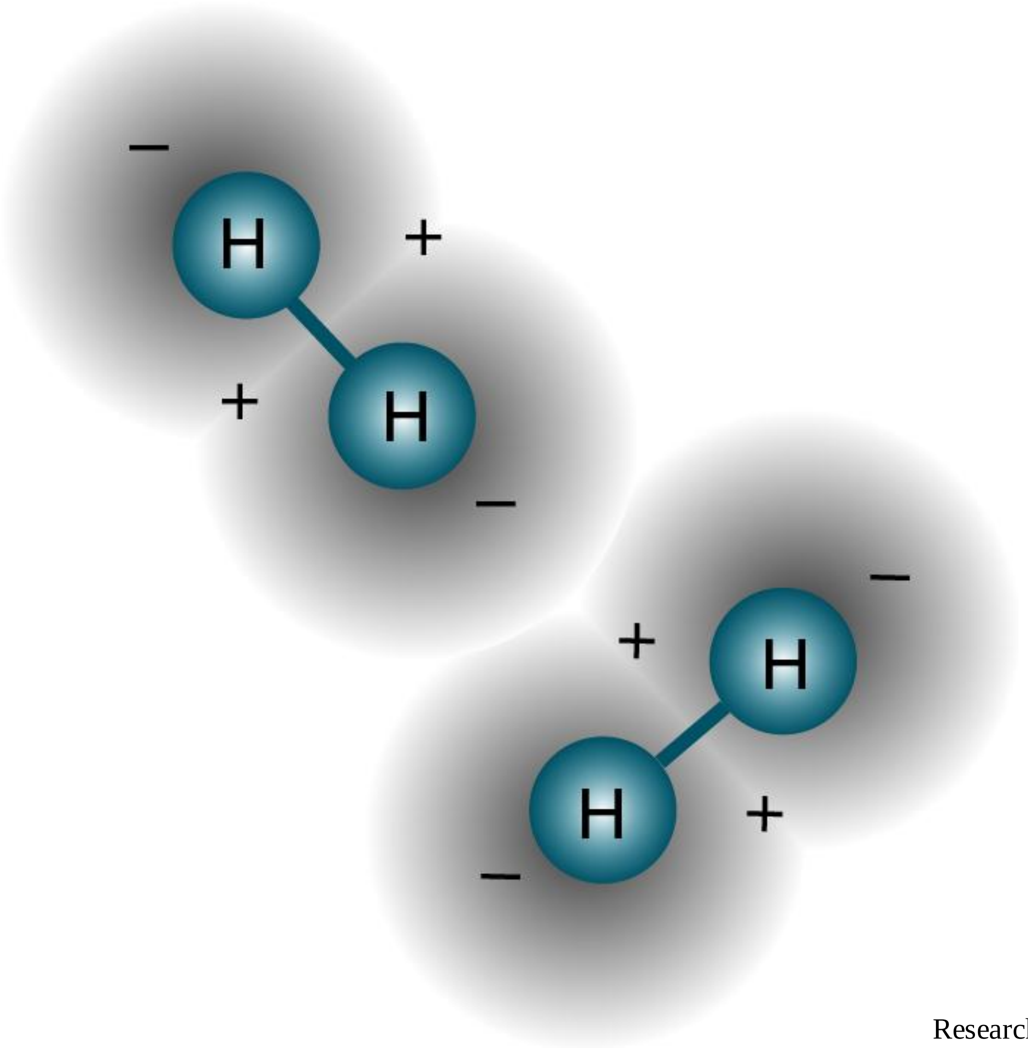
Organizational characteristics and cooperation:

A case study of Dutch cooperative projects on Hydrogen Innovation



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Abstract

For this paper research was done on the organizational characteristics that influence participation in Dutch hydrogen innovation cooperative projects. Organization size was identified as influential on organizational participation in cooperative projects with larger organizations being active in significantly more projects then smaller ones. The influence of technological capital was partially supported by the results. From the four separate hypotheses combined explaining the influence of R&D capability on cooperation, two were supported, one was rejected and one partially rejected. The results also provided evidence for the positive effect of complementarities in products and/or services on the participation in initiated cooperative projects. Lastly, results supported the negative effect of market overlap on the participation in initiated cooperative projects. Two theories were used as scientific basis for the hypotheses, the resource-based view and cognitive distance theory. Both proved to be adequate in their explanation for empirically observed patterns of initiation of cooperative project and organization participation.

Table of contents

Chapter 1: Background

An introduction to hydrogen, networks and the systemic approach

Introduction

Innovation is a sophisticated process for an organization to execute, involving not only development, but also marketing and implementation among other processes. Empirical studies have provided evidence that cooperation helps reduce the complexities associated with the process, and overall has a positive impact on organizations' innovative performances (Hagedoorn, 1993). Especially in high-tech sectors cooperation is often a central part of organizations' innovation strategies (Nooteboom, 2006). Now that sustainable energy development has taken up a high place on most political agendas, cooperation can help drive innovation processes in this high-tech sector. Hydrogen as an energy carrier coupled to sustainable production methods is considered one of the more promising options for at least partial substitution of fossil energy sources (Rifkin, 2002; Zegers, 2006). While over the past years some applications of hydrogen have been presented, specifically in transport, most are still in concept and are as such far from commercially viable. Such applications require a widely spread hydrogen-based energy infrastructure to function correctly, which is nowhere near complete. Introduction of an application residing on a not yet existing energy infrastructure will most likely be rejected by commercial organizations searching for quick and low-risk financial profits like firms tend to do (Christensen, 1997). However, the energy infrastructure itself is not of any value without the proper applications present. Cooperation in particular can help organizations deal with this specific complexity of hydrogen development.

1.0) FUNDAMENTAL THEORIES ON COOPERATION

1.0.1) The systemic approach

Hydrogen as energy carrier is considered a systemic innovation. This type of innovation encompasses a whole sub-system of separate products and services and possibly infrastructure on different levels and in different sectors (Richter, 2001). To replace something as vested as the current energy system, organizations need to approach it as such. Focusing on each specific part one at a time will not easily yield successes. A strong and systemic effort is needed by developing the system as whole rather than the separate parts (Unruh, 2002). Successfully developing and introducing a systemic innovation is a task that often goes beyond the resources of a single organization. It can only be achieved when there is a strong supportive basis for the innovation, comprising of multiple organizations, each dedicating their own set of resources to develop the different aspects of the system. These organizations cooperate on research, development, implementation and market introduction of the system as a whole. Hence the term 'systemic approach' is used for this process (Hodson, 2006).

1.0.2) Cooperation as basis for network formation

Freeman (1991) identified networks of cooperating organizations dedicated to innovation and Hekkert et al. (2005) state that these innovation networks consisting of cooperating organizations can have a large positive impact on hydrogen development. However, it is difficult if not impossible to assess this network of cooperating organizations as whole. This study rather focuses on the basic elements that make up the network, the cooperative projects. By assessing these projects and their inter-organizational links, insights are gained in the factors that influence the forming of the links which in turn result in growth of the network. Figure 1 illustrates the different levels of cooperation.

Dissection of levels of cooperation

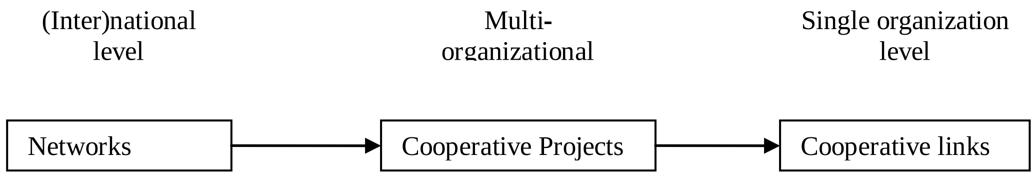

Figure 1

Networks originate through different organizations cooperating via projects on the same technology or field of expertise. When organizations are involved in multiple cooperative projects on the same technology a network of cooperating organizations is formed around that specific technology (Zhang et al., 2006). This way the projects and ultimately the separate cooperative links cause the growth of the network. Therefore the focus of this study lies on the influences contributing to cooperation between organizations. As understanding is gained in these lower dynamics, it is possible to also explain perceived patterns in the higher levels.

1.0.3) Cooperation and the resource-based view

According to the resource-based view, the heterogeneity in resources between organizations forms an important source of performance differences between them (Wernerfelt, 1984; Rumelt, 1984). Hoffmann and Schlosser (2001) stated that this theory is relevant in the field of organizational cooperation. In this study, the resource-based view is applied as the fundamental theory for explaining which type of resources influence cooperation between organizations. The resources itself are defined as the organizational characteristics – or just characteristics for short – as they 'characterise' certain organizational resources. The resource-based view is used in conjecture with Nooteboom's model for cognitive distance and learning (Nooteboom, 1999). This model builds upon the resource-based view while providing insight in the effects of learning and the degree of resource heterogeneity on cooperation.

1.1) MAIN QUESTION, LINK TO THEORETICAL AND EMPIRICAL FRAMEWORKS

1.1.1) Main question

In a former study, Mans (2006) collected data on hydrogen-oriented projects with Dutch organizations involved. From this data he distinguished two local clusters of cooperating organizations. This paper builds upon the information from Mans' study. The data Mans' gathered is used as a starting point, but this research is focused on the qualitative aspects of the separate projects, organizations and the cooperative links. The question is why these organizations chose to cooperate. To be more specific, which of the organizations' characteristics influence the participation in initiated cooperative projects, and hence the formation of cooperative links? The goal of the research is to identify those characteristics.

An analysis is made of the cooperative hydrogen-oriented projects initiated with Dutch organizations involved, the cooperative links formed due to the projects and the involved organizations' characteristics. The resource-based view and cognitive distance theory are used as fundamental theories behind the research. The time frame chosen for this analysis is 2001 – 2006. The starting year 2001 is chosen since this was the year the EU set a new target to replace 20 percent of car diesel and petrol use with less carbon emanating substances by 2020 (EC, 2001). Especially as a gasoline replacement for cars, hydrogen is a promising technology (Lovins and Cramer, 2004). The main question this paper proposes is:

'Which organizational characteristics related to the resource-based view, influenced the formation of cooperative links by Dutch organizations through initiation of cooperative projects on hydrogen technology development between 2001 and 2006?

The study is split into a theoretical and empirical part. The theoretical part concerns the identification of influential characteristics and the construction of a conceptual model that illustrates the relations between the identified characteristics and the forming of cooperative links. The empirical part concerns the analysis of cooperative hydrogen-oriented projects with Dutch organizations involved between 2001 and 2006, and the organizations themselves. Comparing the theoretical relations from the conceptual model to patterns in empirical data will give insight in those characteristics that have likely been influential on the forming of the cooperative links through the projects.

1.2) SUB-QUESTIONS WITHIN A THEORETICAL AND EMPIRICAL FRAMEWORK

1.2.1) Theoretical framework

The general issue assessed in the theoretical part of the research is the relation between specific organizational characteristics, and the forming of cooperative links through the initiation of cooperative projects, all relating to the resource-based view. This encompasses the central sub-question for the theoretical part.

1. *How does the research-based view provide an explanation for the forming of cooperative links between organizations through participation in initiated cooperative projects?*
    a. *Which types of organizations and cooperative links can be identified relating to the resource-based theory?*
    b. *Which types of organizational characteristics can be identified relating to the resource-based theory?*
    c. *How do the identified organizational characteristics influence the forming of the different types of cooperative links, according to the resource-based theory?*

Sub-question 1 is split into three alphabetically lettered sub-sub-questions. Chronologically, these form the guidelines of the chapter and will help answer sub-question 1. The first (a) deals with the definition and outline of the main elements of cooperation, the organizations involved and the links. The second (b) focuses on identification of the organizational characteristics, as distinguished from the resource-based theory, that are relevant concerning their influence on cooperation. The third (c) links the first two together to explain how the organizational characteristics are related to the type of cooperative links formed. With this information a conceptual model can be created that forms the conclusion of the chapter and will be used in the empirical part of the study.

1.2.2) Empirical research

The set-up of the empirical analysis is similar to that of theoretical. Again there is a numbered central sub-question, followed by three alphabetically lettered sub-sub-questions. The questions follow the same outline as sub-question 1 and its three sub-sub-questions.

2. *To what extend does the conceptual model explain the forming of cooperative links between organizations through participation in initiated cooperative projects in the 2001-2006 time frame?*
    a. *Which cooperative hydrogen-oriented projects with Dutch organizations involved were initiated between 2001 and 2006, which organizations participated in these projects and what types of links were formed?*
    b. *What are the empirically determined values of the organizational characteristics for each Dutch organization involved?*
    c. *How do the determined values of these organizational characteristics relate to the patterns of cooperative links formed by the organizations concerned through the cooperative projects initiated?*

From the data on projects initiated the cooperative links as well as patterns in the forming of these links can be identified. The projects, their cooperative links, the organizations involved and their organizational characteristics are all assessed. By comparative analyses using this data the second sub-question and its sub-sub-questions are answered.

1.2.3) Results & conclusion

The results from the empirical research are presented in comparative graphs and tables. Through these figures, the influence of the distinguished organizational characteristics on the different cooperative links formed is explored. The conclusion sums up the characteristics that were likely to be of influence, according to the empirical figures.

Chapter 2: Theoretical framework and hypotheses

A basis of fundamental theories of cooperation for research

Introduction

In this chapter the resource-based view, the theory that is used as a basis for the research is explained as is its connection to the research. The general elements of cooperation are identified and described. Different types of organizations and cooperative links that can be formed are distinguished as well as organizational characteristics of influence on these types. The relations between the different cooperative links and characteristics are hypothesized and placed within two conceptual models. These models and their hypotheses will be used in the following empirical analysis.

2.0) THEORETICAL FOUNDATIONS

2.0.1) The resource-based view

The resource-based view is often used theoretic basis to explain the initiation of cooperative projects and the forming of inter-organizational links through these projects (Rosenkopf and Nerkar, 2001). It considers organizations characterized a collection of resources, physical and non-physical. Those collections of resources are heterogeneous across different organizations. This heterogeneity causes performance differences between those organizations (Wernerfelt, 1984; Rumelt, 1984). Through cooperation organizations combine their different sets of resources. If an organization has use for a certain resource it has the option to develop, purchase or cooperate with an organization that possesses the resource (Hoffmann and Schlosser, 2001). This resource interdependence through heterogeneity is commonly used as explanation for cooperation (Nohria and Garcia-Pont, 1991). In a high-tech environment, like hydrogen development, obtaining and bringing together the right combination of resources for R&D is organizations' primary focus (Yasuda, 2005). Within a high-tech environment technological capital, the aggregate of all technological knowledge an organization possesses is considered the most important resource. Cooperation as a means to combine the heterogeneous technological capital from different organizations takes central place in their innovation strategies (Nooteboom, 2006). Bringing together the right combination of technological knowledge positively affects innovative performance (Hagedoorn and Duysters, 2002). This is essential when tackling sophisticated and multidisciplinary problems (Santoro et al., 2006), like in this case developing and introducing a hydrogen-based energy system as alternative for fossil energy.

2.0.2) The cognitive distance theory

The difference in resources of cooperating organizations, less it have a negative impact on the project, is limited by constraints in cognitive distance. According to the social constructivist view organizations each develop their resources along their own path, within their own specific environment. This results in the resource heterogeneity among organizations that is fundamental to the resource-based view. That resource heterogeneity in turn causes cognitive distance between organizations (Nooteboom, 2000). The theory of cognitive distance centres on differences in terms of knowledge resources, or technological capital between organizations. It is therefore of specific relevance for high-tech cooperative projects (Nooteboom, 2006). Figure 2 represents the model Nooteboom proposed for the relations between cognitive distance, novelty value and absorptive capacity.

Optimal cognitive distance (Source: Nooteboom, 1999)

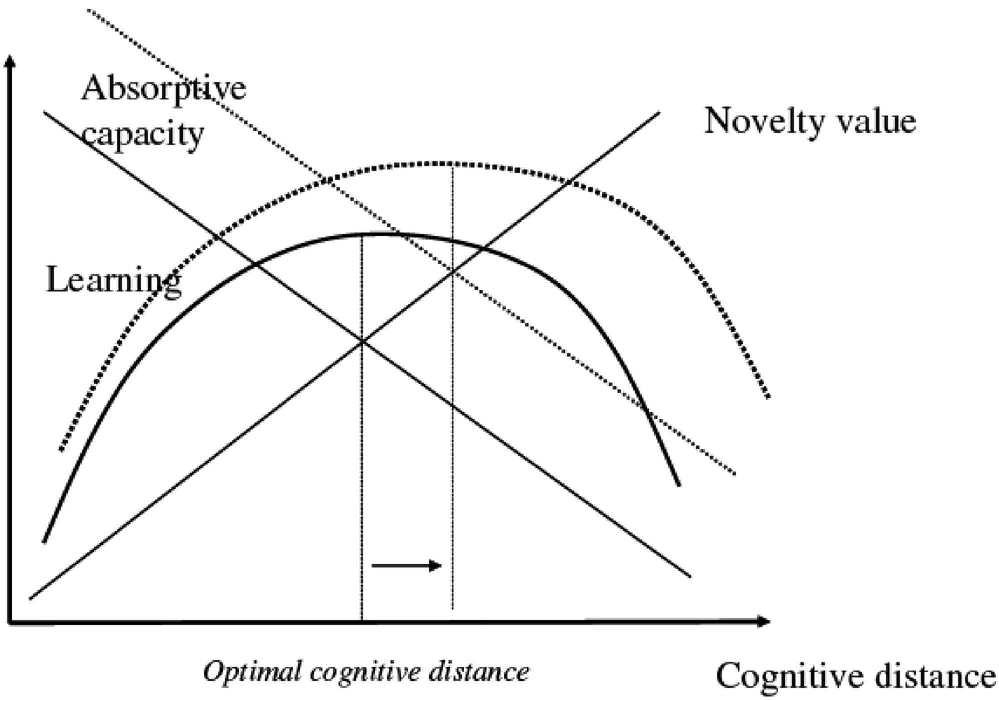

Figure 2

The novelty value the cooperation yields increases with cognitive distance. When the technological capital cooperating organizations possess differs more it can be combined in more ways than more similar knowledge. However, an increase in novelty value culminating in cognitive distance comes at the cost of a decrease in the organization's absorptive capacity. Absorptive capacity indicates an organization's ability to understand the other organization(s) it is cooperating with. It encompasses the organization's ability to store and directly apply the knowledge it obtains from its partners. Absorptive capacity increases with the R&D an organization executes resulting in the accumulation of more technological capital (Cohen and Levinthal, 1990). Organizations that have a high R&D capability resulting in more technological capital and increased absorptive capacity have less problems coping with cognitive distance. They can absorb and store more knowledge (both tacit and codified) from their partners, which in turn can be used in the cooperative project to increase innovation performance.

The effect of more technological capital from increased R&D causing more absorptive capacity is illustrated by the right-shifted vertical line in Figure 2. The line for absorptive capacity is shifted upward into a dotted line, illustrating the increase in technological capital. This causes the intercept with the line for novelty value to move upward as well. More absorptive capacity enables an organization to cope with an increased amount of cognitive distance. Hence the intercept for optimal novelty value/cognitive distance of the cooperation increases.

High novelty value is important for explorative innovation, pushing for more radical innovations. These innovations break with established technologies and have need for combining existing knowledge into fundamentally different technological capital (Rosenkopf and Almeida, 2003; Nooteboom, 2000). Exploitative innovation involves more routinized learning adding to existing knowledge resources rather then creation of new technological capital from scratch through novel combinations. Hence cognitive distance is a complexity and of negative influence on the exploitative innovation process (Hagedoorn and Duysters, 2002).

2.1) TYPES OF ORGANIZATIONS AND COOPERATIVE LINKS

2.1.1) Elements of a cooperation

According to Lambooy (2004) cooperative projects consist of three types of elements. The first elements are the organizations involved, the actors – Lambooy calls them nodes, a synonymous term – and their resources. The second elements are the connections or cooperative links between the organizations involved in the project. The third element is the use of the cooperative links for transfer of a product, but also information or people. More generally said, it consists of the actual usage of the cooperative links by way of partaking in the cooperative project and sharing technological capital and other resources.

2.1.2) Types of organizations and types of cooperative links

Within these elements separate sub-types can be identified. Organizations can be divided into two main groups. The first group consists of private organizations which are privately owned and funded firms. Tidd et al. (1997) distinguish five types of privately funded organizations: supplier-dominated, scale-intensive, science-based, information-intensive and specialized supplier. The second group consists of public organizations, which receive (most of) their budget from the government. The organization types within this group are intermediaries, universities and research institutions. Figure 3 gives a representation of the organization types of each of the two groups, as well as brief descriptions.

Belderbos et al. (2004) identified three different types of cooperative links, related to the different organization types from Figure 3. Horizontal cooperative links are links between competing organizations that are active on the same market or type of market. Vertical cooperative links are links between customers and supplying organizations. Their markets are vertically divided. Institutional cooperative links are links between private and public group organizations. Examples are links between firms and research institutes or universities meant for the exchange of specific knowledge.

Organization groups and types (Tidd et al., 1997)

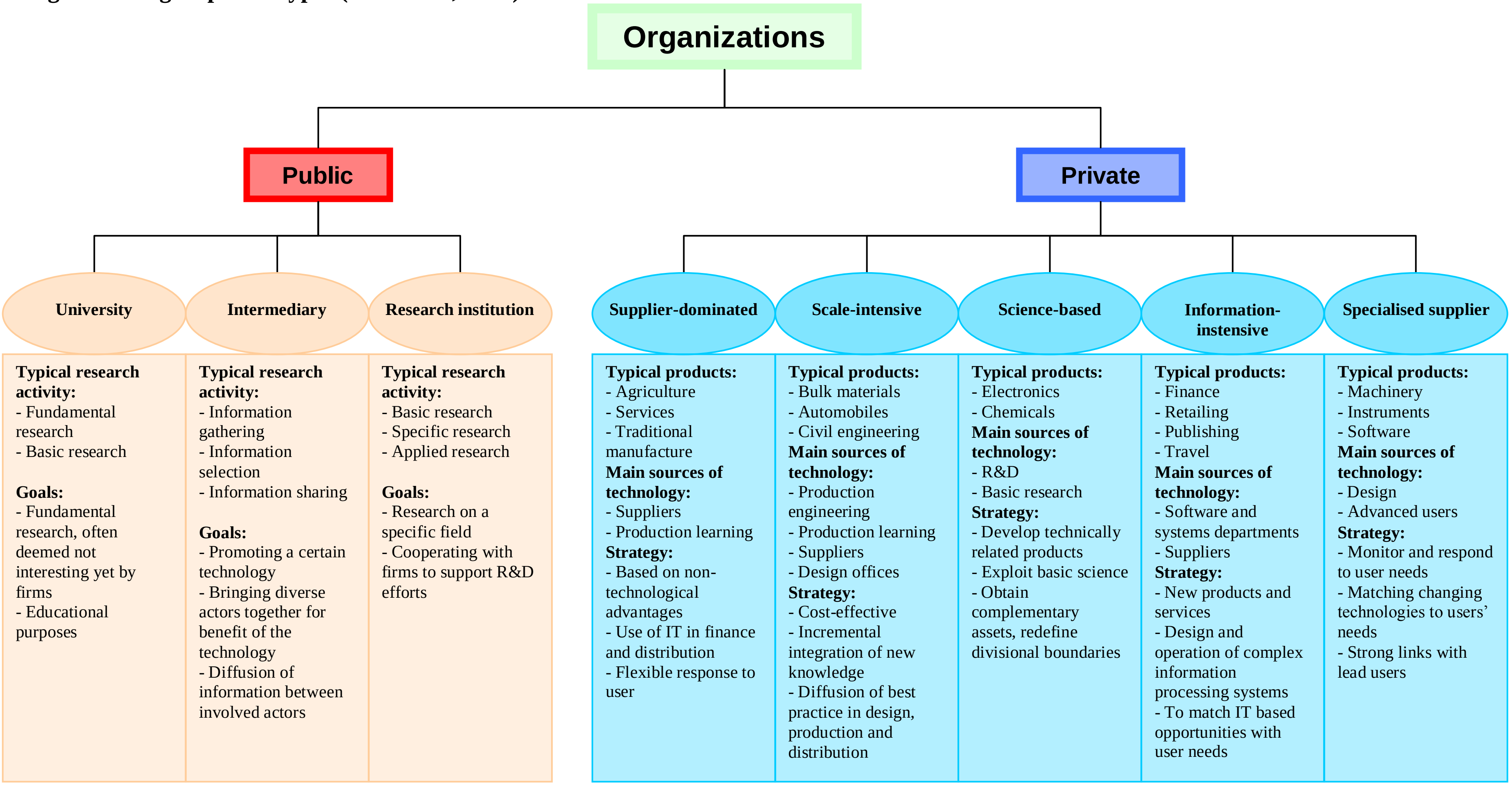

Figure 3

2.2) *TYPES OF ORGANIZATIONAL CHARACTERISTICS DISTINGUISHED FROM THE RESOURCE-BASED VIEW*

2.2.0) A distinction: dyadic and single organizational characteristics

There are two different prerequisites that influence organizations to cooperate. These two prerequisites each contribute a separate set of characteristics. The first prerequisite is that of *possession*. The organization must possess, and be able to allocate the resources to be able to partake in a project. The second prerequisite is that of *necessity*. The resources offered by the project partners must be *needed* by the organization because its sole resources aren't enough to achieve the project's goal (the organization must of course also have an interest in that goal). Due to the different natures of the prerequisites two different sets of organizational characteristics are distinguished, each based on one of the prerequisites. These sets are the single organizational characteristics and the dyadic organizational characteristics. The single organizational characteristics represent the possession side, an absolute value of possession of certain types of resources. The dyadic organizational characteristics represent the necessity side, a relative value of the difference in the resources between that of the organization and its partners. The two prerequisites each represent the dependant variable. Hence, two conceptual models are compiled, each focussing on one of the prerequisites and the relations between that and the appropriate set of organizational characteristics.

2.2.1) The influence of single organizational characteristics on cooperative links

The single organizational characteristics are discussed below. Based on an organization's possession of resources three organizational characteristics have been identified as influential on cooperation: organization size, technological capital and funding type. In the following sections these organizational characteristics are further explained.

Actor size as influence on cooperation

The *size* of an organization, defined as the amount of FTE's indicates the amount resources an organization has. Previous research has identified size having a positive impact on the amount of cooperative projects joined and links formed (Becker and Dietz, 2002; Kaiser, 2002). An organization possessing more human resources can more easily allocate the employees or FTE's needed for the cooperative project than a smaller organization. Also organizations with more resources can be simultaneously involved in more projects than organizations with fewer resources.

Hypothesis 1.1: *The amount of cooperative projects joined increases with organization size*

Technological capital as influence on cooperation

Technological capital is a characteristic that is closely related to the organization types from Figure 3. These types define some important basic aspects of the organization, the most important in this case being the general technological capital. The organization type affiliates to a relative basic R&D expense. For instance, science-based have a higher R&D expenses than supplier dominated since on the markets science-based organizations target knowledge provides an important competitive advantage (e.g. chip makers). They therefore possess a relatively high amount of technological capital. In this specific case of the high-tech environment of hydrogen development relatively large amount of technological capital is a prerequisite for hydrogen-oriented R&D, since the technology is of such technically complicated nature.

The amount of technological capital implies a tendency towards certain *types* of cooperative links. Considering the resource-based view, organizations will prefer project-partners that possess different resources then they own, those they have need of and cannot easily be obtained. Yet the cognitive distance between the cooperating organizations, their knowledge resources, must not be too different as not to hinder understanding between project partners (Nooteboom, 2006). Two organizations with high R&D capability, thus with high amounts of technological capital, have less trouble understanding each other's processes than two organizations of which only one positions R&D as central interest. Considering hydrogen-oriented projects, organizations with a large amount knowledge on hydrogen technology will prefer to cooperate with other organizations with knowledge in a specific other field related to hydrogen technology. Kaiser (2000) stated that all knowledge concerning the cooperative project becomes appropriable to each of the partners, thereby lessening the knowledge gap in terms of the field of expertise the project encompasses. For this gap to be lessened however, both organizations need enough absorptive capacity, through technological capital, to cope with the cognitive distance.

Hypothesis 1.2a: *Organizations with a relatively higher amount of technological capital form more links with other organizations with a higher amount of technological capital*

Direct access to specific knowledge, and learning from partners have been identified as important factors for cooperation (Belderbos et al., 2004; Peng, 2001). This knowledge is dispersed over the organizations involved in the cooperative project via knowledge spillovers. There are two types of knowledge spillovers: incoming and outgoing. Incoming spillovers refer to the knowledge obtained from cooperating organizations, outgoing to that knowledge leaked to the others. Knowledge spillovers can be both voluntary and involuntary. Organizations will often have to share and disclose certain knowledge in order for a cooperative project to be successful and sometimes also to gain extra interest of other organizations for joining the cooperative project (Muller and Pénin, 2006). Spillovers help organizations to deal with the cognitive distance between them (De Bondt and Veugelers, 1991). However, the problem lies in the involuntary part of the outgoing knowledge spillovers. During a cooperative project there is always the risk of involuntarily spilling over knowledge not meant for sharing. In the worst case sensitive knowledge is leaked to competitors. An organization may lose part of its competitive advantage due to these spillovers. Organizations with a high amount of technological capital will especially be at a disadvantage since they have a larger pool from which knowledge can be leaked to partners. More technological capital also raises the risks of cheating and free-riding by partners (Kesteloot and Veugelers, 1995). This puts the advantage of access to knowledge resources against the disadvantage of outgoing involuntary spillovers. The risk of outgoing spillovers is often an important factor for organizations with large amounts of technological capital through high R&D capability to turn down horizontal cooperation.

Hypothesis 1.2b: *Organizations with a relatively higher amount of technological capital form less horizontal links*

Organizations with a large amount of technological capital have more knowledge to lose than those with smaller capital. These negative effects of involuntary outgoing spillovers are less, and therefore less a negative influence on vertical and far least on institutional cooperation (Belderbos et al., 2004). Organizations with a large amount of technological capital will therefore preferably form institutional links.

Hypothesis 1.2c: *Organizations with a relatively higher amount of technological capital form more institutional links*

Considering the resource-based view, organizations with larger amounts of technological capital are at an advantage in high-tech environments, like hydrogen-development. Organizations with more technological capital have more knowledge resources to offer. They have a stronger position in resource interdependence as they are more likely to possess the knowledge needed for a specific hydrogen-oriented high-tech cooperative project. That makes them more desirable as a cooperation partner. And relating to the cognitive distance theory, more technological capital also increases an organization's absorptive capacity. Therefore these organizations are able to cooperate with partners that are at relatively greater cognitive distances. This increases amount of possible partners in cooperation. That larger absorptive capacity can also be put to a specific use. To gain optimal profit from cooperation an organization will try to maximize incoming spillovers while minimizing outgoing. Absorptive capacity is beneficial to that cause. This enables it to absorb and store more knowledge from incoming spillovers and therefore increases the organization's ability to benefit from cooperation in terms of learning (Belderbos et al., 2004). As learning has been identified as important factor for organizations to cooperate, organizations with high absorptive capacity that can learn easier and gain more knowledge through cooperation will use this method more often.

Hypothesis 1.2d: *The amount of cooperative projects joined increases with the amount of technological capital an organization possesses*

Funding type as influence on cooperation

The influence of the funding type on cooperation is connected to the former paragraph of the influence of technological capital through R&D capability on cooperation, specifically to spillovers. As explained in the former paragraph, privately funded organizations may have some objections to horizontal cooperation in certain cases, e.g. working with direct competitors. They will prefer institutional cooperation as a means of access to specific knowledge (Belderbos et al., 2004). Publicly funded organizations (intermediaries, universities, research institutions) have no direct commercial interests or specific market targeted. The only constraint on the amount of cooperative projects they can join is the amount of resources they possess. Therefore public organizations will form more cooperative links than private.

Hypothesis 1.3*:* *The amount of cooperative projects joined is larger for publicly funded organizations*

2.2.2) The influence of dyadic organizational characteristics on cooperative links

The concepts that fit the dyadic organizational characteristic model are discussed in this paragraph. The difference or equality on a dyadic organizational characteristic will result in specific preferences for the forming of cooperative links. Two dyadic organizational characteristics have been identified, the complementarities and market overlap. The cognitive distance theory forms the basis for both dyadic characteristics.

Complementarities

The complementarities in products and/or services refer to the extent to which the different product/services share technology resources. Complementarities have bean identified as influential on cooperation in earlier research (Nohria & Garcia-Pont, 1991). Complementarities have a positive influence on innovation within cooperative projects (Frenken, 2000). The cognitive distance theory forms an explanation on why complementarities influence cooperation. Complementary products/services differ from each other to yield novelty, yet share at least some of their basic technology and knowledge resources. The cognitive distance is smaller compared to products/services which do not share some fundamental knowledge. One of the clearest examples of complementary cooperation is that between producers of a main product and suppliers of components for that specific product, e.g. producers of motherboards and central processing units. Christensen and Rosenbloom (1995) give an interesting view of complementarities in their value chain model (Figure 4). This model ranks different types of complementary products, components and services depending on their market. Products or services are considered as complementary when they share important technology, components and/or are a part of the same value chain. The horizontally linked products/service are complementary as they are components of the central product. The same applies to the vertically linked products in the central column. These products share fundamental knowledge resources as they are co-dependant. Complementarities increase the incentive for the formation of vertical cooperative links (Belderbos et al., 2004).

Hypothesis 2.1: *Organizations which offer complementary products/services are more likely to cooperate*

Market overlap

The resource-based view empathizes resource-interdependence as explanation for cooperation (Nohria and Garcia-Pont, 1991). Organizations that target the same market are competitors, and are more unlikely to cooperate (Belderbos et al., 2004). Their technological capital is largely similar due to their market overlap. In terms of the cognitive distance theory, this exemplifies a relatively small distance and low novelty values. In the paragraph on technological capital as influence on cooperation, it was also noted that due to involuntary spillovers organizations will often be reserved concerning horizontal cooperation, e.g. cooperation with organizations that have high market overlap.

This characteristic is again only applicable to those organizations that are privately funded. Since publicly funded organizations have no commercial interests and do not target a specific market these cannot overlap. Looking at Figure 4, it illustrates when products/services are competing through market overlap. Products or services are considered as competitive when they are part of the same value chain box. This theory results to hypothesis 2.2.

Hypothesis 2.2: *Organizations with higher market overlap are more unlikely to cooperate*

Simplified example of an energy production value chain

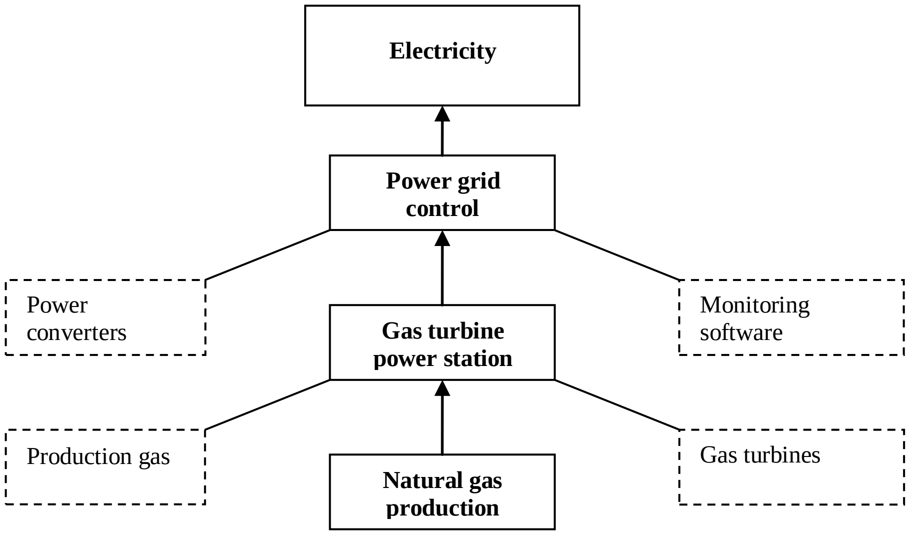

Figure 4

2.3) *THE RELATIONS BETWEEN ORGANIZATIONAL CHARACTERISTICS AND THE FORMATION OF COOPERATIVE LINKS*

2.3.0) Two conceptual models

The first conceptual model (Figure 5) illustrates the relations between the single organizational and the forming of an *absolute amount* of certain cooperation types. The second conceptual model (Figure 6) illustrates the relations between the dyadic organizational characteristics influencing an *incentive* for formation of certain cooperation types. Below each model an operationalisation scheme is given, listing all characteristics as concepts, their dimensions, indicators for each dimension and a variable for each indicator.

2.3.1) First conceptual model: single organizational characteristics

Concepts influencing cooperation types on an absolute basis

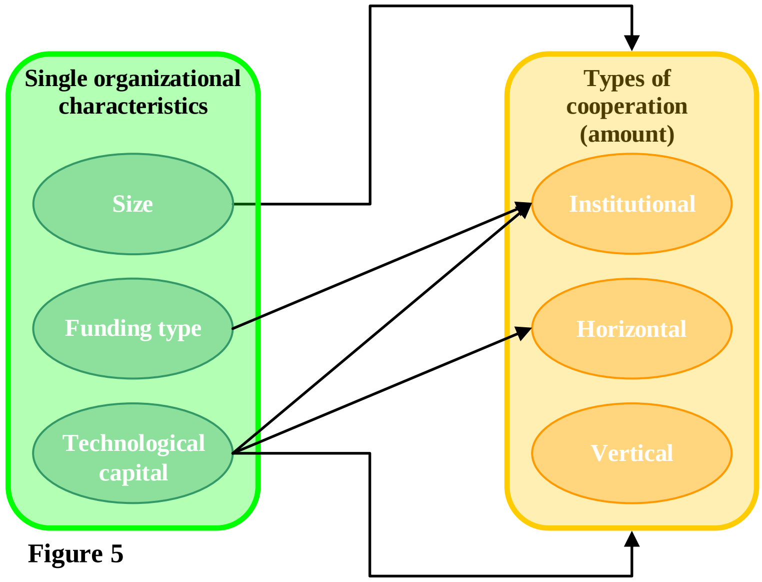

Figure 5

Operationalisation scheme of concepts for Figure 5

Concept	Dimension	Indicator	Variable
Organization size		FTE's	FTE category *: - Micro - Small - Medium - Large
Technological capital		R&D capability	Lickert scale 1-3 (low – medium – high)
Funding type		Funding revenues	Group: - Public - Private
Cooperation type	Vertical	Cooperative links with suppliers/customers	Quantity of vertical links
	Institutional	Cooperative links with public institutions	Quantity of intitutional links
	Horizontal	Cooperative links with competing organizations	Quantity of horizontal links

Table 1

*: Size is based on FTE figures of actors. The Dutch KvK distinguishes four size categories based on FTE figures: Micro (<10 FTE), Small (10 < FTE < 50), medium (50 < FTE < 250) and large (FTE > 250). These are used for determining the empirical value of actor size.

2.3.2) Second conceptual model: dyadic organizational characteristics

Concepts influencing cooperation types on a dyadic basis

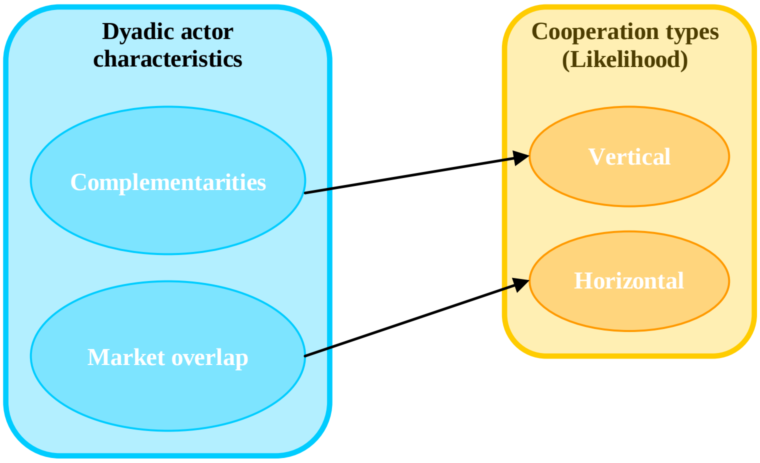

Figure 6

Operationalisation scheme of concepts for Figure 6

Concept	Dimension	Indicator	Variable
Complementarities		Product/service value chain position	Complementary product/service (Yes / No)
Market overlap		Overlap of targeted markets	Lickert scale 1-3 (None/Low – Medium – Full Overlap)
Cooperative links	Vertical	Cooperative links with suppliers/customers	Presence of links with suppliers/customers (Yes / No)
	Horizontal	Cooperative links with competing organizations	Presence of links with competitors (Yes / No)

Table 2

Chapter 3: Method

Process for empirical study

Introduction

In this chapter the method used for empirical research is explained. Data on hydrogen-oriented cooperative projects was gathered and compiled in a database. That database contains information on projects, organizations involved and their characteristics. By assessing the data patterns of projects, cooperation types and organizational characteristics are identified. Analyses focus on whether or not the patterns support the hypotheses from the theoretical framework.

3.0) PHASES AND DATABASE

3.0.1) General structure of the method

The empirical research consists of three phases, each centered on one of the three lettered sub-sub-questions derived from sub-question 2, the central empirical research question. The first phase consists of data gathering on projects and organizations involved. The second phase consists of the ranking of each organizations' and projects' characteristics according to the indicators from the operationalisation schemes. The third phase consists of the analysis of the data gathered in the first and second phase to identify patterns of cooperative link forming and specific organizational characteristics relating to the identified patterns.

3.1) PHASE 1: CREATION OF A DATABASE LISTING PROJECTS AND ORGANIZATIONS

3.1.1) Data gathering on projects

The first part of the empirical analyses consists of the gathering of data on hydrogen-oriented projects within the time frame of 2001-2006. There are a number of selection criteria for projects to be viable for analysis, as it concerns only hydrogen-oriented projects determined with at least one 'Dutch' organization participating. An organizations is considered Dutch if it is either of Dutch origin, or possess a significant presence within the Netherlands, like an EU head quarters. A project must also have a known starting point between the start of 2001 and end of 2006. Finally, the projects must involve at least two organizations else it wouldn't be a *cooperative* project. Projects where at least one of these conditions was unclear are considered unsuitable for the research and removed from further analyses. The first part of the data was obtained through implementation of earlier research of

Mans (2006) into the database. Lacunas in his data were supplemented with own research. Online databases for funding of hydrogen projects, like senternovem.nl and the NWO, proved to be valuable sources of knowledge for project data. The data gathered accumulated to a list of 196 projects on hydrogen, which form the absolute basis of the analysis. After removing the projects not fitting all selection criteria 107 projects remained.

3.1.2) Data ordering

The data is ordered into three basic data sheets and three main sheets. The first basic sheet (B. Projects) list all 196 projects identified, all organizations are listed on the second (B. Organizations) and all Dutch organizations from the projects on the third (B. Dutch Organizations). Information in the database for each project consists of 1: the name, description and when possible abbreviation of the project; 2: organizations involved in the project and their country of origin; 3: starting and when possible ending date of the project; and 4: source of information. The basic data sheets form the fundamental database from which the main data sheets were derived, which were used for the analyses on the relations stated by the hypotheses.

From the basic data sheet 107 projects fit the selection criteria and are compiled in the main sheets. The first main sheet (M. Projects) compiles all of the 107 hydrogen projects fitting the selection criteria. These are ranked according to starting date. For the second main sheet (M. Organizations) all organizations from these projects are listed with along with the amount of projects organizations partook in, their identified type, country of origin, and website/source of information. Dutch organizations are marked red as to easier recognize them. For the third main data sheet (M. Dutch Organizations) all Dutch organizations are listed separately, ranked according to the number of projects they joined during the time frame. Finally a cross table sheet completes the data linking all organizations according to their cooperative links, as well as denominate the amount of times (projects joined in which) a link was formed between two specific organizations.

3.2) PHASE 2: DETERMINING VALUES OF ORGANIZATIONAL CHARACTERISTICS

3.2.1) Qualitative research

While Mans focused the quantitative aspects, this research aims to provide insight in the qualitative aspects – the organizational characteristics their relation to types of links formed – of cooperation on hydrogen. The “M. Dutch organizations” datasheet lists all Dutch organizations involved in projects that fit the selection criteria. For these organizations the organizational characteristics are assessed. The list is ranked firstly on the amount of projects organizations joined during the time-frame, with higher participation on top of the list. Secondly it is ranked alphabetically; with equally active organizations arranged according to their name. This datasheet was used as basis for the assessment of the values/categories of single organizational characteristics for each organization listed. For the assessment of dyadic organizational characteristics it was used in conjunction with the “M. Dutch Projects” datasheet. The following paragraphs 3.2.2 and 3.2.3 explain how each organizational characteristic was assessed and ranked. For the assessment of organizational characteristics only Dutch organizations are taken into consideration.

3.2.2) Single organizational characteristics

The sources used for information on single organizational characteristics are either the organization's website or information from the projects it is involved in. In case no source of information was found the organization is listed as the type other/unknown and highlighted in red. Characteristics from organizations marked as other/unknown are not assessed and they are not taken into consideration in the analyses using organizational characteristics as input values. Before assessing the organizational characteristics, the organization type is determined. While this is not a characteristic itself, it forms the basis of two single organizational characteristics: the technological capital and funding type. The type itself is selected from Figure 3 using information from the information on the organization particularly its purpose, goals and (when possible) R&D activities. Table 3 gives a summary of the indicators used to assess single organizational characteristics from the conceptual model.

Single organizational characteristics & indicators

Single organizational characteristic	Indicator
Organization Size	FTE's (micro – small – med – large category)
Technological capital	R&D capability (low- med – high)
Funding type	Government funded / private funded

Table 3

Organization size

The categories for organization size are those used by the Dutch commerce chamber. There are four categories: micro (< 10 FTE), small (10 < FTE < 50), medium (50 < FTE < 250) and large (250 > FTE). Through the information on each organization the size category is determined.

Technological capital

Cohen and Leventhal (1990) stated that technological capital is determined by an organization's R&D activity. The most obvious indicator then would be the amount of patents an organization has filed. However this data was found too difficult too obtain. Second in place would be use relative R&D expenditures in the form of R&D capability as indicator for technological capital. It consists of the percentage of the organizations revenue/operating budget spent on R&D. Because these expenditures generally don't change very drastically over the course of several years, it is safe to say these are form a good alternative indicator for technological capital. But again these figures are not easy (or cheap) available. Therefore a distinct method for determining R&D capability is used. As the type of each organization is determined, this gives insight in the general expenditures on R&D according to Tidd et al. (1997). For instance, a supplier dominated type doesn't invest much in R&D since its main source of technological capital is its supplier. On the other hand for a science-based type competitive advantage is often obtained through innovation, therefore this type has a significantly higher R&D capability. Table 4 presents R&D capability category related to each type.

Relation between R&D capability and organization type
(Based on Tidd et al, 1997 see also Figure 3)

Low R&D capability organizations	Medium R&D capability organizations	High R&D capability organizations
- Supplier dominated firms	- Intermediary - Scale intensive - Information intensive	- University - Research institution - Science based - Specialized supplier

Table 4

Funding type
There are two categories for funding types. An organization is considered private when most of its funding comes from private investments. It is considered public when most of its funding comes from government investments.

3.2.3) Dyadic organizational characteristics

The dyadic organizational characteristics are assessed using information on the organizations involved in the projects and information on the projects itself. The figures on dyadic organizational characteristics are listed in the "M. Dutch Organizations" datasheet in the row of their respective organization. Figure 7 lists the dyadic characteristics and their indicators.

Dyadic organizational characteristics and indicators

Dyadic organizational characteristics	Indicator
Market overlap	Amount of overlap (low – medium – high) Competitor cooperation (Yes / None)
Complementary cooperation	Complementarities within projects(Yes / None) Complementary cooperative links (Yes / None)

Figure 7

Complementary cooperation
Complementary cooperation is analyzed by comparing for each organization the products/services offered by partners in the projects it participated in. Organizations that in at least one project cooperate with a partners offering a complementary product/service are listed as a 'yes' on complementary cooperation.* Good examples of complementary cooperation include Hexion/Hygear (hydrogen production systems) and Nedstack (fuel cells) which cooperate on multiple projects. Since publicly funded organizations do not produce commercial products/services they are not used in the analysis.

Market overlap
Market overlap is analyzed by comparing for each organization the targeted market to that of the partners in the projects it participated. There are three categories of market overlap: low, medium and high. For each Dutch organization listed in the main sheet an assessment is made of the market it targets. The market the organization targets is determined by assessing the products or services it delivers and a brief description is given with each Dutch organization on the M. Dutch organizations datasheet. Overlap is determined by comparing an organizations' offered products/services to those of partners in all projects participated in. Organizations are ranked according to the cooperative link they formed with highest market overlap*. For instance in the case

of Nefit and Remeha cooperating on the 'WaBest' project both are labeled with high overlap as both organizations target the market for domestic heating. BTG biomass group and Sparqle, cooperating in the "superhydrogen" project, are each ranked with medium market overlap as the first focuses exclusively on biomass and for the second biomass is part of a broader focus. Since publicly funded organizations do not target markets they are not used in the analysis.

[*] The method of ranking the dyadic characteristics of an organization is based on the presence of a single link with a complementary or competing organization respectively. This method was chosen with the foreknowledge that on average privately funded organizations joined two projects during the time frame. If an organization cooperates in a project with a complementary/competitive organization on average that automatically means it does so in at least 50 percent of projects involved. This was deemed a relevant rate.

3.3) PHASE 3: COMPARING ORGANIZATIONAL CHARACTERISTICS TO PATTERNS AND RELATIONS

3.3.1) Analyses of relations and results

The results chapter is split into three parts: general results, single organizational characteristics results and dyadic organizational characteristics results. While the general results explain the growth rate of initiated cooperative projects during the time frame, the single and dyadic organizational characteristics results focus on explain analyses relating to the hypotheses. The analyses of the general results is done on a yearly basis, but the single and dyadic organizational analyses were executed over the six year time frame as whole because results on yearly basis yield limited results.

3.3.2) General analyses and results

The first paragraph explains the results on the general analysis of the hydrogen-oriented projects and cooperating organizations. For this analysis the software program UCINET (Version 1.62) is used. Separate diagrams for each of the six years are created; presenting all Dutch organizations joining initiated hydrogen-oriented projects that year and their cooperative links. Organizations are connected via lines to represent cooperative links. A diagram representation of all organizations connected through cooperative links is presented for each year with tables presenting the yearly figures. The figures presented are: the amount of projects per organization type, the annual amount of projects, the amount of organizations involved in these projects and the average amount of projects per organization during the time frame. A separate term is introduced, the organization involvement. This involves a formula to correct projects for their size, defined by the amount of organizations cooperating in the project.

For the analyses only Dutch organizations are taken into consideration. That also means for the dyadic characteristics, the organizations are only compared to their Dutch partners. Hence it is possible for an organization to have market overlap with a foreign organization in a project, yet not be listed as such. The research is limited to Dutch organizations and characteristic contributing to their cooperation. .

3.3.3) Single organizational characteristics analyses and results

The second paragraph explains the results of the analyses on the relations between the distinguished single organizational characteristics and formation of cooperative links through organizations joining initiated projects. Results are presented of the analyses of the influence of organization size, technological capital and funding type.

The analysis of the influence of organization size on cooperation is straightforward. The size categories of the organizations are compared to the average amount of projects they cooperate in. The analysis of the influence of technological capital on cooperation is split into four separate analyses, each related to one of the four hypotheses of this characteristic. The first analysis concerns the relation between R&D capability and cooperation with organizations with high R&D capability (hypothesis 1.2a). The second concerns the relation between R&D capability and horizontal cooperation (hypothesis 1.2b). The third concerns the relation between R&D capability and institutional cooperation (hypothesis 1.2c). The final analysis concerns the relation between R&D capability and the absolute amount of cooperative links formed (hypothesis 1.2d). Comparative tables are presented for each hypothesis. By comparing the results from the four analyses the actual influence of technological capital on cooperation and selective cooperation can be determined. For the analysis of the influence of funding type on the joining of cooperative projects publicly and privately funded organizations are compared on the amount of project both groups joined on average during the time frame. Results presented in comparative tables and a graph is made for the analysis of hypothesis 1.2a.

3.3.4) Dyadic organizational characteristics analyses and results

The third paragraph explains the results of the analyses on relations between the distinguished dyadic organizational characteristics and the formation of vertical and horizontal links respectively through the joining of cooperative projects. Results are presented of the analyses of the influence of complementarities and market overlap. The analysis of complementary cooperation (hypothesis 2.1) concerns the amount of organizations that formed (vertical) cooperative links with complementary organizations. The analysis of market overlap (hypothesis 2.2) concerns the amount of organizations that formed (horizontal) links with organizations with increasing market overlap. Results are presented in comparative tables.

3.4) LIMITATIONS, CONCLUSIONS AND RECOMMENDATIONS

The results presented in chapters 4.1-4.3 are compared to the hypotheses from the two conceptual models to determine which is supported and which is rejected. Results which are unclear will not definitively rule out the hypothesis concerned. It may for instance still be supported by other research on a different kind of technology. The discussion will assess the limitations of the research and unclear results. All conclusions from the results are summed up in the conclusions chapter. Finally some recommendations will be given for further research.

Chapter 4: Results

Results of the general analyses, influence of single organizational characteristics and dyadic organizational characteristics

Introduction

This chapter is split into three parts. Each part focuses on one of the three analyses. This first part presents the results of the general analyses. The second part presents the results from the analyses of the influence of single organizational characteristics. The final part presents the results from the analyses of the influence of the distinguished dyadic organizational characteristics.

4.0) RESULTS ON GENERAL ANALYSES

4.0.1) UCINET analysis

Six diagrams, one for each year, of the projects initiated and links formed were created using UCINET. The UCINET diagrams illustrate the growth rate of cooperative projects and visualize which organizations are more active by forming more links, as the software will automatically place them in a central position within the diagram. A table below each annual diagram is given listing for each organization type the amount active in the specific year concerned. The number of projects is given, as is the organization involvement that year. Organization involvement is a figure that takes into account project sizes as well as the amount of projects. It is the total sum of the amount of organizations involved in each individual project over a specified year. The formula used is:

Org. Involvement (Year x) = sum [organizations (year x) * no. of projects involved (year x)]
(Formula 1)

The following example explains the reasoning behind the organization involvement figure. If for instance there would be 5 projects in two consecutive years the projects value would show no growth in term of projects. But the organization involvement accounts for the difference between five projects with each ten participants and five projects with each two participants. Below each diagram a description and analysis of the picture is given, where possible comparing it to previous years.

UCINET diagram 2001

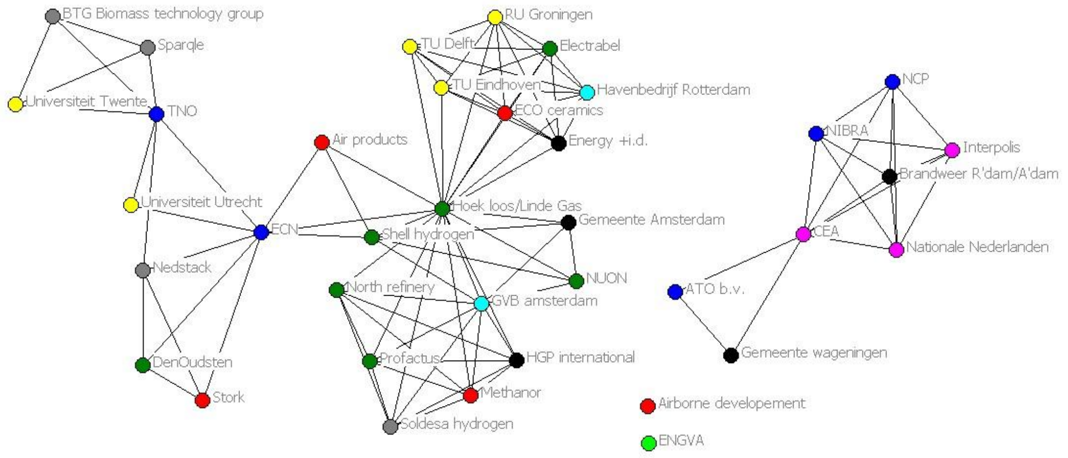

Figure 8

The first diagram presents the projects initiated in the first year of the database information, 2001. Two organizations without links, ENGVA and Airborne development may stand out directly. Organizations without links are active in projects with only foreign organizations. No links can be formed to the other organizations within the diagram as only Dutch organizations are used as input variables.

There is a smaller part where CEA takes up a central position as most active member with two projects joined by that organization. In the larger part ECN and Hoek Loos/Linde Gas share the central positions. Both ECN and Hoek Loos/Linde joined four projects that year. Other active organizations are TNO and Shell hydrogen, each with three projects.

Organization types activity in initiated projects 2001

Per actor type		Totals		
Organization type	**Amount per type**	**Amount of projects**	**Organization involvement**	**Average in project**
University	5	14	48	3,4
Intermediary	1			
Research Institution	5			
Supplier-dominated	2			
Scale-intensive	7			
Science-based	4			
Information-intensive	3			
Specialised supplier	5			
Other/Unknown	4			

Table 5

UCINET diagram 2002

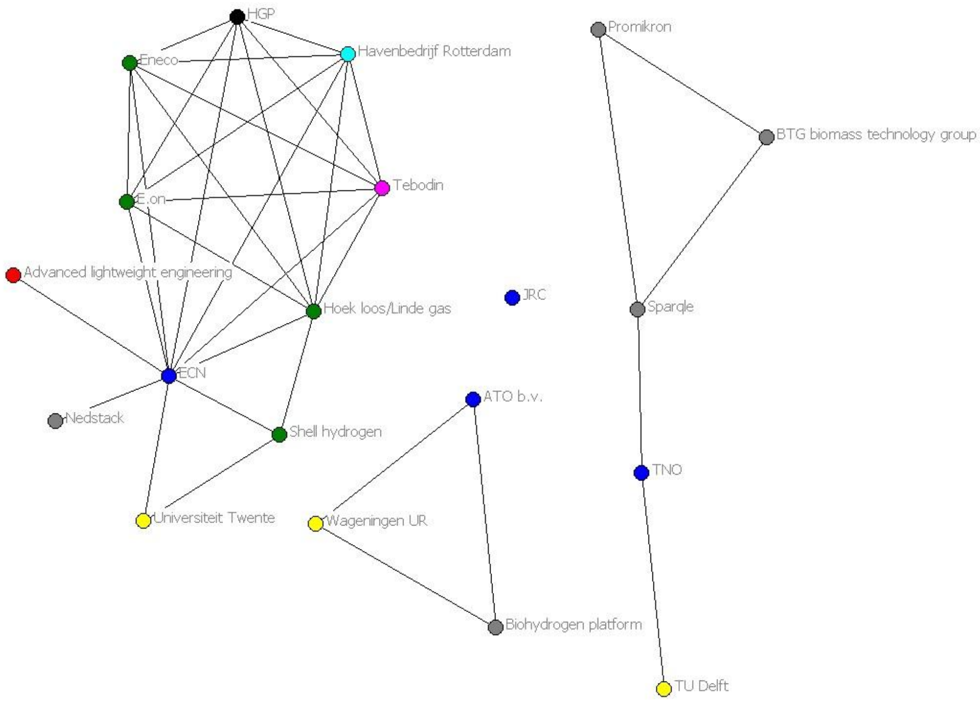

Figure 9

The following year of 2002 shows a slight decrease of organizations but increase of projects initiated. JRC is listed as an organization without links to other actors in the diagram since it only cooperates with foreign organizations in the 'FEBUSS' project. In the most left part ECN again takes a main position as most active organization, being active in four projects. Shell is another active member of this part, with three projects. The right part of the diagram concerns four projects in total, of which TNO joined three (two projects with Dutch organizations, one with foreign) and Sparqle two projects. The middle part concerns only one project, the 'stairway to hydrogen' project.

Organization types activity in initiated projects 2002

Per actor type		Totals		
Organization type	**Amount per type**	**Amount of projects**	**Organization involvement**	**Average in project**
University	3	15	31	2,1
Intermediary	0			
Research Institution	4			
Supplier-dominated	1			
Scale-intensive	4			
Science-based	5			
Information-intensive	1			
Specialised supplier	1			
Other/Unknown	1			

Table 6

UCINET diagram 2003

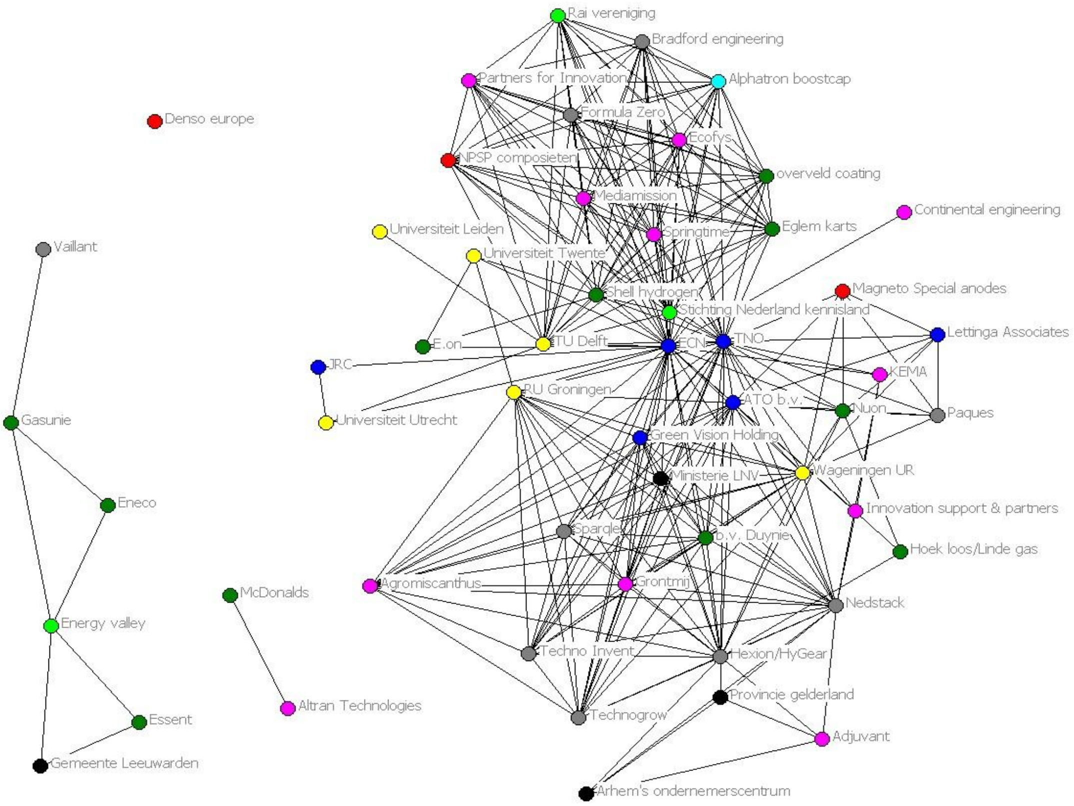

Figure 10

The year 2003 sees a drastic increase in the amount of cooperative links. Though difficult to oversee due to the dense amount of links in the diagram, ECN and TNO again take central positions as most active organizations. ECN joined ten projects this year. TNO joined four projects. Another prominent organization, Hexion/HyGear joined three projects. Energy Valley forms the centre of a separate branch of projects within the network, not linked to the main figure. Energy Valley itself joined two projects in 2003. Overall the figures from table 9 illustrate that the amount of project increased by just over a third compared to 2002. The figures in the table show that the average amount of organizations partaking in projects was larger than in 2003. On average there were just under four Dutch organizations involved in a project in 2003 compared to just over 2 in 2002.

Organization types activity in initiated projects 2003

Per actor type		Totals		
Organization type	**Amount per type**	**Amount of projects**	**Organization involvement**	**Average in project**
University	6	21	82	3,9
Intermediary	3			
Research Institution	6			
Supplier-dominated	1			
Scale-intensive	11			
Science-based	9			
Information-intensive	11			
Specialised supplier	3			
Other/Unknown	4			

Table 7

UCINET Diagram 2004

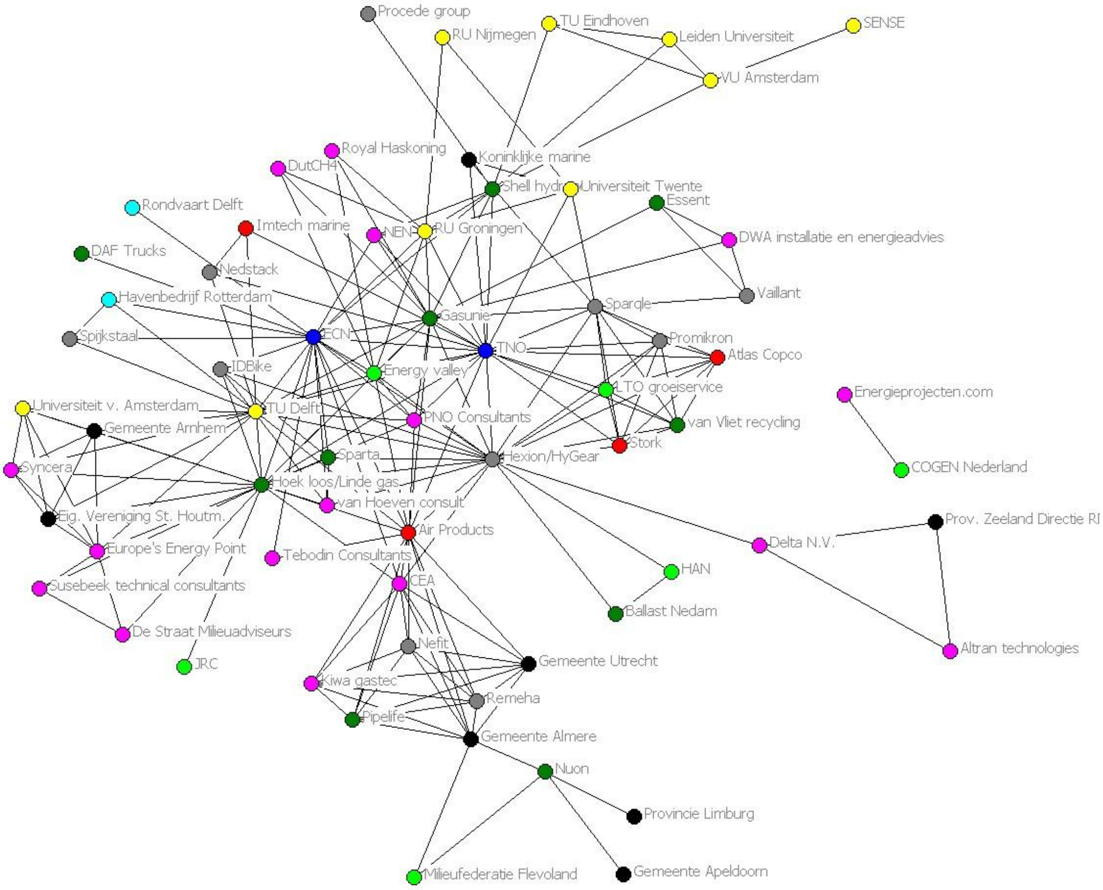

Figure 11

From the 6 year time frame 2004 is the year most projects were initiated. With eleven projects, ECN was yet again the most active organization. Hoek Loos/Linde Gas which partook in six projects and TNO, with seven projects continue to be prominent. Hexion/HyGear also took up a prominent position with six projects. Other prominent organizations were TU Delft (five projects) and Energy Valley (four projects). Again the amount of projects increased compared to the former year. The organization involvement grew from 82 to 122. However, the average amount of organizations partaking in a project decreased somewhat to 3,5. Interestingly, while more projects were initiated, the average participation of Dutch organizations decreased in 2004. This may be due to the 'Formula Zero' project, initiated the prior year that involved a lot of Dutch organizations, thus effectively raising the average. In 2004 no project of such a large size was initiated. Instead there are many projects on a somewhat smaller scale.

Organization types activity in initiated projects 2004

Per actor type		Totals		
Organization type	**Amount per type**	**Amount of projects**	**Organization involvement**	**Average in project**
University	9	35	122	3,5
Intermediary	6			
Research Institution	2			
Supplier-dominated	2			
Scale-intensive	9			
Science-based	10			
Information-intensive	16			
Specialised supplier	4			
Other/Unknown	8			

Table 8

UCINET diagram 2005

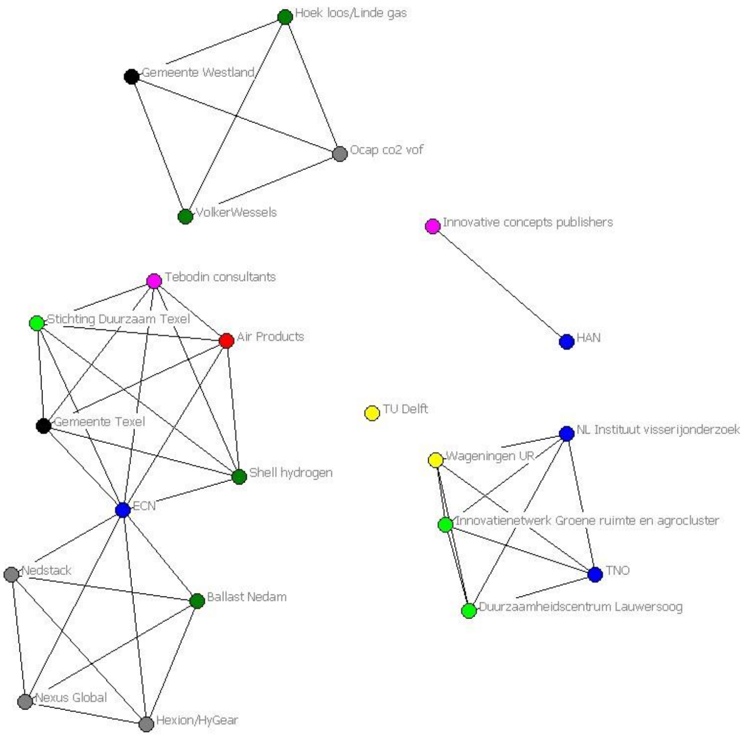

Figure 12

2005 sees a sharp decrease in the amount of projects initiated compared to the peak in 2004. Only eight cooperative projects on hydrogen involving Dutch organizations were initiated in 2005. Though it is not very clear from the diagram, the data indicates Hexion/HyGear was the most active organization in 2005, and joined 3 new cooperative projects. ECN participated in two of the projects initiated. Nedstack also joined two initiated projects, both of which included Hexion/HyGear, which is interesting for the dyadic organizational characteristic analysis since these are complementary organizations. Both TNO and Shell were less active than previous years and both only joined one project this year. Again the average amount of Dutch organizations participating cooperative projects decreased compared to the former year.

Organization types activity in initiated projects 2005

Per actor type		Totals		
Organization type	**Amount per type**	**Amount of projects**	**Organization involvement**	**Average in project**
University	2	8	26	3,3
Intermediary	3			
Research Institution	4			
Supplier-dominated	0			
Scale-intensive	4			
Science-based	4			
Information-intensive	2			
Specialised supplier	1			
Other/Unknown	2			

Table 9

UCINET Diagram 2006

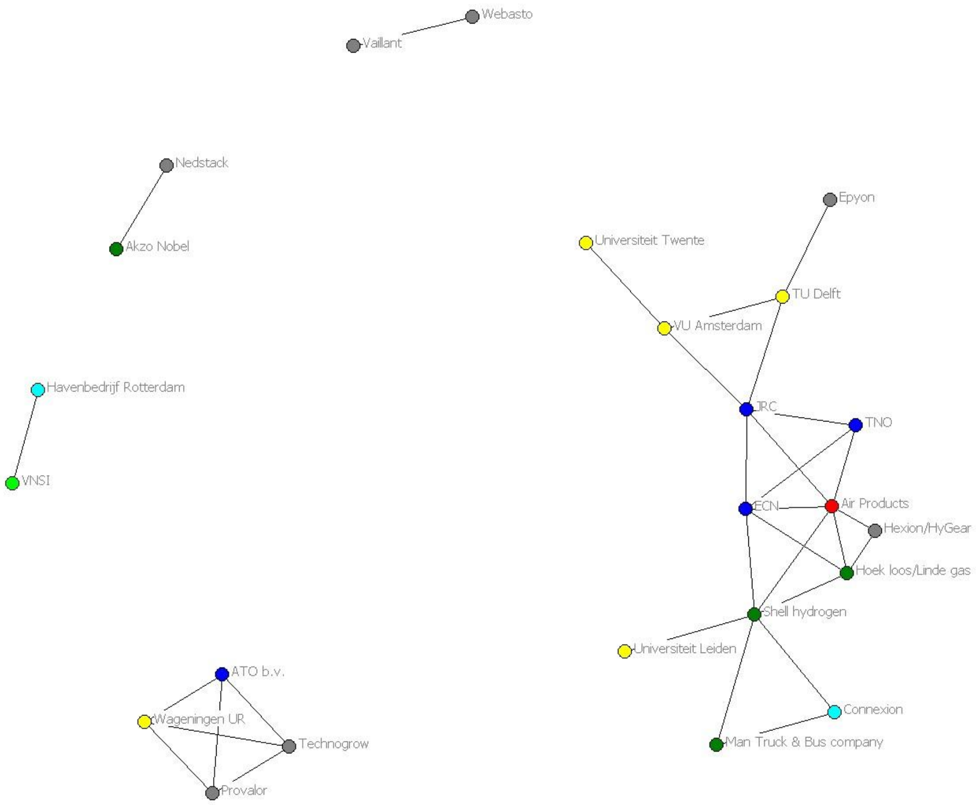

Figure 13

The final diagram depicts the 2006 situation. ECN has reclaimed the position as most active organization in projects initiated with three projects. ECN shares this position with Shell which also joined three projects, increasing its activity compared to 2005. TNO again joined just a single project this year. Other organizations that joined two projects were JRC, Hexion/HyGear and VU Amsterdam. Still, the amount of projects initiated and organizations involved is nowhere near the peak years of 2003, 2004 or even 2001.

Organization types activity in initiated projects 2006

Per actor type		Totals		
Organization type	Amount per type	Amount of projects	Organization involvement	Average in project
University	5	15	35	2,3
Intermediary	1			
Research Institution	3			
Supplier-dominated	1			
Scale-intensive	3			
Science-based	7			
Information-intensive	0			
Specialised supplier	1			
Other/Unknown	0			

Table 10

Organization types activity in initiated projects between 2001 and 2006

Organization type/ Amount	2001	2002	2003	2004	2005	2006
University	5	3	6	9	2	5
Intermediary	1	0	3	6	3	1
Research Institution	5	4	6	2	4	3
Supplier-dominated	2	1	1	2	0	1
Scale-intensive	7	4	11	9	4	3
Science-based	4	5	9	10	4	7
Information-intensive	3	1	11	16	2	0
Specialised supplier	5	1	3	4	1	1
Other/Unknown	4	1	4	8	2	0
Amount of projects	**14**	**15**	**21**	**35**	**8**	**15**
Organization Involvement	**48**	**31**	**82**	**122**	**26**	**35**
Average org. in project	**3,4**	**2,1**	**3,9**	**3,5**	**3,3**	**2,3**

Table 11

Comparing the amount of projects initiated and participating organizations yields some insight in the growth rate of cooperative projects. Focussing on the projects it is clear that the growth rate increased until 2004 after which it fell significantly. In 2005 the amount of projects initiated dropped by about 75 percent compared to the previous year, lowering it to below even the first year. The following year saw the amount of projects almost doubling. When the growth rate is adjusted for the size of the projects, by comparing the yearly organization involvement figures, there is somewhat of a different result. Comparing these figures, an interesting point is the drop in organization involvement in 2002, while there were more projects than in 2001. This means that on average, fewer organizations were involved in the projects that year. The final row of the table confirms this statement through the ‘average organizations in project’ figure. These figures fluctuated over the time frame without a clear pattern.

It is clear the figures for cooperative project growth rate are not quite transparent. In terms of the growth rate of project initiation the years 2003 and 2004 can be marked as high points. The significant decrease afterwards could be explained by the resource-based view. As a result of the increased growth rate, organizations could have allocated all available resources to projects, leaving no resources available for project allocation the following year. It could also be a result of external factors, like a change in sustainable policies. A specific assessment of policies concerning sustainable development might give some insight in that case.

4.1) *SINGLE ORGANIZATIONAL CHARACTERISTICS RESULTS*

4.1.1) Organization size and cooperation

Hypothesis 1.1 states that the amount of cooperative links formed increases with organization size. An analysis was made of the average amount of cooperation compared to organization size. Table 12 presents the results for this analysis.

Amount projects participated for organization sizes

Size	Amount of size	Percentage	Projects total	Projects average
Micro	13	8 %	14	1,08
Small	38	31 %	53	1,39
Medium	19	16 %	39	2,05
Large	52	43 %	211	4,06

Table 12

From the table it is clear that most organizations participating in cooperative projects are of the 'large' category. Almost half of all organizations involved are in that category. Micro type organizations are least, with 11 in total. Based on the average amount of projects each category partook in a comparison was made between activity of the different size categories. From the table it is clear that the average number of projects organizations joined increases with each size category. Large actors on average joined by far most projects of all categories. This supports hypotheses 1.1.

4.1.2) R&D capability and cooperation

The analysis of the influence of R&D capability on cooperation is split into four analyses each focussing on one of the four hypotheses that combined make up for the relation. Each paragraph deals with a separate analysis,.

R&D capability and cooperation with high R&D capability organizations

The first hypothesis on the influence of technological capital on cooperative link forming (1.2a) states organizations with higher R&D capability prefer to work with other organizations with high R&D capability. For the analysis the R&D capability categories are compared to the average amount of cooperative links they formed to other R&D capability categories. Table 13 presents the results, which are visualized in Figure 14.

R&D capability and cooperative links formed with R&D capability categories

R&D capability	Low		Medium		High	
Links with low int.	0	(0 %)	23	(5 %)	25	(3 %)
Links with medium int.	24	(49 %)	211	(43 %)	253	(35 %)
Links with high int.	25	(51 %)	259	(52 %)	445	(62 %)
Total links formed	49	(100%)	493	(100%)	723	(100%)

Table 13

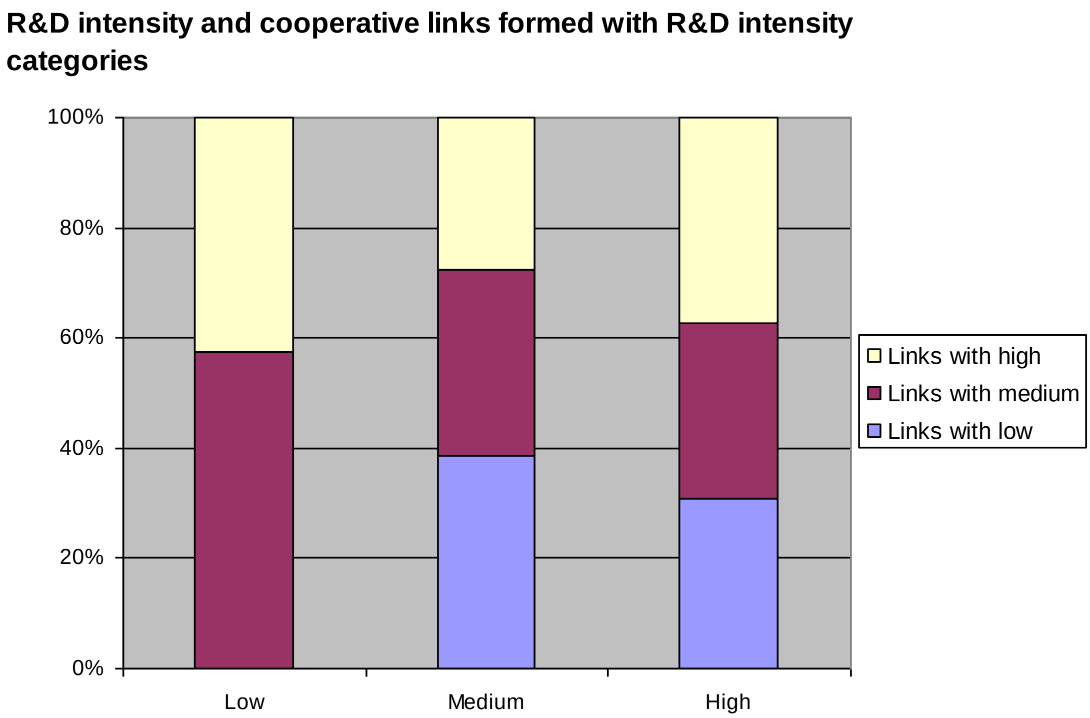

Figure 14

The analysis yields mixed results. It is clear that high R&D capability organizations cooperate more with other high and medium R&D capability organizations than medium R&D capability organizations do. However, the results for low R&D capability organizations contradict the hypothesis. From the results it seems that low R&D capability organizations only cooperate with medium and high R&D capability organizations. The results partially reject the hypothesis.

R&D capability and horizontal cooperation

The second hypothesis (1.2b) states that organizations with higher R&D capability form less horizontal cooperative links, cooperating less with competitors. For the analysis the collective of organizations within each R&D capability category are compared to the amount of horizontal cooperative links they formed. Table 14 presents the results. Only private type organizations were taken into account.

R&D capability and horizontal cooperative links

R&D capability	Total number of organizations	Organizations with horizontal links	Percentage
Low	6	0	0 %
Medium	51	6	12 %
High	32	4	13 %

Table 14

From the results it is clear that competitor cooperation in general is quite low, just above 10 percent. Yet the relation between R&D capability and competitor cooperation presented is the other way around, contradicting the hypothesis. It increases with more R&D capability, though the difference between the medium and high R&D capability categories is only 1 percent. The results do not support for hypothesis 1.2b.

R&D capability and institutional cooperation

The third hypothesis (1.2c) states that organizations with higher R&D capability form more institutional cooperative links, cooperating more with publicly funded organizations. For the analysis the collective of organizations within each R&D capability category are compared to the amount of institutional cooperative links they formed. Table 15 presents the results.

R&D capability and institutional links

R&D capability	Institutional links formed	Other links formed
Low	31 %	69 %
Medium	35 %	65 %
High	39 %	61 %

Table 15

The table indicates that institutional links increase with R&D capability. The difference between the lowest and highest category amounts to 8 percent in total. The percentage increases by 4 percent with each category. The results support hypothesis 1.2c.

R&D capability and cooperation in general

The final hypothesis (1.2d) states the organizations with high technological capital join more cooperative projects. For the analysis the collective of organizations within each R&D capability category are compared to the average amount of projects participated in and cooperative links formed. Table 16 presents the results of the analysis.

Values for R&D capability

R&D capability	Amount of org.	Percentage of total	Projects total	Projects per org. average
Low	7	6 %	13	1,86
Medium	62	51 %	119	1,92
High	53	43 %	198	3,74

Table 16

The results indicate that amount of cooperative links formed increases with the R&D capability. Organizations in the category high R&D capability cooperate most on average. This supports hypothesis 1.2d. Also, the data in appendix 2 shows seven out of the top ten most active organizations being of the high R&D capability category.

Combining all results of the analysis of the influence of technological capital on cooperation, hypotheses 1.2c and 1.2d are supported, 1.2a is partially supported and 1.2c is rejected.

4.1.3) Funding type and cooperation

Hypotheses 1.3 states that government funded organizations join more cooperative projects initiated than private organizations do. For the analysis the collective of organizations within each type are compared to the amount of projects participated in. Table 17 presents the results for the analysis of the amount of initiated projects joined by public and private type organizations.

Public vs. private actor involvement

Organization types		Total projects joined (organizations * projects joined)	
Public	**33 (27%)**	Public	**128 (40%)**
Private	**90 (73%)**	Private	**192 (60%)**

Table 17

The results indicate that from all organizations that have joined cooperative projects initiated over the time frame just over a quarter were publicly funded, the others were privately funded. The second column of the table indicates that 40 percent of organizations joining an initiated project were publicly funded. These values show that while there were fewer different public organizations than private active in the cooperative projects during the time frame, on average these public organizations were more active and participated in more projects initiated. The results support hypothesis 1.3.

4.2) DYADIC ORGANIZATIONAL CHARACTERISTICS RESULTS

4.2.1) Complementarities and formation of cooperation links

Hypothesis 2.1 states that organizations offering complementary products/services are more likely to cooperate. For the analysis cooperation partners were compared on complementary values using the cross-table. The results are given in Table 18. The figures represent the amount of organizations that on at least one occasion cooperated with a complementary organization. Only private organizations were taken into account.

Organizations forming complementary cooperation links

Complementary Cooperation	Organizations (Private)	
Yes	59	(66 %)
No	31	(34 %)
Total	90	(100 %)

Table 18

From the results it is clear that a significant part of the private organizations engaged in cooperation with complementary organizations. About two thirds of the private organizations cooperated at least one time with a complementary organization. A good example in this case are Hexion/Hygear (producer of hydrogen production equipment) and Nedstack, (producer of fuel cells) which are involved in multiple project with another, often also with an energy production company, which in turn complements these organizations too. The results support hypothesis 2.1.

4.2.2) Market overlap and formation of cooperative links

Hypothesis 2.2 states that organizations targeting with overlapping markets are less likely to cooperate. Looking back, Table 14 presented the results on horizontal cooperative link forming, e.g. cooperation between competing organizations with overlapping markets.

Those results indicated that on average, just over 12 percent of the organizations participating in projects over the time frame formed cooperative links with competitors. Keeping those results in mind, for the analysis of market overlap analysis organizations were compared on their targeted markets. Table 19 presents the results on the analysis of the influence of market overlap on cooperative link forming.

Organizations forming links with market overlap

Market overlap	Organizations (Private)	
High	9	(10 %)
medium	12	(13 %)
Low-none	69	(77 %)

Table 19

The figures are similar to those on horizontal cooperation. Just 10 percent of the organizations cooperated with an organization targeting the same market in at least one project. Also, considering that the ‘medium overlap’ category indicates only partial overlap of markets – which could also be exemplified as adjacent markets, thus being a form of complementary cooperation – it is clear that organizations with increasing market overlap formed less cooperative links during the time frame. The results support hypothesis 2.2.

Chapter 5: Limitations, conclusions and recommendations

Final remarks on the results of the research

In the final chapter the limitations and conclusions of the research are discussed. The implications of the research are detailed along with the conclusions. Finally, some recommendations are made for further research.

6.1) LIMITATIONS OF THE RESEARCH AND ANALYSES

The main limitation of the research is the fact that it focuses on a single case. That case centers on hydrogen technology, high-tech research on a technology still in a pre-commercial phase. The R&D on hydrogen is still very much of an explorative nature. This limits the research's implications to cooperation on technologies in the explorative phase. The cognitive distance theory is also more appropriable to these types of technologies than exploitative.

As a result of this emphasis on explorative R&D most organizations involved possess a high amount of technological capital to cope with the technical difficulties of R&D. The technology and research involved in hydrogen development is of a high-tech nature. Organizations with low technological capital have no other option than to cooperate with high amounts of technological capital, less they are able to cope with the complicated nature of this specific technology. Medium and high R&D capability categories by far outnumber low R&D capability in the research. This makes it difficult to effectively assess the activity of low R&D capability on cooperation.

Nooteboom (2006) analyzed the effect of R&D on absorptive capacity. However the results from this analysis were under discussion in that paper. While R&D may increase absorptive capacity and the level of novelty value, the research yielded clear evidence that it reduces the effect of cognitive distance on novelty value. In other words, it lowers the slope of the line for novelty value in Figure 2. There are still uncertainties on the theory of cognitive distance itself.

For the analysis of the influence of technological capital, three different R&D capability categories were used as indicators. The selection of the R&D capability category for an organization was based on the identified organization type. Due to limitations in data availability information on patents was deemed too difficult too obtain, as was absolute knowledge on R&D expenditures as percentages of revenues. Information on both alternative options would be more reliable than the indicator used in this research. The same applies to the analysis of the influence of size, though the categories for that characteristic were based on absolute values rather than the more normative selection used for R&D capability. The same applies to figures for market overlap and complementarities, both normative characteristics. A more specific method of assessment could yield more reliable results.

6.2) *CONCLUSIONS AND IMPLICATIONS*

In this research the relation between distinguished types of organizational characteristics and the participation by organizations in initiated cooperative projects has been analyzed. Two theories were used as a scientific basis for this research. These were the research-based view and, as separate expansion of this theory, the cognitive distance theory. Using the theories, two groups of organizational characteristics were distinguished: single and dyadic. The two groups culminated into two conceptual models each with their own set of relations and associated hypotheses. Out of the five distinguished characteristics of theoretical influence, four were supported through the analyses. The organizational characteristics that have been identified as influential are size and funding type from the single organizational group; with size being of positive influence and publicly funded organizations joining more initiated projects. From the dyadic organizational characteristics complementarities and market overlap were supported as influential; with complementarities being of positive and market overlap of negative influence.

Results on the analysis of the influence of the single organizational characteristic 'technological capital' were mixed. From the four hypotheses relating to this characteristic, two were supported, one was partially rejected and one fully rejected. The results indicated that organizations with more technological capital participated in more initiated projects and formed more institutional links. However, the results did not reject horizontal cooperation for organization with larger amounts of technological capital. The results also showed evidence that organizations with less technological capital had formed more cooperative links with organizations with more technological capital than those organizations with more technological capital had done, thereby partially rejecting the associated hypothesis. While these results do not completely reject the technological capital relations hypothesized in the theory, they are too ambiguous to provide adequate support.

The research has the following implications. From the data on hydrogen/oriented projects it is clear the amount of projects has decreased the last years. If hydrogen technology is to become commercially viable more interest is needed. Considering the move to European environment policies affecting national law, the EU may play an increasing part in the encouraging of organizations to execute hydrogen/oriented research. Considering the positive influence of cooperation, which can also deal with the complexities associated with the necessity of the systemic approach for hydrogen implementation, cooperation should be empathized. Cooperation is a good method of bringing together the right combination of resources. Organizations are limited by their size when choosing to join more cooperative projects, thus need to select the project which is expected to deliver most benefit. Cooperation forms a good alternative to more expensive ways of obtaining knowledge resources. As publicly funded organizations cooperate more these may form the most optimal alternative, when considering possible information leaks to project partners. Large cognitive distance limits organizations understanding, yet it also yields more novelty value. High novelty values in projects on technology still in the explorative phase, like hydrogen, may be beneficial to innovative success. Organizations may be encouraged to cooperate with partners with at a larger cognitive to achieve these high novelty values which positively affect hydrogen innovation.

6.3) *RECOMMENDATIONS*

While this research has provided insight in the dynamics and influential organizational characteristics of the initiation of cooperative projects, new questions have arisen. First question is whether or not the results are appropriable to cooperative projects on an exploitative basis. As the cognitive distance theory centers on explorative rather than exploitative technology further research may be needed.

One of the most important subjects in this research concerned the effects of spillovers. And while a method was formulated in this research to identify influence of spillovers on the forming of cooperative links, additional research can help to further explain the concept. In this research the different externalities of technological capital and relation to the concept of spillovers concerning technological capital were split into different hypotheses. This is a limited method as it is difficult to assess the value of each of the separate hypotheses. Two hypotheses got rejected but how far did this rule out the whole concept of technological capital having influence on cooperation? Future research may focus on developing a more thorough method to assess the influence of technological capital and how spillovers are related to this characteristic.

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Appendix 1: List of actors

Dutch Actors (2001)	No. Projects involved	Actor type	Size	Complementary co-operation	Competitor co-operation	R&D activity
ECN	35	Research institution	large	N/A	N/A	High
TNO	19	Research institution	large	N/A	N/A	High
Hoek Loos / Linde Gas Benelux	16	Scale-intensive firm	large	Yes	Yes	Medium
Shell Hydrogen b.v.	15	Scale-intensive firm	large	Yes	No	Medium
Hexion/HyGear	14	Science-based firm	large	Yes	No	High
TU Delft	13	University	large	N/A	N/A	High
Air products	11	Specialized supplier	large	Yes	No	High
Nedstack Holding b.v.	11	Science-based firm	medium	Yes	No	High
universiteit twente	9	University	large	N/A	N/A	High
Gasunie	8	Scale-intensive firm	large	Yes	Yes	Medium
RU Groningen	7	University	large	N/A	N/A	High
NUON	6	Scale-intensive firm	large	Yes	No	Medium
Sparqle	6	Science-based firm	small	Yes	Yes	High
Joint Research Centre	5	Research institution	medium	N/A	N/A	High
Stichting Energy Valley	5	Intermediary	medium	N/A	N/A	Medium
Wageningen UR	5	University	large	N/A	N/A	High
Agrotechnology and Food Innovations (Voormalig ATO bv)	4	Research institution	small	N/A	N/A	High
CEA	4	Information-intensive firm	small	Yes	No	Medium
Havenbedrijf Rotterdam	4	Suppier-dominated firm	large	No	No	Low
VU Amsterdam	4	University	large	N/A	N/A	High
Altran Technologies b.v.	3	Information-intensive firm	large	No	No	Medium
Ballast Nedam	3	Suppier-dominated firm	large	No	No	Low
BTG Biomass technology group b.v.	3	Science-based firm	small	Yes	No	High
E.on	3	Scale-intensive firm	large	Yes	Yes	Medium
Tebodin Consultants	3	Information-intensive firm	large	No	No	N/A
Universiteit Leiden (LIC)	3	University	large	N/A	N/A	High
Universiteit Utrecht	3	University	large	N/A	N/A	High
Vaillant	3	Science-based firm	large	Yes	No	High
Delta N.V.	2	Information-intensive firm	large	No	No	Medium
Eneco	2	Scale-intensive firm	large	Yes	Yes	Medium
Essent	2	Scale-intensive firm	large	Yes	No	Medium
Europe's energy point	2	Information-intensive firm	micro	Yes	No	Medium
Gemeente Almere	2	Other/Unknown	N/A	N/A	N/A	N/A
GVB Amsterdam	2	Suppier-dominated firm	large	Yes	No	Low
HAN (Kenniscentrum voor Economie, Techniek en Informatica)	2	Research institution	medium	N/A	N/A	High
HGP International	2	Other/Unknown	N/A	N/A	N/A	N/A
Promikron b.v.	2	Science-based firm	small	Yes	No	High
Prov. Zeeland Directie RMW	2	Other/Unknown	N/A	N/A	N/A	N/A
SENSE	2	University	medium	N/A	N/A	High
Stork Product Engineering B.V.	2	Specialized supplier	large	Yes	No	High

Technogrow b.v.	2	Science-based firm	small	Yes	No	High
TU Eindhoven	2	University	large	N/A	N/A	High
Adjuvant b.v.	1	Information-intensive firm	small	No	No	Medium
Advanced lightweight engineering b.v.	1	Specialized supplier	small	No	No	High
Agromiscanthus b.v.	1	Information-intensive firm	micro	Yes	No	Medium
Airborne development b.v.	1	Specialized supplier	medium	No	No	High
Akzo Nobel Chemicals	1	Scale-intensive firm	large	No	No	Medium
Alphatron boost cap	1	Suppier-dominated firm	large	Yes	No	Low
Altlas Copco	1	Specialized supplier	medium	Yes	No	High
Arnhem's Ondernemerscentrum	1	Other/Unknown	N/A	N/A	N/A	N/A
b.v. Duynie	1	Scale-intensive firm	medium	No	No	Medium
Biohydrogen platform	1	Intermediary	N/A	N/A	N/A	Medium
Bradford instruments b.v.	1	Science-based firm	medium	Yes	No	High
Brandweer Amsterdam/Rotterdam	1	Other/Unknown	N/A	N/A	N/A	N/A
Cogen Nederland	1	Intermediary	small	N/A	N/A	Medium
Connexxion n.v.	1	Suppier-dominated firm	large	Yes	No	Low
Continental engineering b.v.	1	Information-intensive firm	small	No	No	Medium
DAF Trucks n.v.	1	Scale-intensive firm	large	No	No	Medium
De Straat Milieuadviseurs b.v.	1	Information-intensive firm	N/A	Yes	No	Medium
DenOudsten bussen	1	Scale-intensive firm	N/A	Yes	No	Medium
Denso Europe b.v.	1	Specialized supplier	large	No	No	High
DutCH4	1	Information-intensive firm	micro	Yes	No	Medium
Duurzaamheidscentrum Lauwersoog	1	Intermediary	N/A	N/A	N/A	Medium
DWA instalatie- en energieadvies	1	Information-intensive firm	large	Yes	No	Medium
ECO Ceramics	1	Specialized supplier	small	Yes	No	High
Ecofys	1	Information-intensive firm	large	Yes	No	Medium
Eglem Karts	1	Scale-intensive firm	small	Yes	No	Medium
Eigenaren Vereniging de Stoere Houtman	1	Other/Unknown	N/A	N/A	N/A	N/A
electrabel s.a.	1	Scale-intensive firm	large	Yes	No	Medium
energieprojecten.com	1	Information-intensive firm	micro	No	No	Medium
ENGVA	1	Intermediary	large	N/A	N/A	Medium
Epyon	1	Science-based firm	small	No	No	High
Formula Zero b.v.	1	Science-based firm	micro	Yes	No	High
Gemeente Amsterdam	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Apeldoorn	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Arnhem	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Leeuwarden	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Texel	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Utrecht	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Wageningen	1	Other/Unknown	N/A	N/A	N/A	N/A
Gemeente Westland	1	Other/Unknown	N/A	N/A	N/A	N/A
Green Vision Holding	1	Research institution	small	N/A	N/A	High
Grontmij b.v.	1	Information-intensive firm	large	Yes	No	Medium
Idbike	1	Science-based firm	micro	Yes	No	High
Imtech marine offshore	1	Specialized supplier	large	No	No	High
Innovatienetwerk Groene Ruimte en Agrocluster	1	Intermediary	small	N/A	N/A	Medium
Innovation Support and Partners	1	Information-intensive firm	small	No	No	Medium

Innovative Concepts Publishers	1	Information-intensive firm	N/A	No	No	Medium
Interpolis	1	Information-intensive firm	large	No	Yes	Medium
KEMA Nederland b.v.	1	Information-intensive firm	large	No	No	Medium
Kiwa Gastec	1	Information-intensive firm	large	Yes	No	Medium
Koninklijke Marine	1	Other/Unknown	N/A	N/A	N/A	N/A
Koninklijke VolkerWessels	1	Scale intensive	large	No	No	Low
Lettinga associates foundation	1	Research institution	small	N/A	N/A	High
LTO Groeiservice	1	Intermediary	small	N/A	N/A	Medium
Magneto-Special Anodes b.v.	1	Specialized supplier	small	Yes	No	High
MAN Truck & Bus company b.v.	1	Scale-intensive firm	medium	Yes	No	Medium
McDonalds	1	Scale-intensive firm	large	No	No	Medium
mediamission	1	Information-intensive firm		No	No	Medium
Methanor	1	Specialized supplier	N/A	Yes	No	High
Milieufederatie Flevoland	1	Intermediary	small	N/A	N/A	Medium
Ministerie LNV	1	Other/Unknown	N/A	N/A	N/A	N/A
Nationale Nederlanden	1	Information-intensive firm	large	No	Yes	Medium
NCP	1	Research institution	N/A	N/A	N/A	High
Nederlands instituut voor visserijonderzoek b.v. (RIVO - WUR)	1	Research institution	small	N/A	N/A	High
Nefit b.v.	1	Science-based firm	large	Yes	Yes	High
NEN	1	Information-intensive firm	medium	Yes	No	Medium
Nexus Global	1	Specialized supplier	medium	Yes	No	High
NIBRA	1	Research institution	medium	N/A	N/A	High
North refinery	1	Scale-intensive firm	medium	Yes	No	Medium
NPSP Composieten b.v.	1	Specialized supplier	small	Yes	No	High
Ocap co2 vof	1	Science-based firm	micro	Yes	No	High
Overveld Coating	1	Scale-intensive firm	medium	Yes	No	Medium
Paques b.v.	1	Science-based firm	small	Yes	No	High
Partners for innovation	1	Information-intensive firm	micro	Yes	No	Medium
Pipelife Nederland	1	Scale-intensive firm	large	Yes	No	Medium
PNO consultants	1	Information-intensive firm	medium	No	No	Medium
Procede group b.v.	1	Science-based firm	small	Yes	No	High
Profactus	1	Scale-intensive firm	small	Yes	No	Medium
Prov. Gelderland	1	Other/Unknown	N/A	N/A	N/A	N/A
Prov. Limburg	1	Other/Unknown	N/A	N/A	N/A	N/A
Provalor b.v.	1	Science-based firm	micro	Yes	Yes	High
rai vereniging	1	Intermediary	N/A	N/A	N/A	Medium
Remeha b.v.	1	Science-based firm	large	Yes	Yes	High
Rondvaart Delft	1	Suppier-dominated firm	small	No	No	Low
Royal Haskoning	1	Information-intensive firm	large	No	No	Medium
RU Nijmegen	1	University	N/A	N/A	N/A	High
Soldesa Hydrogen	1	Science-based firm	N/A	Yes	No	High
Sparta	1	Scale-intensive firm	medium	Yes	No	Medium
Spijkstaal	1	Scale-intensive firm	medium	No	No	Medium
Springtime	1	Information-intensive firm	micro	No	No	Medium
Stichting Duurzaam Texel	1	Intermediary	small	N/A	N/A	Medium
Stichting Nederland Kennisland	1	Intermediary	small	N/A	N/A	Medium
Susebeek Technical Consultants	1	Information-intensive firm	small	Yes	No	Medium
Syncera	1	Information-intensive firm	large	Yes	No	Medium

Techno Invent b.v.	1	Science-based firm	micro	Yes	No	High
Universiteit van Amsterdam	1	University	N/A	N/A	N/A	High
van Hoeven Consult	1	Information-intensive firm	N/A	No	No	Medium
van Vliet recycling	1	Scale-intensive firm	small	No	No	Medium
VNSI	1	Intermediary	small	N/A	N/A	Medium
Webasto	1	Science-based firm	large	Yes	No	High

Appendix 2: List of Projects with Dutch actors involved

Acronym	**Project name**	Starting date	Ending date	Actors involved
	Met Methanol van biomassa naar biomobiel	jan-01		HGP International, Profactus, North refinery, Methanor, Soldesa Hydrogen, GVB Amsterdam, Hoek loos
CPS2FCS	**Critical paths to fuel cells (CPS2FCS)**	jan-01	jul-01	European Natural Gas Vehicle Association (ENGVA), MVV Consultants & Engineers GMBH (DU)
EIHP2	**European integrated hydrogen project - phase ii (EIHP2)**	feb-01	feb-04	Ecn - commission of the european communities, air liquide s.a (fr), l-b-systemtechnik gmbh (du) (coordinator), air products plc (uk), forschungszentrum karlsruhe gmbh (du), adam opel ag (du), bp p.l.c. (uk), daimlerchrysler ag (du), stuart energy europe nv (be), linde ag (Hoek Loos) (du), shell research ltd (uk), norsk hydro asa (no), messer griesheim gmbh industriegase deutschland (du), instituto nacional de tecnica aeroespacial esteban terradas (sp), ford werke ag (du), commissariat a l'energie atomique (fr), bmw (du), det norske veritas a/s (no), volvo technology (corporation) (sw), raufoss a/s (no), national centre for scientific research 'demokritos' (dr)
ECTOS	**Ecological city transport system. demonstration, evaluation and research project of hydrogen fuel cell bus transportation system of the future (ECTOS)**	mrt-01	sep-05	Shell hydrogen b.v. , iceland new energy ltd, university of iceland,, technological institute of iceland, straeto bs, raesir hf., skeljungur ltd (IC), swedish agency for innovation systems (sw), universitaet stuttgart (du), evobus gmbh (du), norsk hydro asa (no)
	Koolmonoxideverwijdering uit waterstofrijke mengsels	mrt-01	mrt-03	TNO-MEP, Nedstack B.V.
	PEM brandstofcelsysteem voor publiek transport	mrt-01	sep-02	ECN, NedStack fuel cell Technology B.V. (penvoerder), Stork Product Engineering B.V., DenOudsten Bussen

INVESTIRE NETWORK	**Investigation on Storage Technologies for Intermittent Renewable Energies**	mei-01	nov-03	ECN, TNO-MEP, Universiteit Utrecht (Copernicus Institute), Sorapec s.a., rbc, association pour la recherche et le developpement des methodes et processus industriels, compagnie europeenne des accumulateurs s.a., hawker sa, commissariat a l'energie atomique (fr), council for the central laboratory of the research councils, it power ltd. (uk), research institute for electrical engineering (ro), institut fuer energie- und umweltforschung heidelberg gmbh, accumulatorenfabrik sonnenschein gmbh, institut fuer solare energieversorgungstechnik e.v., center for solar energy and hydrogen research baden-würtemberg, wirtschaft und infrastruktur gmbh & co planungs kg, forschungsgesellschaft kraftfahrwesen mbh aachen, fraunhofer-gesellschaft zur foerderung der angewandten forschung e.v. (du), germanos sa, centre for renewable energy sources (gr), commission of the european communities (it), dynatex sa (su), risoe national laboratory (dm), sea tudor - sociedad espanola del acumulador s.a., alternativas c.m.r.s.l.(sp), tadiran batteries limited (is), european photovoltaic industry association (be), catella generics ab (sw).
	Waterstof in wageningen	mei-01	dec-02	Gemeente Wageningen (coordinator), ATO b.v. (agrotechnisch onderzoeksinstituut) , CEA
ZEM	**Zero-hazard gas storage by multisensing optical monitoring system**	okt-01	jan-05	Airborne development b.v., centro ricerche fiat s.c.p.a. (it)(coordinator), smartec sa (su), sgs-tuev saarland gmbh (du), ullit sa (fr), university of strathclyde (uk)
VG2	**Vergroening van gas**	okt-01	dec-06	TU Delft (Sectie Energie en Industrie,OCP; WTB; TBM (penvoerder), ECO Ceramics bv, energy +i.d., Electrabel Nederland, Havenbedrijf Rotterdam, Hoek Loos, RU Groningen (Fysische Chemie, Laboratory for high Temperatur Gas Kinetics), TU Eindhoven (Schouten Research)
CUTE	**Clean Urban Transport for Europe (Amsterdam) brandstofcelbussen**	nov-01	jun-06	GVB, Gemeente Amsterdam (Dienst Milieu en Bouwtoezicht (DMB)),Hoek Loos, NUON, Shell Hydrogen, EvoBus
	Waterstof in brandweerbranche en verzekeringswezen	nov-01	dec-01	CEA (penvoerder), Nederlands Instituut voor Brandweer en Rampenbestrijding (NIBRA), Koninklijke Belgische Brandweer Federatie (KBBF),

				Brandweer Rotterdam/Amsterdam, Nationale Nederlanden, Interpolis, Nationaal Centrum Preventie (NCP)
FRESCO	**European development of a fuel-cell, reduced-emission scooter**	dec-01	aug-05	ECN, Selin sistemi spa, university of florence, università degli studi di pisa (it), electrochemical power sources stock company, esma joint stock company (ru), commissariat a l'energie atomique (fr)
SUPERHYDROGEN	**Biomass and waste conversion in supercritical water for the production of renewable hydrogen**	dec-01	dec-05	BTG Biomass technology group bv (coordinator), tno-mep, Universiteit twente (Industrial Polymerization processes), sparqle international b.v., dytech corporation ltd., university of warwick (uk), uhde hochdrucktechnik gmbh (du),
Stairway to Hydrogen	cost-effective production of hydrogen from biomass	jan-02		biohydrogen platform, WUR (ATO b.v.)(coordinator), NTUA Athens, BUTE budapest, JATE BRC Szeged, Air liquide sassenage, INSA Toulouse, University of Freiburg, Enitecnologie, CIEMAT, University of Glamorgan,
HYNET	**Hynet - European Hydrogen energy thematic network**	jan-02	jan-05	Shell hydrogen b.v., Technischer ueberwachungsverein nord e. V., bmw, messer griesheim gmbh industriegase deutschland, tuev sueddeutschland bau- und betrieb gmbh, linde ag (Hoek Loos), l-b-systemtechnik gmbh (du), consejo superior de investigaciones cientificas (sp), raufoss a/s, norsk hydro asa (no), stuart energy europe nv (be), bp international limited (uk), ernst & young association management s.a. (be),
FEBUSS	**Fuel cell energy systems standardised for large transport, busses and stationary applications**	jan-02	jan-07	institute for Energy (JRC), irisbus france s.a., axane fuel cell systems, centre national de la recherche scientifique ensieg, universite joseph fourier - grenoble 1ensieg, centre national de la recherche scientifique, schneider electric industries sas, institut national de l'environnement industriel et des risques, alstom transport s.a., institut national polytechnique de grenoble, institut national polytechnique de toulouse, air liquide s.a (fr)(coordinator), instituto nacional de tecnica aeroespacial esteban terradas (sp), sgl technologies gmbh, sgs-tuev saarland gmbh (du), ineos chlor (fr), johnson matthey plc (uk)

ACCEPT	**Ammonia craking for clean electric power technology**	jan-02	jul-05	Advanced lightweight engineering bv, ECN, vito (be) (coordinator), università degli studi di roma tor vergata (it), risoe national laboratory (dm), dfg-energie, institute fuer energie, oekologie und oekonomie (du), graz university of technology, agrolinz melemin gmbh (au)
EURO-HYPORT	**Feasibility study for export of hydrogen from iceland to the european continent (EURO-HYPORT)**	jan-02	jul-03	Shell hydrogen b.v. ,iceland new energy ltd, university of iceland, icelandic national power company (ic), norsk hydro asa (no), hamburgische elektrizitaets-werke ag (du),
WINEGAS	**Hydrogen ruel gas from supercritical water gasification of wine grape residues and wet rest-biomass (WINEGAS)**	jan-02	jan-03	Sparqle international b.v., promikron bv, biomass technology group bv (BTG), winzerkeller wiesloch eg, feluwa pumpen gmbh, forschungszentrum karlsruhe gmbh - technik und umwelt (du) (coordinator), callaghan engineering ltd. (ir)
	Waterstof als brandstof voor lokaal transport en microwarmte/kracht	mrt-02	mrt-03	ECN (penvoerder), Eneco, E.on benelux, Havenbedrijf Rotterdam HGP, Hoek Loos, Tebodin.
FCSHIP	**Fuel cell technology in ships**	mrt-02	mrt-04	TU Delft Industrieel design, TNO-MEP.Det norske veritas a/s, knutsen oas shipping as, norsk hydro asa, norwegian shipowners association (no)(coordinator), rina spa, color line marine as, norwegian marine technology research institute, fincantieri - cantieri navali italiani spa, university of genova, ansaldo fuel cells s.p.a., d'appolonia s.p.a.(it), university of applied sciences hamburg, mtu friedrichshafen gmbh, l-b-systemtechnik gmbh, germanischer lloyd ag (du), university of strathclyde, lloyd's register of shipping, technology and medicine (uk), waertsilae corporation oy (fi)
CERHYSEP	**Ceramic membranes for hydrogen separation**	mrt-02	feb-06	SHELL RTCA (coordinator), ECN energie efficiency, Universiteit Twente (MESA+ (Inorganic Material Science)), Foundation for technical and industrial research at the norwegian institute of technology, university of oslo (no), centre for research and technology hellas, ceramics and refractories technological development company s.a. (gr), university of the western cape (sa), gkss, membraflow gmbh & co kg filtersysteme (du) (bron2)
	Superschoon	sep-02	jun-04	TNO MEP, Sparqle

REVCELL	**Autonomous energy supply system with reversible fuel cell as long-term storage for pv stand-alone systems and uninterruptible power supplies**	okt-02	okt-06	ECN Schoon fossiel, Nedstack fuel cell components bv, nedstack fuel cell technology bv, hynergreen technologies sa, chloride espana, instalaciones inabensa, s.a (sp) (coordinator), universitaet duisburg-essen, fraunhofer-gesellschaft zur foerderung der angewandten forschung e.v. (du), stockholm universitet
CAFUCEL	**Development of a newly designed capillary fuel cell**	okt-02	jan-05	TNO Industrie, University of newcastle upon tyne, 2s sophisticated systems limited (uk)(coordinator), lantec computer systems gmbh, heggemann flugzeugteile gmbh, fraunhofer-gesellschaft zur foerderung der angewandten forschung e.v. (du)
OPTIMERECELL	**OPTIMERECELL**	nov-02	nov-05	Nedstack fuel cell technology bv, nedstack fuel cell components bv, ruecker iberica sl, fundacion inasmet - asociacion de investigation metalurgica del pais vasco (sp) (coordinator), research and technology centre - brussels centre (be), gencoa ltd (uk), centro ricerche fiat s.c.p.a.(it), german aerospace centre, ikarus coatings gmbh (du), commissariat a l'energie atomique (fr),
BIO-Electricity	**Efficient and clean production of electricity from biomass via pyrolyses oil and hydrogen utilizing fuel cells - target action g**	dec-02	dec-05	Universiteit Twente (Catalycs Processes and Materials CPM, Thermo Chemical Conversion of Biomass TCCB) , Institut De Recherches Sur La Catalyse (Fr), The Queen's University Of Belfast (Uk), Italian Agency For New Technology, Energy And The Environment (It), University Of Patras (Gr), Ansaldo Ricerche Srl (It), Johnson Matthey Plc (Uk)
RENEWABLE-H2	**Integration of renewable hydrogen into the hydrogen economy - target action i**	dec-02	okt-03	Biomass Technology Group Bv (BTG) (Coordinator), Norsk Hydro Asa (No), Uppsala University (Sw)
NFCCPP	**Numerical fuel cell component performance prediction**	jan-03	jan-06	Denso europe b.v., avl list gmbh (au)(coordinator), aachen university of technology, liebherr aerospace lindenberg gmbh, pierburg a.g, forschungsgesellschaft kraftfahrwesen mbh aachen, fev motorentechnik gmbh (du), royal institute of technology (sw), european association of automotive suppliers (be), mira limited, johnson matthey plc, intelligent energy ltd (uk), energocontrol sp z.o.o (pl)

	Virtuele Kracht Centrale	jan-03	jan-05	Vaillant, E.on, Gasunie, Plugpower, Cogen Europe, EWE, Universiteit Essen, Solarzentrum, Ruhrgas (DU), universiteit Lissabon, Sistemas de Calor (SP)
BIOFEAT	**Biodiesel fuel processor for a fuel cell auxiliary power unit for a vehicle**	jan-03	jan-06	ECN (schoon fossiel), Politecnico di torino, centro ricerche fiat s.c.p.a. (it), johnson matthey plc (uk), scandiuzzi s.r.l (it), bekaert vds nv (be)
SOFCNET	**Thematic network on solid oxide fuel cell technology (SOFCNET)**	jan-03	jan-06	Ecn schoon fossiel (coordinator), universiteit twente chemie, shell hydrogen b.v., imperial college of science, technology and medicine, alstom power uk ltd., adelan ltd, commissariat a l'energie atomique, rolls royce plc, university of st andrews (uk), gaz de france, electricite de france, centre de recherches pour l'environnement l'energie et le déchet - gie, valeo climatisation sa, centre national de la recherche scientifique (fr), foundation of research and technology hellas, university of patras (gr), siemens ag, universitaet karlsruhe, bmw, vdi, forschungszentrum juelich gmbh, technical university of munich, h.c. Starck gmbh and co. Kg, university of applied sciences hamburg, german aerospace centre, e.on energie ag, landeshauptstadt duesseldorf, rwe plus aktiengesellschaft, fraunhofer-gesellschaft zur foerderung der angewandten forschung e.v. (du), swiss federal institute of technology, sulzer markets and technology ag, sulzer , swiss federal laboratories for materials (su), the austrian energy agency, intema consult marketing dienstleistungs (au), tractebel sa (be), prototech as (no), institut francais du petrole (fr), delphi automotive systems luxembourg sa, university of aveiro (po), technical research centre of finland, waertsilae corporation oy (fi), university of sherbrooke (ca), risoe national laboratory (dm)

AFTUR	**Alternative fuels for industrial gas turbines**	jan-03	jul-06	Universiteit Twente (WT),Cranfield university, university of manchester institute of science and technology, qinetiq limited, alstom power uk ltd. , aea technology plc , aea technology plc (uk), auxitrol sa, turbomeca sa institut francais du petrole, universite de rouen - haute normandie, institut national des sciences appliquees de rouen, centre national de la recherche scientifique (fr)(coordinator), agricultural university of athens (gr), nuovo pignone spa, universita degli studi di roma tre , national research council of italy , area science park (it), universidade de beira interior , instituto superior tecnico (po), tps termiska processer ab, lund university (sw), universidad de zaragoza (sp),
FCTESTNET	**FCTESTNET**	jan-03	dec-05	ECN, Innovation Support and Partners, KEMA Nederland b.v., NEDSTACK FCT, TNO-WT, Fraunhofer-gesellschaft zur foerderung der angewandten forschung e.v, forschungszentrum juelich gmbh, ballard power systems ag, german aerospace centre, germanischer lloyd ag, university of applied sciences hamburg, center for solar energy and hydrogen research, enbw enegie baden-wuerttemberg ag, universitaet karlsruhe, mtu friedrichshafen gmbh, echem kompetenzzentrum fuer angewandte elektrochemie gmbh, reinz-dichtungs gmbh, aachen university of technology, fev motorentechnik gmbh, dornier gmbh, gkss - forschungszentrum geesthacht gmbh, digatron industrie-elektronik gmbh, vdi - the association of engineering (du), imperial college of science, intelligent energy ltd, lloyd's register of shipping, technology and medicine (uk), centro de investigaciones energeticas, mediambientales y tecnologicas, instituto nacional de tecnica aeroespacial esteban terradas, consejo superior de investigaciones cientificas (sp), association pour la recherche et le developpement des methodes et processus industriels, institut national de recherche sur les transports et leur sécurité, commissariat a l'energie atomique, alphea, ecole nationale supérieure de

				chimie de paris, universite de technologie de belfort-montbeliard, entre national de la recherche scientifique (fr), instituto superior tecnico, institute of mechanical engineering and industrial mangement (pu), cesi, c.r.f. - societa consortile per azioni, universita degli studi di perugia, ansaldo fuel cells s.p.a., national research council of italy (it), royal institute of technology, catella generics ab (sw), delphi automotive systems luxembourg sa (lu), european association of automotive suppliers, vito - vlaamse instelling voor technologisch onderzoek nv, universite de liege (be), centre for renewable energy sources (gr), paul scherrer institut, swiss federal institute of technology lausanne (su), technical research centre of finland (fi), avl list gmbh (au),
	Duurzaam Schiermonnikoog	jan-03		Gasunie (Engineering and Technology), Eneco netbeheer, energy valley
	Friese coalitie MiniWKK	jan-03	nov-04	Essent (penvoerder), Gemeente leeuwarden, Energy Valley
50 PEM-HEAP	**50 Kw Pem Fuel Cell Generator For Chp And Ups Applications**	feb-03	mei-06	ECN,IRD fuel cell a/s (dm)(coordinator), sgl technologies gmbh, hgc hamburg gas consult gmbh (du), gutor electronic ltd.(su), johnson matthey plc (uk),
HYSOCIETY	**Target Action A - The European Hydrogen Based Society (Hysociety)**	feb-03	feb-05	Ecn, instituto superior técnico (po) (coordinator), vlaamse instelling voor technologisch onderzoek,avere, université de liège (be), national technical university of athens (gr), instituto nacional de tecnica aeroespacial (sp), sydkraft ab (sw), imperial college of science, technology and medicine (uk), fraunhofer gesellschaft zur foerderung der angewandten forschung ev, vgb powertech e.v.(du), technical research centre of finland, vtt energy (fi), sintef energiforskning as, stiftelsen rogalandsforskning (no), centre national de la recherche scientifique (fr), italian national agency for new technology, energy and the environment (it), energieverwertungsagentur, the austrian energy agency (au)
	Dealing with Uncertainties in the Transition to a Sustainable Energy System: An integrative Approach	apr-03	jan-09	TU Delft (Faculteit Techniek Bestuur en Management (TBM)), Universiteit Utrecht (Sectie Innovatiewetenschap)

	Formula Zero	jun-03		Formula Zero b.v., ECN, Springtime, TNO Automotive, Shell Hydrogen (sponsor), Ecofys, TU Delft, rai vereniging, Alphatron boost cap, Bradford engineering b.v., Eglem Karts, ESA, Euroresins, Stichting Nederland Kennisland, mediamission, NPSP Composieten b.v., Optima batteries (VS), Overveld Coating, Partners for Innovation
MIGREYD	**Modular Igcc Concepts For In-refinery Energy And Hydrogen Supply**	jun-03	jun-06	Continental engineering b.v., ECN, universitaet duisburg-essen (coordinator), siemens aktiengesellschaft (du), elcogas, s.a. (sp), instituto superior técnico (po),
	Lokaal Waterstof	jun-03		Hexion b.v. (penvoerder), Hoek Loos, ECN, Nuon
H2NE	**Hydrogen Network Enterprise**	sep-03		Adjuvant bv, Hexion, Nedstack, Arnhems ondernemerscentrum, Provincie Gelderland
	Doped Transition Metal Oxides for Photoelectrolysis	sep-03	aug-09	TU Delft (Laboratory of inorganic chemistry), Universiteit Leiden (LIC, Surface Chemistry and catalysis)
	Bioelectriciteit: Bacterien maken groene stroom	sep-03	sep-04	WUR Agrotechnology and food (ATO b.v., Stichting Lettinga Associates), Magneto-Special Anodes B.V., Paques b.v., TNO-MEP, Nuon CTM
BWP II	**Biologische Waterstofproductie II**	sep-03	jul-07	LNV (Directie Kennis) (financier), WUR (ATO b.v., Sectie Proceskunde, Laboratorium voor Microbiologie) (penvoerder), ECN, Grontmij advies & techniek bv, Grontmij Water & Reststoffen b.v., RU Groningen (Microbiele Ecologie), TNO-MEP, Green Vision, Sparqle International b.v., Agromiscanthus b.v., Techno Invent b.v., Hexion b.v., Duynie b.v., NedStack fuel cell technologie b.v., Technogrow b.v.
	Transportbrandstoffen uit bio-olie	okt-03	okt-07	RU Groningen (TLG), Universiteit Twente (TCCB)
	McDonalds Autonoom Duurzaam restaurant	okt-03		McDonalds, Altran Technologies
FULLSPECTRUM	**A new PV wave making more efficient use of the solar spectrum**	nov-03		ECN (Zonneenergie), universiteit utrecht (copernicus instituut), universidad politecnica de madrid (coordinatior), isofoton s.a., consejo superior de investigaciones cientificas, inspira sl (sp) , commissariat a l'energie atomique (fr), jrc, fraunhofer, philipps university marburg, projektgesellschaft solare energiesysteme mbh, rwe space solar power gmbh (du), imperial college of science, technology and medicine, university of glasgow (uk), ioffe physico-

				technical institute (ru), paul scherrer institut, solaronix sa (su), university of cyprus (gr)
	Waterstof Shuttle	jan-04		TU Delft, ECN, Spijkstaal, Havenbedrijf Rotterdam.
Wabest	**Waterstofbenutting in steden**	jan-04		Gemeente Almere, Air Products, Nefit, Pipelife nederland, Remeha bv, Gemeente Utrecht, CEA, Kiwa Gastec.
	Sturing van de overgang naar een waterstofeconomie: evaluatie van concurrerende waterstofstrategieën vanuit het perspectief van meerdere niveaus	jan-04		SENSE, VU-IVM (Instituut voor Milieuvraagstukken)
CORE-SOFC	**Component Reliability in Solid Oxide Fuel Cell Systems for Commercial Operation**	jan-04		ECN, Forschungszentrum Jülich (D), Risø National Laboratory (DK), Haldor Topsøe (DK) Rolls-Royce (UK)
HYTRAN	**Hydrogen and Fuel Cell Technologies for Road Transport**	jan-04	jan-09	ECN, DAF Trucks N.V. ,Volvo (coordinator), opcon autorotor ab (sw), gillet gmbh, adrop feuchtemesstechnik gmbh, daimlerchrysler ag, volkswagen ag, institut fuer mikrotechnik mainz gmbh, rheinisch-westfaelische technische hochschule aachen (du), environment park s.a., nuvera fuel cells europe srl, centro ricerche fiat, politecnico di torino (it), imperial college of science, technology and medicine, johnson matthey fuel cells ltd (uk), weidmann plastics technology ag paul scherrer, institut, (su) regienov - renault recherche et innovation (fr)
	Bijmengen van waterstof in aardgasnetwerk	jan-04		Gemeente Almere, Milieufederatie Flevoland, Nuon (Continuon).
	Brandstofcel Paleiskwartier	jan-04		Essent Infra Solutions, Gasunie (engineering and technology), Vaillant, DWA installatie- en energieadvies
	Delta als duurzame Fleetowner	jan-04		Delta Energy (penvoerder), Hexion
HyWays	**Hydrogen Energy in europe**	jan-04		ECN, Hexion, Air products, LBST (coordinator), Air Liquide, BMW, BP, DaimlerChrysler, Det Norske Veritas, Electricité de France, EHN Combustibles renovables, Nouvo Pignone, Hydro, Infraserv, Linde (Hoek Loos), Opel, Repsol, Statkraft, Stuart Energy Europe, Total, VattenFall, [institutes] Beta-ulp, CEA, ENEA, FhG ISI, imperial college of science technology and medicine, instituto

				superior técnico , ZEW.
SUPERDIESEL	**Ontwikkeling van een superkritische diesel reformer in een hybride brandstofcelsysteem**	jan-04	jan-05	Universiteit Twente (ThW), TNO (MEP), Koninklijke Marine (Het marinebedrijf), Sparqle
	Biogas uit afvalwaterzuivering & afvalstortplaatsen	feb-04	aug-04	Energieprojecten.com, COGEN Nederland
CLEAN CAR		feb-04		HAN (Kenniscentrum voor Economie, Techniek en Informatica), Hexion, Ballast Nedam
	Mechanisms of hydrogen storage in alanates: a first principles approach	feb-04	feb-08	Leiden Universiteit (LIC), TU Eindhoven(inorganic chemistry), VU amsterdam(Chemie), Shell (SRTCA, Innovation and exploratory research)
HELISAFE	**Helicopter Occupant Safety Technology Application**	mrt-04	mrt-07	TNO-automotive, TU Delft Lucht en Ruimtevaart, deutsches zentrum fuer luft und raumfahrt e.v., siemens restraint systems gmbh, eurocopter deutschland gmbh, autoflug gmbh (du)(coordinator), coventry university (uk), politecnico di milano, centro italiano ricerche aerospaziali scpa (it), eurocopter s.a.s. (fr), fundacion para la investigacion y desarrollo en automocion (sp), wytwornia sprzetu komunikacyjnego pzl-swidnik" sa" (pl)
	Atomistic Modeling of lightweight metal-hydrides	mrt-04	jan-09	Universiteit Twente (Computational Materials Science), Radbout universiteit Nijmegen (Electronic structure of materials), RU Groningen (Chemishe Fysica).
Hysafe	**Safety of hydrogen as an energy carrier**	mrt-04	mrt-09	Forschungszemtrum Karlsruhe, Air Liquide, Bundesanstalt für Materialforschung und -prüfung, BMW, Buikding Research Establishment ltd., Commisariat a lénergie atomique, Det Norske Veritas a.s., Fraunhofer Gesellschaft zur Foerderung der Angewandten Forschung e.v., Forschungszentrum Juelich, Gexcon a.s., Health and Safety Executive, Foundation INASMET, Institut national de l'Environment Industriel et des Risques, Directorate General Joint Research Centre (be), Russian Research Centre Kurchatov Institute, National Center for Scientific Research Demokritos, Norsk Hydro ASA, Risoe National Laboratory, TNO, University

				of Calgary, University of Pisa, Universidad Politecnica de Madrid, University of Ulster, Volvo, Politechnika Warszawska
StorHy	**Hydrogen storage systems for automotive application**	mrt-04	sep-08	Adete advanced engineering & technologies , Air Liquide, Austrian Aerospace, Bundesanstalt für Materialforschung und -prüfung, BMW, commissariat a l'energie atomique (fr), cidaut, comat, oerlikon, DaimlerChrysler, Dynetek, Energie Technologie, Environmental Research Laboratory, JRC, Faber Cylinders, Ford, Forschungszentrum Karlsruhe, GKSS, Ife, Institut für Verbundwerkstoffe, Linde a.g. (Hoek Loos), LMA, Magna Steyr, mt aerospace, Material s.a. (be), Öko institut e.v., Inta, Prochain, Peugeot Citroën, University of Nottingham, Volvo, Weh, Politechnika Wroclaw
	Opslag waterstof in bakpoeder	mrt-04	mei-05	Procede Group (nl), Shell Hydrogen (nl)
	Waterstof voor Limburg	apr-04		Provincie Limburg, Nuon power Buggenum
SCARLET	**SCARLET**	apr-04	dec-07	TNO-MEP (penvoerder), LTO Groeiservice, Promikron, van Vliet recycling, Urschel International, Sparqle, Hexion, Atlas Copco, Stork industry services.
NATURALHY	**NATURALHY**	mei-04	mei-09	N.V. Nederlandse Gasunie, ECN, TNO-MEP, NEN Energy resources, Shell hydrogen b.v., RU Groningen (Laboratory for high Temperatur Gas Kinetics) (en 35 buitenlandse actoren)
	Rijden op CNG in Noord-Nederland	mei-04	mei-05	Gasunie (penvoerder), Energy valley, DutCH4, RU Groningen (Wetenschapswinkel)
	Schoon gas in de wijk	jun-04		Air products, ECN, Tebodin consultants
	Waterstof transport en gebruik	jun-04		Gemeente Apeldoorn, Nuon (continuon)
	De Stoere Houtman	jun-04		Eigenaren Vereniging de Stoere Houtman, Hoek Loos, TU delft, UvA, Europe's energy Point, Gemeente Arnhem, Syncera
	Gas+ (NATURALHY spinoff)	jun-04		NV Gasunie/gasunie research (penvoerder), Hoek Loos, ECN, Air products, Hexion, TNO Industries, TU Delft,

				Stichting Energy Valley, PNO consultants
	Sensoren voor efficiënt en veilig gebruik	jun-04		NV Gasunie, ECN, Energy Valley
	Veerpont op waterstof/brandstoffen	jul-04		TNO-MEP, Imtech marine offshore, Nedstack fuel cell technology, TU Delft (scheepsnieuwbouw)
	Rondvaartboot op Waterstof	jul-04		ECN, Rondvaart Delft
ORDE-DW	**Onbalans Reductie van Duurzame Energie in de duurzame woonwijk**	jul-04	dec-06	Prov. Zeeland Directie RMW, Delta N.V., Altran Technologies BV.
ORDE-NJ	**Onbalans Reductie van Duurzame Energie op Neeltje Jans**	jul-04		Prov. Zeeland Directie RMW, Altran Technologies BV.
	Duurzame Waddenvloot	jul-04		Gasunie (Engineering and Technolgy), Royal Haskoning (Milieu), Stichting Energy Valley, RU Groningen (wetenschapswinkel)
Hycycle	**Hycycle**	aug-04	mrt-05	Hexion, Sparta, van Hoeven Consult, Hoek Loos, IDbike, ECN
NEEDS	**New Energy Externalities Development for Sustainability**	sep-04	jan-06	Ecn, ambiente italia srl, consiglio nazionale delle ricerche, cesi, fondazione eni enrico mattei, istituto nazionale per la fisica della materia, politecnico di torino, istituto di studi per l'integrazione dei sistemi (it)(coordinator), akademia gorniczo-hutnicza (pl), centre de documentation de resherche et d'experimentation sur les pollutions accidentelles des eaux, electricite de france, centre national de la resherche scientifique, observatoire mediterraneen de l'energie, helio international, universite de neuchatel, universite de paris i - sorbonne - pantheon, kanlo consultants s.a.r.l, association pour la resherche et le developpement des methodes et processus industriels (fr), centre de developpement des energies renouvelables (ma), centre for renewable energy sources, national technical university of athens, aristotle university of thesaloniki (gr), centro de investigaciones energeticas, medioambientales y tecnologicas (sp), centrul pentru promovarea energiei curate si eficiente in romania (ro), global legislators organisation for a balanced environment - europe, vlaamse instelling voor technologisch onderzoek, katholieke universiteit leuven, universiteit antwerpen, commission of the european communities jrc (be), fraunhofer gesellschaft zur foerderung der angewandten

				forschung e.v., universitaet hamburg, universitaet stuttgart, institut fuer energie- und umweltforschung heidelberg gmbh, ifu, deutsches zentrum fuer luft und raumfahrt e.v. (du), meteorologisk institutt, e-co tech as (no), ecole polytechnique de tunisie (tu), eidgenoessische technische hochschule zuerich, econcept ag forschung beratung projektmanagement, esu-services rolf frischknecht, paul scherrer institut, ecole polytechnique federale de lausanne (su), elsam a/s (dm), university of bath, university of newcastle upon tyne, institute of occupational medicine (uk), international institute for applied system analysis (au), islensk nyorka ehf (ys), jozef stefan institute (sl), kfki atomenergia kutatointezet (ho), lietuvos energetikos institutas (li), mineral and energy economy research institute - polish academy of sciences, uniwersytet warszawski (pl), new and renewable energy authority (yg), profing s.r.o.(sr), risoe national laboratory (dk), tallinna tehnikaulikool, stockholm environment institute tallinn centre, lunds universitet, chalmers tekniska hogskola ab (sw), universitat autonoma de barcelona (sp), university of national and world economy (bu), univerzita karlova v praze (cs), vtt (fl)
	Duurzame optimale energie-toepassing & energiegebruik in Arnhems Presikhaaf	sep-04	mei-05	De Straat Milieuadviseurs b.v., Susebeek Technical Consultants, Europe's Energy Point, Hoek Loos
	SeaWing	jan-05	dec-06	Innovatienetwerk Groene Ruimte en Agrocluster (penvoerder), Nederlands Instituut voor visserijonderzoek bv (RIVO - WUR), Plant research International (WUR), TNO-MEP, Duurzaamheidscentrum Lauwersoog
	DUOGEN	feb-05		Hexion/Hygear, Ballast Nedam (IPM installatietechniek), Nexus Global, NedStack, ECN
	Nieuwe generatie op TiO2 gebaseerde elektroden voor splitsing water in zuurstof en waterstof onder invloed van zonlicht.	mrt-05	jun-06	TU Delft (3mE) (penvoerder), Everest Coatings
	Schone Stroom uit Waterstof	jun-05		Hexion B.V., Nedstack
Wextex	**Waterstof op Texel**	jun-05		ECN, Gemeente Texel, Stichting duurzaam texel, Air Products Nederland, Stichting Shell research, Tebodin Consultants

	Waterstof in het onderwijs	aug-05		HAN (Kenniscentrum voor Economie, Techniek en Informatica), Innovative Concepts Publishers (opdrachtgever)
OCAP	**Organische CO2 voor Assimilatie van Planten**	sep-05		Ocap co2 vof, Koninklijke VolkerWessels, Hoek Loos, Gemeente Westland
NEMESIS	**Development of an on-site fuel flexible hydrogen generator**	dec-05	nov-08	Repsol YPF (es), Ballast Nedam, Hexion/Hygear, Umicore AG (de), German Aerospace Center (de), Center for research and technology Hellas (gr), Instituto Superior Tecnico (po), Nanjing University of Technology (ch)
Hyvolution		jan-06	dec-10	WUR, Technogrow b.v., Provalor, A&F (Part of WUR), and 15 foreign actors
EU FP6 IP NESSHY	**Novel Efficient Solid Storage for Hydrogen**	jan-06	dec-10	National Centre for Scientific Research Demokritos, University of Salford, Air Liquide, Joint Research Centre (jrc) (nl), Stockholm University, Institutt for Energiteknikk, EMPA Dübendorf, University of Birmingham, VU Amsterdam, CNRS, DaimlerChrysler AG, GKSS Forschungszentrum Geesthacht, University of Iceland, Johnson Matthey, Forschungszentrum Karlsruhe, Max-Planck Society, Technical University of Denmark, Middle Eastern Technical University, INETI, IFW, TU Delft, SwRI,
Hylights		jan-06	dec-08	BMW, DaimlerChrysler, Centro Ricerche FIAT, Ford, General Motors, Opel, Peugeot Citroën, Volkswagen, BP, Eni, Repsol YPF, Norsk Hydro asa, Total, Shell Hydrogen, Vattenfall, Air Liquide, Air Products, Linde a.g. (Hoek Loos), Dena, ECN, Kellen, LBST, Bundesministerium für Verkehr, Bau und Stadtentwicklung, Chevron, Hydrogenics
	Samenwerking Vaillant-Webasto	feb-06		Vaillant, Webasto
	PEM Energiecentrale	apr-06	sep-07	Nedstack fuel cell technology, Akzo Nobel
	Kraken waterstof op locatie	apr-06		Hoek Loos, HyGear/hexion
	Brandstofcel in promotieschip nieuwe Maze	jun-06		Havenbedrijf Rotterdam, VNSI,
	Bussen Toulouse op waterstof/aardgas	jun-06	jan-07	Air products, Hygear/hexion, Gaz de France
	Bussen op waterstof in Rotterdam	jun-06	dec-11	Shell Hydrogen b.v., Connexxion n.v., MAN Truck & bus Company b.v.
	Hydrogem car	jul-06		ECN, DaimlerChrysler, Air Products
Fhybrid Scooter	**Scooter powered by hydrogen**	jul-06		TU Delft, Epyon
	Waterstof tankstation	okt-06		ECN, Air Products, (Hydrogem Car) BMW

R2H	**Roads2hycom**	okt-06		Ricardo, IKA aachan, Planet gbr, JRC, IFP, Air Liquide, Centre for renewable energy resources, College of Europe, NTDA energia, ECN, DaimlerChrysler, Gaz de France, Air Products, elementenergy, Instytut Energetyki, Airbus, Norsk Hydro asa, AVL, center cortes, EnergieTechnologie, FEV, bozek, Coretec ventures, CRF (centro cricerche fiat), Volvo, intelligent energy, Risoe, TNO, Icelandic New Energy
EU 6 RTN Hydrogen	**Hydrogen**	okt-06	sep-09	Universiteit Leiden, Shell Hydrogen, University of iceland, EPFL, EMPA, University of oxford, Technical University of Denmark, Chalmers University of Technology, Hydrogen Solar ltd, University of Warsaw
EU FP6 RTRN COSY	**Complex Solid State Reactions for Energy Efficient Hydrogen Storage**	nov-06	sep-09	GKSS Geesthacht, University of Torino, IFW Dresden, ESRF Grenoble, Universiteit Twente, Spanish research counsil CSIC, FZK Research centre Karlsruhe, INP Grenoble, VU Amsterdam, Universitat Autonoma de Barcelona, University of Oxford, EMPA Hydrogen & Energy, Université de Picardie Jules Verne