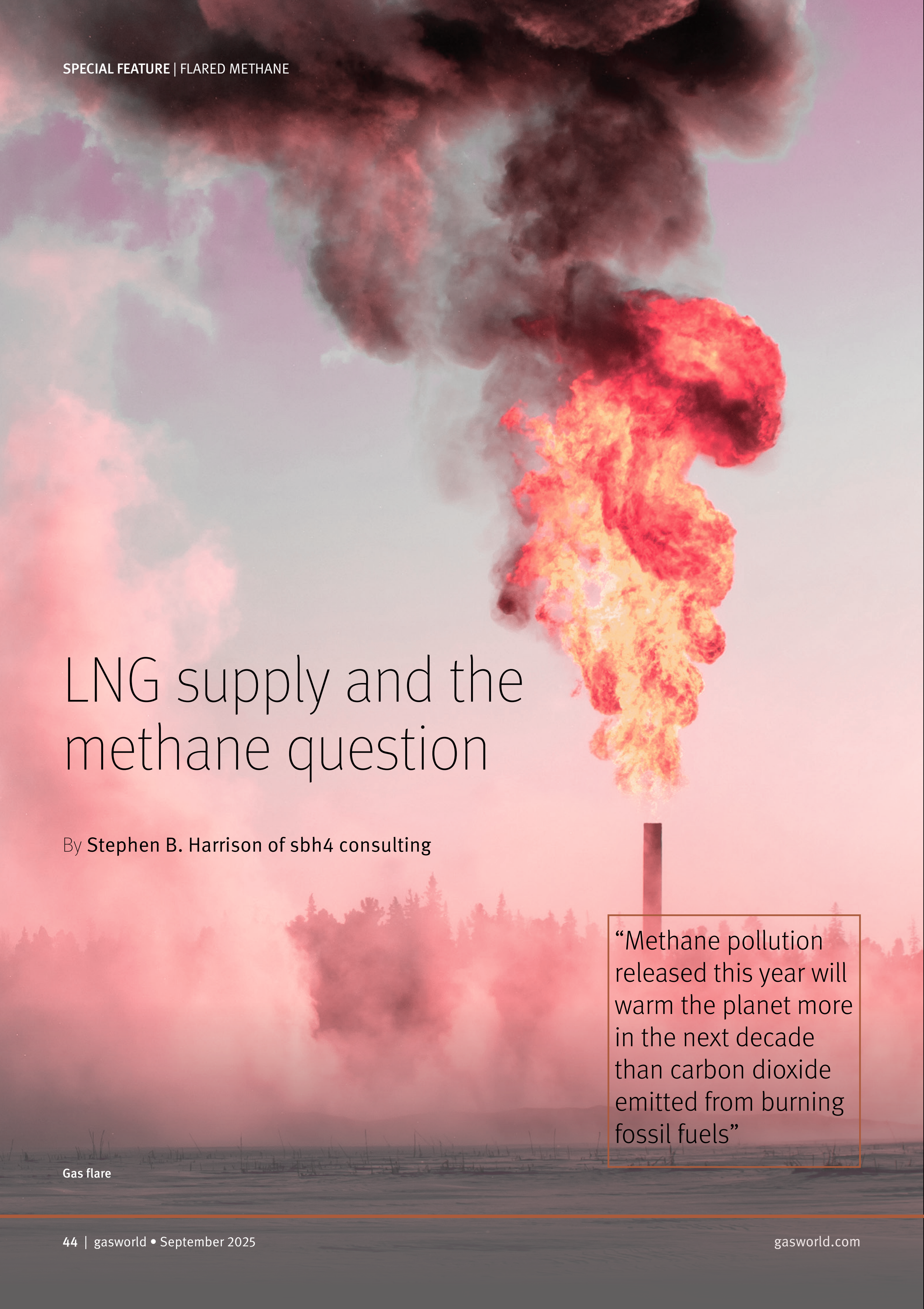


LNG supply and the methane question

By Stephen B. Harrison of sbh4 consulting

> "Methane pollution released this year will warm the planet more in the next decade than carbon dioxide emitted from burning fossil fuels"

Gas flare

Cutting greenhouse gas (GHG) emissions from the LNG supply chain is essential to achieving a Net Zero climate impact from the use of natural gas. But how do we get there?

The Environmental Defense Fund (EDF) is a global non-profit organisation with an office in Brussels. Its mission is to tackle climate change.

Silke Rechenbach, speaking on behalf of EDF's Energy Transition team, frames one challenge when she says that "methane pollution released this year will warm the planet more in the next decade than carbon dioxide emitted from burning fossil fuels. While cutting methane is the single fastest way to slow the rate of global warming, current efforts fall far short of the drastic reductions we need."

Through research and advocacy, EDF has been driving global action to cut methane pollution for over a decade, and it has built a methane-tracking satellite to help scale reductions worldwide. The goal is to reduce global methane emissions from the energy and agricultural sectors by at least 30% below 2020 levels by 2030.

To get there, monitoring of methane leaks is increasingly using sophisticated satellite-based sensors and imaging techniques, delivering a powerful tool to highlight the areas where the most significant improvements can be made.

Methane is a potent GHG, of course, and therefore flaring to yield carbon dioxide, a less potent GHG, is used to reduce the environmental impact of natural gas processing. At the same time, there are global initiatives afoot to reduce flaring. As this transition takes place, the costs can be offset if flared methane can be transformed into valuable products.

Money from methane

What are the prospects to monetise methane? So far the potential to monetise flared methane has been the limited by there being few technologies that can flex in operation to the variable nature of flared methane flow rates.

It is further complicated by the fact that raw natural gas is not pure methane. This means the flare gas processing technology must cope with some higher incondensable hydrocarbons such as ethane, propane and butane. CO_2 and sulphur compounds are also likely to be present in flared gas in upstream natural gas processing locations.

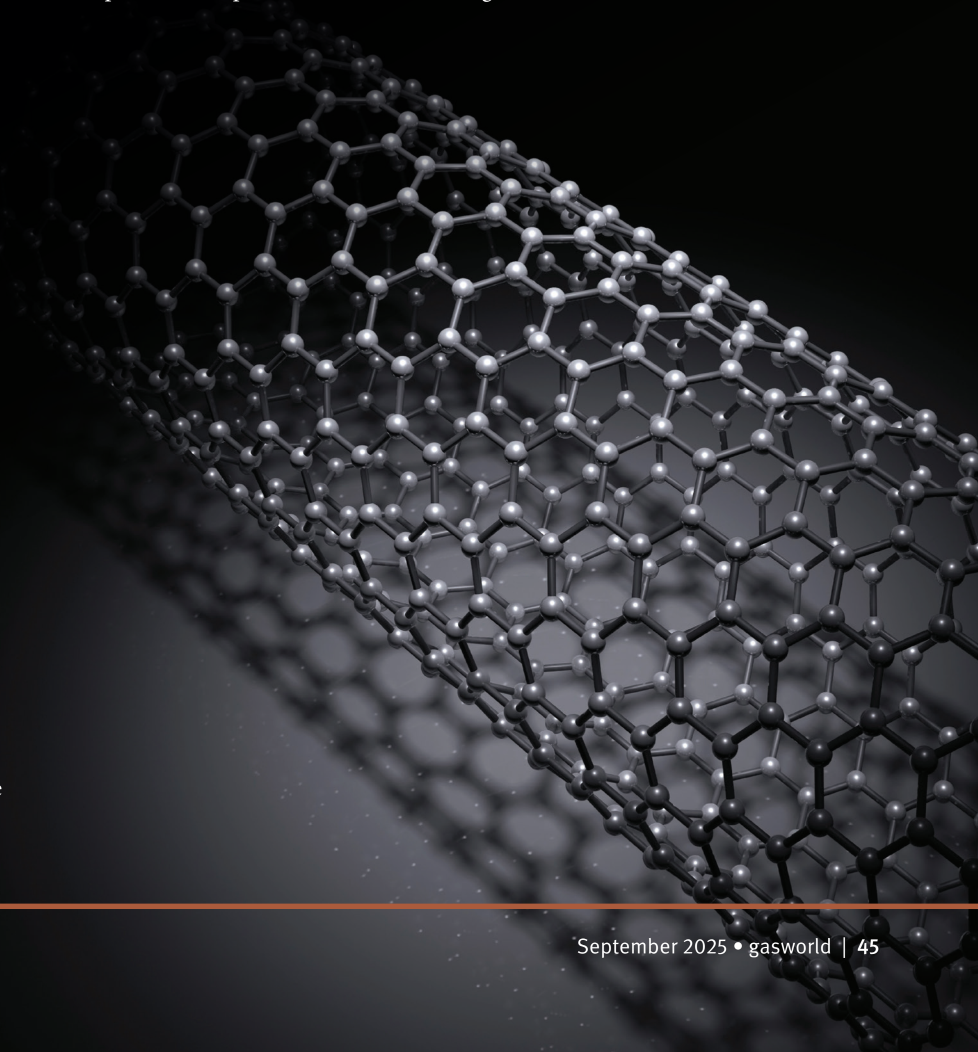
Additionally, in the upstream recovery of natural gas to process as LNG, flares are often in remote locations. This means that transportation of products from the flare or the supply of cooling water to the flare location may present challenges.

The economics of projects drives investment decisions. If the value of the recovered products is higher than the capital expense plus the operating jcosts for processing and distribution, there will be a business case to proceed.

Gas-to-Liquids

Reforming to produce syngas and then Fisher Tropsch (FT) liquid fuels has typically been used at micro-scale to monetise flare gas. Companies such as CompactGTL, based in the UK, and Greyrock Technology (now owned by Infinium), based in the US, have pioneered this with their proprietary technologies.

As mentioned already, one of the challenges when working with flare gas is the variable flow rate and the ▸



Gas processing flare

different composition that various flare gases have. In a single flare, the composition of the mixture can also change over time. These realities mean that the flare gas processing equipment must be highly flexible.

Velocys, a company based in the UK and US, has proven its small-scale FT process when fed with landfill gas at Envia's East Oak Landfill in Oklahoma. Landfill gas shares many characteristics with flare gas. It can contain high amounts of sulphur chemicals and CO_2. Furthermore, it can have a variable flow rate and a variable composition.

The Velocys demonstration plant in Oklahoma ran for 6,000 hours up to its closure in 2018. During that time, it successfully produced 1.6 million litres of liquid fuels at a peak production rate of 200 barrels per day.

Micro and small-scale Gas-to-Liquids (GTL)is likely to remain relevant for flare gas monetisation. Joining it will be a new generation of flare gas monetisation technologies which are flexible, robust, low-cost and yield high-value products.

Dry reforming and methane pyrolysis

Another opportunity in relation to methane could lie in dry reforming.

Chemical reactions reforming rearrange molecules in the feedstock to syngas. Plasma activates these molecules by splitting them and letting them recombine in more favourable products. Essentially, plasma is an electrified process for molecule conversion.

When CO_2 is fed to a plasma at the right conditions, it is split into carbon monoxide and oxygen atoms. When an additional carbon carrier is introduced along with the CO_2 (such as methane from flare gas), oxygen is consumed to make even more CO, and hydrogen is also produced. In other words, dry reforming of methane (DRM for short) is performed.

DRM can be used in combination with methane pyrolysis for e-syngas production. The German start-up Graforce has pioneered a process that it refers to as 'Plasmalysis'. This can convert a CO_2-rich flare gas of 50% methane and 50% CO_2 to syngas with a 1:1 ratio of hydrogen to CO. The gas fields in southeast Asia are very rich in CO_2, and this DRM process may be ideal to monetise the flared gas from these sites.

To enrich the syngas to a 2:1 ratio of hydrogen to CO, which may be required for methanol production and FT for liquid fuels, Graforce hopes to use methane pyrolysis to generate additional hydrogen and blend this with the 1:1 syngas from the plasma-induced DRM.

Turquoise hydrogen and high-value carbon

Pyrolysis of flared methane can yield turquoise hydrogen and solid carbon. Within this broad statement, there are several aspects to unpick.

What form of energy will drive the pyrolysis? Microwave, non-thermal plasma or thermal heat? Some of these require electrical power for the pyrolysis. Is this available in the remote location where the flaring is taking place?

In what form of reactor will the pyrolysis take place? It could be a catalysed fluidised bed, a moving bed or free space? And what type of carbon will be produced? It could be high value carbon nano-tubes, specialty grades of carbon black, graphite, graphene – or worthless soot. Can the process cope with the non-methane components in the raw natural gas?

The nature of the solid carbon product drives the economics of broad field of opportunity. Some methane pyrolysis processes produce low-value soot. Others can yield carbon black, or graphene, which may have a value between €1,000 and €5,000 per tonne. Some can produce even ultra-high value graphite, or carbon nano-tubes which can be worth up to €20,000 per tonne.

As with many apparently simple ideas, it is the detail that counts when it comes to the economics.

Graphene from gas

Here's one example from that field of opportunity. The UK start-up Levidian has developed a microwave plasma process to convert methane to graphene. The use of microwave can generate what is referred to as a 'cold' plasma. While the temperature in the core of the plasma may be more than 700°C, the overall system temperature remains low. This means that specialty grades of carbon, such as graphene, can be produced without being damaged by the high temperatures associated with 'thermal' plasma.

Graphite electrodes

Graphene is composed of a single layer of carbon atoms arranged in a honeycomb pattern. It is incredibly light and is 300 times stronger than steel. It is also an exceptionally good conductor of both heat and electrical current. These properties make graphene a valuable raw material with applications in advanced batteries, tyres and high performance materials.

In January 2025, Levidian announced the successful installation of its patented LOOP technology at the Adnoc Gas Habshan Gas Processing Plant in Abu Dhabi. The Habshan complex processes over 6 billion standard cubic feet of gas per day.

Completed in collaboration with Baker Hughes, an international energy technology company, the installation was a world-first deployment of Levidian's technology at an operational natural gas processing site. The unit will be capable of producing over a tonne each of graphene and turquoise hydrogen each year.

Carbon black

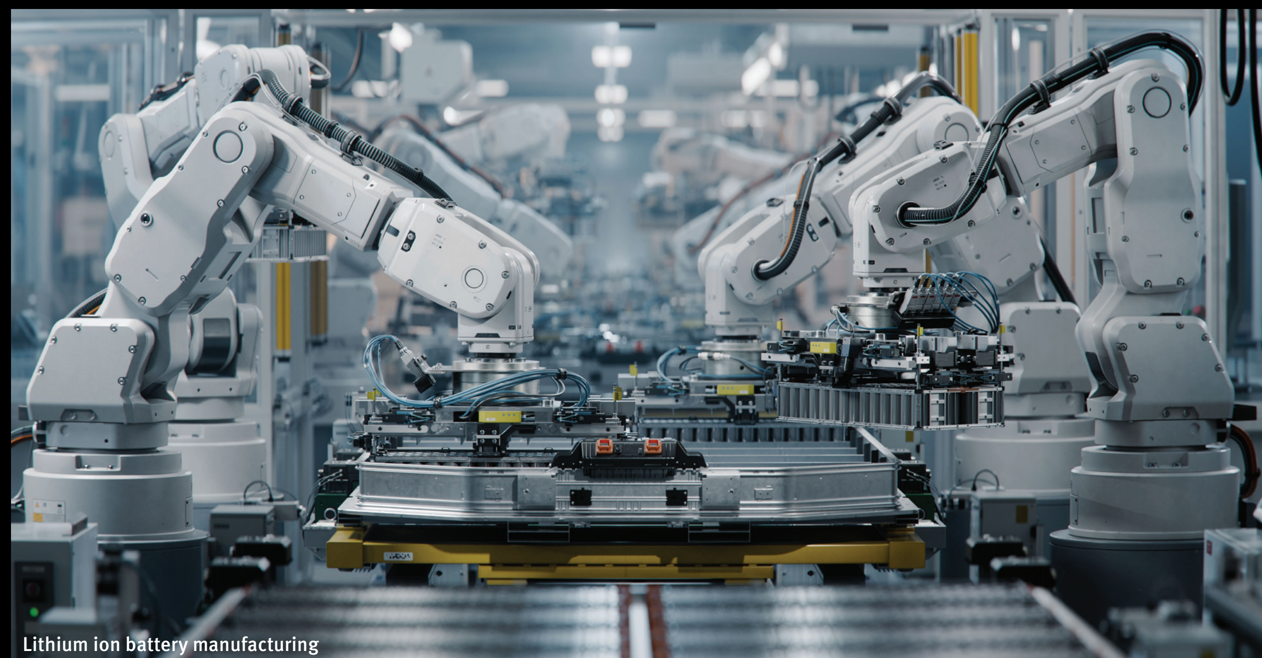
And here's another example. Plenesys, a French start-up based in Nice, has several unique aspects to its plasma-based technology to convert hydrocarbons to solid carbon and turquoise hydrogen.

Ahmed Kacem, the company's COO, says that "we stand out in the field of methane pyrolysis because we manufacture our own plasma torch." This gives Plenesys the ability to rapidly iterate its torch and overall system to optimise efficiency, operational reliability and to manage the nature of the solid carbon produced.

"Over time, we have been able to finetune our process to generate carbon black," says Kacem. "At around €2,000 per tonne, this product can add significant value to gas that would otherwise be flared. Furthermore, carbon black is easy to transport from remote flare locations to market. And producing solid carbon minimises CO_2 emissions from flaring."

One of the operational issues associated with plasma pyrolysis of hydrocarbons is that the plasma electrodes are eroded by the high intensity heat and flow of electrons. To ensure its process operates continuously, Plenesys has innovated and patented an automated electrode replenishment and feeding system.

"Unlike many other plasma torches, we operate with alternating current, not direct current", says Kacem. "This enables us to have much better control of the plasma and avoids the cost and complexity of using a rectifier for electrical power conversion from AC to DC. Furthermore, we have proven our system at elevated pressures, which is a significant advantage for plasma methane pyrolysis because hydrogen compression costs are minimised." gw



Lithium ion battery manufacturing