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Challenges for introducing upgraded biogas (biomethane) to the existing Danish natural gas grid

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Introduction

In the years to come it is expected that a significant amount of biomethane will be introduced to the existing Danish natural gas grid. Locally, the amount of biomethane injected into the grid will often exceed the amount utilised in the low-pressure PE-pipelines. Therefore, it will be necessary to admit the biomethane into the steel pipelines supplying the local networks with natural gas.
From its commissioning, the Danish natural gas grid has been dimensioned for sweet natural gas, with no corrosion allowance at the current operating pressure. It is, therefore, crucial that no gas in the grid will induce corrosion. This project elucidates which parameters are the most crucial in order to have a gas composition that does not jeopardise the safety or shorten the lifetime of the Danish natural gas steel grid.

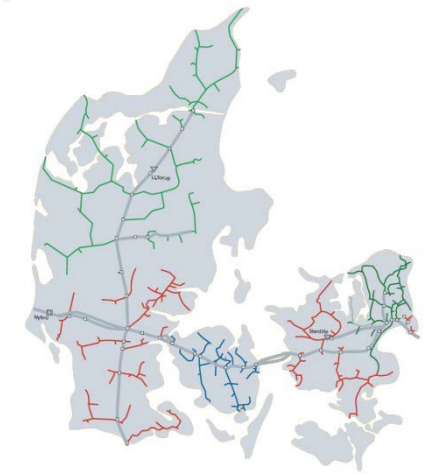

Figure 1 Schematic illustration of the Danish steel grid

Parameters for corrosion in steel pipelines

For this project FORCE Technology made model calculations in order to determine the crucial parameters for corrosion in steel pipelines. Focus was on water, carbon dioxide,

hydrogen sulphide and oxygen, which are four components that most likely could be present in higher concentrations in biogas than in natural gas.

Reaction kinetics for known corrosion mechanisms was modelled, and corrosion rates were calculated at different concentrations of the above mentioned components. The calculations clearly showed that the most crucial component is water. In the presence of water the simplified reaction mechanisms, as shown below, apply for the corrosion in steel pipelines.

Anode: $Fe \rightarrow Fe^{2+} + 2e^-$

Cathode (CO_2): $2H^+ + 2e^- \rightarrow H_2$

Cathode (H_2S): $H^+ + e^- \rightarrow H_{adsorp}$

Cathode (O_2): $½O_2 + H_2O + 2e^- \rightarrow 2OH^-$

The calculations performed by FORCE Technology laid the grounds for the Danish national requirements for the acceptable oxygen content in upgraded biogas injected into the natural gas grid. H_2S and CO_2 are limited by existing regulations to 5 mg/m^3(n) and 3 %, respectively. With these constraints it was found that up to 0.5 % of O_2 can be accepted, without added problems with corrosion. However, as mentioned above, the analysis of the corrosion mechanisms and reaction rates showed that the corrosion rate is very dependent on whether water is present in the liquid phase. Therefore, the authorities have set the constraint for the admission of biomethane that the pipelines are to be dry.

Detection of moisture in the Danish grid

With the constraint of dry pipelines is has become even more necessary for the owners of the pipelines to ensure that there is no water in the pipelines. In the past, moisture has been detected in the Danish grid, although very seldom. This, however, makes it pivotal that there is continuous surveillance of the natural gas grid. All of the Danish grid owners have made contingency plans in case of detection of water in the pipelines.

The distribution and transmission companies are obligated to make an annual report to the authorities stating if any moisture has been detected in the system. If water has been found, a minute description of where the water originated from, a detailed description on how the water was removed as well as a plan on how to avoid the problem in the future are required.

For the detection of water in the grid, inspection of valves and other parts of the system are performed systematically.

Conclusion

Based on the modelling of corrosion rates at different conditions, formal requirements for biomethane have been developed. The most pivotal parameter is the water dewpoint, which is set to -8 °C at 70 bar. With this constraint for water up to 3 % CO_2 and 0.5 % O_2 are allowed in the distribution grids. Due to the gas storage facilities, the allowed concentrations in the transmission grid are lower (2.5 % and 0.1 %, respectively). The overall requirements, stated by the authorities, for injection of biomethane into the Danish gas grid are listed in table 1.

Table 1 Requirements for biomethane in the Danish grid.

	Demands for biomethane in the distribution grid	**Demands for biomethane in the transmission grid**
Wobbe Index (kWh/m^3)	14,1 – 15,5	14,1 – 15,5
Relative density	< 0,7	0,555 - 0,7
CO_2 (mol-%)	< 3.0	< 2,5
O_2 (mol-%)	< 0,5	< 0,1
Ammonia (mg/m^3)	< 3	< 3
Siloxanes (mg/m^3)	< 0,1	< 0,1
Bakteria og micro-organisms	No health risks	No health risks
H_2S and COS (mg/m^3)	< 5 (only H_2S)	< 5 as sulphur
Mercaptane (mg/m^3)		< 6 as sulphur
Total sulphur content (mg/m^3)	< 30	< 30
Water dewpoint	-8 °C @ 70 bar	-8 °C @ 70 bar
Hydrocarbon dewpoint	-2 °C @ 70 bar	-2 °C @ 70 bar