Climate-friendly LNG

Flaring emissions monitoring and gas analysis

By Stephen B. Harrison, sbh4 consulting

LNG, or liquefied natural gas, is a widely traded energy commodity. During 2022 and 2023, natural gas reserves in the Netherlands have depleted and Russian pipeline gas supplies to Europe have reduced significantly. LNG imports to Europe from the US, Qatar, and Australia avoided an energy crisis over this period.

The flexibility of the international LNG supply chain has been stress-tested and proven to be robust.

Revaporized LNG is widely used for power generation and heating. Natural gas has earned a reputation as a clean fuel. When fed to a combined cycle gas turbine, the power generation efficiency from natural gas can be as high as 70%. This is significantly more than coal-fired power generation and results in a lower CO_2 intensity of power from gas than coal. High efficiency also contributes to low-cost power generation.

Combustion of natural gas results in almost zero particulate emissions and almost no sulfur dioxide. On the other hand, gaseous emissions from heavy fuel oil or coal-fired power generation must be treated in flue gas desulfurisation equipment and particulate filtration is also required.

In comparison to coal or fuel oil, natural gas offers many environmental benefits. However, methane is a potent greenhouse gas (GHG) with a global warming potential around 50 times worse than carbon dioxide (CO_2). Natural gas leakages through the entire value chain from upstream gas extraction through to transmission in pipelines or transportation as LNG must be eliminated.

Considering its abundance, flexible logistics, clean burning characteristics and cost-effectiveness the future of LNG looks bright. Whilst usage of some energy commodities such as coal may peak during this decade, the peak consumption of LNG could be as late as 2045. Since it will be around for a long time, climate-friendly production and use of LNG is essential.

To flare or not to flare

It is perhaps counter-intuitive, but flaring natural gas and releasing the resultant CO_2 to atmosphere contributes less to global warming than emitting the same amount of natural gas directly into the air.

Many offshore oil rigs are designed to recover crude oil and are not able to process methane (CH_4) and lighter hydrocarbons. These are sent to the flare where they are mixed with ambient air and burned to form CO_2 and water vapour.

If there is not sufficient air in the flame the hydrocarbons are not fully combusted. If methane, propane, and butane slip through the flare, they pollute the atmosphere and in particular, methane contributes significantly to climate change.

Methanol and carbon monoxide-rich syngas have very low thermal values per cubic metre. Nitrogen purge gas may also be injected to the vent gas header to maintain a positive pressure and air hazardous air ingress. If these gases are present in large quantities in the flare, incomplete combustion may arise due to a lack of thermal energy. To avoid this, natural gas may need to be added to ensure complete combustion of the flared gases.

Gas analysis and process

Process control of a flare is a complex balance of parameters in real-time which requires accurate and responsive gas analysis instrumentation.

The shape of the flare changes with wind speeds and the flow of gases. So, measurement of unburned hydrocarbons after the flare or measurement of the residual oxygen concentration around the flame are not practical process control inputs. And mixing of the combustion gases with ambient air would distort and attempt to make accurate measurements in the open flame. Alternative measurements must be used.

Controlling the ratio of oxygen to fuel in the vent gases flowing to the flare is an effective way to ensure complete combustion. Measurement of the heating value (Wobbe index) of the mix of hydrocarbons in the vent gas can be used to adjust process parameters and ensure complete combustion.

Additional combustion air can be fed to air-assisted flares by increasing the flow from the air supply compressor. On steam-assisted flares, a higher steam flow rate can be used to entrain more air into the flame.

For these control strategies to function effectively, precise measurement of the combustion air requirement of the vent gas flowing to the flare is required.

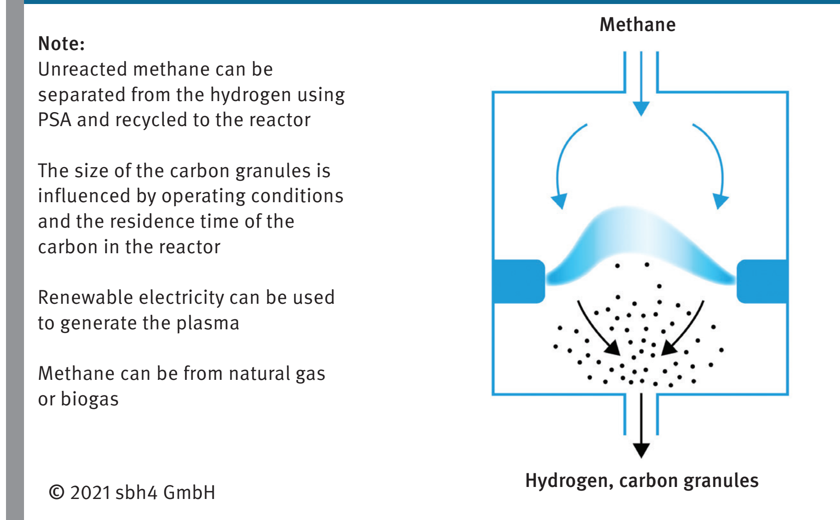
Monitoring combustion stoichiometry before the flare

Wobbe index measurements in steady state systems such as the gas transmission pipeline grid are made using gas chromatography. The composition of the gas stream is analysed and the concentration of each chemical such as methane, propane, butane and butene is multiplied by its known heating value to calculate a weighted average which will equate to the Wobbe index. The Wobbe index is used for invoicing and ensures that the energy value of the pipeline gas meets consumer requirements.

However, gas chromatography is not a continuous process and the delay between extracting the sample and yielding the measurement result can be between two and 10 minutes. In the gas pipeline grid, this time delay is acceptable since changes in the gas composition are comparatively slow.

On the other hand, time is of the essence in flare gas measurement. A smoky flare will be seen immediately by neighbours and even a short period of un-combusted methane emissions would have a negative climate impact. Furthermore, regulations in several countries require that process control of

Figure 1. Plasma Pyrolysis for Turquoise Hydrogen Production



	Plasma Pyrolysis
Process shown	Monolith Materials
Hydrogen content at reactor outlet	~95%
Carbon production	Carbon black as powder or granues
Catalyst required	No
Heating mechanism	Directing heating with plasma
Reactor temperature	2,000°C
Reactor pressure	Close to atmospheric pressure

combustion air to the flare is affected within a 15-minute period.

A widely used method to measure the amount of combustion air required in the flare is to burn or catalytically oxidise a sample of the vent gas in a stream of air. The residual oxygen concentration in the post-combustion gas mixture is measured after complete oxidation of the hydrocarbons has taken place. The difference between the pure air concentration and the residual oxygen represents the amount of oxygen required by the flare.

A benefit of this method is that it reports results almost instantaneously and avoids the time-lag associated with gas chromatography. Gas analyser providers such as COSA XENTAUR and Hobré Analyzer Solutions offer instruments of this type.

Flare gas to liquids

Many oil and gas operators have committed to the avoidance of non-emergency flaring. If process changes are not possible and some natural gas must be vented, flaring can be avoided by converting the excess gas to a liquid energy vector that is easy to store and transport.

Containerised systems to convert excess natural gas to liquid fuels are available from technology providers such as Greyrock and CompactGTL. These systems reform the natural gas and other light hydrocarbons that would otherwise have been flared to syngas. The syngas is then converted to a synthetic crude using Fischer Tropsch Synthesis. The syncrude can be transported to a refinery where it is blended with crude oil to be refined to gasoline, diesel, or kerosene.

Alternative systems, such as those from Bgtl LLC and or the Methanol-to-go® system from Modular Plant Solutions convert the vent gas to syngas then to methanol or dimethyl ether (DME). These liquids are valuable chemical commodities and energy vectors.

A key to successful operation of these small-scale gas to liquids systems is their operational flexibility. The vent gas is not a controlled input and both its flowrate and composition may change over time. For Fisher Tropsh Synthesis, use of micro-channel reactors packed with the appropriate catalysts can enable flexibility since these compact reactors have a lower thermal mass than traditional shell and tube reactors.

Microchannel reactors can also cope with vent gas flowrate changes. This flexibility can not be achieved on traditional large slurry bubble column reactors that have been used on world-scale gas to liquids (GTL) facilities such as Sasol's Secunda CTL and Oryx GTL operations, or Shell's Bintulu and Pearl GTL facilities.

Turquoise hydrogen from vent gas

Pyrolysis of methane-rich vent gas may also be used to avoid flaring. When methane is decomposed in a high energy plasma the CH_4 molecule breaks apart to form carbon and hydrogen atoms. Under controlled conditions, these atoms re-combine to form solid carbon and hydrogen gas molecules.

There are many forms of solid carbon ranging from diamond and high-value carbon nanotubes through to specialty grades of carbon black and low-value soot. Methane pyrolysis has not yet evolved to produce diamonds, but it can be controlled to yield other valuable forms of carbon.

Hydrogen produced from methane pyrolysis is known as turquoise hydrogen. If the process is operated using renewable power to create the plasma, the CO_2 intensity of turquoise hydrogen can be low since the carbon is recovered as a solid rather than being released into the atmosphere as CO_2.

Levidian, based in the UK, offers their LOOP system to convert vent gas that might otherwise have been flared to hydrogen and graphene. Graphene is an allotrope of solid carbon with applications as a pigment in paints and as a cathode material in batteries.

International Development Corporation (IDC) will be one of the first companies to operate a Levidian LOOP reactor in the UAE. Levidian's LOOP technology will also be used by United Utilities in Manchester, United Kingdom, to convert biomethane from biogas to hydrogen and graphene. gw