How do companies decide? Emotional triggers and drivers of investment in natural gas and biogas vehicles

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How do companies decide? Emotional triggers and drivers of investment in natural gas and biogas vehicles

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Abstract

Management research recognizes that companies' investment decisions are driven not only by objective techno-economic models but also by emotion. Alternative fuel vehicle (AFV) investments offer an appealing context in which to study this interaction in energy source decisions, as they are influenced by a diverse set of analytical and emotional elements ranging from fuel costs to environmental values. This study examines companies' vehicle investment decision making in Finland and focuses on the interaction between objective facts and subjective feelings along with the process of choosing the vehicles' energy source.

This article is based on an interventionist case study. Switching path analysis technique (SPAT) was used to investigate companies' switches from conventional fuels to natural gas or biogas. This article identifies the decision-making triggers previously unreachable by energy research and derives implications for the different parties involved by extending understanding of the dynamics between these factors. This article also contributes to the discussion of AFV adoption by unveiling companies' investment criteria and the use of information sources in the processes.

Vehicles as investment objects have different meanings for different organizational actors depending on their organizational role, vehicle use context, and personal preferences. The triggers of the investment action involve subjective factors that closely interact with more objective inputs. In practice, the content of the triggers and drivers varies across contexts and may change over time, but the results of the paper regarding the dynamics of those decisions are transferable to other contexts with innovative energy investments.

Keywords

Alternative fuel vehicle, decision making, switching path analysis technique, energy source, natural gas vehicle

1 Introduction

Energy research has studied energy-related behavior and decision making in the consumer and public sector, but research on such behavior in companies is rather limited [1] despite companies' large impact on the world's energy investments and use. The role of different information sources as objective and subjective inputs[1] in companies' energy source decision-making processes is unknown [3]. Traditionally, energy research interprets energy source choices, such as transportation fuel choices, as techno-economic comparisons (see e.g., [4–8]). These comparative calculations include market information (e.g., fuel costs) and measured factors (e.g., technological performance or emission data). These comparisons give companies suggestions about suitable and optimal investment alternatives. However, the comparative calculations do not necessarily lead to the optimal investment decision. Often, these calculations are simply used by suppliers to persuade customer companies to

[1] The subjective and objective inputs are distinct in this paper: Objective inputs represent the shared understanding of information in the field, including mainly quantitative facts on prices, emissions, and technologies, as well as shared calculation practices. Subjective inputs include the given meanings and interpretations of this information as well as perceptions, values, and emotional triggers. Subjective inputs shape the communication on the objective information; together, they affect the actual investment behavior [2].

make investments. Even though a supplier can demonstrate the cost savings and environmental benefits of adopting the new energy solution, the message might not reach or convince the customer or even fit the customer's decision-making process and criteria. The customer may invest in the new technology for environmental reasons, as a pioneering project, or to differentiate itself from competitors. The mismatch of the supplier's message and customer companies' decision-making criteria can hinder the adoption of new energy technologies.

Broadly speaking, the paper builds on and extends the existing human-centered energy research, where companies' decision making is driven by individuals who collect and interpret information about the business context and related energy aspects [1,3]. More specifically, the contribution of the article is related to the following questions explicitly outlined in the agenda of *Energy Research and Social Sciences* [9]: "What types of information and feedback are most effective at influencing energy producers and users? (Question 20 in [9])" and "How do people make decisions about energy when those decisions necessitate tradeoffs? (Question 30 in [9])" The article focuses on the dynamics of decision making, involving information about complicated phenomena as well as other triggers and drivers of decisions.

In the context of energy source choices, alternative fuel vehicles (AFVs) represent an interesting case example of decision making. Despite the progress in developing necessary technologies and infrastructure, as well as the increased public interest in sustainable solutions, challenges remain in promoting the wider acceptance of AFVs by the general public [10]. The factors hindering the diffusion of new vehicle technologies can be understood more thoroughly by looking at the individual companies' investment decision-making processes. AFV investments represent an example of an energy source decision with multiple criteria, including various facts and valuations. In addition to the techno-economic optimum found through emission and financial calculations, subjective elements such as the vehicle brand, origin of the fuel, and maturity (e.g., pioneer nature) of the technology can also affect the investment decision. However, little is known about the actual inputs and their effects on companies' AFV investment decisions. Instead, the academic literature has studied in detail several crucial factors affecting vehicle purchases and related fuel choices in the consumer context (see e.g., [11–14]), as well as consumers' sensitivity to fuel prices (see e.g., [15–17]).

This study examines the triggers and other inputs in companies' vehicle fleet investment decision-making processes. The research objective is to empirically explore the interaction of objective and quantifiable factors (i.e., facts) and subjective emotions and values (i.e., feelings) initiating and affecting the AFV investment decision-making process. The study aims to answer the following research question: What kind of interaction between objective and subjective inputs influences companies' AFV investment decision-making processes? In examining actual investment processes in companies, we used the switching path analysis technique (SPAT) [18] to trace the chain of events, triggers, and decision-making criteria that made the parties involved realize the investment. The empirical data in this paper consist of in-depth analyses of seven investment cases based on qualitative interviews of the decision makers (customers). An investment calculation tool was designed for visualizing the costs of different vehicle alternatives, thus allowing interviewees to focus on non-quantitative factors. The interviews are supplemented with extensive analyses of the technology under examination, the technology provider (case company), and the use context in Finland.

The case is not merely about Finnish AFV investments, but also about the triggers and drivers underlying innovative energy investments in a broader sense, unveiled by the SPAT analysis. In practice, the content of the triggers and drivers may vary across contexts and change over time, but the results of the paper regarding the dynamics of those decisions are transferable to other contexts. Finland is an example of a country with ambitious environmental targets. Lately, it has exerted much effort into promoting biogas production and utilization. A major part of these efforts comes from the government-owned case company (i.e., technology provider), which is currently also the largest biogas provider in the Nordic countries. There are still very few gas vehicles in Finland, and only a few companies have switched to biogas from conventional fuels. Thus, the interviewed companies represent true early adopters in the field. In decision making, Finnish companies tend to have low hierarchical boundaries and high managerial freedom to work independently [19], which affects the interpretation of the results on decision-making processes also in this study.

The remainder of this paper is structured as follows. The literature review begins with outlining the current understanding of AFV adoption. Then, it presents the existing discussions on subjective and objective inputs in managerial decision-making processes and introduces and elaborates upon SPAT as a critical incident technique to unveil the characteristics of a decision-making process. The research methodology presents the interventionist work in a case context (i.e., the engagement with the technology provider and the customer interview strategy for unveiling the decision-making processes). The findings from the technology provider and the interviews are synthesized at the end. The discussion and conclusion section presents the implications of this paper and discusses the interaction of subjective and objective inputs as well as their influence in triggering investment behavior. Lastly, this paper discusses the limitations of this research approach and provides suggestions for future studies, emphasizing the need to understand the impact of subjective inputs on energy-related decision-making behavior.

2 Literature review

2.1 Companies as early investors in alternative energy sources

The adoption of AFVs is considered one of the most important strategies to address the issues of air quality, climate change, and energy dependence on oil-exporting nations. For example, in Finland, road transportation accounts for approximately 20% of the total greenhouse gas emissions per year [20]. This figure highlights the large potential of new technologies with a lower greenhouse gas economy, especially now that their cost competitiveness compared with conventional solutions has improved.

To enable the wider adoption of AFVs, Garling and Thogersen [21] suggested three promising early adopter groups that should be targeted first with marketing actions: (a) public sector organizations, (b) "green" companies, and (c) multicar households whose transportation need, values, and lifestyle are compatible with owning an AFV. To date, the academic literature has focused on studying the consumer sector as early adopters of AFVs [22]. It has studied in detail the factors affecting vehicle purchases in the consumer context (see e.g., [11–14,23]) and consumers' sensitivity to fuel prices (see e.g., [15–17]). Moreover, there is an ongoing discussion on the aesthetic, emotional, and sensory responses to driving [24] and the effect of different automobile cultures on individuals' car driving [25]. Consumer choices are affected by the influence of both subjective and objective elements. For early consumer adopters of hybrid electric vehicles (HEVs) or electric vehicles (EVs), savings from fuel efficiency constituted only a small part of the reason for adoption. Other justifications included symbolic meanings, such as a strong ethical belief in protecting the environment or opposing war, a desire to reduce dependence on foreign oil, gaining social standing though commitment to the environment, an assertion of individualism, and embracing new technology [26]. Heffner et al. [26] underlined the importance of understanding the meanings as well as their construction and communication for policy makers and others hoping to promote these new types of vehicles.

Green public procurement serves as one instrument for countries developing greener vehicle markets [21]. The procurement procedures follow legislation, formal structures, and routinized mechanisms with an underlying motivation for treating potential suppliers fairly and transparently. One way to enhance the adoption of greener vehicles in public organizations is to incorporate green criteria into the already criteria-based and bureaucratic procurement process [27]. In the European Union, the Directive on the Promotion of Clean and Energy-Efficient Road Transport Vehicles (2009/33/EC) requires public authorities to take into account the lifetime energy and environmental impacts of vehicles, including energy consumption, CO_2 emissions, and other pollutant emissions. However, recent research has noted that information asymmetries and diverging interests between the legislator ("principal") and the procurement departments ("agents") [28] have hindered AFV adoption in the public sector.

By focusing mainly on decision-making mechanisms on the consumer and green public procurement side, academic research has neglected companies as the third significant group of potential early adopters of AFVs. For example, 30% of new passenger car registrations and 91% of new light-duty truck registrations are made by companies in Finland [29]. Company cars play a remarkable role in renewing countries' passenger car fleets, as they operate with faster renewing volumes than consumer customers. In many segments such as employee cars, delivery, and taxi businesses, used passenger vehicles are quickly released to the after-market after a few years of intensive driving. In a rather short period, new technology becomes available to other users in the after-market with a decreased purchase price, thus lowering the barrier to trying the new technology. After being released to the after-market, the vehicles stay in use for over 10 years, with the average passenger car age being 12 years in Finland [30]. When large companies renew their vehicle fleet, one investment decision can include, for example, tens to hundreds of vehicles. In contrast, in the consumer sector, the decision usually concerns only one vehicle at a time. In comparison to the public sector, which also operates with large volumes, companies are permitted to use the decision-making criteria they like with the control procedures they find appropriate for the decision-making process [27].

For a technology provider investing in refilling infrastructure, the long-term profitability of an irreversible investment [31] is highly dependent on the demand for the new AFV technology and the development of the after-market. The supplier may invest in infrastructure by first aiming at increasing demand in the future, or users may adopt the technology, trusting that a wider infrastructure will follow. In earlier literature, this was called the chicken-egg dilemma [10,11,32]. In discussions of AFVs, the lack of wide supply infrastructure and cost- or technology-related barriers have usually been considered the primary reasons hindering wider AFV adoption (see e.g., [32,33]). For example, Romm [32] identified six major historical barriers to the success of AFVs: (a) the high first cost of the vehicle, (b) on-board fuel storage issues (i.e., limited range), (c) safety and liability concerns, (d) high fueling cost (compared with gasoline), (e) limited fuel stations (chicken-egg dilemma), and (f) improvements in competition (better, cleaner gasoline vehicles).

One may also consider other infrastructure limitations as barriers. For example, potentially higher maintenance costs (including spare parts) due to the low AFV volumes may also be considered a barrier. Both

Yeh [10] and Romm [32] suggested governmental actions to overcome the adoption barriers. Based on case comparisons in eight countries, Yeh [10] named reduced fuel prices and shorter payback periods as key means to incentivize the wider adoption of AFVs in companies' vehicle fleets. Separately, in the context of biogas vehicles, the wider use of biogas in transportation is expected to be achieved through reductions in CO_2, reductions in energy taxes and other fees, and investment subsidiaries for private users [34,35]. Finding the right indicators for studying the performance of political actions might remain challenging, as large time delays exist between strategic policy actions and frequently used market penetration indicators (e.g., car sales and infrastructure expansion). The delays might limit the ability of policy makers to assess the performance of their strategy [36].

Any effective policy intervention strategy must be designed based on knowledge of the stakeholder groups, their decision making, and how the intervention would affect the same. Fri and Savitz [37] argued that the value of mitigating climate change is a public good and not one that markets can easily capture. According to them, energy transition will need more than market forces to encourage individuals and organizations to adopt and use the new technology that must be deployed. They also noted that governance structure is an essential element of the energy innovation process and that existing structures are not necessarily designed to respond to the climate problem. They called for more profound changes in individual decision making and institutional behavior. By first understanding the objective and subjective elements behind companies' investment decision processes, the current research can also support policy makers in finding appropriate ways to influence the adoption of natural gas vehicles (NGVs), or more broadly, any AFVs.

2.2 Investment decision making in companies also relies on subjective inputs

Business research has shown that managerial decision making also relies on emotion and feeling [38–41], suggesting that optimal decision making alternates between fact-driven rational thinking and feeling-driven intuition. Allowing decision making to alternate between rational analysis and intuition allows each mode to reinforce the other until an optimal judgment can be made. This optimal decision satisfies both the "hard" elements, namely the facts and figures, and the "soft" elements, namely the hunch or gut feel. However, in their study on enabling wider adoption of EVs, Garling and Thogersen [21] saw a company's energy source choice as a rather rational and analytical decision, as the barriers to adoption are related to governmental subsidiaries, perceived promotional value compared with price, and expected improvements in technology. Emotional aspects have been noted to influence companies' investment outcomes through personal experiences and contacts [42]. Emotional aspects also influence companies' tendency to avoid making the investment decision through negative feelings caused by choice difficulty [43]. In the energy sector, unconscious attitudes toward renewable versus nonrenewable energy sources influence investment behavior and attitudes to risk and return [44].

Investment decisions are often made in interactive groups that share and discuss common and individually known qualitative and quantitative information [45]. Depending on how centralized and formalized the decision-making structure is, the information flow and discussion may be hierarchic, autocratic, bureaucratic, or democratic in nature [46]. Objective and quantitative inputs of the decision-making process (i.e., facts) are based on observations of phenomena or things that exist independently of their observation. However, they are also social constructs, as something can be considered a fact only when it has been carefully recognized and established as such by a group of actors, such as a research community and R&D departments [47]. Alongside objective inputs, subjective inputs influence the decision-making process through values and emotions. Individual values determine people's preferences and likes [47], and emotions influence individuals' thought content and depth of information processing related to decision making [48]. In group processes, emotions also influence interpersonal decision making through their adaptive and interactive character [49]. While investment actions in companies require factual grounding from technical, financial, or scientific figures, facts need support from decision makers' values to create real possibilities for action. These real possibilities are recognized though communication among the decision makers [2,47].

In companies, energy source choices are planned in contexts with high uncertainty regarding future fuel prices and insufficient objective information on the life-cycle costs (LCC) of the investment. One way to address these uncertainties is to model them using real options that take into account the future flexibilities in decision making (see e.g., [50,51]). In this kind of uncertain decision-making context, managers need to trust their experiences and sensing (i.e., intuition) [39,41]. Despite the presence of intuitive and subjective elements in energy sector investments, most articles have investigated "state-of-the-art" innovations such as hydrogen fuel cells or offshore wind turbines. More attention has been paid to the hardware than to the "software" (i.e., human factors behind the technology) [9,52]. The number of empirical studies concerned with energy-relevant investment decisions remains limited [53].

Companies' energy source decisions can be understood more thoroughly by looking at their communication on the recognized possibilities and the inputs that trigger their investment action. Little is known about the objective and subjective inputs affecting companies' AFV investment decisions (except for the work of Nesbitt and Sperling [46] studying how companies' fleet decision-making structures affect AFV adoption). The effect of available technical information and fuel economy, as well as their interaction with subjective inputs, remains unknown in the energy source decision context, particularly in the AFV context.

2.3 Switching path analysis technique for explaining investment behavior and technology adoption

Earlier research has recognized that aside from technical and financial information, subjective inputs also affect the decision-making outcome and the level of energy technologies adopted. Technology adoption theories such as the widely applied unified theory of acceptance and use of technology [54] have been used to map the factors affecting technology diffusion in the consumer context. However, these theories do not explain the decision-making dynamics in organizational settings (e.g., the details of investment decision-making processes). They are insufficient for explaining the actual criteria of the final investment action and clarifying the triggers of the company's investment in the vehicle technology.

The dominant theories in marketing are based on the premise that customers follow a conscious decision-making process in choosing to purchase a good or service from a particular provider. However, it is often difficult to trace back the path of "reasoned actions" that lead a customer to end an incumbent relationship; for example, a long-term commitment to a certain provider may end without any apparent evidence of prior consideration [55]. To gain more understanding of the reasons for companies' investment actions, the supplier can investigate the actual investment behavior. SPAT is one suitable theory for studying the customers' investment behavior [18]. The key idea behind SPAT is to recognize that the switching event is affected by incidents that call for reaction, situational factors, and the influence of the active and passive roles of both supplier and customer [18]. These critical incidents are called triggers. Selos et al. [56] developed the technique further by applying SPAT to business-to-business (B2B) supplier switching processes. B2B case narratives were relatively easily translated into SPAT terminology without the need for notable sacrifices in content.

In this study, SPAT is used for investigating energy source switches in the context of company investments. A switch is considered a decision to invest in vehicles using different fuel technology from what the company used earlier. For instance, a company switches the fuel technology and fuel supplier when investing in AFVs instead of conventional fuel vehicles. SPAT can assist in identifying the switching paths that lead to the adoption of NGVs as part of the vehicle fleet—in other words, switching from conventional fuels to investing in new technology. It is also possible to distinguish the role of subjective and objective inputs in this process when understanding the triggers that lead to the investment decision.

3 Research methodology and material

3.1 Overview of research process and empirical material

This study applies an interventionist approach in a case study setting [57–59], meaning the empirical material is gathered by cooperating closely with a chosen case energy company (i.e., technology provider). The setting is supposed to yield practically relevant yet scientifically novel results. The corresponding author was engaged with the technology provider in creating investment calculation tools to be used with customers to enhance the discussion and understand the factors affecting the profitability of an energy investment. Two of the authors also conducted interviews in customer companies and in the technology network to deepen the understanding of different perspectives and internal facts and feelings in investment decisions. By interviewing (customer) companies about their actual investment cases (using SPAT analysis, see e.g., [18,56,60,61]), the researchers had the opportunity to discover the factors and triggers behind decision making and place them in a wider business context. The empirical work reported in this paper consists of two parts: (1) designing an investment calculation tool with a focus on the vehicle's LCC with different fuels and (2) conducting interviews among the technology provider's customer companies. The interviews focused on the switches to and from using NGVs and the role and content of management accounting information in the switch.

The intentionally participatory [59] role of the researchers also came up through steering group meetings, R&D workshops, and informal meetings in which the researchers offered their expertise for the technology provider's use. This work aimed to outline a relevant research problem and then present an approach to solving this problem. The acquired information was relevant to practical questions related to the marketing strategy and infrastructure network planning. The built trust enabled the researchers to join discussions in the company almost as an insider.

The research material consisted of documented email, phone, and face-to-face discussions; customer

surveys and marketing material provided by the technology provider; customer companies' Excel calculation tools; and 12 interviews. During the research period from January 2015 to August 2016, the researchers also closely followed the public discussion on AFVs. The technology provider and customer files contain all the received documents and meeting notes prepared immediately after each visit. The variety of information sources enabled triangulation of the results.

3.2 Intervention in the technology provider

The technology provider is a relatively large player in the Finnish energy industry, with a little over 300 employees and net sales of over €1.2 billion. This company offers biogas and natural gas for use as a transportation fuel, for electricity and district heat production, and for industrial processes and energy production. It offers liquefied natural gas (LNG) for use as a shipping fuel and LNG or liquefied biogas (LBG) transported by truck to customers outside the natural gas pipeline network. The company is currently planning to develop the gas car infrastructure to provide NGVs to the market. The profitability of the network investment is highly dependent on the future demand for NGVs, which are not yet widely adopted. The supply infrastructure investment is a so-called irreversible investment; it is very specific and has a long lifetime. If this kind of project fails, then it will tie down corporate resources for a long time and will be difficult to get rid of at moderate costs [31].

The company searches for support in ensuring the quality of upcoming large network decisions. Assistance is welcomed in better understanding the decision-making processes on the demand side as well as in identifying and studying the institutions guiding the internal processes. The technology provider is hoping to identify meanings and assumptions affecting decision making in a business environment bearing a conventional engineering mindset. This wish was clearly stated in a meeting with the company's CEO, technology manager, development manager, business development manager, and vice president of strategy and public affairs:

> Discussing feelings [in a business context] is somewhat new for us. We are an engineer-led company and commonly used to think that we make decisions based only on facts. It would be valuable for us to comprehend that both have their place.

3.3 Interviews about investment decision making

The interview invitations were sent to relevant companies that have been involved in AFV investments. The choice of the companies was exploratory. New companies were invited and interviewed until the major results were saturated (snowball sampling). The exploratory process benefited from recommendations given by the technology provider, who was extensively aware of the business context. As a result, the interviews provided rich data [62] from eight companies of different sizes and industries, all with experience in NGVs (Table 1). Another private delivery company was willing to share information about the fuel switch but not to participate in the study. These answers served as useful background information. The interviews with the taxi agency and the taxi entrepreneur using an HEV assisted in identifying the dominant institutions in the taxi business. However, these answers were not comparable with those of other interviewees who had experience investing in NGVs. Therefore, seven companies were eventually chosen for the analysis and findings section (Tables 2–7).

The interviews had a semi-structured "storytelling" nature and followed a question list, but the interviewees were encouraged to share their views using their own words and structure. The question design followed the idea of SPAT [18], in which the interview questions led the interviewee to recall and describe the switching event. The design of the SPAT interview model guided the interviewee to answer the questions from the organization's viewpoint. Thus, this methodology provided information about the behavior in the customer organization instead of representing only individuals' viewpoints. All interviewees held positions in which they were responsible for the vehicle investment decisions in the organization.

The general focus of the interviews was on identifying the triggers and perceived critical reasons for switching. The interviews were divided into four themes: (1) background information, (2) switching situation, (3) used information during the decision making, and (4) refueling network and other potential barriers. The interviews lasted 1 to 2.5 hours, with most lasting around 2 hours.

In the first section, the interviewees described their roles in the company and how vehicles were related to company operations and to interviewees' work. The second section asked them to describe the switching situation and the factors affecting the process. This included questions on the parties and prerequisites involved, the duration of the decision-making process, and specific related events or uncertainties. The researchers asked about interviewees' prior knowledge on different fuel options and whether they independently searched for information to support their choices. Discussing the external parties affecting the decision making, the interviewees also analyzed their/their supplier's active/passive roles in initiating the switching action. The third section discussed the content and role of management accounting information sources, calculations, and measures during the switching process. This section also asked about the role of feelings and intuition during the

decision making. Lastly, the interviewees analyzed their experiences in the refilling station network, its perceived effect on decision making, and other potential barriers hindering future NGV adoption.

The interviewees were not asked directly about the criteria behind their vehicle investment. . Asking direct questions would probably have resulted in a standard prerecorded answer drawn from the company's annual report without any real reflection on the process. One of the interviewees commented on the use of SPAT in her own words:

> It was quite a good experience to start reflecting on this decision again. This interview has brought up for discussion many things that I didn't even remember. Some answers popped up during the next question as the interview went on: Oh, and then there was also this influential factor too!

All interviews used the same set of questions and were recorded and transcribed. This study was described in the same way to each interviewee. Two of the authors were in charge of conducting the interviews. To meet the requirements for validity, the authors used multiple sources of evidence. First, three interviews were conducted collectively, with another researcher participating as an observer. Then, the interviewer's and observer's notes and conclusions were compared. In almost all cases, the interpretations were equivalent. Another cross-check was done with one of the interviewed companies. The largest group interview included 10 participants and was recorded and documented on the spot by the observing researcher. The notes were completed by the rest of the research group and handed to the company for comments. The notes returned with only minor adjustments to word choices, so the 10-person group shared the same understanding of the key points.

The corresponding author analyzed the interviews using Atlas.ti, a program for qualitative data analyses, by coding and grouping quotations from transcribed interviews. The coding was piloted with one transcript, and the notes were cross-checked by the authors of this paper. After discussing interpretations of each selected trial quotation, the researchers agreed on the code families. The switching stories were coded in an iterative process, where new codes were created accordingly based on emerging data. The analysis first listed the emerging criteria and their hierarchy in decision making. The initial coding also recognized if the criteria was brought up in discussion as a negative/neutral/positive fact or feeling. Since facts and feelings were brought up hand in hand in the discussion, the researchers did not classify the quotations as representing only facts or feelings, as this would not do justice to the interviewees' statements. However, it was possible to identify and code the triggers from the switching story, as they were clearly stated by the interviewees.

New codes were created accordingly based on emerging data. The code families were labeled *company, criteria, facts, feelings, institution, institutional work, investments, content and role of management accounting*, and *switching path analysis.* The complete Atlas.ti code list can be found in the appendix.

Table 1 Interviewees

Company	**Title**	**Relation to technology provider**	**Interview type**
Energy	Sales manager	Technology provider	Face to face
Energy	Network development manager	Technology provider	Face to face
Waste management	Head of fleet	Customer	Face to face
Delivery (state owned)	Head of sustainability Development manager Senior asset manager Heavy duty manager Asset manager Category manager	Customer	Group discussion
Delivery (private)	CEO	Customer	Face to face
Delivery (private)	CEO	Former customer	Phone interview
Church welfare	CFO	Customer	Video interview

foundation			
Driving school	Owner and CEO Owner	Customer	Group interview
Taxi A, NGV	Entrepreneur	Former customer	Face to face
Taxi B, NGV	Entrepreneur	Former customer	Face to face
Taxi C, HEV	Entrepreneur	No relation	Face to face
Taxi agency	CEO	No relation	Face to face

Four out of the seven interviewed companies had changed most of or their entire vehicle fleet to NGVs (Table 2). The two largest customer companies and the driving school had adopted NGVs as a pilot project. The pioneer status of NGVs also came up in the other four companies that had switched their entire fleets. The taxi entrepreneurs saw the lifetime of one car as being so short that it allowed quick trials of the technology and, if needed, switching back after a short period.

Table 2 Interviewee background

Company	**Personnel**	**Competitive advantage**	**Vehicle fleet**	**Fuel costs/ revenue (approx.)**
Waste management	Large	Cost-competitive and trustworthy partner supporting customers in recycling, waste management, property maintenance, and cleaning services	Confidential and large, a few heavy-duty garbage trucks are NGVs	15%–20% of total costs
Delivery (state owned)	24,600	Reliable, available, and high-quality service	4,000 delivery vehicles, 40 NGVs, and 10 heavy-duty NGV trucks	2%
Delivery (private)	25	Combination of competitive price and quality in fast delivery and food delivery services, professional appearance, and emphasis on environmental values	20 NGVs and 3 EVs	10%
Church welfare foundation	240	Local home care service provider offering good-quality service that uses environmentally friendly and locally produced fuel	7 NGVs and 1 gasoline van	2%
Driving school	6	Driving education and licenses provided by professional teachers and good customer service	12 vehicles and 1 NGV	not known
Taxi A	1,5	Taxi services with good cars	NGV for two years, have switched back to diesel	7%–10%
Taxi B	1,5	Taxi services and some product delivery, good relations with customers, offering extra services to get more hits through taxi agency	NGV for two years, have switched back to diesel	not known

4 Findings

4.1 Initial situation of the technology provider

The aim of supporting the technology provider's planning procedures provided the researchers with access to discussions on the planned supply infrastructure investment decisions. The decisions were affected by the internal processes of collective analytical thinking (e.g., internal profitability calculations, investment cost evaluations, and demand forecasts) and collective intuitive feeling (e.g., courage to take risk, faith in the product, and assumptions about the customers' decision making). Moreover, the technology providers' planning process is affected by several external stakeholders including consumers, other customers' customers, inhabitants, municipalities, and politicians (e.g., through land use planning, complaints, and regulations and taxes on motive power).

The technology provider has a certain impression of the customers' decision-making criteria for applying the AFV technology. Hypothetically, the customers make investment decisions rationally based on facts such as LCC analysis, in which fuel costs play an important role. In general, the perception is that most customers invest in NGVs owing to lower fuel costs, whereas the rest do so owing to their environmental friendliness. The company has tried to boost demand by basing its marketing on these hypothetical criteria. Rather simplified and clear Excel calculations on yearly fuel costs or total cost of ownership (TCO) have been used to demonstrate the cost benefits gained from the switch to NGVs. According to management, "If the customers were entirely rational, the facts related to the technology should speak for themselves."

The costs included in the company's initial sales tool are the monthly leasing cost and the monthly fuel cost. In sales meetings, it was important to be able to present the TCO figures for the potential customer. When only fuel costs were presented, there were doubts over whether the total costs would be lower than those of the conventional solutions. When the sales team was able to submit a leasing company's offer for all costs except fuel, the leasing price being the same for gas and conventional vehicles, it had greater success in convincing customers.

In addition to the arguments over lower TCO, the technology provider has marketed the gas ideology to companies through arguments on environmental friendliness and the domestic origin of the biogas. Furthermore, it was said that the current network would be made wider in the future. The arguments seem to be proven facts in the internal discussion within the organization: Gas vehicles are seen as a clearly more cost-efficient and environmentally friendly solution owing to their lower fuel cost and CO_2 emission. However, the technology provider is not entirely sure how the customers see NGVs. Parts of the decision process have remained unclear, such as the triggers and effect of subjective inputs in the decision. One of the managers stated,

> There is some sort of a black box in the investment process that we do not understand. Something happens after the door closes and we leave the sales meeting. Even though we agree on facts during the meeting and there is interest in lower fuel costs, the deal is not always realized in the end.

To truly understand the cost structure of the customers' vehicles, the corresponding author created a comparison tool that recognized and estimated the following costs:

Fuel specific

- Capital cost
- Fuel/electricity cost
- Maintenance cost
- Motive power tax
- Vehicle tax
- Extra fuel cost (caused by the limited refueling station network and deviation from usual route)

General

- Tires
- Parking/garage
- Insurance

The calculation tool was used as a facilitator in meetings to open the discussion, question the dominant viewpoints, and enable development by shedding light on concerns and uncertainties concerning the new vehicle technology. The newly provided information also started the internal reflection on the company's pricing principles and marketing messages.

One result from the created tool was that the costs of deviations from the usual route caused by the limited supply network were minor or negligible compared with other costs. The length of the refueling round caused only infinitesimal changes in the total costs, even with long distances to the station—for example, an extra round of 20 km per refill. More significant costs arose from losses in the personnel's working time and reduced vehicle utilization rates, as vehicles did not create any revenue during refueling. The anxiety over limited infrastructure might have also emerged from being dependent on only one refueling station operator or from a station's unsuitability for daily routines. More attention should be paid to overcoming the subjective elements to widen the adoption of NGVs. The development manager reflected on the current procedures as follows:

> When we go to the first sales meeting with the customer, we usually load the potential client full with factual information. Sometimes it could work better if we went to ask about the customers' operations and genuine customer needs. Then we could see if there was any place for adopting the gas option.

4.2 Investment decisions at the customer end

As one example of the investments made by the customer companies in their business, vehicle investments represented a meaningful decision for all companies. The companies provide services for transporting waste, goods, and people, which is only possible using vehicles. In the church welfare foundation, vehicles had been bought for transporting the foundation's employees between client households. The key business was to provide home care services; however, it was equally essential for the company to be able to move its personnel efficiently, flexibly, and safely.

As road transportation was important to the interviewed companies' operations, it was also closely connected to their strategies. Vehicles were linked to companies' competitive advantages by enabling cost competitiveness, reliable and flexible service, environmental friendliness, differentiation as a domestic operator using domestic fuels, and outstanding customer service by offering an effortless, clean, spacious, and safe way to travel.

The significance of NGVs for companies' operations came up through marketing, pilot projects, and funding. From the marketing viewpoint, the domestic origin of biogas and lower CO_2 emissions were seen as two positive marketing arguments for the customer companies' use. Domestic origin was considered a positive attribute, but this point was tricky in public tender invitations, in which favoring domestic origin was not allowed. Therefore, even though domestic origin was a positive feature of fuels, it could not easily be used in marketing. At the same time, the delivery companies, the welfare foundation, and the driving school used environmental friendliness as an explicit marketing argument. According to the waste management company, neither environmental nor domestic origin aspects could be seen as a source of competitive advantage as long as using heavy-duty NGVs was a more expensive solution for them. Waste management customers are not ready to pay extra for these aspects. Both taxi entrepreneurs saw that the slogan stickers communicating that the cars were "driving on domestic biogas" stimulated interest but did not lure additional customer flow at the taxi stand. All companies had made their action of investing in NGVs rather visible by using slogan stickers in marketing. The two largest companies had received funding from the government for investing in heavy-duty NGVs. The involvement of the innovation funding agency implies that the adoption of NGVs is in the early adapter or pioneering phase of the technology adoption curve.

In the larger companies, the capital invested in vehicles was mentioned as a notable asset in the balance sheet. When looking at the cost structure of the companies, fuel costs accounted for 1%–20% of the company revenue. In other words, when investing in vehicles that have better fuel economy and use less expensive fuel, companies are trying to affect this part of the costs. A decrease in fuel cost directly affects the company's key figures through an increase in gross margin, as fuel costs are usually marked as a variable cost in the income statement.. All the taxi entrepreneurs mentioned staff cost as a more noteworthy expense item than fuel cost.

4.3 Nature of the vehicle investment determines the criteria

Vehicle investment can represent various aspects depending on the nature of the company's business. The discussed decision-making processes were never only fact-based, rational, and straightforward processes in which only financial facts mattered. The conversation on vehicles' importance included both fact- and feeling-based argumentation, with an emphasis on feelings.

In the large waste management company, garbage trucks were an asset that tied down a large amount of capital. In this business, vehicles were seen as machine investments, and the process was considered rational and fact driven. To improve the profitability of the machine, utilization rates and capital costs were followed closely. At the other extreme, for the taxi entrepreneurs, the vehicle represented an investment in working space and customer premises and, in some cases, even a status symbol. The taxi was a place for serving customers, which set special requirements for the back seat: It should feel luxurious, spacious, and comfortable. In the case

of taxi companies, the same person worked in the roles of investment decision maker and driver. The taxi entrepreneurs were demanding, especially in terms of the driving experience, and expressed feelings attached to different car models and brands during the interviews. Taxi entrepreneur A pictured the decision in the following way: “If you spend all your working time in that driver’s seat, the car should definitely be to your liking!” Table 3 summarizes how the vehicle investment was viewed in each company.

Table 3 Vehicle as an object for investment

Company	Fuel used in NGVs	Vehicle as an object for investment
Waste management	Natural gas	Machine that maximizes utilization rate and minimizes capital cost
Delivery (state owned)	Biogas	Part of a large flexible fleet with high requirements for technical performance and ergonomics
Delivery (private)	Biogas	Environmental choice, provides means for differentiation
Church welfare foundation	Biogas	Enables operations, safety risk for users, needs to be effortless and easy to use
Driving school	Natural gas	Teaching tool, first contact for youngster to learn safe driving and experience NGVs
Taxi A	Biogas	Working space and customer premises
Taxi B	Natural gas	Working tool

The discussions brought up several switching reasons for each customer company, and the decision criteria of each participant became clearer as the interview continued. The criteria also seemed to form hierarchies, as some criteria were more important than others for the decision maker. The hierarchical criteria levels included both fact and feeling aspects, which were constantly mixed up in interviewees’ statements.

The criteria hierarchies determine the order in which the possibilities are used in action [47]. For example, when facts (e.g., available models) and feelings (e.g., preferences for certain brands) meet, a real possibility for action is born. Other real possibilities can also arise, such as choosing the environmentally friendly fuel. The hierarchy of real possibilities—in other words, the order of decision criteria—indicates which subset is chosen first. For instance, a company can choose the least expensive fuel option among the environmentally friendly vehicles that were first chosen from suitable vehicle models (see the case of the driving school). The criteria hierarchies are presented based on the researchers’ own construction from interviews.

Companies’ operations set several specific requirements for the car model and features. For many, the use purpose was the starting point for decision making. Certain model features are essential for the vehicle to be able to serve the user’s needs sufficiently. For example, automatic gears are fundamental to saving taxi drivers from back pain, a post delivery driver needs right-hand drive and front windows installed at an ergonomically low height, and food delivery sets requirements for the shape of the boot space and attached equipment. Moreover, personal preferences, such as favoring brands from German automobile manufacturers, limit the decision maker’s options. In this light, finding a suitable car model with the appropriate brand, usability features, and purchase price can be a challenge even before considering the fuel type or fuel cost.

In three cases—the waste management company, the state-owned delivery company, and the church welfare foundation—safety was emphasized as a core value. The vehicles constituted a safety risk for the companies’ employees through unsuitable ergonomics, accidents in traffic, and negligence when parking or during use of devices attached to the vehicle. When realized, these risks caused material and maintenance costs as well as losses in workforce and healthcare expenses. In all cases, the decision makers considered natural gas an equally safe alternative to other fuels.

Table 4 shows that there were cases in which the fuel cost did not appear in the criteria discussion at all (e.g., private and state-owned delivery companies) or came after other factors (e.g., driving school). In the state-owned delivery company, the effortless and flexible use of the fleet mattered most. Thus, parameters with a direct impact on usability, such as performance, technical features, warranty issues, and infrastructure

availability, formed the top criteria in decision making.

Overall, the decision-making criteria varied across the companies. Typically, similar themes came up, but in different orders as the storytelling on switching paths progressed. The most mentioned criteria among the companies' top three criteria were model features and usability, fuel/LCC, environment, personal interest/values, and infrastructure/driving range issues. One explanation for these different criteria can be drawn from the ownership structures. Entrepreneurs can effortlessly bring their personal values and vehicle preferences into the decision-making process. In contrast, state-owned companies get strict value-driven requirements for their corporate social responsibility policies from the government. Alternatively, the exchange-listed waste management company expressed its principles in the following way: "The reality is that the decision needs to be economically reasonable. And if some other good additional value is achieved on the side, it is all extra."

Table 4 Criteria for vehicle choice

	Waste management	**Delivery (state owned)**	**Delivery (private)**	**Church welfare foundation**	**Driving school**	**Taxi A**	**Taxi B**
Fuel used in NGVs	Natural gas	Biogas	Biogas	Biogas	Natural gas	Biogas	Natural gas
1. Criteria	Safety	Model features, technical performance, and warranty agreements for a flexible fleet	Environment, for differentiation and personal reasons	Model features, usability, and safety	Model features	Model availability and features	Fuel cost
2. Criteria	LCC	Infrastructure density, maintenance, and refueling	Domestic origin, for differentiation and personal reasons	LCC savings	Environmental values and concerns over fine particles	Personal interest in new technologies	Brand loyalty and model availability in that brand
3. Criteria	Technical performance/range/usability	Personal interest in environmental pilots	Range (out of EVs/ NGVs)	Infrastructure	Purchase price	Fuel cost	Environmental concerns
4. Criteria	Infrastructure			Marketing value from environmental benefits	Fuel cost		
5. Criteria	Environment						

4.4 Triggers of investment action

In SPAT, the decision maker can play an active or passive role in searching for information about current and possible solutions. Current and potential suppliers can play active or passive roles in convincing the customer about the benefits of the offered solutions. This influence can affect the customer's switching behavior, thus acting as an influential trigger for a switch. In addition to being an influential trigger, reactional or situational reasons can make customers change their actions [18]. Situational triggers are defined as changes in the customer's situation that cause the customer to re-evaluate the current solution. Reactional triggers are critical incidents causing a customer to switch suppliers.

After first actively searching for information or being passively used to the current situation, a fuel switch occurred in the customer companies. When describing the switching situation, namely investing in

NGVs, the interviewees cited various reasons for taking action. These triggers explain why the customer company decided to switch to or from using NGVs. Table 5 summarizes the reasons that triggered the company to move from decision-making discussions into investment action based on the researchers' interpretation of the interviews.

Some of the companies emphasized fact-driven attributes when reflecting on the reasons for the switch. Facts, such as capital cost or figures predicting the vehicle's technical performance, determined whether the investment option was recommendable in the waste management company. In line with the criteria, the reason for investing in NGVs was therefore the aim of achieving savings in LCC with no tradeoff with technical performance, safety, or usability. Similarly, the taxi entrepreneurs and church welfare foundation emphasized the significance of expected fuel cost savings during the switch decision. The simplest way of evaluating the cost differences between conventional vehicles and NGVs was to compare the purchase price and annual fuel costs of each fuel type. This was seen as already including the life-cycle perspective and was described as a TCO or LCC evaluation. For example, when the church welfare foundation was asked about the appropriate price difference between gas and conventional fuels, the answer was "We haven't calculated that precisely. But it must be cheaper than diesel and gasoline, as the purchase price for the vehicle is higher."

In contrast, in other companies, values and personal preferences played a clear role in directing the investment decision. The driving school viewed the NGV investment as one way to affect the company's environmental footprint through reductions in produced fine particles and CO_2 emissions. The decision of fixing one out of the 12 vehicles as an NGV was based on the combination of facts related to the emission information of each fuel type and the value of being a responsible company:

> I don't think it is advisable to drive with a diesel car in the city center area because of the fine particle emissions. You can't influence much of what is happening in the world—you are a tiny ant, but you can do your small bit for this environmental cause.

Although they are available, economic facts may not affect the decision if they are not considered as important as other values. The private delivery company saw environmental values and domestic origin as such meaningful attributes that the whole business strategy was built on using domestic biogas and wind power in transportation:

> I don't want to think about it too much [laughter], but I pay 10,000 euros extra yearly for that choice. There, now I said it. And this year the amount will be even more. We would be a different company if we talked only about fossil fuels. I can tell you that the customer can't understand the difference between the fuels. I would probably get as many customers with the fossil fuel. If I had a similar concept, it would be enough.

Personal interest in pioneer projects also seemed to affect decision making regardless of how large the company was. Ranging from the large state-owned delivery company to a taxi entrepreneur, decision makers' interest in trying new technologies and piloting alternative fuels furthered the NGV choice. In the state-owned delivery company, the operations set special requirements for the model features. As no suitable NGV models were available, some engineering curiosity was also needed. The company modified its 40 conventional vehicles to NGVs.

In summary, quantitative information such as LCC or emission information was used as input in the vehicle investment decision-making process. However, quantitative information strongly interacted with other inputs in the process. The values and decision criteria of the organization determined the role of quantitative inputs.

Table 5 SPAT analysis: Triggers to switch to or from NGVs

Company	Switch to/from NGVs	Trigger to switch
Waste management	To	**Influential:** The company expected lower LCC with good technical performance and had a general interest in piloting different technologies.
	From	**Reactional:** Technical problems lowered the utilization rate, and the limited maintenance network caused difficulties in operations. Technology was a big disappointment and will not be used in future investments for heavy- and light-duty vehicles.
Delivery (state owned)	To	**Influential:** Employees' interest in environmentally friendly pilot projects **Situational:** Governmental initiatives for pilot projects and time pressure from regulation: last chance to try gas in EUR 5 type vehicles
Delivery (private)	To	**Influential:** Customer activity through interest in using NGVs for differentiation and personal activity due to valuing biogas for its domestic and environmentally friendly origin **Situational:** Infrastructure and technology were available.
Church welfare foundation	To	**Influential:** The retirement of a personal contact from the former vehicle retailer enabled the open-minded consideration of different options. There was an active interest and search for cost and CO_2 savings. **Situational:** Available locally produced biogas, required availability of models and infrastructure
Driving school	To	**Influential:** Because of environment and cost savings, the decision was made to keep one NGV in the fleet. Close training collaboration with the fuel supplier strengthened the investment decision.
Taxi A	To	**Influential:** Based on own active information search, expectation of lower fuel costs, and lower taxation for NGVs; active interest in piloting combined with availability of a suitable model triggered switching action
	From	**Situational:** No suitable models were available, and investment needed to be done before the estimated unfavorable change in taxation. **Reactional:** Reacted to the rumors on rising taxation
Taxi B	To	**Influential:** Expected fuel cost savings based on own active search and promises from technology provider
	From	**Situational:** Manual gears caused back problems and anxiety for quick change. The preferred model and brand was not available with automatic gears in NGVs. **Reactional:** Rumors on changing taxation caused anxiety and set a deadline for fast decision making. Switching back to fossil fuels was a reaction to the disappointment with the earlier NGVs that had higher than expected fuel consumption, which did not compensate for the higher purchase price.

Four out of seven customers cited their own interest in being aware of the newest technologies and participating in pilot projects as reasons for switching to NGVs. These active customers were affected by influential triggers. Table 6 summarizes the influential active/passive roles [55] in each switch to NGVs. Situational triggers were related to governmental funding incentives by the Finnish Funding Agency for Innovation, features in vehicle models, technology and infrastructure becoming available, and competitive positions in the market. Personal relationships also mattered, as one situational trigger causing the switch was the retirement of a personal contact in the former vehicle retailer company. As the salesperson retired, it became possible to reconsider the car brand and models used.

Table 6 Passive and active roles of supplier and customer during switch to NGVs

	Waste management	**Delivery (state owned)**	**Delivery (private)**	**Church welfare foundation**	**Driving school**	**Taxi A**	**Taxi B**
Fuel used in NGVs	Natural gas	Biogas	Biogas	Biogas	Natural gas	Biogas	Natural gas
Customer	active	Active	active	passive	passive	active	active
Supplier during the switch	active	not mentioned	active	active	active	passive	active

In cases where the supplier had been active, the importance of personal contacts during sales work came up. The interviewees remembered the supplier's sales representative by name and described in detail the steps of the cooperation. The supplier, in the role of information provider, influenced the customer by talking about available models and costs as well as introducing the NGVs as an option..

4.5 Barriers to wider adoption of NGVs

In the cases of switching from NGVs, both taxi entrepreneurs share similar stories. The quick response to uncertainties in future taxation combined with the situation of limited vehicle model availability triggered the taxi companies to switch back to conventional vehicles. Similar reactions have been recognized in the consumer context [63], where the motivations for the switch to more energy-efficient vehicles were not detailed economic analyses but simple reactions to sharp increases in fuel prices.

The customers clearly expressed their satisfaction and dissatisfaction with NGV investment (Table 7). The negative experience of gas as a fuel can arise from several elements: In the case of the waste management company, the maintenance network was not sufficient to serve the company's needs, and the technology in heavy-duty garbage trucks was not reliable. This decreased the utilization rate and return on investment, especially when the NGV option had been considerably more expensive than the conventional one. Although the interviewee pictured the company decision making as rational and driven by financial facts, the bad experience with the pilot influenced future investments. The interviewee stated that he was not interested in passenger NGVs either, owing to the company's bad history with gas for heavy-duty vehicles. As the NGV technology is in different phases of development in passenger cars compared with the heavy-duty side, this argument can be considered feeling driven.

Another unsatisfied investor, taxi entrepreneur B, was disappointed with the fuel and maintenance costs of the NGV. The NGV's maintenance interval was tighter, and the promised fuel cost savings did not materialize. It is possible that the fuel cost savings caused disappointment owing to the car manufacturer's very low consumption promises compared with actual consumption levels. Alternatively, it is possible that the promised savings did exist, but they were too small in relation to the unfavorable difference with conventional solutions in terms of maintenance costs and purchase price.

Table 7 Customers requiring supplier's action

	Waste management	**Delivery (state owned)**	**Delivery (private)**	**Church welfare foundation**	**Driving school**	**Taxi A**	**Taxi B**
Fuel used in NGVs	Natural gas	Biogas	Biogas	Biogas	Natural gas	Biogas	Natural gas
Satisfied with the decision?	no	yes	yes	yes	yes	yes	no
Fuel supply network key issue at the moment?	some impact	yes	no	no	some impact	no	no

Contrary to the technology provider's hypothesis, the infrastructure density seemed to be a key issue only to some customer companies. Three other barriers were mentioned as equally important or even more significant in hindering NGV adoption: First, the lack of general knowledge and awareness about NGVs and their benefits hinders adoption by the general public. Second, the availability of limited vehicle models and

corresponding model features is a barrier, especially in the B2B context. Vehicles are bought to serve specific needs in companies' operations, and it is not advisable to make tradeoffs with practicality for small cost savings. Problems with usability quickly overcome the benefits received from savings. Third, the price difference with diesel was considered too small, as the LCC was viewed to be the same or even lower for diesel. The cost savings compared with diesel are not large enough to compensate for the inconvenience caused by the limited model range or limited refueling and maintenance network availability.

5 Discussion and conclusion

5.1 Overcoming the barriers to investing in alternative energy sources

In practice, the study broke the technology provider's prior assumption of B2B customers being rational, fact-driven, and analytical vehicle fleet investors. The findings also explain the current understanding of the barriers to AFV adoption [32,33]. The results emphasize the importance of enhancing general awareness of NGVs as well as overcoming the chicken-egg dilemma on the vehicle model availability side to satisfy customers' diverse needs and use contexts. The chicken-egg dilemma is more of a problem on the automobile manufacturer's side than on the supply network side. NGVs are already left out of the proposed options in earlier decision-making phases; therefore, the station network does not become a problem. The availability of suitable models and features as well as a maintenance network is important for both large and small companies. As one manager in the state-owned delivery company summarized, a whole network of partners is needed to support successful adoption:

> The wider adoption of NGVs is not a result of one or two parties cooperating. Many partners are needed: It is the importer, the vehicle retailer, the maintenance supplier, and the fuel supplier that are required for the whole planned vehicle's lifetime. Otherwise, we can't take the risk of investing in them.

This message is especially essential for actors aiming at enhancing biogas utilization in biogas ecosystems, where transportation use is seen as the most favorable option in terms of achieved environmental benefits [34].

Lastly, investing in NGVs was associated with being a pioneer in the industry. The pilot status had a positive connotation in conversations. However, it can turn into a stigma or burden when aiming at boosting the wider adoption of NGVs. As long as NGVs are seen as pilot projects, they might not have a place in institutionalized investment procedures and might not become a natural part of vehicle fleets.

5.2 SPAT explains investment behavior and technology adoption

The research objective was to empirically explore what kind of interaction between objective and subjective inputs influences companies' AFV investment decision-making processes. The interaction between objective and quantifiable factors (i.e., facts) and subjective emotions and values (i.e., feelings) can be understood by looking at the triggers initiating and affecting the AFV investment decision-making process. In all cases of switching to NGVs, the influential triggers initiated the process. Either the customer company's active information search or the technology provider's activeness in information provision initiated the path of events leading to investment. As a new and not yet widely institutionalized alternative, AFVs require active informing and notifying to become recognized as investment options. The activeness on the customer side originated from customers' interests; subjective inputs such as valuing the pioneer spirit, domestic origin of the energy source, or environmental friendliness; and objective inputs such as interest in achieving cost savings.

In the switching cases, situational triggers could either hinder the investment decision or enable it to actualize. Situational objective inputs, such as available refilling infrastructure and vehicle models, interacted and coexisted with more subjective situational inputs, such as the decision maker's preferences for certain vehicle models or personal relationships with the retailer's contact person. Together, the subjective and objective inputs created a potential environment for the switch. In two cases, NGV adoption was abandoned owing to reactional triggers, initiated by anxiety (subjective) over the possibly changing taxation (objective). Overall, the objective and subjective inputs seemed to be strongly intertwined, and together, they affected the decision-making processes. The findings strengthen the viewpoints of Sovacool [64], suggesting that in business settings, energy systems are chosen for both their technical and social compatibility, and the choices are made by actors with various concerns and interests.

5.3 Energy source choices in companies' investment decision-making processes

In line with the recent understanding of managerial decision making [39,41,48], companies' energy source investments seem to follow a decision-making process influenced by both subjective and objective inputs. Prior literature has recognized the existence of subjective inputs in the energy sector, such as unconscious attitudes toward fossil fuel or renewable energy sources [44]. This research revealed subjective and objective inputs in actual energy source decision-making cases by studying companies' investment behavior using SPAT. The findings show that AFV investment in companies is a complex decision-making process guided not only by the number of filling stations, maintenance infrastructure, and residual value of the vehicle [34,35], but also by subjective, non-rational elements such as personal interest in the technology or value for domestic fuel origin, piloting, and the environment.

When making investment decisions on energy technology, the decision makers usually also fix their choice on the energy source or fuel type being used. The fuel choice affects, for example, the vehicle's technological performance, environmental friendliness through exhaust discharge, and driver safety. Technological performance includes engine power, efficiency, and durability [65]. These aspects affect a company's operations, financial performance, and emission footprint. From a company viewpoint, the energy source choice is often not related to the company's core business, and companies would rather use their resources on their core business activities [64]. The delivery companies were concerned with delivering packages to people on time, and the church welfare organization was interested in moving its employees effortlessly and safely to customers' premises. To win the cooperation (and acceptance) of people, AFVs need to be designed such that lifestyles and behaviors are not altered [64].

Although the companies expect financial value from their investments, the vehicles may be related to the peripheral activities of the companies; therefore, the decisions are made by managers who do not focus on vehicles and their technologies in their work [64]. Thus, AFVs would need to more easily fit the overall business context, values, and valuations of these managers. If AFVs represent the company's core business, then AFV investments would need to provide direct financial benefits, be in line with the company's brand, or be appealing in other ways. The technology providers would need to understand the decision-making processes [46], use context, and institutions (e.g., public opinions on certain car manufacturers) [66,67] affecting the customers to successfully promote investments in the new technology.

5.4 Conclusion and future research

The article identified the dynamics underlying the companies' AFV investment decision making, which were previously unknown to energy research. The major findings of the paper are about the triggers and drivers of innovative energy investments, unveiled by the SPAT analysis. Although the aspects brought up in individual cases are not necessarily surprising or new to the existing body of knowledge, the dynamics underlying the investment decisions are structured as triggers in a novel yet meaningful way. This enables an extensive examination of the priority and emphasis placed on individual aspects. The fuel price difference or the uncertainties related to those prices are not self-evidently major drivers of the investment decision across the cases, but in some cases, they are overshadowed by other, more subjective considerations. Unveiling the dynamics behind the investment decision making is especially important because companies' formal routines seem to affect the decision making so that the outcomes of the energy source choice can be unexpected or difficult to anticipate from the outside.

When considering the obstacles to and drivers of AFV adoption, more attention needs to be paid to the impact of subjective inputs on the investment decision. Future energy research should aim at developing a better understanding of the decision-making behavior by, for example, applying SPAT to other energy-related investments or switching contexts (e.g., solar panels on office rooftops or biogas plants in the agricultural sector). SPAT could also look at actual AFV investment cases in the public sector, where it has the potential to bring more insights into, for instance, how the roles of policy entrepreneurs [68] initiate the adoption decisions.

Finally, more research is needed to find ways to get the cost (and other financial) information message through in these settings, to provide a comprehensive view on the impacts of the AFV investments to decision-makers. Moreover, if a more sustainable energy source decision is a public good rather than a direct economic benefit for the investing company [37], then we need to find ways to integrate the indirect benefits from sustainability as recognizable and equally acceptable inputs in the decision-making processes. This could help markets capture indirect benefits from sustainability in the future. More research is also needed on the interaction of personal and shared organizational values and their role in triggering energy-related investments.

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Appendix 1 Atlas.ti code list

Company

- Com_Supplier
- Com_Delivery Private
- Com_Church Welfare Foundation
- Com_Driving School
- Com_Waste Management
- Com_Delivery State Owned
- Com_Taxi Hybrid
- Com_Taxi A
- Com_Taxi B

Investment criteria

Environmental factors

ITop_Env_CO2
ITop_Env_Differentation
ITop_Env_Fine Particle
ITop_Env_Impact
ITop_Env_smell / clean
ITop_Env_Value

Financial factors

ITop_fin_depreciation
ITop_Fin_Fuel Consumption
ITop_Fin_Fuel Cost
ITop_Fin_Fuel Cost difference BG NG
ITop_Fin_leasing cost
ITop_Fin_Life Cycle Cost
ITop_Fin_Lifetime
ITop_Fin_Lost revenue during maintenance
ITop_Fin_Maintanance Cost
ITop_Fin_Marketing agreement with Supplier
ITop_Fin_Purchasing Price
ITop_Fin_Regulation/Incentives
ITop_Fin_Resale
ITop_Fin_Stable Fuel Price
ITop_Fin_Taxation
ITop_Fin_revenue_loss_during_refill
ITop_Fin_warranty

Fuel supply network

ITop_Netw_Biogas Availability
ITop_Netw_Density
ITop_Netw_Distance
ITop_Netw_Location
ITop_Netw_Maintanance Service Stations
ITop_Netw_Refill
ITop_Netw_Refill_Machine
ITop_Netw_Refill_stations service

Fuel origin

ITop_Origin_Domestic
ITop_Origin_Waste
ITop_Origin_Verifiability

Values

ITop_Personal_Values
ITop_Pilot_Pioneer
ITop_value_environment
ITop_Value_reliability
ITop_Supplier_Vehicle_Personal Contact
ITop_Tradeoff_fin and practical
ITop_references_creating_realiability
ITop_shareholder targets

Vehicle factors

ITop_Vehic_Driving Experience
ITop_Vehic_Fleet
ITop_Vehic_Model Availability
ITop_Vehic_model_features
ITop_Vehic_Origin
ITop_Vehic_Range
ITop_Vehic_Safety
ITop_Vehic_Technical Performance
ITop_Vehic_Used_Car

ITop_Vehic_Volumes

Criteria order
- Criteria_1
- Criteria_2
- Criteria_3
- Criteria_not

Triggers
- Trig_Influential
- Trig_Reactional
- Trig_Situational

Influential trigger: Passivity and Activity
- SPATIF_Customer_Active
- SPATIF_Customer_Passive
- SPATIF_Supplier_Active
- SPATIF_Supplier_Passive

Facts
- IFa_Negative
- IFa_Neutral
- IFa_Positive

Feelings
- IFeel_Negative
- IFeel_Neutral
- IFeel_Positive

Other related topics mentioned during switching story

Conventional fuels
- ITop_Convent_green wash
- ITop_Convent_Regulation
- ITop_Convent_user experience
- ITop_Convent_prices

Customers' customer
- ITop_Customer's Customer_ Decision Maker
- ITop_Customer's Customer_ Easiness
- ITop_Customer's Customer_ green supply chain
- ITop_Customer's Customer_ marketing
- ITop_Customer's Customer_ Savings
- ITop_Customer's Customer_ Service price
- ITop_Customer's Customer_more demand with NGVs?

Electric Vehicles
- ITop_Electric_Electricity Origin
- ITop_Electric_Environment
- ITop_Electric_Incentives
- ITop_Electric_Model Availability
- ITop_Electric_Network
- ITop_Electric_Purchasing Price
- ITop_Electric_Range
- ITop_Electric_Supplier
- ITop_Electric_technical performance

Investment Process
- ITop_Process_communication
- ITop_process_criteria
- ITop_Process_education
- ITop_Process_procurement

Trends

ITop_Trends_Clean Cities
ITop_Trends_Common Awareness / knowledge
ITop_Trends_Customer Value
ITop_Trends_Environment
ITop_Trends_Vechicles

The Content and Role of Management Accounting in the decision-making process

Management Accounting Content

MAC_tech and cost experience from pilots
MAC_actual cost
MAC_bottomline
MAC_capital
MAC_certificates
MAC_CO2 emission trading
MAC_CO2 Savings
MAC_driver_performance_meters
MAC_fuel cost
MAC_fuel cost difference with diff. fuels
MAC_goal
MAC_guideline/norm
MAC_material stream optimizing
MAC_optimal lifetime
MAC_payback
MAC_price_quality_ratio
MAC_route optimizing
MAC_service pricing
MAC_supplier comparison
MAC_TCO
MAC_technical features
MAC_utilisation rate
MAC_vehicle model comparison
MAC_vehicle_ROI

Management Accounting Role

MAR_affect
MAR_after check
MAR_break assumption
MAR_clarify
MAR_comparing_CO2
MAR_comparing_fuel cost
MAR_comparing_vehicle_models_required_turnover
MAR_controll
MAR_customer relations
MAR_customer service from supplier company
MAR_customer service from supplier company's customer
MAR_ensurance
MAR_gutfeeling
MAR_justifies decisions
MAR_links actions to strategy
MAR_Long translation
MAR_makes visible and concrete
MAR_marketing
MAR_motivator
MAR_neutral/reliable information provider
MAR_not needed
MAR_outsourced
MAR_planning
MAR_raporting
MAR_recommendation for decisionmakers
MAR_scenarios
MAR_Short translation
MAR_updated facts