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PROFILING REGIONAL AND COMMUNITY LEVEL

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The European Commission is supporting the Coordination Action "HyLights" and the Integrated Project "Roads2HyCom" in the field of Hydrogen and Fuel Cells. The two projects support the Commission in the monitoring and coordination of ongoing activities of the HFP, and provide input to the HFP for the planning and preparation of future research and demonstration activities within an integrated EU strategy.

The two projects are complementary and are working in close coordination. HyLights focuses on the preparation of the large scale demonstration for transport applications, while Roads2HyCom focuses on identifying opportunities for research activities relative to the needs of industrial stakeholders and Hydrogen Communities that could contribute to the early adoption of hydrogen as a universal energy vector.

Further information on the projects and their partners is available on the project web-sites www.roads2hy.com and www.hylights.org

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PROFILING REGIONAL AND COMMUNITY LEVEL

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1. Introduction

This report is a deliverable of the Roads2HyCom project, a partnership of 29 stakeholder organisations supported by the European Commission Framework Six program. The project is studying technical and socio-economic issues associated with the use of Fuel Cells and Hydrogen in a sustainable energy economy. Within the project, several studies have been made related to the question of technological evolution, and routes by which Fuel Cell and Hydrogen technologies can enter early then mainstream markets. This report describes a study that looks at how regional factors might influence technology uptake scenarios. In common with other studies within the project, this study has found that regional factors have limited influence on the detail of how technologies evolve, but that an appropriate political climate and "political will" can significantly influence uptake.

Worldwide demand for energy is growing at a rate that is cause for concern. The European "World Energy Technology and Climate Policy Outlook" (European Commission 2003) predicts an average growth rate of 1.8% per annum for the period 2000-2030 for primary energy worldwide. Currently this steadily growing demand is being met mainly by fossil fuel reserves, which largely emit greenhouse gases as well as other pollutants. In addition, those reserves are diminishing and they will become increasingly expensive. The current level of CO_2 emissions per capita for developing nations is 20% of that for the major industrial nations. As developing nations industrialise, this will increase substantially. Forecasts suggest that by 2030, CO_2 emissions from developing nations could account for more than half the world's CO_2 emissions (European Commission 2003). Industrialised countries can and should lead the development of new energy systems to offset this, deploying their head start in innovation and technology. Despite immense costs for this transition, environmental benefits, technology advancement and sustained economic growth could be a worthwhile trade-off.

New energy systems will also improve energy security, which is another major issue. Fossil fuels, particularly crude oil, are confined to a few areas of the world. The continuity of supply is governed by political, economic and ecological factors. The recent diplomatic crisis for natural gas demonstrated this clearly. All these factors conspire to force volatile, often high fuel prices while, at the same time, environmental policy is demanding a reduction in greenhouse gases and harmful emissions. To tackle any of these problems at the right scale, new energy systems require a strong market pull. This requires a suitable policy framework, but cannot be induced by it alone. Policies only create favourable boundary conditions with economic incentives – real-life markets need to develop with the end-users.

One of the most important end-user groups is the regions which have their own interest in local air quality, employment and prosperity through the establishment of innovative technology industries. These "communities", which include cities, regions and larger industrial conglomerations, can play a crucial part in transforming hydrogen and fuel cells from pre-commercialisation technologies into globally significant energy mechanisms by providing niche and early markets, thus nurturing the hydrogen industry and provide testing grounds for a widespread, large-scale deployment. It is for this reason that the European Parliament has adopted a declaration on establishing a green hydrogen economy and a third industrial revolution in Europe through a partnership with committed regions and cities, SMEs and civil society organisations in May 2007 (Gurmai et al. 2007).

Recent years have shown, however, that only a very limited number of communities have set up a community vision for the uptake of hydrogen let alone shown any financial commitment or project activities.

This might be because many communities have never taken into consideration the hydrogen option in their energy agenda. A common perception of hydrogen is that of an immature or expensive technology. As a consequence, hydrogen has not yet found a satisfactory diffusion in local politics and thinking. For a real impact, in terms of environmental benefit, supply independence and innovation, an enormous engagement needs to be aimed for. Considering the substantial time it takes to create and establish markets for new technologies, initiatives as well as activities have to commence promptly.

Not all communities would need that much time, though. There might be communities that have all the prerequisites already to become successfully involved in hydrogen projects but have never thought of hydrogen as an option in their energy agenda. Maybe there is both a local air quality problem and a large source of hydrogen. This would make it easier to introduce an innovative solution for the problem at bearable costs, because the hydrogen would not need to be specially produced. Maybe there are other factors that influence an early uptake or at least a successful series of demonstration projects. As another example, it could be expected that the predominance of a certain energy source, infrastructure, industrial strength or political incentive may impact how the new technologies enter the market in any given region. Such factors may also exist on a "mega-regional" level, where several regions are "clustered" or even all or part of several member states are embraced.

Hence the aim of this task is to identify regions and communities "yet undiscovered" by finding a set of regional factors that might play a significant role in the start up and the success of hydrogen activities, most likely a demonstration project, because of a relationship between a regional characteristic and the attributes of a future technology evolution route. The term "community" (as in "Hydrogen Community") was taken to literally mean a geographical unit (cf. discussion of "community" term in Roads2HyCom Work Package 3; reports to be found online on www.roads2hy.com/wp3.html). These regional factors could be seen as some sort of "generic profile" which fosters the uptake of fuel cell or hydrogen technologies in the region or community. Once a set of parameters is defined, profiling could be carried out for all of Europe, revealing potential "hydrogen communities", i.e. currently unknown regions with favourable hydrogen uptake conditions, and achieving a tentative estimate of the potential of a region to successfully develop hydrogen and fuel cell activities beyond demonstration status, at least for the early stages of the adoption of the new technologies.

The intention was to use this knowledge to influence hypotheses on how the technology itself might develop, via the influence of these regional demands on technology choices [1].

1 See also Bader et al. 2008 an analysis of regional clusters across Europe

In detail, a typology of EU regions (6 to 8 references) and of communities within them (from Roads2HyCom WP3 results) is to be built. The study is then to look at specific current examples of communities within each type of region, based upon:

- Examples and experience gained in hydrogen demonstration projects for transport (such as CUTE) or stationary applications in specific communities
- Experience from related projects in other parts of the world with similar regional characteristics
- Input from projects related to commercialisation of innovative technologies

For transport related projects this Work Task has interfaced with the project HyLights in order to build on the data available in that project (www.hylights.org).

2. Methodology

In the course of the research it became clear that previous assumptions for the methodology to be used in the project Roads2HyCom were rendered obsolete and required a number of adjustments and updates in order to carry out the required analyses. This chapter describes the original goals and methodology and then explains the change in approach, and outlines the next steps in preparing the work task output.

2.1 Original methodology

The factors determining the potential of a region to successfully build demonstration projects could include ‘capacity’ factors (cf. Shaw and Mazzucchelli 2007) like:

- Technical availability of technology, for instance the existence of hydrogen infrastructure or production, relevant industry, etc.
- Availability of finance, for instance low public debt, high average income, access to funding, etc.
- Availability of know-how, for instance trained personnel, universities with relevant courses, average training status of population, etc., or
- Availability of political support, for instance expressed as innovation strategies, political backing for H2&FC, etc.

Other factors are ‘need’-derived, like:

- Traffic profiles, for instance high proportion of public transport, modal mix, congestion taxes etc.
- Pollution problems, for instance GHG, air pollutants, noise etc.
- High energy prices, necessity to import energy etc.

In order to describe these factors a list of possible metrics was drawn up (cf. table 1).

Table 1: Metrics describing region potential for hydrogen and fuel cell take-up in various fields

Main Metric	Sub-Metric
Traffic	number of commuters (across ‚region' boundary)
	modal mix of commuter traffic (across ‚region' boundary)
	modal mix of intra-region traffic
	public transport as passengermiles [1000 km]
	public transport (ticket prices inner-city)
	existence congestion taxes, inner city traffic regulations
	number of cars [1000]
	daily milage per car [km]
	airport existing (number/traveller and visitor per year)
	harbour existing (number/total handling of goods [1000 ton])
	train station existing (number/traveller and visitor per day)
Buildings	number of houses/buildings
	number of flats/units
	percentage of single or double houses
	percentage of multifamily houses
	percentage of non-residential buildings
	total floor space [1000 m2]
Economy	total population
	population density [population/km2]
	GDP per capita [€]
	total GDP in area [mio €]
	public debts [mio €]
	public expenditure [mio €]
Energy	industry/commercial electricity consumption [mio kWh]
	industry/commercial gas consumption [mio kWh]
	industry/commercial heat consumption [mio kWh]
	residential electricity consumption [mio kWh]
	residential gas consumption [mio kWh]
	residential heat consumption [mio kWh]
	total electricity consumption [mio kWh]
	total gas consumption [mio kWh]
	total heat consumption [mio kWh]
	price electricity [€/kWh]
	price petrol [€/litre]
	price diesel [€/litre]
	price residential natural gas [€/kWh]
	price industrial natural gas [€/kWh]
	price heating oil [€/kWh]
	degree days
	CO_2 emission per capita [ton CO2equiv. per year]

Then a typology of regions was defined as follows:

1.	Metropolitan Areas	(>1,000,000 inhabitants)
2.	Urban Areas	(150,000 - 1,000,000 inhabitants)
3.	Interregio Areas (connecting urban areas)	(>1,000,000 inhabitants)
4.	Region	(<500,000 inhabitants)
5.	Rural Area	(<100,000 inhabitants)
6.	Peripheral (remote) Area	(<20,000 inhabitants)
7.	Island (remote) Area	(<20,000 inhabitants)
8.	Non-localised	(fleets, networks, etc.)

The task was then to proceed in three steps:

1. Evaluation of demonstration project success factors: an analysis using output from Roads2HyCom WP3, WP4/5, WP6 and WP7, and the PREMIA, HyWays and HyLights projects in order to identify whether any of the above mentioned metrics can be correlated with the success of failure of hydrogen and fuel cell demonstration projects

2. With the identified parameters run a search over European regions identifying the regions with high potential for running successful projects

3. Analysis of factors indicating a 'high technical potential' for successful operation of a demonstration scheme (e.g. access to hydrogen, existing infrastructure, etc.); run a search for these parameters across European regions

The first selection of regions was made according to the above listing in order to test the feasibility of the methodology. The list is shown in table 2.

Furthermore an initial list of metrics was established oriented at table 1.

Table 2: First selection of sample regions for initial methodology feasibility analysis

Community Type	Community (=Region/Municipality)
Metropolitan areas	Paris Berlin London Hamburg Rome Madrid Barcelona Porto Stuttgart Copenhagen Stockholm
Urban areas	Amsterdam Brussels Munich Oldenburg Bremen Groningen
Inter-regio's	Aachen Liege Maastricht Oldenburg – Bremen – Groningen Aachen – Liége – Maastricht
Regions	*no entries*
Rural regions	*no entries*
Peripheral (remote) regions	Scotland Wales Pays Basque Wangerland
Islands	Iceland Faroer Juist Mynos
Non-localised projects	Pan-EU vehicle fleet Airport network (incl. a/c) Harbour network Train service

2.2 First evaluation of data

Data collection was attributed to the various task partners. An attempt was made to assemble a data set that was as compete as possible in order to be able to analyse any interdependencies of parameters with either project success or failure, or with the theoretical potential of a region to support a hydrogen and fuel cell project.

In order to perform a correlation analysis the regions and locations for the first analysis were chosen as

- The sites of concluded and ongoing demonstration projects (for instance the CUTE sites) or
- As similar sites to the above but lacking demonstration projects (for instance Brussels or Paris as large capitals without H2&FC projects)

In this way sites would be comparable in many aspects and the reasons for the existence, successful completion (and continuation) of projects or the lack thereof would be accessible to analysis. In order to have a broad picture various locations according to the above typology were chosen for data collection. Care was also taken to select regions and locations that were already covered in other projects and demonstration project analysis in order to make maximum use of existing data and analyses. Data were obtained from HyWays, HyLights and the PREMIA projects as well as from Roads2HyCom Work Packages 3, 4, 6 and 7.

It became obvious that the profiling data collected in HyWays were meant for country profiling as input to a pathway selection process model (see D3.14 of HyWays publications; to be found on www.hyways.de). Likewise HyLights had a different focus in their assessment reports and was not specifically addressing the indicators, factors or profiles of regions for the success of a project (see D2.5 and others[2)]; all to be found on www.hylights.org).

When compiling the data, it quickly became clear that comparisons would be extremely difficult. Much data were not available for all sites or were not defined according to the same standards. The gaps in data for all the important fields rendered the analysis useless since the missing data were strewn haphazardly across all categories and sites.

Therefore it was decided to reduce the database in order to perform an in-depth analysis of a limited number of sites with a stable set of data before deciding on further steps.

[2)] D2.5 with a focus on lessons learned and operational experience of transport projects, D3.3 with a Monitoring and Assessment Framework for performance assessments of transport projects, D3.4 as having a workshop for dissemination, D4.2 with a SOTA of H2FC-technologies and end-user requirements and an outlook for a future definition of high-potential regions for transport demonstration projects in successive reports not yet released, D5.1 on a EU-wide policy support scheme, D5.1 and 5.2 about developing indicators for contractual relationships in future transport demonstration projects, and D5.3 about indicators for operational management; see also Bader et al. 2008 for an analysis of regional clusters across Europe.

2.3 Definition of success factors

One of the goals of the task was to determine what parameters from the list in table 1 might determine whether a project was successful or not. Therefore sites were analysed which had conducted projects. The next step was to determine, what properties influenced the 'success' of a project. As a first hypothesis, the continuation of a project without further funding or within follow-up activities was suggested as a definition of 'success'. An 'unsuccessful' project would be terminated for good with no follow-up activity.

Further, similar sites to the above with no projects were included in an attempt to predict the success potential of the latter. These first assumptions were merely used to start the analysis in this work task and are not intended as a concise definition of a 'success factor'.

2.4 Reduction of test database

The database was reduced to the following list (cf.table 3). All cities that conducted a CUTE project[3)] are included, plus three large European cities with no hydrogen activity, plus one city with a different hydrogen project. The reason for this choice is that the project requirements for all the CUTE cities were the same, facilitating a basis for comparison. In addition, and this is what it makes interesting for the present report, some of the cities have discontinued their activities, not engaging in the follow-up project HyFLEET:CUTE[4)]. Meanwhile other cities have extended their bus programmes by initiating further demonstration projects that do not benefit from the European Commission 35% subsidy. This gives an ideal start for a comparison of profiles. Obviously, although all cities had the same starting position, the project was not as "successful" in some cities as in others. This means it did not have the impact and the "sustainability" it could have had.

The inclusion of three large European cities has the advantage of comparing same-sized urban centres with no hydrogen demonstration project. They serve as a reference in answering the question what circumstances encourage the uptake of hydrogen energy projects.

Lastly, Munich with its airport project was chosen as it had a different activity than the CUTE cities, but also discontinued its project.

The first six entries are also labelled as 'C-cities' for continuation of activities after the initial project has ceased, the next four as 'D-cities' for discontinuing the project.

3) FP5 project "Clean Urban Transport for Europe", www.fuel-cell-bus-club.com
4) FP6 project "HyFLEET:CUTE", www.global-hydrogen-bus-platform.com

Table 3: Reduced selection of investigated cities.

City	Project 1 (35 % subsidised)	Project 2 (continuation, also 35 % subsidised)	Project 3 (continuation, no subsidies)
Amsterdam	CUTE	HyFLEET:CUTE	HyFLEET:CUTE
Barcelona	CUTE	HyFLEET:CUTE	
Berlin	CUTE	HyFLEET:CUTE	HyFLEET:CUTE(but subsidies)
Hamburg	CUTE	HyFLEET:CUTE	HyFLEET:CUTE
London	CUTE	HyFLEET:CUTE	
Madrid	CUTE	HyFLEET:CUTE	
Porto	CUTE	no continuation	
Stockholm	CUTE	no continuation	
Stuttgart	CUTE	no continuation	
Munich	H2-MUC	no continuation	
Brussels	no project		
Paris	no project		
Rotterdam	no project		

3. Data

Data came from a wide range of sources, reflecting the diversity of the envisaged data set. Information on housing or general transport came mainly from National Statistical Offices, or the statistical units of the region's or city's administration offices. Specific traffic related data were provided by public transport providers. Standard statistical data, like GDP or population numbers, were drawn from Eurostat. This was the preferred source whenever available as it contains consistent data sets with a comparable methodology like timing and geographical coverage (NUTS codes[5)]).

[5)] Nomenclature of territorial units for statistics – NUTS; more information on http://ec.europa.eu/comm/eurostat/ramon/nuts/home_regions_en.html

4. Results and Interpretation

The main objective of the data analysis was to identify (objective) parameters for assessing the suitability of a community in implementing hydrogen and fuel cell projects. Especially, it was attempted to correlate the success of projects (for instance continuation after funding subsided) with the overall situation of the community as described by the data collected.

The evaluation and interpretation of the data is presented here in three groups:

- Traffic and Population Density,
- Buildings, and
- Finances.

The sites chosen are marked as

- Regular CUTE site, where operations were continued (C-cities)
- (*) Major city without hydrogen and fuel cell project (for reference purposes)
- (**) Discontinued ARGEMUC project
- (***) Discontinued CUTE site (D-cities)

<u>Traffic and Population Density</u>

Since one of the main applications of hydrogen and fuel cells in first demonstration projects has always been vehicles, the first set of parameters investigated here will refer to traffic. Two aspects are especially investigated: the importance of public versus private transport, and the introduction of levies on passenger car access to inner-city areas.

One of the main parameters describing the importance of traffic for a region is the number of commuters. Whilst inner-region transport will most heavily rely on public transport, cross-border commuting involves the highest numbers of private cars.

The figures on transport can thus indicate the relative importance of the two sectors (private and public transport) and the area a hydrogen and fuel cell development would have most impact on and deliver most benefits to the community.

In analysing the data, though, no clear tendency can be seen, with one exception that will be discuss later. Caution has to be applied, though, in interpretation since in some cases it seems that the data sources are not fully compatible and figures might refer to different census methods and definitions.

The first set of graphics shown here refers to commuters, number and type of vehicles and distances driven.

As can be seen from Figure 1, there seem to be two types of cities, those ‘importing’ their workforce (upper half of graph) and those with workforce within the city boundaries. The latter will most probably rely more heavily on public transport since inner-city traffic is often dominated by this.

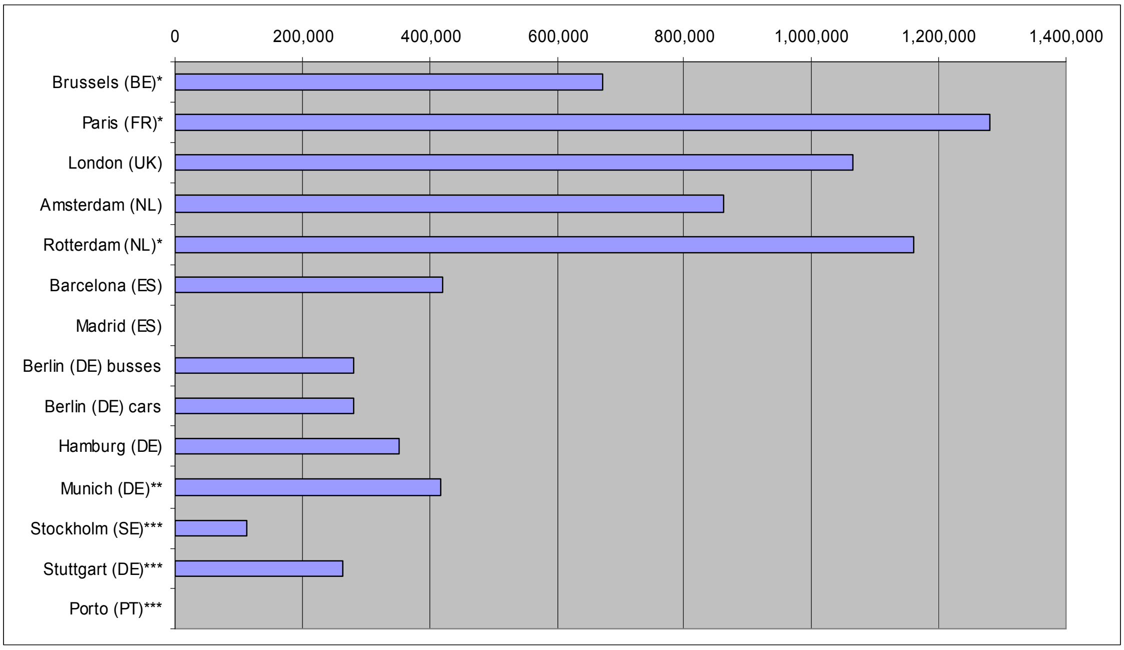

Figure 1: Number of commuters across the region (city) boundaries.

(No data found for Madrid)

Figure 2 seems to partly support this hypothesis (in the cases of Amsterdam and Rotterdam). The cases of Paris and London, though, indicate that the commuters also use public transport. Another explanation may be the statistical definition of ‘public transport’ which might or might not include rail transport (apart from tube and suburban trains). The Dutch cities will traditionally rely more heavily than others on pedestrian and bicycle transport. Nevertheless, the graph shows that public transport is an important factor both in London and Paris. This does not correlate with the successful performance of a hydrogen and fuel cell project, though, since Paris does not have such a project. It should be noted here, though, that due to the low number of hydrogen and fuel cell demonstration projects in Europe it cannot be expected that every large city will conduct such an activity. Nevertheless, it can be noted that there is not even an initiative to begin any hydrogen or fuel cell demonstration in neither Paris nor Brussels.

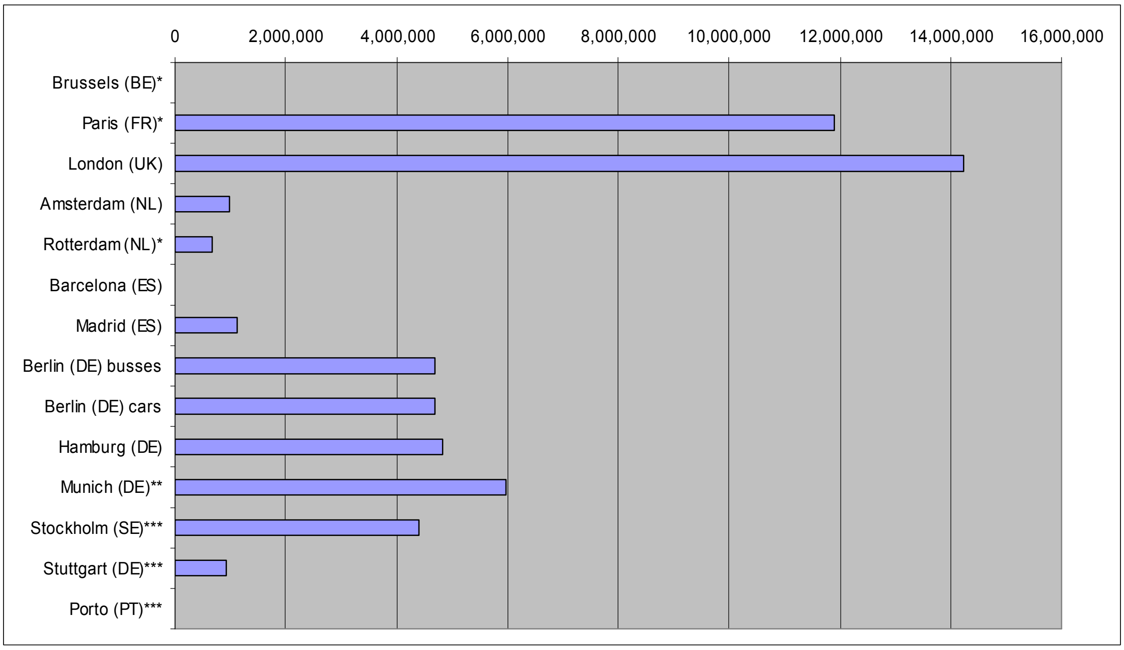

Figure 2: Public transport passenger miles (per year).

(No data were found for Brussels, Barcelona and Porto.)

Figure 3 and Figure 4 compare the number of registered cars and buses. There actually seems to be a negative correlation between the importance (measured in passenger miles) of public transport and the number of cars. The exception is London, but here the number of cars could not be identified at the same level as the other statistical data since the data were only available for Greater London. On the other hand the number of buses does not necessarily correspond to the public transport mileage. This can both mean that the average distance travelled differs, or a major share of transport occurs by tram, tube and suburban rail, all of which are not represented in the bus count.

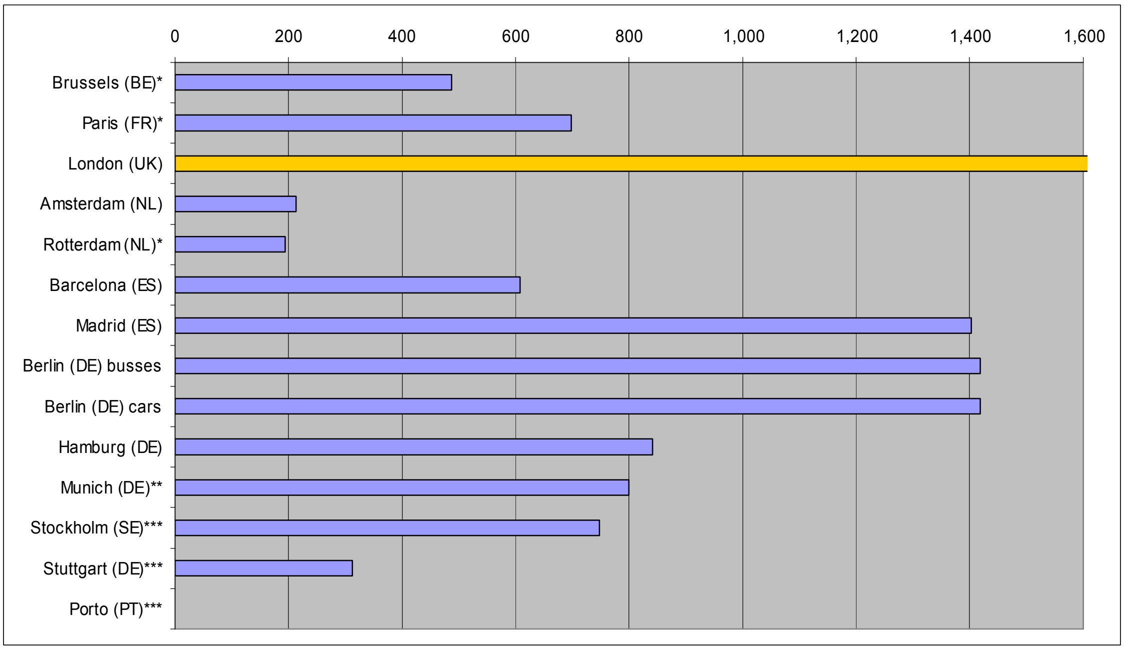

Figure 3: Registered cars.

(The value for London is based on data for Greater London (larger regional area than city))

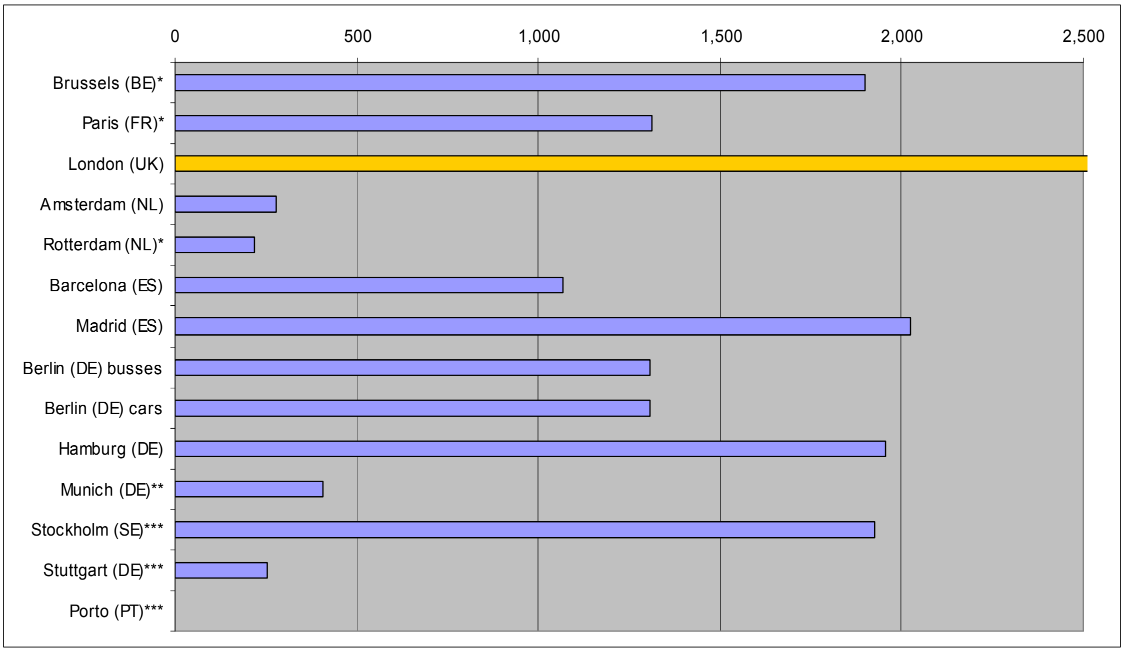

Figure 4: Number of public transport buses.

(Values for London and Porto based on data for Greater London and Grande Porto, respectively (larger regional areas than cities))

Although the figures do not show any correlation between the success of projects and the data displayed, they do indicate that a city like Hamburg with strong public transport will be predestined for a hydrogen bus project. On the contrary, Figure 5 shows that for a city like Stockholm that seems to rely on long distances covered within the city by passenger cars (strangely at the same time sporting a high number of buses) public transport may be of less relevance and thus less of a means of promoting hydrogen and fuel cells. Before judging, though, a more detailed analysis of the case and a re-assessment of the circumstances would be necessary.

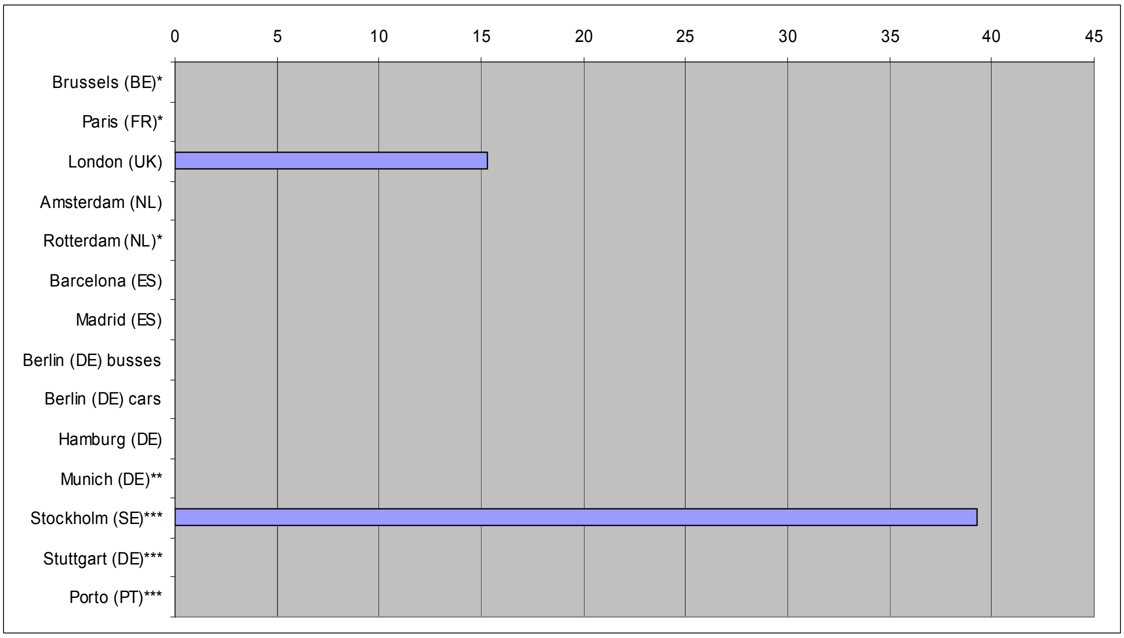

Figure 5: Average distance driven by car per day [km].

(Unfortunately this data was not available for most sites)

Two further aspects were inspected in order to evaluate their possible impact on the attractiveness of hydrogen and fuel cell transport technology: fuel cost (Figure 6) and levies raised on driving in city areas (Figure 7). Again, most European cities show similar conditions in that diesel (pump) prices are quite comparable. The only exception is London, since UK taxation on diesel is generally high. Since London is one of the two cities collecting a congestion tax for driving into the city centre, it could be concluded that the overall situation is rather favourable for a project in efficient public transport. This is actually expressed in the proactive role London is playing in establishing a fuel cell transport project. The other example, Stockholm, is more difficult to assess. On one hand CUTE has not been continued here and some parameters seem unfavourable (as discussed above), but still, Stockholm is also part of the coordinated public procurement agreement which also includes cities such as Hamburg and London.

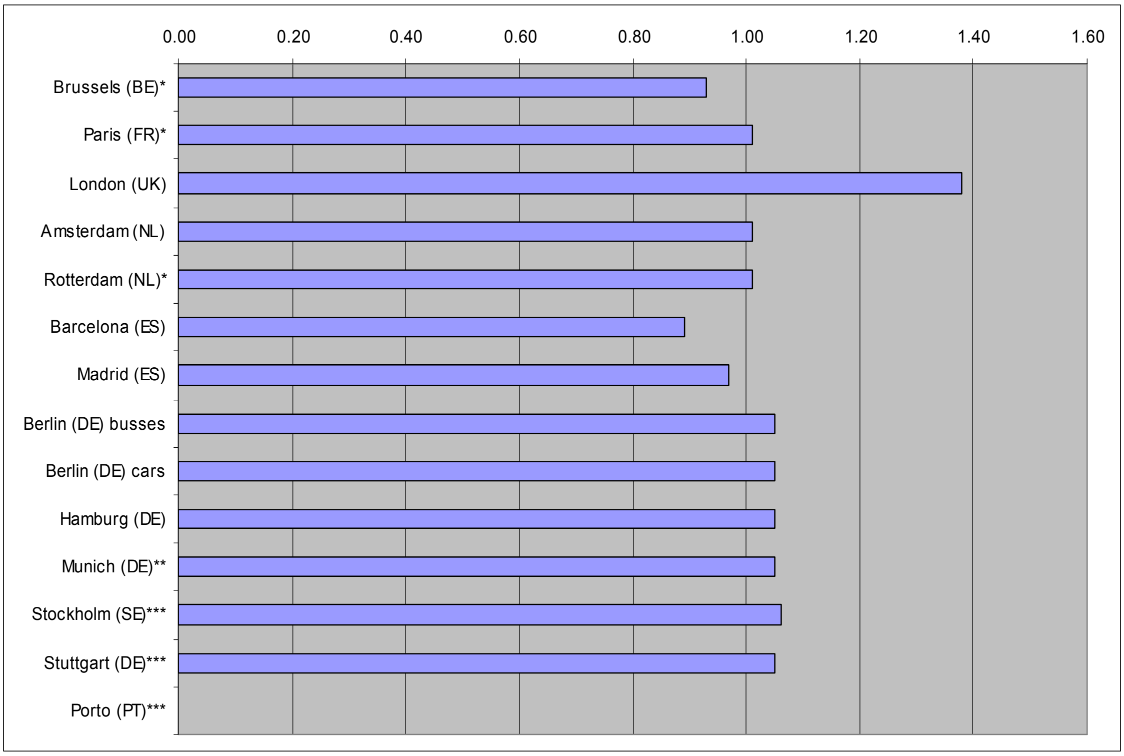

Figure 6: Diesel pump price, as on 17.07.2007 in €/litre.

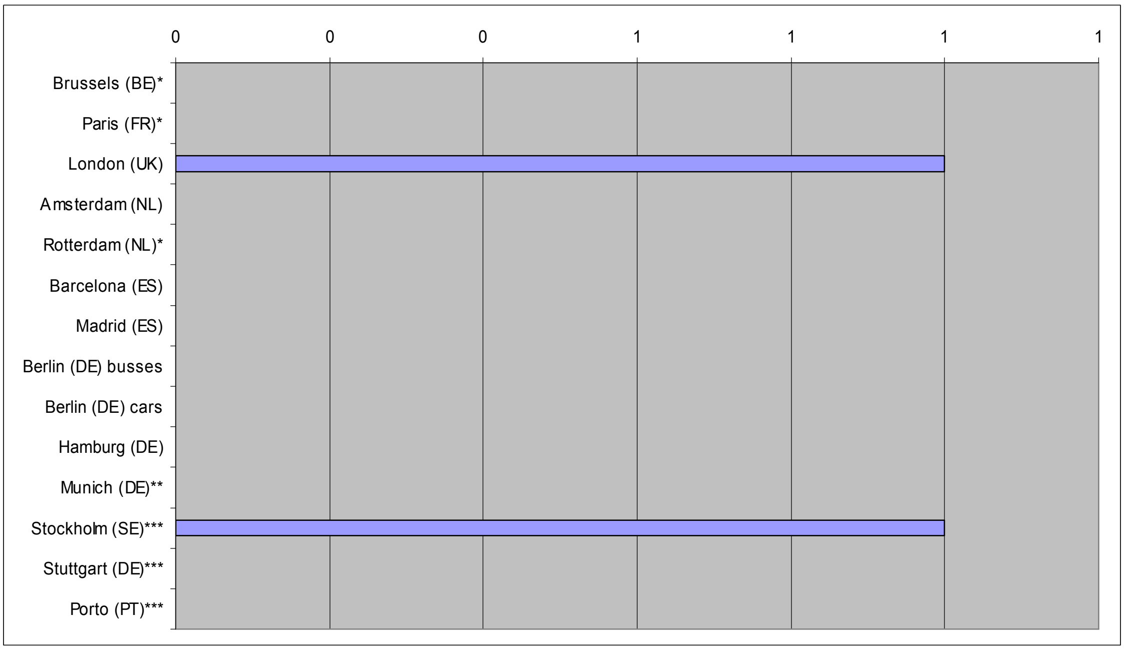

Figure 7: The blue bar indicates the deployment of congestion charges or other traffic regulation schemes.

Looking at other examples of discontinued projects, Munich sticks out with figures very similar to Hamburg (apart from a very much lower number of buses, which might have other reasons, for instance registration in regions surrounding Munich) but with no public transport project and the Munich airport project discontinued. The only difference may be found in the population density, which is higher in Munich (Figure 8), maybe indicating shorter travel to work and less focus on public transport.

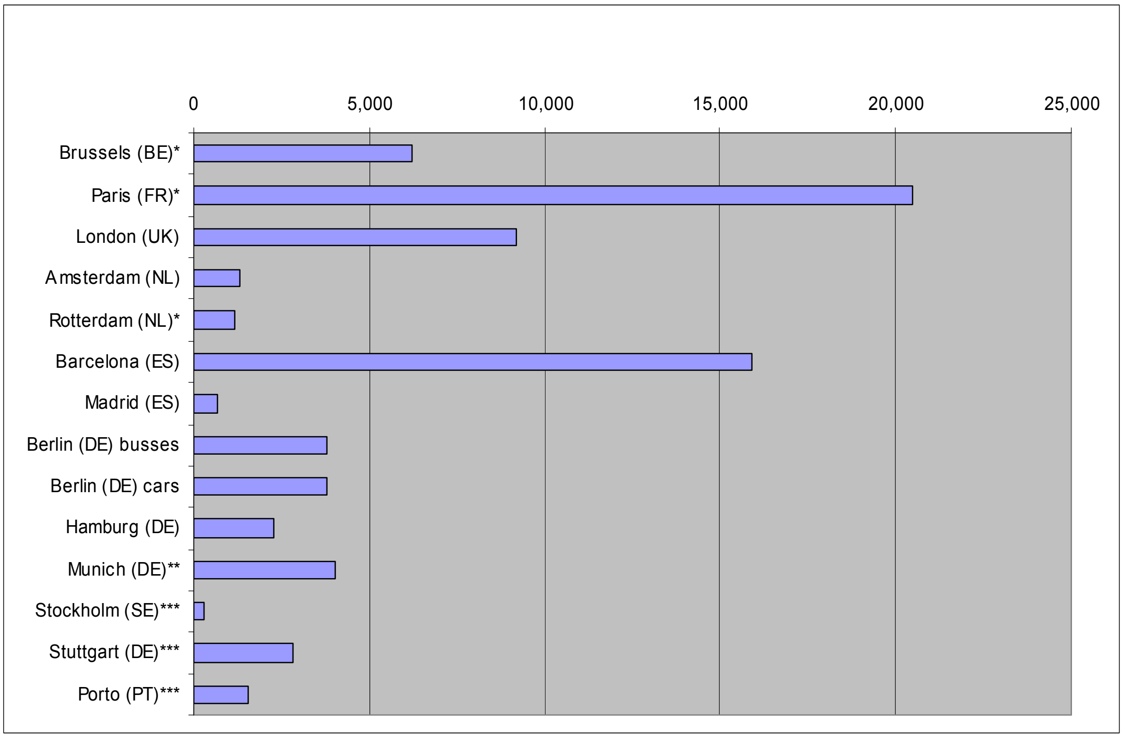

Figure 8: Population density [per km²].

This leads us to the provisional conclusion, that the technical capacities found in any community do not necessarily define whether or not a successful project can be maintained. As a consequence, the search for favourable ‘clusters’ of properties leads to regions and sites that will in theory offer a good basis for hydrogen and fuel cell projects. Nevertheless, this gives no indication of the success of such a project, which seems to be mainly influenced by other parameters.

Buildings

Apart from traffic there is another large field for the deployment of fuel cell technologies: residential fuel cell applications offer higher efficiencies in the stationary sector and deliver heat and electricity to private homes.

For a demonstration of the technology it has certain advantages to first install these applications in multi-family houses as the systems can be larger, thus cheaper per unit of energy delivered. Also the start-stop-cycles are fewer which increases the reliability of the systems.

In addition to these points it needs to be said that demonstrations not only aim at proving the maturity of a technology, but also at raising public awareness and increasing public acceptance. A fuel cell system “hidden” in a single residential house might lack the necessary public impact the technology could have. Therefore, multi-family houses also offer a good basis for show-casing fuel cell technologies to a larger number of people.

Some European cities have an outstanding high proportion of multi-family houses. Figure 9-11 show the total number of buildings, the percentage of multi-family houses, and the total population in the selected cities. Combining the information of these three graphs certain patterns can be identified. Munich, for example, with its 1.2 million residents (Figure 11) has only 140,000 houses/buildings (Figure 9) whereas Brussels with its 1 million residents has nearly 200,000 buildings. Figure 10 shows the resulting difference of these figures as the percentage of multi-family houses, with Munich having a share of more than 90% multi-family houses compared to Brussels with only a little more than 50% share. The same goes for Madrid and Barcelona which both have large populations, but only a small number of houses/buildings, thus a high percentage of those are multi-family homes.

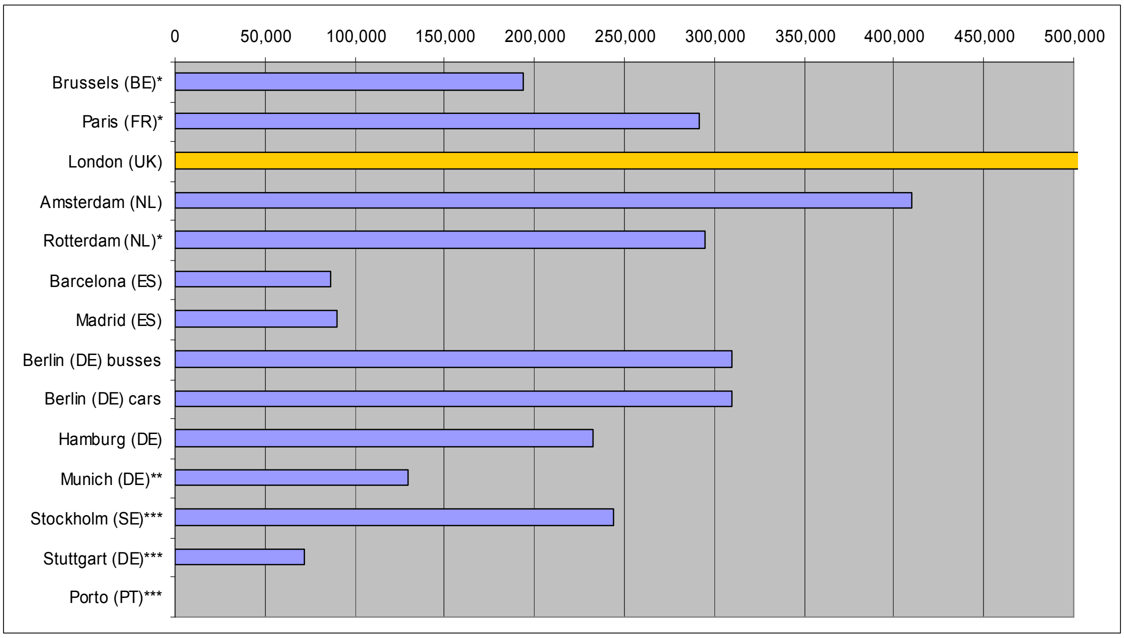

Figure 9: Number of buildings. Value for London based on data for Greater London (larger regional area than city).

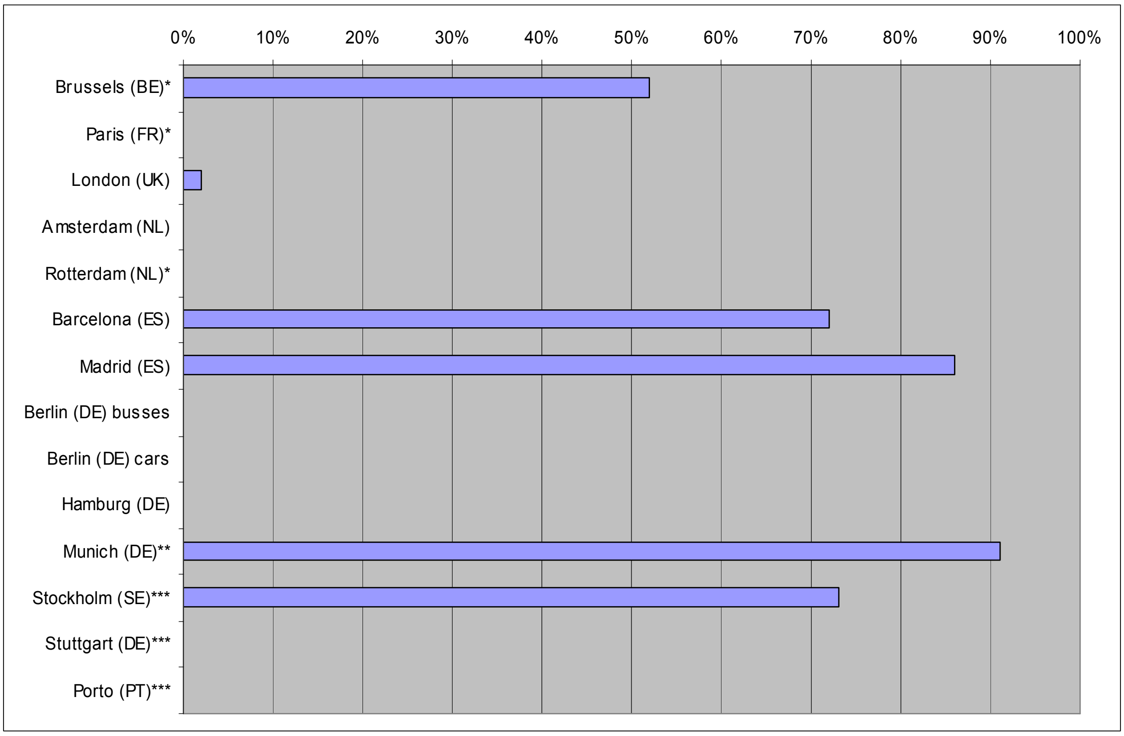

Figure 10: Percentage of multi-family buildings.

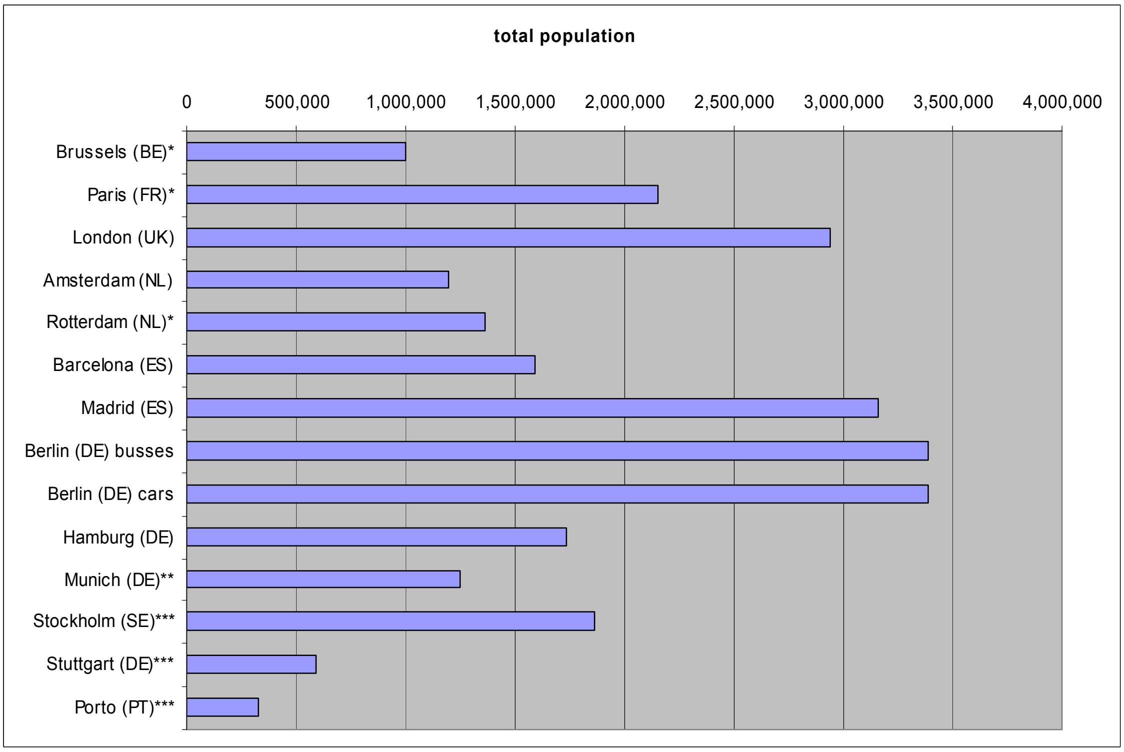

Figure 11: Total population.

Unfortunately, differences in national census regulations result in a poor availability of data in regard to the percentage of multi-family buildings (Figure 10). This is especially a great disadvantage as Figure 12 shows the total number of installed stationary fuel cells, and for most of the cities that do have some units installed no data are available in Figure 10 . Only Madrid and Munich, both having a large share of multi-family homes, have a number of stationary fuel cell units installed. However, this result needs to be treated with caution as no data are available about the type of building in which these fuel cells are installed. Although generally speaking, cities with a high proportion of multi-family homes offer a good basis for the application of stationary fuel cells (see above), also in view of the replication potential of a successful demonstration, the total number of installations remains still so low that at this point they could be installed in every city listed in Figure 9 and no hard conclusion can be drawn to what city has a preferable pattern for their deployment.

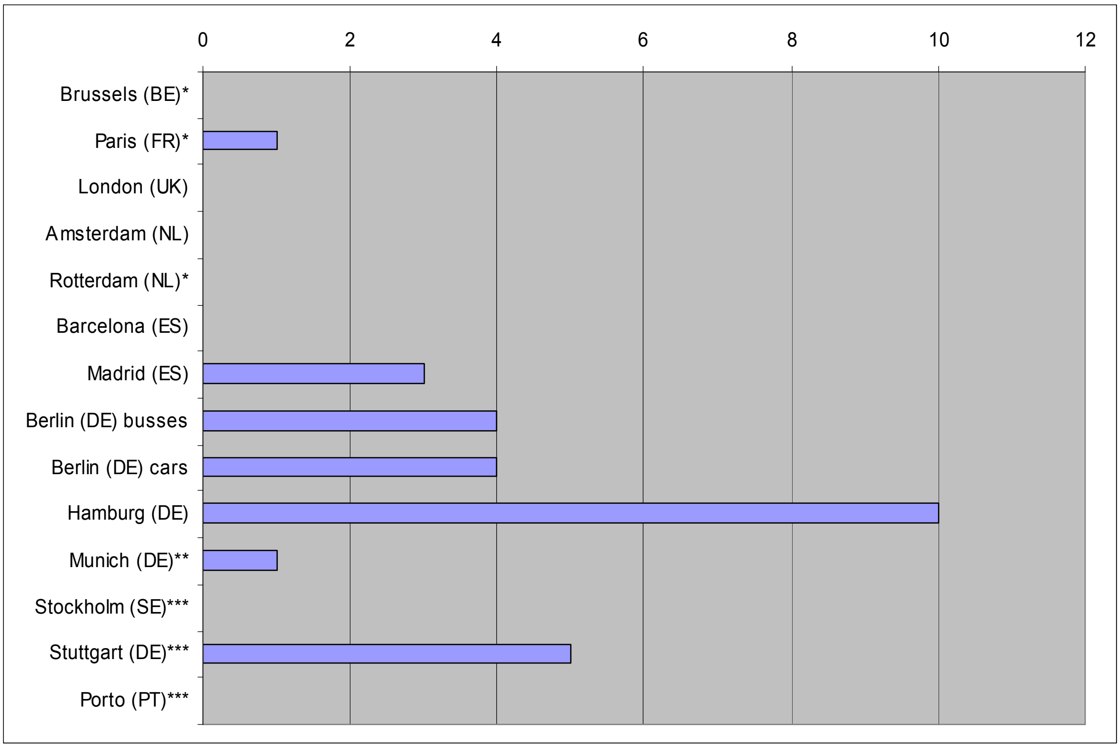

Figure 12: Stationary fuel cells installed.

Finances

Finally, the capability of communities to (co-)finance demonstration projects and to continue them when funding terminates was analysed. In this context the income per capita (indicating private wealth) (Figure 13), public debts (indicating low margins of community governments to operate) (Figure 14) and public expenditure (indicating volume of finance flow) (Figure 15) of those cities engaging in demonstration projects were compared.

Interestingly, public debts do not seem to inhibit engagement in hydrogen and fuel cell demonstrations: both C-cities Berlin and Hamburg are heavily in debt (as measured by the ratio of public debts to annual total spending), while at the same time being two of the most successful and active hydrogen demonstration centres in Europe whereas all D-cities show no sign at all of public indigence (Figure 14).

In this context it may be worth briefly highlighting the partnership structures that had emerged beforehand in some cities to promote the projects. A number of cities, including Berlin (Clean Energy Partnership - CEP) and London (London Hydrogen Partnership - LHP) had established a form of Public-Private-Partnership to foster technology demonstrations in these cities. While these groupings differed slightly in their basic structures, they all represent collaborations between the public authorities and corporations with interests and activities along the hydrogen and fuel cell supply chain, from local bus operators to energy and equipment suppliers. The operating costs of these partnerships are met by contributions from partnership members, allowing for the formation of small teams to promote the hydrogen and fuel cell interests of their respective cities.

On the subject of project financing, it has proven impossible to uncover the exact financing structures of the CUTE and HyFLEET:CUTE demonstrations, owing in part to confidentiality agreements between the partners. Nevertheless, it is clear that the European Commission provided 35% of the costs of each of these projects. Meanwhile, national and/or local governments together with the bus operators appear to have provided the lion's share of the financial support. For example, in Amsterdam the local government and the public transport operator GVB together provided around 50% of the total project costs. This may correlate with the relatively favourable ratio of debts to annual expenditure.

Some of the cities noted above are taking their hydrogen bus projects to a third phase. This is done by securing financial support from local, national or EU sources. With the initial support of the EU in the early stage it was possible in the case of London, for example, to operate and learn from three buses under the CUTE and HyFLEET:CUTE projects, while now the city has plans to introduce 10 more buses in a third phase with local and national funding. Funding in general will be necessary until the commercialisation phase has been reached.

The case of Berlin also exemplifies how hydrogen projects can be imaginatively arranged in line with the normal business of replacing ageing buses with the support of public funding.

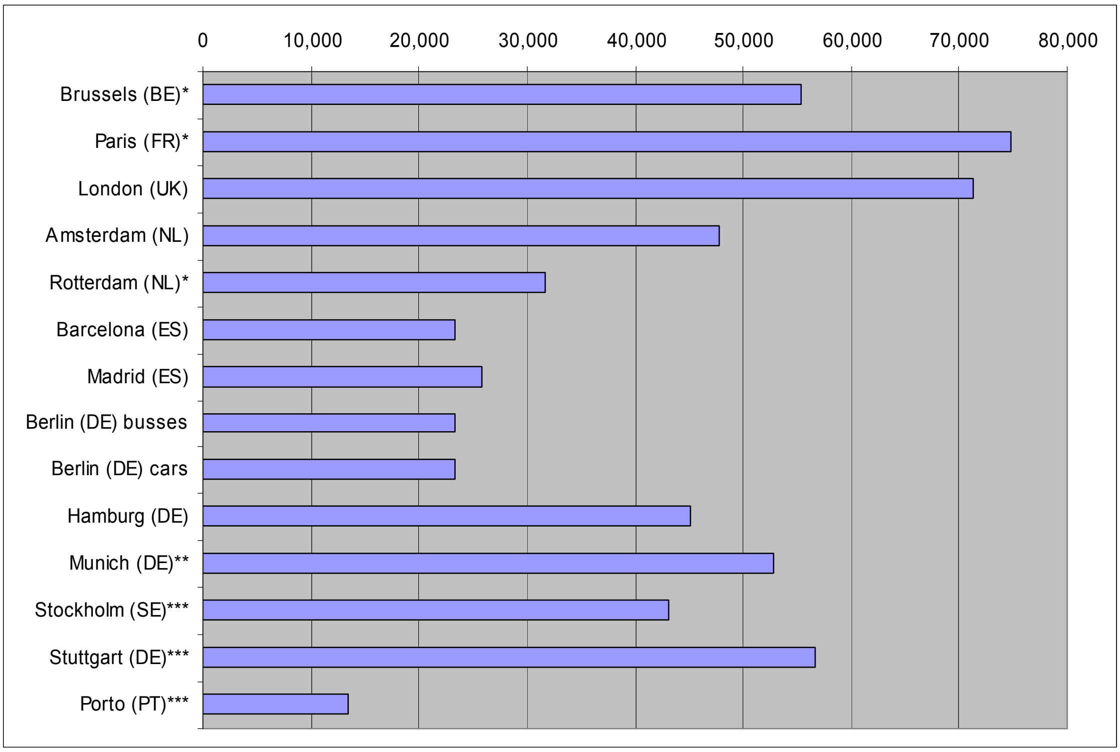

Figure 13: GDP per capita [€/p.y.].

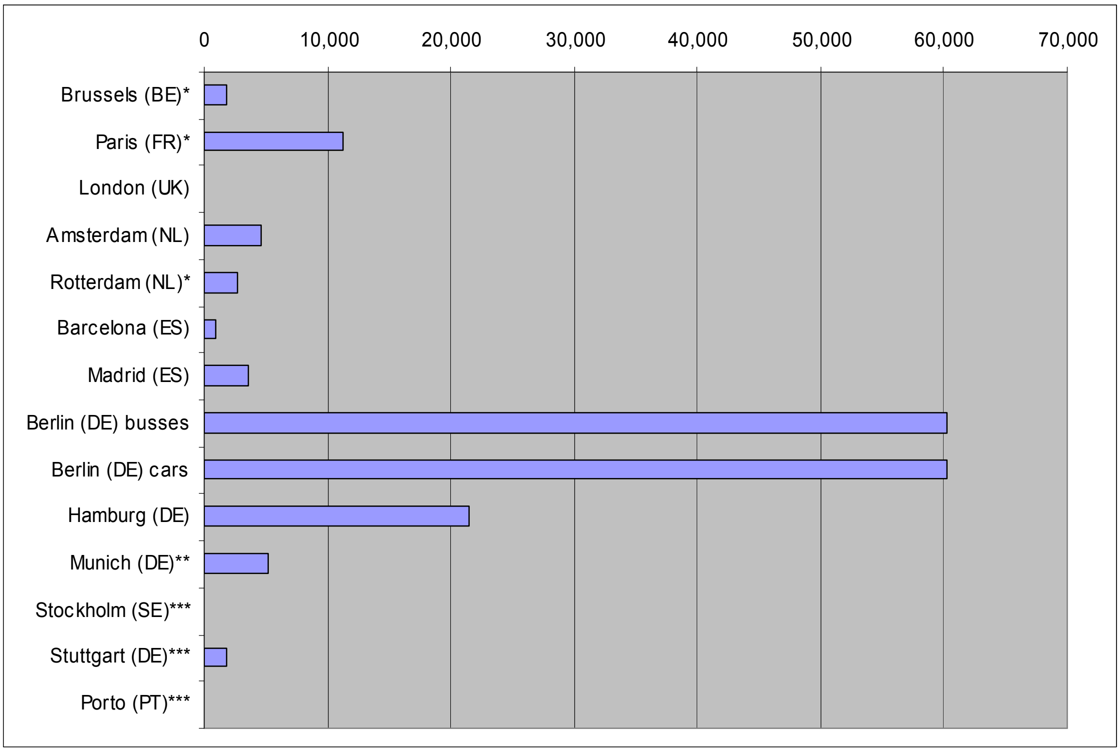

Figure 14: Public debts [M€].

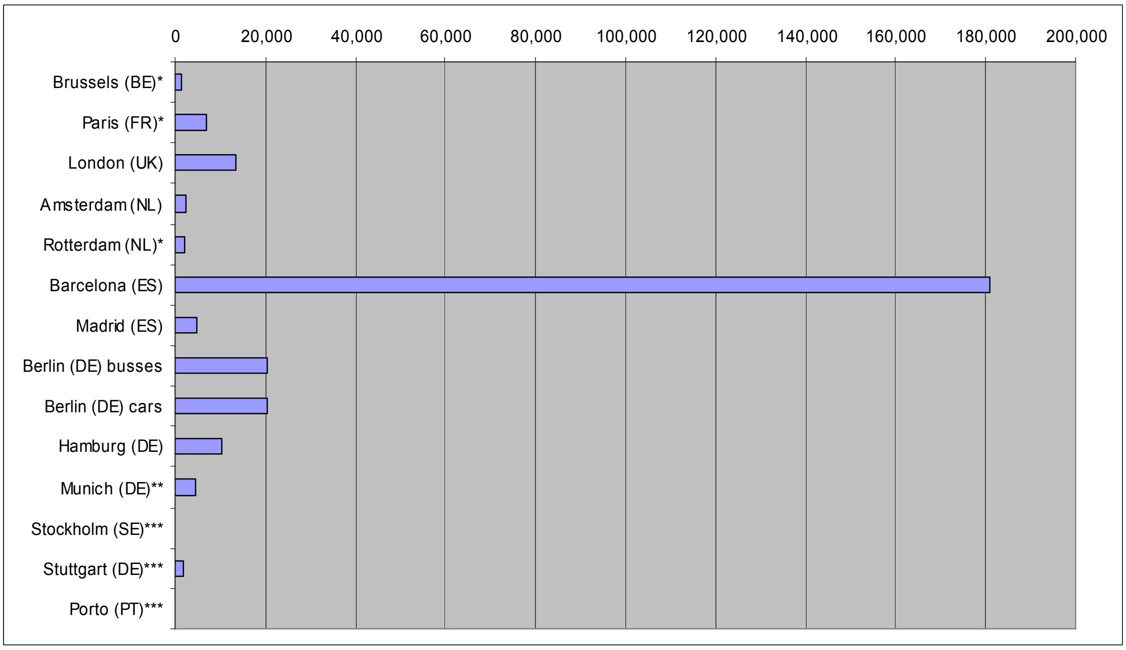

Figure 15: Public expenditure [M€].

The hydrogen ICE buses and the garage acquired under HyFLEET:CUTE in Berlin were needed to maintain sufficient vehicles for the local transport company's (BVG) regular service, and as such could be regarded as a planned procurement by BVG. "Normal" procurement would generally foresee the purchase of diesel buses, but the need to acquire new equipment was seen as a good opportunity to introduce an innovative and cleaner technology to BVG's fleet. Because of the funding nature of EU-projects, not only the "extra bit" of hydrogen technology, but also the necessary BVG-staff required for operation and maintenance of both buses and workshop were eligible costs, and were thus funded with 35% by the European Commission. The total subsidies (for purchase and BVG-provided staff) were enough to match the difference in costs between the standard diesel technology and the finally purchased hydrogen technology, meaning that a sufficient financial equivalent for all the additional hardware costs for deploying hydrogen technologies was secured by EU funding. This is a good example of how regular procurement or rolling stock renewal can be used synergistically for technology upgrades, preparing the ground for a later large-scale introduction through early learning and experiences.

GDP per capita, on the other hand, is an indicator for private wealth and could give some information whether a community is able to pay more for a novel, clean technology. Taking into account, though, that new technologies could be acquired at no extra costs for the operator at this early demonstration phase (see above) this means that no higher tariffs need to be passed on to the customer. Also, the range in which tariffs might be affected at a later stage when funding is no longer available, is unlikely to be that significant that GDP figures can to be deployed to judge on public acceptance of new technologies in the public transport sector.

5. Conclusions

The figures and graphs show a very diverse result. No clear distinctive pattern can be identified for those cities that continued from the CUTE project into its follow-up project HyFLEET:CUTE (continuation cities or C-cities) and those four cities (including ARGEMUC in Munich) that did not (discontinuation cities or D-cities). In fact, the D-cities score more favourable in some values than the average C-city (public transport passenger miles, number of cars, percentage of multi-family houses, number of commuters across region boundaries, population density, public expenditure, stationary FC's). In no case do they score a clear peak value, i.e. there is always a D-city that has a similar value, thereby precluding any specific or extraordinary characteristic of the C-cities, for example the congestion charge in London (C-city), which can also be found in Stockholm (D-city).

It can therefore be concluded that the technical capacities found in any community do not necessarily determine whether or not a successful hydrogen and fuel cell project can be maintained. The same goes for stationary fuel cells where a correlation between the structure of the real estate market and the number of installed fuel cells could not be verified. In addition, this correlation does not even seem to be a necessary prerequisite for installing residential fuel cells, as the numbers of units existing at this time imply. In regard to financing projects it can be shown that public debts are not an obstacle to demonstration project activities. On the contrary, the structure of projects and available EU-funding even enables cities heavily in debt to be the spearhead of public demonstration schemes in Europe [6].

This and the other findings above could lead to the conclusion that neither social factors, the conditions of infrastructure, nor the economic and financial situation of a community decide whether it has the capacities to run a hydrogen project successfully or not. At least the regions and communities investigated do not possess a specific set of technical factors or profiles which necessarily imply the successful implementation of hydrogen activities. The implication for the "technology roadmap" is that these regional factors do not seem to have any particularly significant influence on the course of technology development as it performs today.

It must be noted, though, that the low number of existing projects clearly limits the validity of this result. One may also note that these existing projects are primarily on public transportation where public policies usually are strong. Nevertheless, the lack of any project activities in many of the D-cities and cities without projects indicates a disinterest in the subject.

This result requires cross-checking with similar studies. Therefore the outcome of two other activities is reported for reference in the following, the PREMIA project and results from Roads2HyCom Work Package 3 (Community Assessment).

The FP6-project PREMIA[7)] performed an "Assessment of European Hydrogen Initiatives" (Pelkmans et al. 2007) in early 2007 in which an investigation of the

6 see also Bader et al. 2008 for a short analysis of EU regional funding policy
7) FP6-project PREMIA – R&D, demonstration and incentive programmes effectiveness to facilitate and secure market introduction of alternative motor fuels; http://www.premia-eu.org/

differences between the cities and regions participating in hydrogen and fuel cell demonstration activities was carried out.

In this course a questionnaire was distributed to the CUTE city partners that looked at the different policy drivers and support for the hydrogen and fuel cell demonstrations. Results showed that all cities had some form of political support when deciding to participate in CUTE. Either as national support through the government or government initiatives, as local support from the mayor or other local political actors, e.g. the administration, or from the local industry as local stakeholders through component suppliers, technicians or general technical expertise (see Table 4).

Table 4: Results from the PREMIA questionnaire on policy drivers (Pelkmans et al. 2007)8).

City	National support	Local support	Local industry
Amsterdam	No	-	Yes
Barcelona	No	Yes	Yes
Luxemburg	Yes	-	No
Madrid	No	Yes	No
Porto	Yes	Yes	-
Stockholm	No	Yes	Yes

The importance of political support and will for initiating a hydrogen project could also be shown in a second assessment by PREMIA (ibid.): the project Zero Regio[9)] which features three participating cities in two countries (Germany and Italy) displayed similar results with full support on all levels in favour of the project. The question arising is whether political backing can also sustain a project after funding subsides. Three of the nine European CUTE partner cities terminated activities after the end of the project, not participating in the follow-up project HyFLEET-CUTE. All of them had some initial support, but obviously lacked political momentum when deciding on the future of their hydrogen activities. The PREMIA questionnaire shows that both D-cities Stockholm and Stuttgart were disappointed with the costs incurred by the project which may have lead to the decrease in support. In the case of Stuttgart the official municipal council correspondence prior to the end of the CUTE project (see Annex 1) clearly indicates the disappointment and subsequent re-focussing of activities. The city of Porto, the third D-city, even regarded the entire demonstration activity as not useful, causing a minimal support on the political side for any follow-up project.

Similar results can be seen in the Roads2HyCom "Scoping Catalogue" (Shaw and Mazzucchelli 2007), that aims at providing a basis upon which the "fit" of hydrogen and fuel cell technologies to defined community frameworks can be evaluated. In

[8)] According to the project co-ordinator in Amsterdam both the CUTE and the HyFLEET:CUTE project were approximately financed with 35 % by the EU, 10 % by the Dutch government, and 5 % by private sponsors, meaning that there was local and national support.
[9)] FP6-project Zero Regio - Lombardia & Rhein-Main towards Zero Emission: Development & Demonstration of Infrastructure Systems for Alternative Motor Fuels (Bio-fuels and Hydrogen); http://www.zeroregio.com

this study the potential for the integration of hydrogen and fuel cell technologies was investigated for the three main community types: cities, regions, and islands/remote areas. It was shown that "all three community types are characterised by strong support from local authorities […] and high involvement from the citizens". Independent of the community type, these factors were regarded as "crucial for successful hydrogen integration".

In summary, even if social structure, infrastructure conditions, economic situation and other technical capacities (as industrial expertise, access to hydrogen sources etc., not analysed here – cf. Steinberger-Wilckens and Truemper 2007) might be identified as beneficial for performing a hydrogen and fuel cell project, no indication could be found in the data inspected that these would necessarily imply the successful implementation of such a project, and therefore, by implication, the nature of technology development carried out as input. Apparently, political will and support is still the most influential driving force, above and beyond financial considerations. It is obviously not only important for the initiation of a project, but also crucial for its continuation. The lack of the required political leadership, determination, and decisiveness may lead to a discontinuation of projects. Certainly this support does not need to come from politicians only, but is also understood as political appraisal of any plans for engagement from industry and other stakeholders.

Even communities with dire budgetary restrictions can leverage infrastructure development and improvement utilising available project funding, given a sufficient drive is established. Unfortunately the aspect of the source of funding, for instance the mobilisation of private finance and finance from outside the community (e.g. industrial OEM's) could not be analysed due to lack of access to these data. One may also note that the mechanisms of being innovative as a region in general, political will and financing are not yet fully explored – regions with innovative industries in general seem to offer favourable conditions to the emerging hydrogen economy too (Bader et al. 2008).

As a result of these findings, the Roads2HyCom project revised its approach to postulating a roadmap for technology evolution. No further account was taken of specific regional influences; instead, further analysis of technology evolution was based upon non-location specific measures such as cost-effectiveness, environmental impact and technology maturity. While it remains likely that regional factors do influence what is needed of technology (for example the relationship between areas of high wind energy or biomass harvesting and a possible future hydrogen production route), the implied needs at technical level can be assumed to be mostly generic. In simple terms this means that a functional specification for a hydrogen and fuel cell application such as a city bus or CHP plant is generic, even though the envelope of that specification is influenced by regional extremes such as climate or usage profile. This in itself is an important conclusion – successful hydrogen and fuel cell products need to be engineered for global application, even if local political will promotes clusters of early adoption. Aligning these various regional approaches of early adoption in a coherent European and world-wide strategy, e.g. by forming trans-regional clusters and distribution networks (see Bader et al. 2008 for policy conclusions), will be one of the challenges for the full deployment of hydrogen in the next 10-20 years.

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Steinberger-Wilckens R., Truemper S.C. (eds.) (2008): *European Hydrogen Infrastructure Atlas" and "Industrial Excess Hydrogen Analysis*. Deliverable 2.1/2.1a of the Roads2HyCom project (available on www.roads2hy.com), Document Reference R2H2004PU.1

Annex 1

Stellungnahme zum Antrag	41/2005

Landeshauptstadt Stuttgart
Der Oberbürgermeister
GZ:

Stuttgart, 09.09.2005

Stellungnahme zum Antrag

Stadträtinnen/Stadträte – Fraktionen , FDP-Gemeinderatsfraktion
Datum 03.02.2005
Betreff Umweltfreundliche Pkw und Lkw im städtischen Fuhrpark - Brennstoffzellen in Stuttgarter Bussen

Anlagen

Text der Anfragen/ der Anträge

Im Rahmen des Projekts CUTE sind seit Herbst 2003 bei der SSB drei Brennstoffzellenbusse im Einsatz. CUTE ist ein Forschungsprojekt, das zusammen mit Industriepartnern, gefördert von der EU, vom Bund und vom Land, durchgeführt wird.

Es war von Anfang an auf einen zwei Jahre dauernden praktischen Betrieb der Fahrzeuge ausgerichtet. Während dieser Zeit fanden umfangreiche Analysen von Komponenten statt, um Erfahrungen für deren Weiterentwicklung zu sammeln. Auch wenn sich mit der erprobten Fahrzeuggeneration noch kein wirtschaftlicher Einsatz dieser Antriebstechnik im Linienbusverkehr darstellen lässt: Angesichts der umfangreichen Erkenntnisse und Erfahrungen, die gewonnen werden konnten, und der hohen Verfügbarkeit, die bei diesen Fahrzeugen erreicht wurde, war das Forschungsprojekt sehr erfolgreich. Gestützt auf die Versuchsergebnisse gibt es für Folgegenerationen erhebliches Optimierungspotenzial.

Über die Chancen, diese Fahrzeuge über das Ende des auf 30. September 2005 befristeten Probebetriebs hinaus einzusetzen, gab es bereits Mitte vergangenen Jahres mit DaimlerChrysler als wichtigstem Industriepartner, erste Kontakte.

Der vom DaimlerChrysler-Konzernvorstand artikulierte Wunsch, mit der Brennstoffzellentechnologie gerade in Stuttgart noch länger präsent zu sein, ist nachvollziehbar. Auch für die Landeshauptstadt war zu überlegen, ob sich damit im Jahr der Fußball-WM eine besondere Chance bietet, sich als Technologiezentrum zu präsentieren.

Abgestimmt mit dem SSB-Vorstand hat die Stadtverwaltung entschieden, den Einsatz der Brennstoffzellenbusse nicht über September 2005 hinaus zu verlängern. Die Gründe:

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Die SSB hat sich gegenüber ihrem Aufsichtsrat und dem Gemeinderat zur Restrukturierung und zur Senkung des Defizits verpflichtet. Sie kann, vor allem in Zeiten sinkender öffentlicher Zuschüsse für den ÖPNV, keine weiteren finanziellen Lasten übernehmen. Das um ein Jahr verlängerte Engagement im Feldversuch der Brennstoffzellenbusse hätte das Unternehmen mit 1,5 – 2,0 Mio. € zusätzlich belastet.

Das für das Verkehrsressort zuständige Innenministerium hat definitiv erklärt, dass es über den vereinbarten Zweijahreszeitraum hinaus keine weiteren Zuwendungen gewähren wird. Die äußerst angespannte Mittelsituation im ÖPNV-Bereich zwingt das Land dazu, auch bei durchaus wünschenswerten Projekten, strenge Maßstäbe an die Nutzen-Kosten-Relation anzulegen.

Mit dem Ende des Versuchs werden auch die bestehende Wasserstofftankstelle und der Dampfreformer zur Wasserstoffproduktion auf dem Gelände der EnBW in Gaisburg abgebaut. Dort wird die EnBW ein Flüssiggaslager errichten. Bei einem Parallelbetrieb von Flüssiggas und Wasserstoff würde die Genehmigungsbehörde zusätzliche bauliche Sondermaßnahmen fordern, um die beiden Anlagen vor einer gegenseitigen Beeinflussung im Störfall zu schützen. Die finanziellen Zusatzbelastungen, die sich daraus ergeben, sind in den genannten Kosten für den Weiterbetrieb nicht berücksichtigt.

Unabhängig von diesen Auflagen, lässt die Wasserstofferzeugung in ihrer bisherigen Form Probleme erwarten: Dass der Dampfreformer noch für ein Jahr verfügbar ist, wird von der SSB in Frage gestellt. Es ist also sehr wahrscheinlich, dass auch hier nochmals investiert werden müsste, was die erwähnten Folgekosten ebenfalls nicht beinhalten. Eine Alternative dazu wäre die Wasserstoffversorgung mit Trailern. Aber auch dann entstehen erhebliche Mehrkosten, denn damit würde sich der Preis pro Kilogramm Wasserstoffgas ungefähr verdreifachen.

Der AWS nimmt zur Anfrage wie folgt Stellung:

Teil 1: Umweltfreundliche Pkw und Lkw im städtischen Fuhrpark

Der AWS beschafft und betreibt bereits heute Fahrzeuge mit der neuesten Abgastechnologie, soweit sie auf dem Markt verfügbar und technisch sinnvoll ist, wie z. B.:
- 1 Sattelzugmaschine **Euro 5** für das Schadstoffmobil
- 10 Abfallsammelfahrzeuge **Euro 4**
- 2 Winterdienst-Lkw Euro 3 mit **Partikelfilter**
- zahlreiche Pkw und Transporter nach Euro 4 bzw. Euro 3 mit **Partikelfilter**
- diverse Pkw mit Erdgasantrieb, sowie
- 1 Pkw mit Hybridantrieb

Dadurch kann der AWS gewährleisten, dass durch die regelmäßige und wirtschaftlich sinnvolle Erneuerung des Fuhrparks (d. h. Ersatz i. d. R. alle 8 Jahre) zum Jahr 2010, dem Zieltermin im Maßnahmenkatalog von 36, im städtischen Fuhrpark (ausgenommen Branddirektion) grundsätzlich Fahrzeuge eingesetzt werden, die den Partikelgrenzwert der Euro 4/5-Abgasnormen in Höhe von 0,02 g/kWh einhalten. Zu-

Seite 2

sätzlich befasst sich der AWS auch mit Alternativen zum Dieselmotor, wie z. B. dem Erdgasantrieb, der erst gar keine Rußpartikel produziert.

Teil 2: Brennstoffzellen in Stuttgarter Bussen

AWS sieht innerhalb des städtischen Fuhrparks keine Verwendungsmöglichkeit für die Busse mit Brennstoffzellenantrieb.

Zudem wird die für die Wasserstoffgewinnung erforderliche Infrastruktur zurückgebaut. D. h. der für den Betrieb der Brennstoffzellen erforderliche Wasserstoff kann in Stuttgart nicht mehr getankt werden.

Dr. Wolfgang Schuster