UTRECHT UNIVERSITY
DECEMBER 2009


# STIMULATING DUTCH NGV CONSUMERS:

# LESSONS FROM SWITZERLAND

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ANALYSIS OF THE NGV CONSUMER ADOPTION
IN THE SWISS AND DUTCH INNOVATION SYSTEMS

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Research: SIM Master Thesis (45 ECTS)

## Abstract

Several countries in the world have a large natural gas vehicle (NGV) fleet, like Pakistan, Argentina and Italy. This is in contrast with the Dutch system that is facing barriers and where consumers do not adopt NGVs. Switzerland has been facing the same problems for a long time, but the system is emerging over the last years. The aim of this research is to investigate how the Dutch system can overcome the adoption barriers based on lessons from the other countries.

In this paper, consumer adoption of NGVs has been analysed using the Technological Innovation System (TIS) framework. The rate of adoption is determined by the consumer decision process based on the perceived attributes of the technology and by the influences of the agents in the TIS framework (governmental, supplier, intermediary and knowledge agents). This has been researched using a literature study in the world leading countries and interviews with NGV drivers and NGV experts in the Swiss and Dutch system.

In the Swiss and Dutch systems, innovators are adopting NGVs based on the relative advantage of the technology. The difference is that Swiss consumers also perceive a financial advantage, contrary to the Netherlands where only the environmental advantage is perceived by NGV consumers. Supplier agents have another origin in the Swiss and Dutch system. In Switzerland, traditional gas companies are the most important suppliers, in the Netherlands new entrants take this role. The role of intermediary and (local) governmental agents is comparable in Switzerland and the Netherlands. However, these agents are already focusing on consumers in Switzerland, where in the Netherlands the focus is still on governmental and company fleets. In all the systems where NGVs were successfully implemented, knowledge institutions had a positive attitude towards the technology. This is also the case in the upcoming Swiss system, however in the Netherlands most of the knowledge agents are negative on NGVs.

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# 1. Introduction

## 1.1 Problem description

Many regions in the world experience local air quality problems due to high traffic congestion. Conventional fuelled vehicles, especially diesel vehicles, emit NOx and particulate matter (PM) which is harmful for human health, nature and buildings. Natural gas vehicles (NGVs) are a possible solution to this problem, because these vehicles have almost no NOx and PM emissions (Bach & Lienin 2007). NGVs also decrease the oil dependence which is becoming a problem in the current geopolitical situation.

The Netherlands is a natural gas country with important natural gas reserves and a good distribution network. It would thus be relatively easy to make the transition to NGVs in this country. However, there are currently only 20 natural gas stations and only a few hundred NGVs (IANGV 2008). When confronted with these statistics, authors often refer to the chicken and egg problem (Janssen 2005): No one wants to invest in natural gas stations when there are no natural gas vehicles, and vice versa. The main goal of this research is to investigate how Dutch consumers can be stimulated to adopt NGVs.

The successful diffusion of an innovation is a combination of technology push and demand pull. This involves the influences of many different actors in and between the technology side and the demand side. The Technological Innovation System (TIS) framework captures these influences. The central idea of this framework is that innovation occurs because of interactions between the different actors in the system (Hekkert et al. 2007). The different types of agents in the system are: governmental agents, suppliers agents, intermediary agents, knowledge agents and consumer agents (Alkemade et al. 2007). Authors using the TIS framework often focus on institutions. However, this focus is not appropriate when investigating consumer adoption. Therefore, the focus of this research is on the role of consumers in the system and the influences of other agents on the consumers' decision to adopt NGVs. This interaction process has been analysed in countries with a high level of NGV adoption in order to get insights on how consumer adoption can be stimulated in the Netherlands. These insights can be used by Dutch policy makers and NGV entrepreneurs in their stimulation of the NGV technology.

Examples of countries where a network of natural gas stations has been succesfully implemented and where consumers have adopted natural gas vehicles are Italy (580.000 vehicles), Argentina (1,7 million), Pakistan (2 million) (IANGV 2008). Italy was the first country in the world to introduce NGVs at the beginning of World War II, but due to low gasoline prices in the 1950's the use of NGVs declined. However, Italy experienced two periods of growth in the 1970's with the oil crisis and in the 1990's due to improvements in the NGV technology (Cola et al. 2000). Argentina started its NGV program in 1984 (Fracchia 2000). The main reason was that the use of NGVs would make it possible to export more oil and so increase national revenues. The national government played an important role by performing the first conversions on governmental vehicles and by ensuring fuel quality and a low natural gas price (Janssen 2005). The development in the Pakistani system is the most impressing with a growth from 0 in the year 2000 to 2 million NGVs at the end of 2008 (IANGV 2008). This growth started when the government sought to replace diesel by natural gas and established a price advantage for natural gas in the beginning of 2000's (Yeh 2007). The successful breakthrough of NGVs in the world leading countries Italy, Argentina and Pakistan can give us important insights for the stimulation of NGV adoption in the Netherlands.

These world leading countries are not completely comparable to the Netherlands, since they have different demographies and automotive sectors, which implies that it might be difficult to transfer the successful policies. Switzerland is one of the countries best comparable to the Netherlands for this research. Both Switzerland and the Netherlands are demographically similar with comparable land size, population size, population density[1] and income. The automotive sector is also highly similar: both countries do not have a domestic car industry and have a comparable car fleet size (Janssen, 2005). Furthermore, both countries have been inactive in the NGV sector for a long time and are currently in the early stage of adoption (see Table 1.1), whereas the world leading countries are in a later stage of adoption. Consumer adoption in the Netherlands should be compared to consumer adoption in the world leading countries some years ago. Consumer adoption in the Swiss case is in the same stage of adoption as in the Dutch case. However, in

[1] The overall population density of Switzerland (186 inhabitants/km2) is much lower than the population density of the Netherlands (395 inhabitants/km2). However, Switzerland is for 70% covered by mountains. The more habitable part of Switzerland has a population density of 380 inhabitants/km2, which is nearly the same as the population density of the Netherlands.

contrast to the Netherlands, Switzerland has successfully overcome the first barriers towards widespread adoption. The Swiss system is now emerging with many active parties, a high growth in new gas stations and new NGV drivers (IANGV 2008). Different stakeholders have interest in a larger NGV adoption. The gas industry wants to promote NGVs in order to increase their market share and has expressed the goal of 300.000 NGVs in 2020. Local governments are willing to increase local air quality and see NGVs as a possible solution (Janssen et al. 2006). This emergence has been realised without the implication of a strong national government willing to push NGVs on the market, like it was the case in the world leading countries. The top-down approach in these world leading countries is probably not applicable to the Netherlands, because the Dutch government lacks the political will to push NGVs onto the market. The bottom-up approach of the Swiss system may be more applicable to the Dutch case. Therefore, the focus of this research is on analyzing the drivers for consumer adoption in the Swiss case. The way the Swiss system is encouraging consumers to drive NGVs and the way the Swiss system is emerging can be applied to the Netherlands. The important characteristics of the NGV system of each case are shown in table 1.1.

***Table 1.1 Country profile of the different cases (based on IANGV 2008, Lyon 2007 and Janssen 2005)***

| *Country* | *Case 1* **The Netherlands** | *Case 2* **Switzerland** | *Case 3* **Italy** | *Case 4* **Argentina** | *Case 5* **Pakistan** |
|---|---|---|---|---|---|
| *Year system started* | 2000's | 2000's | 1930's | 1980's | 2000's |
| *# NGVs*[2] | 1.110 | 6.820 | 580.000 | 1.700.000 | 2.000.000 |
| *% NGV / tot. veh.* | 0.00014% | 0.0013% | 1,1% | 22% | 52% |
| *# CNG stations*[2] | 21 | 106 | 700 | 1800 | 2600 |
| *# NGVs per station* | 53 | 64 | 828 | 944 | 769 |
| *Stage of adoption*[3] | Innovators | Innovators | Early adopters[4] | Early majority | Late majority |

The NGV technology is more or less the same in all these countries (see section 1.2 for a short overview of the technology). The focus is therefore on the differences in innovation system interactions: the influences from the different agent groups on the consumers and the consumers decision process. More specifically, the following research question is addressed:

*-What lessons can be learned from the consumer adoption in the natural gas vehicles innovation system of Switzerland and the world leading countries (Italy, Argentina and Pakistan) for the stimulation of the consumer adoption in the Dutch natural gas vehicles innovation system?*

This question is addressed with the following sub-questions:

*1. What have been the reasons for the successful consumer adoption of NGVs in the world leading countries (Italy, Argentina and Pakistan) when the innovation system was emerging?*

*2. What are the drivers for consumer adoption in the Swiss NGV innovation system and how were the barriers overcome?*

*3. What are the drivers and barriers for consumer adoption in the Dutch NGV innovation system?*

*4. What recommendation can be given to the different actor groups in the Dutch system?*

[2] Number of CNG stations and NGVs counted at the end of 2008

[3] Based on Rogers (2003). This theory is elaborated in section 2.1.4.

[4] Although the NGV market share is only 1%, Italy can be classified in the early adopters stage. Different authors say that 10% market share is the final goal for NGVs (Gaudi & Gozzi 2004) and therefore Italy has an NGV market penetration of 10% of the total possible market.

## 1.2 NGV technology

Most natural gas vehicles use the same type of combustion engine as gasoline vehicles. Diesel engines can also be used, however this is more complicated because of the dual fuel concept that must be used for diesel cycle NGVs. This concept means that the natural gas mixture is ignited by a small amount of diesel (Matic 2005). The natural gas can be stored in the car as compressed natural gas (CNG) or as liquefied natural gas (LNG). CNG is gaseous natural gas stored at very high pressures (around 200 bars) and LNG is liquid natural gas stored at very low temperatures (under –162ºC) (Matic 2005). The gas stations in Switzerland and the Netherlands take gaseous natural gas from the distribution network and compress it to the CNG form. Filling up only takes about 2-3 minutes due to a stock of compressed natural gas at the stations. It is also possible to refuel NGVs at home with a Phill installation. This is a small compressor that takes the natural gas from the network and compresses it to the required 200 bar. The problem is that refuelling with a Phill installation takes about 6 hours. This is a nice solution for people with a garage and the possibility to refuel during the night (Holdigaz 2009). NGVs can also drive on biogas or on a mixture of natural gas and biogas. This biogas can be produced from waste materials by anaerobic digestion or fermentation. This type of biogas is environmentally neutral and can be produced without the use of extra agricultural space which is a major issue in the biofuels discussion. Biogas must be purified to a natural gas level in order to be used in NGVs. This purified biogas is often called "green gas".

Although the pressure of CNG is very high, the CNG tanks in the cars still take more space than gasoline or diesel reservoirs. Car manufacturers resolve this problem in different ways: smaller reservoirs, smaller luggage boots or reservoirs under the car. All these options have disadvantages, respectively: lower cruising range, less space for luggage and less space between the car and the ground. Other disadvantages are the higher purchase price, the loss of power and the fact that new gas stations are needed. The short-term advantages of NGVs are the lower emissions levels in comparison to diesel and gasoline (Bach & Lienin 2007), the lower fuel costs and the fact NGVs can start under severe cold because the fuel is in gaseous state. The long term advantages are the fact there are large natural gas reserves in the world and the possibility to switch to biogas (Janssen 2005). These advantages and disadvantages of NGVs compared to conventional fuelled vehicles are summarized in table 1.2.

***Table 1.2 Advantages and disadvantages of NGVs***

| ***Advantages of NGVs (Bach & Lienin 2007, Janssen 2005)*** | ***Disadvantages of NGVs (Janssen 2005)*** |
|---|---|
| Lower fuel costs | Higher purchase price |
| Lower emission levels | Space taken by the CNG tanks |
| Possibility to switch to biogas | Lower cruising range |
| Start under severe cold | Loss of power |
| Large natural gas reserves | New fuelling stations needed |

## 1.3 Outline of the thesis

The theoretical framework for this research is discussed in chapter 2. The theory is operationalized in the methodology chapter 3. The results from the literature study on the world leading countries are presented in chapter 4. The results from the Swiss and Dutch cases are presented respectively in chapter 5 and 6. The research questions is answered based on these results in the conclusion chapter 7. Finally, the theory, the method and the conclusions of this research is discussed in chapter 8.

# 2. Theory

The theoretical framework for this research is discussed in this chapter. As explained in the introduction, the central goal of this research is to understand consumer adoption. Consumer adoption is determined by the consumer decision process as well as by external influences. This chapter starts with Rogers' model on the rate of adoption of an innovation (Rogers 2003). This model can be seen as the starting point of the theoretical framework for this research, because it combines both the internal consumer decision process and the external influences on the consumer adoption. These internal and external influences are discussed in this chapter in respectively section 2.1 and section 2.2. Bodies of literature that discuss the internal influences are the Perceived attributes of innovations (Rogers 2003), the Neoclassical theory of consumer behaviour (Krugman & Wells 2005), the Car adoption characteristics (Lane 2005, Hoen & Geilenkirchen 2006) and the Type of adopters (Rogers 2003). The body of literature that discuss the external influences is the Technological Innovation System framework (Hekkert et al. 2007, Alkemade et al. 2007, Carlsson & Stankiewicz 1991).

Rogers (2003) elaborated on a model to explain the rate of adoption of innovations. According to his theory, there are five types of variables influencing the rate of adoption of an innovation (figure 2.1): Perceived attributes of innovations, Type of innovation-decision, Communication channels, Nature of the social system, Extent of change agents promotion efforts (Rogers 2003).

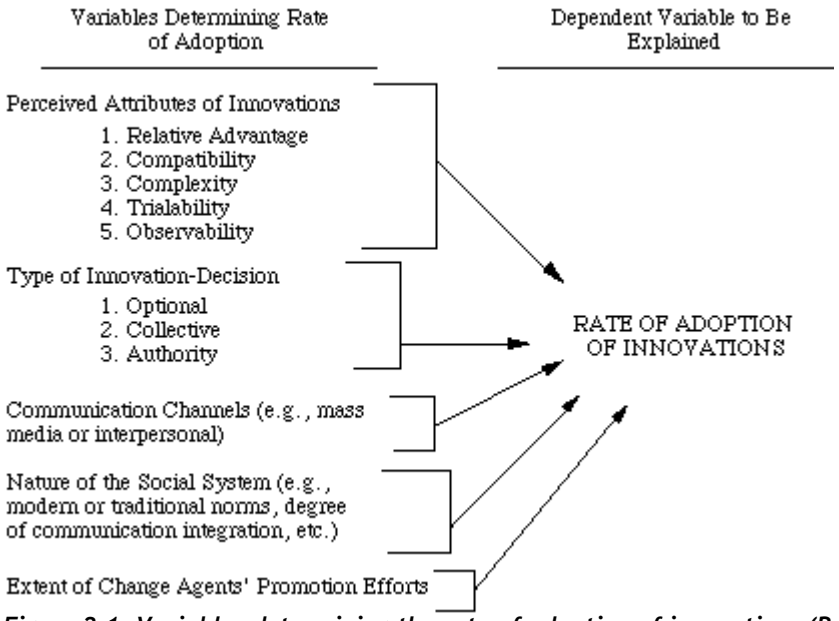


***Figure 2.1: Variables determining the rate of adoption of innovations (Rogers 2003, p.222)***

According to Rogers, the first variable (perceived attributes of innovations) has the most important influence on the rate of adoption and therefore Rogers focuses his research on this variable (Rogers 2003). This variable only takes the internal decision process of the consumers into account. The other four variables may also be important, because these are the external influences on consumer adoption. The internal decision process is elaborated on in section 2.1 and is based on the perceived attributes of figure 2.1 and the neoclassical theory on consumer behaviour. The Technological Innovation System framework is used to elaborate on the external influences on consumer adoption (the four other variables of figure 2.1) and is elaborated in section 2.2.

## 2.1 Consumer decision process

The theory on the consumer decision process is discussed in this section. This process corresponds to the optional type of decision in Rogers' model (figure 2.1). The diffusion of a new technology depends on the decision of the consumer to adopt this technology. This section starts with the elaboration of the perceived attributes of innovation from Rogers' model (section 2.1.1). In order to be able to operationalize the five attributes in the methodology chapter (section 3.1), the neoclassical theory of consumer behaviour and car

adoption characteristics are discussed in respectively section 2.1.2 and 2.1.3. Since this research has multiple cases, the adoption can be in different stages with different type adopters. The characteristics of the different adopter groups are discussed in section 2.1.4.

### *2.1.1. Perceived Attributes of Innovations*

According to Rogers, the rate of adoption of an innovation is mostly influenced by the way consumers perceive the new technology. This perception is based on different attributes of the innovation. Rogers classified these attributes in five categories:

1. Relative advantage: *the degree to which an innovation is perceived as better than the idea it supersedes* (Rogers 2003, p. 229).
2. Compatibility: *the degree to which an innovation is perceived as consistent with existing values, needs and experience of the potential adopter* (Rogers 2003, p. 240).
3. Complexity: *the degree to which an innovation is perceived to be relatively difficult to understand and to use* (Rogers 2003, p. 257).
4. Trialability: *the degree to which an innovation may be experimented with on a limited bases* (Rogers 2003, p. 258)
5. Observability: *the degree to which an innovation is visible to others* (Rogers 2003, p. 258).

The new technology will be adopted when the relative advantage, compatibility, trialability and observability attributes are perceived as higher and when the complexity attribute is perceived as lower than those of the existing technology. Most of the time, a new technology is perceived as higher in one attribute and lower in another. The value consumers give to the different attributes is then important in the adoption decision.

### *2.1.2. Neoclassical theory of consumer behaviour*

According to the neoclassical theory of consumer behaviour, consumers try to maximize utility: "a measure of the satisfaction the consumer derives from consumption of goods and services" (Krugman & Wells, 2005). Each individual uses consumption within the limits of his budget in order to increase utility and will choose to consume the goods or services giving him the highest utility. Different consumers have different preferences and therefore assign different levels of utility to goods or services. Two products fulfilling exactly the same needs are perfect substitutes and provide the same utility to the consumers. When two products are perfect substitutes, a slightly higher price of one product will cause consumers to choose for the other product only (Krugman & Wells 2005).

In the automotive sector, the different car models are substitutes of each other fulfilling the same end: moving persons or goods from one point to another. This implies that most models are substitutes and a price difference should have a large impact on the adoption. Because there is a lack of information about total costs, the purchase price has a larger influence than the running costs. When a consumer is looking for a new car, the purchase price determines which models are considered. It is only after this first screening that a consumer will look at other factors, like fuel economy, safety or image (Lane & Potter 2007). There is even evidence that fuel economy is only looked at after the purchase has been made (Kurrani & Turrentine 2002). Even when consumers use their cars, they are unable to make correct assumptions on fuel costs (Turrentine & Kurrani 2007). Due to this lack of information, the consumers are unable to make a complete rational choice when they buy a car. This non-rational choice is known in behavioural economics under the term *bounded rationality*. People make decisions that are good enough rather than perfect, because seeking for the perfect decision requires too much time and effort (Krugman & Wells 2005).

### *2.1.3. Car adoption characteristics*

In section 2.1.2, we argued that most car models are substitutes, since they fulfil the same main need. However, different car models are not perfect substitutes, because they have different characteristics besides the main characteristic of driving from one place to another. Different authors have investigated which characteristics were important in the car purchase. The Transport Research and Environmental Change Institutes (TRI-ECI) made a list of the 15 most important vehicles characteristics that influence the purchase choice (Lane 2005). Muconsult did comparable research and made a distinction between private individual consumers and consumers leasing their car at their company (Hoen & Geilenkirchen 2006). Table 2.1 shows the ranking of the 15 most important characteristics for both researches.

*Table 2.1: Ranking of the importance of vehicle characteristics in purchase choice*

| Ranking | TRI-ECI (Lane 2005) | Muconsult - Private (Hoen & Geilenkirchen 2006) | Muconsult - Lease (Hoen & Geilenkirchen 2006) |
|---|---|---|---|
| **1** | Reliability | Purchase price | Physical size of car |
| **2** | Safety | Fuel Economy | Number of doors |
| **3** | Comfort | Resale value | Purchase price |
| **4** | Purchase price | Running costs | Engine size |
| **5** | Appearance | Number of doors | Luggage boot size |
| **6** | Fuel Economy | Physical size of car | Car type |
| **7** | Internal Space | Car type | Colour |
| **8** | Physical size of car | Fuel type | Brand |
| **9** | Brand | Colour | Fuel type |
| **10** | Env. impact (emission levels) | Car body | Car body |
| **11** | Engine size | Engine size | Acceleration |
| **12** | Resale value | Luggage boot size | Running costs |
| **13** | Fuel type | Environment | Environment |
| **14** | Financial package available | Acceleration | Fuel Economy |
| **15** | Recommendation | Brand | Resale value |

### *2.1.4 Differences in types of adopters*

Consumers have different characteristics and do not all adopt a new technology at the same time (Geroski 2000). There are different groups of consumers having different perceptions of the characteristics of new and old technologies. Some people also perceive one of the attributes of innovation (section 2.1.1) or car adoption characteristics (section 2.1.3) as more important than other people do. Rogers (2003) has defined a technology adoption lifecycle which describes the potential diffusion of a new product in five different adopter groups:

1. *Innovators*: First to adopt in a very early stage of the innovation process. They are willing to take risks, often have substantial financial resources and a technical knowledge (Rogers 2003).
2. *Early adopters*: Role model for other members of the social system. They are aware of their important position and try to maintain this position by making quick judicious decisions which will trigger the mass to adopt an innovation (Rogers 2003).
3. *Early majority*: Adopts a new technology when they see that the implementation was successful in the early adopters group. This group takes its time to make a deliberate decision in order to avoid the start-up problems of an innovation (Rogers 2003).
4. *Late majority*: Adopts an innovation when there is a pressure from the environment or when the innovation has proven higher performance (Rogers 2003).
5. *Laggards*: Last to adopt an innovation. They are very conservative, isolated from the rest of the social system and often have limited resources (Rogers 2003).

The innovator group is defined as the first 2,5% consumers in a system to adopt a new technology. The early adopters as the next 13,5%, the early majority the next 34%, the late majority the next 34% and the laggards the last 16% (Rogers 2003). These are percentages of the total possible market for an innovation. Due to different resources, the total possible market is not the same for all the countries.

## 2.2 Technological Innovation System

The central idea of the Innovation System (IS) framework is that an actor does not innovate exclusively on his own, but that other actors in the system also have an influence (Hekkert et al. 2007). In the IS framework, there are different actor blocks interacting with each other: the governmental sub-system, the knowledge infrastructure, the intermediary infrastructure, the supply side and the demand side (Alkemade et al. 2007). Since the focus of this research is on consumers, the emphasis is on the processes within the demand side as discussed in section 2.1 and the interactions with the other IS blocks. Many firm and government policy instruments are focusing on the demand side and the IS framework is very well suited to understand the use of these instruments (Edquist & Hommen 1999).

Since the subject of this research is a specific technology (NGVs), the Technological Innovation System (TIS) is the most suitable framework to analyse the influences of different agents on potential NGV consumers. The definition generally accepted in literature for the technological (innovation) system is (Carlsson & Stankiewicz 1991, p.94):

> *a network of agents interacting in the economic/industrial area under a particular institutional infrastructure (...) and involved in the generation, diffusion, and utilization of technology.*

Since consumers are at the centre of this research, we analyse the influence of the institutional infrastructure and the other agents groups on the adoption decision of consumers. Institutions and the network of agents are influencing the consumers decision to adopt a new technology by their policies, information supply and marketing (see figure 2.2). The literature on the different interactions between the agents groups and the consumers is discussed below. The focus is on the direct influences of each agents groups on the consumer decision process and therefore the indirect influences are left out.

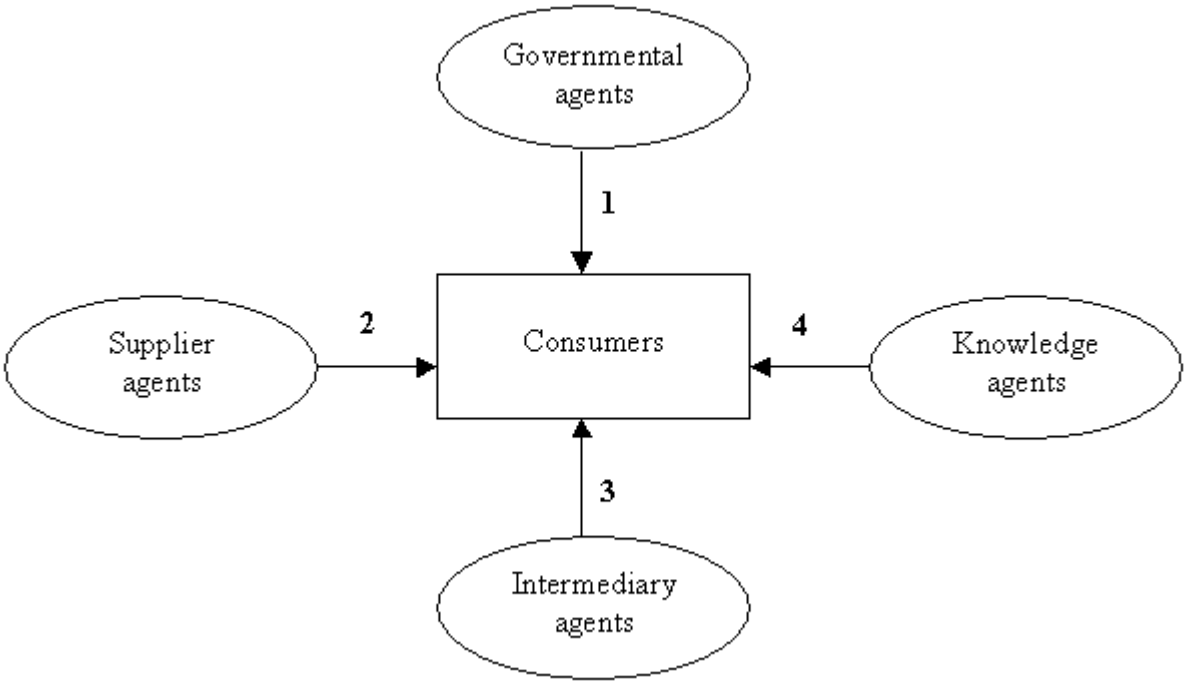


***Figure 2.2 Technological Innovation System with the consumer in the centre***

The influences of the different agent groups can be related to the variables of Rogers model (figure 2.1). These different influences are discussed in the following sections:

- Arrow 1: Influence from governmental agents (section 2.2.1).
- Arrow 2: Influence from supplier agents (section 2.2.2).
- Arrow 3: Influence from intermediary agents (section 2.2.3).
- Arrow 4: Influence from knowledge agents (section 2.2.4).

Beside these four types of external influences, consumer adoption is also determined by the internal decision process of the consumers themselves. This process within the central box of figure 2.2 has been discussed in section 2.1.

### *2.2.1 Influences from the governmental agents on the consumers*

Governmental agents play an important role in the consumer decision process (arrow 1 in figure 2.2). These agents can be local, regional, national or international. Together, these different governmental agents are responsible for the *nature of the social system* in Rogers' theory, because they set the norms and maintain the communication network structure. Porter (1990) describes which tools a government can use to improve demand conditions. The influence of the governmental agents on the consumers is determined by the use of the following constructs:

- *Government procurement*: The government is the largest buyer and can therefore play an important direct role by adopting the technology itself (Porter 1990). Government procurement has a direct influence on consumer adoption, because consumers see the technology in use around them. This construct implies that the governmental consumers are forced to use the technology and that the type of innovation decision from Rogers' model is governmental authority.
- *Regulation of products and processes*: Governmental agents can regulate the products and the processes by which products are made. It can impose standards for safety, emission or energy efficiency (Porter 1990). Consumers often see new technologies as uncertain. Safety standards can increase trust in the technology and so increase adoption. Emission and energy efficiency standards can give an advantage for new (cleaner) technologies, because the consumer can see that this technology is environmentally superior to the incumbent technology.
- *Stimulating early or sophisticated demand*: Governmental agents can launch programs that encourage early demand. This will reduce the risks perceived by firms or consumers towards the new technology (Porter 1990). High purchase prices are often a problem for new technologies, which the government can reduce with a grant (Lane & Porter 2007).
- *Technical standards*: Governmental agents affect the adoption rate by setting technical standards. In many fields, technical standards increase compatibility which is positive for consumers (Porter 1990). With a higher compatibility between new and old technologies, the new technologies are more attractive for consumers and the adoption will be higher.

### *2.2.2 Influences from the supplier agents on the consumers*

The supply side influences the consumer adoption (arrow 2 in figure 2.2) by its marketing, which is the process of interesting consumers in a product or service. Supplier agents are responsible for the *change agents' promotion efforts* in Rogers' theory with their marketing process. The relationship between the supplier agents and the consumers should be based on dependence, trust and commitment in order to achieve a positive marketing result (Sorce 2002):

- *Dependence*: The need of one party to maintain the relationship with the other party in order to achieve desired goals. Transaction costs make a partner replaceable only at higher costs (Lewin & Johnston 1997). The dependence of consumers on suppliers is based on the amount of suppliers on the market. When there are only a few suppliers, consumers are dependent on these suppliers and they will adopt their products more easily.
- *Trust:* The belief of one party that its needs will be realized by the other party (Sorce 2002). The parties must rely on each other and therefore become vulnerable to each other (Lages et al. 2008). The consumer adoption is slow when there is uncertainty around a technology. When consumers know the suppliers and therefore trust them, this uncertainty is lowered and the adoption increased.
- *Commitment*: Adoption of a long term relationship between the exchange partners. This implies the willingness to make short-term sacrifices in order to realize long-term benefits (Sorce 2002, Lages et al. 2008). Suppliers can also increase their commitment when they incite their employees to use the technology. This corresponds to the collective type of innovation decision in Rogers' model. Consumers are more willing to adopt a new technology when they experience that suppliers commit themselves to this technology by making short-term sacrifices.

### *2.2.3. Influences from the intermediary agents on the consumers*

The intermediary agents influence the consumers (arrow 3 in figure 2.2) by their role as key bridge between a wide range of users (Bessent & Rush 1995). Their most important role is to share information and knowledge between the different parties involved in the innovation system. This makes them responsible for the *communication channels* of Rogers' theory. There are different ways intermediary agents can improve the consumer decision process:

- *Direct transfer of specialized knowledge* (Bessent & Rush 1995): A consumer gets access to knowledge which can increase his or her willingness to adopt a technology. Without the intermediary agents, the consumer would not have access to that knowledge.

- *Experience sharing*: An intermediary organisation carries experience and ideas from one location to another (Bessent & Rush 1995). Consumers learn about new technologies which are used elsewhere. This can increase their interest in the adoption of this technology.
- *Articulate and define the needs*: An intermediary organisation can help consumers define their needs (Bessent & Rush 1995). This articulation will normally be done for large users (firms or government) who have difficulties understanding their needs and problems.

### *2.2.4. Influences from the knowledge agents on the consumers*

The knowledge agents influence the consumer decision process (arrow 4 in figure 2.2) with the information from their research. They are responsible for the content of the information sent by the different other agents in the system and so for the content of the *communication channels* in Rogers' theory. Two kinds of research influence the consumers in their decision process:

- The knowledge agents can research the effects of the new technology directly.
- The knowledge agents can perform research on competing technologies, which can influence the way consumers look at the new technology.

# 3. Methodology

In this section, the theoretical concepts of chapter 2 are operationalized in section 3.1 and the methodology for data collection and data analysis are discussed in respectively section 3.2 and 3.3.

## 3.1 Operationalization

The first step of the methodology is to operationalize the theoretical concepts. The theoretical concepts of figure 2.2 are operationalized for the NGV cases in table 3.1 based on the theoretical framework as discussed in chapter 2.

The first concept is the influence of the ***governmental agents*** on the consumers (arrow 1 in figure 2.2). The four dimensions of this concept as exposed in section 2.2.1 are operationalized with the following indicators:

- The total number of governmental NGVs determines the *governmental procurement*.
- The total number of safety or energy regulations regarding NGVs determines the *regulation of product and processes*.
- The total number of specific subsidies on NGVs or CNG and non-financial incentives determine the *stimulation of early demand*.
- The number of NGV or CNG technical standards determines *the technical standards*.

The second concept is the influence of the ***supplier agents*** on the consumers (arrow 2 in figure 2.2). The three dimensions of this concept as exposed in section 2.2.2 are operationalized with the following indicators:

- The number of suppliers offering NGVs in the automotive and CNG in the fuel sector determines the *dependence* of the consumers on these suppliers. If there are only a few suppliers offering NGVs and CNG in comparison to the total amount of vehicle and fuel suppliers, consumers will have a low dependence on NGV and CNG suppliers because they can turn to others without high costs (Lewin & Johnston 1997).
- The number of years the NGV and CNG suppliers are active in the sector determines the *trust* consumers will give them, because consumers tend to attach themselves to a brand (Sorce 2002).
- The amounts invested in the NGV sector determines the *commitment* of the suppliers, because this will improve NGVs' reputation and technology.

The third concept is the influence of the ***intermediary agents*** on the consumers (arrow 3 in figure 2.2). The three dimensions of this concept as exposed in section 2.2.3 are operationalized with the following indicators:

- The number of organisations informing the consumers about NGVs determine the *direct transfer of specialised knowledge*.
- The number of workshops and conferences about NGVs with the presence of intermediary agents determine the *experience sharing*, because these are the possibilities for potential consumers to come in contact with the NGV technology.
- The number of firms having bought one or more NGVs after being assisted by intermediaries determines the *articulation and definition of the needs*, because this means that an intermediary has articulated the needs of a firm and that the purchase of NGVs was the result.

The fourth concept is the influence of the ***knowledge agents*** on the consumers (arrow 4 in figure 2.2). The two dimensions of this concept as exposed in section 2.2.4 are operationalized with the following indicators:

- The number of publications about NGVs determines the *direct research*. Consumers read or hear about these publications which influence their perception of the NGV technology. This research can influence the consumers positively or negatively depending on the outcome.
- The number of publications about conventional or other alternative fuels determines the *indirect research*. Consumers read or hear about these publications which influence their perception of the conventional or alternative fuel. This perception indirectly influences the perception on NGVs, because NGVs and conventional or other alternative fuelled vehicles are substitutes of each other. This research can influence the consumers positively or negatively depending on the outcome.

The fifth concept, ***consumer decision process***, involves the process taking place in the central box in figure 2.2. Based on different indicators, consumers choose if they adopt a new technology. In the NGV case, these indicators are the car characteristics mentioned in section 2.1.3. These characteristics are categorised in the five dimensions proposed by Rogers (section 2.1.1):

- *Relative advantage*: This attribute is perceived as higher when the new technology is superior in comparison to the existing technology. As discussed in section 2.1.2, the financial aspect is one of the most important aspects of a technology. In the NGV case, fuel consumption and environmental impact are the other indicators of the relative advantage dimension based on the car adoption characteristics of table 2.1. A vehicle with low consumption and emissions is perceived as better than one with high consumption and emissions.
- *Observability*: This attribute is perceived as higher when the new technology is more visible than the existent technology. Advertisements play an important role in this attribute, because it makes the technology visible to the population. The other indicators based on the characteristics of table 2.1 are the appearance and the brand of the vehicle, because both indicators influence the way consumers look at a vehicle.
- *Trialability*: This attribute is perceived as higher when the new technology can be tried out. In the NGV case, a vehicle can be tested at a garage or an exposition and the number of these test sites is an indicator for the trialability attribute.
- *Compatibility:* This attribute is perceived as higher when the new technology is consistent with consumers' values and experiences. The compatibility of a car is highly determined by the number of fuelling stations, because drivers must be able to fill up their tanks. The other indicators based on the characteristics of table 2.1 are the resale value and the recommendation of other drivers. These indicators show that the vehicle is compatible with the car market and will increase the adoption.
- *Complexity*: This attribute is perceived as lower when the new technology is easy to understand and use. In the NGV case, the most important question is if the car is easy to operate and if filling up is simple, because these are the points where NGVs differ from conventional vehicles.

The dimensions and indicators discussed in this section are summarized in the operationalization table 3.1.

*Table 3.1: Operationalization of theoretical framework*

| Concept | Dimension | Indicator |
|---|---|---|
| 1. Influence from **governmental agents** on consumer decision process | *Government procurement* | Number of governmental NGVs |
| | *Regulation of products and processes* | Number of safety/energy regulations regarding NGVs |
| | *Stimulating early or sophisticated demand* | Number of subsidies on NGVs or CNG, Non-financial incentives |
| | *Technical standards* | Number of NGV or CNG technical standards |
| 2. Influence from **supplier agents** on consumer decision process | *Dependence* | Number of suppliers in the automotive/fuel sector |
| | *Trust* | Years the NGV/CNG suppliers are active in the sector |
| | *Commitment* | Amounts invested in the NGV sector |
| 3. Influence from **intermediary agents** on consumer decision process | *Direct transfer of specialised knowledge* | Number of organisations informing the consumers about NGVs |
| | *Experience sharing* | Number of workshops, conferences about NGVs with the presence of intermediary agents |
| | *Articulate and define the needs* | Number of firms having bought 1 or more NGVs after being assisted by intermediaries |
| 4. Influence from **knowledge agents** on consumer decision process | *Direct research* | Number of positive / negative publications about NGVs |
| | *Indirect research* | Number of positive / negative publications about other alternative fuels (in comparison with NGVs) |
| 5. **Consumer** decision process | *Relative advantage* | Price, Fuel consumption, Environmental impact (emission levels) |
| | *Observability* | Advertisements, Appearance, Brand |
| | *Trialability* | Number of test drive possibilities |
| | *Compatibility* | Resale value, number of fuelling stations, recommendation |
| | *Complexity* | Car operation and filling up |

The differences in type of adopters is taken into account in this research to understand the differences between the innovation adoption in the Netherlands/Switzerland and the world leading countries. In the Netherlands and Switzerland all adopters are considered innovators. Since the world leading countries are in a further stage of adoption, another consumer group is adopting NGVs. These consumers have different reasons to adopt than innovators. The internal influences on the consumer decision process in the Netherlands can therefore be compared more easily to Switzerland than to the world leading countries.

## 3.2 Data collection

Data for this research has been collected for the different cases of table 1.2:

-*World leading countries*: Literature study about the history of the NGV adoption in the most successful countries (Italy, Argentina and Pakistan). This literature has two different kind of sources. The first possibility is research from within the world leading countries themselves. These researches are often country profiles presented at natural gas vehicle conferences across the world. Experts from a country share their knowledge about their national system with experts from other countries. The second possibility is research from countries where NGVs are not adopted (yet). Researchers from these countries have investigated the emergence of NGVs in the leading countries in order to learn for their country. This literature has been reviewed in order to find the main characteristics of an emerging NGV innovation system and to find what relations consumers had with other actors in the system.

-*Swiss case*: The data collection in Switzerland has been divided into two parts: a quantitative and a qualitative. The quantitative part consists of 35 interviews with consumers who have already adopted the technology. The goal of these interviews was to find out the reasons for the adoption. The idea was that the

NGV drivers would present the adoption reasons and influences by themselves, therefore the questions were open:

- Who made the adoption decision?
- What was/were the reason(s) to adopt an NGV?
- Did an organisation or institution influence you positively in your adoption decision?
- Did an organisation or institution influence you negatively in your adoption decision?
- Are you positive about your NGV?

The interviews were open discussions with the NGV drivers, in which they shared their adoption and driving experiences. Therefore, most of the time, more questions than the five written down here have been asked. NGV drivers were enthusiastic about their cars and took the time to answer these questions. The interviews took place at different gas stations (Zurich, Wadenswil, Adliswil, Meilen, Lausanne, Cossonay, Morges, Rolle, Villars St-Croix, Yverdon, Basel).

The qualitative part consists of 9 interviews with important actors in the Swiss NGV innovation system. The following agents of the Swiss system have been interviewed:

- EAWAG: Water research institute of Switzerland. Jochen Markard welcomed me at EAWAG in Dübendorf, where we discussed the theoretical and practical part of my research. He gave me some advice for the theoretical framework and mentioned some important agents in the Swiss NGV system I could interview for my research.
- Municipalities of Morges, Lausanne and Yverdon. These municipalities try to promote NGVs in their regions.
- Gas companies: Cosvegaz and IWB. These companies try to increase their market share by promoting NGVs.
- Touring Club Suisse (TCS): Swiss motoring association having performed crash tests with NGVs.
- Gasmobil. This organisation has an intermediary function in the Swiss NGV system.
- Opel garage Benninger in Pampigny. This garage had an Opel Zafira CNG as a show model.

*-Dutch case*: The data collection in the Netherlands has been similar to the data collection for the Swiss case. The same interviews with NGV drivers have been performed at gas stations in Den Haag, Nieuwegein, Schiphol, Haarlem and Groningen. The number of interviews with NGV drivers is a little lower in the Netherlands (21), because there are less drivers and therefore harder to get in contact with. The qualitative part has the same role as in the Swiss case and the 11 interviewees in the Dutch case are:

- CNG-net (subsidiary of Ballast Nedam) and Fuwell (subsidiary of Nijol). These organisations build and run natural gas stations.
- Eco Mobility Services. This taxi company has a car running on CNG.
- Ford garage in Hoofddorp and Opel garage in Zeist. Ford and Opel are two of the brands with most NGV models.
- TNO. Research institute having performed different research about natural gas vehicles, often in comparison to gasoline and diesel vehicles.
- ANWB. Dutch motoring association.
- RWE. Gas supplier in the Dutch system.
- Aardgasmobiel. Intermediary in the Dutch NGV system.
- Gas station holder Elan on the University complex in Groningen having a CNG pump.
- Facilitair bedrijf Universiteit Groningen having two NGVs.

## 3.3 Data analysis

The data obtained from the interviews with NGV drivers and NGV experts has been analysed in order to answer the research questions. From the interviews at the gas stations, it was possible to find out who makes the adoption decision: consumers, companies or government. This is already an interesting result, since this is quite unknown in the Dutch case. The data from these interviews has also been used to find out which are the most important characteristics for adoption and which influences the TIS agents groups have on consumer adoption. Based on these findings, the characteristics that are important for the first adopters in the Dutch and Swiss case have been identified. This makes it possible to advice the different agent groups on which characteristics they should focus their marketing on. Furthermore, the interviews with NGV drivers show which agents groups influenced the consumers the most in the decision process. The interviews have been the same in Switzerland and in the Netherlands, so a comparison between the Swiss and the Dutch case is possible. The characteristics and the influences from the agents groups can be compared which can lead to learning points for the Dutch system.

The influences of the actors in the different innovation systems on consumer adoption have been analysed with the data obtained from the literature study and the interviews with NGV experts. Based on the indicators of table 3.1, we have compared the influences of the agents groups between the different cases. Indications for influences from governmental, supplier, intermediary or knowledge agents in the world leading countries have been found in literature. In the Swiss and Dutch case, the implicated agents were interviewed themselves and could explain their influences and how they perceive the influences from other agents in the innovation system.

# 4. World leading countries

In this section, the NGV innovation systems of the world leading countries (Italy, Pakistan and Argentine) are discussed. The consumer adoption characteristics and the influences from the different agent groups are elaborated on. For each of the three cases, first there is a narrative description section on the development of the NGV innovation system and then an analytical part on the observed theoretical influences.

## 4.1 Italian system

The Italian NGV innovation system experienced two periods of rapid growth in its history. In the first half of the past century, Italy became the first country with an NGV fleet. In the 1970s, the system had to be completely built up again after the rise of gasoline and diesel vehicles in the 1960s. This second growth period was based on entirely new technologies (fixed tanks instead of exchangeable cylinders) and can therefore be seen apart from the first growth period. The history of the Italian system is discussed in a narrative description (section 4.1.1) and in a theoretical analysis (section 4.1.2). At the end of this section, there is a short conclusion on the Italian system (section 4.1.3).

### *4.1.1 History of the Italian NGV system*

***First rise 1930s-1950s***
Italy was the first country in the world to introduce natural gas vehicles in the mid-1930s (Yeh 2007). The NGV market started in northern Italy, where a gas field was found near a populated area. This provided a significant local gas market without the construction of a major pipeline network (IANGV 1997). The NGV diffusion thus started from a local niche market. The refuelling method was based on exchangeable cylinders. At a filling station, empty cylinders were replaced by full ones, which did not require complex technologies. However, intensive hand labour was needed for exchanging the gas cylinders (Cola et al. 2000). At the end of the 1930s and during the 1940s, the NGV market extended to the rest of the country, especially for self-sufficiency reasons. This was reinforced by the political propaganda and the war-time conditions before and during World War II (Cola et al. 2000). This resulted in over 1500 filling stations at the beginning of the 1950s (Matic 2005).

***Decline in the 1960s***
In the 1960s, gasoline and diesel were easy to find and cheap to use. Europe (including Italy) was developing rapidly and the abundance of these fuels was a key factor in this process. This brought the NGV innovation system into a critical situation, because gasoline and diesel vehicles were cheap and widely promoted. This critical situation was reinforced by the lower relative advantage of NGVs due to practical and technical limitations, like the exchange of the gas cylinders and the very low cruising range (Cola et al. 2000). NGVs survived in some places with fixed tanks instead of the disappearing exchangeable cylinders. At the beginning of the 1970s, only 100 filling stations were left in Italy (Cola et al. 2000).

***Second rise in the 1970s***
A new refuelling technology arose in the 1970s: natural gas was pumped into the consumer's vehicles with a small compressor using hydrodynamic technologies. Even though this was costly, 80 new filling stations connected to gas pipelines were established (Cola et al. 2000). So, when the energy crisis occurred in 1973, the NGV innovation system was in a recovery phase. During the crisis, the Italian government and ENI (the Italian oil and gas company) favoured diversification and self-sufficiency, because they were afraid of the consequences if the automotive sector would remain completely dependent on oil. The governmental stimulation resulted in the construction of a widespread gas pipeline network. Due to these large developments, natural gas became scarce. This led to the neglect of the NGV sector in order to keep gas for industry, electricity and heating (Janssen 2005). However, those people driving NGVs still experienced the higher relative advantage of NGVs (lower costs and emissions), even if there was no widespread environmental awareness yet (Cola et al. 2000).

***Large crisis avoided in 1980s***
The supply restrictions and the new stability in other fuel prices led to a new potential crisis for the NGV sector in the beginning of the 80s. However, a major crisis was avoided thanks to different developments in the 80s (Cola et al.2000). Firstly, natural gas was imported from Algeria and distributed in the country

through an extended pipeline network. Secondly, the national government had a positive influence in the system by including CNG in the standards fuels and developing a plan for the construction of 600 filling stations. Thirdly, main bodies in the car and oil industries started to be interested in the NGV technology, among others because environmental concerns were increasing (Cola et al.2000).

***The entrance of Fiat in the 1990s***
Even though a crisis was avoided in the 1980s, NGVs were seen as completely different from conventional vehicles and NGV consumers were scarce. In the 1990s, new hydraulics and electronics technologies arose giving the possibility to reshape the system (Cola et al. 2000). The most important change was the entrance of Fiat in the NGV world. In 1997, the Fiat Marea was the first bi-fuel car on the market, followed a year later by the Fiat Multipla. The space for passengers in these cars was not affected by the gas cylinders under the vehicles (Janssen 2005).

After a few years of incubation, public authorities released investment plans for urban buses, garbage trucks and distribution vans. Due to complex standards, technical lead times and bureaucratic procedures, the different initiatives of the sector had to be supported by qualified advisors organizations (Cola et al. 2000). Oil companies, like ENI (AGIP), started to sell CNG at their own fuel stations. Italian industries developed the NGV sector by continuous product improvements and by promotional means. The Italian government officially saw the NGV sector as one of the possibilities to meet the Kyoto Protocol targets, leading to different initiatives for the stimulation of early demand (Cola et al. 2000):

- Favourable tax regime for NGVs
- Setting a minimum of environmental friendly vehicles in public transport (50% in 2003)
- Economic incentives for the purchase new NGVs or transformation of conventional vehicles to CNG
- Support for the development of the distribution network

This resulted in 350 filling stations in 2000 (Cola et al. 2000) with about 1000 vehicles per refuelling station (Yeh 2007). In literature, this is seen as the optimal balance between filling stations profitability and NGV driver convenience, because this proportion was also found in other successful countries (Janssen 2005, Yeh 2007).

***Stagnation in passenger cars and increase in heavy duty vehicles in the 2000s***
The market for passenger cars has been stagnating over the last years due to:

- Diesel competition (low taxes, good performance, wide model range) (Yeh 2007).
- Vehicle conversion is becoming more difficult because of On-Board-Diagnostics requirements. An OBD system can detect engines and exhaust problems and is mandatory in Europe and Northen America. This is a problem for the conversion of gasoline vehicles to natural gas, but not for factory made NGVs. (Matic 2005)
- Italian standard filling nozzle is incompatible with NGV1 standard, meaning that adapters are needed for foreign NGVs coming in Italy or Italian NGVs going abroad (Matic 2005).

The stagnation in the passenger car sector was not experienced in the heavy duty vehicle sector, which experienced a rapid increase in heavy duty natural gas vehicles. This was induced by an increase of filling stations with recent innovations from Italian knowledge agents (lower energy consumption and noise, suited to biogas, etc…). The government has been an important driver of this rapid increase by ordering urban busses and public company vehicles and by contributing to NGV taxis and filling stations (Gaudi & Gozzi 2004).

The market stagnation of passenger cars as well as the construction of new filling stations resulted in a value under the 1000 vehicles per refuelling station (Yeh 2007). However, Gaudi & Gozzi (2004) are foreseeing that the Italian NGV sector is still in a trend towards 10% market share.

### *4.1.2 Theoretical analysis*

The influence of the different agent groups on the consumers and some elements of the consumer decision process are discussed in this section.

***Influences from governmental agents***
As seen in the theory chapter, the governmental agents can influence consumers in different ways. In the Italian case, the types of governmental influences identified in literature were all partially present:

-*Government procurement* was present in both the first and the second rise. In the second rise, governmental trucks, busses and vans drove on natural gas. However, it can be noted that the government adopted NGVs only after an incubation time.

-*Regulation of products and processes* has been present in both rises. In the first rise, the war time conditions made self sufficiency important for the Italian government and NGVs were therefore highly promoted. In the second rise, the government imposed a quota of environmental friendly busses to the public transport sector.

-*Stimulation of early demand* was not really needed in the first rise, since the gas fields were close to populated areas and since no expensive filling stations were needed. In the second rise, the government financially supported the construction of a pipeline network, the implementation of natural gas stations and the purchase of NGVs.

-*Technical standards* were not really needed in the first rise, since there was only one simple main technology. In the second rise, technical standards appeared only in the 2000s.

***Influences from supplier agents***
Probably the most important impulse in the second rise was the entrance of the main car manufacturer Fiat in the NGV sector. From that moment on, NGV consumers could directly buy a bi-fuel car leading to two major advantages. Firstly, conversion of gasoline cars was not needed anymore. Secondly, the Fiat Marea and Multipla could drive both on natural gas and gasoline. Fiat is well known and has a positive reputation for all the Italians. The *commitment* of Fiat to the NGV sector by launching two different models gave the consumers confidence in NGVs. In Germany, Volkswagen is currently taking the same step as Fiat by launching bi-fuel models, which could boost the emerging German system.

Another important impulse in the second rise was the commitment of oil & gas companies. Although natural gas could be seen as a direct competitor of oil, companies like AGIP (part of the ENI group) began to sell natural gas at their existing fuelling stations. ENI does not see natural gas vehicles as competitors, but as possibilities to increase their gas turnover. Consumers know companies like AGIP and therefore put *trust* in them more easily.

***Influences from intermediary agents***
In the system of the first rise, intermediaries were not part of the system yet. In the second rise, the intermediaries were important in the NGV innovation system. Before the standardization process, complex standards, technical lead times and bureaucratic procedures were hazards for the companies and consumers. Qualified intermediaries were important in supplying these parties with *specific knowledge*. Intermediary agents *shared their experiences* and their knowledge in workshops and conferences. The role of the intermediary agents in the *articulation of the needs* was not so important, since this was already dealt with by the strong influence of the governmental agents.

***Influences from knowledge agents***
The Italian NGV knowledge infrastructure is responsible for *direct research* about NGVs. In this area they might be considered the best in the world (Cola et al. 2000). Technical changes made it possible to survive the different crises the system faced, like in the 1980s. The Italian knowledge agents were also involved in the second rise in the 1990s, because hydraulic and electronic technologies gave the opportunity to reshape the system. Consumers perceive new NGV technologies positively since their origin is in Italy. The knowledge agents can also adapt their products more easily to the Italian consumer since they are close and well known to them.

***Consumer decision process***
At the beginning of the second rise in the 1970s, NGV consumers experienced the benefit from lower costs and less pollution. This shows the importance of the *relative advantage* characteristic for the innovator group in the Italian NGV sector. The entrance of Fiat was an important impulse in the second rise. This well known *brand* increased the *observability* of NGVs and led to the adoption of early adopters. Nowadays, everyone in Italy knows NGVs as normal vehicles in the same category as diesel or petrol vehicles. Consumers does not experience NGVs as more *complex* as conventional cars anymore, since driving and filling up is seen as normal. The same conclusion can be made for *trialability* and *compatibility*, because there are enough test possibilities and fuelling stations.

Gaudi & Gozzi (2004) are foreseeing that the Italian sector is in a trend towards 10% market share. This can be seen as the total possible market for natural gas vehicles in Italy. At the end of 2008, the total market share

of NGVs was around 1%, so the share of the possible market was about 10%. According to Rogers' theory, this percentage means that the adoption is in the *early adopter* group phase. After an incubation time at the beginning of the second rise, the government and other consumers decided to adopt NGVs. These consumers wanted to see positive results from the experiences from the first consumers before adopting the technology themselves. This shows that these consumers are part of the *early majority* group, since they were waiting till the technology and the fuelling system were mature. Driving on gasoline and diesel are still fine solutions for the transport sector. Therefore, there is no pressure from the environment to drive on natural gas and the *late majority* is not adopting NGVs yet.

### *4.1.3 Conclusions*

Italy is not a traditional natural gas country with large natural reserves and distribution networks. However, this disadvantage was overcome in the history of the Italian NGV innovation system. This history is characterised by two separate rises, before and during World War II and at the end of past century. In both rises, ***governmental agents*** had an important influence on the consumers in the system. NGV technology has been pushed by these agents during war conditions in the first rise and energy/environmental crisis in the second rise. However, the government has not been the first driver of the rises, since their procurement and standards came in a later phase of the rises.

All the agent groups have had a more or less positive influence on the consumer adoption in the Italian case. ***Supplier agents*** have probably had the most important influence in the second rise. The entrance of Fiat in the system was the beginning of a more widespread adoption. Beside this supply of NGVs, CNG was also promoted by an important supplier: the ENI group. This oil and gas company is the most important energy supplier in Italy and has had an important influence on Italian consumers.

## 4.2 Pakistani system

At the moment Pakistan is the country with most NGVs even though NGV adoption only started in the 2000's. This adoption period is too short to justify a historical description and therefore the system at the end of the 2000s is presented in section 4.2.1. The theoretical implications are discussed in section 4.2.2.

### *4.2.1 Description of the Pakistani NGV system*

Pakistan was the country with the most NGVs in the world at the end of 2008 with 2600 fuelling stations (IANGV 2008) and 2 million NGVs, implying a market share of 52% of the total vehicles in the country (Lyon 2007). The system experienced an amazing progress, because there was no NGV in Pakistan before the year 2000 (Lyon 2007). Key players in the Pakistani NGV innovation system are:

- Private companies: Investors found benefit in investing in the NGV innovation system (Matic 2005).
- Companies associated with large oil and gas companies (e.g. Shell, Pakistan State oil company) (Matic 2005)
- Car manufacturers (e.g. Honda, Toyota, Suzuki, Kia) that produce factory fitted CNG petrol cars and 3Wheelers, partly produced in Pakistan (Matic 2005).
- The Hydrocarbon Development Institution of Pakistan (HDIP) that delivers technical support, operates different CNG stations and cylinder testing facilities and advises the government (Ashraf 2005).
- The Government, divided in a policy (Ministry of Petroleum and Natural Resources) and a regulatory part (Oil&Gas Regulatory Authority). They are responsible for the following key drivers for the development of the system (Matic 2005) (Ashraf 2005):
    - -Governmental promotion of NGVs
    - -No custom duties on import of CNG equipment and conversion kits
    - -No sales tax on import of CNG equipment and conversion kits
    - -Building of CNG stations are approved easily
    - -No customs on import of natural gas buses
    - -Favourable price of natural gas (for buses 35% lower than diesel)
    - -Natural gas tariffs that are linked to petrol price in order to keep a favourable CNG price

The system was also influenced by other drivers which were not directly the result of agents acting in the system, like the availability of natural gas in the country and the presence of a gas infrastructure (Ashraf 2005).

### *4.2.2 Theoretical analysis*

The influences of the different agent groups on the consumers are discussed in this section. Due to the low amount of literature about the Pakistani system, it is not possible to say anything about the influences from the knowledge agents and about the consumer decision process.

***Influences from governmental agents***
*Governmental procurement* is not an important factor in Pakistan. The private sector and consumers are responsible for the investments and execution. The Oil&Gas Regulatory Authority sets *safety and technical standards* based on the advises of the HDIP. The *demand is stimulated* by many different financial (e.g. no custom duties, no sales tax, natural gas tariff linked to petrol price) and non-financial incentives (e.g. easy approval fro CNG stations, CNG priority). The consumers are widely informed about NGVs by governmental promotion.

***Influences from supplier agents***
Car manufacturers (e.g. Honda, Toyota, Suzuki, Kia) and oil & gas companies (e.g. Shell, Pakistan State oil company) are all very active in the system. The consumers feel that all the important firms have a positive attitude towards NGVs. This shows the *commitment* of the supply side and therefore the consumers have confidence in NGVs. Furthermore, since the whole supply side chooses for NGVs, the consumers do not really have an alternative and are *dependent* on the suppliers.

***Influences from intermediary agents***
The HDIP is an important intermediary in the Pakistani NGV innovation system. Their most important task is to supply *specified knowledge* to the governmental institutions.

### *4.2.3 Conclusions*

The Pakistani NGV innovation system is fascinating since it grew from 0 to 2 million vehicles in ten years. The problem is that there is not a lot of information about the system, among others because Pakistan is not a western country. From the poor information on the Pakistani system, it can be learned that the ***governmental agents*** play a very important role. The national government decided to widely promote NGVs in order to be less dependent on oil. Other agent groups have also influenced the consumer adoption. However, these agents were often motivated by governmental agents.

## 4.3 Argentine system

The history of the Argentine system is discussed in section 4.3.1 and its theoretical implications in 4.3.2.

### *4.3.1 History of the Argentine NGV system*

At the beginning of the 1980s, new gas fields were discovered and taken into production. Natural gas pipelines were already in operation, since natural gas was widely used in households (Estevez et al. 2005). In 1984, the Argentine government decided to start a program to substitute oil in the transport sector by this new found gas. The idea was to increase oil export and so national revenues (Fracchia 2000). The government could increase oil taxes without massive protests because natural gas was a good and cheap substitute. The Department of Energy had plans to substitute 2 million OET (oil equivalent ton), convert 130'000 vehicles and build 270 filling stations in the period 1984-1994 (Maubro 2004). The idea was to convert gasoline taxis, privately owned cars and vans in the first five years. Then, from the fifth year on, diesel public transportation and trucks would be converted to CNG (Estevez et al. 2005).

The NGV launch took place in December 1984 in the centre of Buenos Aires near governmental buildings. The first vehicles to be converted were a result of governmental procurement in order to show the commitment by the authorities (Gwilliam 2000). Other governmental policies were also implemented to encourage CNG use:

- Strict certification to ensure fuel quality (Gwilliam 2000)
- 65 percent price difference between natural gas and gasoline (Janssen 2005)
- Guaranteed gross margin for filling stations (Gwilliam 2000)
- Non-financial support for local conversion kit industry (Gwilliam 2000)

- A very active state owned gas entity ensuring standards for the system (Matic 2005)

In the initial period (1985-1991), many investors were attracted to put money into filling stations, because there were high expectations about the rate of NGV conversions (Janssen 2005). Investors came from within the fuel and car industries, like oil companies willing to break away from the "petrol station rule". At the time, there had to be a 2 km distance between two petrol stations from the same company. Natural gas stations gave oil companies the opportunity to exploit more stations within the same distance. Some investors were also completely new in the sector since the payback time for a filling station was only 2 years (Fracchia 2000). The workshops for the conversion and the small factories for the conversion kits also emerged thanks to these new investors (Estevez et al. 2005). Authorities had a very proactive attitude in the management of these projects (Matic 2005). The system grew rapidly in the first years due to the conversion of nearly all the taxis in Buenos Aires, since the payback time for conversions was only 50 days (Janssen 2005). The chicken and egg problem could be overcome with this large taxis fleet, the set of policies and the economic conditions. In the period from 1984 till 1990, the NGV sector was responsible for a decrease of 1% of the total national unemployment and it increased the GNP by $400 million annually (IANGV 1997).

In 1991, a governmental program to increase monetary stability was started. This led to an investment boom in filling stations (Fracchia 2000). The effect was that the balanced growth between the number of NGVs and CNG stations was disturbed. This balance was only restored at the end of the 1990s (Janssen 2005). The Argentine economic crisis of 2002-2003 was responsible for a CNG sales increase of 27% over 2003 (Matic 2005). In December 2008, there were 1800 fuelling stations and 1.75 million NGVs in Argentina with a growth percentage of 5% compared to 2007 (IANGV 2008). NGVs accounted for 22% of the market share in 2007 (Lyon 2007). The NGVs are divided in private vehicles (90%), utility vehicles (8%) and taxis (2%) (Maubro 2004).

All the elements for NGV conversions or fuelling stations are fabricated in Argentina (Matic 2005). The country also exports its equipment and services to other countries, especially in Latin America (IANGV 1997). Diesel engines have not been converted to CNG due to low fuel prices and the high benefits for agriculture (Fracchia 2000). Still the government wants to convert the diesel busses in the urban transport to natural gas. Some companies are also developing natural gas scooters or other vehicles for city use (Maubro 2004). NGVs produced by car manufacturers never took a significant part of the market (Janssen 2005). This could change in the future, since representatives of the big car manufacturers were present in Buenos Aires during the International Conference on Natural Gas Vehicles (Maubro 2004).

### *4.3.2 Theoretical analysis*

The influences of the different agent groups on consumers are discussed in this section. A clear influence from intermediary agents was not found in the literature. Some elements of the consumer decision process are also discussed.

***Influences from governmental agents***

As seen in the theoretical part, the governmental agents can influence consumers in different ways. In the Argentine case, the governmental agents played a very important role. They had a clear goal and influenced consumers and other actors in the system in order to reach that goal. The different theoretical concepts of governmental influence were all executed in the Argentine system:

-*Procurement*: The first conversions were effectuated on governmental vehicles to show the governmental commitment to the new technology.

-*Regulation of products and processes*: the government ensured fuel quality by strict certification. Consumers' trust in the new technology increased by these quality certifications.

-*Stimulating early or sophisticated demand*: governmental agents stimulated the early demand with different policies. They assured that natural gas was 65 percent cheaper than gasoline. Gross margin was guaranteed for those who build new filling stations and the local conversion kit industry was supported by governmental incentives. The demand is not in the early phase of adoption anymore. However, the government does not end its support and even wants to convert diesel busses to natural gas and promotes the building of more filling stations.

-*Technical standards*: a state owned gas entity is ensuring technical standards in the NGV system.

***Influences from supplier agents***
The two important groups of supplier agents in the Argentine case were the filling station builders and the workshops. Due to a governmental rule of only 1 gasoline/diesel station in a 2km distance range, oil companies were very eager to build natural gas stations. Consumers recognized and *trusted* the gas delivering companies since they were the same companies that were responsible for the gasoline/diesel distribution. There were also new entrants who invested in the system because they wanted to profit from the governmental promises of guaranteed gross margin for the building of natural gas stations.

Workshops and new entered small factories are the other supplier agents playing an important role in the system since they were responsible for the conversion of vehicles to natural gas vehicles. These workshops and small factories *committed* themselves to the system since they were ensured of work because of the conversion of all the taxis in Buenos Aires. Car manufacturers do not play a role in the Argentine system at the moment, because Argentine consumers drive with converted vehicles. However, this could change with the entrance of large car manufacturers on the world NGV market (VW, Ford, Fiat).

***Influences from knowledge agents***
All the NGV equipments, conversion and gas stations are developed , built and distributed in Argentina. This involvement of the Argentine research sector show the commitment of the different agents to *direct research* on NGVs and to the entire NGV innovation system which influences the consumers in a positive way.

***Consumer decision process***
The first consumers were governmental agents and taxis drivers. These first consumers were forced by the governmental authority to drive on natural gas. Other consumers could therefore see NGVs driving around before taking the decision to switch to natural gas, which increased the *observability* of NGVs. The consumers who freely made the decision to drive NGVs were therefore directly part of the *early adopters* group, since the *innovators* were governmental agents and taxis drivers. The financial support by the governmental agents gave the NGVs a positive *relative advantage*. The other attributes (trialability, complexity and compatibility) in the beginning all were negative for NGVs in comparison to conventional vehicles. However, due to the high involvement of the governmental and supplier agents these obstacles were quickly overcome for the first adoption groups.

### *4.3.3 Conclusions*

The ***governmental agents*** played a very important role in the Argentina system. They were the pioneers of the system having a very clear plan of where they wanted to be ten years later. All the theoretical influences governmental agents can have on the consumers were present. Furthermore, the government also influenced ***supplier and knowledge agents*** in an important way. With this governmental support, these agents could influence the consumers in a positive way.

# 5. Swiss system

As said in the introduction, consumer adoption has been increasing in the Swiss NGV innovation system over the last years. In this chapter, the drivers and barriers for this adoption are discussed. The Swiss NGV innovation system is heavily regional dependant. The number of vehicles and stations is higher in regions where main agents are active. Gasmobil (section 5.3) ensured that the regions without these main agents also got at least one station in order to make it possible to drive from one part of the country to another without refuelling problems [H].

The Swiss system is analysed in this chapter following the sequence of the theoretical framework: influences from governmental agents (5.1), influences from supplier agents (5.2), influences from intermediary agents (5.3), influences from knowledge agents (5.4) and perceived attributes in consumer decision process (5.5). This chapter ends with a section on the other influences (5.6) and a concluding section on the Swiss system (5.7). The whole description of the Swiss system is based on the theoretical concepts of chapter 2. The different concepts are discussed using the dimensions of the operationalization (table 3.1). These dimensions are in *italic* in the description of the system.

## 5.1 Influences from governmental agents

As in many countries, there are two kind of governmental agents having distinct influences on the consumers: local and national governmental agents.

***Local government***

Local governments are very important agents in the Swiss NGV innovation system. Switzerland is very regionally organised and local governments as cantons or municipalities have high decision power. Governmental *stimulation of early demand* therefore originates mainly from local initiatives [G, H, I]. The agents are closer to the consumers which facilitates the promotion and other exchanges between these two groups. A problem might be that regions with weak promotional efforts from local governments could stay behind. For example, in some cantons, NGVs pay more road tax than in others [U]. However, in most places, the local promotion is strong.

In Morges, the first NGVs resulted from *governmental procurement* since municipal vehicles drive on natural gas since 2000. At the beginning, they drove in converted Peugeot Experts with a power loss of 15%, which was not a good promotion [H]. Since a couple of years, they drive on superior factory model cars with advertisement on it which is a better promotion for potential consumers. The municipality was responsible for a large stand about NGVs on the local market. This stand was set up in collaboration with Gasmobil, from which they got the promotion truck. The municipality also *stimulated early demand* by paying two third of the creation costs of a public gas station, one third came from Gasmobil [H]. Besides the personal consumers, the municipality also tries to reach local companies by explaining them the advantages of CNG. In this, the municipality fulfils an intermediary agent role in *articulating the needs* of local firms.

In Basel, the local government is also *stimulating early demand* and helping IWB (see section 5.2) who is very active in the promotion of NGVs. On the Auto Expo, there was a police car in front of the entrance with advertisement saying "I drive on natural gas". This is important for consumer's observability when they see that the local *government procures* NGVs for the police and shows that driving on natural gas is safe and advantageous. Taxi drivers in Basel said that their companies were persuaded to drive on natural gas by the support from the local government. Four taxi companies in Basel have natural gas vehicles [U].

***National government***

The consequence of the regional organisation in Switzerland is that the national government has a smaller role in the NGV innovation system. In 2008, the national government decided to *stimulate early demand* by exempting natural gas from the mineral oil tax which reduced the CNG price by 30%. Since that moment, finance has become one of the reasons to drive NGVs (see section 5.5) [D]. A condition for this tax advantage is that 10% of biogas must be added to the natural gas [B, D, E, H].

Different actors also criticized the role of the national government. The homologisation process for transformed vehicles is long and costly. A driver said that her brother did not transform his car due to this

problem [U]. The paper work for creating a natural gas station also takes a long time and slows the expansion of the system. Gasmobil therefore lobbies for better conditions for natural gas on a political level [E].

## 5.2 Influences from supplier agents

The different supplier agents in the Swiss NGV innovation system are gas companies, biogas companies and garages. Gas companies have a major role, since they are responsible for the creation of the CNG pumps at existing gas stations. Biogas companies are new entrants on the market willing to increase their market share by promoting NGVs. In the Swiss system, car manufacturers are represented by their garages.

### *Gas companies*

Gas companies are probably the most important agents in the Swiss NGV innovation system. Their incentive to be *committed* to NGVs is clear: they want to sell more gas in order to increase their market share. As said earlier, Switzerland is organised regionally and this is also the case for gas companies. Each city and even small town has its own gas company responsible for the gas supply in the region. Two examples of regional gas companies are Cosvegaz and IWB. Cosvegaz is a small company providing gas for Cossonay[5] and its region. IWB is a larger company providing gas for Basel[6] and its region.

Cosvegaz is the gas company of the region around Cossonay. They are very active in the promotion of NGVs. All their employees drive in natural gas vehicles with large advertisements. The company decided to buy all kind of new natural gas vehicles in 2008 and is planning to sell them on the second-hand market for a bargain price in 2010. This will stimulate the second-hand market and give the possibility for less wealthy people to drive on CNG. Cosvegaz opened five public (natural) gas stations in the region, installed many Phill installation and constructed two non-public stations for local companies [B]. For the installation of a Phill equipment, consumers only have to pay between 500 and 1500 CHF. This is not much since the real installation costs are around 7000 CHF. Consumers who want to buy a new NGV get 1000 CHF reduction on the car purchase if they agree to drive at least one year with advertisement for driving on CNG [B]. Cosvegaz cooperates with a large horticulturist in the region in order to get to the necessary 10% biogas addition. All these promotional activities led to an increase in CNG sales. From January to August 2009, Cosvegaz had already sold as much CNG as in the whole year 2008. The company is now looking for natural gas under the Geneva Lake with the expectation that there might be enough for 10 years for the whole country [B].

Industrielle Werke Basel (IWB) is the gas company for the city of Basel and its region. The company has 130 diverse natural gas vehicles full of NGV advertisement, like cars, vans, busses, trucks and crane lorries. As Cosvegaz, they also give a 1000 CHF reduction for the purchase of a new NGV. IWB also pays for the conversion of a conventional car to CNG [D]. The company has installed ten public (natural) gas stations in Basel and the region. IWB also launched the project "Hundert Umwelt-Taxis in der Region Basel" (Hundred Environment Taxi's in Basel region). In collaboration with local government and Novatlantis (see section 5.4), they have a goal of hundred NGV taxi's in the region by 2015 and this goal will probably be reached (IWB 2009). IWB is also responsible for many promotional efforts, like advertisements on vehicles and posters in Basel (see appendix 3). At the Auto Expo Basel, IWB had the largest stand of the whole exposition. The stand was at the entrance, so everyone coming to the exposition had to pass through it.

### *Gas stations*

Gas companies must find gas station owners willing to sell natural gas. The involvement of the gas stations in Switzerland is not high, but they are also not lobbying against the installation of natural gas pumps. The price of natural gas is always shown on the price boards and calculated in comparison to a litre of petrol in order to show the price advantage of CNG. In contrast to the Netherlands where the natural gas pump is often behind the truck pump, there is always a nice place for the Swiss NGVs to fill up (see appendix 3). Inside the station, there is often advertisement from Gasmobil explaining the advantages of driving on natural gas.

[5] Cossonay is a small town 14 km northwest of Lausanne with around 2.700 habitants.

[6] The city of Basel has around 167.000 habitants and the metropolitan area around 830.000.

**Biogas companies**

In Switzerland, driving on natural gas has been pushed by the growing biogas sector. Kompogas was one of the first companies in the world to produce biogas, is world leader in high-solids anaerobic digestion and has factories all over the world. Kompogas is promoting the use of biogas as a fuel in Switzerland in order to increase their market share. Eight trucks of the largest national retailer Migros were already driving on biogas from Kompogas before the emergence of the NGV innovation system (Janssen 2005). Due to the high involvement of Kompogas, the biogas system evolved which also influenced the NGV sector positively [A]. In Switzerland, there is at least 10% biogas added to the natural gas mixture and some CNG stations even offer gas consisting of 100% biogas. Several agents in the Swiss NGV innovation system, such as biogas companies or local governments, see NGVs as a stepping stone technology towards biogas vehicles.

***Garages***

There is no national car manufacturer in Switzerland. The NGVs are therefore imported from mostly Germany (Opel, VW, Mercedes), Italy (Fiat) and France (Citroën). The garages play an important role in the distribution of NGVs in Switzerland. In different interviews, experts pointed to the lack of commitment of the garages to NGVs [B, D, H].

The Benninger Garage (Opel) in Pampigny sold an Opel Zafira CNG to a customer in 2004. In 2008, the customer wanted to change his Zafira for the new CNG model. The garage bought the 2004 model back and used it as a replacement car. The garage told that they would install a Phill installation if the experience was positive. However, this was not the case: people did not know what it meant when the gas tank was empty, the car had 10% less power and there was no gas station in the village. The garage wants to sell the car on the second-hand market. The garage holder said that Opel Switzerland tries to push NGVs from above, but that no garage in the region is enthusiastic [F].

## 5.3 Influences from intermediary agents

There are different organisations playing an intermediary role in the Swiss NGV innovation system. The most important are the motoring associations and Gasmobil.

***Motoring associations***

Touring Club Suisse (TCS) has 1.6 million members and is the largest motoring association of Switzerland. One of its actions is to test cars or car elements. TCS tested natural gas vehicles in a crash test and the results were positive. This is a very important discourse in taking away the fear for NGVs as riding bombs. Since TCS is an established organisation known for its objectivity, this test has a positive influence on the consumers. The TCS decided to launch the "TCS drives on natural gas" promotion in which 26 NGVs are used as a promotional tool (TCS 2009). The division in Cossonay drives an NGV showing their confidence in their crash test and in the NGV technology. The TCS employee said that they bought it for this political reason [C]. Since the TCS is driving itself on CNG, they can *share experiences* with their members. On their site, TCS promotes natural gas vehicles as one of the cleanest transport options.

Verkehrs Club Schweiz (VCS) has 120.000 members and is the second largest motoring association in Switzerland. This organisation has the environmental aspect as their main goal and considers NGVs as one of the options to achieve this goal. The NGV promoters said that this organisation has a positive influence in the Swiss system [E]. The promotion of both the TCS and the VCS is part of the *direct transfer of specialized knowledge* dimension, since they inform consumers and organisations about the advantages of NGVs

***Gasmobil***

Gasmobil is an organisation created in 2002 with the goal of introducing and promoting natural gas and biogas vehicles on the Swiss market. It was founded by different national and regional gas companies in order to create a centre of competence for the whole country [E]. Over the last years, the main task has been to coordinate the realisation of gas stations. The goal of 100 stations in 2008 has been achieved since there were 106 stations in 2008 (IANGV 2008). Gasmobil also ensured there were gas stations in each region, so that drivers can cross the country without fuelling problems. For example, the station in Morges has been realised by the municipality of Morges in collaboration with Gasmobil and has been built along the main road between Lausanne and Geneva [H].

Gasmobil is also responsible for the promotion of NGVs in Switzerland. This promotion can be classified in the different theoretical concepts of intermediary agents:

*Experience sharing:*

- They had a stand at the international Motor Show of Geneva and large advertisements on the website of the Motor Show (Salon-Auto 2009).
- On the local market in Morges, there was a large advertisement truck which the municipality lent from Gasmobil [H].
- Gasmobil coordinated the creation of the largest stand at the Auto Expo Basel owned by Industrielle Werke Basel (see section 5.2) [D].

*Direct transfer of specialized knowledge:*

- There are flyers from Gasmobil promoting natural gas / biogas at the different gas stations and at the offices of the different gas suppliers.
- Gasmobil informs different organisations in the Swiss system about the advantages of driving on CNG [E].

*Articulate and define needs:*

- Gasmobil cannot articulate and define needs as a real intermediary agent. Since it is a party with interests in the NGV sector, Gasmobil does not show the other alternatives to different organisations. However, due to their information about NGVs, different organisations took the step to drive on CNG.

## 5.4 Influences from knowledge agents

Many knowledge agents perform direct research on NGVs and have a positive influence on the consumers in the NGV innovation system. Most of these knowledge agents are located around Zurich and the Eidgenössische Technische Hochschule (ETH), Swiss Federal Institute of Technology. EMPA, a research institute of the ETH domain, is conducting research about catalytic converters for natural gas vehicles. Some results of this *direct research* were exposed as promotion at the Auto Expo in Basel [D]. EMPA also conducted research on the emissions of different kind of vehicles which shows the advantages of NGVs over conventional cars (Bach & Lienin 2007). These results are used by Gasmobil and other NGV promoters to show the advantages of NGVs to potential consumers.

Novatlantis is an organisation applying the results of the ETH domain to sustainable development projects in urban settlements. Driving on natural gas/biogas is seen as one of the (more) sustainable options for the urban areas. The Swiss Federal Institute of Technology of Zurich and Lausanne, the Paul Sherrer Institute (multi-disciplinary research centre), EMPA, EAWAG (aquatic research institute) are some examples of the knowledge agents participating in the Novatlantis projects (Kasemir et al. 2004). These well known knowledge agents accept that their names are used for NGV promotion.

## 5.5 Perceived attributes in consumer decision process

Of the 35 interviews at gas stations in Switzerland, 12 were consumers and 7 were employees who took the decision to drive NGVs themselves. These adopters with an optional choice described which attributes of their car were important in their choice for NGVs. The reason most often cited was the environmental aspect. Early NGV drivers are green thinking people who give less importance to the disadvantages of NGVs than to the environmental advantages. The second motivation that was expressed quite often was the financial aspect (see table 5.1). Since the federal government decided to lower the tax on natural gas, the payback mileage of NGVs is between 30.000 to 50.000 km depending on car type and gas price fluctuations (Gasmobil 2009). Non-green thinking people also start to be interested in NGVs due to this price advantage. The financial motivation was also present for the green thinking people. Half of the interviewed consumers with environmental motivation said they compared NGVs with electrical vehicles (EV), but the EV option was too expensive and they turned to NGVs [U]. Financial and environmental advantages are both part of the *relative advantage* attribute. Besides the less unpleasant smell cited by gas company employees in the city of Basel, no consumer named another reason to drive NGVs [U]. We can therefore conclude that the four other attributes of Rogers are not experienced as better.

*Table 5.1: Adoption reasons under adopters with free choice*

| | 1st reason: Environment 2nd reason: Finance | 1st reason: Finance 2nd reason: Environment | Environment only reason | Finance only reason |
|---|---|---|---|---|
| Consumers | 3 (25%) | 3 (25%) | 6 (50%) | 0 (0%) |
| Firms | 1 (14%) | 0 (0%) | 3 (43%) | 3 (43%) |
| **Total** | **4 (21%)** | **3 (16%)** | **9 (47%)** | **3 (16%)** |

NGV drivers were nearly all generally positive about driving on natural gas. However, they all experienced some disadvantages. The disadvantage most often cited was the loss of power, which is a problem in mountainous Switzerland. The other disadvantages in order of citations are: the cruising range, the amount of stations and the space occupied by the tanks [U]. Even if there are around 120 gas stations in Switzerland, different NGV drivers complained about the lack of stations alongside the motorways. For the French speaking part, the lack of stations in France was also experienced as a problem [U]. The complains about the amount of stations shows that the *compatibility* of NGVs is still lower than conventional cars. The other disadvantages (loss of power, cruising range, space of the tanks) are part of the *relative advantage* attribute. For most people, these disadvantages have a higher weight than the two advantages cited above and they keep driving conventional fuelled vehicles. One NGV consumer experienced disadvantages for long drives due to the cruising range and the amount of stations, but used an NGV for the short drives near the station in her hometown [U]. So, for her, the *relative advantage* of NGVs for short drives was higher than of conventional cars, but for long drives the *relative advantage* was lower and she would take her husband's gasoline car or the train.

Different actors involved in the system also experienced that people are afraid of natural gas vehicles, because they think that these cars are driving bombs. According to Voindrot [H], this problem will be resolved once people see more NGVs driving around without any problem. So, the *observability* is too low at the moment, which slows down the adoption. However, the number of NGVs driving around with advertisement is increasing, which raises the *observability*. Due to a low commitment of the garages (see section 5.2), the *trialability* of NGVs is low, because people do not have many places to test these vehicles. The *complexity* of NGVs is higher than conventional cars for people who are not used to new technologies. A garage holder explained that people driving in an NGV often called to ask if there was a problem with the car when the light of the CNG tank came up on the dashboard and to ask how they should fill up with CNG [F]. However, after a few drives, these problems fade away and the *complexity* of NGVs is on the same level as conventional cars.

There are four types of decision making processes in the Swiss system. Firstly, consumers who freely choose to drive NGVs. Secondly, gas companies that drive NGVs in order to promote and sell more natural gas. Thirdly, firms that make a free choice to implement NGVs in their vehicle fleet, but their employees are forced to drive in it. Finally, some bus and taxi companies that are forced to drive low emissions vehicles and NGVs are one of the few options. Consumers and gas company employees were nearly all positive about NGVs [U]. The first group because they made the decision themselves. The second group because they identify themselves with the company where they work. The only group NGV drivers with some negative reactions were the employees of firms other than gas companies. Their firm obliges them to drive on natural gas and they only perceive the negative aspects of driving NGVs (loss of power, cruising range) and do not perceive the financial and environmental advantages personally [U]. However, about half of this group was also positive and since the group is the smallest in the Swiss case, it has a smaller effect than the positive perceptions of the other groups. Two of the interviewed consumers bought their car due to positive reactions from other drivers [U], showing the importance of positive consumer experiences.

## 5.6 Other influences in the system

Besides all influences exposed in section 5.1 till 5.5, the Swiss system has also a geographical advantage. Switzerland is a small country and it is therefore easy to build up a covering network of gas stations. A strong government is not needed to build up this infrastructure, like in larger countries [H]. Another geographical advantage is the place of Switzerland in Europe between Italy, the European leader in NGVs (see section 4.1), and Germany, a country where the government is heavily pushing NGVs .

The different interviewed actors experienced some obstacles for the diffusion of NGVs in Switzerland. Consumers are exposed to many technologies and tend to mix up everything. They often do not know the differences between GPL and CNG or between biofuels and biogas. The inconveniences of GPL (prohibition in

underground parking) or biofuels (competition with food production) are extrapolated to natural gas and biogas [H]. The biofuels boom in 2007-2008 was negative for the Swiss NGV innovation system. Many people were saying that biofuels was the solution and NGVs were not promising enough. Since the end of 2008 and the outcome of different researches on the effects of biofuels on the food sector, biofuels are put on the back burner and NGVs are seen as a good solution [H]. The financial crisis at the end of 2008 was negative for the NGV innovation system. Due to the crisis, people are postponing investments in new cars and continue to drive their old cars or buy second-hands. Potential NGV drivers will have to wait a couple of years before second-hands NGVs come on the market [H]. The oil industry is not cooperating, but does not counteract because they do not see NGVs as a major threat till now [D].

## 5.7 Summary of the Swiss system

The influences of the different agent groups are summarized in this section (see figure 5.1). Consumers adopt NGVs for two important characteristics: the financial and the environmental aspect of NGVs. These two aspects are part of the relative advantage attribute.

The influences of the local governmental agents is positive (bold arrow in figure 5.1). Municipalities and cantons stimulate early demand and drive NGVs themselves. The influences of the national governmental agents is less positive (thin arrow in figure 5.1). They stimulate early demand, but they are also slowing the expansion of the system by their paper work.

The influences of the supplier agents is positive for the gas companies (bold arrow in figure 5.1) and nearly inexistent for the garages (no arrow in figure 5.1). Gas companies are major drivers in the Swiss system by their involvement in the creation of gas stations and the promotion of NGVs. Garages do not want to change and continue to sell and promote conventional vehicles.

The influence of the intermediary agents on consumer adoption is positive (bold arrows in figure 5.1). Gasmobil and the motoring associations (TCS and VCS) are fulfilling the different theoretical dimensions: transfer of knowledge, experience sharing and articulate needs. The last dimension is partly taken into account by local government agents.

The influence of the knowledge agents on consumer adoption is positive (bold arrows in figure 5.1). The different knowledge institutes (EMPA; ETA) or knowledge organisations (Novatlantis) perform direct research about NGVs in order to improve and promote the technology.

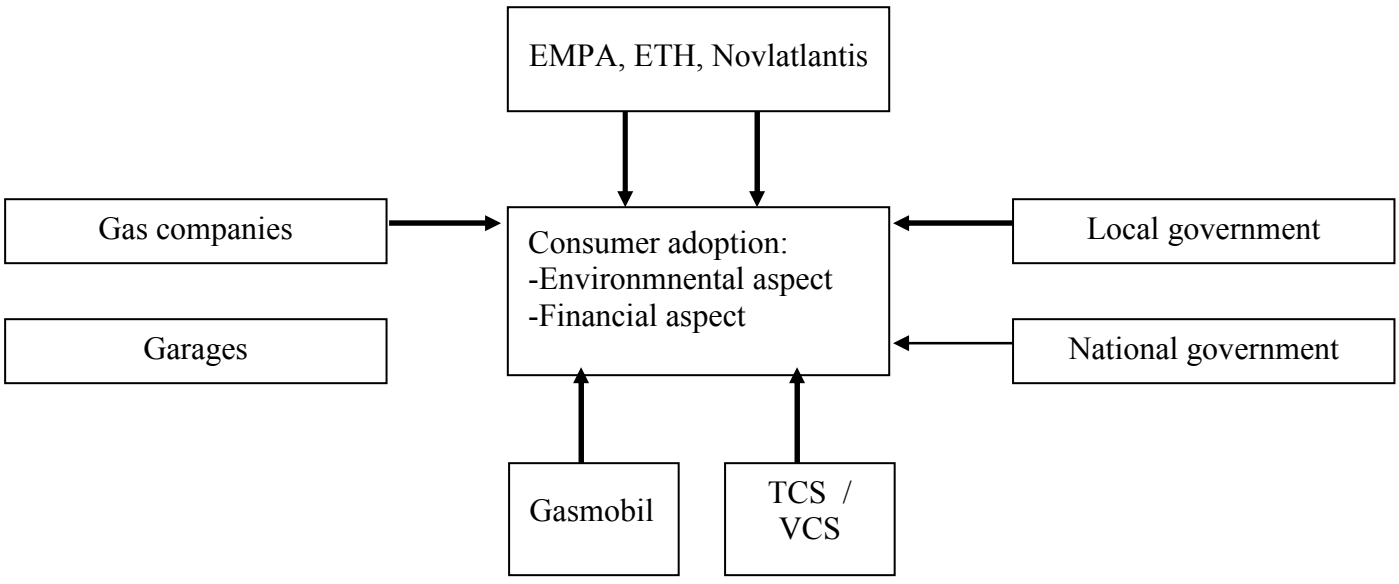


***Figure 5.1: Influences of the different agent groups in the Swiss system***

# 6. Dutch system

The Dutch NGV innovation system faces several barriers that must be overcome for an increase in consumer adoption. These barriers and the drivers in the system are discussed in this chapter. For the Dutch case, it was more difficult to interview NGV drivers, because there are not so many NGVs in the country. Interviews with consumers are even more difficult because there are nearly no private consumers in the Netherlands. Only one consumer and five employees who took the decision themselves to drive NGVs have been encountered at gas stations in the Dutch system. The sections about the perceived attributes in consumer decision process (6.5) is not only based on the interviews with these decision makers, but also on the expert interviews and on the experiences of the other NGV drivers. These drivers did not take the decision themselves, but are aware of the company reasons to drive on CNG (see appendix 2).

The sections about the influences of the different agents in the Dutch NGV innovation system are: governmental agents (6.1) and supplier agents (6.2), intermediary agents (6.3) and knowledge agents (6.4). This chapter ends with a section on the other influences (6.6) and a concluding section (6.7) on the different findings in the Dutch system. The whole description of the Dutch system is based on the theoretical concepts of chapter 2. The different concepts are discussed using the dimensions of the operationalization (table 3.1). These dimensions are in *italic* in the description of the system.

## 6.1 Influences from governmental agents

The different governmental agents, from local till national governments, are helping the NGV innovation system to evolve. They *stimulate early demand* by giving different subsidies for the construction of gas stations or the acquirement of NGVs [J]. Enne-Jacob Wierda (Fuwell) has the experience that there is quite a lot support for the construction of CNG stations. However, he says the support for the purchase of NGVs is still insufficient [S].

***Local government***

*Governmental procurement* occurred in several places where busses, vans or garbage trucks were replaced by their CNG counterparts. Bus companies are obliged to have a certain amount of NGVs in some cities or provinces, since local governments are concerned with (local) air quality [S]. The problem is often that governmental agents stop *stimulating early demand* after the granting of subsidies, because they are often afraid to commit themselves to only one technology [S]. Some examples of local governmental agents are the municipality of Haarlem and the provinces of Zeeland and Utrecht.

The municipality of Haarlem is the pioneer in the Dutch NGV innovation system. In order to increase air quality, the city decided to run all the busses and garbage trucks on CNG. This *governmental procurement* lead to the replacement of 85 diesel busses by CNG busses in 2006 [R]. The air quality has been improving and the municipality is positive about their NGV fleet. This positive attitude towards NGVs has a positive influence on consumers. They see NGVs around them, CNG stations are built in the city and they notice that the air quality is improving. However, the municipality of Haarlem does not see it as its goal to convince consumers to switch to NGVs [R].

The province of Zeeland also forced some bus companies to switch to CNG or biogas. The province wants to stimulate the NGV sector in order to achieve the transition from diesel to natural gas and later biogas (Kroese et al. 2009). The province of Utrecht is *stimulating the early demand* directly. They give a subsidy of 1000 euro to consumers who buy a new natural gas car till 7500 kilogram and till 5000 euro subsidy for heavier vehicles. They also give subsidies for companies for a maximum of ten cars and 25.000 euro. The province also subsidises the implementation of a new natural gas station (Provincie Utrecht 2009).

Some municipalities are counteracting the development of the NGV innovation system. Ruben Kramer from Eco Mobility tried to open a CNG station in Almere, but the municipality blocked the project. He also said that not one governmental agent helped him with his NGV taxi company, leading to the bankruptcy of his firm [K]. A driver at a station said that the municipality of Zoetemeer was slowing the process of implementing a CNG station due to permit problems [V].

*National government*

The national government is *stimulating early demand* with low excise tax on CNG, lower BPM taxes on the purchase of a new NGV and subsidies for the installation of new CNG pumps. The low excise tax dates from the end of 2006 and the lower BPM taxes from April 2009. The tax advantages are however much less than the tax advantages for electric vehicles which are BPM free [S].

Even if these financial policies are positive and important, the national government is not a fervent promoter of natural gas vehicles. There is no global NGV implementation goal and the different ministries do not agree on the benefits of driving on CNG. The Ministry of Environment (VROM) is against the implementation of NGVs, because they do not see a reason to invest in a natural gas infrastructure when conventional cars become cleaner [R]. The Ministry of Transport (VW), in collaboration with SenterNovem, is more positive about NGVs. They are directly confronted to particulate matter problems and see NGVs as a possible solution [R].

There are no *technical or safety standards* in the Netherlands for NGVs, beside an inspection every 10 years on the vehicles [J].

## 6.2 Influences from supplier agents

In this section, the different supplier agents are discussed. Like in Switzerland, the car manufacturers are represented in the Dutch system by their garages. Most of the natural gas stations in the Netherlands are built by CNG-Net or Fuwell. CNG-Net is a new entrant in the NGV sector. Fuwell is a subsidiary of an oil company. The role of the gas companies is also discussed since these were so important in the Swiss system.

*Garages*

There is no national car manufacturer in the Netherlands and NGVs are therefore imported. Some importers try to stimulate the sale of NGVs, like Volkswagen who is giving away 1000 kg of gas with the purchase of a new NGV [S]. Garages play an important role in the distribution of NGVs in the country. As in the Swiss case, there is a lack of commitment of the garages to NGVs.

Ford is one of the car manufacturers with the most NGV models. However, most of the garages in the Netherlands do not have any NGV model in their show room. Willem Roelofs from Ford Hoofddorp said they are waiting for NGVs to succeed in the German market before importing them into the Netherlands. Their sustainable policy is focussing on bio-ethanol vehicles, E85 [L].

ZAM Opel garage in Zeist has a Opel Combo CNG and a Phill installation. The vehicle is a promotional tool and there are advertisements on it. The promotion is not aimed at consumers, but at companies and governmental agencies. Tim Veldboer from ZAM Zeist said that NGVs are not interesting for consumers at the moment due to the low amount of gas stations. However, for companies it can be profitable to install a small station at their locations and drive on CNG. He said that Opel Netherlands also promotes NGVs for companies and governmental agencies, but not for consumers [Q].

*CNG Net / Ballast Nedam*

CNG Net is the most important organisation in the Dutch NGV innovation system. They build and run most of the (natural) gas stations (20 of the 31 in operation in October 2009). The other stations are built and run by Fuwell (6), OrangeGas (2), DeltaOil (1), Salland Oil (1) and Cogas (1) (Aardgasmobiel 2009). CNG Net promotes driving on natural gas in order to increase their revenues from their investments in the stations.

CNG Net started as DutCH4, a pioneer in the Dutch system for driving on natural gas. Ballast Nedam, a large building company, incorporated DutCH4 in their company in 2007. DutCH4 became CNG Net and has the support of one of the largest companies in the Netherlands. CNG Net has the goal to have built 250 natural gas station in 2012 (CNG-Net 2009). This ambitious goal would imply 50 stations by the end of 2008. With only 20 stations, they were far behind, but CNG Net remains very ambitious and does not change its original goal. The construction of a CNG pumps, around 370.000 euro's each, is realised with an *commitment* of 80 million euro's from Ballast Nedam [J]. Some stations, like in Nieuwegein near the office of CNG Net and Ballast Nedam, are already profitable. All the employees of CNG Net as well as the directors of Ballast Nedam drive NGVs. Other employees are advised and stimulated to drive NGVs [J].

The final goal of CNG Net is that 30-40% of the Dutch vehicles drive on biogas won from garbage. This goal is also used as a promotional tool to show that natural gas has a green future. Biogas is more expensive and

therefore less interesting for the Dutch drivers without financial support. CNG Net does not stimulate the conversion of existing cars to NGVs, since factory vehicles are more reliable than the converted vehicles [J].

CNG Net does not build new gas stations, but installs natural gas pumps at existing stations. Therefore, they must collaborate with the gas station holders in the country. CNG Net experienced that the gas station holders are willing to collaborate. The station holders see it as part of their corporate social responsibility. However, CNG Net is responsible for the financing, the running and the promotion of the pump. The holder of the Elan gas station in Groningen said that CNG Net organised everything from subsidies till building [O]. CNG Net experienced that Shell Netherlands is working against NGVs in the Netherlands. However, most of the Shell gas stations are independent franchises and can decide to allow CNG at their stations [J].

At some stations, NGV drivers must have a CNG Net card to be able to refill their vehicle. This is not a problem for most of the companies who are used to visiting a limited number of gas stations. However, this is a problem for private consumers who fill up at different places. CNG Net is changing this policy and in the future drivers can fill up with their normal cash card (CNG-Net 2009).

***Fuwell***

Nijol Oliemaatschappij B.V. is an oil trading company based in Nijmegen. Some years ago, the municipality of Nijmegen was concerned about air quality and approached Nijol with the question if they were willing to build a natural gas station in Nijmegen. Nijol saw an opportunity and established a subsidiary, Fuwell who is responsible for the creation of natural gas stations.

Fuwell's policy is to implement CNG stations in regions where there are potential NGV drivers. Before the creation of a new station, Fuwell talks to different actors in the region to see if there is a chance that there will be enough NGV drivers after a certain time. Fuwell does not invest in a region where the investments probably cannot be earned back. For example, they chose to build a CNG station in Eindhoven after the promise of different companies to purchase NGVs. This process is slowed down by the financial crisis, because companies are less willing to invest in a new vehicle fleet [S].

The consequence of this policy is that most of the stations are in industrial zones, because it is easier to talk to local companies or governments than to individual consumers. Fuwell will not implement CNG stations on the motorways, because there is are no gas pipeline near the Dutch motorway system. Their policy is therefore to create stations at industrial zones not far away from a motorway exit, like in Nijmegen. In the future, the stations will probably have LNG delivered by trucks. Fuwell has no direct arrangements with CNG Net for the creation of a covering CNG station infrastructure, but they do not counteract each other. Fuwell will not open a station in a city where CNG Net has already opened a station [S].

Fuwell does not want to promote NGVs to private consumers directly. They think people will be resistant, because they are a commercial company with an interest in the NGV technology. Fuwell is hoping that governmental agents will do promotional activities, since consumers see the government as a more neutral actor in the system. Fuwell's idea is that each CNG station would have a natural gas consultant responsible for bringing the different regional actors together. The promotion can then be organised with all these actors [S].

***Gas companies***

Gas companies in the Dutch system are not very active in the NGV innovation system. They are waiting to see if NGVs have a future in the Netherlands before investing any time and money. The gas and electricity company RWE is member of Aardgasmobiel (see section 6.3). The directors and some employees drive on natural gas and they have a private natural gas station at their Dutch head office in Hoofddorp. René Hoogendam said that since they sell natural gas, it is logical that they also drive on it. However, he said that RWE was not planning a large promotion for NGVs in the Dutch system, but that this could maybe change in the future if the NGV innovation system emerges [P].

Smit (Aardgasmobiel) said that gas companies have the will to produce electricity, because they get more added value from producing than from only reselling. Therefore, even if gas companies sell natural gas, they are not willing to promote NGVs on a large scale [R].

## 6.3 Influences from intermediary agents

The same kind of intermediary agents as in the Swiss system can be found in the Dutch system: motoring associations and Aardgasmobiel.

***ANWB***

The Koninklijke Nederlandse Toeristenbond ANWB has 3.9 million members and is the largest motoring association of the Netherlands. One of the tasks of the ANWB is to respond to their members on questions about vehicles. Over the last years, there was not a single question about NGVs, so the ANWB does not feel the need to inform their members about this technology [T]. On the sustainable level, there are many questions about electric vehicles or biofuels which the ANWB answers in its magazines, on its site or directly at the phone. The ANWB therefore asked the Federation Internationale de l'Automobile (FIA) to perform crash tests with electric vehicles. However, no crash test with NGVs has been performed [T].

The ANWB does not see NGVs as a promising technology, because there are too much inconveniences to consumers: higher purchase price, low amount of stations, holiday difficulties in France [T]. The price incentive of CNG is too low to encourage consumers to make detours for a CNG station. The ANWB experienced a strong lobby from the NGV sector. Different agents tried to convince the ANWB with promotional material. However, due to the low amount of ANWB members driving NGVs, the ANWB did not feel the need to accommodate to this lobby [T]. So, none of the theoretical influences is fulfilled by the ANWB.

***Aardgasmobiel***

Aardgasmobiel (AM) is an independent cooperation association aiming to promote NGVs. AM bundles al kind of organisations involved in the Dutch NGV innovation system, like car manufacturers, gas stations builders, gas companies and lease companies. AM has two major goals: the implementation of a gas station infrastructure and the promotion of natural gas vehicles in different target groups. In order to achieve these goals, AM has an important lobby role at local and national government levels [R]. Gerrit Kadijk (TNO) argued that AM's lobby is very strong towards local governments using non rational arguments to convince grantors [M].

AM looked how NGV diffusion occurred in other countries and saw that NGVs are firstly diffused in niches, first in public transport, then taxi's, then vans from local government organisations or firms and finally private cars. The promotional activities of AM follow this sequence and therefore does not focus on consumers yet, because they think that the money can be better used for promotional activities aimed at firms or local governments [R]. So, the *direct transfer of knowledge*, the *experience sharing* and the *articulation of the needs* are all present, but these influences are not aimed at private consumers.

NGVs will become interesting for consumers when more gas stations offer CNG in the country. Ton Smit, director of Aardgasmobiel, expects that the amount of gas stations in 2010 will be enough to awake consumer's interest. The high involvement of different car manufacturers can also accelerate consumer's adoption. The number of NGV models is increasing rapidly. Smit is waiting for the arrival of Volkswagen Golf and the Toyota Corolla on the Dutch market. Volkswagen has different CNG models, but they are still exclusive, like the Passat. Toyota already launched the Corolla CNG in India where it is a success. The automotive industry is very active and Ton Smit expects that if the Dutch government would involve itself, the NGV innovation system would develop rapidly [R].

The focus in sustainability in the Netherlands is heavily biased towards $CO_2$ emissions. Aardgasmobiel (natural gas mobile) will therefore change its strategy to biogas and become Groengasmobiel (green gas mobile). Even if natural gas already scores better than gasoline and even diesel on the $CO_2$ emissions, the advantage of biogas is much higher. Groengasmobiel will however be dependent on governmental policies, because biogas must be produced and is more expensive than natural gas. Ton Smit expects that the government cannot refuse fiscal advantages for biogas, even if there is no certainty about governmental policies. Ton Smit expects that biogas vehicles will have an important market share in the future. The biogas will come from manure, organic waste, sewer strip and set aside land. Biogas has many advantages: low environmental impact, no dependence on oil/gas countries, local employment [R].

## 6.4 Influences from knowledge agents

The most important knowledge agents in the Dutch NGV innovation system are probably Energie Centrum Nederland (ECN), Planbureau voor Leefomgeving (PBL), TNO and the Universities. All these agents are independent and try to perform objective research, and they are known and respected for that.

ECN, PBL and TNO are all sceptical on CNG as vehicle fuel. On the short term, they do not see large advantages for NGVs in comparison to diesel vehicles. On the long term, they do not see natural gas as a sustainable solution. Van der Wees (2009) did a discourse analysis about the NGV case in the Netherlands. After different interviews with involved people, he placed ECN and PBL in the criticasters coalition of NGVs. This is confirmed by the way these agents show up in the media concerning NGVs. Hanschke et al. (2009) performed a research on behalf of ECN about four different transition pads to a sustainable road transport. This research is *direct* and *indirect* at the same time, because NGVs and other sustainable transport modes are analysed. This research was reviewed by employees from TNO and PBL. The conclusion is that the Netherlands should focus on electric vehicles and hydrogen, because according to them NGVs do not emit less $CO_2$ than conventional vehicles. These conclusion were adopted and propagated by the media, which influenced consumers negatively.

Gerrit Kadijk (TNO) performed different *direct* and *indirect* researches on emissions of natural gas, diesel and/or gasoline vehicles. His researches are often cited in newspapers in connection to driving on natural gas. Over the last 5 years, 50 newspaper articles had TNO *direct researches* about NGVs as a subject. Most of these articles were negative for NGVs since it was said that the emission levels of CNG were around the same as diesel (De Telegraaf 2007, Eindhovens Dagblad 2007). The research most often cited was a study on natural gas busses in comparison to diesel busses (Kadijk & Verbeek 2007). The client for this research was VDL Bus & Coach N.V., bus manufacturer delivering only diesel busses. VDL used this research in different newspapers to show that local governments should not push CNG busses. As an answer, MAN (bus manufacturer delivering natural gas busses) used a research from the Technical University in Graz (Austria) and a research from CE Delft to show that natural gas busses have lower NOx and particulate matter emissions (Smokers&Otten 2007).

Gerrit Kadijk said that, although VDL started this discussion in the media to sell more products, it is important that his study brought in some nuances, because there are many parameters in a comparison between diesel and natural gas [M]. Gerrit Kadijk believes that consumers and firms will not drive on NGVs without financial incentives. In his vision, NGVs have to many disadvantages to be attractive. He argues NGVs are more expensive in the running costs and that the relative advantage of NGVs is therefore lower than conventional vehicles. Kadijk also argues that natural gas busses cannot improve their concept significantly anymore in contrast to diesel busses which can improve their emissions in the coming years [M].

The Rijksuniversiteit Groningen (RUG) also performed *direct research* about NGVs, especially for the feasibility of driving on CNG in the Northern part of the Netherlands (Kooistra & de Vries 2004). The results were mainly positive and therefore RUG wanted to step into the NGV innovation system. In collaboration with CNG Net (section 6.2), Hanzehogeschool, local governments, SenterNovem and the Gasunie, they realised a natural gas pump at the gas station at the campus of the university. Hanzehogeschool (University of Applied Sciences in Groningen) also performed different *direct researches* about NGVs, like the conversion of a TukTuk and a Opel Astra to CNG (Hanzehogeschool 2009).

## 6.5 Perceived attributes in consumer decision process

All the NGV drivers said that environment was the most important reason to drive on CNG [V]. The persons who took the decision to drive on CNG are green thinking people and see the *relative advantage* of NGVs on the environmental level. Ruben Kramer started Eco Mobility Services, a one taxi company using a Volvo V70 CNG. He expected to get more clients with a taxi driving on CNG, because of the green reputation of his vehicle. However, this was not the case and he was forced to stop his initiative [K]. Some companies also use the environmental relative advantage for their image towards governmental agents, consumers or other companies [S]. For example, an express courier company had an advertisement on its car stating that they drive on natural gas. This advantage can also be categorized as *observability*, because the company wants that the technology is visible to others.

Besides this express courier NGV, vehicles have nearly no advertisements and potential consumers can not see any difference with other vehicles, which results in a very low *observability* of NGVs. There is no publicity at or in the gas stations and the price of CNG is not shown on the price board of the gas stations. The garages show no publicity for NGVs in their showrooms and almost never have any NGV on display. This also decreases

the *trialability*, because consumers are not able to make a test drive. Due to a low amount of stations, the *compatibility* is still very low. This is especially the case for consumers, because nearly all the stations in the Netherlands are in industrial zones. This increases the compatibility for the firms in this zone, but decreases the compatibility for consumers who are forced to drive to these zones to fill up their cars. The *complexity* of NGVs is higher than conventional cars, because the drivers must get used to NGVs. Different drivers get the sensation that sometimes their tank contains less fuel than other times after filling up. Furthermore, they are used to measure their fuel in litres and they do not trust that they can drive the same distance with a certain amount of CNG measured in kilograms [V].

The largest NGV group in the Netherlands is the group forced by governmental authority. Bus companies and waste contractors in, for example, Zeeland, Haarlem, Den Haag were forced or heavily motivated to drive on CNG by local governments. The second group are employees forced by their employer's authority to drive NGVs. The third group are employees who took collectively the decision to drive NGVs themselves. The final group are consumers who took the decision freely. This group is however nearly inexistent in the Netherlands. The first two groups were mainly negative about driving on CNG. They experience the disadvantages as the short cruising range and the lack of gas stations, but they do not experience the financial and environmental advantages. This was even the case for Ballast Nedam employees (see section 6.2). People are used to be able to drive some 800 km on one tank and since people are conservative, a lower cruising range is perceived as a major disadvantage [S]. The consumers and employees who took the decision themselves were all very positive about driving on CNG. They were mostly green thinking people who did not experience the disadvantages exposed above or who thought the environment was more important than these disadvantages [S, V]. As said earlier, this group is however nearly inexistent.

## 6.6 Other influences in the system

Shell is an important player in the Dutch system, because they control an important part of the transport fuel chain in the Netherlands. Shell is afraid that margins will diminish when they sell natural gas instead of gasoline/diesel and are therefore are resisting NGV developments in the Netherlands [J]. For example, Fuwell does not get permission to build a CNG pump at a Shell owned station [S].

There is a major diesel lobby in the Netherlands. VDL Bus & Coach N.V. has a contract with their engine supplier (DAF) that they will use only diesel engines [S]. Therefore, they are lobbying for diesel busses in newspapers and in meetings with politicians. This lobby is backed by TNO researches and Telegraaf articles [R].

The electric vehicle lobby is also strong in the Netherlands, supported by the windmill and the nuclear energy lobbies. The windmill and the nuclear energy markets can be enlarged by the entrance of electric vehicles on the market. In section 6.2, we have seen that gas companies also want to produce electricity and are therefore also positive about electric vehicles. The politicians, like Prime Minister Balkenende, are also promoting electric vehicles with an investment 65 million euro's. In comparison, the development of all the other alternative fuels receives only 25 million [S].

In section 6.3, we have seen that Aardgasmobiel will become Groengasmobiel. This change is needed since there is a $CO_2$ hype in the Netherlands. The environmental impact of a vehicle is often only measured in $CO_2$ emissions. This is of a disadvantage to NGVs, since their main advantage is in the lower emissions of NOx and particulate matter. According to Tom Smit, population's health should also be accounted in the impact of a vehicle, but this is not often the case in the Netherlands [R].

## 6.7 Summary of the Dutch system

In this section the influences of the different agent groups is summarized (see figure 6.1). Consumers adopt NGVs for one important characteristic in the Netherlands: the environmental aspect. This aspect is part of the relative advantage attribute. The type of decision is mostly authority from governmental or supplier agents.

The influences of the local governmental agents is positive (bold arrow in figure 6.1). Municipalities and provinces stimulate early demand and drive NGVs themselves. The influences of the national governmental agents is less positive (thin arrow in figure 6.1). They stimulate early demand by the lower taxes, but do not have a clear plan for driving on CNG.

The influences of the supplier agents is positive for CNG-Net and Fuwell (bold arrow in figure 6.1) and nearly inexistent for the garages (no arrow in figure 6.1). CNG-Net and Fuwell are major drivers in the Dutch system by their involvement in the creation of gas stations and the promotion of NGVs. Garages do not want to change and continue to sell and promote conventional vehicles.

The influence of the intermediary agents on consumer adoption is positive for Aardgasmobiel (bold arrow in figure 6.1) and inexistent for the ANWB (no arrow in figure 6.1). Aardgasmobiel is a major actor in the NGV sector and lobbies at different levels. The organisation fulfils different theoretical dimensions: transfer of knowledge, experience sharing and articulation of needs. However, these influences are mostly not directly on consumers, but on governmental and supplier agents. The ANWB has no members driving on CNG and does not see a future for NGVs.

The influence of the knowledge agents on consumer adoption is negative (dotted arrows in figure 6.1). The different knowledge institutes (TNO, PBL, ECN) perform direct and indirect research about NGVs and its competitors. Conventional or other alternative fuels seem to have the preference of these institutions.

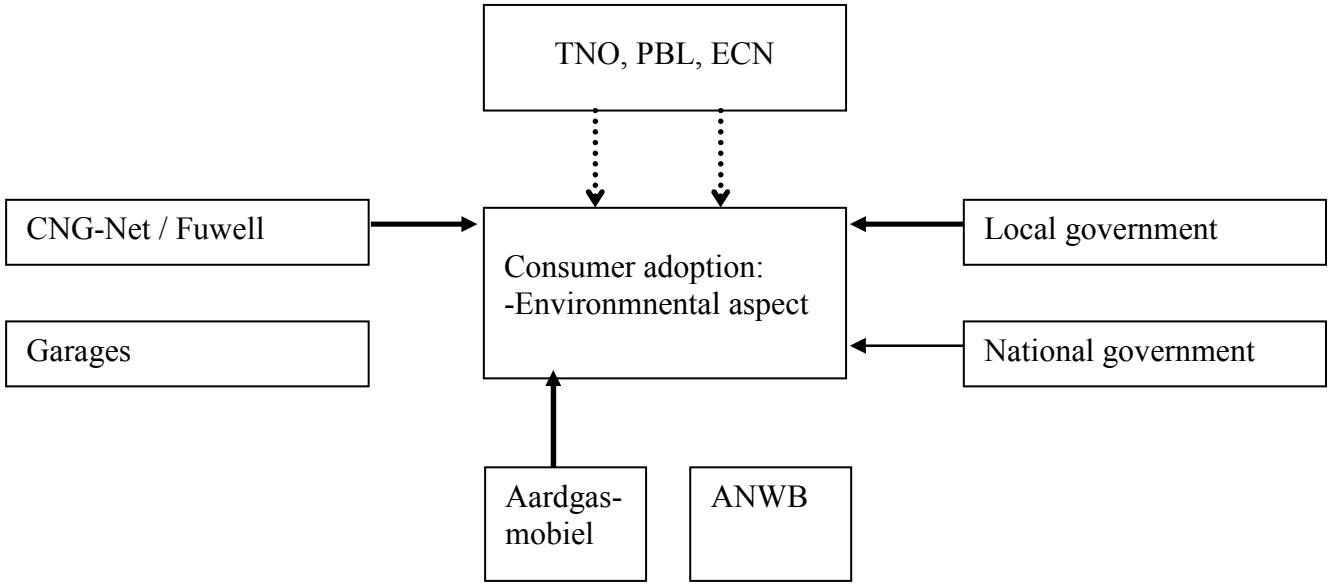


*Figure 6.1: Influences of the different agent groups in the Dutch system*

# 7. Conclusion & Recommendations

Several countries in the world have a large natural gas vehicle (NGV) fleet. Pakistan, Argentina and Italy are world and European leaders with NGV fleets of respectively 2 million, 1,7 million and 580.000 vehicles and a market share of respectively 52%, 22% and 1% (IANGV 2008). On first sight, the Netherlands seems to be a perfect country for the implementation of NGVs. It has large natural gas reserves, a good distribution network and local air quality problems due to high NOx and PM emissions. However, the Dutch system is facing barriers and consumers do not adopt NGVs. Switzerland has faced the same problems for many years, but has managed to overcome the first barriers and consumer adoption is starting in the country. For the Dutch system, the Swiss system is an useful case to learn from, since both countries have been inactive in the NGV sector for a long time and are in the same stage of adoption. Furthermore, both countries are comparable in land size, population size, population density, income, automotive sector and size of their car fleets (Janssen 2005).

In this research, consumer adoption in the different NGV innovation systems has been analysed with Rogers' diffusion of innovations theory (Rogers 2003). This theory says that the rate of adoption is determined by five variables: perceived attributes, type of decision, communication channels, nature of the social system and change agents' promotion efforts. The first variable is operationalized with car adoption characteristics. The four other variables are operationalized with the influences from the different agent groups in the innovation system (Alkemade et al. 2007).

Rogers argues that the rate of adoption is mostly determined by the perceived attributes variable (Rogers 2003). However, in the NGV case, the rate of adoption can be determined more accurately with all the five variables. In this research, we have seen that the influences from the different agent groups accounted for a major role in consumer adoption. Natural gas vehicles are not a simple technology that can be implemented without an involvement of different agents, since a whole new fuelling infrastructure is needed. The perceived attributes, car characteristics in the NGV case, determine a part of the consumer adoption. However, the high differences between the analysed systems (the Netherlands, Switzerland and the world leading countries) can only be explained with the influences of the agent groups in the systems.

In this chapter, a conclusion of the different system analyses is given by answering the research questions, for the world leading countries (RQ1), the Swiss system (RQ2) and the Dutch system (RQ3). The answer to the fourth research question consists of recommendations for the Dutch system based on the analyses of the other systems. Finally, a short summary is given as an answer to the main research question. The theoretical concepts used in this research and explained in chapter 2 are written in *italic* in the answers.

*1. What have been the reasons for the successful consumer adoption of NGVs in the world leading countries (Italy, Argentina and Pakistan) when the innovation system was emerging?*

Governmental agents play an important role in the NGV innovation systems of all the three world leading countries. In the Argentine and Pakistani cases, these agents had a clear plan and all the possible theoretical influences were present. ***Governmental agents*** were the first NGV drivers (*governmental procurement*), imposed safety and quality standards (*regulation of products and processes*), procured subsidies and information (*stimulating early demand*) and imposed technical standards (*technical standards*). In the Argentine system, we have clear examples that the governmental agents influenced not only the consumers but also the other agent groups. These groups on their turn have also influenced the consumer adoption. The influences of the governmental agents in the Pakistani and Argentine systems were so important that the ***other agent groups*** had to follow their example.

The Italian NGV innovation system experienced two specific growth periods, in the 1930s and in the 1970s. This is curious at first sight, because Italy is not a traditional natural gas country with large reserves and a good distribution network. However, different conditions made these rises possible, like wartime conditions in the 1930s and the energy crisis in the 1970s. These conditions were also experienced in other countries, but the Italian NGV innovation system was influenced by very active agents. In the second rise of the system, ***governmental agents*** played an important role, even if they were more reacting than acting. *Governmental procurement* came after an incubation time and *technical standards* only came in the 2000s. However, they *stimulated early demand* by financial support and *regulated products and processes* by quota's, which influenced the system positively. National government saw NGVs as one of the most important means to achieve the goals of the Kyoto protocol. They elaborated a clear plan of 600 natural gas stations. Besides the

governmental agents, ***supplier agents*** played an important role in the system. Oil and gas company ENI was an important driver in the Italian system. ENI did not see the rise of the NGV innovation system as a threat, but as a possibility to increase their market share. Car manufacturer Fiat also influenced the consumers positively with their *commitment* to NGVs by launching different models on the market. The influence of the Italian ***knowledge agents*** was also positive, since they performed *direct research* about NGVs to show the environmental advantages of NGVs and to develop the NGV technology. Intermediary agents supplied *specific knowledge* and *shared their experiences* to overcome complex standards and bureaucratic procedures. The influence of consumers on other consumers was also important, because mouth to mouth advertisements made it possible to survive a large crisis in the NGV innovation system in the 1980s.

*2. What are the drivers for consumer adoption in the Swiss NGV innovation system and how were the barriers overcome?*

The most important driver in the Swiss system is the involvement of *gas companies*. These ***supplier agents*** finance and run natural gas stations in their region decreasing the infrastructure barrier the system was facing. They influence consumers by their *commitment* to the NGV technology: subsidies on NGV and CNG, own vehicles on CNG with advertisement, sale of second-hand vehicles, direct promotion at Auto-Expo's. New entrants were also important in the system, because they were responsible for the biogas production and promotion. The role of biogas is important in the Swiss NGV innovation system. Swiss companies have been forerunners in biogas production. They logically turned to NGVs, because they wanted to use biogas in other areas than electricity production. The national government promotes the use of biogas by exempting natural gas with 10% biogas from mineral oil taxes. The different organisations in the NGV innovation system use this biogas share as an advertisement tool. Car manufacturers are represented in the Swiss system by their garages. Most of these garages are afraid to change and not willing to promote NGVs

Another important driver in the Swiss system is Gasmobil, a very strong ***intermediary agent***. Gasmobil is the centre of competence for the Swiss NGV innovation system supporting the different gas companies. They *transfer specialized knowledge* about NGVs in the system by producing promotion material used by the gas companies or other organisations. Gasmobil also ensured that the network of natural gas is sufficient and largely achieved their goal of 100 gas stations in 2008. The organisation also *shares their experiences* in different workshops and conferences, like Auto Expo's and markets. The motoring associations TCS and VCS are other intermediary agents in the Swiss system. Both organisations *transfer specialized knowledge* by informing consumers about the advantages of NGVs. TCS employees drive NGVs themselves and *share their experiences* with consumers.

Local ***governmental agents*** are highly involved in the Swiss system, because they are concerned about local air quality. *Governmental procurement* is influencing Swiss consumers since governmental vehicles with large advertisement drive on CNG. *Early demand is stimulated* by subsidies on NGVs and on CNG stations, by low taxes on CNG and by promotional activities for NGVs. Local governmental agents also play the role of intermediary agents by *articulating* car fleet *needs* of local companies.

Different ***knowledge agents*** in the Swiss system influence consumer adoption positively by their *direct research* on NGVs. Their research improves the NGV technology and is used for promotional activities.

The environmental advantage of NGVs has been the most important perceived attribute in the ***consumer adoption decision***. With the lowering of the mineral oil tax, economic motives started to appear as a reason for NGV adoption. The financial advantage of CNG is shown at the gas stations with the price of CNG converted to a litre of gasoline. Both the environmental and the financial aspect are part of the *relative advantage* dimension. However, NGVs also score negatively on this dimension due to loss of power, lower cruising range and less space due to large gas tanks. These disadvantages are quickly becoming smaller with the entrance of different new models on the Swiss market. *Compatibility*, *trialability*, *complexity* and *observability* are all negative for NGVs in comparison to conventional cars. The differences are however on the decline with for example the construction of gas stations (compatibility) or NGVs with advertisement (observability).

*3. What are the drivers and barriers for consumer adoption in the Dutch NGV innovation system?*

The most important driver in the Dutch system is the involvement of ***supplier agents***, especially CNG pump holders like CNG Net and Fuwell. CNG Net has the goal of installing 250 natural gas stations in the Netherlands before the end of 2012. Even if this goal will be hard to reach, CNG Net builds many gas stations in the country with the help of governmental subsidies. The employees of CNG Net and some employees of Ballast Nedam also drive NGVs themselves showing the *commitment* of the company to the NGV technology. Like in Switzerland, car manufacturers are represented by their garages, but these are not motivated to promote NGVs.

Another driver in the Dutch system is ***intermediary agent*** Aardgasmobiel. This cooperative association coordinates the diffusion of CNG pumps and NGVs in the Netherlands. All the main actors in the Dutch NGV innovation system are part of the association, like car manufacturers, gas station builders, gas companies and lease companies. Aardgasmobiel transfers knowledge directly and shares their experiences in the system by their promotional activities. They articulate the needs of local governments by their important lobby activities and try to convince them to change local car fleets to NGVs.

Different local ***governmental agents*** have a positive influence in the system by governmental procurement and by pushing public transport to drive on CNG. Most of the natural gas vehicles driving in the Netherlands are a result of these influences. Local governmental agents stimulate early demand by subsidising the construction of new CNG stations. However, local government do not have the will to promote NGVs to consumers yet. National governmental agents also stimulate early demand by lower taxes on NGVs. The national support stops there and the other theoretical dimensions are not executed.

***Knowledge agents*** have a negative influence on consumer adoption, because they perform direct and indirect research showing the advantage of conventional or other alternative fuels. Consumers hear of the results of these researches via the media and become sceptical about the NGV technology.

The environmental advantage of NGVs has been the only perceived attribute leading to ***consumer adoption decision*** in the Dutch system. The environmental impact of a car is part of the relative advantage variable. However, NGVs also score negatively on this variable: lower cruising range, higher purchase price, less place due to gas tanks. The other variables are also not in favour of NGVs in comparison to conventional fuelled vehicles. The most important barrier is the compatibility variable resulting from the low amount of natural gas stations. This barrier will be overcome if the high goals of CNG Net, Fuwell and Aardgasmobiel can be met.

The competition from conventional or other alternative fuels has probably an important indirect role on the NGV consumer adoption in the Netherlands. The electric vehicle lobby could be another barrier to the NGV innovation system. Different important agent groups in the Netherlands decide to focus on this technology, like local and national governmental agents, intermediary or knowledge agents. The diesel lobby is probably also an important barrier to NGV developments in the Netherlands and has an important influence in the government. Shell has a large influence in the system and does not want to loose market share to CNG. VDL busses only drive on diesel and therefore VDL promotes diesel as a cleaner solution than natural gas busses. VDL is supported by TNO results which according to them show the lower CO2 emissions of diesel busses. This shows that different agent groups, often focus on CO2 emissions and not on other noxious emissions. Aardgasmobiel and the other actors in the NGV innovation system want to overcome this CO2 hype barrier by focussing on biogas.

*4. What recommendation can be given to the different actor groups in the Dutch system?*

The only perceived attribute of NGVs which is a reason for ***consumer adoption decision*** in the Dutch system is the environmental aspect. In Switzerland another indicator of relative advantage is also an adoption reason: the financial advantage. This financial motive was made visible at the gas stations with the price of CNG converted to the price of one gasoline litre on the price boards. In the Netherlands, the price of CNG is not even mentioned. A recommendation for Dutch gas stations would be to show the financial advantage of CNG like in Switzerland. This will also increase NGVs' observability which is lower in the Netherlands. Observability can also be increased with advertisements on NGVs like in Switzerland. The compatibility variable has been improving in the Swiss system over the last years with the implementation of a covering gas station network. A recommendation for the Dutch system is to improve the compatibility of NGVs by constructing new gas stations in order to make NGVs more attractive for consumers. To reach this amount of stations, CNG Net will have to achieve their goals. The goals in the Dutch system could be too optimistic and when these are not

reached, the trust in the NGV innovation system could decline. In the Swiss system, the goals were largely reached, contrary to the Dutch system were the goals for 2008 were not reached. Another recommendation is that gas pumps become available near motorways and in the cities. Till now, nearly all the gas stations are in industrial zones, which results in fuelling difficulties for consumers. NGV drivers had different views on the technology in the Swiss and Dutch case. Swiss NGV drivers were mostly positive and Dutch NGV drivers mostly negative about driving on natural gas. A recommendation for the Dutch system is to make NGV drivers committed to their natural gas vehicle. In Switzerland, NGV drivers are more committed to the NGV technology, because they all drive with advertisement on their vehicles. This advertisement is obligatory for one year for consumers or companies using a subsidy from a gas company or a local government. This rule could be used in the Dutch system to promote NGVs.

Gasmobil and Aardgasmobiel are both strong ***intermediary agents***, respectively in Switzerland and in the Netherlands. Both organisation are responsible for the transfer of knowledge and experience sharing. Aardgasmobiel's promotional focus is on local governments and firms. This is a logical choice, since NGVs are not attractive for consumers due to the low amount of gas stations. A recommendation for Aardgasmobiel is to also focus on consumers when there are enough stations, like Gasmobil did in Switzerland.

The type of ***supplier agents*** is different in Italy, Switzerland and the Netherlands. The important supplier agents in the Dutch system are new entrants like CNG-Net. Gas companies are the most important drivers in the Swiss system. Car manufacturer Fiat and the ENI oil and gas company has been important drivers in the Italian system. In the Dutch system, the oil company Shell is counteracting NGVs. If the Dutch gas companies would commit themselves more to NGVs, the system could evolve more rapidly.

Local ***governmental agents*** are quite active in the Dutch system. A recommendation for local governmental agents is to focus also on consumer adoption like some local governments in the Swiss system. Promotion of NGVs to consumers could increase air quality of the cities even more than can be achieved by converting public transport vehicles to CNG only. The national government in the world leading countries has always had clear plans and goals for the future. A recommendation for the Dutch national government is to expose a clear plan for the NGV innovation system.

In all the successful examples, ***knowledge agents*** were positive about NGVs. Italy and Argentina are both world leaders in NGV technology and have a large NGV fleet. Knowledge institutions in these countries showed the advantages of NGVs in comparative studies and also improved NGV technology with their research. Dutch NGV promoters have to use promotion material from Austria, because Dutch knowledge agents are negative about NGVs. A recommendation for knowledge agents in the Dutch system is to point out the advantages of NGVs in comparison to conventional technologies like knowledge institutions in other countries do.

The role of ***biogas*** was very important in the development of the Swiss NGV innovation system. A recommendation for the Dutch system is to focus on the advantages of biogas. Aardgasmobiel already announced that they would switch to biogas, because of the relative advantage on the environmental level. The national government should follow this movement by supporting biogas. The "biogas" concept can have negative connotation since it can be associated with the negative effects of first generation biofuels on the food industry. In the Swiss system, the different agents therefore used the terms "Kompogas", "Naturgas" or "green gas" instead of "biogas". A recommendation for the Dutch agents is to use the term "green gas" in their biogas promotion.

*What lessons can be learned from the consumer adoption in the natural gas vehicles innovation system of Switzerland and the world leading countries (Italy, Argentina and Pakistan) for the stimulation of the consumer adoption in the Dutch natural gas vehicles innovation system?*

In the Swiss and Dutch systems, innovators are adopting NGVs based on the relative advantage of the technology. The difference is that Swiss consumers also perceive a financial advantage, contrary to the Netherlands where only the environmental advantage is perceived by NGV consumers. Supplier agents have another origin in the Swiss and Dutch system. In Switzerland, traditional gas companies are the most important suppliers, in the Netherlands new entrants take this role. The role of intermediary and (local) governmental agents is comparable in Switzerland and the Netherlands. However, these agents are already focusing on consumers in Switzerland, where in the Netherlands the focus is still on governmental and company fleets. In the world leading countries, knowledge institutions always had a positive attitude towards NGVs. This is also the case in the upcoming Swiss system, however in the Netherlands most of the knowledge agents are negative on NGVs.

# 8. Discussion

The consumer adoption analysis of the Swiss and Dutch cases are only based on 35 and 21 interviews with consumers. For a better view of the consumer adoption in the two countries more interviews with NGV drivers is required. This was difficult to achieve within the limited time frame of this research since there are not many NGV drivers in both countries (yet). Furthermore, the design of this research led to interviews with people at the gas stations. Since some NGV drivers have a Phill installation at home, not all the NGV drivers could be interviewed. The problem might be that the consumers having a Phill installation are a special group. These problems were partly resolved by the fact that I performed interviews with NGV drivers. I could really discuss with them about their motive to drive on natural gas, which I would have missed with questionnaires. Furthermore, the expert interviews confirmed most of the findings from the interviews with NGV drivers.

The Swiss system is regional dependent, which might be a problem for this research, because it was not conducted in all the different regions of Switzerland. It might be that consumers in other regions have other characteristics. For example, in a region with less stations, consumers experience the low cruising range as a higher inconvenience. In order to avoid this problem as much as possible, the data for the Swiss case were retrieved in different regions in the German and French part of the country (Zurich, Basel, Lausanne, Yverdon, Rolle).

The consumer adoption and the innovation system analyses of the Swiss and Dutch case are snapshots of the systems. All the expert and consumer interviews were realised in the year 2009. Another comparable research should be performed in a couple of years to see the evolvement of both systems over time.

The analysis of the Italian, Pakistani and Argentine cases were based on a literature study. The conclusions of these analysis would have had a better foundation of the same method as in the Dutch and Swiss cases would have been used. However, due to time and financial limitations, it was not possible to travel to these countries. Furthermore, interviews with consumers would have been interesting when these systems were in the innovator stage of adoption. Nowadays, the Italian, Pakistani and Argentine system are so evolved that it is difficult to compare it to the Dutch system.

One of the dimensions of the knowledge agents was indirect research on NGV technology. However, due to the focus on NGVs in this research, it was difficult to look at all the research on other transport technologies. One of the dimensions of the intermediary agents (articulate and define needs) was taken into account by governmental agents in different systems. In the Italian, governmental agents played such an important role that they also articulated the needs of different organisations. In the Swiss system, some municipalities defined the needs of some local firms by talking with them about their vehicle fleets. The question is if this dimension is theoretically assigned to the wrong agent group or if the NGV case is an exception.

This research combines Rogers' theory and the innovation system theory. The innovation system theory fitted the four variables Rogers did not research deeply (Type of innovation-decision, Communication channels, Nature of social system and Extent of change agents promotion efforts). However, more research is needed to find out if the innovation system theory actually completes Rogers theory.

The combination of Rogers' theory and the innovation system gave a nice approach in operationalizing the rate of adoption of NGVs. However, this approach does not take into account the negative influences of actors outside of the innovation system. In the Netherlands, the diesel and electric vehicle lobbies are important for the NGV sector. Even if both lobbies not always influence the NGV innovation system directly, they have negative influences on the NGV adoption. Due to promotional efforts of the diesel and electric vehicles lobbies, consumer perceive diesel and electric vehicles as better concepts than NGVs. The same statement can be drawn for the Swiss system, where some actors experienced negative influences from the biofuels sector in 2008 when that sector was flourishing.

# 9. Acknowledgement

I am very grateful to all the persons who have contributed to this research. First of all, I want to thank Floortje Alkemade for her precious support. Without her, I would not have performed this research. Her advice was always very constructive, especially in the moments when my research seemed to be in a deadlock state. I also want to thank Jacco Farlo for his role as a second reader, especially his recommendations on my research proposal were instructive. My thanks also goes to Jochen Markard for his help in the Swiss system and his theoretical revision. My acknowledgments also go to the Giannini, Thuner and Sauty families for their warm welcome during my stay in Switzerland. I also want to thank the Utrecht University for their financial support for my research in Switzerland. Finally, I am grateful to my parents for reading through my thesis.

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## 10.2 Interview list

| | *Contact* | *Organisation* | *Interview date* | *Interview sort* |
|---|---|---|---|---|
| [A] | Jochen Markard | EAWAG | 10.09.2009 | At EAWAG, Dübendorf |
| [B] | Philipe Leuthold | Cosvegaz | 11.09.2009 | At Cosvegaz, Cossonay |
| [C] | Name unknown | TCS | 14.09.2009 | At gas station, Cossonay |
| [D] | Stephan Krähenbuhl | IWB | 17.09.2009 | At Auto Expo, Basel |
| [E] | Ralph Tschopp | Gasmobil | 17.09.2009<br>09.10.2009 | By phone<br>By mail |
| [F] | Ernest Benninger | Benninger garage | 22.09.2009 | At Benninger garage, Pampigny |
| [G] | Jean-Galbert Rosselet | Municipality of Lausanne | 23.09.2009 | By mail |
| [H] | Serge Voindrot | Municipality of Morges | 23.09.2009<br>26.09.2009 | At municipality, Morges<br>At local market, Morges |
| [I] | André Gallandat | Energy services, municipality of Yverdon | 02.10.2009 | By mail |
| [J] | Eric Siewers | CNG Net | 16.06.2009 | At CNG Net, Nieuwegein |
| [K] | Ruben Kramer | Eco Mobility Services | 12.10.2009<br>20.10.2009 | At gas station, Schiphol<br>By mail |
| [L] | Willem Roelofs | Van Kalmthout, Ford garage | 14.10.2009 | At van Kalmthout, Hoofddorp |
| [M] | Gerrit Kadijk | TNO | 21.10.2009<br>06.11.2009 | By mail<br>By phone |
| [N] | Name unknown | Facilitair Bedrijf RUG | 21.10.2009 | At RUG, Groningen |
| [O] | Name unknown | Olijve's Oliehandel BV | 22.10.2009 | By phone |
| [P] | Rene Hoogendam | RWE | 23.10.2009 | By phone |
| [Q] | Tim Veldboer | ZAM Opel garage | 27.10.2009 | By mail |
| [R] | Ton Smit | Aardgasmobiel | 02.11.2009 | By phone |
| [S] | Enne-Jacob Wierda | Fuwell | 09.11.2009 | At Fuwell, Nijmegen |
| [T] | Wytske de Pater | ANWB | 19.11.2009 | At ANWB, Den Haag |
| [U] | Interviews with NGV drivers in Switzerland | | 07.09.2009-<br>28.09.2009 | Diverse gas stations |
| [V] | Interviews with NGV drivers in the Netherlands | | 22.06.2009-<br>23.10.2009 | Diverse gas stations |

# 11. Appendix

## Appendix 1: Swiss NGV drivers interviews at gas stations

| | *Where* | *Who* | *Motive 1* | *Motive 2* | *Influence* | *Experience* |
|---|---|---|---|---|---|---|
| 1 | Zurich | Gas company | Environment | None | Gas company | Positive |
| 2 | Zurich | Firm | Environment | None | Gas company | Negative |
| 3 | Zurich | Gas company | Gas sale | Environment | Gas company | Positive |
| 4 | Cossonay | Gas company | Gas sale | Environment | Gas company | Positive |
| 5 | Cossonay | TCS | TCS politics | Finance | TCS | Positive |
| 6 | Cossonay | Gas company | Gas sale | Environment | Gas company | Positive |
| 7 | Cossonay | Gas company | Gas sale | Environment | Gas company | Positive |
| 8 | Lausanne | Firm | Finance | None | - | Positive |
| 9 | Lausanne | Consumer | Finance | Environment | Local gov. | Positive |
| 10 | Lausanne | Firm | Finance | None | Local gov. | Negative |
| 11 | Lausanne | Firm | Environment | None | - | Average |
| 12 | Villars St-Croix | Consumer | Environment | Finance | Local gov. | Positive |
| 13 | Yverdon | Consumer | Finance | Environment | Consumers | Positive |
| 14 | Yverdon | Consumer | Environment | None | None | Positive |
| 15 | Yverdon | Consumer | Environment | None | Local gov. | Positive |
| 16 | Yverdon | Consumer | Finance | Environment | None | Positive |
| 17 | Basel | Gas company | Gas sale | Environment | Gas company | Positive |
| 18 | Basel | Taxi | Environment | None | Local gov. | Positive |
| 19 | Basel | Consumer | Environment | Finance | None | Positive |
| 20 | Basel | Firm | Environment | None | Local gov. | Average |
| 21 | Basel | Gas company | Environment | Gas sale | Gas company | Positive |
| 22 | Basel | Firm | Environmnent | Finance | Local gov. | Positive |
| 23 | Basel | Gas company | Environment | Gas sale | Gas company | Positive |
| 24 | Basel | Gas company | Gas sale | Environment | Gas company | Positive |
| 25 | Basel | Gas company | Gas sale | Environment | Gas company | Positive |
| 26 | Basel | Gas company | Environment | Gas sale | Gas company | Positive |
| 27 | Basel | Gas company | Gas sale | Environment | Gas company | Negative |
| 28 | Basel | Taxi | Finance | Environment | Local gov. | Positive |
| 29 | Basel | Gas company | Environment | Gas sale | Gas company | Average |
| 30 | Lausanne | Firm | Finance | None | - | Negative |
| 31 | Lausanne | Consumer | Environment | None | Local gov. | Positive |
| 32 | Lausanne | Consumer | Environment | None | None | Average |
| 33 | Morges | Consumer | Environment | Finance | Gas company | Positive |
| 34 | Pampigny | Garage | Test | None | Consumers | Negative |
| 35 | Rolle | Consumer | Environment | None | None | Positive |

## Appendix 2: Dutch NGV drivers interviews at gas stations

| | *Where* | *Who* | *Motive 1* | *Motive 2* | *Influence* | *Experience* |
|---|---|---|---|---|---|---|
| 1 | Schiphol | Firm | Environment | Image | Government | Negative |
| 2 | Schiphol | Firm | Environment | None | None | Average |
| 3 | Den Haag | Firm | Environment | - | - | Average |
| 4 | Den Haag | Firm | Environment | None | Consumers | Negative |
| 5 | Den Haag | Firm | - | - | - | Negative |
| 6 | Haarlem | Firm | Environment | None | Government | Negative |
| 7 | Haarlem | Firm | Environment | None | Government | Average |
| 8 | Nieuwegein | Ballast Nedam | Gas sale | Environment | Ballast Nedam | Positive |
| 9 | Nieuwegein | Ballast Nedam | Gas sale | Environment | Ballast Nedam | Negative |
| 10 | Schiphol | Firm | Environment | None | Government | Average |
| 11 | Schiphol | Consumer | Environment | None | None | Positive |
| 12 | Schiphol | Taxi | Environment | Image | None | Positive |
| 13 | Groningen | Firm | Environment | None | University | Positive |
| 14 | Groningen | Firm | Environment | Image | - | Positive |
| 15 | Groningen | Firm | - | - | - | Negative |
| 16 | Schiphol | Firm | Environment | None | Government | Average |
| 17 | Schiphol | Firm | Environment | Finance | Geen | Positive |
| 18 | Schiphol | Firm | Environment | Image | Government | Negative |
| 19 | Schiphol | Firm | Environment | - | - | Positive |
| 20 | Nieuwegein | Ballast Nedam | Gas sale | Environment | Ballast Nedam | Positive |
| 21 | Nieuwegein | Ballast Nedam | Gas sale | Environment | Ballast Nedam | Negative |

## Appendix 3: Pictures of gas stations and advertisements in the Swiss system


erdgaszürich
ZH 88846


MIGROL
Sortie
MIGROL


Natürliche Energie.
Erfahren Sie alles
über Erdgasfahrzeuge.
Erdgas-
Wettbewerb
an der Auto Basel
17. – 20. September 2009
sauber
günstig
sicher
www.gvm-ag.ch
erdgas
biogas
energieschweiz
LWB