"GHG-EMISSIONS OF THE NATURAL GAS LIFE CYCLE COMPARED TO OTHER FOSSIL FUELS (IN EUROPE)"

Lechtenboehmer, Stefan, Wuppertal Institute for Climate, Environment, Energy

Dr. Fischedick, Manfred, Wuppertal Institute; Dienst, Carmen, Wuppertal Institute; Hanke, Thomas, Wuppertal Institute

ABSTRACT

The role of natural gas in the European energy market is increasing. This is particular true for a climate protection strategy as gas has lower specific CO_2-emissions and many appliances have higher efficiency compared to competing energy carriers such as coal and oil. However there is still a debate concerning the indirect upstream emissions of the imported energy which might have significant impact on the GHG-ranking of energy carriers. While most of the existing studies dealing with the LCA of natural gas show only a comparatively low influence of gas losses to the GHG-balance, some reports come to significant effects, especially those assuming high losses in the Russian process chain.

Against this background our main topic is the examination of the upstream-analyses, which are used in European Life-Cycle Analyses. Especially we are focussing on the quality of the used input-data for the natural gas provision (namely from Russia), which is the most decisive and a very uncertain part of the analyses. We have carried out a comprehensive comparison of different existing LCA's and upstream-analyses for European countries, esp. Germany. Our results show that some LCA's are based on incomplete and partly outdated information. Sometimes even speculative data are used at central parts of the analyses. – These inconsistent assumptions of the direct methane emissions from the preliminary Russian gas-chain result from a lack of information about the Russian gas industry and the rare concrete measured data. Due to the obvious necessity of proved and transparent data, we built up criteria for an improved data-set for data collection campaigns such as adequate number of technical components, geographical distribution, statistical significance, independent verification and transparency of data. These quality criteria are designed to comply with IPCC and other international quality standards.

In addition a new measurement-campaign at Russian compressor stations, considering the new given criteria, was originated by Ruhrgas and Gazprom and is presently conducted. By means of a comparison of the existing studies and looking at the most recent information for the most significant parts of the life cycle, more reliable data can be refined. The results of the new campaign

might be able to close the gap of primary data and can be used as a basis to extract some solid results and produce requirements for LCA's and upstream analyses concerning the natural gas system.

1.INTRODUCTION: THE ROLE OF NATURAL GAS IN EU CLIMATE CHANGE MITIGATION POLICIES

The European energy mix has been subject to a constant change during the recent decade. The share of natural gas has been constantly rising since 1986. Gas has in 2001 reached a share of about 21 % of EU's primary energy supply (Meinhart et al. 2002). This increase mainly gets at the expenses of coal and to a lower extent also at the expenses of oil (IEA2002).

Thus fuel switch has made an important contribution to the EU-wide stabilization of GHG-emissions between 1990 and 2000 (Gugele/Strobel/Taylor 2002). The driving forces behind this were the switch from coal to gas in UK-electricity generation and in East-German energy sector as well as in West-German heating systems (Gugele/Ritter/Mareckova 2002).

The EU expects a continuation of the "fuel-switching trend". The most recent EU-wide GHG projections (Primes-Model) show that between 1990 and 2000 the CO_2-intensity of the primary energy supply has decreased by about 7 to 8 %. Until 2010 a further decrease by another 6 to 7 % – to be achieved by higher shares of renewable energies and natural gas – is projected (Gardiner et al. 2003). And the fraction of gas in the EU's primary energy supply is expected to rise to 27 % until 2010; Meinhart et al. 2002).

In spite of the fact that fuel switch to natural gas and renewable energy sources is an important part of EU GHG-mitigation strategies there has been a political debate on the adequateness of fuel switching from coal to natural gas. Especially in Germany – with a still important role of domestic coal – the issue of indirect emissions is being discussed with a focus on the potential methane releases of the natural gas production and transportation facilities namely in Russia which currently supplies about one fifth of EU's and about a third of Germans natural Gas supply. These are under suspicion to compensate or maybe overvompensate the relative advantages of natural gas in comparison with oil, coal and lignite (e.g. DEBRIV 2001, Ewers/Renzenbrink 2002).

As a result of this debate plans are tabled to include these indirect emissions into the GHG-oriented energy taxation of natural gas within the ecological taxation system (and possibly into the EU-emission trading scheme). Of course these policies might be able to cease the current trend towards natural gas.

Against this background LCA's and especially upstream analyses become more and more important as their results are used in energy policy and will possibly be used as a basis or at least a justification for GHG-related energy taxation schemes In this situation the question of correctness, accurateness and transparency of the used LCA's becomes extremely important.

2. UPSTREAM GHG-EMISSIONS OF ENERGY CARRIERS SUPPLIED TO THE EU

In Life cycle analyses the different processes in all life phases of a product are investigated and balanced due to several aspects such as energy-use, material flow, air pollutions or GHG-emissions etc. In the lifecycle of natural gas for instance the upstream processes up to the end-user can be divided into:

production → processing → transmission → distribution

All in all the emissions released in this process chain are named indirect emissions. With the objective of the comparison of GHG-emissions from natural gas to other fuel-types, we concentrated our investigation on the emissions of the upstream processes considering the most important LCA's which are currently used for the analyses of products/fuels consumed in Europe (such as GEMIS, ETH 1996, Umberto, etc.). Several published studies concerning the emissions of the fuel-life-cycles use as a basis for their analyses the computer-based model Gemis. This model can be adapted to own datasets and assumptions (e.g. VDEW 1996, Fichtner 2001, ExternE, Joanneum TH Graz). Regarding the results of the considered LCA's, especially the indirect emissions vary depending on the assumptions used in the different analyses while the direct emissions – resulting from the fuel-combustion – are calculated on the same basis and are not under discussion.

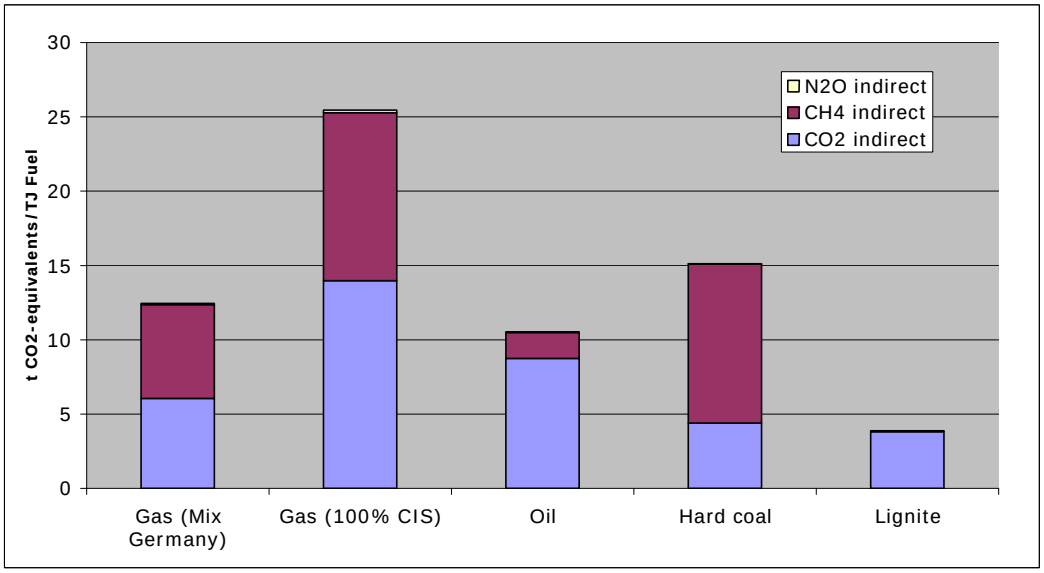

Fig. 1: Indirect emissions (in CO_2-equivalents) of different fuel-types (according to GEMIS 4.13)

The direct emissions of lignite, hard coal and oil are – in order - higher than of natural gas. With the exception of lignite, the indirect emissions of all fuel-types play a major role determining the total emissions see figure 1 and 2. For natural gas they are – in some cases – assumed to be as high as the direct emissions. As shown in figure 1 carbon dioxide and methane have more or less equal shares calculating the indirect GHG-emissions. Emissions of nitrous oxide are negligible. However, for lignite only the CO_2-emissions resulting from auxiliary energy (electricity for mining equipment) are significant. Indirect emissions of hard coal also result from mine gas outlets (in particular high in German deep-coal mines), while the emissions of oil arise from several processes such as production, processing, transport, refining etc. The indirect emissions of natural gas mainly derive as CO_2 from the used energy for the compressing of the gas, and as CH_4 from gas-releases for maintenance-work at pipelines, at compressors and in the production as well as leakages.

2.1 A COMPARISON OF UPSTREAM ANALYSES FOR NATURAL GAS

Indirect emissions of natural gas supply vary strongly between producing countries. Therefore the indirect emissions of the analyses are extremely sensitive on the supply-mix. For a hypothetical one hundred percent supply of natural gas from the CIS to Germany for instance the emissions would be – according to Gemis - twice as high compared to the actual supply-mix used in Germany (see figure 1). Other analyses like Fichtner (2001) or a study commissioned by the lignite-industry (Rheinbraun 2001) even assign several times higher indirect emissions to the Russian gas – as one can see in fig. 2. According to these studies the total GHG-emissions of natural gas would be

supposed to be higher than those of oil or lignite even when the higher efficiency of the use of gas would be considered. A result that would totally change the ranking of fuels compared to other analyses.

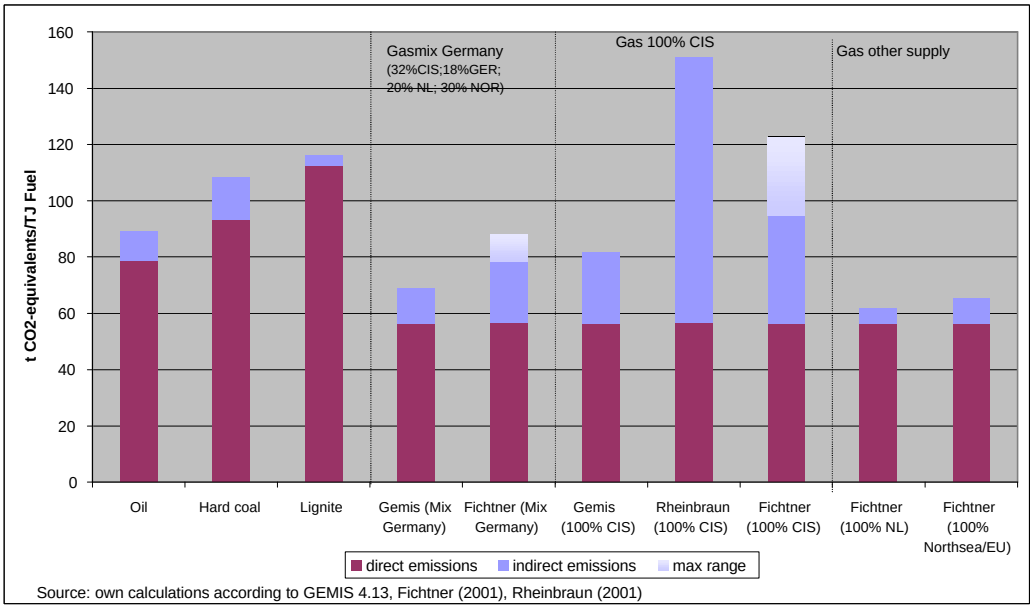

Fig. 2: Direct and indirect GHG-emissions (in CO_2.equivalents) of different fuel-types in comparison with the emissions from the natural gas life cycle under different assumptions and LCA's

To find out the reason for these huge differences in the LCA's we analysed the input data used by the upstream analyses. It turned out that the differences – apart from a reasonable variation of estimates for other parameters – mainly result from different assumptions for the direct methane emissions from the Russian gas production, processing and transport facilities. Emissions from the local Russian distribution systems – which may be significant – have not been regarded, as they are not relevant for the indirect emissions attainable to EU-gas consumption.

Tab. 11: Assumptions on gas releases from the Russian gas export system

In % of production	**Production**	**Processing**	**Transport**	**Total**
Gemis 1996	0,5 %	0,25 %	1,12 %	1,87 %
ETH 1996	0,4 %	0,25 %	0,3 %	0,95 %
VDEW/Gemis 1996	0,5 %	0,3 %	1,5 %	2,2 %
Dedikov et. al 1999	0,1 %		0,9 %	1 %
Fichtner 2001 - Leakages - Venting/Flaring (from Oil-Industry)				 5 – 8 % 1 – 3 %

Source: Fichtner 2001, Rheinbraun 2001

While most of the LCA's (such as Gemis, ETH and VDEW/Gemis) rely on technical analyses and assumptions their results concerning the indirect

emissions of natural gas are more or less comparable, ranging from about one to two percent of Russian gas production emitted by leakages, etc. They are also in the same range with Dedikov et al. (1999). The latter present the results of a metering campaign carried out by the German Ruhrgas and Gazprom to verify methane emissions from the Russian gas industry. In contrary to this Fichtner (2001) assume the methane emissions from the gas industry to be as high as 5 to 8 % and add 1 – 3 % for venting and flaring of gas from oil production, a third of the last being unburned CH_4.

The background for these wide differences in the emission ratio assumed for the Russian gas industry, is the relative lack of information about technology technical standard and current state of the Russian gas pipeline system. The first sources of information after the political changes in the former SU came from Rabchuk et al. (1991). These were educated worst case guesses trying to produce maximum emission levels for the relevant parts of the gas industry. As a result Rabchuk et al. estimated the leakages of the Russian gas industry between 3.3 and 5.75 % of the total production, some 2.4 up to 3.95 % resulting from production, processing and transport, the rest from distribution in Russia, which is not relevant for the exported gas.

In the following years a couple of assumptions occurred in literature, most of them stated relatively high emissions with no or hardly any evidence, some of them even quoting questionable sources (see Matthes 1993). That's true as well for the current Fichtner study. The main source Fichtner (2001) relies on is one single study commissioned by Greenpeace (2000). This study cites sources that are – due to critics – mere guesses (Fritsche/Matthes 2001). Even the German Greenpeace organisation does not back the interpretation of their study made by Fichtner (Greenpeace 2002).

These results show that – in order to gain reliable results for policy decisions – it is important to go further into the question of the state of the Russian gas industry.

In the last decade two international metering campaigns were carried out to pave the ground for more solid assumptions about the CH_4-emissions from the Russian gas industry. One campaign was carried out by US-EPA and Gazprom in 1995.The other was conducted by Ruhrgas and Gazprom in 1996 and 1997.

The EPA/Gazprom campaign measured the emissions in four compressor stations in the Moscow region according to the methodology developed in the US (GRI/EPA 1996). The campaign concentrated on leakages at compressor stations as it was known from the US that they are source for the highest share of emissions from the gas industry. Although never officially published the results are described in a draft-version (Gazprom/EPA 1996). The

Ruhrgas/Gazprom campaign covered production and processing facilities in the Yamburg field (which is the main supplier of gas for the export to western Europe). It also covered two compressor stations with adjacent pipeline sections east of the Ural and a pipeline section in the Wolga region (Dedikov et al. 1999).

According to Popov (2001) the campaigns came to comparable results, both estimating the leaks of compressor stations at about 2 billion cubic metres of methane.

2.2 RESULTS FROM ONGOING FIELD RESEARCH IN RUSSIA

In spite of the two field-measurement campaigns in Russia during the mid nineties, the database still could be improved to verify the previous results, to reduce the uncertainty to raise the representativeness and to better reply on information merely based on guesses and assumptions. To contribute to this we developed a concept for a new measurement campaign to be carried out jointly by Ruhrgas and Gazprom. The main targets of this campaign are to create a more recent and reliable data-set on CH_4-emissions from the Russian gas export system. It is designed according to international standards (IPCC 1996; GRI/EPA 1996) and the measurements and calculations will be independently verified.

After measurements at four compressor stations and adjacent pipeline sections – two on the “so called” central corridor and two on the northern corridor – our preliminary assessment back up the results gained by the two earlier campaigns. While the emissions resulting from technological processes (maintenance, gas controlled valves etc.) are to be found at a comparable level to the mid nineties the number and size of leakages seems to have been reduced considerably due to technical and organisational measures (among others better equipment with gas detection devices, development and import of sealing oils for valves) introduced by Gazprom. Though the campaign is still in progress, the yet preliminary results can be used as indicators. If they are going to be confirmed, indirect emissions are not causing a significant change in the rate of the total GHG-emissions of fossil fuels.

3. CONCLUSION

An in depth comparison of the upstream analyses of the existing LCA's showed that the indirect emissions of the fuel supply chain can play a decisive role in determining the sum of GHG-emissions. Depending on the underlain supply-mixes and assumptions the indirect emissions of natural gas vary by the factor of 10 in different LCA’s. Thus the GHG-emissions of natural gas can either be much more favourable or adverse concerning the ecological impact compared with life-cycle GHG-emissions of hard coal, oil and lignite.

It turned out that the enormous high upstream emissions of the (Russian) natural gas supply-chain in some analyses are based on questionable sources and assumptions. Therefore the quality of the input data is important to allow for credible basic data. Certain quality standards should be implemented and monitored to build up such homogeneous and proved data.

Further research is to be made to better verify the GHG-emissions of the Russian gas supply by conducting new measurements and preferable additional monitoring of the emissions. Measurements should be taken in the production and export system at several components of different age and technique in diverse regions with different infrastructural and climatic conditions. The new campaign aspires to reach these objectives. Additionally statistics of the Russian gas production and transmission system have to be revealed in order to better calculate on a basis of the new carried out emission-factors for different components. Through this a sufficient statistical significant sample can be achieved on which reliable and standard emission-factors for upstream analyses might be developed.

Furthermore by means of an investigation of the Russian gas system, huge CH_4-mitigation potentials could be identified. By these measures emissions could be further reduced as it was shown after comparable studies in other countries (e.g. US Gas STAR Program).

Supposed that the results of the previous and new measurements reflect the emissions in a correct range, the use of natural results in much lower GHG-emissions (direct and indirect) than the use of other fossil fuels. Hence a fuel switch to natural gas can be one strategy component in European climate protection strategies. However natural gas – as all fossil fuels - is limited and produces still high GHG-emissions. It can thus only be used for a certain time frame. For a long-term sustainable energy-system other strategy elements such as improved efficiency, use of renewable energies and CHP have to be actively and immediately exploited.

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