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Les acteurs de l'entreprise à la recherche de nouveaux compromis ?
Construire le schéma d'analyse du GERPISA

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TESTING TECHNOLOGICAL TABLEAUS: ACTOR COALITIONS IN HYDROGEN AND FUEL CELL DEVELOPMENT[*]

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The concept of a zero-emission, high performance car holds an attractive upside, where important societal wants, such as bettering living conditions and/or bettering the environment can be attained, and the private transport market is sustainable and can be increased.

A number of the internationally known carmakers have thrown in their chip in this development. Relatively small US developers such as Plug Power Inc., Ballard and Fuel Cell Energy Inc. are cooperating with the car and energy industry in developing this technology.[1] Ballard, as an example, is cooperating with General Motors and Ford, while at the same time supplying fuel cell components to Honda, Nissan and Volkswagen.[2] Providers of infrastructure are project partners with carmakers and cooperates with manufacturers of fuel cells.[3] Furthermore, many projects are to a large extent financed through public funds, in effect being public-private partnerships.[4]

Topping this off, many of the large carmakers have internal efforts on fuel cells. Some of our informants point to the R&D conducted by Adam Opel AG in Rüsselsheim, as the most extensive European, in-house, development effort. Other carmakers have their own in-house development as well. On the other hand, senior level research managers in the German car

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[1] The market capitalization of these companies are as follow: Plug Power Inc.; $305M, Ballard; $1.3B, Fuel Cell Energy Inc. $202M (as of 08/04/2003).

[2] E.g. Ballard Inc. news release dated November 25, 2002.

[3] E.g. Stuart Energy Co. news release dated February 18, 2003

[4] The Clean Urban Transport project (CUTE) conducted by the European commission involves €18.5M of public funds.

industry have serious doubts of the viability of Hydrogen/Fuel cell car concepts, finding them too complex and expensive to manufacture (Jürgens 2002).

Furthermore, suppliers to carmakers have started to look into what consequences at hydrogen and fuel cell vehicle might have for future production. For example, as hydrogen poses other demands on storage tanks, Norwegian supplier Raufoss has developed composite tanks specified to 700 bars for compressed hydrogen.

Thus, on a number of fronts, the promises of a hydrogen economy is being tested, albeit slowly. And it might seem that expressed goals of the visions of a Hydrogen Economy are easier to see than the dynamics and function of the vision. The former is a sustainable transport system, a vision even spelled out in the "state of the union" address of the US president, the latter is more opaque.

This paper describes the dynamics between the energy industry, car industry and public policy using the case of fuel cell development activities as a pivotal point.

The paper seeks to illustrate the dynamics of early phase concept development, where the concept itself is tested while not knowing if the concept is feasible, production-wise, technically or if there is a market for it.

Thus, in relation the analytical framework proposed by Boyers and Freyssenet (2002), concept development of this kind have a local, company specific style, but also an important relation to the active policy-framing of cars and transport. Furthermore, the differences in market-preferences and policy-preferences between Europe and the US make different strategies for concept development more likely. The paper uses empirical material from a number of demonstration sites in Germany, Switzerland and the USA.

The analysis in the paper pivots around the "muddling about"-dynamics of such early phase fuel cell concept testing and development. The real, day-to-day testing of such concepts is a far cry from the well-functioning cars and support systems that are available in the marketplace.

On a slightly different note, these tests are portrayed as the opening-up of new area of energy-use, implying the Hydrogen Economy (Hoffmann; Rifkin). The paper, accordingly, tries to follow the relation between demonstration sites and policy as well. In the policy field, demonstrations are important as they give life and reality to different technological visions (Dierkes), such as the hydrogen economy. Therefore, the paper argues that early phase concept demonstrations interact with policy (goals for emission levels, research programs). The American FreedomCar-initiative[5] is such an example, which pairs changes in emission policy with a drive for hydrogen cars. The paper argues that public funding for fuel cell projects, which seems to be quite easy to come by at this time, is available to fill policy purposes.

THEORETICAL UPTAKE

In the analysis of the cases, there are two central concepts that will used to understand the dynamics and relationship between fuel cells, the car industry and public policy.

First, we have "technological visions", guiding images for socio-technical development (Dierkes; Næsje 2000). Here the image, broadly understood, guides policy and holds together loose threads as well as span over different sectors in society.

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[5] Cf. U.S. Department of Energy, http://www.energy.gov/

The function of the vision is both to guide the processes per se and the images of where the process is going to end. As the process of innovation and development moves on, gains in materiality and gains in experience demands adaptation from the vision.

The visions hold both a collective and an individual aspect. The paper will not dwell on organizational factors that drive knowledge diffusion between the individual engineers, in intra- or inter-firm groups. The knowledge and experience base between engineers in an established field when tackling a new technology such as fuel cells, involves – at least on the theoretical level – an need to scan or explore the field. After such an initial phase, a targeted effort can be made. In most cases, this initial phase is not necessarily on the screen of senior management at all. For example, the assessment of using heat-pump technology with carbon dioxide as working fluid for heating and air-conditioning of Mercedes-Benz vehicles (Næsje 2000) is only one of a number of such assessments being conducted. The assessment is a fairly mundane undertaking, between engineers, then to be taken into standard procedures before implementation. Fuel cell technology, on the other hand, involves a much more diverse set of actors.

Such a diverse set of actor pose a methodological challenge. How are we to engage the real drivers and find the important actors in the innovation process, when there are several, separate goals of the process? Adding to this, if fuel cells not only can open up new markets, but also score policy points, the political economy between national authorities and carmakers is of importance as well.

The object of interest here is not so much a singular object as a collage of visions and realities. According to Latour (1996), the reality of things, or technology, consist of an set of actants, where it adds little to the analysis to distinguish between material (i.e. technological) and human (or political) factors. Arguably, the fate of a technology—in retrospect—is not in the hand of the technology alone. Other actors and resources, or actants, need to be enrolled. In one of Latour's analytical plots, he argues that the failure of a French tram-technology was due to the fact that the technology was "not loved enough" (Latour 1996).

Second, we see that the interdependence between the different actors in the field form mixed-actor coalitions. Obviously, small actors, such as demonstration sites are more dependent on large actors, such as the carmakers. Nevertheless, the dynamics of these relations represent a possible win-win situation, as funding is placed and as emission regulations are changed. Actor coalitions will here be used to describe the shared interest between demonstration sites and different actors. This is not to say, however, that *all* interests are shared. As we will see, the interests are shared on specific topics, and to a certain extent, specific solutions. On the other hand, interests are split on a great number of topics, for example on distribution of cost when moving from demonstration sites to real installations.

At this point the coalitions also represent the overarching productive models and business strategies of different carmakers, most prominently a distinguishable Daimler-Chrysler approach, a BMW approach and a Toyota/Honda approach.

A note on data and methods

The empirical material for the paper consists of a set of interviews at six different demonstration sites, including on-site observation of systems and vehicles. The sites are located in Germany, Switzerland, and the US. Furthermore, it includes a set of interviews on the policy level as well as use of different policy documents. The analysis here will use material on the following demonstration sites: München Airport; the refuelling site of Berliner Verkehrsbetriebe (BVG) at Usedomer Strasse in Berlin; the National Fuel Cell Research

Center at UC Irvine in California and the SunLine Co./Chula Vista Transit outside of San Diego, California. The sites were visited in October 2002 and March 2003. Most actors are outspoken opinion on policy, but to fill in on national policy climates, two interviews focussing solely on this will be used.

The analysis of the cases will move on different levels. These are: the level of direct operation of demonstration sites, on the level of identifying the knowledge front of fuel cell and most promising roads to the "hydrogen economy", on the level of the relation between car industry and public policy, say on emissions, and, last, on the critical link between visions and artifacts.

Testing tableaus

The next section consists of a description of the four central demonstrations.

München airport

Demonstration site in the outskirts of the München Airport. Started up in late 1998, with the expressed goal of testing all possible chains between well and wheel for Hydrogen. The financing of his €17 mill. installation is a typical example of the public-private cooperation all such sites have. The State of Bayern together with federal government provided about half of the funds, while a consortium of companies like carmaker BMW and infrastructure provider like Linde AG provided the rest.

The hydrogen project at Münich airport (H2MUC) was initiated in 1995 by the government of the Free State of Bavaria, or more precisely the Bavarian State Ministry of Economic Affairs, Transportation and Technology. Leading enterprises then joined a working group together with the government in order to realize the project. The consortium consists of industry companies (13 different companies in all) traditionally delivering equipment which would apply to a hydrogen refueling station. The companies comprised in the consortium are listed in reference [ ].

The project was financed in the way that the consortium of companies funded 50% and The Free State of Bavaria provided the remaining 50% from public funds. The total investment cost for the project was 17 mill € (34 mill DM) . This cost does not include the hydrogen fuelled vehicles. The three hydrogen fuelled buses (NEOPLAN Internal combustion engine (ICE) hydrogen fuelled buses) in operation at the airport had an approximate cost of 1 mill. € each. 17 mill € was the initial cost estimate. Any extra expenses where shared between all project parties involved according to a key agreed upon. Approximately X% of the total costs of installing the system was X% man-hours, while the component costs contributed around XX%. No problems where reported in the phase of acquiring the different equipment.

The rationale or basic idea for initializing the project was the high air emissions from airports in general. One aircraft landing and taking off at the airport was said to equal the emissions from 50 cars. In addition, the airport is a transit for a large amount of people and the project group emphasizes the public acceptance that demonstration of hydrogen fuelled buses for transporting passengers would give. Therefore the Münich Airport was chosen as the site for demonstrating hydrogen fuelled zero-emission vehicles.

An objective was to test hydrogen production and storage in relation to a filling station for future zero-emission vehicles. In addition, the fully automatic refueling and operation of the bus-fleet vehicles was important to test under the safety requirements of an airport.

Furthermore, the project recognized the importance of public awareness of the hydrogen energy solutions and the project therefore aimed at being the first publicly accessible automatic hydrogen refueling station for passenger cars.

A long term goal that motivated the project also seem to be the need to keep up with the development in Japan and the USA in order not to loose the opportunity for creating European solutions and to create domestic employments in high technology sectors.

The political drive for the project was that the politicians in the free state of Bavaria wanted to show awareness to environmental issues. As early as in the 1980ies, The Greens in the Bavarian Parliament suggested using the potential of 1500 cars, used on the airport Munich to reduce carbon dioxide emission. The opportunity came in 1995, when the state sold there stocks in the local energy utility, and had economically opportunities to reinvest in environmental energy solutions. The Bavarian Department of Economics and The State of Bavaria initiated the project on the airport Munich, using a closed area to test 3 busses (2 MAN busses, 1 Neoplan bus) for transportation of passengers.

The amount of 34 mill DM were decisive to the realization of the project, it would not be able for the private companies to take such a risk by themselves. This political will in the state can there be understood as a main driving force. The political background for this is of course that the ecological movement was strong in Germany during the 1980s, and "The Greens" as a political party experienced increased popularity. It therefore became important for the traditional conservative parliament in Bavaria to show willingness to invest in environmental issues. They pushed the parliament president Stuber to come up with environmental solutions .

The Airport in München was chosen because it became a local symbol of as pollution area, with high air traffic. It was discussed as the main environmental problem in Bavaria. But the site was also chosen to be public available, in order to influence on people's attitude to environmental energy solutions,

Other important goals for the industrial partners was to test different paths to pure hydrogen solutions, test safety and security solutions, and for the private companies it represents a pilot project to get experience that can be implemented elsewhere.

Accordingly, the largest number of hydrogen vehicles at the site is a number of luxury cars from carmaker BMW, most of the model 750. The engine of these are in effect converted otto-engines, adjusted so that it will run on hydrogen. They tank compressed hydrogen. Fuel economy is comparable to or a little worse than similar models that runs on gasoline. Emissions are lower, with no carbon dioxide emissions, but not zero. Some of our informants view this as a cumbersome and un-elegant solution. As one explained to us; such cars are not the hydrogen economy, finding fuel cells to be the technological elegant solution.

The learning's so far has been to find safety solutions with high functionality, to experiment with filling station that is of practical purpose, to demonstrate and show to the public in order to change attitudes. The last goal must also be considered successful, when we visited the site, we where a number in a row of visitors just that day. A less successful learning is the cost: It came out to be much more expensive than expected.

Further plans is to invest in two more buses, There is also plan for a new filling station for natural gas in Freisling, derived by Mannesman.

Berlin – BVG

Set up on a defunct buss parking lot in northern Berlin, the goal for this hydrogen filling station is to provide refueling opportunity for (coming) hydrogen busses used in the public transport network in Berlin. Again a public-private project, this time all cost are shared between energy company TotalFinaElf and the European Commission. The public transport company, BVG, only provides space for the station.

The Initial goals of the project are to demonstrate feasibility for regular service of hydrogen vehicles, generate a positive response on the part of the users and customers, and help to enhance the image of the public transport systems of the future.

In contrast to the filling station in München, this is not primarily a demonstration project, but the clear goal is to operate the filling station as an integral part of the bus fleet operation scheme. The nozzle for filling liquefied hydrogen is exactly the same as the one found at München.

According to the initiators of this hydrogen filling station, the solution must be competitive, both in terms of cost of hydrogen (compared to conventional fuels) and the costs for hydrogen infrastructure investments (competitive with traditional refueling stations).

The most interesting political aspect of the case is the fact that there were no hydrogen buses in Berlin at the time of the opening of the site. At the opening, a lot inhabitants, politicians and business men took part, and BVG had borrowed a bus from München to demonstrate the filling station. But soon after the opening, the bus was returned to München. The lack of buses and the somewhat uncertain delivery time of the buses was not reflected in the Newspapers reporting from the opening day.

In Birsfelden, there was a lot of attention brought to the fact that the fuel cell system was located in a schoolyard. This filling station is located in the middle of the town, also nearby a residential area. Interesting enough, safety aspect of this location has not at all been a subject in the public debate.

Compared to München, the technical solution is very simple. There are no robotics involved for liquid hydrogen fillingThe ambition is that bus drives themselves are going to fill hydrogen gas, in the same way as they fill diesel today.

There is an information center at the site of the filling station, with a classroom, folders, posters and brochures on hydrogen as energy carrier.

The main driving force seems to be the possibility of funding from the European Union. There is also a political agenda for Berlin to acquire an image as a green city, through the program Clean Energy Partnership Berlin. The filling station symbolises a will to prioritise environmental solutions.

The entire project is part of a European Union undertaking to demonstrate such a vehicle in normal fare-paying service first in Berlin and later in Copenhagen and Lisbon, largely to collect data under different operating conditions.

At this time, BVG has initiated or planned several projects. From spring 2003, the first hydrogen driven bus will be put in operation. This bus will be a MAN-prototype, with a length of 12 metre, using liquid? hydrogen. The tank on the roof of the bus has a capacity for 600 litres of hydrogen, which allows a range of 200 kilometres.

Over the next three years, BVG and its partners will collect numerous operation data about the daily use of this new technology, maintenance costs, and reliability. In 2003, Berlin's typical municipal buses, the legendary double-deckers, are expected to use the new technology as well. Two double-decker fuel cell buses are already ordered and will be implemented in a project financed by the German Ministry for Economics. A three-year project will test two 13.5 metre models with hydrogen-driven fuel cells. In the end of 2003, the first public hydrogen filling station will open at the Messerdamm.

In 2004/05, a third station shall open in Spandau. At the same time, BVG will establish the use of fuel cells and hydrogen drive technology in Berlin as regular service, using up to three articulated buses in an optical tracking system. The trial phase will start in spring 2004, and will last over three years. For this project, the Berlin-Spandau line has been selected. The Federal Department of Economy already announced financial support for this project.

This project aims at demonstrating hydrogen fuel as a real and competitive alternative to conventional diesel/gasoline in a similar environment and with the same requirements with respect to convenience and safety. The system physically resembles a conventional hydrocarbon filling station environment, the only visible difference being the considerable cryogenic hydrogen storage tank, pressure vessels (both located over ground), the hydrogen evaporators and the special filling nozzles.

San Diego – Chula Vista with Sunline Transit Co.

This demonstration is set up inside the Transit Company's maintenance area for busses. Currently it consist of a fast-fill, portable hydrogen fueling station from Stuart Energy Co. It is supposed to enable the City of Chula Vista to test and demonstrate fuel cell buses and other hydrogen vehicles. The system can also be used to provide remote fueling services for hydrogen vehicle demonstrations and special events.

The goal of this project is to demonstrate and incorporate Fuel Cell vehicles in the transit co. regular service. The locations of Palm Springs and Chula Vista are important for the demonstration, as well. These local communities have committed themselves to especially environmentally friendly standards.

Compressed natural gas (CNG) has been used for quite some time in Chula Vista and the Transit Co has currently 25 low-floor CNG busses. The argument of our informants was then that a shift to compressed hydrogen was a minor one, as they had in-house know-how on operating facilities where compressed gasses are stored and refueled to busses. Plans was that maintenance on the vehicles proper would also be carried out on site with in-house staff, as there were no perceived special difficulties in maintaining such a vehicle.

The strategic – if somewhat mute – goal of the project is to try out hydrogen as one link in a chain of more environmentally friendly energy sources.

There were, however, no fuel cell busses operated on site when we were there. The demonstration site is working on a proposal to the Federal Department of Energy and to other state authorities on the financing of between one and three busses. One 30-foot bus (a relatively small one) costs more than $1M. Busses that use internal combustion for propulsion are much cheaper, but as one of our informants stated: "cost is no issue".

In the first period, the demonstration will rely heavily on its local partner, the SunLine Corp. in Palm Springs. They will share engineering resources and vehicles, As important as what they do now is stratigic alliances they make for the future. Our informants from the two transit organizations were emphatic on how well they were cooperating, and that they will share important relations with federal and state agencies. Accordingly, acquiring a car within the efforts from California Air Resources Boards goal of 250 zero-emission vehicles[6] is one of several targets of the demonstration.

The demonstration is in itself an example of the seemingly not-so-complicated building of infrastructure. The portable unit is loosening the link between the geographic site and the demonstration. As in the Berlin case, the situation is that the demonstration sites are waiting for the manufacturers of fuel cell vehicles to deliver. On the other hand, the carmakers Honda and Toyota are separately supplying fuel cell vehicles based on their hybrid-electric platforms. Other demonstration sites have been able to get a hand on some of these vehicles. The Toyota is using its hybrid-electric platform equipped with a 90kW fuel cell stack developed in-house, while Honda is using a 78 kW stack from Ballard. Let us return to this in the next case, at the National Fuel Cell Research Center outside of Los Angeles.

National Fuel Cell Research Center at UC Irvine

The approach of the National Fuel Cell Research Center (NFCRC) at University of California, Irvine campus, is different from the other, more "pure" transportation demonstration sites. The site itself has close ties with the energy industry and especially producers of different types of combustion hardware, such as gas turbines. Siemens-Westinghouse is one example. This site makes an "open-platform" available for manufacturers, in effect conducting beta-testing on different systems. Beta-testing means that systems are set up in a simulated real-world environment and then monitored for performance and failures, and to some extent changed on site. The beta-testing on stationary systems is conducted according to certain methodological rules, but our informant played down this aspect when it came to transport.

The NFCRC have a contract with Toyota for the lease of two Toyota fuel-cell vehicles. These vehicles are based on existing electric-hybrid drive-train, with permanent magnet electric motors and a "booster" battery. It is installed in the *Highlander* model, a small SUV (the *Kluger V* platform). The fuel cell stack is made in-house, and has a maximum output of 90 kW.[7] One vehicle has been delivered, and one more is expected before summer 2003. The current lease is $20 000 per month per car. This does probably not reflect the real cost of the vehicle. It can be noted that the lease Honda has set for its vehicles is $500 per month.

The choice of this site as a good one for demonstrating a fuel cell vehicle is due to several reasons. On the face of it, the site can offer links to leading academic research on the application of fuel cell systems and the handling of hydrogen. Also, the open platform solution incorporates the methods necessary for collecting market-near experiences. Both are important for the manufacturers. On the other hand, our informant at the NFCRC also stressed the number of linkages and the good diplomatic skills the center and its staff possessed. Further proof of the center' diplomatic skill is that it has been able to conduct projects for competing manufacturers on the same location. To attain status as a National Research Center

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[6] California Air Resources Board (CARB), "Description and Rationale for Staff's Additional Proposed Modifications to the January 10, 2003 ZEV Regulatory Proposal", Policy brief dated March 5, 2002 (www.arb.ca.gov).

[7] Technical information on the Toyota FCHV-4 is available on http://www.toyota.com/about/environment/technology/fchv.html

is another sign of its skills, as well as – on a more local level – it has been able sway building authorities to accommodate technical solutions on and off campus.

Discussion: Visions in reality

All the demonstration sites mentioned above have a mixed status from an analytical point of view. They are very much about giving reality to the vision of a hydrogen economy. Thus far, the opening ceremonies, a point which will be addressed below, is the clearest links between the production and sustainment of the vision an its reality.

On site, the message of the demonstration is mixed. Most of the sites are conducting what at best can be called early-phase demonstrations. The learning-cycles or experience gathering in each site is very local and specialized. The strategy used on-site seem to be a small, and incremental one, where the grand vision is referred to constantly, e.g. in Chula Vista, the refueling unit has printed "FreedomFuel" with large types all over it. At the same time, when the sites are presenting their own role, sites have a local, "making this solution work"-understanding. In terms of driving the innovation/implementation process, this might be a necessary step. In the relation between the vision and its statements, the sites seem to have an instrumental but important role, providing carmakers physical infrastructure, space, and back-up when vehicles roll out of R&D-departments.

The process of linking and enrolling resources and making alliances, seen from the local demonstration site, is also a process of making the site less likely to be cut off from further demonstration tasks. Accordingly, the solution seen in Chula Vista, where the refueling station is portable, is a sign of weaker ties to the vision than the München site. Analytically, enrolling resources is one of the fronts the sites are fighting on (Latour 1987).

The relation goes the other way as well. But seen from the carmakers, powerful allies by any standards, demonstration projects has another meaning. First of all, the availability of potential site is large. The carmaker can choose the most attractive site. In the observations made and according to informants, no critical development on singular parts would be made at the demonstration site. Accordingly, the purpose of a demonstration project is to demonstrate the feasibility of a system. Moreover, the demonstrations can be seen as the most resent expression of the vision of the Hydrogen Economy. At this time, alas, the strain between the vision and the reality is quite large.

Thus, the relation is at least two ways, from the carmakers collecting bargaining chips by offering EVs, while regualtors seeks to lessen environmental and health problems. Conspicuously, more in California, than in Europe.

Carmakers' strategy

Currently there are a number of models available between carmakers on how to realize the vision. It is worth stressing that when seeing carmakers' strategies from the vantagepoint of a demonstration site or from a policy-making agency the, special angles rise in importance. The demonstration sites have stronger loyalty to fuel cells (and by extension: to the vision) than to specific carmakers, one informant argued. From policy making agencies, the developments in the field are watched with some caution.

Nevertheless, it is interesting to see how much of the distictive productive models (Boyer 2002) the different companies use in such early phase development.

In the US, and especially in the California, the two Japanese carmakers Honda and Toyota are leading the development of alternative energy conversion for vehicles. Unlike Ford, who has delivered electric vehicles for niche markets, the two Japanese makers have produced vehicles for the mass-market. The Toyota Prius hybrid electric car is made in more than 100 000 ex.

Accordingly, these two makers have extensive knowledge on alternative drive-trains, of which an hybrid-electric platform is an example of. Seen from the demonstration sites, these makers also have the most “promising” solution, as it is a less complicated task to add a fuel cell to an existing platform, than to develop something from scratch. In the newest developments in California, the goal of 250 zero-emission vehicles in the period between 2003-2008 is comparatively easy for these makers to achive.

Furthermore, the strategies of these two makers seem to be essentially the same. Developing alternative vehicles for the mass-market, thereby establishing reliable platforms for later developments. The inclusion of fuel cell technology, even if it was not foreseen when hybrid electric vehicles was planned, is easy as well. There is one important difference though, Toyota has chosen to keep its development in-house, while Honda has cooperating with Ballard, a Canadian company.

Of other distinguishable strategies, we have the strategy of BMW. They have chosen to convert existing internal combustion engines to run n hydrogen. A number of our informants from the demonstration sites were quick to dismiss these cars, as not being “real” hydrogen cars. On the other hand, these cars – and converted IC busses – have the advantage of being easy to convert, making a number of vehicles available from an early time, for instance in München. Accordingly, such a strategy gives life to otherwise quiet infrastructure installations.

DaimlerChrysler has cooperated with Ballard in the Xcellsis. The direct involvement of DaimlerChrysler is ended, but the development efforts of this company and of DaimlerChrysler, seem to more directed towards fleet vehicles and busses. DaimlerChrysler has installed fuel cells in the Citaro-model bus. Now, almost all existing and planned (excluding UC Irvine, which has acquired two Toyota FCVH-4s) are connected to some type of public transport. Our informants were also adamant on the cost issues of fuel cells stacks. The argument used goes as follows: The engine cost of bus in installed effect is much higher than in a small car. A fleet operator has maintenance and refueling centralized, and, obviously, often a public transport unit has well-established economical-political clout, more than one would expect from a small organization. In essence, this is an argument that follows a Schumpeterian logic; as niches are taken, cost goes down and the technology moves into new realms.

Actor coalitions

First, there is one striking observation to be made. The NFCRC site, the site with the closest ties to the energy industry and the smallest transport demand is also the site that has the easiest access to small fuel cell vehicles. No other site was able to get their hand on small vehicles.

Now, the development of fuel cells and the hydrogen economy is to a large extent a public-private cooperation. The cases all have very substantial public funding, to the extent that the car industry itself is only a supplier of parts – cars as it were – to these co-operations. In terms of direct benefit for carmakers, it its doubtful if the demonstrations, as such, contribute to the development of fuel cell cars. Most of the technical testing and development would be better off in-house. The fate of the vehicle is out of the carmakers hands when it enters a demonstration phase. And, currently, fuel cell vehicles are not at the point where being exposed to “real-life” adds to it.

On the contrary, it would seem that the demonstrations are more one of actors or actants of the Hydrogen vision. Such actors push carmakers to make fuel cell vehicles, albeit in small numbers.

For the car industry, contributing in such demonstrations, however mundane in reality, must have more to it than just demonstrating.

Having a push to develop roadworthy vehicles is important for the car industry. But as important are the potential consequences of not partaking. As seen in the transactions of the California Air Resource Board (CARB), the number of zero-emission vehicles demanded from carmakers is directly discussed, with potential large consequences. This aspect of the car industry is less directly managed by European authorities, but the loop-side of not part-taking in environmental effort is the possibility that harder regulations, e.g. of emissions, will be imposed.

In the actor coalition that makes up the drive for a Hydrogen Economy, the demonstrations, the suppliers of hardware such as fuel cells, and – to some extent – eco-movement are in the driving seat. The bottom line in the vision’s argument is that hydrogen from renewable sources will solve both local and global environmental problems, is can be agreed upon by a great number of actors. The critical question is the timeframe. Both from a policy-perspective and seen from carmakers and energy companies realizations in the short can only be demonstrations. Thus, the demonstrations are the expression of the vision mediated through the interest of these three actants.

CONCLUSIONS

There is one easy question to be answered first: Are there signs of serious effort of going to ramp-up of competitive fuel cell vehicle in the next 5 years? The simple answer would be no. But it must be said that both Honda and Toyota have positioned themselves in such a way that a move to mass production would be relatively easy. Such a move would require much progress in the development of fuel cells, both in terms of production cost and in terms of operational stability.

The paper has illustrated the messy, muddling-about dynamics of early realization of the Hydrogen Economy. The production models (Boyer 2002) used later in the development process has not taken hold. It is an example of an development effort that is included on the policy level and the regulation of the industry, seen most strikingly in the adjustment of California Air Resources Board’s goal for percentage of zero-emission vehicles in the coming years, from 10% of all new cars, to 250 vehicles totally in the full period 2003-2008.[8]

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[8] “[The] *minimum floor requirement, if met by all manufacturers, would result in a cumulative total of roughly 250 Type III ZEVs produced by the large manufacturers over the 2001-2008 model years. Staff believes that this number of Type III ZEVs is sufficient to satisfy the need for small-scale demonstration programs of fuel cell vehicles. Small-scale demonstrations are the next logical step in the path to commercialization of this technology*.” California Air Resources Board, “Description and Rationale for Staff’s Additional Proposed Modifications to the January 10, 2003 ZEV Regulatory Proposal”, Brief dated March 5, 2002 (www.arb.ca.gov)

As for innovation processes in the car industry – apparently demonstrations are established for the long haul and for introduction of new concepts that need extensive adjustments from the market and potential users. It less clear if fuel cells has developed or will develop into such a status.

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