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REQUIREMENTS OF FUTURE GAS DISTRIBUTION NETWORKS

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ABSTRACT

Gas distribution networks have grown and developed into its present structures over the last 40 to 50 years. At present, it is becoming increasingly apparent that these networks no longer comply in all respects with the demands of the users. This is not primarily a capacity related problem, as it has become clear that gas consumption, due to increasing energy efficiency and energy savings, is usually still relatively low compared to the possibilities offered by the network. The problems which arise are more related to how the network can be used, the flexibility of the network, and the product and service differentiation which can be offered to the end user. A preliminary study has been carried out in order to further explore and define these issues. The problem definition of the study can be summarized as follows: "From a technical, economic and regulative perspective, what changes can be expected in future regarding the requirements which the gas distribution networks will have to comply with, and how can these changes be implemented?" . The necessary information was mainly acquired via interactive brainstorming sessions with various stakeholders, such as staff personnel from power companies, other utilities, telecom and ICT companies, universities, R&D institutes, and engineers. During these brainstorming sessions, wide use was made of interactive ICT facilities . The first question which arose was: "What are the most important developments which will affect gas supplies in the coming decades, according to the parties involved?". Important issues which surfaced in this regard include the decreasing availability of gas, growing social concerns regarding the safety of the gas network, high expectations regarding the reliability of the gas system, and technological developments in the field of information technology. The participants in the sessions also formulated a range of requirements as to how gas distribution networks will need to function in future. The most important and urgent requirements mentioned were: decreased vulnerability to damage, increased economic efficiency, more 'intelligence' built into the networks in order, for example, to achieve optimum economic results for the end user, improved communication in order to increase public feelings of safety, demonstrable safety, and flexibility of the transport infrastructure with regard to the use of various gases. The complexity of the requirements was also investigated. As it turned out, the participants generally expected increased complexity in realizing the new requirements from a management/administrative perspective rather than from a technical perspective. Increasingly complex requirements from a management point of view included: equal access to market parties, active integration with other infrastructures, improving safety/terrorism related features, application of capacity related rates, and improved communication in order to increase the public perception of safety. This preliminary study will be used to define targeted follow-up studies, in which the technological, economic and regulative aspects will be dealt integratively.

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1. INTRODUCTION

The Dutch gas distribution network has grown and developed into its present structure over the last 40 to 50 years. Gas is presently the predominant energy source in the Netherlands; domestic heating, hot water supply and cooking are mostly done by using natural gas. More than 6.5 million of customers are connected to this extended gas grid, which has a length exceeding 130,000 km. The larger part of this gas grid is the low and medium pressure gas distribution network (about 120,000 km), the high pressure transmission system is about 11,000 km long. At present, it is becoming increasingly apparent that this network no longer complies in all respects with the demands of the users (end users, industry, power companies). This is not primarily a capacity related problem, as it has become clear that gas consumption, due to increasing energy efficiency and energy savings, is still relatively low compared to the possibilities offered by the network. The problems which arise are more related to how the network can be used, the flexibility of the network, and the product and service differentiation which can be offered to the end user. It is expected that the same situation will hold for other gas distribution networks in Europe.

Parts of the current gas distribution systems are about approaching their design lifetime. Replacement or renovations of these systems will require huge investments in the near future and important decisions about the design of these systems have to be made. The decisions will be important for at least the next four to five decades. Moreover renovation of the current distribution network is no longer simply a matter of replacing old pipes for new ones, because probably many new design parameters have to be taken into account. What these new parameters are, will be the topic of this paper. Liberalisation may ask for new requirements to the gas networks. These needs partly have a technical background, but liberalisation may also ask for new approaches on economy and regulation of the gas distribution systems.

A preliminary study has been carried out in order to further explore and define these issues. The problem definition of the study can be summarized as follows: "From a technical, economic and regulative perspective, what changes can be expected in future regarding the requirements which the (Dutch) gas distribution networks will have to comply with, and how can these changes be implemented?" The study is aimed on insight into the future requirements (technical, economic and regulative related) which gas distribution networks will have to comply with and how these requirements can be satisfied.

This paper is structured as follows. First an overview of the methods used in this study will be given. Next an overview of foreseen developments with relevant for gas supply and distribution will be given. Then the most important requirements on future gas distribution systems will be listed. Finally the most important conclusions and recommendations will be presented.

2. METHODS

The study started with literature search, which showed that the issue of innovation of gas distribution networks hardly has been subject of systematic research. As a start, the project therefore consulted experts on the topic. A wide range of stakeholders were invited for these sessions, such as staff personnel from power companies, other utilities, telecom and ICT companies, universities, knowledge institutes, engineers, etc. During these brainstorming sessions, wide use was made of interactive ICT facilities in the so-called Group Decision Room of the TU Delft (Technical University Delft). The use of the decision room facilities enabled an efficient consultation of experts with the use of information technology. In particular modern ICT supports the generation of new ideas in an interactive way. The participants in the sessions were able to react directly on ideas generated by all other participants. By doing this optimal use of synergy was made. In this way 3 questions were explored during the brainstorm-sessions :

- Which developments will affect the gas supply and distribution in the coming years?
- Which requirements will be important for gas distribution in the next decades?
- Which will be the priorities in the technical and non-technical requirements on gas distribution in the coming decades?

The brainstorm-sessions gave a lot of information, which was further analysed and summarized by the authors of this paper.

3. FORESEEN DEVELOPMENTS ON GAS SUPPLY AND DISTRIBUTION

The first question covered by our explorative research was: "What are the most important developments which will affect gas supplies in the coming decades, according to the parties involved?" Important issues which surfaced in this regard include the decreasing availability of gas, growing social concerns regarding the safety of the gas network, high expectations regarding the reliability of the gas system, and technological developments in the field of information technology. Below these issues will be evaluated in some more detail.

Availability of natural gas

It is generally believed that gas supply will change drastically in the coming decades. Natural gas will be supplied from different resources, sometimes far away from the place of use. Natural gas will be traded worldwide, which means hard competition, but also more political implications. This may have consequences for the price as well as for the security of supply. Access to natural gas will also be affected by modern gas transport technology. Recently a lot of technological developments took place in the field of LNG. Therefore transport of natural gas from remote places by means of LNG will be possible in an economic way besides the usual transport by pipelines. The composition of future natural gas may also fluctuate more. It is expected that gas storage will be necessary to accommodate possible hick-ups in the gas supply.

These developments will demand for more flexibility in the design, operation and management, but also in the regulation of the gas (distribution) networks. The networks should be able to handle different types and qualities of gas in the systems. This does not only mean technological tools, but will also require new tools for flexible management of the systems and advanced regulation of gas distribution networks.

Geographic and demographic developments

It is generally expected that the temperature will further increase in the coming decades by the greenhouse gas effect. This will have its influence on the daily and seasonal demand curve of natural gas. The greenhouse gas effect may also result in a raise of the sea water level and the water table onshore. Especially in countries like the Netherlands this effect may be profound. Demographic effects will also effect the demand of natural gas, for instance the further ageing of the population. The demand curve of the elder people is different from that of the younger people. The elder people may also choose to live part of the year in another country, like to stay in a warmer country during wintertime. Finally a stabilization of the population is expected in the mature European countries or even a slight decrease.

Societal developments

Future gas distribution may be affected by two societal developments. First security will become more and more important. The threat of global terrorism will certainly affect the design and operation of future gas networks. This will effect security of supply as well as safety. Secondly, safety will be high on the priority list of future gas distribution systems, even more than today. The operators of these networks will be obliged to show that safety is a prime issue in the

design and operation of these networks. This also means that communication about safety issues will become of increasing importance. Closely related to this is the reliability of the gas distribution systems. People will not tolerate interruptions in the gas delivery or any kind of incidents or accidents to the gas system.

Political developments

Political developments in Europe will more and more have their impact on the management and operation of gas distribution networks in the various countries. National legislation and regulation will be replaced by international rules. International standardization and harmonisation will determine the technology used in gas networks, like e.g. the CEN standards for systems for gas supply.

Developments in building and the related energy demand

Buildings of the future will probably have a much lower energy demand. These developments are also forced by the authorities. The mix of various energy sources to fulfil the future energy demand of the cities of tomorrow will also change. Various energy sources will be combined like e.g. gas and sunlight. These developments may result in a strong change in the demand of natural gas.

It is expected that the demand may vary strongly in time. A stronger relation between different energy supply systems is expected like in gas and electricity systems where cogeneration is used.

Market developments

In future competition in the gas market will increase ; natural gas will become a commodity. This also means that management of the gas streams will become a key issue : deliver gas in time and at the right pressure and quality. To support these activities a lot of data have to be monitored and controlled. These information systems will also be necessary to satisfy the requirements of an increasing number of shippers using the gas distribution networks.

Technological developments

A whole range of technological developments and innovations will affect the design, architecture and management of the gas distribution system. More sophisticated pipe materials will be explored and tested. Composite materials are expected to have high potential in this respect because they provide both flexibility and strength which will be required for modern systems. Developments in sensor technology may also become very relevant for gas networks. The scale of sensors is becoming smaller and smaller (nano-technology), by which use in gas distribution systems will become more likely. By using sensor technology real time measurement of different properties of the gas stream and the piping system will become possible. It is therefore expected that sensor technology will extend the monitoring control and management of gas distribution systems significantly, especially when it will be combined with modern ICT innovations. Robotic systems is another promising technology affecting the gas distribution, e.g. to monitor the condition of pipelines or easy-on-site repair.

Environmental developments

Society will ask more and more for the use of sustainable fuels and a low environmental impact of the networks used. Leakage of gas (methane or other gases) should be low and accountable. Materials taken out should be recycled. It is expected that more sustainable gases, like biogas and hydrogen, will be introduced in the future networks.

4. REQUIREMENTS TO FUTURE GAS DISTRIBUTION SYSTEMS

The participants in the sessions also formulated a range of requirements as to how gas distribution networks will need to function in future. The most important and urgent requirements mentioned were: decreased vulnerability to damage, increased economic efficiency, more 'intelligence' built into the networks in order, for example, to achieve optimum economic results for the end user, improved communication in order to increase public feelings of safety, demonstrable safety, and flexibility of the transport infrastructure with regard to the use of various gases. Below these various requirements will be further elucidated.

Demonstrable safety

Safety has always been an important aspect of gas distribution, and it is widely accepted that this will be the same in future. However, in future it will be requested to demonstrate clearly to the public that the safety level is according to the levels the society expects. This means that safety management should be demonstrated in a transparent way to all interested. An effective safety management system should be in place. Regulation should provide for clear rules and standards in this respect.

Security and safety

Terrorism added a new dimension to the safety of gas distribution networks : the vulnerability of the system. Gas pipelines could be a target of terrorist attacks. Measures should be taken to decrease the vulnerability to acceptable levels. Advanced remote monitoring technology could help controlling and protecting the pipeline system. It is also important that the information systems are well-protected ("cyber security"). Besides technological measures attention should be paid to more social-psychological aspects : reduce the fear for terroristic attacks by the people. The authorities play a key role in this respect.

Reliability

A reliable gas distribution network should be available, resulting in a demonstrable level of security of supply to various customers.

Flexibility

In the future a flexible gas distribution network is requested. The system should be able to adapt to changes in gas quality, variations in supply and demand, and to react on sudden failures and incidents in the system.

Sustainability

It is expected that sustainability standards will become more important in future. This will also affect gas distribution. Probably more stringent requirements on the pipeline materials will be requested. Emissions of methane from the gas distribution networks should also be reduced and be traceable. Lifecycle chain management may be introduced widely. Moreover more sustainable

gases, like biogas and hydrogen, will be introduced in the gas distribution system. The future systems should be able to accommodate these new gases.

Load management

In future the gas to be distributed will come from many sources. It is also expected that demand may fluctuate much more, partly caused by new applications like micro co-generation. Demand and supply should be managed more, which asks for e.g. remote controlled gas chain management. More storage facilities and gas processing plants are also expected. An integrated management of the gas distribution network, gas producing units (e.g. biogas plants), storage facilities and gas processing (mixing) installations is foreseen.

Tracking and tracing

Since the gas originates from various national and international sources, tracking and tracing of the gas becomes important, especially when calamities or incidents occur. A tracking and tracing system should therefore be available.

Fulfilling (international) standards and specifications

In the past gas distribution systems were designed and operated according to specifications mainly set up by the gas companies itself (self-regulation). Now society asks for the use of broad-accepted standards and specifications. These standards are often established by international committees (e.g. ISO and CEN committees). The gas distribution companies of the future should demonstrate that their systems have been designed and are operated according to these requirements.

Vulnerability for third party damage

One of the main causes of incidents in gas distribution networks is damage by third parties during digging in the neighbourhood of the pipes. Measures should be taken to reduce this vulnerability. The location of underground pipelines is an important aspect in this respect.

Integration/coupling with other energy systems

The energy (and other utility) systems are expected to be more interconnected in future to fulfil the demands of the customers. An example is the introduction of decentral (micro) cogeneration

systems, fed by gas and delivering heat and electricity. In this way demand and load management of electricity and gas systems will be closely connected. Modern gas distribution systems should be able to handle this.

Strict control of capital and operational costs

Society asks for an efficient gas transport at low costs. Because it is expected that also in future gas distribution will be a regulated business, the regulator will monitor these costs closely and will judge the capital and operational costs of the gas distribution network operators carefully. A balance between the economic, safety, reliability and environmental aspects will be made. The need for low-maintenance of components used in the systems is highly requested.

New services for customers

It is expected that customers will demand more services from the gas distribution companies in future. More and more gas shippers will ask for real-time information about the gas transported for them by the network operator. Intelligent remote ICT systems are required to fulfil these needs. Smart metering systems are also necessary.

More intelligence

A more integrated, intelligent gas distribution network ("smart utility concept") is requested, in which e.g. by using sensors (for measuring various operational parameters and the real-time condition of the network components), artificial intelligence and ICT, a better control will be possible. A control on day-to-day operations, as well as a control on maintenance, repair and replacement issues.

The complexity of the requirements was also investigated. As it turned out, the participants generally expected increased complexity in realizing the new requirements from a management/administrative perspective rather than from a technical perspective. Increasingly complex requirements from a management point of view included: equal access to market parties, active integration with other infrastructures, improving safety/terrorism related features, application of capacity related rates, and improved communication in order to increase the public perception of safety.

5. CONCLUSIONS

This preliminary study has yielded additional insight into the requirements which gas distribution networks will have to comply with in future. It seems to be clear that the end users of gas facilities will have a greater say in future. Employees from a wide range of companies and institutions involved expect that the further introduction of ICT will result in more intelligent networks. In addition, society will increasingly make greater demands with regard to the (demonstrable) safety and reliability of these networks. Although it is the technological developments which will make it possible to comply with future requirements, many of the persons involved consider the requirements from a management/administrative perspective to be the most complex issue. This preliminary study will be used to define targeted follow-up studies, in which the technological, economic and regulative aspects will be dealt with integrative.