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Abstract

The hydrogen hype of the last decade has passed and it is now seemingly substituted by the electric vehicle hype. A technological hype can have both positive as well as negative consequences. On the one hand it attracts sponsors for technology development but on the other hand the high expectations might result in disappointment and subsequent withdrawal of the sponsors. In this paper I ask the question to what extent the car industry has created the hype and how it has done so. The industry's role is studied through their prototyping activities and accompanying statements on market entry. I conclude that the car industry has indeed inflated the hype, especially through its public statements on market release after the turn of the millennium. Furthermore, the industry has shown a double repertoire of both highly optimistic and more modest statements. From this I take that statements are used deliberately to serve the industry's interests whenever needed. Without neglecting the positive outcomes of hype, public and private funding for R&D efforts, more modest promises could serve the development of sustainable mobility better.

Keywords: Fuel cells; hydrogen; hype; automotive industry; electric vehicles

Introduction

The hydrogen hype is over so it seems. The automotive industry, governments, and the public have now turned their eyes to the electric car in the hope to find the clean car of the future. In this paper I discuss the general notion of technological hypes and I relate this to the hydrogen hype and the role of the automakers in creating it. I will argue that the automotive industry has contributed to the hype by both developing and showing off their hydrogen prototype cars and by making overly optimistic statements about going commercial with hydrogen. I will contrast this with the current hype-like dynamics for battery electric vehicles.

1 Technological hypes

In public discourse, the word hype has a negative connotation and it is often used to talk down short-lived upsurges of attention for some phenomenon and the accompanying unrealistic expectations. When it comes to technology and innovation, experts appear to be fond of using the hype argument; only the enlightened one can separate fact from fiction and thus realistic from unrealistic expectations. To speak of hype is often not just an attempt to make way for realism; it also used to warn for the negative consequences of the hype. That is, hype is inevitably followed by disappointment and that disappointment could put an end to the development of the new technology.

Associating hype with just the downside of disappointment does not do justice to the earlier positive effects of the hype however. An innovation may also need a hype to gain legitimacy and credibility in its early stages of development. That is, innovation relies not only on scientific and technological achievements and breakthroughs, but also on expectations of future potential. More specifically, expectations of technological progress help to stimulate, steer and coordinate collective action on the sides of researchers, engineers, firms and funding agencies in order to make the innovation work. And therefore it is not so much of interest whether expectations are realistic or not, and this can only be decided with hindsight, but whether they are widely shared and whether they are powerful enough to create support for the technology in the making. This role, and the deliberate use, of expectations and hype has been analyzed in detail by scholars active in the so-called sociology of expectations (Van Lente 1993; Borup et al. 2006). Typical hype-disappointment dynamics have been studied in this body of literature as well (Ruef and Markard; Brown and Michael 2003; Konrad 2006). A concept that is often taken as reference by these scholars is the '*Gartner hype cycle*' (Gartner 2008). It is a tool that is used by the Gartner consultancy firm to position new technologies on a timescale and to make recommendations about the timing of strategic investments in the technology. Even though hype cycles take on different shapes and sizes for different technologies, the Gartner cycle provides a clear illustration of the basic dynamics. The graph the company uses plots the visibility of a technology on a timeline. An archetypal illustration of the timeline is presented in figure 1. After a first technology trigger, the visibility increases sharply and makes for hype, up until what is called the peak of inflated expectations. As the peak is reached disappointment gets the upper hand and subsequently the visibility drops rapidly, which then results in the trough of disillusionment. After some time the technology might recover and slowly but surely the visibility increases again (now accompanied by more modest expectations) and the technology might make its way to the market after all.

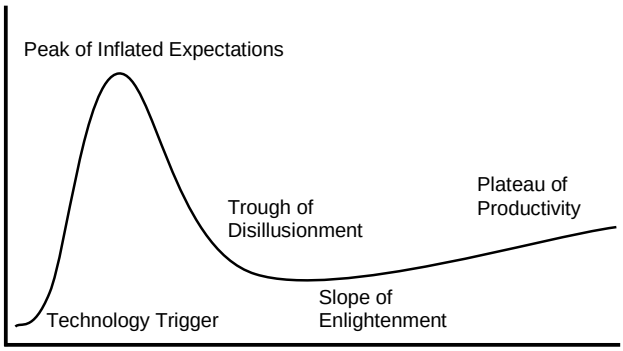

Figure 1: The Gartner hype cycle

2 Hydrogen and the peak of inflated expectations

In order to understand the role of the established car industry in creating the hydrogen hype, I will first discuss some general understandings of the hydrogen hype. Secondly I will discuss the industry's part in the creation of the hype and the role of their prototypes and statement therein.

The basic outline as sketched by the Gartner hype cycle seems to hold for hydrogen technologies. Experts have made claims about hydrogen being a hype (Romm 2005) and engineers and scientists have also claimed that the hype is now over (Frenette and Forthoffer 2009). Even though public funding has not immediately been threatened by the apparent disappointment and decrease of visibility (Ruef and Markard forthcoming), more recently US Department of Energy funding has been cut to a minimum. Much of the resources are taken away from hydrogen in favor of the electric car and stationary fuel cell applications such as auxiliary power units (DOE 2009). Whatever the consequences may turn out to be for funding, the notion of hydrogen economy seems to have taken a blow.

As said, the focus of this paper is on the car industry's actions and words that have driven the hydrogen hype to its peak. Hypes never fall from the skies; they are created in complex social processes. And even though the industry is not the only instigator of the hype, it has certainly played a very significant part in it. The peak of inflated expectations of hydrogen technologies is thus also created by the car industry. O'leary (2008) quotes the founder of the hype cycle Jackie Fenn on this phase:

> a phase where *"Over-enthusiasm and unrealistic projections, a flurry of well-publicized activity by technology leaders result in some successes, but more failures, as the technology is pushed to its limits. The only companies making money are conference organizers and magazine publishers." (Fenn 2007)*

It is hard to tell whether hydrogen technologies have actually failed and whether this is the consequence of '*pushing the technology to its limits'*, but one could safely say that they have not lived up to expectations, for instance in terms of cost reductions and travel range. For instance, the hydrogen car that is closest to market introduction is the Honda FCX Clarity and about its production costs are nothing but speculations (of up to 1 million dollars) and it only has a maximum range of about 240 miles[1]. Many hydrogen experts, like (Romm 2006), will argue that hydrogen was always

[1] According to Honda, http://automobiles.honda.com/fcx-clarity/refueling.aspx (visited sept10-2009)

overestimated and would never have been able to live up to its inflated expectations. But whether or not expectations where indeed too high from a realist point of view is not so much of interest here. I take, following the sociology of expectations, a more constructivist position here and ask the question what the sources of the hydrogen hype were and what the exact role of the industry was in creating it.

3 Measuring hype

In existing literature on expectations and hypes, some form of media attention is taken as measure for visibility of the technology and thereby as a yardstick for hype (Ruef and Markard; Alkemade et al. 2006; Geels et al. 2007; Dignum 2009). Media attention is then measured in quantitative terms (counting positive and negative articles) as well as qualitative in order to gauge the hype more accurately. I propose to take a different approach by measuring the industry's prototyping efforts and to analyze the accompanying statements made by the OEMs. The first measure is thus the number of hydrogen prototype models that are constructed and presented by the manufacturers. To study the prototyping activities a database was compiled with prototypes of hydrogen vehicles that were developed from 1960s onwards. The data was collected through an online search process and by comparing and combining a small number of existing databases.

The second measure for hype results from statements that were made by the industry spokespersons on their intentions on taking hydrogen cars into production and releasing them on the (consumer) market. To gather the statements, the archives of a leading information source on the car industry[2] were used. To find the relevant statements the following search terms were used: 'hydrogen' and/or 'fuel cell'. This resulted in 151 unique hits of which 20 contained explicit statements on planned or estimated year of production and market entry.

4 Prototyping activities

Prototypes are not only used as R&D tools in a trial and error learning method in which novel technologies are fitted together and tested in the configuration of the prototype, they are also used as communication tools. Manufacturers show off their latest achievements and designs at car shows and in car magazines. By doing so, the prototypes are used as expectations tools, materialized expectations, to shape expectations with consumers, governments, competitors and so forth. The message communicated hereby is twofold. On the hand prototypes are used to showcase the potential of the novel technologies. On the other hand, manufacturers show the world that they are actually working on the (sustainable) car of the future. Both of these messages are important for the manufacturer since it needs to convince outsiders that it is a) taking it supposed responsibility in producing more environmentally friendly cars and (b) that the route(s) they choose to go for in searching for the car of the future is indeed viable and credible. Hydrogen prototypes have been around for over 40 years, but a peak in prototyping activity started only 15 years ago. The most probable trigger for the peak was the California mandate on zero-emission vehicles (van den Hoed 2005). Even though patent statistics have shown that car manufacturers performed research on all thinkable alternatives such as electric and hybrid vehicles(Pilkington et al. 2002; Frenken et al. 2004; van den Hoed 2007; Oltra

[2] www.just-auto.com

and Saint Jean 2009), from their prototyping activities from 1990 up till 2006 speaks only one serious option; hydrogen (Bakker and Lente 2009).
During the peak that lasted roughly from 1997 till 2006, 189 prototypes were constructed. All but a few of these were developed by the incumbent industry. BMW, Honda, Ford, Daimler (DaimlerChrysler during most of the time) and Toyota were the industry leaders with respect to hydrogen prototypes. All other major OEMs were also involved in hydrogen prototyping, however to a lesser extent. From 2006 onwards prototyping activities decreased sharply. The exact explanation for the decline of hydrogen is rather contested. Some experts suggest that a number of the companies prefer to scale up their hydrogen programs in the direction of commercialization and therefore no longer produce prototypes. Honda and Daimler[3] have done so, for instance. A more likely explanation however, may be the shift towards hybrids, plug-in hybrids and full battery electric.
To gain more insight in the rise and fall of the hydrogen hype we have collected statements of car manufacturers in which they have made claims on expected and planned timing for scaling up production and entering the market.

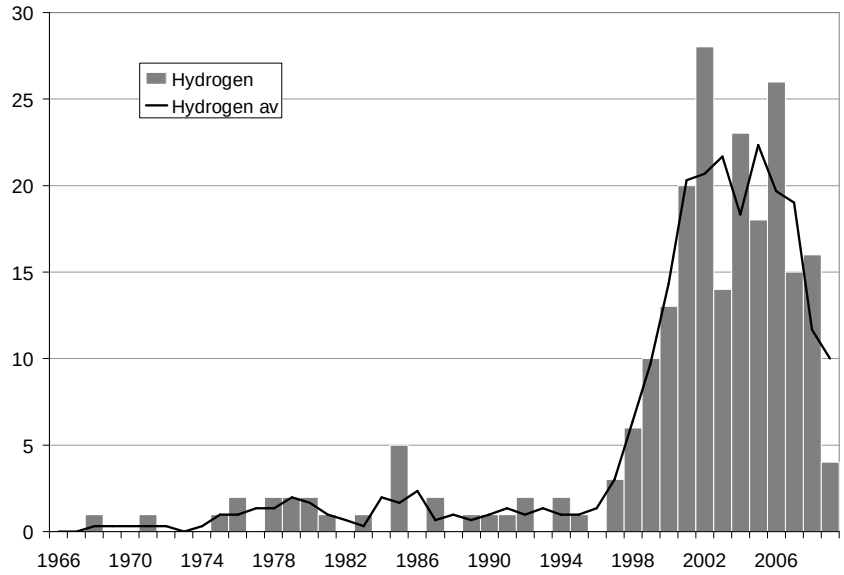

Figure 2: Hydrogen prototypes, number of prototype vehicle models per year, with three year average line

5 Statements

When we turn to the statements that were put forward by industry spokespersons, ,often CEO's or heads of R&D departments, we find that Daimler, Honda, Toyota, GM, Ford, and Volkswagen have made explicit comments about the expected market release of hydrogen cars. The statements are listed in tables 1 and 2. Especially Daimler, Honda, Toyota and GM have made strong statements, in 2001, about being ready for market in 2004. Daimler claimed furthermore to invest 1 billion dollars in hydrogen technologies. In 2002 however, Ford, GM and Toyota came out with statements that either postponed the planned year of release or at least warned that reasonably priced cars were much further away. In later years only Honda and

[3] Personal communication with an industry hydrogen expert

Daimler issued statements about market entry within a couple of years. The rest of the industry leaders only talked about going commercial after 2010 and beyond.

Table 1: Optimistic statements

Year	Firm	Statement	Years ahead
2000	Daimler	2002 busses on market	2
2001	Daimler	FCV's on the market in 2004	3
2001	Honda	FCV's on the market in 2004	3
2001	Toyota	FCV's on the market in 2004	3
2001	GM	FCV's on the market in 2004	3
2001	Toyota	FCHV4 on the market in 2003	2
2002	Ford	Start production 2004, full launch 2010	2
2006	Honda	Sales from 2009	3
2007	Daimler	B-Class production in 2010	3
2008	Daimler	On sale 5-8 years	5-8

Table 2: Modest statements

Year	Firm	Statement	Years ahead
2001	Toyota	Reasonably priced 2010 earliest	9
2002	Ford	2010 50k/yr production	8
2002	GM	End of decade retail market	8
2002	Toyota	10-15 yrs relatively modest price	10-15
2003	Toyota	No significant volume before 2015	12
2003	GM	May put FC's in cars end of decade	7
2003	Ford	Commercial in 2020	17
2004	Ford	If ever…	x
2005	Honda	5% share in 2020	15
2007	VW	Not widely available till 2020, infrastructure	13

A rough divide can be recognized between the most optimistic promises that were made in those early years, when the statements reflected hopes of entering the market in two to three years time, and the more modest statements in the following years. The industry then showed more modesty with claims on market entry in seven to eight years. But some the optimistic and modest statements are made in the same year and new insights and sheer disappointment in the technology's progress cannot be the only explanation. One possible interpretation of this divide in statements is that the industry actually has two repertoires of statements on hydrogen. One repertoire consists of highly optimistic statements about hydrogen and is geared towards raising additional, governmental, funds for R&D and demonstration projects. The other repertoire, with the more modest statements, is used to hold off strict emissions regulations that governments might want to impose in their belief that the technology is 'ready'.

In order to explain why hydrogen cars will take so many years to become feasible, the OEMs provide two main arguments, the first is the cost of the fuel cell system and thus of the hydrogen car as a whole. The second argument builds on the lack of hydrogen infrastructure that is needed for any consumer to even consider buying a hydrogen vehicle. Typical statements are listed in table 3. Of course, the chicken and egg problem is a much debated issue in hydrogen communities and the companies involved. Both sides, the automotive and energy industry, tend to point to each other

for taking up the glove and solve this issue. GM for instance, in 2008, asked the energy industry explicitly to build more hydrogen fuelling stations.
Especially the infrastructure issue is somewhat outside the responsibility of the car industry and is therefore well suited to explain the failure of commercialization of hydrogen cars.

Table 3 Firms' explanations for hydrogen disappointment

Year	Firm	Statement
2000	Honda	Shift to FC when infrastructure is completed
2000	GM	Cost reductions, safe and reliable infrastructure
2003	Toyota	H2 not be practical until a more efficient method of producing hydrogen without CO2 emissions had been developed
2007	Honda	FC long way from economic, infrastructure issues as well
2007	VW	The problem lies mainly in providing a hydrogen infrastructure
2007	Toyota	Cost of the FC system
2008	Toyota	Cost and infrastructure
2008	GM	Energy industry must build more hydrogen fuelling stations

6 Influence of prototypes and statements

What the exact role of these statements was in the increase of the hype and the decrease afterwards remains somewhat speculative. But, since car companies are the most important actors with respect to a hydrogen economy it seems logical to assume that their statements had a huge effect on expectations held in general. Especially statements on market entry find significant resonance in the expectations held by wider society and governments. It is hard, and most probably not just, to compare all the statements on the basis of the market entry year that was mentioned. There are significant differences between claims such as: start of production, market entry, producing cars that are commercially viable and affordable for consumers, reaching mass market, and significant market shares. Nonetheless, statements where highly promising in 2001 and some remained so up till 2007. Governments and consumers have taken these messages and shaped their expectations of the hydrogen car accordingly. For instance, public funding in Germany for fuel cell and hydrogen technology have risen since the turn of the millennium (Budde and Konrad 2009). And the EU Joint Technology Initiative for hydrogen technologies is focused mainly on demonstration projects and the build up of the hydrogen infrastructure, rather than on additional R&D on propulsion technology. Indicating that governments have taken the message that hydrogen is to be taken serious and that support for the up scaling of hydrogen technologies is timely.

7 Conclusion

Contrary to popular belief, hydrogen is not always ten years away; it used to be only two years into the future. With its prototypes and overly optimistic statements, the automotive industry has had a big share in creating the hydrogen hype. On the one hand this has led to increasing support from sponsors, as the result of the high expectations. On the other hand it created huge potential for disappointment in governments and the general public. As technological breakthroughs were not

realized and market entry was not achieved, the resulting disappointment has led to a breakdown of expectations and paved the road for the hybrid and electric vehicle. The industry's double repertoire of both highly optimistic and more modest statements, suggests that the statements are used deliberately to serve the industry's interests whenever needed.

Now however, the hype seems over and the automotive industry speaks hardly of anything but hybrids and electric vehicles. Funding for hydrogen seemed to remain stable (Ruef and Markard; Suurs 2009), but recently the US Congress has cut practically all funding for mobile fuel cells[4]. Much of the funding is shifted to electric vehicles. For electric vehicles, the same dynamics appear; a multitude of prototypes and highly optimistic statements from the industry on entering production. There is one difference however. In case of EVs there are a far greater number of new-entry firms that have developed and marketed EVs. This is a sharp contrast with the hydrogen prototype hype in which only the incumbent OEMs were involved (Bakker and Lente 2009).

Without neglecting the positive outcomes of hype, public and private funding for R&D efforts, more modest promises could serve the development of sustainable mobility better. Be it for the revival of hydrogen or the current surge of battery electric vehicles.

[4] The Feds "Zero Out" Hydrogen Research, May 8, 2009 http://industry.bnet.com/auto/10001393/the-feds-zero-out-hydrogen-research/

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