The Global Energy Challenge:

Reviewing the Strategies for Natural Gas

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Natural Gas Unlocking the Low Carbon Future

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INTERNATIONAL GAS UNION · UNION INTERNATIONALE DE L'INDUSTRIE DU GAZ

24th World Gas Conference

ARGENTINA | 2009

5-9 October

The main message

Natural gas – consisting mainly of methane (CH_4) – is by far the most clean-burning of the fossil fuels. Natural gas is already contributing to a lower global climate footprint by replacing the more carbon rich (and hydrogen-poor) coal and oil. This role can be greatly expanded in the next decades through:

- Expansion of the geographical availability of natural gas to customers seeking low carbon solutions
- Development of technology and marketing to promote natural gas use in sectors such as transportation (land, sea)
- Cooperation with renewable energy sources such as biogas and intermittent sources such as solar and wind
- Using the expertise and empty reservoirs of the gas industry to make geological storage of carbon dioxide (CO_2) a global climate solution

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IGU, October 2009

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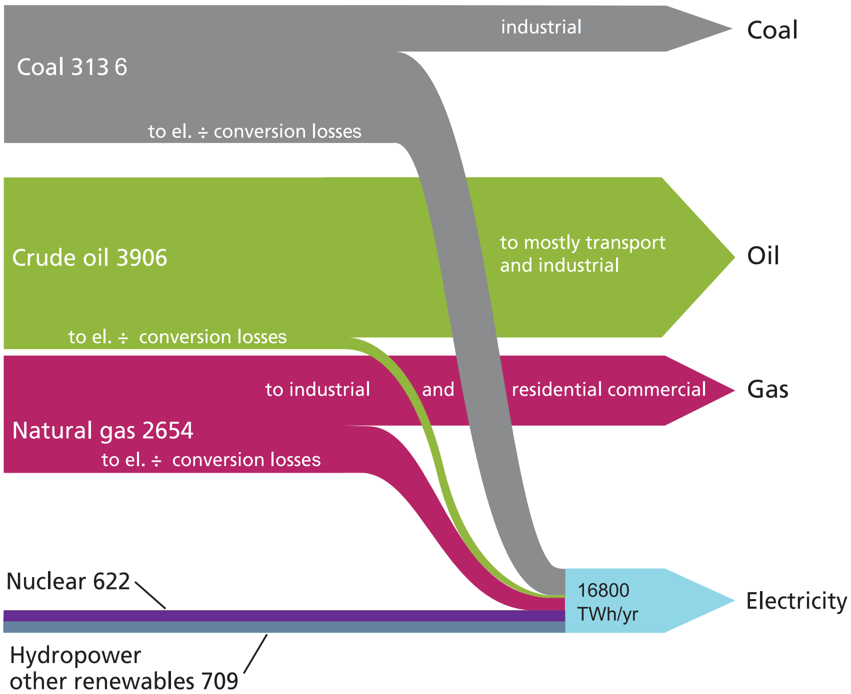
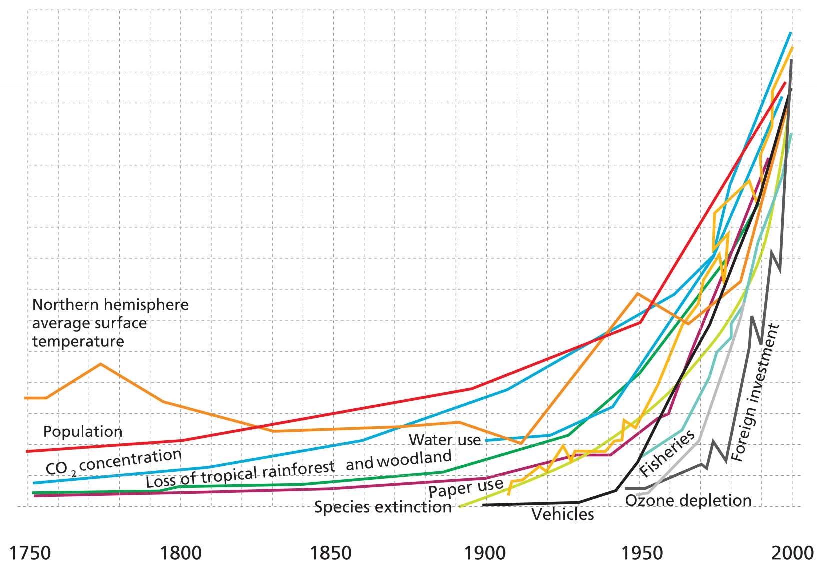
The role of natural gas in climate change mitigation

Energy is fundamental to the quality of our lives. Today, we are totally dependent on an abundant and uninterrupted supply of energy for living and working. It is a key ingredient in all sectors of modern economies and without abundant energy supplies the Earth would not be any way near feeding today's 6.7 billion people or the 9 billion that are expected by 2050.

On the other hand, climate change is a key challenge facing humanity. While secure and affordable energy supplies are needed for economic development worldwide, we know that nearly 70% of all CO_2 emissions are energy related. An increase is expected in CO_2 emissions from 20.6 Gt in 1990 to 62 Gt in 2050, more than tripling in 60 years (IEA base line, 2008).



Simplified global energy flow diagram (left) showing primary energy inputs (coal, oil, natural gas) plus uranium and hydropower plus other renewable resources converted into electricity.
Figures in million tonnes of oil equivalent per year.



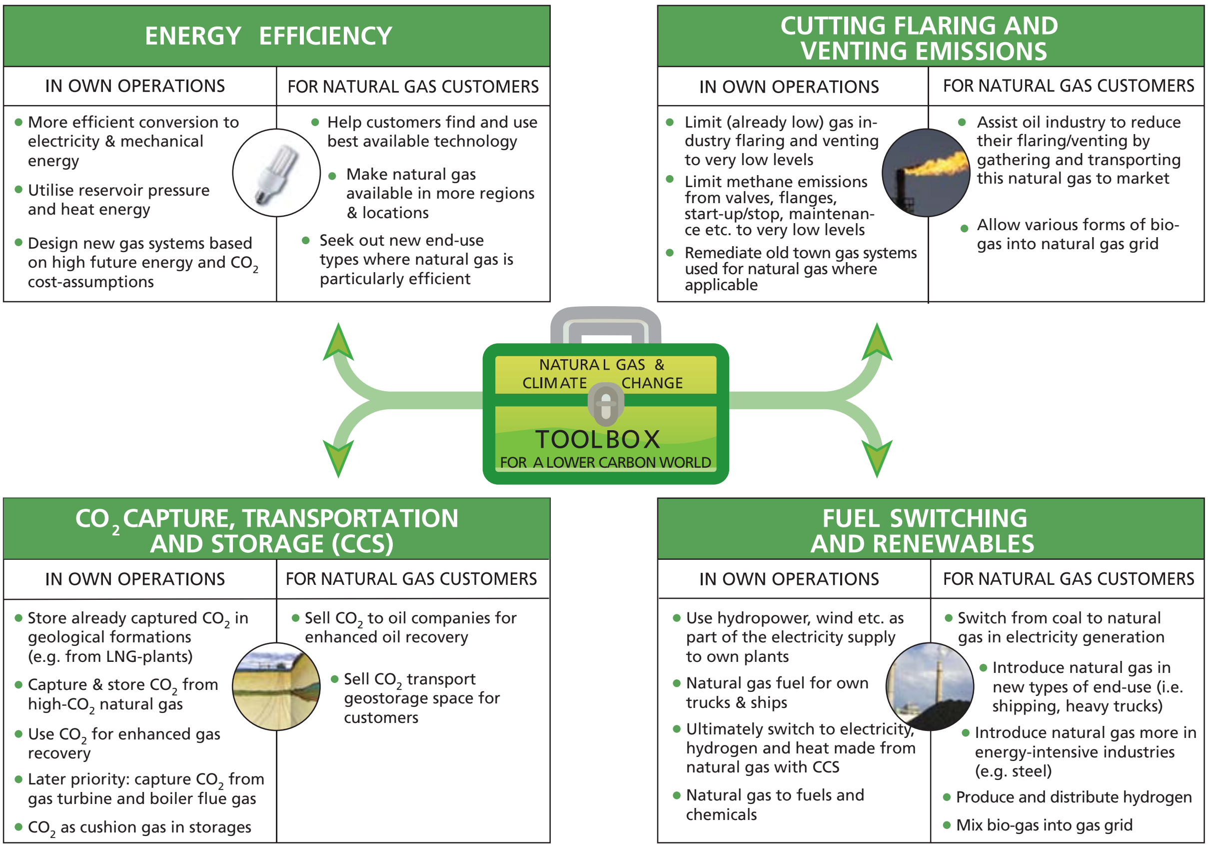
In this graph we see examples of the problems arising from global growth. (Source: New Scientist, 2008)

Natural gas is not only part of the climate change problem, but also becoming an equally important part of its solution. This executive summary - and its more comprehensive companion report available on the IGU website - tells about the many ways that the natural gas industry can and does clean up its own operations. Important as this is, however, the main contribution of natural gas lies in making it possible for the gas customers to reduce their greenhouse gas emissions. This happens for instance when heavily CO_2-emitting coal is replaced with natural gas with its much lower emissions. On top of the inherent low carbon properties of natural gas, the gas users almost always will be able to reduce emissions further in highly efficient equipment (e.g. gas turbines, highly efficient boilers, fuel cells). This effect can only be fully utilised by the most clean-burning of fuels.

Toolbox – how the natural gas industry can help unlock the low carbon future

Where it has been available, natural gas has long been the fuel of choice. This is due to the efficiency of large scale gas transmission, the flexibility and controllability at the consumption point of natural gas, and on account of its low emissions of CO_2 and low levels of pollutants. These qualities make gas attractive in direct utilisation in homes and businesses, in centralised power generation, in industrial processes and in local combined heat and power (CHP) plants. In many countries natural gas has also been taken into use in the transport sector with great success. The latter most often motivated by improving the pollution situation in metropolitan areas, but having typically a ¼ reduction of climate footprint as a side effect.

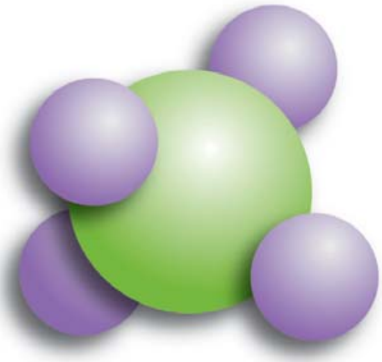
This figure illustrates the four major tools by which natural gas can be used to lower the climate change footprint of energy production and end-use. The tools can be used both in the natural gas industry's own operations or in the hands of the gas customers.



The toolbox for natural gas-related mitigation of climate change. We differentiate between what the natural gas industry can do within its own operations and what this industry can do for its present and emerging customers. The focus is on reduction of carbon dioxide and methane emissions to atmosphere.

Natural gas – low in carbon, high in hydrogen

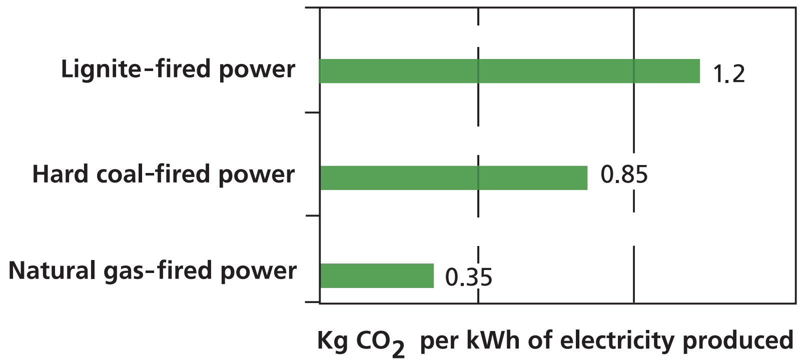
Among all the fossil fuels, natural gas is the most environmentally-friendly, producing the lowest CO_2 emissions per unit of energy. Chemically speaking, the methane molecule in natural gas consists of four atoms of hydrogen and one of carbon. Depending on the quality of alternative fuel, the combustion of natural gas therefore results in at least 25-30% less CO_2 than oil and at minimum 40-50% less than coal.



The difference is even greater when comparing with lignite (brown coal) or various types of heavy oil. The CO_2 emissions can be further reduced by using natural gas in high efficiency applications such as in gas turbine based electricity generation. This results in CO_2 emissions per useful kilowatthour of electricity being typically ⅓ of a lignite-fired power plant. Natural gas thus offers unique - and often overlooked - advantages in terms of greenhouse gas benefits.

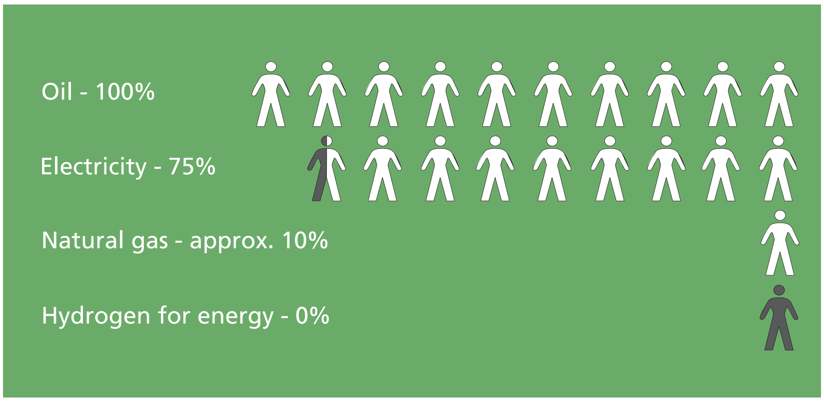
Electricity and natural gas – twins of clean energy

There is a strong link between the future of electricity and natural gas. Today 41% of global energy-related CO_2 originates in electricity generation, mostly from coal-fired generation plants. It is important to note this role of electricity and that its share of final energy use has been growing for decades.



An old coal-fired power plant (left) and a modern gas turbine-based gas-fired (brown coal) power plant (right). Compared to a lignite (brown coal) power plant a gas-fired plant emits about ⅓ as much CO_2.

It is a widely published fact that some 1.6 billion people - about one in four of the world's population – live without access to electricity. In comparison only one in ten global households have direct access to natural gas to use for heating, cooling and cooking.



Shares of the global population having access to the various forms of energy. Electricity has coverage of about ¾ of the global households. Natural gas is physically available to perhaps 10% of global households. Those without access to natural gas or electricity, have their options in general limited to more polluting fuels, such as coal briquettes, low grade biofuels or oil products.

If by magic we could switch all the world's coal-fired power plants to modern natural gas-fired combined cycle plants, we would see a reduction in global CO_2 emissions by ⅕ (over 5 $GtCO_2$/yr). While not entirely realistic, this thought experiment illustrates the huge potential for fuel switching to natural gas, in particular in the electricity generation sector.

Fuelling vehicles and ships with natural gas

The use of natural gas as a fuel for all sorts of vehicles (NGV's) are increasing rapidly around the world. It is vprojected that this end-use sector will increase ten-fold, to 65 million vehicles by 2020. This many NGV's would consume about 400 GSm3 of natural gas, amounting to 14% of today's natural gas consumption.

A natural gas-fuelled bus in India (left) and the LNG-fuelled ferry Bergensfjord in Norway (right). Both reduce the CO_2 emissions compared to their normal hydrocarbon fuel by about ¼. In addition the pollution of NOx, soot and so forth is greatly reduced.

Another important – and in climate terms mostly overlooked – sector is ship transportation. Today only a couple of handfuls of large ships use liquefied natural gas (LNG) for fuel, but the interest is growing due to approaching regional and global regulations for emissions from ship traffic. The use of LNG as a ship fuel can save as much as one quarter of CO_2 emissions and even more in other types of emissions.

Capturing and storing CO_2 in geological formations

The gas business is the pioneering industry in the area of CO_2 capture and storage (CCS) that is expected to be an important technology for mitigating climate change.




There are at present four large scale operating CCS projects globally. All at the scale of one million tons per year injection capacity. From left to right: Sleipner (Norway), In Salah (Algeria), Snøhvit (Norway) and Weyburn-Midale (Canada).

The expertise on geological storage arises from many decades of finding and producing natural gas from geological formations. In addition the gas industry operates over 600 sites for geological storage of natural gas for the purpose of tackling seasonal or daily swings in consumption.

Hydrogen from natural gas

Like electricity, hydrogen is an energy carrier that is CO_2 free at the point of end-use. The global production of hydrogen currently stands at around 500 billion Nm3, predominantly from the industrial-scale steam-reforming of natural gas for petroleum refining and chemicals manufacturing.

Hydrogen production under these circumstances is both reliable and cost-effective. Hydrogen has already been used as a fuel. Town gas, which was widely distributed during the first half of the 20th century before being replaced with natural gas, was 50% hydrogen. If hydrogen again becomes a fuel of choice, natural gas will most certainly be the main source. An aspect not widely known is that in the process of making hydrogen from natural gas, CO_2 is already today captured in a concentrated form and in principle ready

Renewables and natural gas – weaving a mutual relationship

In much the same way as we see the electricity grid being used both for nuclear, fossil and renewable electricity, we already see biogas from many sources being transported in the natural gas grid. The volume today is low, but the trend is sharply rising.

Many renewables (e.g. solar, wind) are intermittent and not necessarily available when the energy customers demand them. This is why we see that mutually-beneficial relationships have been established between solar thermal energy and natural gas to make steam for power generation. Less direct, but equally important is that a regional electric grid with much sporadic renewable input needs quick-start electricity generation to guarantee supply to customers. Natural gas-fired turbines are already being used in this way, something that coal and nuclear power are not well suited for as they may take hours to come up to full load.

Energy and emissions at the production and processing stage

Unlike oil fields, there is as a rule no attempt to increase the recovery of natural gas from a pure gas field through energy intensive increased recovery methods in the reservoir (increased condensate recovery through recirculation of gas being the exception). When gas fields are emptied, their pressure is reduced and the lower wellhead pressure will at some point in time require installation of a compressor facility that is usually driven by a gas turbine or a gas motor. Energy consumption and emissions at the processing stage depend on the composition, pressure and temperature of the raw natural gas, the age and quality of the technology of the plant, availability of cooling water (if any) as well as on operational practices.

The emissions of methane and the amount flared do not depend on the gas quality but rather reflect the technology used throughout the gas chain. The averaged total of consumption and losses (see table) for production and processing is about 3.5% for all countries and regions. In determining the greenhouse effect of the processing step, the fugitive emissions are an important factor, as methane itself has a 25 times higher greenhouse impact per kg emitted than the CO_2 resulting from flaring/combustion of the same weight of natural gas.

For LNG, the amount of energy needed for processing is higher due to the additional cooling and liquefaction step. The average gas consumption over these plants is about 10% of the plant natural gas throughput. For the LNG capacity under construction, this figure is about 8% with the best – typically benefitting from cold cooling water - about 6%.

	Average	Average	Average (existing)	BAT (1000 km)	Average	Min	Max	Average
Percentage covered	54%	79%	69%	N.A.	27%	N.A.		34%
Natural gas consumption	3.52%		10.3%					
- Energy	2.73%	4.1%	8.8%	0.21%	0.43%	0.13%	2.0%	0.16%
- Fugitive/venting	0.58%	0.4%	0.2%		0.00%	0.00%	0.10%	0.42%
- Flaring	0.48%		0.5%					
Electricity (MJ/Nm_3)					0.042	0.047	0.205	0.003
Fuel oil (MJ/Nm_3)				73.8				
Emissions (g/Nm_3)								
CO_2	62.05	132.12	280.22	9.59	8.88	3.39	10.80	0.16
CH_4	4.01	3.35	5.90		0.03	0.16	0.75	4.32
NO_x	0.07	0.05	0.99	0.01	0.004	0.002	0.10	
SO_2			0.003	0.01				

A global look at the natural gas chain (Source: IGU LCA-report 2006)

Increased interest in hydrocarbon gas exploration in some geological basins is tempered by the risk of encountering high levels of non-hydrocarbon gases which reduce energy density and increase production costs. On average, the global risk of encountering more than 1% concentrations of CO_2 in a gas accumulation is less than 1 in 10, and the risk of encountering higher than 20% concentrations of CO_2 is less than 1 in 100.

In some other gas regions CO_2 contamination will be less, but still sufficient to cause removal at a gas processing plant. Sometimes such contamination by CO_2 occurs together with hydrogen sulphide (H_2S). These contaminants are normally removed to a low level in order to fulfil a gas customer specification or to make it technically possible to produce LNG.

Carbon dioxide captured from natural gas has an important place in climate mitigation even if the amount of this CO_2 contamination does not amount to great tonnages. This is because these sources consist of almost 100% pure CO_2 in volumes ranging from a fraction of a million ton to several million tons per source. The first geological CO_2 storage projects (CCS projects) for climate change reasons are in this category.

Energy and emissions at the transportation stage

The energy consumption and CO_2 emissions arising from transportation of natural gas is closely connected to the distance covered both for pipelines and for the shipping part of an LNG chain. For pipeline transportation of natural gas the average consumption and losses globally is about 4.5%, $^{9}/_{10}$ of which is energy use (see table).

Emission data for pipeline transmission are available for several European countries as well as from USA, Canada, Russia, Australia, Iran, Algeria and Argentina. Together these countries are responsible for about 80% of the global production volume, hence an almost equivalent percentage of global pipeline transportation is covered.

A global overview of the natural gas chain

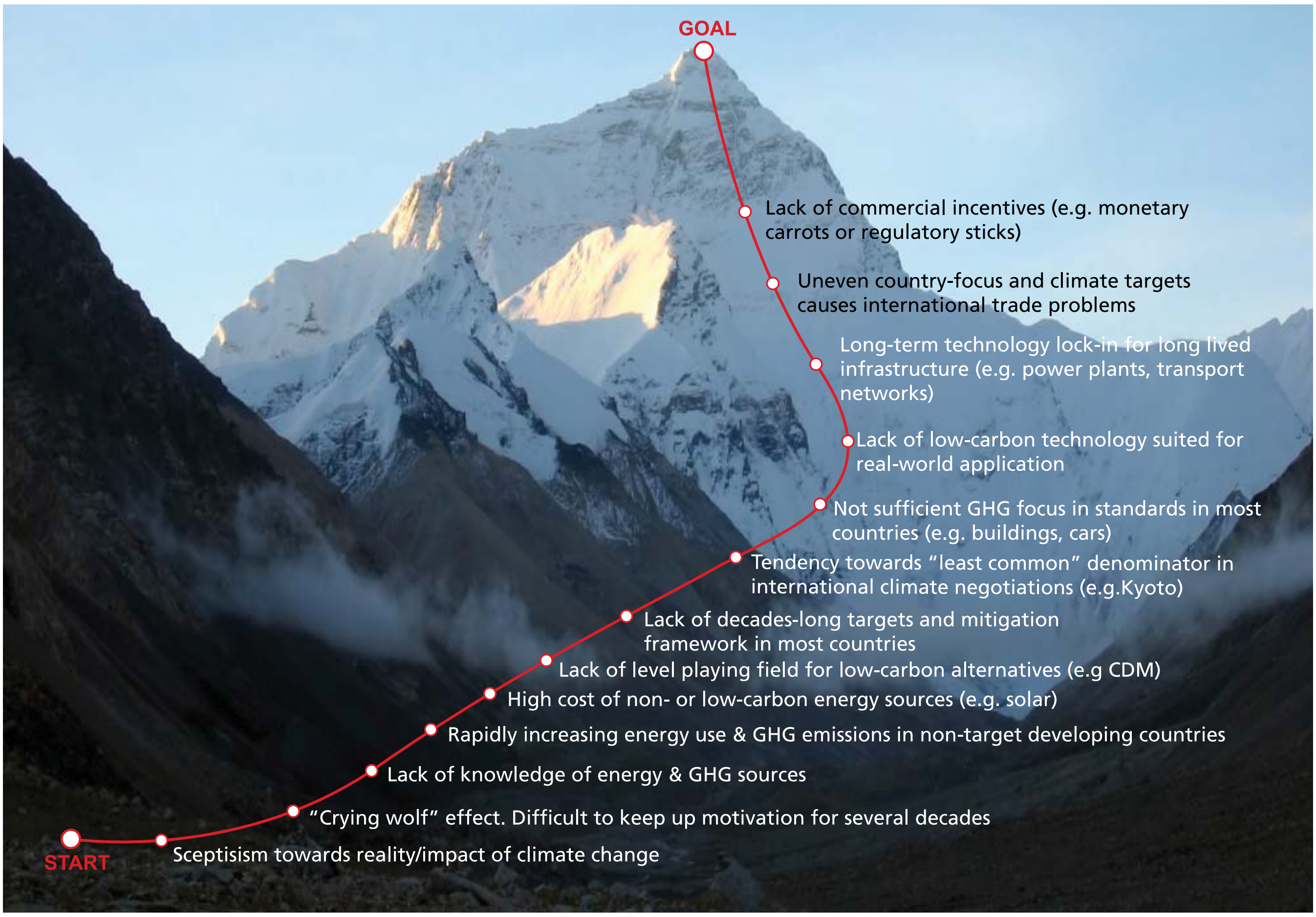
In the last couple of decades one of the issues in the natural gas chain is the loss of product through fugitive emissions, plus intentional gas venting. Natural gas - mostly methane - has a high global warming potential (GWP 25 times that of CO_2) and loss of methane to the atmosphere and climate impact are therefore closely related. This means that reducing losses leads to improved environmental as well as economic performance. While venting - or flaring may not always be easy to avoid, the fugitive emissions can be substantially reduced, as has been shown in many projects around the world. The energy efficiency of processing and transporting natural gas may always be improved as plants are refurbished and better technology introduced. Most of this energy is provided by the natural gas itself and thus also results in the undesirable loss of saleable product.

A gas pipeline in Tierra del Fuego in South America, the world's southernmost gas production facility (Source: BASF)

LNG production has a climate impact per unit of energy produced (end-use not included) that is almost 3 times larger than for production of pipeline quality natural gas. When looking at the combination of production and transport, however, the impact of LNG is only 35% higher than for pipelined natural gas when assuming a transport distance of 5,000 km.

Barriers to action

With natural gas such a good medicine against climate change, why do we see limited implementation and enthusiasm? There are many reasons for this, some of which are illustrated in the following mountain route. One problem for most people and media is to understand how natural gas can be both part of the climate problem and at the same time an important part of the solution. This can only be understood through knowledge of the present energy system (i.e. domination by coal, oil) and possibilities and limitations for the future of energy in the decades ahead. This type of knowledge is not as widespread as it should be for informed climate policy.



How a mountaineer might view barriers to climate change mitigation. Not all the indicated barriers are equally relevant to specific countries, companies or individuals, but the route to the top contains a number of difficult obstacles between the valley and the top of the mountain.

Many of the climate change mitigation actions involving natural gas have not yet happened or are only slowly being developed due to barriers that come in many forms. The most important barrier-breakers are removal of institutional (mostly government) barriers, making natural gas accessible to more consumers, deployment of better technologies as well as expectations of increasing costs of emissions of greenhouse gases to the atmosphere. High energy prices will also work in the direction of an efficient energy system both in the industrialised and in the industrialising countries of the world.

The natural gas industry cannot afford to be complacent in a world increasingly concerned about climate change and its effects on human society. The comprehensive IGU report (on which this brochure is based) on the contribution of natural gas to mitigation of climate change, illustrates that there is still a way to go. Much is already being done, however, that will transform both the gas industry and the way consumers use natural gas in the 21st century, to the benefit of a reduced global carbon footprint.

About the International Gas Union (IGU)

The International Gas Union is a worldwide non-profit organisation aimed at promoting the technical and economic progress of the gas industry. The union has more than 100 members worldwide on all continents. IGU also cooperates with many global energy organisations. The members of IGU are national associations and corporations of the gas industry. IGU's working organisation covers all aspects of the gas industry, including exploration and production, storage, LNG, distribution and natural gas utilisation in all market segments. IGU promotes economic growth through sustainable development of the gas industry. For more information, please visit www.igu.org

For the triennium 2006-2009 the areas of interest are covered by the following Working and Programme Committees and Task Forces:

Exploration & Production
Storage
Transmission
Distribution
Utilisation
Sustainable Development
Strategy, Economics & Regulation
Developing Markets
LNG
Task Force on Research & Development
Task Force on Gas Market Integration (GMI)

The present report is an executive summary of work carried out in cooperation between several programme committees headed by PGC A for sustainable development. The full report is available from the IGU secretariat and is also available as a PDF-file on the IGU website: www.igu.org

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A special thank to StatoilHydro for providing the graphics and layout work for the report.

Natural gas - the short version:

• Natural gas, the cleanest fossil fuel, is a highly efficient form of energy. It is composed chiefly of methane; the simple chemical composition of natural gas is a molecule of one carbon atom and four hydrogen atoms (CH_4)

• When methane is burned completely, the products of combustion are one molecule of carbon dioxide and two molecules of water vapour

• Natural gas delivered to customers is almost totally free of impurities, is chemically less complex and its combustion therefore results in less pollution than other fuels

• In most applications the use of natural gas produces near zero sulphur dioxide (the primary precursor of acid rain), very little nitrogen oxides (the primary precursor of smog) and far less particulate matter (which can affect health and visibility) than oil or coal

• Technological progress allows cleaner energy production today than in the past for all fuels, although the inherent cleanliness of gas means that environmental controls on gas equipment, if any are required, tend to be far less expensive than controls for other fuels

Pollutant (relative; coal 100%)	Natural Gas	Oil	Coal
Carbon Dioxide	56%	79%	100%

• Natural gas is highly efficient. About 90% of the natural gas produced is delivered to customers as useful energy. In contrast, on average only about 27% of the energy converted to electricity reaches consumers

• Due to its cleanliness natural gas will normally be used in substantially more efficient machinery or appliances (e.g. gas turbines) than other fossil fuels. This further increases the beneficial climate effect compared to coal or oil

Abbreviations:

CDM: Clean development mechanism
CH_4: Methane
CNG: Compressed natural gas
CO_2: Carbon dioxide
CCS: Carbon capture and (geological) storage
Gt: Gigatonne
IEA: International Energy Agency
IGU: International Gas Union
LNG: Liquified natural gas
Nm^3: Normal cubicmeter

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