The gas quality challenge

ir. R.N. van Eekelen, P.W.J.L. Mans MSc, ing. R.J. Mooij, Alliander, Arnhem, the Netherlands

Abstract

Previously gas quality has never been an important theme for the gas distribution sector, and expertise is scarcely existing at Liander, a gas distribution company in the Netherlands. The developments towards multiple and fluctuating sources of gas supply, the changes in gas demand and specific customers groups with stricter gas quality specifications and new regulation on gas quality have led to a renewed interest and role for the gas distribution sector in gas quality.
This challenge leads to an increasing need for a general gas quality management system at gas distribution companies. A part of this gas quality management system is already in place at Liander by means of a gas quality monitoring and control system for Green Gas producers that inject into the gas distribution grid. This system should be extended to cover not only green gas. It should also include measures to be taken when events and mechanisms in the gas distribution grid itself have a negative impact on gas quality.. The gas quality management system will enable Liander to reliably inject local Green Gas and supply our existing and new customers with gas that is safe and suitable for the intended use of gas.

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1. Introduction

The gas distribution infrastructure in the Netherlands has for decennia been based on a single source, the Groningen Gas. Gas from the Groningen gas field has a very stable and constant gas quality and therefore gas quality has previously never been an important theme for the gas distribution sector in the Netherlands. However, the production of the Groningen gas field is decreasing rapidly and the import of gas from other qualities is increasing. Recent years we have also seen the emergence of local injection of Green gas and in the future we are likely to be confronted with injection of SNG (synthetic natural gas), power-to-gas, hydrogen or other renewable gases which will impact the gas quality in the gas distribution grid. Due to the decrease of production of the Groningen gas field, increasing imports of gas with different qualities, and local injection of renewable gases, the gas infrastructure in the Netherlands must be upgraded to accommodate multiple and fluctuating sources of gas supply. Furthermore there are development in the regulatory regime on gas quality specifications in the Netherlands, that have impact on the admitted gas quality to be distributed in the gas grids and the role and responsibilities of grid operators regarding gas quality.

On the demand side the gas distribution sector is also facing changes. For decennia the gas in the gas distribution grids was primarily used for heating, hot water and cooking. Last years a new growing market for gas has emerged: gas for mobility. The CNG filling stations offer attractive opportunities for capacity management due to their stable gas demand profile independent of seasonal influences. On the other side they have stricter gas quality specifications and demand more focus on gas quality aspects.

The developments towards multiple and fluctuating sources of gas supply, the changes in gas demand and specific customers groups with stricter gas quality specifications and new regulation on gas quality have led to a renewed interest and role for the gas distribution sector in gas quality. Previously gas quality has never been an important theme for the gas distribution sector, and expertise is scarce. Liander is a gas distribution company in the Netherlands with 2,3 million connections and is facing the challenge to incorporate gas quality management into their organization. The way Liander addresses this challenge will be described in the next chapters.

First the new regulation for gas quality will be addressed with the main roles and responsibilities of the different parties. Also the main factors determining the gas quality in the gas distribution grid will be shortly discussed. Next the main parts of a gas quality management system in gas distribution will be described, with a description of the parts that are already in operation at Liander. Finally conclusions will be made on steps to be taken that result in an effective gas quality management and control system at Liander that is robust , reliable and ready for the future.

2. Regulatory regime for gas quality in The Netherlands

The Dutch gas distribution sector is liberalized, which means that the supply and distribution of gas is carried out by two separate companies; an energy supply company and a grid operator. Before liberalization the supply and distribution of gas was carried out by the same company. Nowadays a number of roles can be differentiated. Only the roles and responsibilities concerning the gas quality in the gas distribution grids will be discussed. New regulation in the Netherlands by a Ministerial Decree will provide gas quality specifications for the gas distribution grids, and will be operative in October 2014 (**Attachment I Quality specifications in the Ministerial Decree establishing regulations**

for natural gas composition) . This regulation provides clarity on the gas quality specification for injection of renewable gases and on the role of the national grid operation (TSO) and regional grid operators (DSO).

In the Ministerial Decree the specifications are split in entry specifications and exit specifications for the gas distribution grids. The regional grid operator has no role in gas quality treatment and therefore the entry and exit specifications are in general equal. The only main difference between the entry and exit specifications for G-gas is the specification for the water dew point. For gas distribution grids operated with a pressure below 0.2 bar, the water dew point is not specified. These low pressure parts of the gas distribution grid in the Netherlands are prone to leakage of ground water into the pipelines via joints due to the low pressure.

2.1 Local injector of (renewable) gas

The local injector of renewable gas is in general also the producer of the gas. He is responsible for ensuring that the produced and treated gas meets the gas specifications before injection into the gas distribution grid. The gas producer should therefore have his own quality monitoring system in place to prevent injection of off-spec gas. The gas producer must use measurement instruments that meet the regulatory accuracy and perform various gas quality measurements on continuous en periodical base according to the measurement codes.

2.2 National grid operator

The national grid operator is by law responsible for supplying gas that meets the quality specifications. Therefore the grid operator must have a quality monitoring system to monitor the gas quality at the city gate stations (where gas from the national grid enters the gas distribution grids).

2.3 Regional Grid operator

The Dutch Gas law states that the regional grid operator is obligated to decline injection of gas into their grids that doesn't meet the quality specifications and is in that way responsible for the quality of the gas that they distribute. The regional grid operator should therefore check and monitor whether gas quality complies with the set of specifications. In contrary to the national grid operator, a regional grid operator currently has no role in the gas quality treatment.

2.4 End users in the Regional Gas distribution Grid

There is no regulatory difference between different types of end users regarding gas quality specifications. End users can rely on the gas that complies with the lower band width specifications. Because gas is used in different appliances, different kinds of quality issues can occur when specifications of the gas do not meet the requirements. These different issues need different countermeasures from the regional grid operator.

3. Gas Quality in the gas distribution grid

Gas quality is not only defined by the components of the gas, but also by the olfactory degree and physical properties like temperature, water dew point and and calorific value. Injection (both at the city gate station and local injection) and distribution of the gas in the grid can alter the gas quality.

The main factors that determine the gas quality at the domestic delivery point (gas quality $_{exit}$)are (see 4 Green Gas Injection station and monitoring and control system at Liander):

- Gas $quality_{entry}$ at the City Gate station
- Gas $quality_{entry}$ at the local injection station
- Events and mechanisms in the pipeline, for example:
    - Leakage of water into old low pressure grids (< 0.2bar)
    - Corrosion of the pipeline itself
    - Lubricants used in gas distribution operation (for regulators, valves etc.)
    - Work on the gas grid that may result in water, dust, pebbles or other pollutions in the pipeline

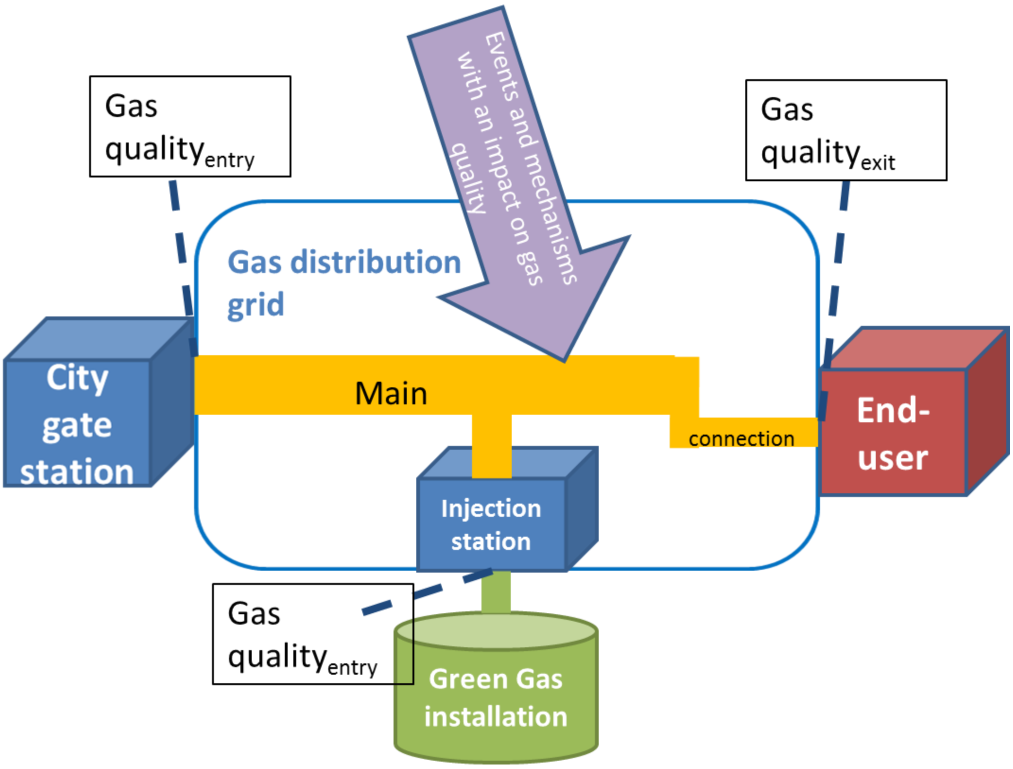

Figure 1 Schematic representation of the factors determining the gas quality in the gas distribution grid

When looking at the gas volume distributed for a typical gas distribution grid with local green gas injection(see Figure 2 The gas volume and demand in a typical gas distribution grid with green gas injection over a year) it can be concluded that the main part of the total volume in the gas distribution grid is still supplied at the city gate station. Therefore the gas quality at the exit point will be mainly determined by the gas $quality_{entry}$ at the city gate station. On the basis of Figure 2, it can also be concluded that in summertime when gas demand is very low, the volume of gas in the gas distribution grid can consist up to 80 to 90% of locally injected Green gas(which is produced constantly all year round). The gas quality in the summertime will therefore be mainly determined by the locally injected Green gas.

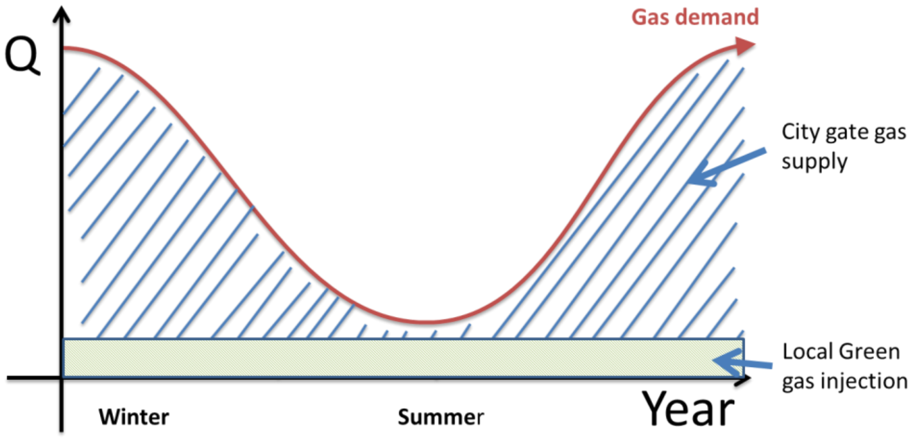

Figure 2 The gas volume and demand in a typical gas distribution grid with green gas injection over a year

Other factors that can have an impact on gas quality at the exit point besides the quality of the gas at the entry points are events and works in the gas distribution grid infrastructure itself. A regional grid operator faces problems with dirt ,dust and fluids in their gas distribution grids. The origins of this dirt and dust can for example be works in the gas grids without proper cleaning resulting in clogged filters at gas stations or could even lead to gas station failure. Leakage of water into old low pressure grids, can lead to moisture problems. Another source of water in gas distribution grids can be pressure tests with water for new gas distribution pipelines. In recent years moisture problems in the gas distribution grids have led to complaints and even claims from CNG filling stations. The developments on the demand side have therefore led to an interest in the influence and possibly negative impact of gas distribution operations on the gas quality distributed in the grids. Before that, there never has been severe issues in gas distribution operations.

4. Gas quality management and control system

To be able to perform the tasks and responsibilities as stated in the Dutch gas law a regional gas distribution operation should at least have a gas quality monitoring and control system in place. To effectively anticipate on gas quality issues, meet increasing customer demands and an a growing number of local injection points the monitoring and control system should become part of a more general gas quality management system.

The main components of the gas quality management system should consist of three layers that are connected and each have their input and output (see Figure 3 The gas quality management and control system):

- Gas quality monitoring and control
- Design of monitoring & control mechanisms
- Gas quality policy

Main bottleneck for the quality management and control system is the knowledge and expertise on gas quality. Only few field employees have the required competences and experience to understand and translate the gas quality measurement results into correct actions en reports. Also little attention is payed to the possible effects of regular works in the gas distribution grids on the quality of the gas. With a gas quality management system on all three levels Liander secures the gas quality distributed in their grids.

The three levels of the gas quality management system will be shortly discussed with a description of the parts that are already in operations at Liander.

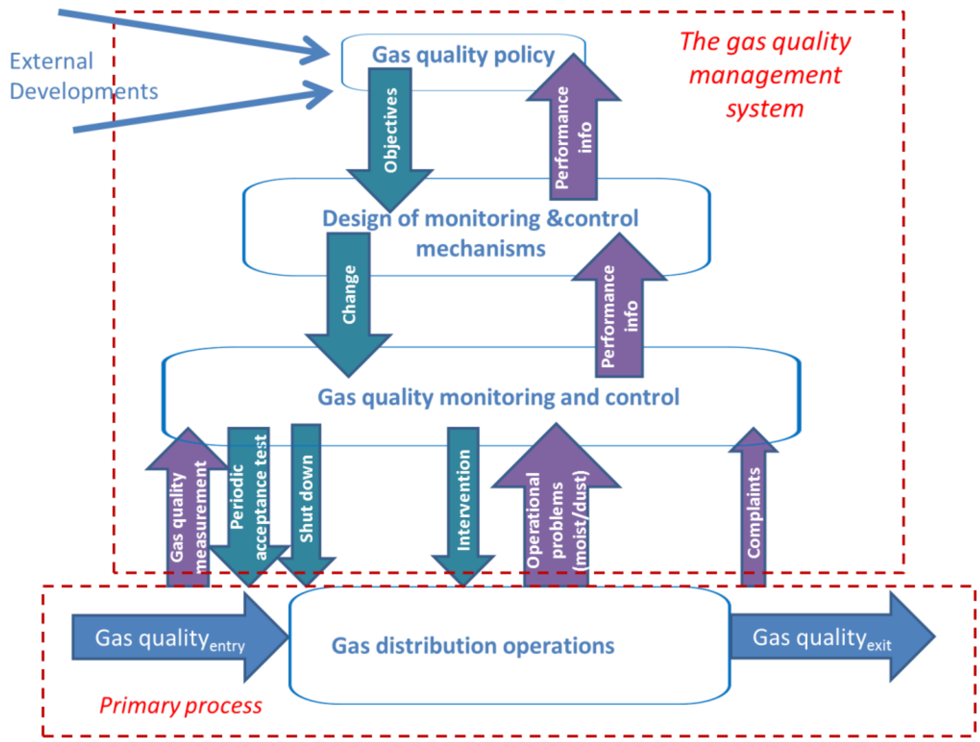

Figure 3 The gas quality management and control system

4.1 Gas Quality Monitoring and Control

Important part of the gas quality monitoring and control systems is the concept of how to monitor the quality in sufficient detail and with sufficient certainty and guaranties. At Liander the Liander Control Room (LCR) is charged with the daily monitoring and control of the gas quality.

At Liander the gas quality monitoring and control can be split in two main parts:

- Monitoring and control of the gas quality at the City gate stations, Liander has 186 City gate stations that provide their gas distribution grids.

- Monitoring and control of the Local injectors, currently only 6 active Green gas producers inject their gas into the gas distribution grid of Liander.

For the gas distribution operation there is no active control system in place.

The monitoring and control responsibility at Liander is divided in two layers of control. The first level of control is the monitoring and control of the gas quality measurement results of the National grid operator and the Local Green Gas injector. In addition to this level Liander performs periodic gas quality sampling as a part of acceptance tests of the gas injected into the gas distribution grid .

City gate station monitoring and control

Together with the national grid operator rules have been established on how to monitor and control the gas quality .The results of measurements at the metering points of the national grid operator are available via a secured program (Cars). The odorisation of the gas is controlled according to the Metering Code for the National Grid Operator. Gas analyses are taken periodically and available for Liander through gas analysis reports and online with SCADA.

When the gas quality is not conform specifications Liander contact the National Grid Operator(TSO) and discuss measurements to be taken. At the city gate stations there is no emergency shutdown procedure available for a DSO, only the TSO can take measures.

Liander does not individually perform acceptance tests at city gate stations. The regional grid operators in the Netherlands jointly perform acceptance tests by means of samples taken at selected City gate stations yearly.

Green gas monitoring and control

For the monitoring of the gas quality at local green gas injection points the Liander Control Room has established a protocol with each local Green gas injector concerning gas quality monitoring and control and other aspects of daily operations. In this protocol agreements can be found on necessary actions and communication when the gas to be injected is not according to specifications . The Liander Control Room has several methods available for monitoring and control of the gas quality:

- With SCADA systems and a communication station an online connection has been established between the continuous gas quality measurement data of the green gas injection installation and the Liander Control Room (see Figure 5 with a the representation of the general SCADA screen at the Liander Control room for monitoring injection of Green Gas).
- Results of periodic samples taken by the green gas producer
- Acceptance test:
  - Liander takes periodic samples to monitor the gas quality. The types of analyses are summarized in Table 1 Types of Measurement and frequency.

Table 1 Types of Measurement and frequency

Type of Measurement	Frequence
Sample	Twice per year
Audit	Twice per year
Control measurement results	Monthly
Calorific value	Once per year
Odorisation	Monthly

  - Liander also has the possibility to connect a mobile measuring system to be able to measure the gas quality continuously for a certain period of time

All methods aim to detect a non-conform gas quality before injection into the gas distribution grid and to enable a rapid reaction and disconnection of the system to prevent injection of gas not according to specifications.

An important part of the monitoring and control system at Liander is the Injection station (see Figure 4 Green Gas Injection station and monitoring and control system at Liander) that enables both the online communication of the gas quality measurement data of the Green gas produces as well as facilitating in a remote emergency shutdown (by means of a remote controlled safety valve). Furthermore the Injection station functions as a pressure monitor to prevent a too high pressure in the grid when the pressure system of the green gas producer fails.

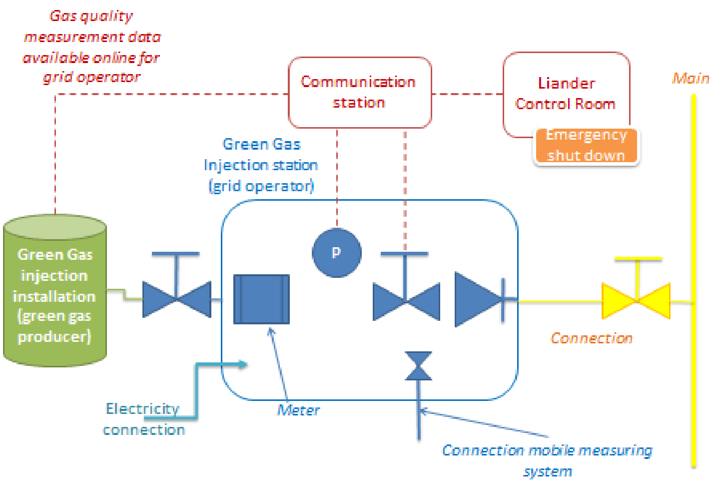

Figure 4 Green Gas Injection station and monitoring and control system at Liander

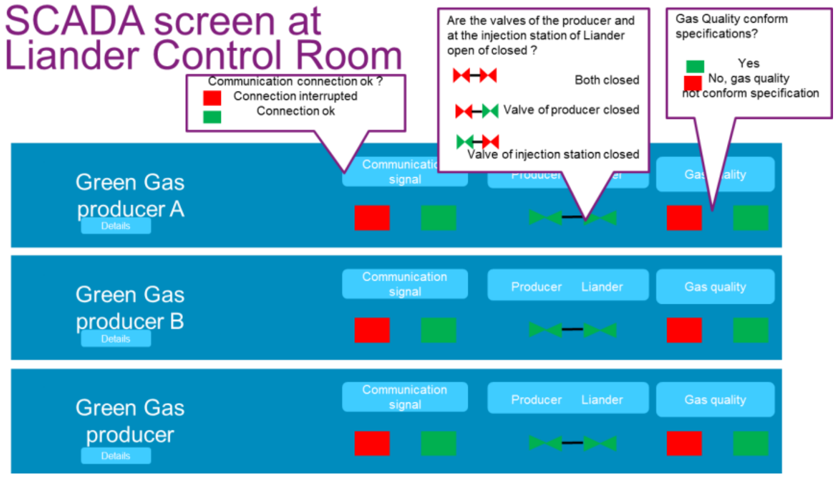

Figure 5 The general SCADA screen at the Liander Control room for monitoring injection of Green Gas

Gas distribution operations and gas quality

As stated before events and works in the gas distribution grid infrastructure itself can also have an impact on the gas quality. A local grid operator faces problems with dirt ,dust and fluids in their gas distribution grids. These operational problems and complaints are now resolved on an ad hoc basis and not in relation to gas quality standards en objectives. Standard protocols and measures need to be developed to be able to handle these problems from a broader perspective and to be able to prevent these kind of gas quality issues.

Gas quality at the exit point

At the delivery points Liander has no gas quality monitoring and control system. Gas quality measurements are only taken by means of samples in case of complaints from customers about gas quality.

4.2 Design of monitoring and control systems

At this level the gas quality strategy is described with measures to be taken when gas quality issues arise and changes are needed in the gas monitoring and control systems. This level is to be further developed within Liander.

A risk analysis of green gas injection and measures to be taken are available in the risk and strategy documents. A risk analysis of the quality of the gas that enters our grids at the city gate stations and the effect of works in the gas grids on the gas quality is still missing. To get an overview and to be in control of possible gas quality problems now and in the future the overall gas quality risks should be analysed.

Monthly reports on gas quality from the Liander Control Room are available for each Green Gas injection point. (see Figure 6)

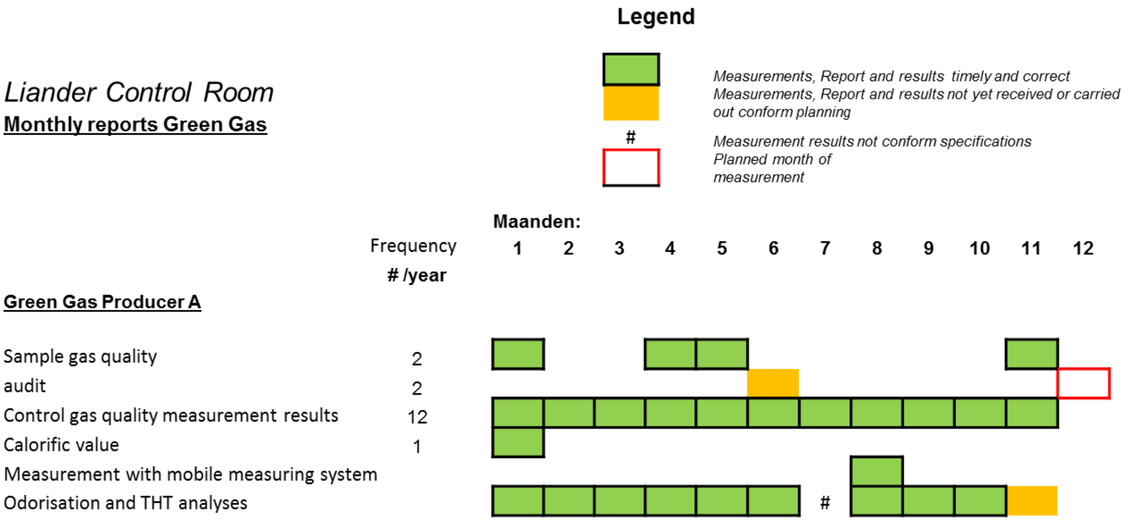

Figure 6 Monthly reports on gas quality from the Liander Control Room for one Green Gas producer

Also aggregated yearly results are available for the Green Gas injection points (see Figure 7). Also reports of the acceptance tests taken at selected City gate stations the regional grid operators are evaluated and reported yearly.

# Gas Quality measurements overall 2013	83
# Samples gas quality	8
# Monthly control gas quality measurements	45
# Mobile measuring system	1
# Odorisation and THT:	42
# Quality measurements non conform gas quality specifications:	7
• # Odorisation and THT non conform	6
• # Samples gas quality non conform	1

Figure 7 Aggregated results of gas quality measurements in 2013 at Liander

These reports are however not yet used in the continuous improvement cycle. For example, they are not yet part of the quarterly reports on the quality and capacity of the gas grid at Liander. Also complaints from customers should be linked with the gas quality performance.

4.3 Gas Quality Policy

Parts of this level are in place, but the context is still missing. Gas quality is not yet a part of the Strategic Long Term Asset Management Policy at Liander. On a strategic level, Liander has initiated several project to better comprehend the effects and risks of future changes in gas quality, for example:

- Co-funding of research on the impact of gas quality on materials used in the regional grid (as part of the EDGAR-program).
- Pilot projects with new gas distribution concepts like CO_2, biogas, Bionet (a separate grid with adapted gas appliances that is supplied with a mixture of biogas and conventional natural G-gas)
- Strategic studies on the impact of Power2Gas
- Development of sophisticated simulation tools to predict gas quality near-real time

At Liander a Gas Quality Policy should be developed based on expected changes in the direct environment or future developments. For example developments like changes in regulation, customer demands for stricter water dew points, or the injection of gas produced from local power-to-gas installations and their impact on the gas quality in the grid should be anticipated. At least a gas quality objective should be formulated, that can be measured.

With this gas quality policy Liander will be prepared to face future gas quality challenges and prevent issues that need to be corrected afterwards.

5. Conclusions

The developments towards multiple and fluctuating sources of gas supply, the changes in gas demand and specific customers groups with stricter gas quality specifications and new regulation on gas quality have led to a renewed interest and role for the gas distribution sector in gas quality. This challenge leads to an increasing need for a general gas quality management system in gas distribution operations. Main part of the gas quality monitoring and control system are already in place at Liander. Gas quality policy and strategy need to be developed to have an effective , reliable and robust gas quality management system.

The developments on the demand side have therefore led to an interest in the influence and possibly negative impact of gas distribution operations on the gas quality distributed in the grids. Historically this has never been an issue at gas distribution operators. Liander needs to develop standards, methods and measures to be taken to anticipate and prevent a negative impact on gas quality in gas distribution operations.

Furthermore to be able to manage and operate this system the knowledge and expertise in gas quality should be further developed. The gas quality management system will enable Liander to reliably inject local renewable gases and supply our existing and new customers with gas that is safe and suitable for their intended use.

Attachment I: Quality specifications in the Ministerial Decree establishing regulations for natural gas composition

G-gas as injected at an injection point

Gas quality		Value	Unit
Wobbe index		43.46 – 44.41[2]	MJ/Nm^3
Calorific value		See footnote [3]	
Heavier hydrocarbon content		≤ 5	mol% PE
Water dew point		≤ -8	°C (at 70 bar(a))
Natural-gas condensate		≤ 80	mg/Nm^3 at -3 °C at any pressure
Temperature	in RTL and HTL networks	10 – 30	°C
	in RNB network[4]	5 – 20	°C
Oxygen content	in RTL network	≤ 0.5	mol%
	in HTL network	≤ 0.0005	mol%
Carbon dioxide content	in RTL network	≤ 10.3[5]	mol%
	in HTL network	≤ 3	mol%
Hydrogen content	in HTL and RTL networks	≤ 0.02	mol%
	in RNB network	≤ 0.5	mol%
Sulfur content based on inorganically bound sulfur (H_2S and COS)		≤ 5	mg/Nm^3
Sulfur content based on alkylthiols		≤ 6	mg/Nm^3
Total sulfur content	<u>before odourisation</u>		
	peak value	≤ 20	mg/Nm^3
	annual average	≤ 5.5	mg/Nm^3
	<u>after odourisation</u>		
	peak value	≤ 31	mg/Nm^3
	annual average	≤ 16.5	mg/Nm^3
THT content (odourant)	in HTL network: odourless gas	0	mg/Nm^3
	in RTL network: odourised gas	10 – 30	mg/Nm^3
	in RNB network: odourised gas	10 – 30	mg/Nm^3
Silicon content based on siloxanes		≤ 0.4	mg/Nm^3

G-gas at domestic delivery points

Gas quality		**Value**	**Unit**
Wobbe index[6] [7]		43.46 – 44.41	MJ/Nm³
Heavier hydrocarbon content		≤ 5	mol% PE
		Until 1 July 2016, no limit applies on very cold days and in exceptional circumstances[8]	
Water dew point		≤ -8	°C (at 70 bar(a))
Natural-gas condensate		≤ 80	mg/Nm³ at -3 °C at any pressure
Oxygen content	in storage	≤ 0.0005	mol%
	elsewhere	≤ 0.5	mol%
Carbon dioxide content		≤ 10.3[11]	mol%
Hydrogen content		≤ 0.02	mol%
Sulfur content based on inorganically		≤ 5	mg/Nm³
bound sulfur (H_2S and COS)			
Sulfur content based on alkylthiols		≤ 6	mg/Nm³
Total sulfur content	before odourisation		
	peak value	≤ 20	mg/Nm³
	annual average	≤ 5.5	mg/Nm³
	after odourisation		
	peak value	≤ 31	mg/Nm³
	annual average	≤ 16.5	mg/Nm³
THT content (odourant)	in HTL network: odourless gas	0	mg/Nm³
	in RTL network: odourised gas	10 – 30	mg/Nm³
	in RNB network: odourised gas	10 – 30	mg/Nm³