a stepping stone towards biogas [37]. With this strategy focused on the consumer market, this ministry profoundly differs from the Ministry of Environment in its support for ANG, since the Ministry of Environment only supports ANG and biogas in niches in its measures [33,37,44].

As argued in the biofuels case, **public transport companies** believe every alternative is interesting, as long as good environmental performance can be combined with high reliability. Furthermore, the extra costs of implementing the alternative should be paid by the principal party. The main task of public transport is to provide high quality and reliable transport against acceptable costs. For improving environmental performance, the question is which alternative delivers the best emissions against the lowest costs within a high quality and reliable public transport scheme [42]. ANG is a reliable alternative, but there are also important drawbacks for public transport. The following drawbacks are causing the strong lobby of public transport to set a norm instead of obliging the use of a technology.

First of all, large investments in infrastructure and buses are necessary for implementation. Since considerable environmental gains are also possible when diesel is used, the principal party has to compensate for the costs of a more expensive technology such as ANG if they oblige public transport to use this technology. Second, ANG has a limited driving range, which causes problems when larger distances need to be driven, in regional transport for

example. In a strict transport scheme, there is no time to refuel the buses between trips. As a consequence, ANG limits flexibility, which results in reliability risks. Finally, the buses need to be sold or put in operation elsewhere when the concession period ends. Therefore, the public transport companies need to be certain that the buses will have an acceptable residual value in five years [42].

As the implementer of innovation and environmental policy, **SenterNovem** believes ANG is one of several promising options for the transport sector as a whole. As argued, SenterNovem and the Ministry of Transport have been in disagreement with the Ministry of Environment on the support of ANG. SenterNovem believes ANG has environmental benefits on the short term, but there is also a long term perspective. The reserves are larger than those of other fossil fuels and biogas is a CO_2 neutral alternative. Therefore, it is important to give firms incentives to use ANG at present. Otherwise there is no alternative when oil products become scarce and no preparation for biogas [44].

TNO is an independent technological institute in the Netherlands. It has no interest to prefer certain alternatives. Its most important task is to compare different aspects of alternatives in an objective way. TNO can present trade-offs, but politicians will decide which aspects are most important and this choice will lead to support for certain alternatives [45]. ANG seems to be a compromise in several ways, which is interesting for the short term, but it has limited potential for the long term. ANG is cost effective and the necessary modifications to the car and infrastructure are small compared to electric or fuel cell cars. The driving range is limited, but not as limited as the driving range of electric cars. Biogas could provide a long term perspective, but there are several uncertainties. While the long term potential seems limited, TNO believes it is beneficial to support ANG and biogas on the short term to see how they will compete with diesel and biodiesel. In the end, the market will determine which alternative is best [45].

6. Synthesis

In this chapter, an attempt is made to combine the insights of both case studies in order to provide lessons with respect to theory and practice. The first three sections will elaborate on the theoretical implications of the results. In Section 6.4, the implications for practitioners will be presented.

6.1. Conflicts between technology specific coalitions

This section will elaborate on the implications of the results for the theory on technology specific coalitions. The first section will elaborate on general patterns in the emergence of a discourse. Second, a synthesis of the findings on the internal structure of the discourses will be presented. The third part will elaborate on the external factors that have had a significant influence on the discourses.

6.1.1. Development of discourse through time

In both cases, the general perception of the technology was positive at first, followed by criticism and a countermovement. This development could be the result of a growing amount of actors that is drawn into a TIS and more specifically, into technology specific coalitions. The development of sustainable alternatives is often started by entrepreneurs supported by governments. When the entrepreneurs get more support from the government and technologies are increasingly implemented, large industries are drawn into the discourse, both supporting and opposing the technology. For example, several car manufacturers have started to develop ANG cars, while competing manufacturers and the oil industry strongly oppose ANG.

6.1.2. Internal structure: coalitions

As argued, Sabatier (1988;1998) proposes that actors will organize themselves in 2 to 4 coalitions within the discourse. Considering the division of the actors over three or four coalitions in the two cases, the results of this research confirm this proposition. The formation of the coalitions within a discourse generally appears to be as follows. First of all, there is a coalition of strong supporters of the specific technology, which is often opposed by a coalition of criticasters. Second, there are one or two coalitions of supporters of competing technologies. Third, several actors try to evaluate technologies in an objective way or to provide general support to sustainable alternatives.

Moreover, government actors generally act as policy brokers within a discourse, since they try to find a compromise without choosing to solely support a specific technology. In the biofuels discourse for example, the government actors clearly have this role, because they try to support the implementation of biofuels while making sure that these biofuels are produced in a sustainable way. This is a compromise between the supporters of biofuels and the opponents of biofuels, who stress that biofuels production has to be sustainable.

Finally, the results show that it is likely that at least one large (incumbent) industry has to support a technology to enable successful implementation. ANG is supported by several car

manufacturers and ANG entrepreneurs have merged with larger companies. As a result, the development of ANG is stimulated through a low excise rate and investments in fuelling infrastructure. On the other hand, the biofuels entrepreneurs are much less successful, possibly because the large industries have generally rejected first generation biofuels.

6.1.3. Internal structure: beliefs

Coalitions differ in beliefs on a broad range of factors. In this section, the distinction between technological and non-technological factors will be used to summarize the most important differences in beliefs.

Technological factors

Three technological factors turn out to play an important role in discourses on sustainable transport alternatives. First of all, the energy efficiency and CO_2 reduction potential are an important argument to support or oppose the implementation of a technology. In both cases, the supporters emphasize the CO_2 reduction that the technology can provide. On the other hand, the opponents generally emphasize the limitations of the technology to reduce CO_2 by comparing to other alternatives or the incumbent technology.

Second, the cost effectiveness of the specific technology is important. Large investments are necessary for the development of production capacity and distribution infrastructure. Supporters of a specific technology often trivialise the costs of implementation of their technology and refer to the costs of alternatives to justify their support. Opponents of technologies strongly emphasize the costs of implementation to show that the technology is unnecessary or undesirable.

Third, the production potential of alternatives is an important factor in discourses. Since the production potential of more advanced alternatives such as second generation biofuels and biogas is uncertain, the coalitions mainly differ in their beliefs on the production potential of these alternatives. Opponents of alternatives often argue that there is not enough sustainable biomass available to make these options worthwhile. Moreover, because there is also demand for biomass in other sectors, opponents often argue that it is not sensible to use the limited amount of available biomass in the transport sector.

Non-technological factors

The following non-technological factors play a large role in the discourses. First of all, for many actors, it is important whether there is a market for a specific technology. Opponents often use the argument that there is no market for an alternative. They believe that there is no demand for an alternative because it does not provide enough advantages or it is too expensive. For example, the oil industry does not believe there is a market of ANG, because it has no environmental advantages compared to LPG.

Second, two other important factors in the discourses are the presence of production capacity and distribution infrastructure. Opponents of alternatives often emphasize the large investments that have to be done in production capacity or distribution infrastructure. These

investments are an important reason to reject an alternative. On the other hand, these investments are downplayed by supporters, who believe the investments are necessary as a stepping stone towards alternatives with large CO_2 reductions.

Finally, the appropriate regulation by the government is an important issue in discourses. Through regulation, governments try to stimulate the implementation of an alternative in existing markets, for example public transport. However, the firms in these existing markets have protested against this policy, because they feel limited in their freedom to choose alternatives against the lowest costs. Additionally, several car manufacturers and the oil industry have also asked the government to set norms instead of forcing them to use a technology.

6.1.4. External factors

Four external factors have turned out to play an important role in discourses on sustainable transport alternatives.

Increases in food prices

The large increase in food prices in 2008 has been very influential in the implementation of biofuels and especially first generation, which is based on food crops. This price increase has been the start of an intense societal debate, in which a broad range of actors has played a role. Through the media, the public opinion on biofuels has changed dramatically. The ethical argument that it is not right to use food crops for biofuels production while a considerable part of the world population is undernourished has had a very strong influence [33]. Although the real effects of biofuels on food markets are uncertain, this ethical argument has had a considerable influence on the public opinion and it has diminished the legitimacy of biofuels in society.

Increases in fuel prices

The oil price is an important benchmark for every alternative, since alternatives become more competitive when fuel prices increase [37]. The strong increase of the oil price in 2008 has provided a sense of urgency: alternatives have to be developed before oil becomes too scarce [32].

The role of political priorities

As argued, there has been a shift in political priorities in the last decade. While local air pollution initially was perceived as the most important environmental problem, there has been a strong interest in mitigation of climate change since 2006 [37]. This interest for the problem of global climate change has pushed the air quality problem to the background. This shift has had a strong effect in the ANG discourse, because the ANG lobby was focused on air quality. When climate change became more important, the supporters of ANG also needed to emphasize the potential of biogas, because ANG was criticized for its limited CO_2 reduction potential [31]. This case shows that political priorities have a large influence on the discourses between actors. In general, the criteria for the desirability of alternatives seem to change over time.

The development of other technological innovation systems
Another important external factor for the legitimacy of a technology is the development of other technological innovation systems. Furthermore, the development of the incumbent technology is often used as a reference by opponents of sustainable alternatives. For example, the substantial decrease in emissions of diesel technology is often used as an argument against ANG.

6.2. Actors

This section will provide a synthesis of the most important interests of a selection of actors.

6.2.1. National government

In general, national government actors select alternatives on cost effectiveness, emissions and other environmental effects. The biofuels case shows that the EU goals can be an important driver for a national government to implement an alternative. Furthermore, national governments often act as policy brokers, but ministries can also be supporters or opponents of an alternative. In the biofuels discourse, the ministries and SenterNovem form the sustainable biofuels coalition, which clearly has the role of a policy broker. Through their actions, this coalition tries to find a compromise between the wishes of all other coalitions in the discourse. However, the ANG case shows that the national government actors do not always have this role. In the ANG discourse, national government actors have been divided over different coalitions in the discourse. While the Ministry of Transport and SenterNovem are quite positive about ANG and try to support ANG on the large scale, the Ministry of Environment has not been very supporting.

6.2.2. Local government

Municipalities select alternatives mainly on their costs and environmental performance. They need to implement alternatives to comply to the EU norms for air quality and to protect the health of citizens. However, a municipality cannot support all alternatives simultaneously, because its budget is limited. The municipalities often become large supporters of a specific technology when they have made the choice to support it. Examples are the support for ANG in Haarlem and the support of electric cars in Amsterdam. As a consequence, municipalities become involved in the lobby for a specific technology, although they do not have a commercial interest.

6.2.3. Knowledge and technology institutes

The knowledge and technology institutes evaluate alternatives on their costs, environmental effects, energy efficiency and innovativeness. Although every institute has its own focus, they are generally interested in long term transitions. As a consequence, knowledge institutes generally favour long term solutions such as second generation biofuels or electric cars. On the other hand, knowledge institutes believe first generation biofuels and ANG do not fit in a long term energy transition to sustainable mobility.

6.2.4. Environmental NGO's

NGO's strongly support alternatives with much CO_2 reduction potential, because they have very ambitious goals for climate change mitigation, Consequently, the NGO's have criticized first generation biofuels and ANG, because these alternatives do not have enough CO_2 reduction potential to reach these necessary goals. On the other hand, environmental NGO's are much more enthusiastic about zero emission alternatives, especially electric cars, because they believe these alternatives do have the necessary potential.

6.2.5. Entrepreneurs

In general, entrepreneurs are a strong driver of the development of sustainable alternatives. For example, in the ANG case, there are a few entrepreneurs who work on a network of filling stations. These entrepreneurs are characterised by a strong belief in the potential of a technology. Sometimes, they even present their technology as superior to other alternatives. In the ANG case for example, a filling station entrepreneur presented biogas as the only sustainable alternative for the short term and production from biogas as the most efficient way to produce hydrogen. On the other hand, this actor criticised the potential of other alternatives.

6.2.6. Public transport

Public transport companies are interested in every alternative with good environmental performance, because they wish to decrease their environmental impact on a local and global scale and fossil fuels become increasingly scarce. Therefore, trials have been done with several alternatives and ANG has already been implemented. However, while public transport is interested to experiment with a broad range of alternatives, they are quite conservative in the implementation of these alternatives. This is especially the case when considerable investments are needed in bus technology or fuelling infrastructure. These investments form an economic risk while the use of new technology forms a reliability risk. Therefore, public transport is both a supporting and a blocking actor within the discourse.

6.2.7. Large incumbent industries

In both cases, the car and oil industries play different roles. Their most important beliefs and interests will be summarized in this section.

In general, car manufacturers evaluate alternatives on costs, energy efficiency, emissions, fuel quality and the necessary adjustments to car and infrastructure. As becomes clear from the ANG case, the support for sustainable alternatives differs within the industry. In this case, actors from the car industry are divided over different coalitions. An ANG coalition, a diesel coalition and an electric vehicle coalition compete for funds and legitimacy. The severe competition between ANG and diesel supporters shows that manufacturers can choose to diversify their activities by supporting an alternative or to block an alternative to defend their interests in the incumbent technology. As a consequence, car manufacturers can both be a supporting and a blocking actor within a TIS, depending on their strategy..

The oil industry selects alternatives on several criteria, but the driving range and the fit to the existing infrastructure are especially important for this industry. The driving range is an important criterion for many consumers, so the oil industry has a commercial interest to support alternatives with a good driving range. Second, the oil industry has done large investments in the current infrastructure and as a consequence, this industry supports the alternatives that suit best to this infrastructure, for example second generation biofuels and hybrid cars.

6.3. Coordination and its effects

This section presents a synthesis of the results on cooperation between the actors within the coalitions and the effects of this cooperation on technological innovation systems. This synthesis elaborates on the lobby activities by actors within coalitions, cooperation between government actors and lobby activities by individual actors.

6.3.1. Coordinated lobby activities

In the ANG case, the actors that form the Aardgas Mobiel organization have pursued an important coordinated lobby to change institutions in favour of ANG. This organization consists mainly of car manufacturers, filling station entrepreneurs and energy companies. The lobby of several car manufacturers and filling station entrepreneurs has resulted in a low excise rate for ANG and a subsidy program for filling stations of alternative fuels. At present, these measures are a strong driver for the adoption of ANG vehicles and the realization of a national network of filling stations. This example shows that a coordinated lobby by a broad coalition can lead to the change of institutions in favor of an emerging sustainable alternative.

On the other hand, there is no strong coordinated lobby within the biofuels case. Not many actors are willing to participate in the implementation of first generation biofuels, so there is not a strong lobby for first generation. On the contrary, many actors reject first generation biofuels due to the negative publicity resulting from the food-fuel debate. Another reason for the weak lobby for biofuels could be that there is no need to change institutions on the short term. This is caused by government policy, because changes in car and infrastructure are not necessary when small percentages of biofuels are blended with fossil fuels. Another consequence of this government policy is that the market for pure biofuels is not developing at all, because biofuels remain more expensive than fossil fuels [31,41].

6.3.2. Coordinated activity by the government

Although there is no significant coordinated lobby within the biofuels TIS, the government actors are clearly cooperating. For biofuels, the government faces a dilemma: it is a strong supporter of biofuels, but this alternative became increasingly criticized. As a result of this criticism, the government actors have implemented sustainability criteria on a national level. Recently, sustainability criteria have also been determined on a European level and as a consequence, the large European market asks for sustainable biofuels. On the one hand, this approach is beneficial, because the government shows clearly in which direction the TIS should develop. On the other hand, it does not accelerate its development, especially since the government has lowered its goals from 5,75 percent to 4 percent biofuels in 2010. This has

been the direct result of the countermovement initiated by NGO's. As a result, the market for biofuels will be smaller in 2010, which gives entrepreneurs less incentives to invest in biofuel production.

In the ANG case, there is a lack of coordination by government actors. The government is even divided over different coalitions, since there is discussion within the government on the desirability of ANG and the ways to support it. As a consequence, the government lacks a clear shared vision on ANG. Moreover, the government is currently spending an increasing amount of funds on electric cars. As a consequence, the ANG market players perceive the long term investment perspective as unclear, because there is too much fluctuation in government support.

6.2.3. Lobby activities by individual actors

Instead of pursuing a coordinated lobby with a broad range of actors, many actors pursue a lobby to defend their own interests or serve their own goals. An example from the biofuels case is the countermovement of NGO's against biofuels, especially first generation. Ultimately, their lobby has resulted in the implementation of sustainability criteria and the lowering of the national goals for biofuels. However, the most evident example of individual lobbying activities can be found in the ANG case, in which public transport, the oil industry and several car manufacturers ask the government to set norms instead of imposing specific alternatives. These different actors all have their own lobby in the ANG discourse, without clearly cooperating with each other. A possible explanation for this behavior is that these vested actors all have enough financial resources and political power to pursue their own lobby. Therefore, these actors believe cooperation is not necessary to reach their goals.

6.4. Implications for policy makers

In this section, the implications of the results for the policy makers are presented.

6.4.1. Management of expectations

Governments have often followed supporters of alternatives in their opportunistic vision of the potential of a specific technology. This has occurred both for biofuels and ANG in their early phases of development. There was often much enthusiasm about the potential of the technology and there was less attention for the drawbacks. When the implementation of both alternatives progressed on the larger scale, the involved actors faced their practical drawbacks and undesirable effects. As a result, many actors became disappointed and the perception of the alternatives became excessively negative. The results of this research show that this creation of excessively positive and negative expectations can block the development of the technological innovation system. Therefore, it is crucial that policy makers act as a policy broker, in the sense that they communicate a balanced vision of a alternatives, in which both benefits and drawbacks are emphasized.

The current enthusiasm for electric cars also seems to be an example of excessively positive expectations. Actors often emphasize the relatively low price of electricity, the efficiency of the cars and the fact that they have no direct emissions. However, there seems to be less

attention for the limited driving range, expensive battery packs and the lack of renewable electricity production. The result is an overly optimistic image of electric cars, which creates high expectations, especially by consumers. To realize the large potential of electric cars, it is crucial that the government balances benefits and drawbacks to provide realistic expectations for all actors and especially consumers. Otherwise it is likely that actors get disappointed again when they discover the drawbacks of the technology, which can block its development.

6.4.2. Development of a shared vision

The results of the ANG case show that the government actors do not always have a shared vision on the desirability of a technology. An important task of the government is to support several promising alternatives simultaneously. On the one hand, several alternatives get chances to develop and on the other hand, competition between these alternatives is induced [37]. Considering this ambition, it is important that government actors act as a policy broker in the discourse. However, in the ANG case, two government actors are supportive of ANG, while another government actor believes the technology has limited potential. The government actors seem to follow supporters and opponents in the discourse, instead of communicating a clear shared vision of ANG. However, the market players ask for a clear vision from the government, because when it is not clear what the government wants with a technology, the investment perspective is uncertain. This uncertainty can hamper the development of the TIS, because it is likely that less investments are done. Therefore, it is important that the government actors develop a shared vision on a technology.

6.4.3. Development of general and consistent policies

At present, sustainable transport alternatives are often supported separately. Due to the sequence of positive and negative expectations on several alternatives, the support has been fluctuating. For example, there was much more support for biofuels before the food-fuel discussion. Such fluctuations result in uncertainty for consumers and firms, because it is not clear in which alternative they should invest. Moreover, entrepreneurs need consistent support from the government to reduce uncertainties for their long term investments. A solution for this problem could be to develop a general policy based on environmental performance instead of separate support measures. Through this policy, alternatives with the best environmental performance are rewarded. Implementing such a policy could make government support less sensitive to the fluctuations caused by sequences of positive and negative expectations.

6.4.4. Involving incumbents

As argued, incumbent actors have much political power and financial resources to pursue a lobby against a sustainable alternative in order to defend their own interests in the incumbent technology. They often present a selection of information that serves their goals best and sometimes even use misinformation to support its own technology or criticize a sustainable alternative [31,39]. Therefore, it is crucial that government actors accurately assess these attempts to block the development of sustainable alternatives. On the other hand, the ANG case shows that the involvement of incumbent actors in the development of a sustainable alternative can also have beneficial effects. When incumbent actors are willing to support an alternative, their political power and financial resources can be used to gain legitimacy for the

alternative. As a consequence, it is also important that government actors try to involve incumbents in the support for sustainable alternatives.

7. Discussion

First of all, section 7.1 will provide a theoretical discussion. Second, the method will be discussed. Finally, the possibilities for further research are presented.

7.1. Theoretical discussion

This research shows that the AC Framework is quite suitable for conceptualizing discourses between different actors. While the concepts are quite simple, the use of these concepts results in a detailed overview of the conflicts that form the discourses under study. However, the technology specific coalitions concept also has its problems. The most important theoretical problem that has been encountered in this research is that it is difficult to take the interests of actors into account within the Technology Specific Coalitions Framework. No theory has been found that can help to take interests into account. However, the results of this research show that interests indeed do play an important role. Therefore, an actor typology based on interests could provide more detailed insights on the type of actors that are involved in discourses on sustainable alternatives.

7.2. Discussion on method

First of all, this discussion of the method will reflect on the data collection. The second part will elaborate on the external validity of this research, which is the domain to which the findings of the research can be generalized [20].

7.2.1. Data collection

Interviews have been a suitable method for this research, because it is hard to derive beliefs from literature and beliefs are inherently subjective. An attempt has been made to involve all the important actors within the technological innovation systems under study. With approximately 80 percent, the response rate was quite high. Sixteen persons have been interviewed for this research. Ten interviews have been about biofuels and twelve about automotive natural gas. The results are extensive, because every actor has determined the most important events in the last five years and every actor has elaborated on the conflicts. Moreover, multiple sources have been used for both the historical introduction and the beliefs of the coalitions within the discourse. Furthermore, it was quite straightforward to operationalize beliefs and derive the conflicts from these beliefs.

However, beside the general drawbacks of interviews, there were two problems in data collection. First of all, actors will often present themselves as willing to implement sustainable alternatives, while their actions suggest that they also block this implementation in several ways. Because the statements of actors are not always in line with their actions, their real motives and interests can be hard to discover. Consequently, it might be interesting to take both the statements and the actions of actors into account. These actions could be investigated by examining publications and investments by actors.

Second, the data collection on the effects of cooperation between actors and the discourse in general has been problematic, because many effects can be classified and it is difficult to define a complete set of operational measures. Moreover, obtaining enough data on effects was difficult, because the interview respondents generally expressed that it is difficult to establish causes and effects. Therefore, a theoretical refinement of cooperation and its effects might result in more specific measures, which can provide more data on these concepts.

7.2.2. External validity

Since only two cases are investigated, it is difficult to generalize the results of these cases. However, important similarities between both cases have been found, which can form a starting point for a general theory. These similarities can be found in the composition of the coalitions and the criteria that play a role in both discourses, namely energy efficiency, cost effectiveness and the production potential. On the other hand, both cases are derived from the transport sector, so it is not possible to determine whether discourses in other sectors have the same patterns. Therefore, it is important that more cases will be investigated and especially cases of sustainable technologies outside the transport sector.

7.3. Further research

Based on the issues discussed in 7.1 and 7.2, the following recommendations for further research are proposed.

7.3.1. Development of the theory through replication

More case studies have to be conducted to test the external validity of the theoretical framework and the findings of this research. Since both cases of this research are derived from the transport sector, it is especially important to investigate discourses on sustainable technologies in other sectors. For example, an investigation of the competition between technology specific coalitions in CO_2 storage or wind power could provide more insight in the general suitability of the Advocacy Coalitions Framework to analyze discourses in detail. Furthermore, such an investigation could provide additional insight in the general factors or beliefs that play a role in discourses.

7.3.2. Development of actor typology

As argued in 7,1, no theory could be found in literature that can help to take interests into account in explaining the positions of actors within the discourse. The results of this research have been an indication for the importance of interests in discourses. Therefore, the development of an actor typology could help to explain the role of interests more specifically.

7.3.3. Cooperation between actors and its effects

In this research, an attempt has been made to explain the influence of cooperation between different actors and the discourse in general on activities within technological innovation systems. Another possibility for further research is a theoretical refinement of the cooperation and effects concepts and translation to more specific measures.

8. Conclusion

The goals of this research were to provide (1) more transparency in political discourses on sustainable transport alternatives (2) more insight in the goals and interests of individual actors within these discourses and (3) more insight in the cooperation between actors within political discourses. In this chapter, the answers to the three research questions will be given.

The first research question was as follows:

RQ1: Which differences in beliefs cause the conflicts between technology specific coalitions on the desirability of different alternatives for sustainable transport in Dutch environmental policy?

It is likely that three or four technology specific coalitions will be involved in a discourse on sustainable alternatives. These coalitions comprise a coalition that supports a specific technology, one that criticizes the technology, a group of actors that supports a broad range of alternatives and possibly a coalition that supports a competing technology. In general, the conflicts between the coalitions are caused by differences in beliefs on institutions and especially technological factors. Technological factors such as energy efficiency, CO_2 emissions, cost effectiveness and production potential have a central role in conflicts between coalitions. Supporters of a technology will often strongly emphasize and even exaggerate the benefits of the technology, while opponents will strongly emphasize the drawbacks. Finally, the actors that support a broad range of alternatives act as policy brokers, because they try to find a compromise between the competing coalitions.

Now the second research question will be answered, which was formulated as follows:

RQ2: Which specific goals or interests can explain the positions of individual actors within the discourses?

The position of each individual actor within the discourses is significantly determined by their goals and interests. First of all, entrepreneurs strongly support one technology, because they have a commercial interest in this specific technology. Second, knowledge institutes are often quite critical on sustainable alternatives, because it is uncertain whether the alternatives fit within a long term transition. Third, environmental NGO's often support radical alternatives with large CO_2 reduction potentials, because their goal is to prevent climate change. Fourth, incumbent industries often criticize alternatives by referring to the performance of the incumbent technology and they generally choose to support alternatives that require small changes in cars and infrastructure. Finally, government actors often try to find a compromise in the discourse, because the government intends to support a broad range of alternatives without preferring one specific technology.

Finally, the third research question was as follows:

RQ3: How does cooperation between actors within the coalitions influence the development of technological innovation systems?

First of all, it seems that in general, there is not much cooperation between different actors within the technology specific coalitions. However, the ANG case shows that cooperation between different actors can be effective to change institutions in favor of a sustainable alternative. Furthermore, this cooperation shows that especially the combination of the strong lobby activities by entrepreneurs and the political power of incumbent actors can be effective in changing institutions. On the other hand, no cooperation between actors has been found in the biofuels case, presumably because there is no need for a change in institutions on the short term.

Second, there is cooperation between government actors. This cooperation is necessary, because the government has to find a compromise between the competing coalitions in the discourse. Moreover it has to reduce uncertainty for investors, entrepreneurs and consumers by communicating clearly in which direction the technological innovation system should develop.

Finally, several individual lobby activities often hamper activities within a TIS. Environmental NGO's often criticize sustainable alternatives, because they demand larger CO_2 reductions for instance. The lobby activities of incumbent and vested actors are another example, in which they use their financial resources and political power to pursue their own lobby to defend their interests.

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[41] Oil company 2009, *Personal communication with the Manager Energy Transitions*.

[42] Public transport company 2009, *Personal communication with a Senior Purchase Officer*.

[43] SenterNovem 2009a, *Personal Communication with the GAVE coordinator*.

[44] SenterNovem 2009b, *Personal Communication with a Senior Policy Officer*.

[45] TNO 2009, *Personal communication with a Consultant & Business Developer Sustainable Road Transport*.

Appendix A. Actors

This appendix consists of an overview of the involved actors and the interviewed actors for both cases.

A.1. Actors biofuels case

In Figure A.1, the actors involved in the biofuels TIS are shown. Figure A.2. shows the actors that have been interviewed for the biofuels case.

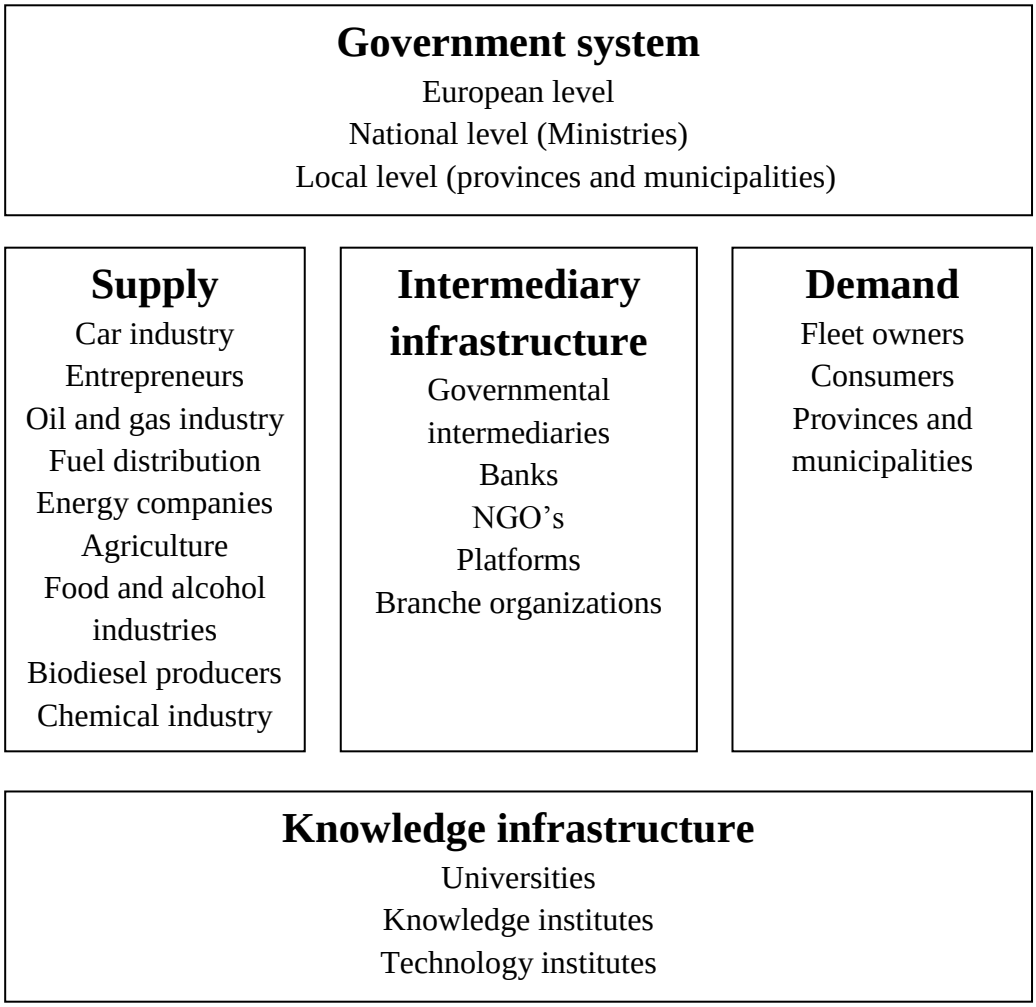

Figure A.1. Overview of the involved actors for biofuels (Ros & Montfoort, 2006)

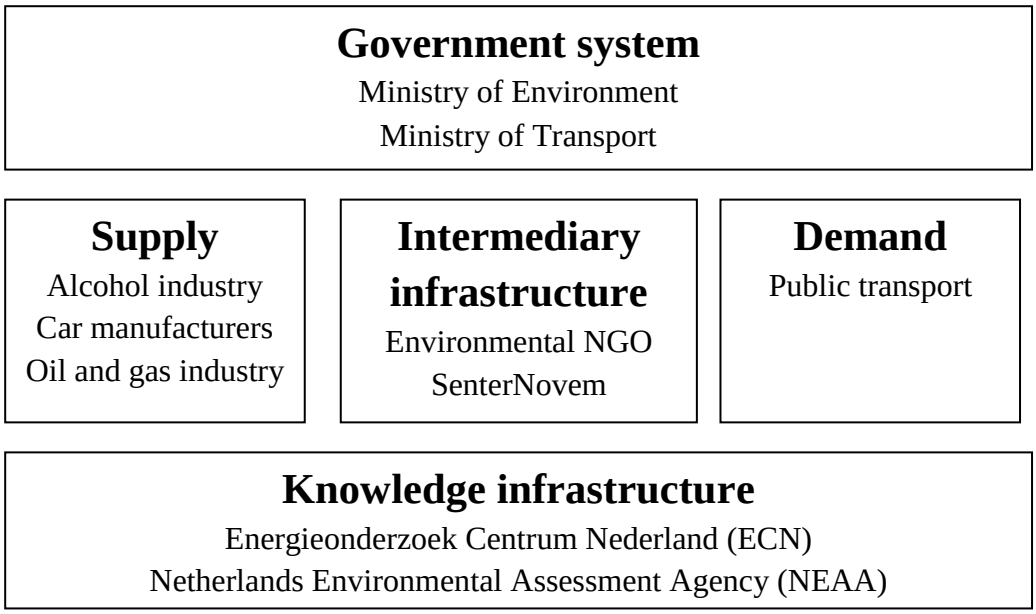

Figure A.2. Overview of the actors interviewed for the biofuels case

A.2. Actors ANG case

In Figure A.3, the actors involved in the ANG TIS are shown. Figure A.4. shows the actors that have been interviewed for the ANG case.

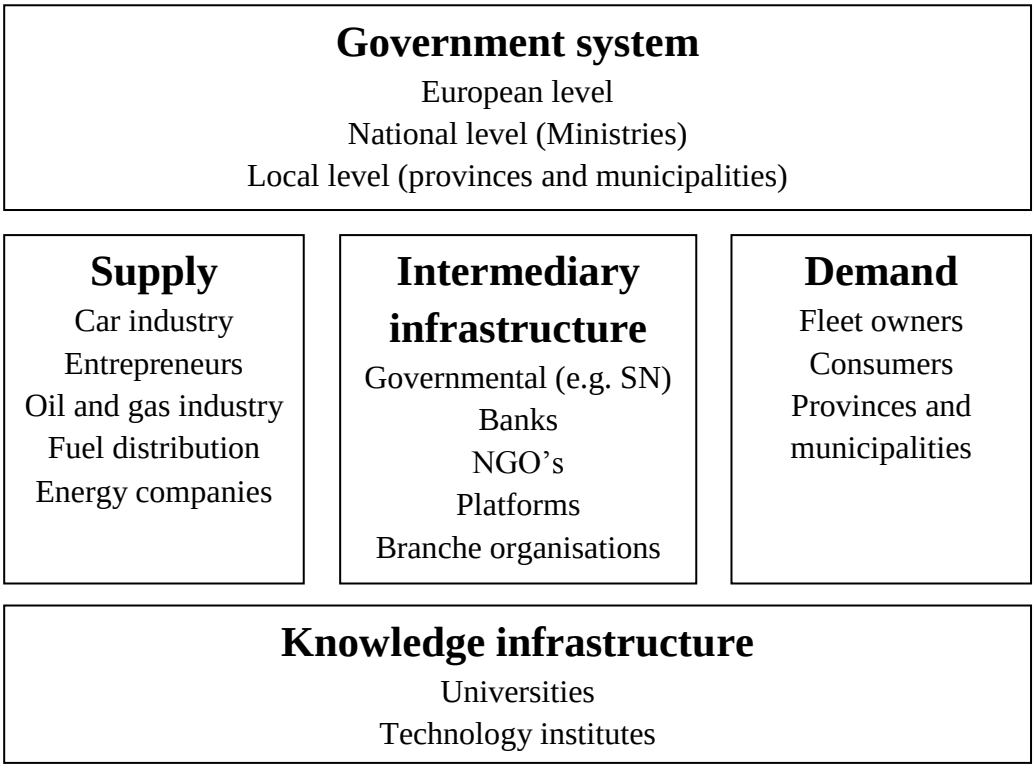

Figure A.3. Overview of the involved actors for automotive natural gas ([23])

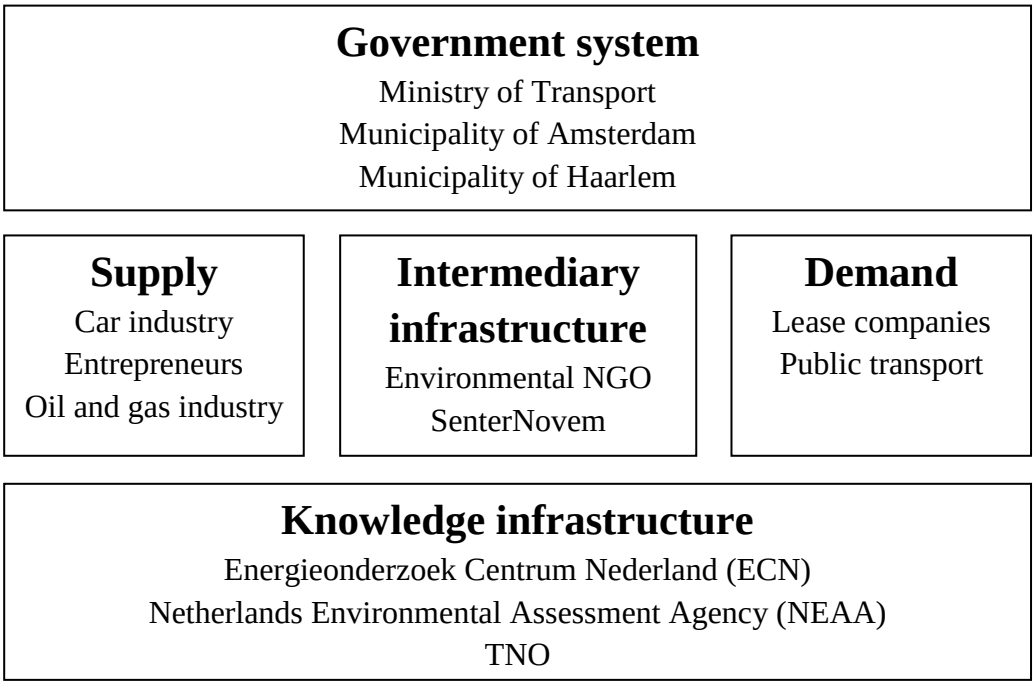

Figure A.4. Overview of the actors interviewed for automotive natural gas

Appendix B. Interview questions

This appendix consists of the operationalisation, format for the interview questions and the specific interview questions for both cases. The operationalisation is similar to the table shown in the method chapter, except the interview questions have been added. These interview questions correspond to the format presented in B.2.

B.1. Operationalisation

Table B.1: Operationalisation of the theoretical concepts in interview questions

Research question	Concept	Dimension	Indicator
RQ1	Events	N/A	Q7
	Beliefs	General	Q1
		Long term potential	Q3c
		Niche/Large scale	Q3d
		Lock-in	Q8 -12
	Coalition	Shared beliefs	Q3a, Q5a
	Competing coalitions	N/A	Q4, Q6
	Conflicts	N/A	Q7b
RQ2	Specific goals/Interests	Directly/not directly involved in development	Q2
		Specific goals	Q2
		Specific interests	Q3b
		Support for other technologies	Q4
RQ3	Coordinated activity	N/A	Q5b
	Conflict outcomes	N/A	Q7c
	Effects	N/A	Q7d

B.2. Format Interview questions

(Q1) What is the opinion of your organization on [specific technology]?

(Q2) (If relevant) Is [specific technology] being implemented at present? What has been realized in practice (amount of litres, vehicles, filling stations et cetera)? Have goals been set for the future?

(Q3a) Does your organization support [specific technology]?

(Q3b) Which interests play a role?

(Q3c) What is the long term potential of [specific technology]?

(Q3d) Is [specific technology] only suitable for niche markets or also for large scale use?

(Q4) Does your organization support other technologies? Why/why not?

(Q5a) Which actors agree with your organization?

(Q5b) Has your organisation formed a coalition with these actors to form a lobby?

(Q6) Which actors disagree with your organization?

(Q7) Certain events in the field of sustainable transport or in politics can influence the image of [specific technology] and result in discussions. Which three events have been most important concerning [specific technology] in the last five years?

For each event:
(Q7a) Why?

(Q7b) Which discussion has resulted from each event?

(Q7c) What was the result of the discussion? (consensus or one side winning the discussion)

(Q7d) Did this result lead to new initiatives, research or policy?

Lock-in

(Q8) Do you know the lock-in concept?

(Q9) Do you think that the support of [specific technology] could result in an undesirable lock-in?

(Q10a) Do [other technologies] build on [specific technology]? Is knowledge of [specific technology] necessary for the implementation of [other technology]?

(Q11) Is support for [specific technology] resulting in the shaping of institutions (markets, laws and rules, standards, investments in production and distribution infrastructure) that are necessary for the implementation of [other technology]?

(Q12) Will the actors involved in [specific technology] also be involved in [other technology]?

B.3. Interview questions biofuels case

(Q1a) What is the opinion of your organization on first generation biofuels?

(Q1b) What is the opinion of your organization on second generation biofuels?

(Q2) (If relevant) Are biofuels being implemented at present? What has been realized in practice (amount of litres, vehicles, filling stations et cetera)? Have goals been set for the future?

(Q3a) Which alternative (first or second generation) has the preference of your organization?

(Q3b) Which interests play a role?

(Q3c) What is the long term potential of biofuels? For first generation? And for second generation?

(Q3d) Are first generation biofuels only suitable for niche markets or also for large scale use?

(Q3e) Are second generation biofuels only suitable for niche markets or also for large scale use?

(Q4a) Which actors agree with your organization?

(Q4b) Has your organisation formed a coalition with these actors to form a lobby?

(Q5) Which actors disagree with your organization?

(Q6) Certain events in the field of sustainable transport or in politics can influence the image of biofuels and result in discussions. Which three events have been most important concerning biofuels in the last five years?

For each event:
(Q6a) Why?

(Q6b) Which discussion has resulted from each event?

(Q6c) What was the result of the discussion? (consensus or one side winning the discussion)

(Q6d) Did this result lead to new initiatives, research or policy?

Lock-in

(Q7) Do you know the lock-in concept?

(Q8) Do you think that the support of first generation biofuels could result in an undesirable lock-in?

(Q9) Do second generation technologies build on first generation technologies? Is first generation knowledge necessary for implementation of the second generation?

(Q10) Is support for the first generation resulting in the shaping of institutions (markets, laws and rules, standards, investments in production and distribution infrastructure) that are necessary for the implementation of the second generation?

(Q11) Will the first generation actors also be involved in the implementation of second generation?

B.4. Interview questions ANG case

(Q1) What is the opinion of your organization on automotive natural gas?

(Q2) (If relevant) Is automotive natural gas being implemented at present? What has been realized in practice (amount of litres, vehicles, filling stations et cetera)? Have goals been set for the future?

(Q3a) Does your organization support automotive natural gas?

(Q3b) Which interests play a role?

(Q3c) What is the long term potential of automotive natural gas?

(Q3d) Is automotive natural gas only suitable for niche markets or also for large scale use?

(Q4) Does your organization support other technologies? Why/why not?

(Q5a) Which actors agree with your organization?

(Q5b) Has your organisation formed a coalition with these actors to form a lobby?

(Q6) Which actors disagree with your organization?

(Q7) Certain events in the field of sustainable transport or in politics can influence the image of automotive natural gas and result in discussions. Which three events have been most important concerning automotive natural gas in the last five years?

For each event:
(Q7a) Why?

(Q7b) Which discussion has resulted from each event?

(Q7c) What was the result of the discussion? (consensus or one side winning the discussion)

(Q7d) Did this result lead to new initiatives, research or policy?

Lock-in

(Q8) Do you know the lock-in concept?

(Q9) Do you think that the support of automotive natural gas could result in an undesirable lock-in?

(Q10a) Do hydrogen technologies build on automotive natural gas technologies? Is knowledge of automotive natural gas necessary for the implementation of hydrogen?

(Q11) Is support for the automotive natural gas resulting in the shaping of institutions (markets, laws and rules, standards, investments in production and distribution infrastructure) that are necessary for the implementation of hydrogen (or another form of sustainable transport)?

(Q12) Will the actors involved in automotive natural gas also be involved in hydrogen?