LIFE CYCLE ASSESSMENT OF GREENHOUSE GAS EMISSIONS ASSOCIATED WITH NATURAL GAS AND COAL IN DIFFERENT GEOGRAPHICAL CONTEXTS

Life cycle assessment (LCA) evaluates the potential environmental impacts of a product or system during its entire life cycle – from raw material extraction to end of life. For each life cycle stage, LCA identifies and quantifies all inputs and outputs of material and energy. These are then translated into potential impacts through environmental modelling. The potential life cycle impacts of different products can be consistently compared on a common comparison basis (for example, 1 kWh of electricity produced). LCA is regulated by the ISO 14040-14044 standards.

Natural gas could play an increasingly important role in meeting the Paris Agreement's target to keep the increase of average global temperatures below 2°C by 2100. In fact, compared to a typical new coal plant, natural gas emits 50 to 60 per cent less carbon dioxide (CO_2) when combusted in a new efficient natural gas power plant[1]. Using natural gas to substitute all coal consumed in power generation would reduce CO_2 emissions by 5 Gt per year[2] – around 10% of total anthropogenic greenhouse gas (GHG) emissions.

However, the gas industry is challenged by GHG emissions over the lifecycle of the entire gas value chain. Some claim that the intrinsic benefits of gas may be limited or even negated by upstream methane emissions, and, in the case of Liquefied Natural Gas (LNG), the extra energy required for liquefaction.

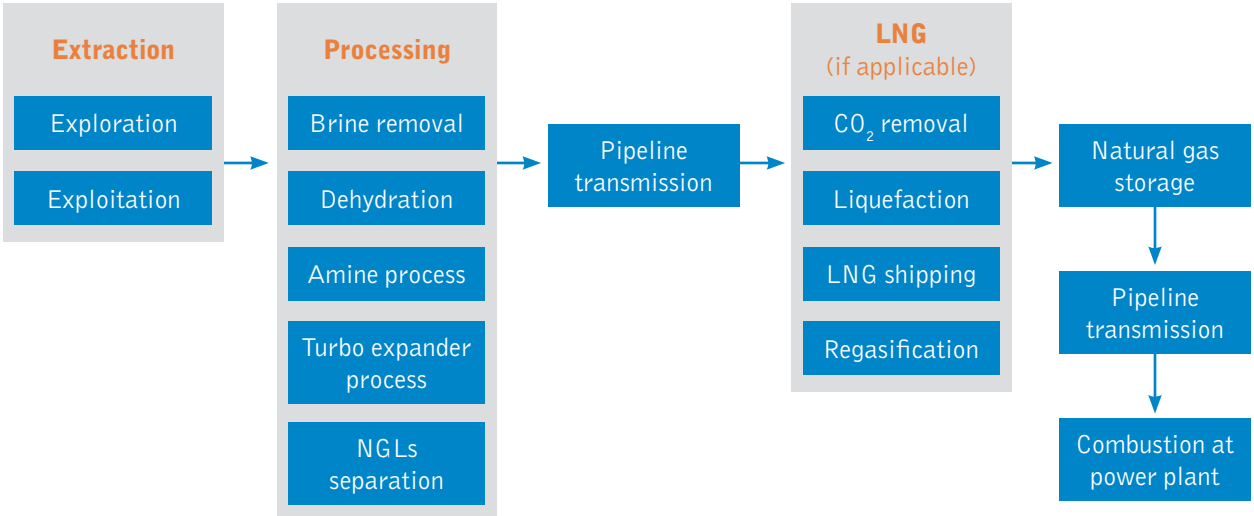

Figure 1: Natural gas life cycle[3]

1. Source : USC USA – Environmental Impacts of Natural Gas 2016
2. Source : IEA – CO_2 Emissions from Fuel Combustion 2014
3. If the natural gas is not converted into LNG, liquefaction, shipping and regasification steps should not be considered.

OBJECTIVES AND SCOPE OF WORK

TOTAL has mandated the International Reference Centre for the Life Cycle of Products, Processes and Services (CIRAIG) to:

"Establish and compare the life cycle GHG emissions of natural gas and coal from different sources (conventional and unconventional) and geographical contexts in order to produce electricity in Europe and Asia."

To do so, the CIRAIG:

- Estimated the life cycle GHG emissions from different gas chains in which Total is involved (see Figure 2). This sample does not reflect Total's portfolio in terms of production share, but rather aims to cover the range of gas chain typologies and their associated GHG emissions: both conventional and unconventional gas, onshore and offshore productions, and one chain without gas liquefaction were investigated.

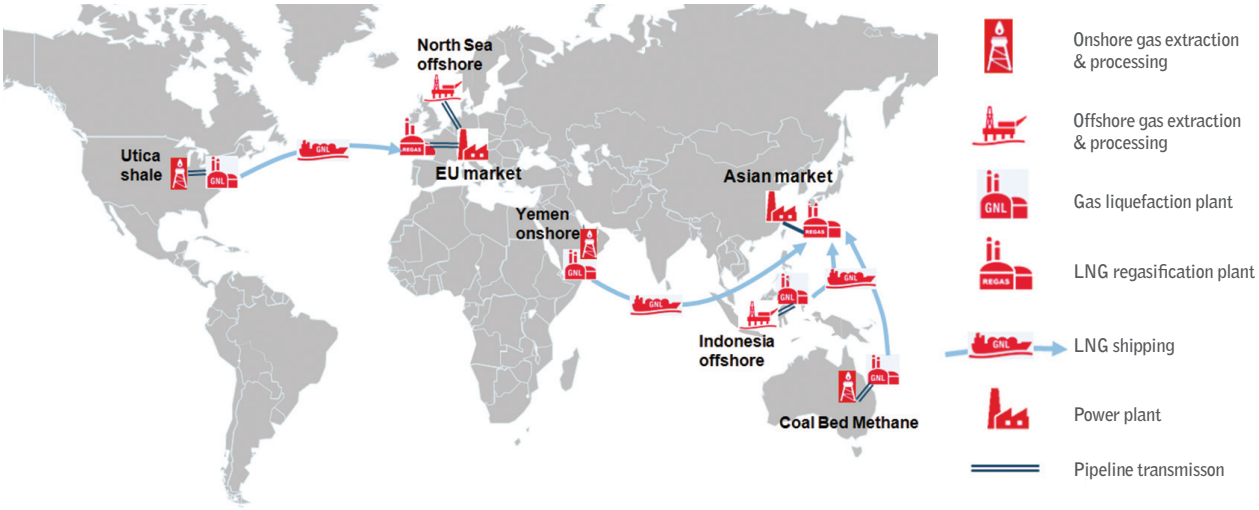

Figure 2: Evaluated natural gas chains

- Compared lifecycle GHG emissions of the selected gas chains with those of the eight largest hard coal productions and their related supply chains. (see Figure 3)

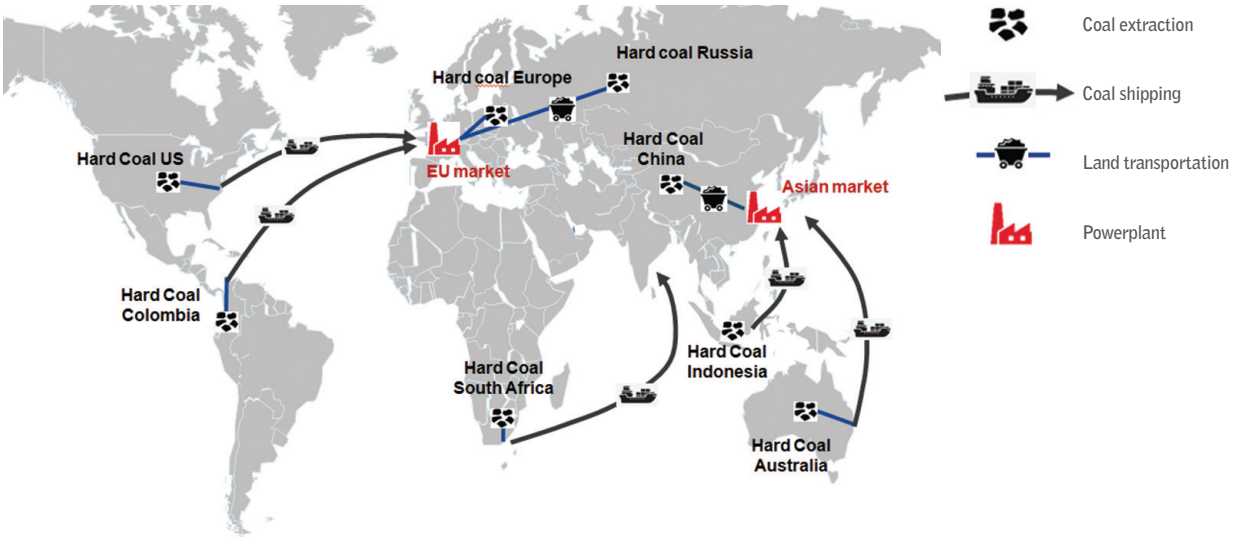

Figure 3: Evaluated coal chains

RESULTS

Results show, that on average life cycle GHG emissions are approximately 50% lower for natural gas chains than for coal chains for the same destination market.

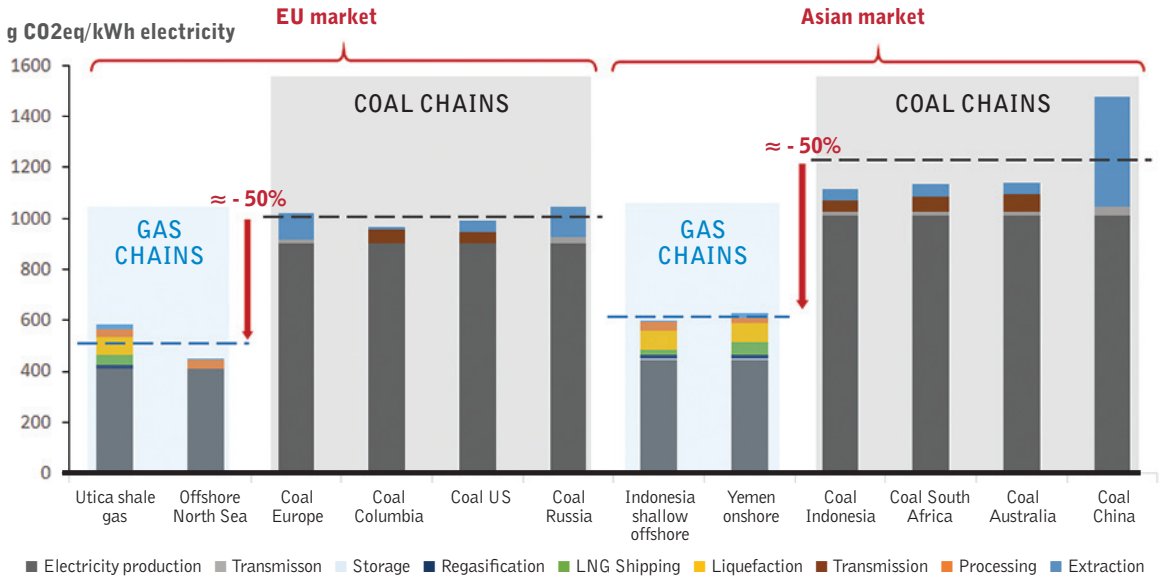

Figure 4: Natural gas and coal life cycle GHG emissions

Methane emissions from gas chains represent between 5% and 20% of total upstream[4] GHG emissions.

For coal chains, methane emissions are mainly generated by underground coal mining and range from 7% to 70% of upstream GHG emissions.

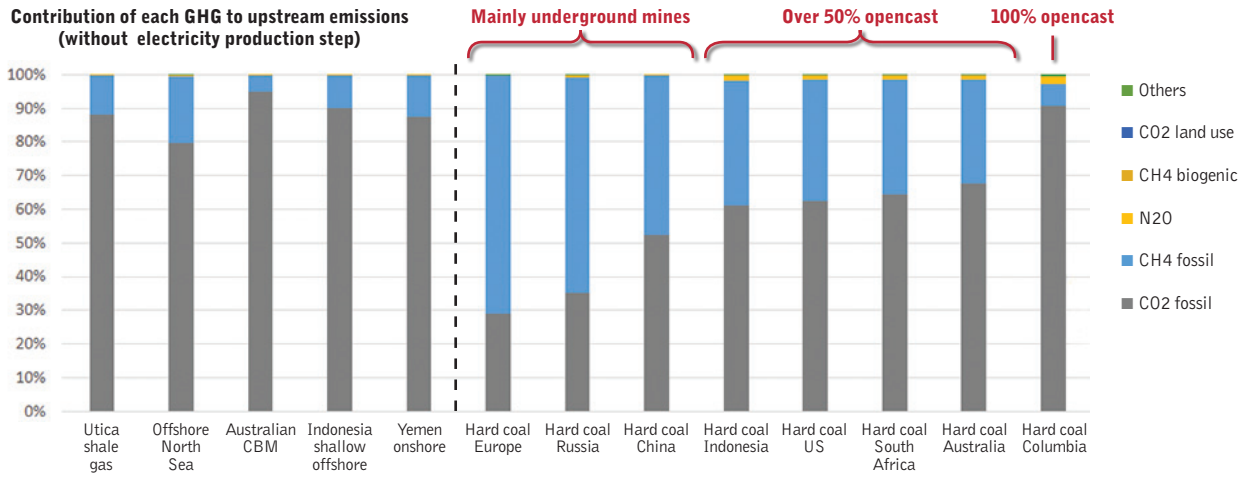

Figure 5: GHG emissions upstream contributions

4. Without considering GHG emissions from electricity generation.

SENSITIVITY ANALYSIS:

Sensitivity analyses were performed to test the consequences of modifying some influential parameters. Chief among them, is the electricity generation step for which power plant efficiency has a critical influence. Figure 6 shows that even with a new-built, high-efficiency coal-fired plant (ultra-supercritical technology, 46% efficiency) the coal life cycle GHG emissions remain higher than for natural gas.

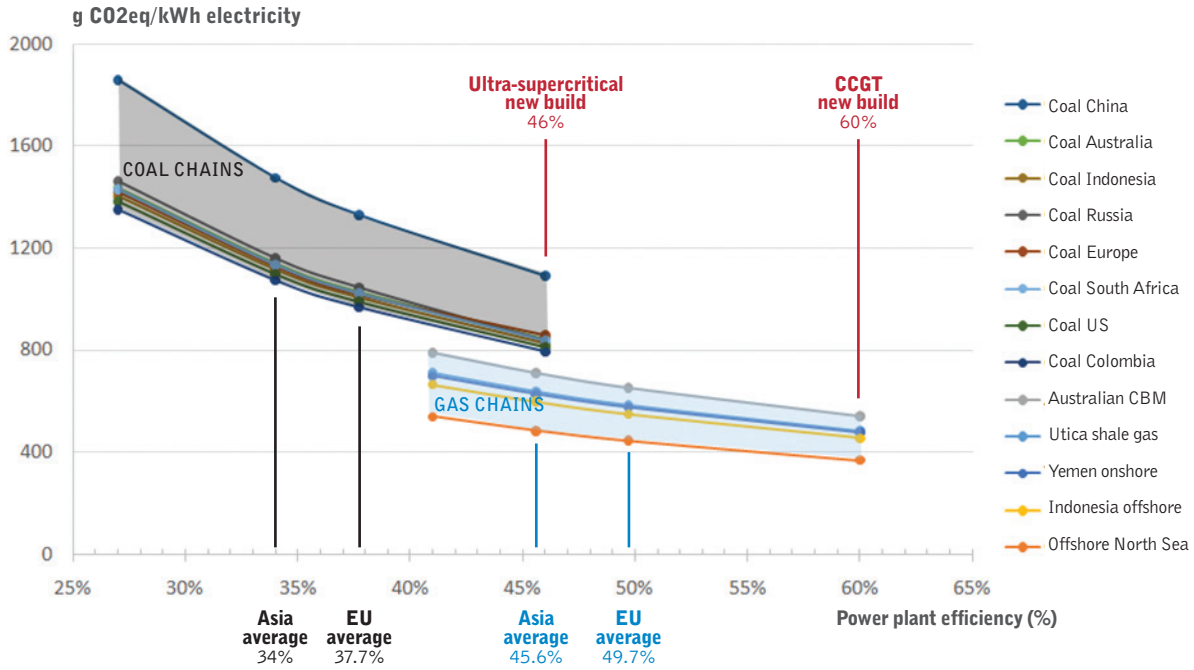

Figure 6: Life cycle GHG emissions according to power plant efficiency

Several other important parameters were tested: variations in shale gas fugitive emissions, variations in natural gas and coal low heating value, methane capture during coal extraction, change in the GHG GWP's reference year (2013, 2007 and 2001) and time horizon (20 and 100 years) and a change in allocation rules (energy, mass and economic). All of which amounted to the same conclusion, natural gas emits fewer GHGs than coal.

In fact, it took a probabilistic approach (a Monte Carlo simulation at a 95% confidence interval) to find a situation in which coal may be better than natural gas. Such a situation simultaneously considered the best case scenario for coal and a worst case for European imports of shale gas in which fugitive emissions were around 7% of the EUR.

THE CRITICAL REVIEW PROCESS:

ISO14040:44 requires an independent critical review to be performed before communicating to the public the results of a comparative LCA. The panel was composed of independent third parties - industrial as well as LCA experts. The critical review report concluded that the study was robust and meeting the standard's requirement.