Minimizing greenhouse gas emissions

Greenhouse gas emissions of the Norwegian natural gas value chain 2016
Introduction

The purpose of this report is to present findings from a recent comprehensive study assessing the emissions related to natural gas produced on the Norwegian Continental Shelf and delivered to Statoil’s main gas markets in the UK and Germany*.

It provides an overview of methane and total greenhouse gas (GHG) emissions associated with offshore production, gas processing, subsea pipeline transportation to Europe, and final distribution to customers.

All estimates for the upstream and midstream emissions are based upon periodically reported data provided to the Norwegian authorities. As Statoil is not a downstream operator, estimates related to the downstream sector, including the storage, transmission and distribution of gas, are based on the most recent study for Europe, published by NGVA (Natural & bio Gas Vehicle Association) in May 2017 [1]. The NGVA study represents both a continuation of, and a complement to, two other large studies: the Exergia study [2] and the DBI study [3], which were concluded in 2015 and 2016, respectively.

* See as well Statoil’s Climate Roadmap, available on Statoil.com.
The climate benefits of natural gas

Carbon dioxide is by far the most significant, anthropogenic greenhouse gas emitted to the atmosphere, with methane coming in second position (Figure 1 to the left). About 20% of all human-induced methane emissions come from oil and gas production and distribution (Figure 1 to the right).

![Figure 1: Global contribution of anthropogenic methane and other greenhouse gas emissions [4] and sources of anthropogenic methane emissions [5].](image1)

Greenhouse gases from the oil and gas industry consist of carbon dioxide ($\text{CO}_2$), methane ($\text{CH}_4$) and nitrous oxide ($\text{N}_2\text{O}$). The global warming potential (GWP) of these gases is dependent on the time-frame taken into consideration.

When combusted, natural gas - which is mostly methane - generates about half as much $\text{CO}_2$ as coal for the same quantity of energy generated. However, methane leakages along the value chain can reduce the climate benefits of natural gas, as compared to coal. Using the immediate warming effect and a GWP for methane of 100, a 3.2% methane loss rate will offset the climate benefit of combusting natural gas vs coal [7]. However, this is a very conservative approach. Statoil and the Norwegian authorities refer to the GWP factors defined in the 2007 4th Assessment Report (AR4) of the Intergovernmental Panel on Climate Change (IPCC) and utilise a methane GWP of 25. Using this approach, the climate benefits of natural gas compared to coal exist for methane loss rates up to 14% [6].

![Figure 2: Influence of different Global Warming Potentials (GWP) on the calculation of the methane loss rates for which the climate benefits of natural gas compared to coal disappear.](image2)
Norwegian gas production and distribution to the European market

Total gas production (i.e. total exported volumes from producing assets) in Norway was 116 million Sm³oe in 2016 (Figure 3). Of the 116 million Sm³oe of gas, Statoil-operated units on the Norwegian Continental Shelf (NCS) produced 80 million Sm³oe [8] [9], representing approximately 69 % of all gas production on the NCS in 2016.

Of the total gas production, liquefied natural gas (LNG) accounted for close to 7 million Sm³oe in 2016. Hammerfest LNG is the only large-scale LNG production facility in Europe. The LNG produced at the Hammerfest LNG facility is transported by vessels to Europe and the rest of the world. All other natural gas produced on the NCS is transported to Europe by pipelines.

Figure 3: Historical and forecast production in Norway, 1970-2021 (source: Norwegian Petroleum Directorate [9])

Rich gas from Statoil-operated NCS installations is piped to two onshore gas processing facilities, Kårstø and Kollsnes, where it is separated into liquid products (i.e. propane, butane, naphtha and stabilised condensate) and natural gas. Gas from the Shell-operated Ormen Lange gas field, as well as some of the gas produced in the northern Norwegian Sea, is processed in Nyhamna. The liquid products are shipped to customers worldwide, while the natural gas is compressed and transported by subsea pipelines to the UK and central Europe (Figure 5). The pipelines utilised for subsea gas transport are constructed from sections of steel pipe welded together and coated to decrease friction and resulting pressure fluctuations. The pipelines are also designed to tolerate high pressures, typically between 157 and 212 bar. As there are a very limited number of connections and flanges in the subsea pipeline system, the risk of methane leakage is very low.
Two thirds of exported Norwegian gas enters the EU through either the UK or Germany. The remaining gas is exported primarily to France and Belgium. The German entrance points are through Europipe I/II and Norpipe to Emden and Dornum. In the UK, the Easington and St Fergus gas terminals are connected to the Langeled and Vesterled pipelines as well as to the FLAGS (Far north Liquids and Associated Gas System) transport system in the British sector of the North Sea.

About 40% of the gas consumed in Europe is used by residential and commercial customers. In addition, power and heat generation account for 28% of the gas consumption, while approximately 22% is used as an industrial feedstock. The remaining 10% is used for a range of other applications.
Emissions related to the gas value chain

Calculation of upstream and midstream emissions

Natural gas is primarily produced together with oil and condensate. The energy generated on the installations is used for the total production of oil, condensate and gas. Hence, the specific allocation of relevant emissions to the gas value chain is not straightforward. The same issue exists for emissions related to onshore gas processing, where the natural gas is separated from the liquid products.

To address this methodological challenge, a standard and pragmatic approach consists of allocating GHG emissions on the basis of the energy content of the different hydrocarbon streams produced. The GHG intensity for the natural gas value chain can then be calculated by dividing the allocated GHG emissions by the quantity of natural gas produced, excluding the gas used for energy production or re-injected for production support purposes.

The emission and production data used in this report consists of the GHG emissions reported to the Norwegian authorities for 2016 [11]. The methane emissions are quantified using the updated methodology developed by the industry and the Norwegian authorities, as described in a June 2016 report [10].

Estimation of downstream emissions

The downstream sector of the value chain is characterized by its complexity, with the distribution of the natural gas streams across countries and borders depending on the commercial conditions in the European market. As Statoil is not directly involved in the downstream sector, neither as operator nor partner, the company does not have access to a primary set of emissions data for the downstream sector. Hence, data from the most recent overview study, published by NGVA (Natural & bio Gas Vehicle Association) in May 2017 and executed by the consulting company thinkstep [1], have been used. This study is a continuation of, and a complement to, two other large studies carried out respectively by Exergia for the European commission DG Energy in 2015 [2] and by DBI in 2016 [3]. The NGVA uses an approach and methodologies closely related to the ones used by DBI and Exergia, but the NGVA study builds upon a larger proportion of primary data collected directly among the operators, including Statoil.

The NGVA study addresses lifecycle emissions for the transportation sector. In order to enable a comparison between Statoil’s results and the NVGA figures, the emissions specifically related to the transportation sector (e.g. fuel dispensing) have been subtracted from the NGVA data.
Results and discussion

Total GHG emissions

Figure 6 and Table 1 present the natural gas value chain GHG intensity from the Statoil study compared with the NGVA study.

1. The Statoil study includes:
Natural gas produced at the Norwegian Continental Shelf, processed at onshore facilities in Norway, transported by subsea pipelines and distributed to customers in the UK and Germany.

2. The NGVA study includes:
Natural gas produced and processed in the EU, Russia, Norway and other gas producing countries, transported by pipelines or as LNG, and distributed to customers in Europe. The average GHG intensity is shown for different parts of Europe, where the UK is included in EU North and Germany is included in EU Central.

![Figure 6: Greenhouse gas intensity in the gas value chain (* = results from NGVA study, May 2017)](chart.png)
<table>
<thead>
<tr>
<th>GHG INTENSITY (gCO₂eq/GJ)</th>
<th>Germany</th>
<th>United Kingdom</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>EU Central (NGVA)</td>
<td>STATOIL</td>
</tr>
<tr>
<td>Exploration</td>
<td>2200</td>
<td>1487</td>
</tr>
<tr>
<td>Production</td>
<td>3200</td>
<td>324</td>
</tr>
<tr>
<td>Processing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Transport</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Terminals</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>UPSTREAM + MIDSTREAM</strong></td>
<td>5400</td>
<td>1811</td>
</tr>
<tr>
<td>Transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>1600</td>
<td>1200*</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>DOWNSTREAM</strong></td>
<td>1600</td>
<td>1200</td>
</tr>
<tr>
<td><strong>TOTAL</strong></td>
<td>7000</td>
<td>3411</td>
</tr>
</tbody>
</table>

Table 1: GHG intensity along the gas value chain for the gas distributed in EU Central and EU North (NGVA study) and for the Norwegian gas distributed in the UK and in Germany (Statoil study)

*data from NGVA EU central; **data from NGVA EU North

The comparison between the estimates obtained for the Norwegian gas in Statoil’s study and the results from the NGVA study indicate that the GHG intensity for the gas produced in Norway is low compared to gas production in other countries. This can, in large part, be explained by a high focus on energy optimization and extensive emission reduction programs driven by safety risk and a high carbon tax. The use of renewable hydropower electricity at the Norwegian onshore gas processing plants also contributes to the low level of total GHG emissions across the value chain.

Also of note is the fact that NGVA obtained their results from the use of a model based on standard emission factors (thinkstep GaBi 5), while the Statoil study is directly based on the emission data reported to the Norwegian authorities for 2016 [11]. The NGVA results for the different EU regions also cover all natural gas delivered to each region, including LNG, which contributes to higher emissions figures, than those estimated by Statoil.

Methane emissions

Figure 7 and Table 2 present the methane emission ratios from both the Statoil and the NGVA studies. The NGVA study does not show methane emission data for the different EU regions nor per producing country; NGVA just reports the average methane emissions for all gas consumed in Europe. Gas consumed in Europe originates from production in EU and imports. Norway is the second largest gas supplier to Europe, after Russia, and followed by Algeria, Qatar, Nigeria and Libya [12].
Figure 7: Methane emission ratio (%) along the gas value chain from production to delivery to customers for Norwegian gas to UK/Germany (Statoil) and average gas to Europe (NGVA)

<table>
<thead>
<tr>
<th>% METHANE EMISSION</th>
<th>Average for all gas consumed in EU (NGVA)</th>
<th>Norwegian gas to UK/Germany (STATOIL)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Exploration</td>
<td></td>
<td>0.012</td>
</tr>
<tr>
<td>Production</td>
<td>0.291</td>
<td></td>
</tr>
<tr>
<td>Processing</td>
<td></td>
<td>0.006</td>
</tr>
<tr>
<td>Transport</td>
<td>0.100</td>
<td>0.006</td>
</tr>
<tr>
<td>Terminals</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UPSTREAM + MIDSTREAM</td>
<td>0.391</td>
<td>0.017</td>
</tr>
<tr>
<td>Transmission</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Storage</td>
<td>0.209</td>
<td>0.209*</td>
</tr>
<tr>
<td>Distribution</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DOWNSTREAM</td>
<td>0.209*</td>
<td>0.209*</td>
</tr>
<tr>
<td>TOTAL</td>
<td>0.600</td>
<td>0.226</td>
</tr>
</tbody>
</table>

Table 2: Methane emission ratio along the natural gas value chain (* = data from NGVA EU Total)
Figure 8 visualises the contribution of methane emissions to the total GHG emissions for the up- and midstream part of the value chain for Norwegian gas. This contribution is small, accounting for less than 4% of the total emissions.

One of the main outcomes of this study is that the methane emissions in the upstream and midstream sectors appear to be considerably lower for Norwegian gas than for other gas streams to Europe. This can be explained by several factors, in particular the high focus on limiting methane emissions at offshore installations due to safety risk and the extremely low gas leakage rate for subsea pipelines from Norway to the UK and Germany.

According to the NGVA study, the upstream and midstream sectors appear to be the major contributors of methane emissions in Europe. However, the situation is different for the gas produced and processed in Norway. For Statoil’s gas value chain, from production in Norway to delivery to customers in the UK and Germany, the upstream and midstream sectors represent less than 10% of the total methane emissions.

Overall, methane contributes to less than 4% of the total GHG emissions in the upstream and midstream Norwegian gas sector, while the NGVA study shows that over 27% of the GHG emissions along the European gas value chain are methane.

Finally, the level of total methane emission levels along the gas value chain largely confirms the significant climate benefit of natural gas compared to coal. This is the case both for Norwegian gas delivered to customers in the UK and Germany, with emission rates below 0.3%, but also for all gas consumed in Europe, with an average emission rate of 0.6%.
Conclusions

The GHG intensity associated with Norwegian gas delivered to customers in the UK and Germany appears to be significantly lower than the corresponding average for all gas consumed in Europe.

$\text{CO}_2$ is the main greenhouse gas associated with the upstream and midstream sectors of the Norwegian gas value chain. Methane, when converted to $\text{CO}_2$ equivalents, represents just 4% of the total GHG emissions.

For the gas value chain from the Norwegian Continental Shelf to end-users in the UK and Germany, the results of our study indicate that over 90% of methane emissions occur in the downstream part of the gas value chain, i.e. in the transmission and distribution segments.

Considering the gas value chain from production to delivery to customers in the UK and Germany, the methane emissions associated with Norwegian gas are below 0.3%, while the average for all gas consumed in Europe is 0.6%.

The estimated levels of methane emissions support the climate benefits of natural gas compared to coal, both for the Norwegian gas and for the average of all gas consumed in Europe.

References

1. NGVA – Greenhouse Gas Intensity of Natural Gas
3. DBI: Critical Evaluation of Default Values for the GHG Emissions of the Natural Gas Supply Chain. October 2016 (executive summary – DBI to be contacted for complete report)
4. IGU Amsterdam Executive Committee meeting. Fugitive Methane Emissions. 10.19.2016 (IGU members restricted) (executive summary – DBI to be contacted for complete report)
8. Statoil Annual report 2016
9. Norwegian Petroleum Directorate
11. NOROG Environmental report for 2016
12. Eurostat 2016