



Why has the introduction of natural gas vehicles failed in Germany?—Lessons on the role of market failure in markets for alternative fuel vehicles[☆]



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HIGHLIGHTS

- We analyze market failure in the German market for natural gas vehicles.
- Coordination failure is the most important reason for market failure to arise.
- Minor factors: regulatory deficits, imperfect information, bounded rationality.
- Policies encompass stabilizing expectations and supporting actor coordination.
- Our results are instructive for policies and investor strategies in AFV-markets.

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ABSTRACT

Despite private investments exceeding two billion Euros and tax incentives of more than 500 million Euros, the market share of natural gas vehicles (NGVs) in Germany has lagged far behind expectations and behind market developments in other countries. With total cost of ownership being on average lower for NGVs than for gasoline and diesel vehicles this raises the question of the existence of market failure in the German NGV-market. We use a case study approach where we combine quantitative data with insights from a multi-industry expert panel and in-depth interviews with experts from industry, government and civil society in order to examine whether and how different types of market failure contribute to the status quo in the German market for NGVs. We conclude that coordination failure in complementary markets, an artificially created monopoly of service stations at motorways, imperfect information, bounded consumer rationality, and principle-agent-problems are the most prominent market failures inhibiting the development of a functioning market for NGVs. Our results are instructive for the design of effective public policies and investor strategies aiming to create markets for alternative fuel vehicles.

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1. Introduction

“The adoption of alternative fuel vehicles has been regarded as one of the most important strategies to address the issues of

energy dependence, air quality, and, more recently, climate change. Despite decades of effort, we still face daunting challenges to promote wider acceptance of AFVs by the general public”.

Yeh (2007), Energy Policy

With transport intensity being on the rise for decades, decoupling the mobility of goods and persons from emissions of transport-based greenhouse gas (GHG) is one main approach in the fight against climate change. One key strategy to achieve this goal is to substitute fossil gasoline and diesel by hydrogen, electricity, natural gas, or biomethane. Among the different types of alternative fuel vehicles (AFVs) that have become available over time, natural gas vehicles (NGVs) were among the first mature and

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Table 1
Literature on market failure in the market for AFVs.

| Type of market failure | |
|--|---|
| Coordination failure in incomplete markets | Achtnicht et al. (2012), Germany; Backhaus and Bunzeck (2010), Netherlands; Collantes and Melaina (2011), Argentina; Köhler et al. (2010), Germany; Melaina and Bremson (2008), Argentina; Meyer and Winebrake (2009), US; Oltra and Saint Jean (2009), France; Sandén and Hillmann (2011), Sweden; Wang-Helmreich and Lochner (2012), Germany; Yarime (2009), Japan; Yeh (2007), International |
| Failure of competition | Yarime (2009), Japan |
| Incomplete information | de Haan et al. (2007), Switzerland; Howarth and Sanstad (1995), Theoretical; Lane and Potter (2007), UK; Zhang et al. (2011), Theoretical/US |
| Bounded rationality | Brownstone et al. (2000), US; EPA (2010), International; Eppstein et al. (2011), Theoretical; Greene (2011), Theoretical/US; Greene et al. (2009), Theoretical; Howarth and Sanstad (1995), Theoretical; Tran et al. (2013), US/EU; Ziegler (2012), Germany |

marketable technologies. NGVs are fuelled with compressed natural gas (CNG) and reduce GHG emissions by 17–24 per cent compared to gasoline and diesel vehicles and up to 95 per cent when fuelled with biomethane (EUCAR, 2011). However, despite substantial public and private investment of more than 2.5 billion Euros (Initiative Erdgasmobilität, 2011), NGVs have been adopted far slower in most OECD markets than expected.

The German vehicle market, which is the largest vehicle market in the European Union with approximately three million vehicles sold annually (Kraftfahrtbundesamt, 2014), is a prominent example for a market where the uptake of NGVs has lagged far behind expectations. With a population of 91,500 NGVs in 2010, equivalent to 0.2 per cent of the total vehicle population, the share of 0.5–1.0 per cent, which was forecasted for 2010 by an expert group from industry, research and politics as part of the Nation Fuel Strategy 2004 (BMVBS, 2004) has been missed by far.¹ At current growth rates, the share of NGVs will rise to 0.4 per cent until 2020, rendering the target of 2.0–4.0 per cent, which was forecasted for 2020 out of reach.² It currently remains uncertain if the NGV-market will eventually gain momentum or collapse. In retrospect, it seems that during the last two decades both industry and politics have failed to set appropriate conditions and incentives for the development of a functioning market.

In their analysis of the US vehicle market, Portney et al. (2003) argue that the existence of market failure in AFV-markets is a major reason why GHG-efficient technologies have not been adopted on a large scale. Despite this claim, few studies have empirically examined the existence of market failure in AFV-markets (see Table 1). With respect to the German case, four empirical studies have provided evidence for the existence of coordination failure between vehicles and the corresponding infrastructure (Achtnicht et al., 2012; Köhler et al., 2010; Wang-Helmreich and Lochner, 2012) and for bounded consumer rationality (Ziegler, 2012) in AFV-markets. However, no attempt has been made so far to shed light on the interrelations between these types of market failure or to systematically relate them to the state of the NGV-market.

¹ The following institutions formed part of the expert group which was responsible for forecasting the development of the German NGV-market as part of the National Fuel Strategy 2004: Association of the German Petroleum Industry (MWV), Fachagentur Nachwachsende Rohstoffe (FNR), Federal Environment Agency (UBA), Federal Ministry for Economic Affairs and Energy, Federal Ministry of Education and Research, Federal Ministry for the Environment, Federal Ministry of Finance, Federal Ministry of Food and Agriculture, Federal Ministry of Transport, Members of the Clear Energy Partnership (VES), German Energy Agency (dena), German Association of the Automotive Industry (VDA), Gesellschaft für Mineralöl-Analytik und Qualitätsmanagement, ifeu Institute Heidelberg, Institute for Energy Process Engineering and Chemical Engineering (IEC), Leipziger Institut für Energie, Ludwig-Bölkow Systemtechnik (LBST).

² The forecasts are subject to the assumption that the composition of vehicles in the NGV-market is the same as in the market for conventional fuel vehicles.

This paper intends to fill this gap by examining the joint occurrence of different types of market failure in the German NGV-market. Using the case study approach proposed by Yin (2007) we draw on various sources of quantitative data and complement these with qualitative data from a multi-industry expert panel and from interviews with representatives from industry, government and consumer associations.

Our results contribute to the literature in three respects. First, we provide a comprehensive overview of the empirical literature on the existence of market failure in AFV-markets, which has not been available before. Second, we address the lack of comparative research on market failure in AFV-markets by assessing the relative importance of different types of market failures in impeding the creation of a functioning NGV-market. Third, the paper contributes to a general understanding of how market failure is hampering the introduction of AFV-technologies. The case of NGVs is a precedent for the introduction of other AFV-technologies, especially electric vehicles (EVs), as in most OECD-countries the political focus has shifted from gas-powered vehicles to EVs. According to plans of the federal government, Germany is supposed to become the leading market for EVs with a population of one million by 2020, equivalent to two per cent of the total vehicle fleet (BMU, 2009). However, despite substantial public funding of 1.5 billion Euros between 2009 and 2013 (Bundesregierung, 2011) with about 9000 registrations in 2013 market uptake has remained low. As EVs currently are at a stage within the product life cycle that NGVs have passed about fifteen years ago, the failure of NGV-introduction provides a valuable case for deriving lessons on the market introduction of AFVs in general (see Bunzeck et al., 2010, on technological status and market penetration of each technology).

In addition, the market for NGVs is well suited for an analysis of market failure, because in contrast to other AFVs NGVs are technically and financially competitive as they come with the same design and comfort levels as conventional fuel vehicles. After 20,000–40,000 km the total cost of ownership is lower for NGVs than for comparable conventional fuel vehicles (Growitsch et al., 2013; Kuhnert et al., 2012). Hence, product failure can at this stage of technology development not be held responsible for low sales numbers any more. In fact, NGV-markets in Italy, Argentina and Sweden exhibit high growth rates (NGV Global, 2014). With about 140,000 registrations per year, NGVs have attained a population share of 1.6 per cent in Italy. In Argentina, a vehicle share of more than 17 per cent has been reached. The current share of NGVs in Sweden, where NGVs were introduced at the same time, is now four times higher than in Germany. The success of NGVs in other OECD-markets (see Fig. 1) raises the question of what is hampering a similar market development in Germany and which lessons can be derived for the design of markets for other AFVs, first and foremost for EVs.

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