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Features of Compressed Natural Gas Physical Distribution: A Bulgarian Case Study

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Abstract: Building a competitive and resource-efficient transportation system involves the achievement of a number of ambitious goals. Two of the main instruments in the European transportation policy in this field address the significant reduction of GHG emissions and oil dependency in transportation. Alternative fuels and compressed natural gas (CNG) in particular have huge potential for achieving these goals. The main problem that limits its wide utilization is related to the insufficient number of CNG refueling stations, especially along highways and routes from the core TEN-T network where no gas pipelines are available. Therefore, the aim of this research is to study a possible solution to building daughter CNG refueling stations which can be used as basis for formulating some recommendations for their accelerated construction along TEN-T core network as well as providing some initial knowledge to be used later for more comprehensive research. The research is based on the case-study method, which allows the presentation of the described best practice. The process of data collection is based on semi-structured interviews, study of normative documents, observation of daily sales and direct observations which were processed with the help of qualitative and quantitative methods for time series analysis—trend and seasonal component as well as descriptive statistics tools. Scientific literature and research as well as secondary data provided by international institutions are also used.

Keywords: physical distribution; logistics activities; compressed natural gas (CNG); CNG refueling stations; daughter CNG refueling station; CNG refueling infrastructure

1. Introduction

During the past few decades, the demand for natural gas as motor fuel has been growing on a global scale. This trend is the result from realizing its ecological and economic advantages, from the advances in technologies for using it in internal combustion engines and increasing the fuel delivery capacity from local sources and import. In addition, the increase in the density of the refueling infrastructure, the possibilities that fuel serve as an instrument for achieving the goals for transport decarbonization and the encouraging policy of local authorities to stimulate the use of alternative fuels, which can be seen in a number of European countries should also be taken into account. Over the past years, these practices have found wider implementation in other areas around the world—for example, China. The strategic documents in China define and allow for priority utilization of fuel in transit bus traffic, taxi transport, vehicles employed in delivering logistics services, personal vehicles, sanitation vehicle fleet and trucks [1] (p. 525). According to data provided by the International Energy Association (IEA) until 2015, the transport sector consumed 7% of the total world consumption of natural gas, while in 1973 this share was 2.7%. The analysis of this data illustrates that the use of fuel in transport increased 2.6 times during the period [2] (p. 40).

These circumstances stimulate the interest of the researchers in the topic of usage of CNG. From the beginning of the century, this interest has been growing and the aspects of studies and research

diversified. In just four years—from 2011 to 2015 40% of the research in the field conducted between 2001 and 2015 has been published [3].

Given the stronger demand for natural gas as compressed fuel, the need for building the necessary refilling infrastructure has acquired greater importance. At the same time, however, the natural gas transmission and natural gas distribution networks have a different degree of density and development, which limits the selection of location for building CNG refueling stations near the gas pipeline [4] (p. 106), [5] (p. 6), [6] (pp. 671–672).

The mass utilization of CNG requires the construction of a sufficiently dense network of CNG refueling stations, which can make its use beyond cities possible. The main barrier here, however, is its insufficiency which is unanimously agreed upon in literature by theoreticians [7] (p. 592), [8] (p. 9), [9] (p. 96), [10] (p. 29) and practitioners [11] (p. 94), [12] (p. 13), [13] (p. 314).

The advances in CNG carriage and storage technologies, as well as the development of the logistics concept provide possibilities for building daughter CNG refueling stations where demand is highest. This is achieved through carriage, warehousing, and storage of CNG under high pressure of around 200 bars by using battery-vehicles [14] (the term is adopted in chapter 1.2, vol. I, p. 15). Natural gas is compressed at the mother station, which is joined to the gas pipeline network and delivered to the daughter station where sales are organized and where, in order to guarantee high pressure during refueling, an additional compressor is used.

The subject matter discussed in this article belongs to the broader issue about building a distribution network and the management of fuel deliveries in transport. The physical distribution plays an important role since it guarantees the availability of fuel in the refueling stations and plays a key role in achieving the desired level of customer service. Therefore, the question about the characteristics of the physical distribution to the CNG refueling stations is topical both in the practice and in the theory.

The need for its development ensues from several fundamental issues. From a practical point of view there are three. The first one is related to the insufficient number of CNG refueling stations along TEN-T core network, which limits the free movement of people with natural gas automobiles and hinders the sustainable integration of the transportation systems of EU member states. The second issue concerns the impossibility to achieve the ambitious goals of the Commission's White paper if the necessary number of refueling stations are not built in the territory of TEN-T core network by 31 December 2025 [15] (article 6, point 8, p. 14). The third one is connected with the decreasing sales of gas distribution companies in EU due to the wide implementation of the energy efficiency measures, which have to be offset. From a theoretical point of view, the need for discussing this issue results from the fact that it has not been sufficiently researched until now. Therefore, the aim of this research is to study a possible solution to building daughter CNG refueling stations which can be used as basis for formulating some recommendations for their accelerated construction along TEN-T core network as well as providing some initial knowledge to be used later for more comprehensive research.

The abovementioned issues concern several groups of stakeholders. The first and the second one-concern EC policy makers. The gas distribution enterprises are interested in the solution of the third issue and the academia in the last one.

The achievement of the research goal is related to searching for the answers to several research questions that can be organized in a research questions matrix—Table 1.

The key limitations can be grouped as follows: First, the focus is solely on CNG which can be used in low-energy modes of automobile transport, second, only the delivery method to the daughter station which is not connected to a gas pipeline will be considered and third, only the activities related to the physical distribution along the logistics channel will be studied. The scope of the study does not include the features of the activities in the remaining stages of the logistics process—supply and compression operations, as well as the matters related to deliveries of liquefied natural gas to the LNG refueling stations.

Table 1. Research questions matrix.

Research Questions	Formulation	Grounds	Affected Stakeholders
RQ 1	How to accelerate the process of building CNG distribution network along TEN-T to meet the requirements of Directive 2014/94/EU?	The question aims to provide information about giving recommendations to policy-makers related to the ways to support this process.	EC
RQ 2	How to diversify the distribution channels of gas distribution companies in EU?	The question refers to providing information about designing the CNG logistics channel and the management of physical distribution.	Gas distribution companies
RQ 3	How to continue research in this field?	The question aims to provide information about future research.	Scientific community

Following the Introduction the present study is organized as follows. Section 2 discloses the role of distribution in the context of the contemporary complex subject matter along the supply chain and offers a conclusion about the degree to which the topic was studies. Section 3 offers a description of the selected research subject, justifies the research methods used and the sources of information. Section 4 presents the peculiarities of the physical distribution of CNG to the daughter CNG refueling station based on the case study. Concluding remarks, recommendations for stakeholders, as well as agenda for future research are provided in Section 5.

2. Background and Literature Review

2.1. Overview of Distribution and Its Role in the Supply Chain

Distribution is the final stage of the logistics process. As such, it is a key strategic variable in the management of the company logistics system and has an increasing potential for achieving a competitive advantage [16] (p. 63).

The integrated Supply Chain Framework [17] (p. 6) shows that distribution is used to achieve integration of the company's logistics with the one of the remaining participants ahead in the supply chain through the distribution network. The modern interpretation of distribution claims that it includes the movement and storage of the product between the enterprise which supplies it and the client in the supply chain [18] (p. 123). It can be well disclosed through Vitasek's definition, i.e., "the activities associated with moving materials from source to destination can be associated with movement from a manufacturer or distributor to customers, retailers or other secondary warehousing/distribution points" [19] (p. 63). Therefore, we can conclude that distribution also includes the independently formed partial links between the individual participants in the supply chain and can be initiated both in production and in commercial enterprises. Given all that and considering the fact that the product flow changes its content in the abovementioned chain, we should add that not only materials can be distributed, but also ready products which are to be sold, i.e., goods.

We can conclude that distribution is a set of logistics activities, which are carried out during the third stage of the logistics process. It is necessary to specify that these activities are also carried out during the other stages—supply and operations and have certain specific characteristics in terms of organization, management, volumes, and frequency of performance during each of them. Their cumulative interaction at all stages of the logistics process and the supply chain contributes to providing time, place, and quantity utilities of the product to the client [20] (p. 36).

The traditional understanding about the range of logistics activities within the framework of physical distribution includes: "transportation; inventory maintenance; order processing; product scheduling; protective packaging; warehousing; materials handling and information maintenance" [21] (p. 10). Moreover, in scientific literature broader understanding can be found according to which we

can also add: "order fulfillment; demand forecasting; procurement; customer service; facility location; return goods handling; parts and service support; salvage and scrap disposal" [20] (p. 39). Depending on the specific nature of movement of the product flow and the related specific logistics tasks, the set of these activities in the distribution systems of companies from different industries varies and illustrates significant diversity. This calls for an in-depth study in order to manage it adequately.

Nowadays some of these supply chain activities are getting more and more complex due to the need for improving their competitiveness and sustainability. This requires more comprehensive optimization of the solutions and considering of the factors related to the impact on the environment since the logistics activities are resource consuming and have the potential to improve the results of their implementation. One such strategic solution is the green facility location. Nowadays, it is growing in importance in logistics network design due to its potential in terms of reducing the ecological and social consequences of the delivery process. That is why there has been growing interest among researchers in this subject matter over the past few years [22–26].

The development of green logistics systems fully supports the sustainability policies of a lot of governments and local authorities. Limiting the harmful impact of logistics on the environment, however, is only one of the instruments. What is also needed is the optimization of the energy consumption not only in the field of transport operations but also in activities relating to warehousing and packaging [27]. Energy efficiency spares resources for future economic and social development. From the supply chain perspective it can be viewed as a strategic advantage which guarantees cost savings, improved competitiveness, and profitability even for weaker companies [28], since it provides for using the capacity of all participants in the supply chain. Apart from the traditional forms of interrelation between the participants sharing, the financial resources and the joint participation on the capital markets allow for making higher investments in energy efficiency and bring better results for the entire supply chain. In order to achieve that a decision-support models has been developed [29]. Better energy efficiency can be achieved through increasing the utilization of capacity in transport, warehousing, and transshipment activities of logistics service providers, shippers, and end-consumers in the areas of in-and out-bound logistics, list mile, as well as reverse logistics [30]. The urbanization processes and the increasing social impact of noise and air pollution on human health underline the importance of the issues related to last mile distribution, especially in the case of using urban freight transport. With respect to that, the issues related to the type of vehicles and replacing the conventional with alternative motor fuels are becoming more important [31]. The energy efficiency of operations is a modern problem that supply chains experience and concerns both inbound and outbound links through questions related to first and last mile logistics.

The potential of technologies in the era of Industry 4.0 made possible the development of hyperconnected logistics solutions and the implementation of real-time scheduling optimization model that guarantee operations' energy efficiency [32]. Assignment and scheduling problems of vehicles are the subject matter of a big numbers of modern ITS research. They can even facilitate the optimization of the transport operations in a global supply chain [33]. The matter is well studied even for individual segments and products in the supply chain—for example, petroleum fuels distribution. Heuristics and hybrid genetic algorithm can successfully be used to draw a plan for deliveries to petrol stations for a time horizon set in advance where the delivery routes can be planned following criteria to minimize the total distance travelled [34]. Moreover, the model can be applied without any significant change to resolve other similar cases of distributors along the supply chain [34] (p. 491). Furthermore, the subject is well studied on a weekly basis based on criteria to minimize the total distance travelled by tankers and maximize the tankers resource utilization in different configurations of the distribution network—from a storage depot [35] and from a set of storage depots [36].

2.2. Review of the Studies Conducted in This Field

The scientific literature contains data illustrating that the interrelation between the use of CNG as alternative fuel in transport and the logistics subject matter find expression in the field of sustainable

logistics. According to Rushton, Croucher and Baker the topicality of the issue is based on the desire to limit the harmful impact of the use of conventional fuels on the environment and more specifically in the field of automobile transport. The authors point out that the interrelation with the sustainable logistics is conducted in relation to its ecological (related to the effects of the generated by transport greenhouse gasses which contribute to climate changes) and the social aspects (related to the effects on human health caused by noises and harmful emissions) [7] (pp. 584–585) (pp. 590–591).

Over the past years, a number of authors started to present the questions about the use of CNG as part of the subject matter of city logistics. CNG is the potential choice of transport companies operating in urban environment. For instance, a part of freight movements in the city environment in Yokohama that are organized in a joint delivery system with shared low emission CNG vehicles are used [37] (pp. 143–145), [38] (pp. 25–26). An example of best practice shows that as an option to reduce the noise in case of late evening deliveries to supermarkets in Brussels CNG trucks are used [39] (p. 115). The possibility to limit CO_2 related to climate change [40,41] and air pollution [40,42] turns the use of CNG into an alternative for city bus fleets [43]. The role of the support of governments and local authorities in the promotion of CNG use is also very important and pointed out in studies [44] (pp. 207–208).

Another study focuses on the usage of alternative fuels and in particular CNG and its infrastructure as a factor in the policy on decarbonization, set forth in Directive 2014/94/EC [45]. The role of CNG as a prerequisite for reducing the dependence on conventional fuels and increasing the energy security in transport is also discussed [46].

The subject matter of the use of CNG is discussed in the research literature in the context of the activity of logistics operators. They can be an active participant in the policy of mitigating the negative environmental impacts of long haul freight transport, not only through investments in conversion of their heavy duty vehicle fleet to work with natural gas but also with participation in building CNG refueling stations based on the example of UK's Howard Tenens [47] (pp. 51–52).

The subject matter in the field of using CNG in automobiles is interdisciplinary. A number of researchers in various sciences have expressed interest in it and consequently the available research studies are extremely varied.

The analysis of the conducted research shows that the issues related to the technical measurements, environmental aspects of CNG vehicles and the technology for CNG usage have been studied most thoroughly [3]. They comprise more than 80% of all research conducted in this area between 1991 and 2015. The economic aspects of the use of CNG vehicles, however, are considerably less studies and they amount to merely 5.84%. Moreover, in this category there is no data showing that the subject matter related to the implementation of logistics concept in the process of organizing deliveries to CNG refueling stations was studied [3] (p. 352).

Building CNG refueling stations requires a connection with the existing pipeline, which should be used for natural gas deliveries [48] (p. 11), [49] (p. 3), [50] (p. 2). This pipeline can be part of a transmission or distribution natural gas network. This requirement determines the higher density of CNG refueling stations in cities where there is a well-developed system of natural gas distribution pipelines or the areas with denser system of transmission and distribution natural gas pipelines [50] (p. 2), [4] (p. 106), [6] (p. 670). Some studies apply traditional methods and techniques for facility location of CNG refueling stations to a different degree [48,49]. Frick et al. apply the cost-benefit analysis to determine the most efficient locations for building new CNG refueling stations on the premises of the existing gas stations in Switzerland. This approach will allow for sharing the existing infrastructure and as a result lower the investment costs for building shops, rest rooms, workshops, car wash installations, cafeterias, kitchens, offices etc. A key factor in the research is the cumulated distance to the next filling pipeline in km. for all options considered concerning the number of built CNG refueling stations. It is used to determine the investment costs for building a pipeline connection with the existing transmission and distribution pipelines in Switzerland, which, in its part, is needed to guarantee the deliveries of natural gas to the newly-built station [48]. The research presents an approach for building a CNG

refueling stations network at national level and providing investments needed for the construction of 350 new stations. The research results, however, are applicable only for the construction of CNG refueling stations in the territory of existing gas stations and a precondition for joining them to the gas pipeline. These features make it inapplicable in those cases where these requirements cannot be met due to underdeveloped natural gas transmission and distribution network, desire to achieve quickly a certain degree of density of CNG refueling stations and insufficient investment. The construction of gas pipelines is an expensive undertaking—according to expert evaluations the construction of 1 m costs between €300 and €600 [12] (p. 13). Even today, more than a decade after conducting the research merely 26% of gas pipelines or 91 of the planned 350 new stations in Switzerland are built [51] (p. 6), and there is no information whether they are located in the territory of existing gas stations. This calls for the need to study better the cases where the connection between the points in the CNG distribution channel is made not through pipelines but through automobile transport. If the investment costs for building a distribution system for CNG deliveries to daughter CNG refueling stations are known, they can be replaced with investment costs for building a gas pipeline following the Frick et al. model. To determine accurately their amount, however, a preliminary exploratory study should be carried out since in the research process such a study was not found. The study is needed to identify, study and summarize the typical characteristics of the logistics activities and their interrelation during the distribution process in the above mention systems.

Chikishev, Chainikov, Anisimov suggest an approach for determining the necessary number and capacity of CNG refueling stations in the town of Tyumen. It is based on the static analysis with maximum required daily demand volume of around 40,000 m^3 and their location based on the expert evaluation of the busiest routes along the entrance/exit city highways where possibilities exit to provide services not only to the natural gas vehicles but also to the transit vehicles [49]. The results from the study are valid for the town of Tyumen where there are over 1000 km natural gas pipelines and about 30 gas control points within the borders of the city [49] (p. 3). Expert evaluations aimed to determine the location of CNG refueling stations can be used there and in other regions with high density of natural gas transmission and distribution network but when there is no gas pipeline more quantitative and qualitative factors have to be taken into consideration. The least that is required in such a case is land for two sites—the mother station and the daughter station. They can be situated in areas with various degree of access to labor resources, different land prices, and local tax policies etc. This suggests that when building a daughter CNG refueling stations other facility location methods can be implemented. The appropriate ones can be pointed out if we study in detail the features of the activities related to the physical distribution in a functioning logistics system of the abovementioned type.

Another study pointing out that for companies involved in passenger and freight regular services transport by minibuses in Tyumen, which are retrofitted on gas-diesel is possible to build mini CNG refueling stations with performance under 100 nm^3/hour. This can actually be accomplished everywhere in the abovementioned city due to the high density of pipelines with different capacity in the city which was already mentioned. The authors, however, suggest that this should be done in the garage in order to eliminate the considerable zero runs and the loss of time needed to refuel the only existing station, which is 12 km away from downtown [50]. The mother-daughter station model can be applied in those cases where no pipeline runs near the garage. To determine the requirements related to building the daughter station, the needed equipment, the safety and the logistics processes, however, the features of the physical distribution in this type of logistics systems should be studied in greater detail.

While the matter of building a network of CNG refueling stations connected to pipelines seems to have been studied, though not very comprehensively, the topic of building daughter CNG refueling stations network has not. In the course of this research, only one study was found. It focuses on logistics costs and in particular, transportation costs.

The mother–daughter stations model has been studied in the context of identifying the total expenditure for transport of CNG to daughter stations with various capacity and located at different distances from the mother station. To achieve this a mathematical model with three varieties has been used. Each of them accounts the necessary number of trucks and battery-vehicles with five options for achieving the necessary capacity of the station considering three different distances between two stations [52]. In this model it is assumed that own trucks are used which run up to 300 km/day. In practice, however, it is possible that the demand model differs from the one pointed out in the research. It allows for reaching the theoretical maximum on a daily basis, which equals the capacity of the daughter station. Some daughter CNG refueling stations can have an explicit seasonal component in demand on certain weekdays or various months while on others a growth trend can be observed within a few years. It can be due not only to natural reasons but also to the encouraging policy of local authorities on the use of natural gas in the region. The increase in demand requires adequately adding additional capacity in the distribution system. With different demand patters there are different needs for transport operations. In fact, deliveries can vary from a few hours to several days. In the latter case if, the delivery involves a truck and one driver they will not be used efficiently. The presented model also includes making investment in own trucks and battery-vehicles. However, when the market is developing and demand uncertain, there might be other solutions to reduce the investment and operational costs. These, in their part, can render the model with its current assumptions inapplicable. For instance, the transport activity can be assigned to logistics service providers who specialize in transportation of hazardous goods. Big energy distributors who deliver CNG to a various groups of clients can share a battery-vehicles fleet to deliver to the end energy consumers and daughter CNG refueling stations since the technology is completely identical. Trucks can also combine when providing services to a different type of clients which will increase their usability. The investment cost for land, on the other hand, can be reduced since the daughter CNG refueling stations can be located in the territory of existing gas stations that hold a permit. If we are well familiar with the specific features of the physical distribution activities in the mother-daughter model, we will be able to identify more alternative solutions for building the logistics channel and use more efficiently the set of tools of the logistics concept.

The research papers also touch upon private issues of logistics related to the management of logistics activities such as CNG production schedule and their relation to costs at a time-of-use electricity tariff environment as well as developing the design of logistics systems for natural gas from energy distributors that directly can applied in mother–daughter station model.

Kagiri, Zhang, and Xia consider the CNG production costs and find out that when using fast fill cascade station it is possible to reduce electricity costs to around 60% if the compressor work schedule is improved in a time-of-use electricity tariff environment. It can be used to reduce the fuel end price and in this way to stimulate consumers to use widely ecological fuel which would facilitate the reduction of harmful emissions [53]. The focus of the research is just the energy efficiency of the compression operations. The distribution process, however, includes a number of other possibilities for improving energy efficiency. The synergy effect of their joint implementation would contribute to improving the sustainable results along the distribution system to daughter CNG refueling stations. There is potential in the transportation activities, for instance. The deliveries to the mother station are made with environmentally friendly pipeline transport and the deliveries to the daughter stations can be made with trucks with natural gas engines. Furthermore, the premises can be build following the energy efficiency standards. Even green facility location methods can be used to determine their location since the availability of a pipeline is not a prerequisite. In order to outline the possibilities for taking advantage of the synergy effect of the energy efficiency measures along the entire distribution process it is necessary to identify and study better all physical distribution activities in the existing distribution systems using mother–daughter station model and to outline their specific characteristics.

There is also a research paper, which focuses on the specificities of compressed and liquefied natural gas delivery management via land transport—automobile and rail, which are the result of their

different product characteristics. The results show that planning of specialized distribution systems for natural gas is required [54]. However, the research does not demonstrate the complex peculiarities in the organization and management of all physical distribution activities in the mother–daughter station model.

The analysis of the research shows that while there are studies and knowledge about the construction of CNG refueling stations connected to gas pipelines, the construction of daughter CNG refueling stations, which are not connected to gas pipelines, and the management of fuel deliveries there has not been studied yet.

Research literature abounds in studies dedicated to the physical distribution matters. These, however, consider mostly consumer and investment goods and are not conducted in the context of the entire CNG distribution process.

The analysis of the research carried out in this field shows that CNG physical distribution is considered in the context of some aspects of the logistic activities—in particular facility location and transportation. Physical distribution, however, involves a lot of other activities such as: Transport schedules, compression schedules, packaging, warehousing and storage, labeling, reverse logistics, inventory management, customer service and information services that have not been the subject of an independent study. Therefore, currently, there is no comprehensive knowledge which reflects the complex features of all activities part of the CNG physical distribution and which can be used as the grounds for future research. In addition, this hampers the performance of gas distribution companies which want to build CNG distribution channels. They need to know what key competence in the field of logistics they need to develop in order to decide whether to organize in-house or outsourced logistics. This call for the need for conducting an exploratory study. At this stage, it can be viewed as a preliminary study of the issue, which will contribute to laying the foundations of specific knowledge in the area. This will allow not only for conducting studies that are more comprehensive in the future but also for the better use of the existing knowledge. For example, it seems that the organization of the deliveries for daughter CNG refueling stations is similar to that of deliveries to petrol stations. In both cases road transport is used and determining the permanent location of the station is more flexible since it does not have to be connected to the pipeline. This suggests that some available solutions in the field of distribution to petrol stations, for instance—vehicle routing, green facility location etc. can be borrowed and implemented. This can be found useful by other researchers who can validate the results of their studies into this specific field or to exclude it.

3. Research Methodology

3.1. Context of the Study

The present study was conducted in Bulgaria—a country with one of the best-developed systems for consumption of CNG in transportation. The choice can be motivated with the following arguments. The country has experienced a high degree of market penetration on natural gas vehicles relative to the other EU-28 states [51] (p. 4). Bulgaria is also among the top 5 EU-28 countries in terms of number of car running on natural gas and average CNG passenger vehicles per CNG station and it comes 8th in terms of number of CNG refueling stations [51] (pp. 5–6). The country exhibits a low level of development of natural gas distribution network because its construction began in the beginning of the century. Therefore, there is a well-developed CNG market for end energy consumers, which are not connected to the distribution and transmission network. The deliveries to those users are essentially conducted following the same organization of processes and technical equipment used in the mother-daughter station. Given these circumstances, Bulgaria has gained a lot of experience in the distribution of CNG as well as experts in this sector. This is why Bulgaria is good place for conducting such a research. The results from the research can be useful for countries that have the same degree of development of natural gas distribution like the Western Balkans and the experience in the utilization of natural gas as engine fuel and the construction of an adequate infrastructure for

its use can be shared with EU member states. Therefore, a Bulgarian company CNG Ecogas JSC was chosen as the object of research.

The current study is based on various sources of information. Research literature and studies made by researchers in different countries around the world, secondary data for statistical purposes provided by IEA, normative documents from the EC and UNECE-ITC, a report by European Gas Forum, good practice examples from EC, and company information from CNG Ecogas JSC have been used.

The beginning of the activity related to delivery of CNG in the research object was put in 2006 by a company that later participated with its specialized assets and know-how in the setting up of a joint venture—CNG Ecogas JSC. It was founded in 2008 and today it is the biggest distributor of CNG to residential and business customers as well as local gas-distribution networks, which are not connected to natural gas transmission and distribution network in Bulgaria with market share of around 65%. Some 97% of sales is made through the mentioned distribution channels and the remaining 3% belong to sales of CNG as motor fuel which are made through own distribution channel—daughter CNG refueling station which is not part of the urban distribution network and is situated in the city of Burgas. It is supplied by the mother station in the town of Kameno, which is also owned by CNG Ecogas JSC. The mother station provides 24/7 service and meets not only the needs of the daughter station but also directly refueling automobiles in the station, as well as to residential and business customers and local gas distribution networks, company's clients in the region through specially designed filling section with high-flow equipment for fast filling.

Currently the daughter station fills mostly passenger cars—99%, while other classes of vehicles have an insignificant share—about 1%. In the period of 2008–2012 some 10% of sales belonged to city and urban buses but today the logistics operator has discontinued their use and has addressed another market segment.

3.2. Applied Methods

The present research employs a two-stage approach. The first stage focuses on collecting initial information about the research object and the industry based on questions and through conducting semi-structured interviews. In addition, normative documents are being identified, the utilized company documentation and data are being determined, as well as the secondary data and the research methods. This is the stage of the preliminary study. During this stage, the subject matter is being discussed and questions for the semi-structures interviews to be used in the second stage of the study are specified, the details related to the organization of conducting the interviews are also agreed upon.

The second stage concerns the main study. During this stage is gathered information from respondents in thematic fields, the collected data is being analyzed along with the normative and company documentation and direct monitoring visits of the delivery process between mother and daughter stations are carried out.

The case study method allows for a detailed research of the state, causative factors and sensitive areas relevant to the subject matter studied in the specific company and therefore is directed mainly to disclosing good practices at micro level. It is appropriate when trying to figure out answers to the research questions 'how' and 'why' [55] (p. 6). The analysis of the research questions in Table 1 shows that they are mainly 'how' type questions. Apart from that, there is need for conduction a preliminary exploratory study in theory, which can be the basis for conducting broader research in the future. Therefore, the current research employs the case study method. It allow to specify how the activities related to the physical distribution to daughter CNG refilling stations are organized, what their peculiarities are during the usual process in time as well as why certain logistics solutions are preferred and selected. Another argument in favor of selecting this research method is related to the fact that the mother–daughter station delivery method is implemented by only five companies

in Bulgaria. This fact eliminates the possibility for conducting extensive research, especially in the current situation where the issue under consideration is poorly researched.

In the process of collecting data for the case study, the following methods were used: semi-structured interview, analysis of normative documents and the author's direct observation of the activity that encompasses the 2010–2015 period, which are the base for identifying the studied logistics activities within the physical distribution. They are used as thematic areas to formulate the questions asked during the interviews—Table 2. In the case of semi-structured interviews, there is the possibility for the interviewer to ask additional, specific, and comparative questions, provoked by the answers provided by the participants. The requirement is that these questions should be within the scope of the studied thematic areas—Table 2.

Table 2. Thematic areas of conducting a semi-structures interview.

No	Thematic Areas	No	Thematic Areas
1	Transportation	7	Reverse logistics
2	Transport schedules	8	Inventory management
3	Compression schedules	9	Customer service
4	Packaging	10	Location of CNG refueling stations
5	Warehousing and storage		
6	Labeling	11	Information services

The interviews are conducted with the two executive officers of the company, with the "Logistics" manager and the manager of "CNG refueling stations trade operations" who is in charge of planning and the operational management of the activity of the mother station in the town of Kameno and the studied daughter CNG station in Burgas.

The preliminary study lasted 2 weeks and the main one 12 weeks. There was one interview each week conducted individually with each respondent and was focused on a separate topic from those presented in Table 2. This approach gave the interviewer the chance to prepare better and the interviewees to plan their appointments and fit them in their weekly schedule. Structured data about the participants, the duration of the interviews and the participants' experience in the sector are shown in Table 3.

Table 3. Duration and respondents in the semi-structure interviews.

			2017													
	Interviews Duration	Experience in the Sector	Preliminary Study		Main Research—Indexes of the Fields from Table 2 Are Used											
Respondents			May (weeks)		June (weeks)					July (weeks)				September (weeks)		
	min		2	3	1	2	3	4	5	1	2	3	4	2	3	4
CEO 1	60	Since April 2005	X	X	1	2	3	4	5	6	7	8		10	11	9
CEO 2	60	Since October 2006		X	1	2	3	4	5	6	7		8	10	11	9
"Logistics" manager	90	Since 1977 in Logistics Since 2014 in CNG field			1	2	3	4	5	6	7		8	10	11	9
Manager of "CNG refueling stations trade operations"	75–90	Since November 2006		X	1	2	3	4		6	7	8	5	10	11	9

Semi-structured interviews were used at both stages of the study. The aim of the questions in the preliminary stage was to collect information about the research object. They are grouped as follows:

1. Questions to establish the relevant experience of the managerial team and the corporate activity in the sector.
2. Questions concerning the market share and the main competitors in the sector.

3. Question whose aim was to establish the key competency, the field of activity and the distribution channels.
4. Questions about the portfolio of services provided and an estimate of their structure.
5. Questions about general and specific regulations in the sector, trends at national and European level.
6. Other questions initiated by the interviewed and the interviewer.

The questions included in the main stage of the research aim to establish the specific characteristics of the physical distribution activities and their management in the research object. They are grouped as follows:

1. Questions about planning the logistics strategy and design of the distribution system which involve the infrastructure, the equipment, personnel and safety.
2. Questions about the implemented methods, techniques and instruments for logistics activities management.
3. Questions about the logistics activities and solutions at strategic, tactical and operational level.
4. Questions about the control of the distribution system, including the implemented systems of indicators and software.
5. Questions concerning the normative documents.
6. Questions about plans and the need to implement more modern instruments for logistics activities management.
7. Questions initiated by the interviewed and the interviewer.

During the second (main) stage of the research, company documentation related to the organization of deliveries was studied along with financial reports in order to calculate the relative shares of sales through the used distribution channels.

The delivery process between the mother station and the daughter station was subject to three direct monitoring visits.

The data collected during the semi-structured interviews is processed through a content analysis.

In addition, when studying the characteristics of end user demand quantitative methods for time series analysis and in particular identifying the development components—trend and seasonal component—were implemented. The case study research allows for the use of quantitative data and analysis methods [55] (p. 14), [56] (p. 4), [57] (p. 554), which contribute to the more comprehensive and detailed study and in this specific case we use them to specify the demand nature which we take into consideration when defining the used inventory management model. Data, collected from 731 records of daily sales of the daughter CNG refueling station in Burgas, registered between 1 January 2015 and 31 December 2016, have been analyzed. During their collection, the observation method was implemented, while for their analysis—the descriptive statistics tool-kit. The 2017 daily sales data are left out of the analysis. The reason for that is that access to the station during the first half of the year was limited due to reconstruction of the main road and the sales during the period differ from the typical levels.

4. Features of the Organization of the Physical Distribution to Daughter CNG Filling Stations of CNG Ecogas JSC in the City of Burgas

4.1. Transportation, Transport Schedules and Compression Schedules

The transportation of CNG from the mother station in the town of Kameno, where the operations related to compressing are carried out, to the daughter station in the city of Burgas is performed via specialized vehicles. It complies with the regulations for transporting class 2 hazardous freight under ADR agreement. The employed vehicles should have a uniform approval for transport of hazardous goods [14] (vol. II, chapter 9.1, 9.2 and 9.7, pp. 585–600, pp. 609–611). The drivers—a training certificate for the given class [14] (vol. II, chapter 8.2, pp. 567–572), and the vehicle should

have special equipment on board [14] (vol. II, chapter 8.1, pp. 563–565) and instructions how to behave in an emergency situation [14] (vol. II, 2016, chapter 5.4, article 5.4.3, pp. 255–261).

In transport natural gas is considered hazardous freight with the following permitted description: "UN 1971, Methane, Compressed, 2.1, (B/D)" [14] (vol. II, article 5.4.1.1.1., pp. 245–246). It is also necessary to use special routes since there are restrictions for moving through tunnels from categories B, C, D and E [14] (vol. II, 2016, chapter 8.6, article 8.6.4, pp. 581–582).

The company uses own transport for deliveries. It also has a signed framework contract with a transport subcontractor for all clients filled from the station in Kameno. This guarantees high reliability of the deliveries and in fact provides 24/7 possibility for conducting transport operations.

The work of the drivers is planned in accordance with the requirements of Regulation (EC) No 561/2006, as well as the acts related to its implementation in Bulgaria [58].

The transportation is planned and managed in accordance with the orders received from the daughter station which are included and consolidated in the transport schedule. It is run in line with the schedule for compressing in the mother station where battery-vehicles from the station in Burgas are distributed and get turned on for filling only between 11:00 p.m. until 07:00 a.m. during the summer time period and from 10:00 p.m. until 06:00 a.m. during the winter-time period regardless of the time of their arrival. The aim is to use cheaper electricity at night and to guarantee higher cost efficiency of the compression operations.

With respect to transport operations, a recommendation can be made in terms of studying the opportunities for replacing heavy-duty vehicles with CNG vehicles. They are extremely appropriate because they can be refueled at both the starting and end points. What is more, for the logistics systems with several daughter CNG refueling stations this option has potential for achieving synergy effect in the field of sustainable transport solutions. It can be utilized if vehicle routing problems software is implemented. In this way higher energy efficiency of transport operations will be achieved since the effect of the reduced harmful emissions due to the fuel used for transport operation will be increased as a result of optimizing the routes.

The matter related to the optimization of the electricity costs in time of use tariff environment in master compression schedule can be a lot more complex in distribution systems with several daughter CNG refueling stations, which implement DPR approach to inventory management. In this case it affects the interrelation with electricity distribution companies back in the supply chain by purchase schedule due to the need for providing wide ranging time windows by specific rate.

4.2. Packaging, Warehousing and Storage, Labeling and Reverse Logistics

CNG should be packaged in cylinders according to the requirement of packaging instruction P 200 [14] (vol. II, 2016, pp. 64–87). They are made from steel with capacity of 90 L. When being used it is necessary to meet requirements for sealing off, periodic inspections and level of filling which are set forth in P 200 packaging instruction [14] (vol. II, 2016, pp. 64–87).

Warehousing and storage is under high pressure. This presents certain risks for the people, the equipment, and the environment, which means that the respective safety measures should be taken to limit them.

CNG is warehoused in battery-vehicles. The cylinders "are linked to each other by a manifold and permanently fixed to this vehicle" [14] (vol. I, chapter 1.2, p. 15), and hence are considered an element of the vehicle. In practice, battery-vehicles are a mobile warehouse. This is what makes it possible to be moved at any one time where demand occurs with the help of a vehicle. Along with that it is a specialized store since only CNG under high pressure can be stored there. Chapter 6.8 regulates the "requirements for the construction, equipment, type approval, inspections and test . . . of . . . battery-vehicles" [14] (vol. II, chapter 6.8, p. 461).

Storage is organized on a site designed and certified for one-time stay of two battery-vehicles and is located on the territory of the daughter CNG refueling stations. All fire protection requirements concerning the spacing from the charging columns are observed. In addition, the storage site is

protected with concrete safety walls. Unlike filling stations with conventional petroleum products where the tanks are installed under the station, the daughter CNG refueling stations storage is done in mobile warehouses, outdoors and at a distance which leads to higher investment costs for land and safety equipment, as well as higher operational costs for site supervision. This fact should be taken into consideration when a decision about the location of the daughter stations of the existing petroleum products gas stations is made.

The daughter CNG refueling station have a fast-fill system which for has a buffer reservoir which holds around 600 m^3 and facilitates customer service since the needed filling pressure is reached very quickly.

The main risk during carriage, storage, and manipulation of UN 1971, Methane, compressed is based on its flammability. This requires that the packages should be marked adequately to indicate the high risk of flammability. In his particular case are used labels from group 2.1 flammable gases [14] (vol. II, chapter 5.2, pp. 223–233), and the requirements for using signs indicating danger on the vehicles are set out in the regulations of Chapter 5.3 of ADR [14] (vol. II, chapter 5.3, pp. 235–244).

When transporting and using battery-vehicles reverse logistics activities are also present. The first one is connected with the return of remains of the load, which happens with every delivery and is the result of technological peculiarities and the nature of the load. In such cases the transport document contains one of the two specified options for description: "UN 1971, Methane, Compressed, EMPTY UNCLEANED, 2.1, (B/D)" or "UN 1971, Methane, Compressed, RESIDUE, LAST CONTAINED, 2.1, (B/D)" [14] (vol. II, article 5.4.1.1.6.1., p. 247). The second operation is related to transporting the battery-vehicle to the cleaning, planned, or emergency repair stations. In this case "carriage in accordance with 4.3.2.4.3" is conducted which should be specified in the transport document [14] (vol. II, article 5.4.1.1.6.3 (a), p. 248).

In terms of packaging solutions related to utilization of CNG composite cylinders should be sought. They are much lighter than the steel ones and would reduce the weight of the battery-vehicle which will result in an increase of the quantity of transported CNG.

4.3. Customer Service

CNG Ecogas JSC has introduced a two-level system for customer service evaluation. Its first aspect is focused on measuring the direct service provided to the daughter station by the mother station and the second refers to the evaluation of the service provided to end clients with natural gas automobiles, which takes place at the daughter CNG refueling station in Burgas. The system consists of traditional indicators.

In order to evaluate the services provided to the daughter station by the mother station are used indicators for order cycle time. They are with predetermined order fulfillment time standard of 18 h and monitoring the deviations from the partial cycle times related to processing, transportation, and compression. Another used indicator is timely delivery, which is calculated as a percentage of orders delivered within the set time standard of 18 h from the total number of orders. The order fill time, calculated as percentage of the full orders with accepted standard of 5500 m^3 CNG in one battery-vehicle from all orders is also used. These indicators allow company to use a modified version of the perfect order, which shows deliveries on time and in full in absolute terms as a number and in relative terms as a share (%) of the perfect orders out of all orders.

To evaluate the services provided to the end customers of the daughter station, the indicator complaints from clients in absolute and relative terms is used.

The company calculates the specified indicators on monthly, quarterly, and annual basis.

A recommendation can be made to CNG Ecogas JSC mostly concerning the improvement of the second pillar of the customer service evaluation system, namely the indicators for end client service in the daughter CNG refueling station. The possibilities in this field can be categorized in several directions. First, introduction of an indicator for product availability as a correlation between the number of clients where CNG is available and the total number of clients expressed in percentage,

which will indicate possible issues with the compressor of the daughter station and interrupting the deliveries to the station. Second, introducing the indicator order fill rate for end clients, calculated as a percentage of delivered full orders with standard for filling the car gas container of 200 bars from all orders of end clients. Third, introducing order fill time indicator in the order cycle of the end clients. A common standard can be set for time needed for one car as well as a standard for partial times, which encompass compression operations, providing services, and time spent at the cask desk. Fourth, the set standards for time needed to service one automobile make it possible to calculate the timely delivery indicator as percentage-serviced cars within the set time standard for all serviced cars. Fifth, these indicators allow for the implementation of the modified version of the perfect order for one car which presents the deliveries on time and in full in absolute terms as a number and relative measure as share (%) of the perfect orders from the orders of all automobiles. These indicators can be measured on the basis of observations of servicing end clients once or twice a year depending on the capacity of the company to provide the necessary resources for carrying it out.

4.4. CNG Inventory Management

When defining the stock management model it is of great importance to determine the demand characteristics. Table 4 presents the results from the implemented methodological tool-kit used to determine its manifestations in the research object.

Table 4. Descriptive indicators and sales seasonal index rates (%) at daughter CNG refueling station in Burgas, calculated on weekly basis for the period 1 January 2015–31 December 2016.

Week Days	Total Seasonal Factor (%)	Summer Seasonal (%) April–September	Winter Seasonal (%) October–March
Monday	115.1	110.3	84.1
Tuesday	84.7	96.1	84.3
Wednesday	64.4	76.0	98.2
Thursday	111.4	89.9	110.2
Friday	105.9	112.6	110.6
Saturday	108.2	108.5	109.7
Sunday	110.3	106.5	102.9
Descriptive Indicators	**Total Period**	**Summer April–September**	**Winter October–March**
Mean demand thousand m^3	931.8	950.8	912.8
Coefficient of variation Vσ %	25.82	25.05	26.50
Number of cases	731	366	365

The analysis of the autocorrelation function shows that the research data contain a trend and a seasonal component, which is explicitly illustrated on a weekly basis. In addition, a check has been performed to see if the characteristics of the seasonal component are sustainable during the different periods during the year since the daughter CNG refueling station provides services for transit traffic during the summer vacation. To do this the data is codified with a dummy variable in two periods—summer and winter, which run from April through September and October through March, respectively. The seasonal component analysis shows that on Friday, Saturday, and Sunday there is higher demand on weekly basis during both periods—winter and summer. There are no significant changes in demand on weekly basis during the summer and winter, which illustrates that the typical consumer behavior model is around one fill every 4–5 days and the majority of the fills are made by city vehicles.

The variance coefficient during the entire research period, as well as separately during the summer and the winter is relatively low—below 30%. This shows that the data about the daily consumption are close to the mean valuations and the studied totality is homogeneous in terms of the research indicator. Under these conditions, we can assume that demand is constant.

In times of constant demand, the company uses the fixed order quantity approach—condition of certainty. The managing parameters of the approach are volume and reorder point. The volume of the order is fixed. It depends on the capacity of the used battery-vehicles. In this specific case the firm uses battery-vehicles with capacity of 5800 m^3. When their capacity was determined the traditional Wilson model for economic order quantity EOQ is used, which provides an answer to the question 'how much' to order. This is the basis for determining the capacity at which the order costs and inventory carrying costs for CNG are minimized.

The reorder point (ROP) provides an answer to the question 'when' to order. It represents the stock level at which an order for new delivery is placed. The reorder point is calculated as follows (1):

$$ROP = d \times L, \tag{1}$$

 where:

d—average daily demand for the respective period which is calculated as the demand for the period is divided by its duration in days.

L—lead time in days.

The firm implements two modifications for the reorder point during the summer and winter period based on the average demand for the past two years. The delivery lead time is 18 h or 0.75 days and is constant for the two periods.

It should be pointed out, however, that other daughter CNG refueling stations can exhibit a different demand pattern depending on its variations on weekly and seasonal basis, which depend on the consumer behavior models in the local region where the service is provided. The lead times in the distribution systems can also vary considerably depending on long transport distances between the mother and daughter CNG refueling stations, traffic congestion prerequisites, specific weather conditions in some regions or the terms and conditions of the contracts signed with CNG distributors. The logistics concept provides a wide range of models for inventory management, which could be appropriate in these cases. For example, in case of higher demand it would be more appropriate to implement the min-max inventory management approach that is an adaptation of the fixed order quantity approach. In addition, in case of variable demand and/or lead time the fixed order quantity approach—condition of uncertainty could be applied, when it is necessary to use safety stocks and even the DRP approach in several daughter CNG refueling stations.

4.5. Facility Location of CNG Refueling Stations

The daughter CNG refueling station of CNG Ecogas JSC is strategically located in the suburbs of Burgas, Kraiezerna Street where the transit traffic to the settlements and resorts along the south Black sea coast passes. This location of the station guarantees that not only natural gas vehicles in the city fill their tanks there but also those who pass by. On the other hand, Burgas is situated along the Orient/ East-Med corridor of the TEN-T network [59]. This fact creates conditions for the daughter station to become one of the exit points for international journeys from Bulgaria to Central and Western Europe by natural gas vehicles and if the necessary number of refueling stations is provided this will be possible in the other parts of the route.

The mother station is located 24 km from the town of Kameno. The road network offers three alternative routes between the two stations along which there are no restrictions for transportation of hazard goods. This fact improves delivery security in case of unforeseen circumstances.

The decision to select the location of the two stations—the mother station and the daughter station, was taken by investors based on the factor rating method. The key decision criteria with the respective weight are:

- Price of land for industrial construction (20%);
- location along the strategic road infrastructure (15%);
- current and future potential for market penetration in the region (15%);

- availability of labor resources in the region (10%);
- opportunity for joining the stations to the critical infrastructure such as gas pipelines, electric grid and other utility services (10%);
- transport costs for guaranteeing sales in the region (10%);
- investment costs in the mother-daughter station model (10%);
- labor costs (5%);
- local taxes (5%).

It is recommended that the construction of new distribution systems with several daughter CNG refueling stations should be carried out in line with the principles of green facility location. This will enhance the potential for achieving a synergy effect with other solutions, which guarantee sustainability of the logistics system—for instance, the replacement of the conventional fuels with alternative ones and the implementation of route optimization systems. The logistics set of tools of methods for green facility location is extremely diverse. According to literature data, the deterministic models are applied more often than the stochastic models [23] (p. 5). To resolve green facility location problems different kind of models can be used: planar models, discrete models, network models, K-Median Models, location-allocation models, Geoffrion and Graves Distribution System Design Model, as well as locational cost-profit-volume analysis, the transportation model, factor-ratings and center of gravity method [24]. Various optimization techniques can be implemented within the individual methods. For example, the network models can use mixed integer linear and mixed integer non-linear programming, as well as other techniques [23] (p. 6).

4.6. Information Services

CNG Ecogas JSC uses a system of operational tracking, monitoring, and security of vehicles through Internet and by using GPS and GSM technologies. A fuel sales reporting system, which allows sales registration and invoicing, has been introduced. The company accounts the actual transportation work between the stations through using their own software, which provides a possibility for analytical distribution of transport costs by stations and for calculating the indicators for the logistics features of the transported CNG in terms of weight-volume and weight-value correlation. The remaining data about the events related to the management of the logistics activities are recorded and kept in a database that are processed with computers, standard software and in line with the needs of the information and management system.

The connection between the daughter and mother stations is conducted along traditional communication channels like: e-mail, telephone, courier shipment, and in-company shipment during the delivery.

A wider implementation of transport management systems TMS is an option, which include a routing optimization module. It would be particularly useful if the mother station supplies several daughter stations in the area where it provides services. Providing EDI exchange, on the other hand, will ensure an opportunity to implement improved inventory management approaches in retail such as Quick response or Continuous Replenishment.

5. Conclusions

The present case study illustrates the specific application of the logistics concept in the energy sector and in particular, the distribution of CNG to daughter CNG refueling stations which are not part of the transmission and distribution natural gas network. The study outlines some key features related to the management of the logistics activities at strategic and mostly operational level. It reveals several important results, which serve as basis for formulating recommendations to stakeholders. First, the described good practice shows policy makers that a working and reliable solution for the fast construction of infrastructure CNG refueling stations along core TEN-T can be provided. The creation of conditions for financing projects in this field will support the policy for broadening the use of

alternative fuels in EU. Second, gas distribution companies can diversify their channels of distribution. They already have a description of a good practice for management of physical distribution in the logistics channel, which they can implement after modifying it in line with the finance and modern achievements of the theory in the field of supply chain management. Third, the academia now has at their disposal an initial explanatory research. It provides more comprehensive knowledge about CNG distribution process that is based on a complex study of a wider range of logistics activities. Thus, it builds upon and extends previous research which concern some aspects of facility location and transportation activities. Furthermore, it provides grounds for:

- Better analysis of the investment and operational costs;
- selection of facility location methods;
- requirements for building stations, safety and planning of logistics processes;
- outlining the opportunities for implementing outsourcing solutions;
- achieving a better synergy effect of the energy efficiency measures in more than one activity in the distribution system,

when applying the mother-daughter station model.

The research also confirms the universal implementation of the logistics set of tools for managing CNG distribution in this specific area of energy sector about which not much was known until recently. In addition, it helps for the better formulation of the research fields, validation of the results from other research and conducting research that is more comprehensive in the future.

The EC can use the good practice presented in this article describing the accelerated construction of CNG refueling stations located along the roads of TEN-T network. The expected outcome is related to creating conditions for travel by cars running on natural gas in the territory of the entire Union, which will contribute, to achieving the goals set out in Directive 2014/94/EU and will provide opportunities for better market penetration of these vehicles. Currently, the vehicles running on natural gas in the entire EU find it difficult to perform long-haul journeys since the main CNG refueling infrastructure is concentrated in the urban areas where there is a dense natural gas distribution network but there are only a few gas pipelines along the transit highways. The accelerated construction of daughter CNG refueling infrastructures along TEN-T land route requires financial aid from the EU budget both for direct investments in the construction of stations and for information campaigns to influence consumers' views and behavior. The establishment of technological consortia involving European manufacturers of equipment and centers for exchange of good practices that should be taken into consideration by the policy makers in the field are also needed.

Policy makers should not simply set the agenda of modern research, but also involve a wider base scientific society and business in conducting sustainability policies. Thus, the theoretical and practical achievements can be used faster to resolve real public problems.

Gas distribution companies that would like to diversify their market niches by configuring distribution channels for natural gas as compressed car fuel can use the model for building daughter stations. This will give them the opportunity to lower investments in expensive gas pipeline infrastructure and along that to reach faster the locations where demand arises. This niche creates good opportunities for sales development since the measures for energy efficiency lead to reduced consumption of natural gas by households. At the same time, the annual consumption of one car is comparable with that of one household. Moreover, in the majority of cases the members of one household live together in one place but own more than one car, which creates opportunities for cross sales. In the bigger licensed territories, it is even possible to build several daughter stations in a given area, which can be filled from the mother station located in an area, which guarantees efficient delivery. To achieve this goal the gas distribution companies should build the necessary key competency in the area of logistics, to use the skills and know-how of CNG distributors, if such exist or to establish joint ventures with them.

The main lesson to be learned by managers is connected with the awareness of an extremely wide range of activity of the logistics concept. Its achievements do not only contribute to the improvement of the organization of the activities related to physical distribution through ready-made decisions—for instance, optimization of transport and the utilized capacity of the vehicles, but also show how its modern set of tools can be implemented to build quickly sustainable distribution systems for natural gas as motor fuel.

The research contributes to the categorization of the used terminology in the field since it has been fully conducted in compliance with the terminology adopted by the Economic Commission for Europe—the UN Inland Transport Committee in the European Agreement Concerning the International Carriage of Dangerous Goods by Road—ADR.

Future research in the field can verify the degree of applicability of such practices in other regions around the world. Research that offer ways to optimize some logistics activities, to provide comparative characteristics of the physical distribution to daughter CNG refueling stations and LNG refueling stations, to validate the results from other research in line with the described practice and to test different types of hypothesis can also be conducted. Furthermore, the study of the investment costs for mother-daughter station solution will provide basis for modifying and adapting the Frick et al. model for this case.

Conflicts of Interest: The author declares no conflict of interest.

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