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Planning and permitting procedures for hydrogen refuelling stations

Analysis of expected lead times for hydrogen infrastructure build-up in the Netherlands

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Abstract

The successful introduction of a hydrogen refuelling infrastructure for vehicles in the Netherlands requires – amongst other –permitting processes for hydrogen refuelling stations. An important finding of the European HyFLEET:CUTE (Clean Urban Transport for Europe) research project which successfully employed 33 buses in the public transport systems of 9 different cities was that the cost-effective development of hydrogen refuelling stations requires a harmonisation of safety requirements and permitting processes. Permitting processes are determined by available codes, standards and regulation. (International) regulation constitutes high-level and strict harmonisation. As long as none of this is available, permitting can be supported by guidelines, e.g. safety requirements. Such guidelines serve to build trust and common expectations and requirements among stakeholders. This, in turn, can render permitting processes more effective and efficient.

This report discusses two European research projects aimed at the development of guidelines, codes and standards. Subsequently, the current situation in the Netherlands and experiences and status quo in the US, Norway, Germany and Italy concerning permitting procedures are highlighted. Although no European or (global) international standards are available yet, most stations planned so far have received required permits. Due to a lack of standards and because each demonstration project usually involves authorities which are new to the topic and often makes use of different refuelling technology, permitting lead times vary greatly between six months to two years. In Germany technical and safety guidelines have been developed for refuelling stations operating with gaseous hydrogen. In the Netherlands such guidelines are currently under development. In Italy required regulation is already in place, but still has to prove its ability to decrease the complexity and resulting length of the permitting process. The different countries are calling for European legislation in order to ensure permitting processes that are similar in length as to those currently in place for conventional refuelling stations, namely six months.

Currently, partially due to a lack in regulation, the success of hydrogen refuelling pilot projects depends on committed efforts of all pilot partners and open and frequent communication among project partners and other stakeholders. Technological learning with respect to materials, components and systems is important. Additionally, institutional learning with respect to appropriate safety guidelines is crucial for efficient and safe technology implementation. There are also important aspects of (social) learning that require attention and support, e.g. learning about the set-up of permitting processes (e.g. department interaction within authorities), networking of relevant stakeholders and sharing of knowledge and experiences. The transition of a hydrogen refuelling infrastructure from pilot project to (large-scale) demonstration phase can benefit from collective efforts on local, regional, national and international level.

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Summary

The THRIVE project aims to provide realistic estimates for the cost and time it takes to realise a hydrogen refuelling infrastructure for passenger vehicles in the Netherlands. Permitting procedures (and sometimes the national planning system as a whole) are often downplayed as 'potential barriers' for infrastructure development. Relevant issues for infrastructure planning relate to the balancing of environmental and nature protection interest, industrial and economic interest, local safety considerations and the global interest of countering climate change. Important questions are how refuelling locations are designated, who is involved in this and what type of worries or opposition from relevant stakeholders are to be expected. In terms of legal procedures, it is important to be aware of required permits and licences and the length of (formal) lead times. Therefore, this report provides insight in institutional and socio-political aspects regarding spatial planning and decision-making affecting the development of a hydrogen refuelling infrastructure. This report builds on experiences from hydrogen demonstration projects in the Netherlands, US, Norway, Germany and Italy as well as the work of earlier research projects concerned with safety guidelines for hydrogen refuelling stations.

The HyApproval project (FP6) produced a handbook of technical and regulatory requirements to assist authorities, regulators, refuelling station owners, companies and organisations to facilitate the approval process of hydrogen refuelling stations in Europe. The HyApproval handbook[1] includes some country specific issues that are based on experiences gained during a demonstration project. Stakeholders from demonstration projects in the Netherlands, four other European countries and China agreed that coordination of the process of planning, constructing and operating a hydrogen refuelling station is of crucial importance. Generally, three stages of safety assurance have been identified by HyApproval: (1) the prevention of accidents - by applying state of the art technology, following technical standards and developing simple handling procedures to users and operators, (2) mitigation of accidents, e.g. by creating safety zones and distances, and (3) a structured emergency response by optimally preparing emergency services. In the Netherlands, three permits have to be attained: an environmental, a building and an operating permit. For the first permit, a Quantitative Risk Assessment (QRA) is required for each station.

The HySafe Network of Excellence was constituted by 24 partners from 12 European countries, one from Russia and one from Canada. Achievements included amongst others the development, harmonisation and validating of methodologies for safety assessments and modelling of hydrogen dispersion, combustion and explosion, benchmarking and validation of Computational Fluid Dynamics (CDF) tools. At the end of the project, risk assessment methodologies still required refinement, further research on safety in tunnels was needed and current knowledge should be used to develop (ventilation) criteria for safe parking of hydrogen vehicles in confined spaces, such as parking garages. The HyApproval handbook was deemed a good starting point for efforts to harmonise approval procedures for hydrogen refuelling stations.

In the Netherlands, two demonstration projects have so far been implemented which help to provide insight into actual or potential bottlenecks when it comes to the permitting of a novel type of refuelling station. The HyFLEET:CUTE project in Amsterdam profited from a close, fruitful and trustful cooperation among the different stakeholders involved in the permitting process: the project implementers, local authorities, the local fire brigade, *DHV Milieu en Infrastructuur BV* (an engineering consultancy responsible for the risk analysis) and the *Nederlands Instituut Fysieke Veiligheid* (NIFV Nibra - Dutch Institute for Physical safety). Even negative

[1] The complete HyApproval handbook and other deliverables of the project can be downloaded from http://www.hyapproval.org/publications.html.

publicity and official protesting by a neighbouring company did not harm the permitting and operating of the hydrogen refuelling station for the length of the project.

Figure 1.1 *The hydrogen bus employed during the HyFLEET:CUTE project in Amsterdam*
Source: http://citybus2500.fotopic.net.

The second demonstration project, however, encountered problems due to a lack of regulation and lack of cooperation among project partners and responsible authorities. It resulted in a criminal investigation against two of the project partners which is still pending at the time of writing. The *Nederlandse praktijkrichtlijn* (Dutch practical guideline) NPR 8099 for hydrogen refuelling stations which is currently under development will hopefully prevent such events in the future and support permitting processes until Dutch or even European legislation is available.

For the four other countries, the US, Norway, Germany and Italy, discussed in this report experiences are rather mixed. Currently, permit lead times for hydrogen stations in California can vary between 2-3 months up to two years, depending on the project location, the backlog of work of the responsible planning department, the knowledge of the authorities having jurisdiction, or any special requests on the project (e.g. extra equipment, safety, etc.) and the addition of requirements by local fire departments. In order to facilitate and speed up permitting procedures, the National Renewable Energy Laboratory (NREL) of the US Department of Energy has conducted 'permitting workshops' in California and elsewhere in the US. These workshops primarily target local authorities, providing background information and resources (e.g. useful web links) and sharing experience from others who have permitted stations. NREL is also developing an on-line 'Permitting Tool' to support local authorities. The permitting of hydrogen stations is expected to be significantly simplified by a new National Fire Protection Association (NFPA) standard addressing, amongst other, all safety matters and permitting issues related to hydrogen. Its publication has been scheduled for August 2011.

The permitting lead time for a hydrogen refuelling station in Norway should be about six weeks but due to unfamiliarity with the new fuel it currently takes about four to six months. Codes, standards and guidelines used are those of the Air Liquide 'Handbook for Hydrogen Refuelling Station Approval', NFPA 50A Standard for Gaseous Hydrogen Systems at Consumer Sites and European Industrial Gases Association (EIGA) Gaseous Hydrogen Stations.

This report follows the developments of four German demonstration projects that have been implemented or are still running: HyFLEET:CUTE, the Clean Energy Partnership, HyCologne and Zero Regio. None of these projects has experienced severe permitting problems or delays and all stations planned have been approved. Due to good preparation and close cooperation among project implementers and responsible authorities permitting lead times were about two to three months. One of the outputs of the Zero Regio project is the Merkblatt (code of practice) 514 published by the Vd-TÜV (Verband der Technische Überwachungsvereine - association of technical inspections organisations). All information provided solely deals with gaseous hydrogen and will be used by the TÜV in future approval processes.

The Italian permitting processes are the most complex and protracted of all examples discussed in this report. A ten months lead time for the multi-fuel station including hydrogen was followed by further complications with a regulation then coming into effect requiring larger safety distances. To ensure the continuation of the project a compromise was found in setting up a 3x2m concrete wall as safety measure.

Within the framework of the Dutch research project THRIVE, of which this report forms part, a model has been developed to project the up-take of hydrogen vehicles and accompanying refuelling infrastructure development based on a number of parameters.[2] One scenarios analysed, here called the 'high case scenario' is rather optimistic and assumes proactive work by the three main implementing parties: car manufacturers, refuelling infrastructure developers and the government. Current activities in the Netherlands do not seem like precursors of a very large ramp-up of hydrogen refuelling infrastructure in the near future, as for example projected in the THRIVE 'high case scenario'. Instead there are (so far) three scattered pilot projects, one of which has been successfully implemented, another one is currently underway and a third one which could not hold its promise to provide a mobile refuelling station due to permitting problems. Experts asked for feedback on these projections foresee a slow increase of stations in Germany until 2015 and a steeper increase upon vehicle mass-production. The Netherlands are likely to follow these developments with a three to five year delay.

The recommendations resulting from this report for the Netherlands encourage a close cooperation of demonstration project partners and other stakeholders as well as an early notification of responsible authorities. Until NPR 8099 is finalised other guidelines as those produced in HyApproval, HySafe and by the German Zero Regio project may be of help for future demonstration projects. In general, the development and implementation of national legislation is desirable, especially for the early commercialisation phase of hydrogen vehicles and stations. Future, especially large-scale demonstration projects can provide important insights for the development of safe and suitable legislation.

[2] More information on the THRIVE research project and the model developed can (soon) be found on the project website http://www.ecn.nl/nl/units/h2sf/rd-programma/studies/thrive-project/.

1. Introduction

This report presents part of the research carried out in the framework of the THRIVE ('Towards a HydRogen Infrastructure for VEhicles in the Netherlands') project. The THRIVE consortium consists of ECN and TNO as research institutes as well as Shell and Linde Benelux representing the industry. The project aims to provide plausible routes and technological options for a hydrogen infrastructure for refuelling of vehicles in the Netherlands. *Plausible* in this context does not only refer to cost and technical feasibility, but also explores other aspects, such as socio-economics, e.g. consumer behaviour with respect to the introduction of innovative technologies and other, non-technical issues that need to be considered during the introduction process.

The project is based on the assumption that commercial roll-out of hydrogen vehicles and the development of the necessary infrastructure commence in the current decade (2010-2020). The 'plausible development' is then projected for the first 15 to 20 years after commercial introduction with a focus on hydrogen as a transport fuel for passenger cars and light duty vans, trucks and buses.

Part of the socio-economic research by ECN (unit Policy Studies) is an analysis of current spatial planning and permitting procedures and the possible length of permitting lead times that have to be taken into account for the future build-up of a hydrogen refuelling infrastructure. The Netherlands are central to the analysis, but the report also builds on experiences of a number of current or past hydrogen demonstration projects in the US, Norway, Germany and Italy.

This report first discusses the rationale for writing this report (1.1), followed by the questions guiding the research (1.2) and the applied methodology (1.3). The second chapter deals with the work and outcomes of two research project funded by the European Commission: HyApproval (2.1) aimed to design a handbook for the approval process of hydrogen refuelling stations in Europe and HySafe (2.2) contributed to the advancement of modelling and quantitative risk assessment methods for approval processes and safety aspects. The third chapter discusses possible permitting lead times in the Netherlands and the fourth chapter does the same for four other countries: the US, Norway, Germany and Italy. The report ends with conclusions and recommendations for approval processes of hydrogen refuelling stations in the Netherlands.

1.1 Rationale for the analysis of permitting procedures

The THRIVE project aims to provide realistic estimates for the cost and time it takes to realise a hydrogen refuelling infrastructure for passenger vehicles in the Netherlands. Permitting procedures (and sometimes the national planning system as a whole) are often downplayed as 'potential barriers' for infrastructure development, but they can pose serious problems to the realisation of a refuelling network.

At the national, provincial and local levels (sometimes contradictory) interests have to be weighed against each other and conflicts can become manifest. Relevant issues for infrastructure planning relate to the balancing of environmental and nature protection interest, industrial and economic interest, local safety considerations and the global interest of countering climate change. Important questions are how refuelling locations are designated, who is involved in this and what type of concerns or opposition from relevant stakeholders are to be expected. In terms of legal procedures, it is important to be aware of required permits and licences and the length of (formal) lead times. Therefore, this report provides insight in institutional and organisational aspects regarding decision-making affecting the development of a hydrogen refuelling infrastructure.

This report builds on experiences from hydrogen demonstration projects in the Netherlands, US, Norway, Germany and Italy as well as the work of earlier research projects concerned with safety guidelines for hydrogen refuelling stations (e.g. HyApproval[3]). One aim of this report is to serve as a handbook to those involved in the permitting and planning of a hydrogen refuelling station, pointing out important documents and guidelines developed to date and the problems that may occur during the process of planning and taking a station into operation. Finally, it discusses the shortcomings of existing legislation and recommendations for dealing with current lack of regulation and developing permitting procedures based on stakeholder interaction and learning among involved parties.

1.2 Research questions

The report at hand aims to answer the following research questions:

- What are recent developments (e.g. results of research projects, published guidelines) with regard to permitting and spatial planning of hydrogen refuelling stations?
- What practical experiences exist in the Netherlands concerning the planning and permitting of hydrogen refuelling stations?
- What practical experiences exist in other countries concerning the planning and permitting of hydrogen refuelling stations?
- What are expected lead times of the required permitting procedures for a hydrogen refuelling station in the Netherlands?

1.3 Methodology

This report is fully based on desk research. Important publications dealing with spatial planning, permitting and safety guidelines for hydrogen refuelling stations were consulted. Additionally, interviews were conducted by phone or email with people who had practical experiences with the permitting procedures in different countries. A list of all interviewees can be found in Appendix A.

[3] HyApproval was a project financed under Framework Programme 6 by the European Commission. The main objective was to develop a 'Handbook for the approval of hydrogen refueling stations' to be used for the certification of such stations in Europe. More information can be found at: http://www.hyapproval.org/.

2. HyApproval & HySafe - two previous research projects

The two projects HyApproval and HySafe contributed greatly to developments of codes and standards, according to experts we interviewed for this report. Generally, the requirements for hydrogen refuelling stations are similar across countries but usually more strict in Northern-European countries than elsewhere. In the following the two projects and their outcomes are discussed in more detail.

2.1 HyApproval

The HyApproval project, sponsored by the European Commission within the Sixth Framework Programme (FP6) aimed at developing a universal handbook of technical and regulatory requirements to assist authorities, regulators, refuelling station owners, companies and organisations to facilitate the approval process of hydrogen refuelling stations in Europe. HyApproval was carried out by 25 partners from industry, small and medium enterprises (SMEs) and research institutes from October 2005 until September 2007. Many of the project partners had experience with the planning and permitting of hydrogen refuelling stations in various countries. The work was supported by key partners from China, Japan and the USA, providing insights in regulation, codes and standards outside the EU. The project took as point of departure developments and outcomes of previous research projects in the hydrogen field:

- Commercial hydrogen vehicles are expected to enter the market by 2015.
- The European Union has set a target for the use of hydrogen in the total transport fuel mix for 2020.
- The founding documents of the European Hydrogen and Fuel Cell Technology Platform (HFP - established in 2003 by the European Commission) provide a 'Snapshot 2020' in which it is estimated that between 800,000 and 1.2 million hydrogen cars will be on the road by 2020.
- The European Integrated Hydrogen Project (EIHP) had drafted regulations for hydrogen-fuelled road vehicles and guidelines for hydrogen refuelling stations. (HyApproval aimed to finalise the latter.)
- The HyWays project (finalised in mid-2007) concludes that strong policy support and accelerated learning can lead to 1 million hydrogen vehicles on European roads by 2020.
- HyWays estimated that these vehicle numbers would require some 400-500 stations in urban centres and along highways connecting these centres during the large-scale demonstration phase 2010-2015 and some 13,000-20,000 stations in the phase of developing demand until 2025. For massive roll-out (after 2025) demands the same spatial distribution of refuelling stations as for conventional fuels.
- In order to facilitate the introduction of hydrogen vehicles, the European Commission initiated in October 2007 support for formal approval of a regulation on vehicles driving on liquid or compressed gaseous hydrogen.
- The HyFLEET:CUTE (Clean Urban Transport for Europe) project (2007-2009) emphasised the need for harmonisation of safety requirements and permitting processes in order to enable the cost effective development of hydrogen refuelling stations.

A draft version of the developed HyApproval handbook of technical and regulatory requirements were shared with Dutch, four other European and Chinese authorities to reach 'broad agreement'. Procedures thereby defined were expected to support hydrogen refuelling station approval in any European country.

The key recommendation of the HyApproval consortium[4] is the set-up of an EC regulatory framework controlling requirements, standards and authoritative bodies. For the time until such a framework is established, authorities are advised to adopt a permitting process structured as follows: one single authority, relying on the evaluation of one expert body, referring to a pre-established set of requirements and approval criteria. For the development of such criteria, international standards should be the framework of choice.

Figure 2.1 *Hydrogen refuelling stations involved in the HyApproval Project*
Source: Executive summary of the HyApproval Handbook.

The HyApproval handbook[5] includes some country specific issues that are based on experiences made during a demonstration project. Stakeholders from demonstration projects in the Netherlands, four other European countries and China agreed that coordination of the process of planning, constructing and operating a hydrogen refuelling station is of crucial importance. Hereby, it needs to be identified who (i.e. which authority) takes over the role of the coordinator and that discrepancies among stakeholders are resolved early in the process. Additionally, the requirements for community relations efforts need to be checked early and complied to. The neglect of community concerns and issues may impede the implementation of the project (i.e. establishment of a hydrogen refuelling station).

Generally, three stages of safety assurance have been identified by HyApproval: (1) the prevention of accidents - by applying state of the art technology, following technical standards and developing simple handling procedures to users and operators, (2) mitigation of accidents, e.g. by creating safety zones and distances, and (3) a structured emergency response by optimally preparing emergency services. Several actors are involved in ensuring risk mitigation and coordinated emergency response and (also due to a lack of pre-defined requirements) 'the duration, cost and prospect of success of a permitting procedure for a hydrogen fuelling station are very unpredictable' (Air Products et al., 2008).

[4] An executive summary of the HyApproval handbook can be downloaded from http://www.hyapproval.org/publications.html.
[5] The complete HyApproval handbook and other deliverables of the project can be downloaded from http://www.hyapproval.org/publications.html.

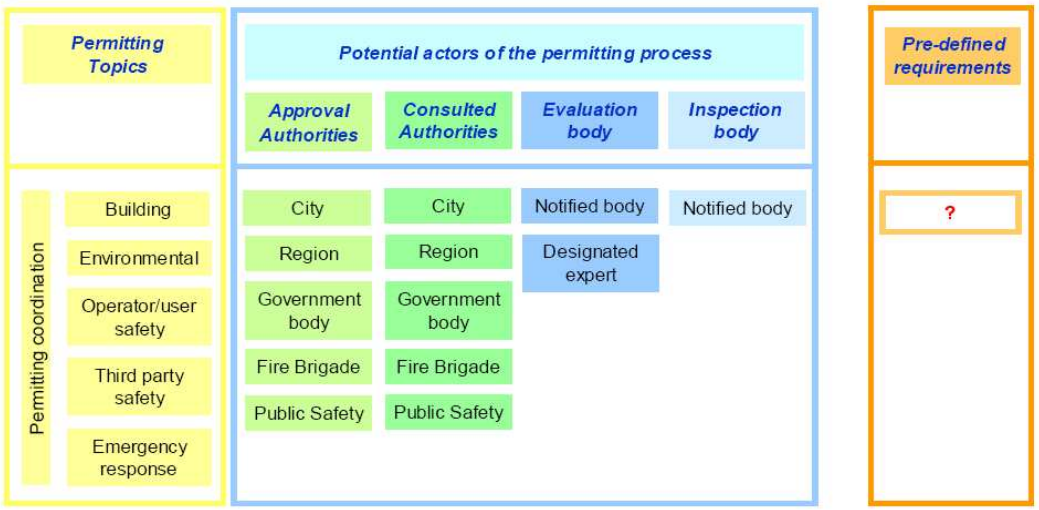

Figure 2.2 *The potential complexity of the permitting process*
Source: Air Products et al., 2008.

In the Netherlands, three permits have to be attained: an environmental, a building and an operating permit. For the first permit, a Quantitative Risk Assessment (QRA) is required for each station. For the demonstration project in Amsterdam (cited by HyApproval) no specific guidelines existed. Amongst other the *Besluit Risico's Zware Ongevallen* (BRZO) was applied, also to derive safety distances for the planned hydrogen refuelling station.[6] Details on the process of permit application and issuing can be found in the following section on practical experiences with hydrogen refuelling installations in the Netherlands.

The safety distances determined by the QRA also apply to spatial planning purposes and in case criteria cannot be met, relocation of the planned project is necessary. Additionally, before the operation of the station, personnel and emergency response forces were trained and regular checks devised to be carried out by the fire brigade, the station owner and the Ministry of Housing, Spatial Planning and the Environment (VROM).

Dutch participants of the HyApproval project criticised that the public had not been included in the project research and it was generally remarked by some interviewees (nationality unspecified) that the labour inspectorate had not been included in approval processes foregoing the operation of hydrogen refuelling stations.

2.2 HySafe

The Network of Excellence (NoE) HySafe[7] (March 2004 - February 2009) sponsored by the European Commission was constituted by 24 partners from 12 European countries, one from Russia and one from Canada. The consortium represented research institutes, industry and universities. Achievements included amongst others:

- development, harmonisation and validating of methodologies for safety assessments, e.g. risk managements and risk assessment methodologies, acceptance criteria, risk based deter-

[6] The BRZO (Serious Accidents Risk Decree) is the implementation of the European Council Directive 96/82/EC which applies to industrial establishments where dangerous substances are present in quantities exceeding the thresholds in the directive. Additionally, requirements for similar substances (PGS 25, US NFPA 50A/B, EIGA 15/96, ISO 15916) and more general requirements (97/23/EC, 89/392EC, 93/68/EC, 389/336/EC, ATEX, BAT) were used.

[7] More information can be attained under www.hysafe.org - unfortunately not all project deliverables are available online.

mination of safety distances and zone classification and the development of reference Quantitative Risk Assessment models (HyQRA).
- modelling of hydrogen dispersion, combustion and explosion, benchmarking and validation of Computational Fluid Dynamics (CDF) tools.
- set-up of specialised research facilities.
- investigations on the use of hydrogen in enclosed spaces (e.g. tunnels, garages).
- development of a Hydrogen Incident and Accident Database (HIAD).
- biennial Report on Hydrogen Safety.
- organisation of training and educational programmes on hydrogen safety and other dissemination strategies targeting various stakeholders.
- recommendations for the safety aspects of the use of high pressure hydrogen in fuel cell cars.

At the end of the project, risk assessment methodologies still required refinement, further research on safety in tunnels was needed and current knowledge should be used to develop (ventilation) criteria for safe parking of hydrogen vehicles in confined spaces, such as parking garages. The HyApproval handbook was deemed a good starting point for efforts to harmonise approval procedures for hydrogen refuelling stations. A European regulation for type approval of hydrogen-fuelled motor vehicles had already been published. Recommendations proposed by the HySafe consortium included:

- further work on harmonisation of approval procedures for other hydrogen systems in order to avoid varying local or regional approval regimes and to facilitate the introduction of hydrogen as transport fuel.
- National and international support and cooperation, including private-public partnerships.
- Support for dissemination and knowledge sharing, e.g. for the International Association for Hydrogen Safety, International Energy Agency (IEA) activities related to hydrogen safety, International Partnership for the Hydrogen and Fuel Cells in the Economy (IPHE), and continuation of the HySafe initiatives concentrating on education and trainings and the HIAD database. Authorities should financially support future efforts shared by research industry and regulatory bodies for the safe introduction of hydrogen as transport fuel.

3. Expected lead times in the Netherlands

3.1 Sustainable public transport in the Netherlands - experiences with permitting in two pilot projects

Two hydrogen pilot projects have been realised so far in the Netherlands, both employing hydrogen buses for public transport. One of them took place in Amsterdam and no significant permitting problems have been encountered. It has been taken as exemplary for permitting procedures in the Netherlands in the HyApproval project (see Section 2.1), although permitting procedures vary slightly between Dutch provinces and depend on the stakeholders involved. The second project encountered more problems. Both these projects are discussed here in detail in order to highlight important aspects conducive to success or failure of the installation of a hydrogen refuelling system.

HyFLEET:CUTE in Amsterdam
Several organisations and authorities were involved in the process of developing a hydrogen refuelling station for three hydrogen buses in Amsterdam. First, the *Gemeentevervoerbedrijf* (GVB) Amsterdam applied as the (future) hydrogen refuelling station owner for an environmental permit (which includes external safety issues) and a building permit at the *Dienst Milieu en Bouwtoezicht* (DMB - the Department for Environment and Building Supervision). Information and documents required during the application process were:

- (technical) description of the hydrogen refuelling station and its operation.
- Process Flow diagrammes.
- Quantitative Risk Assessment (QRA, including description of lay-out, location and surroundings of the hydrogen refuelling station).
- Risk assessment studies.
- Mitigating safety measures, including explosion and fire protection (in particular measures to prevent and detect hydrogen accumulation, e.g. under roofs or canopies).
- Shut-off procedures.

The DMB is an advisory board to the Amsterdam City Council and prepared all necessary paperwork for the permit. For the building permit compulsory advice by the Amsterdam fire brigade was required. The fire brigade required no technical details, but a short description of the processes, risk assessment studies and intervention measures. The (compulsory) recommendations it gave were developed in cooperation with the *Nederlands Instituut Fysieke Veiligheid* (NIFV Nibra - Dutch Institute for Physical safety).

Parallel to these processes, hearings were organised to inform neighbouring commercial and private residents about the plans. The municipal zoning plan did not have to be adapted for the project. It is nevertheless advisory to consult local authorities whether such changes may be necessary. The permits were granted by the City Council mid March and mid April 2003, respectively, after regular lead times for such permits and without any objections by third parties.[8] Normally, the lead time for an environmental permit is about six months. Because of the novelty of the project and the unfamiliarity with permitting of a hydrogen refuelling station, GVB invested sufficient time to formulate a strategy and consult with the authorities. Unfortunately, how long these preparatory measures took has not been indicated by our interviewee. However, he is convinced that in a possible follow up project, which would again require the issuing of permits for a hydrogen refuelling station, the preparatory processes would consume less time, as all parties involved, including the authorities, gained experience during this project. After it was

[8] Since no regulations for hydrogen stations were available, regulations for similar substances were employed. Please see section on HyApproval 2.1 for details.

clear what data are required, it took GVB, Shell Hydrogen, Linde Gas Benelux and DHV Milieu en Infrastructuur BV (an engineering consultancy responsible for the risk analysis) about three to four months to gather the information.[9]

Construction of the station started in the beginning of July 2003 and was finalised in the beginning of September of the same year. In other words, excluding preparatory consultation among project partners, authorities and advisory bodies, the total time to prepare the application and to warrant the environmental permit took about ten months. Application and warranting procedures for the building permit ran parallel and consumed less time and effort because only the plans for two buildings had to be approved. The following flowchart developed by the HyApproval consortium depicts this process in general terms:

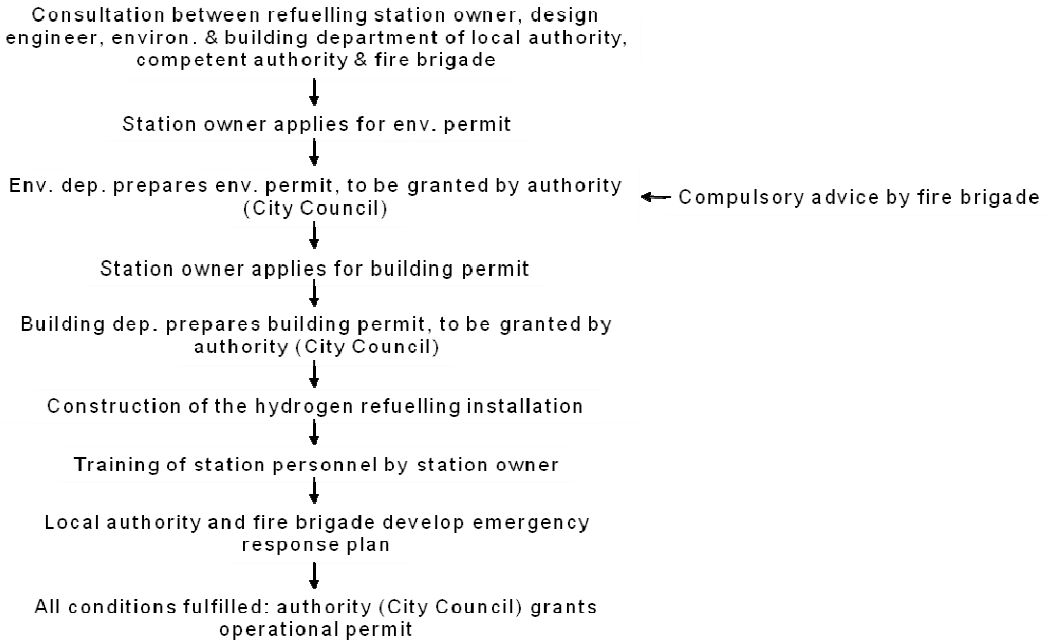

Figure 3.1 *Flowchart of the permitting process in the Netherlands*
Source: Air Products et al., 2008.

During the time it took to apply for and approve permits and to construct the station, no opposition had been met by stakeholders, including neighbouring residents and companies. For reasons unknown to the authors, the company owning an adjacent natural gas pressure reduction station started a discussion on safety and risks by means of a television item ('The dangerous situation of the hydrogen refuelling station') in the end of September 2003. This company had previously shown no interest in the hydrogen project and not attended any of the public hearings. This caused the *Ministerie van Volkshuisvesting, Ruimtelijke Ordening en Milieubeheer* (VROM - Ministry of Housing, Spatial Planning and the Environment), that has the authority (but not the obligation) to become involved in permitting processes, to become engaged. VROM contacted the *Rijksintituut voor Volksgezondheid en Milieu* (RIVM - National Institute for Public Health and the Environment) for advice on the situation. Although all authorities agreed on the station lay-out and location as it stood, GVB proposed to relocate the buffer storage of the hydrogen installation, while the electrolyser and the compressor, both associated with lower risks, would remain where they were. The owner of the gas reduction station accepted that offer and the buffer storage was relocated mid-November 2003. Afterwards, the station could finally be taken into operation.

[9] Personal communication, A. Frits van Drunen, GVB, 11 November 2009.

The arrival of the three buses, however, was - for reasons unknown to the authors - delayed until the end of October. The process required for their technical licence was carried out by Daimler in Germany in cooperation with the Dutch authority *Rijksdienst voor het wegverkeer* (RDV - Department for road traffic). With the approval of RDW the three hydrogen buses were allowed to operate in the public transport service.

Already before the buses arrived, however, the owner of the natural gas pressure reduction station started an official protesting procedure against all permits (environmental, building and operational) granted to the GVB hydrogen refuelling station for buses. These protests were finally overruled almost half a year later, in May 2004. Until then, the buses had already been in use since their arrival in October of the previous year.

These occurrences show that opposition can emerge suddenly and fiercely, even if all required procedures, including public hearings, have been followed properly. The question why this project proceeded smoothly despite the resistance it met is relevant but has not been enquired during this research. One reason may be that the cooperation among all project partners, authorities and advisory bodies involved in the project had worked well throughout the process, as the GVB project manager himself emphasised. This group of stakeholders had committed to the realisation of this project and was not impressed by the opposition drawn up by the company owning the neighbouring natural gas station. One reason why the negative publicity initiated by the natural gas station owner had little impact was that the hydrogen project was generally well received by the Amsterdam City Council and depicted rather positively in the media. The reason why authorities did not accede to the official objection to the hydrogen refuelling station may again be the conviction that the project planning and permitting procedures had been followed properly and external safety measures sufficiently considered by all parties involved.

The cooperation among all organisations involved in the project was deemed extremely successful by our GVB interviewee, especially in the light of the difficulties the project faced with the protests of the adjacent company. Recommendations based on the experiences made during this pilot project were the following:

- Decide early whether the chosen location is suitable in terms of necessary safety distances.
- For this purpose, conduct a QRA early, also because changes of plans are less cost-intensive earlier in the project.
- Based on QRA results get in touch with responsible authorities as early as possible (if no regulation on hydrogen refuelling installations exists, as it was the case of the construction of the HRS in Amsterdam, it is important to grant authorities and advisory bodies time to get acquainted with subject).
- Support and facilitate an open dialogue among all stakeholders involved.

The second Dutch hydrogen project

In 2007, the government of the province the second hydrogen project in the Netherlands was located in made budget available for sustainable transport projects. A pilot project was developed, together with a public transport company operating in the region. [10] For the duration of two months (October/November 2008) a hydrogen bus was to be for public transport services in three different cities. To this end, a temporary hydrogen refuelling station was planned at the bus depot in collaboration with two branches of an international gas company.

In the beginning of 2008, contact was established with local authorities in order to apply for the necessary permits. Due to the fact that no (safety) regulation for hydrogen refuelling systems were available, the municipality decided to apply CNG regulation instead. The municipality announced that due to a lack of regulation this pilot would be treated as a 'legal exception' and allowed the pilot project to proceed with implementation. It is unknown to our interviewee if the municipality tried to contact Amsterdam authorities involved in the permitting processes of the

[10] Interviewees are known to the authors.

HyFLEET:CUTE hydrogen refuelling station three years earlier. It is certain that these experienced authorities were contacted at a later point in time when problems arose, but uncertain whether contact was established at the time of permit application or any time in between allowing the project to proceed and the actual installation of the hydrogen refuelling station 1.5 years later.

The public transport operator (voluntarily) provided technical drawings, commissioned a quantitative risk assessment and trained its employees. Standards used for the hydrogen installation were those employed in Belgium, Spain and Luxembourg. The local authority (municipality) and the local fire brigade were frequently informed about the development of plans, results of the risk analysis and general proceedings of the pilot. After this year-long preparation, an *activiteitenbesluit* (enactment of activities) based on the *Publicatiereeks Gevaarlijke Stoffen* (PSG - Publication series on dangerous substances) was granted by the municipality to the installation of the temporary hydrogen refuelling unit.

In September 2008, the mobile hydrogen refuelling station was set up on the premises of the bus depot. A ceremonial opening of the station to which also a number of politicians were invited was planned for 3 October 2008. One day prior to the opening, an inspector from the regional fire brigade and an inspector from the municipality paid a visit to the site and subsequently filed a list of complaints. The municipal inspector criticised the fact that regulations had not been followed, while the inspector from the fire brigade had a list of safety complaints. He demanded an extra emergency button, larger safety distances between the stored hydrogen and electrical equipment, a different lay-out of the station and different on-site safety equipment for incidents. The fire brigade intended to file a restraining order to stop the whole project and file a law suit against the municipality, because it did not agree with the municipal decision to apply CNG regulations for the hydrogen refuelling unit.

Within one week, all issues raised by the two inspectors were fixed. Project implementers hoped that the municipality would grant again the status of 'legal exception' and allow operation of the station, if all safety issues were taken care of. During this time, the bus was already in operation and refuelled at the Amsterdam station of the HyFLEET:CUTE project. When a second inspection was conducted, a (minor) hydrogen leakage between the recently delivered hydrogen tank and the hydrogen refuelling system was detected due to the misfit of two cables. The police and the fire brigade arrived and determined an evacuation of the site. After the fire brigade allowed staff from the gas supplier to near the site again, the leakage was quickly fixed.

Following these events, trust between project partners was exhausted and the bus continued to refuel in Amsterdam, in order to allow an otherwise smooth progress of the pilot in the planned two-months timeframe. Two weeks after the leakage detection, the local City Council overruled all decisions of the municipality and decided to neither grant the status of 'legal exception' to the pilot on the grounds of no available legislation, nor to allow the use of the mobile station for refuelling.[11] At the time of writing, a criminal investigation against the public transport and the gas companies involved in the project is still pending.

One objective of this pilot project had been to learn about permitting procedures for hydrogen refuelling stations, about what kind of problems may arise and what regulation is required. However, a lack of communication and cooperation among stakeholders made the fulfilment of this objective impossible. Moreover, the most important objective of the project, namely permitting, installing and operating a hydrogen refuelling unit for buses could not be realised. The following recommendations can be put forward on the basis of experiences made during this pilot:

- All stakeholders should become involved early and commit themselves to the project. Instead of granting a 'legal exception', everyone should aim for the proper application and issuing of required permits. For the individual stakeholders this entails:

[11] Both, bus and refuelling unit, have been employed in other projects since then.

- The permit issuing authority needs to research available regulation and safety guidelines, e.g. in cooperation with authorities who already collected experiences during earlier pilot projects. Close collaboration between the different entities of the same authority is advisory (e.g. Department issuing the permit, Department of Transport, Council, etc.).
- The local fire and rescue services should consult early with their regional umbrella organization and with partner organizations in other cities who have experience with such projects.
- The technical partners involved should take care of appropriate delivery and handling of their material and collaborate closely with other pilot partners and stakeholder for proper education and training for involved stakeholders.
- The pilot project manager should take care to enroll pilot partners in the project that have proven to be supportive and cooperative (possibly in other projects elsewhere). Additionally, the pilot manager should implement communication strategies that support frequent information exchange among all project partners and other stakeholders involved.

3.2 Guidelines for Hydrogen Refuelling Stations in the Netherlands - Nederlandse praktijkrichtlijn NPR 8099:2010

In March 2009, the Dutch Minister of Housing, Spatial Planning and the Environment Jaqueline Cramer informed the *Tweede Kamer* (Second Chamber) that a *Nederlandse Praktijkrichtlijn* (NPR - Dutch practical guideline) for hydrogen refuelling stations had been commissioned to the *Nederlandse Normalisatie-instituut* (NEN - Dutch Standardisation Institute) by SenterNovem.[12] This step had been taken due to a lack of national and international regulation and the need to develop risk analysis methodologies, knowledge on risks associated with hydrogen as vehicle fuel and training measures for refuelling station personnel and drivers of hydrogen-powered vehicles. The Minister indicated that such guidelines were already available in the USA and under development in Europe.

The draft of NPR 8099[13] for hydrogen refuelling stations was published by NEN in January 2010 and is expected to be finalised in a few months. The document includes amongst other the following:

- Information on chemical and physical characteristics of hydrogen.
- Requirements for the design and construction of hydrogen refuelling stations.
- Current regulation relevant for hydrogen refuelling stations (regarding e.g. substance safety, occupational safety).
- Relevant legislation and regulation on environmental safety, spatial planning and permitting procedures.
- Information on general safety aspects.
- Guidelines on internal and external safety distances.
- Information on safety aspects with respect to different types (e.g. on-site hydrogen production vs. delivery) or system components of hydrogen installations (e.g. storage).
- Guidelines on signage, also understandable to the public in form of pictographs.
- Guidelines on ventilation, emergency stop switches, maintenance, emergency and evacuation plans.

[12] SenterNovem is the agency of the Dutch Ministry of Economic Affairs, and has been renamed to Agentschap NL in January 2010.

[13] The full English title of this document is: NPR 8099 Hydrogen fuelling station - Guide for safe application of installations for delivery of hydrogen to vehicles and boats with respect to fire, workplace and environment. The draft can be purchased from http://www2.nen.nl/nen/servlet/dispatcher.Dispatcher?id=BIBLIOGRAFISCHEGEGEVENS&contentID=287067

- Guidelines on current permitting procedures (including the advice to consult competent authorities, involve the fire brigade and set up stakeholder meetings).
- Information on required information for the application for an environmental permit (e.g. drawings of station lay-out and process flow, QRA).

Based on experiences made in coming pilot and demonstration projects in the Netherlands and elsewhere and the development of regulation in other countries or on European level these guidelines are to be refined and made more appropriate.

3.3 Discussion and conclusions - collaboration as key to efficient and successful permitting of a hydrogen refuelling infrastructure in the Netherlands

Both Dutch hydrogen demonstration projects that have been implemented so far have encountered problems during the permitting process. The project in Amsterdam encountered less problems during the application and approval process for the required environmental, building and operational permits due to an excellent cooperation between the project partners, responsible authorities and safety organisations. However, this success was endangered in a period when another stakeholder, the owner of a neighbouring natural gas high pressure reduction station filed official protest against the project. Again, only the good collaboration among all other stakeholders ensured the successful continuation of the project. The second pilot project could not be completed as originally planned because the lacking regulation was not compensated with close cooperation among project implementers, local authorities and advisory bodies to achieve issuing of proper permits.

The experiences gathered from these two projects point to the importance of networks among all relevant stakeholders and open, transparent communication between all actors involved. Currently, stakeholders much rely on the sharing of information and close collaboration because there are so few empirical experiences. So far every project has been a premiere for everyone involved, because the demonstration projects took place in different cities and different authorities and advisory bodies were involved. The second Dutch pilot project may have encountered less permitting problems if stakeholders had contacted their counterparts in Amsterdam earlier.

In order to check current knowledge when it comes to permitting and safety guidelines for hydrogen refuelling stations two 'cold calls'[14] were made to the fire brigades of Rotterdam and Arnhem. Authorities themselves were not contacted directly as 'unnecessary disturbance' of authorities not yet confronted with permitting a hydrogen refuelling station was not appreciated by industry involved in the THRIVE research project. The intention of 'cold calls' to fire brigades was to see how well prepared responsible persons feel when confronted with the task of having to advice and provide information to authorities. During the call interviewees were amongst other asked about the role and responsibilities of the fire brigade in permitting processes for refuelling stations; their knowledge about the risks relating to hydrogen; how they develop safety measures and emergency response plans; what kind of information about a hydrogen refuelling station would be required in order to perform necessary tasks; whether they are aware of national and/or international developments concerning permitting procedures and safety measures for hydrogen refuelling stations.

The fire brigade Rotterdam referred the 'cold caller' to the Milieudienst Rijnmond (Environment Agency of the Rijnmond region) which handles such issues for Rotterdam. At the fire brigade no permitting cases of a hydrogen refuelling station were known and they had so far not yet been informed about specificities regarding hydrogen as transport fuel. The respondent from Arnhem indicated that the first step is to consult colleagues from other regions more familiar

[14] We labelled a spontaneous call without prior notice a 'cold call'.

with the topic if confronted with the task of advising authorities and developing emergency response plans for a hydrogen refuelling station. Some information is already available regarding hydrogen as a hazardous material. The time it takes to get more familiar with the topic and to be able to advice the responsible authority as well as to develop fire prevention and safety requirements was estimated with 40 hours. The knowledge and experience base grows with each station to be permitted and allows faster processing in the future. Of course, the fire brigade requires information on risk sources, incident scenarios and effect distances, the possibilities for disaster control and the ability for on-site accident prevention in order to give sound advice. The interviewee was to some extent aware of national and international developments concerning permitting and safety guidelines for hydrogen refuelling stations.

The 'cold calls' again exemplify that permitting procedures may slightly differ per region and that the owner of a future hydrogen refuelling station is best advised to get in touch with responsible authorities and other entities involved in the process early on. Additionally, it seems helpful if stakeholders approach those who already have experience with the subject matter for input and advice. Authorities and fire brigades may be best prepared for implementation of large-scale demonstration projects and early commercialisation of hydrogen vehicles and refuelling stations by nation-wide notification with respect to available guidelines and contacts to previous, successfully implemented projects and their partners.

It can be expected that in the future, lead times for permits of hydrogen refuelling stations will be similar to those of conventional ones (six months), as already shown by the HyFLEET:CUTE project in Amsterdam. At the moment achieving these lead times requires extensive preparation which will be diminished by increasing experience and the establishment of official guidelines, standards or new regulation. The guidelines for hydrogen refuelling stations (Nederlandse Praktijkrichtlijn 8099) are a first, important step towards much awaited official regulation.[15] Future demonstration projects (e.g. one currently under development in Arnhem) will reveal the effects of these guidelines and the need for further actions.

[15] Another report written in the framework of the THRIVE project discusses available regulation, codes and standards for hydrogen refuelling stations in more detail: Heidebrink, I. (forthcoming). *Regulations, standards and codes of practice affecting the design, installation, operation and maintenance of a hydrogen refuelling station.* TNO report.

4. Experiences concerning spatial planning and permitting procedures in four other countries: US, Norway, Germany and Italy

4.1 California Fuel Cell Partnership in the U.S.

The members of the California Fuel Cell Partnership (CaFCP) have worked towards commercialisation of hydrogen as fuel for passenger cars since 1999 when zero-emission transportation became a key element in state and national energy policy. The partnership consists of 31 members, including auto manufacturers, energy companies, fuel cell technology companies, transit and government agencies.[16] In terms of scale and scope the Californian efforts are unmatched by other initiatives. Currently there are about 300 hydrogen fuel cell vehicles and 22 hydrogen stations in operation in California. In February, 2009, CaFCP members published an 'action plan' that details a strategy for deploying hydrogen fuelling stations and fuel cell vehicles in California. In April 2010, the progress of and next steps for the action plan were published. Amongst others, this plan projects the development of early 'hydrogen communities' for passenger vehicles with clusters of retail hydrogen stations in four Southern California communities, with additional stations to support the next identified communities and a network of connector stations. Additionally, codes, standards and regulations are under development with a state-of-the-art hydrogen station in the Sacramento area that will enable regulatory agencies to validate new test procedures.

Currently, permit lead times for hydrogen stations in California can vary between 2-3 months up to two years, depending on the project location, the backlog of work of the responsible planning department, the knowledge of the authorities having jurisdiction, or any special requests on the project (e.g. extra equipment, safety, etc.). The fact that each city may have various departments that have the final say in the issuing of permits and requirements may be added to existing NFPA (National Fire Protection Agency) standards and IFC (International Fire Code) further complicates the situation in California. Michigan may be the only state with a 'uniform' protocol for permitting a hydrogen refuelling station. In all other US states similar complications as in California may arise.[17]

One of the current obstacles to fast permitting is the unfamiliarity of authorities with hydrogen and related refuelling equipment. In order to facilitate and speed up permitting procedures, the National Renewable Energy Laboratory (NREL) of the US Department of Energy has conducted 'permitting workshops' in California and elsewhere in the US. These workshops primarily target local authorities, providing background information and resources (e.g. useful web links) and sharing experience from others who have permitted stations. NREL has also developed an online *permitting tool* to support local authorities.[18]

The permitting of hydrogen stations is expected to be significantly simplified by a new NFPA standard (NFPA 2) addressing, amongst other, all safety matters and permitting issues related to hydrogen. Its publication has been scheduled for August 2011.

Concerning the transportation of hydrogen by trucks and through pipelines no problems are currently foreseen. Both means of delivering hydrogen have been in use for decades for other industrial processes and hence permitting procedures and required safety measures (e.g. load identification signage for trucks) are well established.[19]

[16] For a list of all members, see www.cafcp.org.
[17] Personal communication, Jennifer Hamilton, CaFCP, 29 June 2010.
[18] This tool can be accessed via the CaFCP Emergency Responder website: www.er.cafcp.org.
[19] Personal communication, Jennifer Hamilton, CaFCP, 22 July 2009.

Sometimes, neighbours, special interest groups and NGOs may cause lengthy permitting procedures by means of public opposition. From the technology implementers' perspective such opposition is largely caused by a lack of knowledge and met with information campaigns for involved stakeholders, communities and/or the general public.[20] The CaFCP is one of the driving forces of this process by enhancing collaboration of its members, educating officials and disseminating experience (e.g. in aforementioned workshops). A large part of streamlining has already been achieved by pilot and demonstration projects and is expected to be advanced by current/future projects, because authorities are able to contact other, already experienced authorities and because organizations building the stations are often able to build on previous (in-house) experiences. Our interviewees believe that the new NFPA standards will largely resolve current problems.

4.2 HyNor in Norway

The Hydrogen road in Norway (HyNor) is the Norwegian national initiative for the introduction of hydrogen as transport fuel. It is funded by private companies, station and car owners and local, regional and national public institutions. The funders cooperate with several research institutions and NGOs in local projects for the development of a hydrogen refuelling infrastructure and car fleet. For so far eight refuelling stations have been made available to a vehicle fleet consisting of about 20 vehicles. The fleet is planned to be extended by 2011 to 35 cars and five Fuel Cell buses. In addition to national development HyNor is active in cooperation initiative with Iceland, Sweden, Finland, Germany and the US.

The permitting lead time for a hydrogen refuelling station in Norway should be about six weeks but due to unfamiliarity with the new fuel it currently takes about four to six months. First, the county area plans have to be changed for the right purpose. Second, the Directorate for Civil Protection and Emergency Planning has to be notified for stations exceeding 400 litres of hydrogen stored on-site (which basically applies to all hydrogen stations). Based on lay-out of the station, classification of hazardous areas and a risk analysis the Directorate issues the permit required to commence station construction. Codes, standards and guidelines used are those of the 'Handbook for Hydrogen Refuelling Station Approval' (by Air Liquide), NFPA 50A Standard for Gaseous Hydrogen Systems at Consumer Sites and EIGA Gaseous Hydrogen Stations.

[20] Personal communication, Nico Bouwkamp, CaFCP, 22 July 2009.

Figure 4.1 *Hydrogen station infrastructure of the HyNor initiative*
Source: http://www.hynor.no/om/information-in-english.

To the knowledge of one of our interviewees no project has experienced problems with permitting and no project has been disapproved due to safety reasons. At the end of 2009 already four hydrogen stations had been approved by the Directorate for Civil Protection and Emergency Planning. Also the Norwegian organisations carrying out risk analyses (e.g. DNV or Scandpower) have gained experience. Already implemented projects have extended the available knowledge base and contributed to a decrease of permitting lead times. Safety guidelines for hydrogen stations are under development and expected to be published this autumn.[21]

4.3 HyFLEET:CUTE, Clean Energy Partnership, HyCologne and ZeroRegio in Germany

Several hydrogen demonstration projects have been or are currently being implemented in Germany. In the following, each of them will be summarised briefly with a focus on their permitting experiences and lessons learned concerning safety measures.

HyFLEET:CUTE
In 2006 four hydrogen buses were introduced in Germany as part of the HyFLEET:CUTE project. Their refuelling site had been installed on the premises of the *Berliner Verkehrsbetriebe* (BVG - Berlin transport company). Two of the lessons learned as formulated in 2008 were the importance of intense collaboration with local authorities and of the development of a Safety Management System, including the training of personnel.

[21] Personal communication, Arne Dybwad, DSB, 21 August 2009; Bjørn Simonsen, IET, Nov/Dec 2009.

Clean Energy Partnership

The Clean Energy Partnership (CEP) has been established in Germany in 2002 and started a demonstration project in Berlin in 2004 with two hydrogen refuelling stations and 17 hydrogen cars which was affiliated with the HyFLEET:CUTE project. In 2008, the CEP entered the second phase with 13 partners representing energy suppliers, car and refuelling industry. During this phase the partnership is extended to the Hydrogen Region Hamburg-Berlin. In the end of 2009 industry and governmental representative signed an agreement to establish a hydrogen refuelling infrastructure across Germany. During the first phase of its existence the CEP achieved the following:

- Administrative hurdles to the construction of a hydrogen infrastructure were identified, and partially overcome. Recommendations for future actions have been given. This information is, unfortunately, not accessible in more detail to the authors.
- Insights into customer acceptance and technological suitability for everyday use of car and refuelling station could be gained.
- Both hydrogen stations (Aral and TOTAL) are publicly available and integrated into existing refuelling stations. It has been shown that an integration of the necessary equipment and operational workflows is already possible and safe.

Figure 4.2 *700 bar refuelling at the TOTAL station of the CEP in Berlin*
Source: www.cleanenergypartnership.de > press > downloads

- Suitability for everyday use is accredited to the Aral hydrogen station by its tenant. Minor technical dysfunction could usually be overcome by means of remote maintenance. The inclusion of hydrogen in his station lead to some little extra tasks (e.g. assisting customers during the refuelling process) he did not mind taking care of.
- There were no complaints or substantiated worries of participating vehicle users concerning safety, neither when driving nor when refuelling.
- Person-in-charge for the TOTAL station attributes the success of the project to close collaboration of involved policy and industry partners. Involved in planning and permitting were:
  - *Senat für Stadtentwicklung* (Senate for urban development): participated in the procurement of an exceptional regulation for on-site hydrogen production (without which important technical insights into on-site hydrogen production based on an LPG reformer could not have been achieved → proved to be technically and financially difficult to maintain)

  - *Senat für Wirtschaft, Technologie und Frauen* (Senate for economy, technologie and women): participated in the procurement of an exceptional regulation for on-site hydrogen production
  - *Berliner Landesamt für Arbeitsschutz, Gesundheitsschutz und technische Sicherheit* (Berlin regional authority for occupational health and safety and technical safety): support for planning, construction and maintenance permissions
  - TÜV Rheinland Industrie Service GmbH: support for planning, construction and maintenance permissions
  - *Berliner Feuerwehr* (Berlin fire brigade): detailed information and training seminars were given concerning the handling of FCVs in case of an accident. These seminars were later also expanded to a broader audience (beyond the borders of Berlin) in order to sensitise emergency services.
- The stations' construction and maintenance adheres to strict safety regulations. There are detailed emergency plans which were elaborated in close collaboration with involved industry partners, local authorities and the local fire brigade. The same holds for continuous technical safety surveillance. Emergency plans and reporting chains were tested during several different alarm practices. External bodies, such as authorities and emergency forces were included. Cooperation was successful.
- One issue raised that had previously received little attention: safety in repair and maintenance shops. The CEP developed together with accident prevention and insurance associations regulations for the handling of hydrogen vehicles in garages (repair and maintenance shops). These regulations will be made obligatory by the associations in order to concretise the rather general federal regulations. guidelines for the handling of hydrogen vehicles in garages together with accident prevention and insurance associations. Here again no further information is available to the authors.
- A literature review has been finalised on the current status of safety-related knowledge worldwide. However, the findings do not suffice to derive final safety regulations. Hence, experiments will be conducted, in order to for example find out how much hydrogen leakage can still be considered safe. Developed regulations will then be made official and binding.

HyCologne

HyCologne is a regional innovation cluster and knowledge network between the German cities Cologne, Hürth and Brühl. At least 20 organisations and companies are involved. Source of the hydrogen are several chemical plants in the area (three Bayer, one Degussa and one Vinnolit plants) where hydrogen occurs as by-product of chemical processes. Assuming a consumption of about 1 kg per 100 km this hydrogen can potentially fuel about 450 000 cars. As part of the HyCologne project, two hydrogen buses are deployed.

The permitting process first requires a notification of the responsible municipality concerning risk and safety. So far no rejection has occurred. Then a building permit is required the lead time of which takes about 4-8 weeks. In case of the first hydrogen refuelling station for HyCologne no problems were to expected because the municipality was permit applicant and issuer at the same time. Therefore, close collaboration between stakeholders was given since the beginning. Secondly, an operational permit is required. Technical drawings care checked by the TÜV prior to construction and again afterwards in order to ensure that safety distances, required materials for fire protection etc. are adhered to and incorporated. Such a final check only takes 2-5 hours. Once the station is in operation, regular checks of sensors, for leakages etc. are required by the TÜV every 6-8 months. The project has not experienced any problems with permitting. Of course authorities were not familiar with the topic yet, but they took care to get informed and permits were processed swiftly. In that respect the active exchange of knowledge and experiences between different regions and countries support the advancing of permitting processes and help shorten lead times. Demonstration projects greatly contribute to familiarisation with the topic and substance. One of our interviewees acknowledged that such demonstra-

tion projects will have little permitting problems if strong partners are involved and good networks for collaboration have been established.

Figure 4.3 *Hydrogen refuelling station in Hürth*
Source: http://www.hycologne.de/wasserstoff-tankstelle-in-huerth-eroeffnet-chemergy.phtml.

Acquiring permits and developing emergency plans for a hydrogen installation storing less than 30t is a comparatively fast process in Germany, because stricter regulations apply for larger amounts of stored hydrogen. If more than 30t of hydrogen are stored, larger safety distances apply and it has to be ensured that the fire brigade can arrive at the station in 5 minutes or less required.

Concerning public acceptance no details are known yet, but surveys indicated that 95% of the population does not have safety concerns. They indicate that their feeling of safety is linked to the approval of the project by the TÜV Rheinland. It seems people trust the high safety standards applied by the TÜV who cooperates with KEMA (global company specializing in strategic & technical energy consultancy, operational support, measurements & inspection, and testing & certification) that has experience from Dutch project.[22]

Zero Regio in Germany
The Zero Regio project is financed by the European Commission under the 6th Framework Programme. It was carried out by 16 partners from four different countries over the duration of five years (2004 - 2009). The German sub-project of Zero Regio project is located in Frankfurt am Main (Federal State of Hessen) and makes use of hydrogen forming as by-product of chemical processes in an industrial area. The hydrogen is delivered via pipeline to a public refuelling station where hydrogen cars used for 'everyday purposes' can be filled.

[22] Personal communication, Boris Jermer, HyCologne, 30 November 2009.

The infrastructure for transporting hydrogen from source to station in Frankfurt consists of:

- Hydrogen centre of Infraserv Höchst where the by-product hydrogen is compressed up to 225 bar and stored marking the starting point (hydrogen source) of the infrastructure built within Zero Regio
- Buffer storage at 300 bar with a capacity of 2.4 m^3 geometric vol.
- Ionic liquid compressor for 900 bar (capacity 900 Nm^3/hr).
- Transport pipeline for a design pressure of 1000 bar from source to station (1.7 km) (Infraserv, 2006).

The approval procedure for a refuelling station offering several fuels (including hydrogen) requires a building permission and an operating permit for each individual refuelling unit (dispenser). The owner and operator of the stations has to file the application for the building permit with the competent authority (in this case the magistrate of the city of Frankfurt). The following offices of the magistrate are involved in the approval process:

- Building Supervision authority
- City Planning Authority
- Environment Authority
- Order and Regularity Authority

Other authorities involved are the Regional Commission Darmstadt with its department 'Environment Frankfurt' and the Lower Authority for Nature Protection and Conservation.

Figure 4.4 *Hydrogen dispensing units in Frankfurt-Hoechst*
Source: http://www.admin.zeroregio.de/CDROM/englisch/05openingagip/openingagip.html.

The application for the building permit had to follow the rules of the state Hessen[23]. It was filed in the beginning of April 2006 and granted in mid-June 2006. A lead time of 2-3 months is common for refuelling stations. Hydrogen specific questions, e.g. related to safety did not delay the approval formalities, also because they become more important when it comes to approval of operation.

The application for the operation of the hydrogen refuelling facilities has to be filed by the companies constructing the systems (in this case Infraserv and Linde) with the same authority as the building permit. The authorities involved in the approval process was the Department of Labour Protection and Safety Frankfurt (Arbeitsschutz & Sicherheitstechnik Frankfurt) of the regional commission in Darmstadt.

[23] For a complete list of the files submitted, please refer to Deliverable D4.7 of the Zero Regio project.

The application for an operating permit needs to be in accordance with the TRG 730 (Technische Regeln Druckgas - Technical regulations for compressed gas.[24] Operation approval is obtained in accordance with Paragraph 13 BetrSichV (Betriebssicherheitsverordnung - operating safety regulation) from the regional commission in Darmstadt. The application was filed in the beginning of June 2006 and the permit granted in the end of October 2006. The lead time of five months was longer than expected by the project managers. Although all required documents, including a safety evaluation by a certified independent authority had been provided, some clarifications were required. The 'delay' in approval could largely be accredited to a lack of information and know-how of the responsible personnel (Sapio & Infraserv, 2006).[25]

One of the outputs of the Zero Regio project is the Merkblatt (code of practice) 514 published by the Vd-TÜV (Verband der Technische Überwachungsvereine - association of technical inspections organisations). It was developed by a small, result oriented working group, many members of which had been involved in the planning and permitting processes of cars and stations in Germany and Italy for Zero Regio.[26] The code of practice 514 contains important definitions, requirements for pipes, dispenser, storage facilities etc., safety distances, safety measures against excess pressure, requirements for electrical systems, inspections and testing, etc. All information provided solely deals with gaseous hydrogen. Solutions concerning communication between cars and dispensing unit have been ignored, because no industry standard was available at the time. The code of practice was finalised in November 2008 and will be used by the TÜV in future approval processes.[27]

The TÜV is active worldwide, but always operates according to German (or EU) standards. The TÜV Merkblätter (codes of practice) are highly acknowledged and widely used, because they are always composed by an expert committee (in this case coming from Germany, Austria and Switzerland) and checked by external experts from university, industry (here, for example, from the gas and car industry) and TÜV internally.[28]

4.4 ZeroRegio in Italy

The Zero Regio project includes two demonstration projects, one in Germany (Frankfurt, region of Rhein-Main) which is discussed in the previous chapter and one in Italy (Mantova-Valdaro, region of Lombardy). In Italy one refuelling unit for compressed hydrogen at 350 bar was built as annex to a conventional multi-fuel public refuelling station.

[24] For a complete list of the files submitted, please refer to Deliverable D4.7 of the Zero Regio project.
[25] Personal communication, Heinrich Lienkamp, Infraserv, 4 August 2009.
[26] Excerpt of the list of contributors to the Vd-TÜV Code of practice: Air Liquide, Bosch, BMW Group, Daimler AG, Deutscher Wasserstoff- und Brennstoffzellen-Verband e.V., GM Powertrain Germany GmbH, Linde Gas, Infraserv, MBtechnology GmbH, Shell Hydrogen B.V. ,Thüringer Landesbetrieb für Arbeitsschutz und technischen Verbraucherschutz, Total, TÜV Hessen, TÜV Nord, TÜV Süd.
[27] Personal communication, Lars Komrowski, TÜV Hessen, 4 August 2009.
[28] An English code of practice (translation of the TÜV Merkblatt) was published at the World Hydrogen Energy Conference (WHEC) 2010 and is available from the TÜV website http://www.vdtuev.de/publikationen/merkblaetter.

Figure 4.5 *Layout of the ENI service station in Mantova*
Source: http://www.admin.zeroregio.de/CDROM/englisch/10openingeni/opening/index.html.

The two projects thus have different technical set-up and also proceeded quite differently in terms of permitting, mostly due to the different permitting systems. The process took much longer in Italy and resulted in different safety requirements than in Germany. For example, in Italy it was made a requirement to build a bunker for hydrogen storage which of course increased the cost and construction time of the project and gave a deterring message to the public. According to our interviewee, EU regulations may have been interpreted differently. Additionally, the approval process is much more complex in Italy than in Germany, includes more involved institutions, more individual steps and each facility of the station, including the hydrogen installation required an individual application. Due to the fact that the approval procedure was quite unclear in the beginning, a lot of time and effort had to be invested in preparation before even initiating the approval process. The following steps had to be undertaken:

1. The requesting company files the application[29] for the 'Single Authorisation Act' to the competent municipal office (in this case the Sportello Unico per le Imprese - single front office for companies).
2. The competent authority checks the completeness of the documentation and forwards it to the following public entities to obtain advice:
   a. Regione Lombardia (Trade and Fuel Office)
   b. Mantova Fire Brigade
   c. Technical Revenue Office
   d. Local Health Agency (ASL)
   e. e. Regional Environmental Protection Agency (ARPA)
3. Once advices are obtained and the town planning and building standpoint have concluded the technical inquiry, the competent authority prepares the text of the 'Single Authorisation Act' and submits it to the Municipal Building Commission. Once the 'Single Authorisation Act' has been approved it has a validity of three years starting from the beginning of construction works.
4. The applicant has to notify the competent authority when construction works will begin and end.
5. When construction has been finalised, the entities responsible for accident prevention and control carry out the test inspection of the station.

[29] For a complete list of the files submitted, please refer to Deliverable D4.7 of the Zero Regio project.

The permitting process in Italy was initiated when ENI applied for the 'Single Authorisation Act' at the Sportello Unico in August 2003 for a multi-fuel service station, already one year before the Zero Regio project was approved by the European Commission. In July 2005 the hydrogen facilities were added to the application and the 'Single Authorisation Act' was finally approved in May 2006. A 10 months lead time had not been anticipated at the start of the project and was mostly due to extensive safety analysis required in absence of regulation. Approval practices of other countries, e.g. Germany where the other Zero Regio demonstration project was located, did not help to speed up formalities.

Since August 2006, a new regulation for hydrogen dispersion systems is active in Italy. For the Zero Regio demonstration project the new legislation posed a new challenge. It is based on a 'technical rule' that had been approved in 2004 and which included suggestions by the Zero Regio consortium. However, the new regulation requires safety distances 50% larger than those mentioned in the draft 'technical rule' which was applied in the design of the ENI station. Therefore, in 2006/2007 some mediation between the demonstration project implementers, the local fire brigade and the newly enacted regulation became necessary. A 3x2 m concrete wall became a safety requirement. In order to avoid sending an alarming message to the public, some pipe construction was used as 'artistic mask'.

Figure 4.6 *Zero Regio hydrogen refuelling unit in Mantova showing the 'masked' concrete wall*
Source: http://www.admin.zeroregio.de/CDROM/englisch/10openingeni/opening/index.html.

Finally, in September 2007 the opening ceremony of the public multi-fuel station including hydrogen took place with a 10 month delay. This delay had been buffered by means of a SAPIO mobile hydrogen refuelling unit in order to ensure implementation of the pilot project. The on-site hydrogen production unit was only inaugurated again 10 months later, in July 2008 due to internal procedures of the project partners responsible for this unit. This delay was again buffered by SAPIO this time by hydrogen truck deliveries.

Apart from problems and delays in the approval processes of the hydrogen refuelling station, the Italian Zero Regio partners also met problems in the approval processes of the hydrogen vehicles. In the end, three different permitting pathways had been taken for the three different vehicles, a tank pressure of only 200 bar and transit permission had to be acquired from the owner of each road to be used. Transit was not permitted for tunnels and highways.

The Italian project implementers concluded that this demonstration project revealed the great inadequacy of the existing Italian regulatory system with respect to permitting requirements and procedures. The new legislation, catalysed by the demonstration project will most likely make it easier and faster to attain building permits for public hydrogen refuelling stations. Required safety distances have been revised and will most likely be appropriate for current stations and technical standards (Sutti, 2010) although proof for this assumption has to be obtained by the next hydrogen refuelling demonstration project in Italy.

4.5 What the Netherlands can learn from other countries

In California, the new code NFPA 2 Hydrogen Technologies Code which is expected for 2011 is much awaited. Until then increasing knowledge base and growing experience from several demonstration projects help to streamline efforts and speed up permitting processes. Similar impressions have been reported from Norway. So far no problems with permitting have been encountered there and existing regulation seems to allow smooth application and approval processes. In Germany the growing number of implemented demonstration projects also facilitates permitting and also here official guidelines, comparable to the NPR 8099 have been developed. In Italy approval of hydrogen refuelling stations follows very different, more complex procedures than in the other countries considered here. However, a new regulation which is in place since 2006 may improve the situation but it has yet to prove its effects.

The Netherlands are among those countries that are currently developing official guidelines, which serve as intermediate step until EU regulation becomes available. A field where the Netherlands can improve, until official safety and permitting guidelines are available, is the collaboration and communication among relevant stakeholders of ongoing demonstration projects. Although interviewees from the US, Norway and Germany report varying lead times for permitting procedures, based on the complexity and novelty of the technical systems to be used, no one shared experiences of a failed, or almost failed project as occurred in the Netherlands. For the Netherlands, recommendations are mainly based on experiences made in Dutch projects, corroborated by experiences made in other countries. One lesson learned is to ensure a careful selection of project partners for demonstration projects. A second lesson learned is the emphasis on open, frequent and transparent communication among project partners, involved authorities, advisory bodies and independent risk analysis organisations. A third lesson concerns the sharing of previously made experiences, e.g. between experienced and 'virgin' stakeholders who are involved in such process for the first time. Possible tools for frequent and efficient communication could be regular meetings and workshops at which experienced project partners share their insights and discuss a current project with all parties involved. That way a 're-invention of the wheel' may be avoided, and mistakes made in one project may be avoided in future ones. The exchange of such knowledge and experience is not only crucial for companies and organisations implementing such projects but also for those who are responsible for issuing permits and providing safety, accident prevention and emergency response advice.

Experiences from other countries show that an organisation that coordinates the development and sharing of knowledge among stakeholders interested in hydrogen infrastructure development is lacking in the Netherlands. Such an organisation, as embodied, for example, by the CaFCP in the US, the CEP in Germany, HyNor in Norway, and the Japan Hydrogen and Fuel Cell Demonstration Project (JHFC) in Japan can hold an important networking function and can contribute to all issues mentioned above: it can help select appropriate project partners and support collaboration and communication. Therefore, such organisation can serve as first 'national contact point' for fuel suppliers, transport companies or authorities that are (about to become) involved in a pilot or demonstration project. It can constitute a network of experts familiar with regulation, permitting procedures and actors involved in the planning, permitting and implementation of a hydrogen refuelling station in a particular country. Such a 'network or partnership organisation' can help speeding up planning and permitting processes by connecting the appro-

priate people from fire departments, authorities, knowledge and normalisation institutes, regional and state government, industry organisations, etc. If a question arises, the best suited respondent can more easily be found if all contacts run together within one organisation. Additionally, such an organisation can operate as important industry representative by showing a coherent image of collaboration to the outside world, taking care of public relations and providing information. Damage done by dispersing incoherent information, e.g. concerning the characteristics of hydrogen, among the public, authorities or other stakeholders can be avoided if knowledge and findings are shared and discussed within such a partnership organisation.[30] Preferably, public interest groups or non-governmental organisations are invited to participate in discussions and the development of agreements, guidelines and procedures.

[30] Personal communication, Nico Bouwkamp, CaFCP, 1 July 2010.

5. Expert opinion on THRIVE model assumptions

This report forms part of the THRIVE research project and aims to support the work conducted in this project to model the development of a hydrogen refuelling infrastructure and hydrogen vehicle uptake in the Netherlands. The relevant question is therefore, whether the current status of the hydrogen refuelling infrastructure, safety guidelines and permitting procedures supports assumptions made in the building and running of the THRIVE model. The only case discussed here is the 'high case scenario' in which support and actions from policy makers, original equipment manufacturers (OEMs) and oil and gas companies (for refuelling infrastructure development) are assumed to be high, resulting in the following station build-up: 17 stations available in 2015, another 22 in 2016, again 22 in 2017 and another 44 in 2019 (see Table 4.1). These are assumed to be spread over the country in many different municipalities.

Table 5.1 *THRIVE model assumptions concerning refuelling infrastructure growth, 'high case scenario'*

Year	2015	2016	2017	2019
Total amount of public H_2 stations available in NL	17	39	61	105

Experts from the infrastructure industry have been asked to reflect on the current status of hydrogen in the Netherlands and the potential of such a development. One issue raised by experts was the lack of harmonisation of existing regulation across different countries which has already been discussed in this report. Companies see that their experience gained in one country cannot be transferred to another country, which may hamper large-scale refuelling infrastructure roll-out in Europe.[31]

Specifically for the Netherlands, the most recent approval process for a hydrogen refuelling station in Arnhem has been a success largely due to strong support of local authorities in close collaboration with the fire brigade. The expert contacted assumes that a smooth permitting process in one municipality has positive impact on following processes, even if implemented in other municipalities, due to the fact that it has been shown to be possible elsewhere. The permitting process in Arnhem was strongly facilitated by research done at TNO showing that safety distances for hydrogen can be smaller than for LPG and petrol. The soon to be published NPR 8099 is meant to provide support to local authorities and is expected to make future permitting processes easier. Furthermore, there is a document in preparation at the Dutch fire brigade association that provides information to local fire brigades how to deal with a fire at or near a hydrogen refuelling station. This document is also likely to contribute to smoother permitting procedures in the future. These developments are perceived positively by industry. Nevertheless, experts are hesitant to make future projections concerning refuelling station infrastructure development. In their view, it depends on all stakeholders involved (i.e. car and infrastructure industry, consumers, authorities/policy makers) and in their view developments are especially dependent on decisions made by policy makers with respect to financial support (e.g. tax incentives) for consumers in order to facilitate the market entry of hydrogen cars.[32] Another ECN report written in the framework of the THRIVE project discusses the relation of consumers' decision to buy cars driving on an alternative fuel (e.g. hydrogen) and the necessary refuelling infrastructure required (Mourik, Bunzeck & Backhaus, forthcoming).

Other experts agree that projections about the build-up of hydrogen refuelling infrastructure in the Netherlands are difficult to make but assume those shown in Table 4.1 are too optimistic.

[31] Personal communication, Phillipe Mulard, TOTAL, 26 June 2010.
[32] Personal communication, Peter Bout, Air Products, 18 June 2010.

Strong impetus can currently be observed in Germany, based on an industry agreement between OEMs and refuelling industry, financially supported by the government. The current planning foresees about 10 hydrogen refuelling stations in Germany by 2011. Experts expect slower advancements in the Netherlands, also because the car industry promoting hydrogen strongly in Germany is lacking in the Netherlands. More concretely, experts see proceedings in the Netherlands follow those in Germany by 3 - 5 years. Currently they assume little progress until 2015 when series production of hydrogen vehicles is expected to start and refuelling infrastructure ramp-up is needed to provide service to these vehicles. Only by 2019, when mass-production of hydrogen vehicles is expected to start, large-scale infrastructure developments are likely to occur, because then stations become more economically viable and investment risks much lower. Of course, if hydrogen mobility proves to be a success earlier, the confidence and readiness to invest of industry grows. Conversely, any indication of a lack of action and confidence on the part of any stakeholders involved can retard all developments by several years. In other words, the figures assumed in the THRIVE model may materialise, but rather at a later stage. Current activities in the Netherlands give no indication for a hydrogen station ramp-up of 17 stations by 2015 and the Netherlands are more likely to follow the (currently more moderately projected) developments in Germany. [33]

[33] Personal communication, Gert Jan Kramer and Jurgen Louis, Shell, 24 June 2010.

6. Summary and conclusions - preparing the Netherlands for the permitting of a hydrogen infrastructure

The report at hand discusses permitting procedures and experiences gained in the Netherlands, the US, Norway, Germany and Italy, as well as the important work towards European safety regulations for hydrogen refuelling stations done by the HyApproval and HySafe projects. Concerning the developing of safety guidelines and appropriate permitting procedures, the Netherlands appear well on track and in a similar position as other countries. Concerning the communication among project partners the Netherlands experienced one 'model' project. In the Amsterdam HyFLEET:CUTE project the excellent communication and collaboration among everyone involved allowed a smooth permitting process and helped shield the project from unjustified protests. Recently, another hydrogen station in the city of Arnhem has undergone permitting procedures successfully, without any public opposition. This can also largely be attributed to close cooperation of project partners, local authorities and the fire brigade. [34] However, the Netherlands also have record of one permitting procedure 'gone wrong' in which collaboration among partners and communication with authorities led to the a near-failure of the project. The following table summarises the status of permitting procedures and safety guidelines in different countries and the experiences made during pilot projects:

Table 6.1 *Summary table of current safety guidelines and bottlenecks in permitting procedures for five European countries*

Country/State	Safety guidelines or regulation under development or already available	Current permitting lead times as reported by pilot projects	Current bottlenecks	Measures taken to countervail bottlenecks
The Netherlands	NPR 8099:2010 (final version to be published soon), document prepared by the Dutch fire brigade association for local fire brigades on how to deal with fire at or near a hydrogen refuelling station	6 months (+ project-dependent preparation time)	Lack of guidelines and regulation, lack of knowledge of authorities and fire and rescue services, lack of coordination/ communication	Close cooperation and frequent communication among network of relevant stakeholders, e.g. by setting up a partnership organisation (similar to CaFCP, CEP & HyNor, for example)
California	NFPA 2 (under development, publication scheduled for August 2011)	2 months - 2 years (depending on type of project and stakeholders involved)	lack of knowledge of authorities and fire and rescue services	Workshops to increase knowledge of and familiarity with subject matter, development of online 'permitting tool' to support local authorities during permitting processes by NREL

[34] Personal communication, Peter Bout, Air Products, 18 June 2010.

Country/State	Safety guidelines or regulation under development or already available	Current permitting lead times as reported by pilot projects	Current bottlenecks	Measures taken to countervail bottlenecks
Norway	Air Liquide 'Handbook for Hydrogen Refuelling Station Approval', NFPA 50A and EIGA Gaseous Hydrogen Stations, safety guidelines currently under development (to be published autumn 2010)[35]	4 - 6 months (+ preparation time)	(no project has experienced significant delays or disapproval due to permitting issues)	Close cooperation and frequent communication among network of relevant stakeholders
Germany	TÜV Merkblatt (code of practice) 514 + Betriebssicherheits-verordnung (safety regulation during operation)	Building permit: 2 - 3 months (no delay; operational permit: 5 months (some delay)	Lack of knowledge of relevant authorities	Constant enlargement of hydrogen refuelling network (collecting experiences), dissemination of TÜV Merkblatt 514
Italy	(since August 2006) regulation for hydrogen dispersion systems (incl. safety regulation)	10 months (+ preparation time)	Complex permitting system (each component requires individual permit, many institutions/ authorities involved)	Regulation is likely to speed up processes

Based on the review of experiences made in the Netherlands and abroad the following recommendations for future demonstration projects can be put forward:

1. Any hydrogen refuelling project is based on a fruitful collaboration of all partners. Therefore, project partners should be selected carefully and good communication should be first priority.
2. Close contact with responsible authorities and advisory bodies should be sought early in the process to avoid problems at a later stage and enable smooth approval processes for required permits. Early contact helps to establish trust and open communication necessary to master potential complications at a later stage.
3. Transparent communication among all project partners, but also with responsible authorities and advisory bodies is crucial for good project implementation.
4. Evaluate early possibly conflicting interests of stakeholders (e.g. private neighbours, companies) in the close vicinity of the project and seek active exchange in order to avoid protest arising at a later stage in the project.
5. Keeping good records and including a project evaluation helps establishing a knowledge base which future projects can rely on. Pilot projects serve to build up experience and expand knowledge, therefore leaving records of both as project output provides important support for all stakeholders involved in future/other projects.

[35] Personal communication, Arne Dybwad, DSP, 2 July 2010.

Of course there are actions that can be undertaken to speed up and facilitate the permitting process for hydrogen refuelling stations in a late demonstration/early commercialisation stage of the technology:

1. Information about existing regulation and guidelines[36] and the application thereof can be disseminated to all relevant authorities and advisory bodies, e.g. Nederlandse praktijkrichtlijn (Dutch practical guideline) for hydrogen refuelling stations NPR 8099 among local authorities and document of Dutch fire brigade association among local fire brigades.
2. Information can be disseminated through media (e.g. local newspapers) to increase the general familiarity with the new technology.
3. Organisations or companies implementing a demo project and the authority responsible for permits could actively seek contact and exchange with the implementers of already successfully implemented projects (currently the HyFLEET:CUTE project in Amsterdam). Regular meetings or workshops with experienced parties facilitate such exchange.
4. The Californian example of an online 'permitting tool' that can support local authorities during permitting processes may be another helpful approach to efficient and successful permitting procedures.
5. A partnership organisation similar to the CaFCP, for example, can support all of the above listed processes by facilitating the formation of networks and supporting exchange among relevant actors from industry, knowledge and normalisation institutes, authorities, fire and rescue associations, regional and state governments, public, etc.

Experts are calling for European legislation in order to ensure permitting processes and lead times comparable to those currently in place for refuelling stations, namely six months. Once such regulation is in place, permitting procedures will be largely harmonised among European countries. The time until such regulation has been developed and implemented might best be bridged by extensive stakeholder cooperation within and across countries. Knowledge and experiences are currently accumulated in different countries. Pilot projects are of high importance for technological learning regarding codes and standards. Institutional and organisational learning with respect to appropriate (safety) requirements and permitting procedures is also crucial. Additionally, (social) learning occurs during pilot and demonstration projects, e.g. concerning the different roles stakeholders (need to) take in permitting processes, appropriate timing of actions for the application and issuing of permits and the necessary information exchange to make such processes efficient. All these learning processes are of prime importance for a smooth transition to (large-scale) demonstration projects, which in turn pave the way for actual commercialisation of hydrogen refuelling stations. Most of the current permitting problems and uncertainties regarding risks and safety are likely to abate after the first roll-out of several hydrogen refuelling stations in each country and the implementation of EU regulation.

[36] Another report written in the framework of the THRIVE project discusses available regulation, codes and standards for hydrogen refuelling stations in more detail: Heidebrink, I. (forthcoming). *Regulations, standards and codes of practice affecting the design, installation, operation and maintenance of a hydrogen refuelling station.* TNO report.

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Wurster, R. (2004): *Hydrogen Regulations, Codes and Standards for road Vehicles and their refuelling Infrastructure in Europe*. Presentation given at the CUTE - Bringing a fuel cell bus fleet on the road in European cities project meeting, 14-15 June 2004, London, GB

Appendix A List of interviewees

Name	Organisation	Information provided
Peter Bout	Air Products	Permitting experiences made in Arnhem, NL and public acceptance of hydrogen refuelling stations
Nico Bouwkamp	Californian Fuel Cell Partnership (CaFCP)	Permitting and safety information based on experiences and legislation in California, US
A. Frits van Drunen	Gemeentevervoerbedrijf (GVB) Amsterdam	Experiences as project manager of the HyFLEET:CUTE demonstration project in Amsterdam, the Netherlands
Arne Dybwad	Directorate for Civil Protection and Emergency Planning, Norway	Provided information about role of Directorate in the permitting process
Jennifer Hamilton	Californian Fuel Cell Partnership (CaFCP)	Permitting and safety information based on experiences and legislation in California, US
Gert Petra Haugom	Det Norske Veritas AS (DNV)	Experiences made in Norwegian demonstration project
Ingrid Heidebrink	TNO	HyApproval reports and background documents (e.g. interview summaries with stakeholders)
Nadine Hölzinger	Element 1 - Coordination Centre of Hydrogen Berlin, project by Spilett New Technologies GmbH	Permitting experiences made in Berlin and the CEP
Boris Jermer	HyCologne	German spatial planning and permitting procedures
Lars Komrowski	TÜV Hessen	Contributed to the 'TÜV Merkblatt Anforderungen an Wasserstofftankstellen' and efforts to streamline permit processes
Gert Jan Kramer	Shell	Expert reality check of THRIVE model assumptions
Heinrich Lienkamp	Infraserv	Lead times experienced in the Zero Regio project
Jurgen J. Louis	Shell	Expert reality check of THRIVE model assumptions
Pascal Meyvaert	Linde Gas	Permitting experiences in Belgium
Phillipe Mulard	TOTAL	Permitting experiences in Germany and Belgium
Bjørn Simonsen	Institute for Energy Technology	Experiences in Norwegian demonstration projects