Transparency into gas flaring within the global LNG supply chain

A thought piece by capterio

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Executive summary

- **Gas consumption is growing due to its perceived lower GHG emissions, and LNG is growing even faster. As the consumer preferences and legislation focusses attention on emissions, companies are increasingly marketing "carbon-neutral" LNG with offsets from carbon credits.**

- **However, several lines of thought are increasingly challenging the credentials of the "carbon neutral" claims. This uses satellite data (which is tracked for every asset and every company globally) to explore flaring associated with the LNG supply chain (from upstream, liquefaction and regasification).**

- **We demonstrate how supply chain emissions from flaring can – for some assets – *double* the total CO2-equivalent emissions associated with LNG cargos, making their "carbon-neutrality" more challenging to achieve.**

- **We hope that our global rankings of the flaring associated with LNG liquefaction and gasification terminals will help to sharpen the focus on the topic leading to improved operations and reduced emissions.**

Introduction

The World Bank's report for 2020 highlights that gas flaring (the deliberate combustion of gas associated with oil and gas production) stood at 142 Billion Cubic Metres per year. Whilst flaring is modestly down versus 2019 (only due to lower oil production), it remains a major global environmental and economic challenge, and the fundamentals (i.e. flaring per barrel of oil produced) are heading in the wrong direction. Not only does flaring burn gas and entrained liquids with an annual sales potential of $20-30 billion, but it also generates around 1.2 billion CO2-equivalent tonnes of emissions per year. That's large enough that, if "gas flaring" were a country, it would be the 5th largest gas consumer worldwide.

Underlying gas consumption has been growing at 2.8% per year (2014-2019, according to the bp Statistical Review of World Energy, excluding temporary fall in 2020 due to COVID), in part due to its perceived lower GHG emissions than other fossil fuels and potential role as a bridging fuel to a low-carbon society. The Liquefied Natural Gas (LNG) market subset (representing 13% of gas consumed) is, however, seeing more dramatic growth (some 7.7% over the same period), driven by international trade, coupled with increasing demand for the product as a substitute for marine fuel oil to power the global shipping industry.

At the same time, a new market is growing for "carbon-neutral" LNG, within which offsets are provided from the purchase and use of carbon credits linked to energy efficiency, reforestation, afforestation, land management, renewable or carbon-capture projects. Whilst the market is very small today (only c. 16 cargoes have been delivered in the 25 months since the first carbon-neutral from Shell, some 0.1% of all LNG cargos, according to paper this month from Columbia), there is a growing range of mostly Asian buying countries (Japan, South Korea, India, China, Taiwan, Singapore[1], plus also the UK and Mexico), most of whom are looking for ways to shift from coal. Similarly, there is a growing range of suppliers, dominated by Shell, but also including JERA/ADNOC, bp, Total, Mitsui, Mitsubishi, PetroChina, Gazprom, RWE and Cheniere.

But the underlying methodology behind the certification "carbon neutrality" of LNG is neither standardised nor transparent, raising potential concerns over "greenwashing". Some "carbon-neutral" LNG cargoes appear to be misleadingly labelled. For example, JERA's cargo only includes offsets from final use, whereas the RWE's cargo only incorporated emissions from production to delivery. Other "carbon neutral" LNG cargos are sourced from very high-flaring assets (and it is very unclear whether these emissions have been appropriately accounted for).

Buyers need increased visibility into LNG's "full lifecycle" with "verified and certified emissions using completely transparent measurement methodologies", according to Professor Stern at the Oxford Institute for Energy Studies (OIES). Whilst, such standards (e.g. ISO 14021) already exist, they are currently not applied.

Satellites provide visibility into flaring worldwide

Gas flaring is visible from space by satellites, and volume estimates are routinely derived globally from the thermal anomaly associated with the combustion. We are grateful to the Colorado School of Mines' Earth Observation Group for their leadership in developing the satellite tracking technology.

At Capterio, we have worked with this satellite data extensively through the last two years. We have developed two flare tracking tools – "FlareIntel" (our free open-access tool) and "FlareIntel Pro" (our subscription tool), each of which monitor every flare for every asset and for every company worldwide.

In collaboration with Jefferies, the investment bank, we have mapped and researched the flaring associated with LNG facilities in the upstream, midstream and downstream (Figure 1). Whilst this paper focusses only on the flaring-related emissions we, of course, acknowledge that there are many other sources of emissions in the LNG value chain. Emissions sources include "venting" (e.g. from storage tanks) and "leaking/fugitives" (e.g. from pipelines, valves and fittings) in the upstream, midstream and downstream, plus also "boil off" during shipping (although this varies significantly by engine technology and voyage duration), and during loading and unloading of cargoes and others.

[1] Many of these countries have signed up to a newly-formed "Carbon Neutral LNG Buyers' Alliance), a body created to promote carbon-neutral LNG within Asia.

Figure 1: Global map of flaring observed at LNG liquefaction and regasification plants. Note that the many LNG facilities are not visible in this figure had no observable flaring in 2020. Upstream assets linked to the global LNG supply chain are not illustrated.

Quantifying flaring-related emissions for LNG

The six main categories of emissions associated with the global LNG supply chain include: (a) upstream production, (b) upstream transportation, (c) liquefaction, (d) shipping, (e) regasification, and; (f) end-use (e.g. a power plant or a consumer). It is important to note that whilst flaring from LNG liquefaction and gasification terminals represents only 1.6% of all flaring (the equivalent annual gas consumption of Poland, Iraq or Kuwait), flaring can be a large component of the emissions for an individual LNG cargo.

For an individual LNG cargo, final end-use emissions (the producers' "scope 3") normally dominate the total lifecycle emissions (at some 2.76 tonnes CO2-equivalent tonnes per tonne of LNG). The standard assumption for "Well to Tank" (WTT) emissions for an average (non-value-chain specific) supply chain are estimated, by the UK's BEIS, at 0.88 tonnes CO2-equivalent tonnes per tonne of LNG.

However, supply chains with high flaring in the upstream, midstream and downstream can add considerably to the total life cycle emissions. If flaring is particularly high, flaring can double the CO2-equivalent emissions associated with the end-used combustion of the LNG (Figure 2, or equivalently, at 50% to the currently assumed end-to-end emissions).

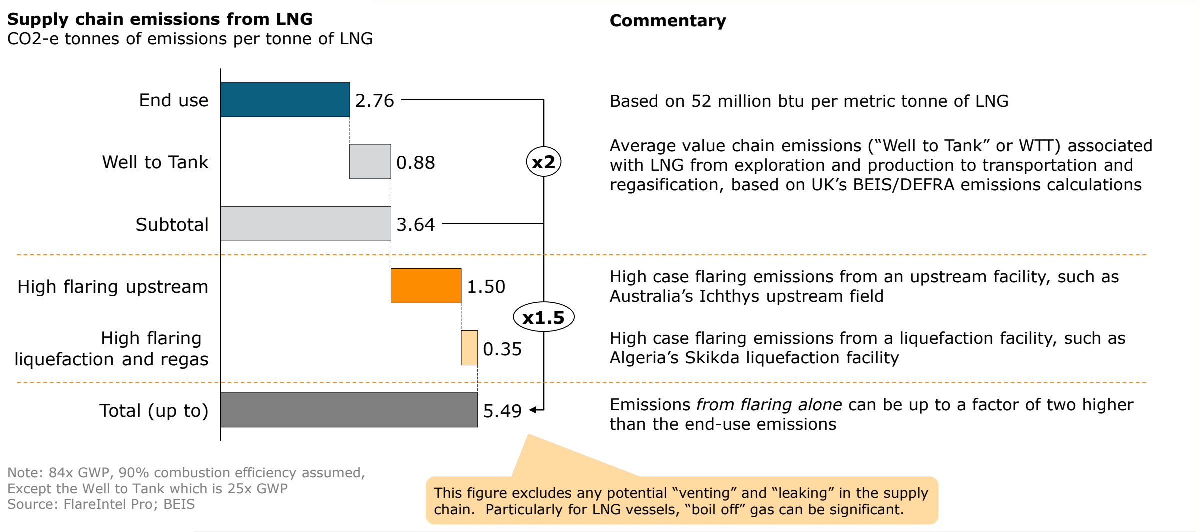


Figure 2: Overview of the lifecycle emissions from flaring alone associated with a high-flaring supply chain. The emissions from flaring can mean that the total supply chain emissions from flaring alone are double that of "scope 3" emissions. Global average scope 1&2 emissions are sourced from a study commissioned for the UK's DEFRA. Note the UK's estimate of Well to Tank emissions are on a 100-year GWP basis.

Let's explore this analysis across the value chain, with illustrations from specific assets.

Upstream emissions

Australia's Ichthys field (operated by INPEX) is an interesting case (Figure 3) not only because it has high gas flaring, but also because the asset is the single source of upstream production for Ichthys LNG. Other LNG liquefaction terminals (especially those sourcing gas from the Permian in the US) have much more complicated upstream supply chains, making it much harder to track the embedded emissions.

Indeed, until late November 2020, the *Ichthys* FPSO and platform regularly flared 50 million scf/day – we understand due to very high reservoir pressure combined with high condensate with potential slugging issues and insufficient capacity/performance associated with a gas booster compression module – leading to very high emissions. Yet this same asset supplied Total's first so-called carbon-neutral LNG cargo from Australia to Japan in October 2020 (and flared 58 million scf/day on the day of the announcement). Upstream facilities flaring at this level can add up to 1.5 tonnes CO2-e tonnes per tonne of LNG (although this particular asset may be particularly high). This realisation begs the obvious question: were the offsets paid for by Verra (formerly known as VCS, Verified Carbon Standards) emissions certificates sufficient to account for these very high rates of upstream flaring?

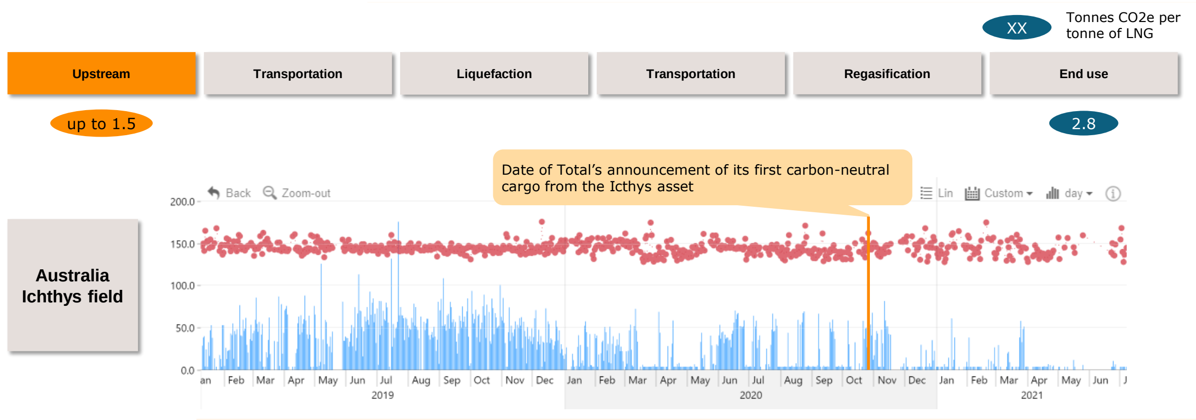


Figure 3: Flaring associated with Australia's Ichthys field, the upstream source for multiple LNG cargoes to Asia, including Total's first so-called carbon-neutral LNG cargo. The blue bars are the flaring volume (as measured daily, the red dots are the flare temperature). We estimate that the upstream flaring associated with this asset can generate up to 1.5 additional CO2-equivalent tonnes per tonne of LNG. The Ichthys field is the dedicated and sole supplier of gas to the Ichthys LNG plant. Upstream suppliers to other LNG liquefaction plants (e.g. in the US) are considerably more complex to resolve uniquely.

LNG liquefaction plant emissions

We have also observed large flaring volumes at liquefaction plants. Figure 4 illustrates regularly flaring up to 25 million scf/day at Algeria's Skikda liquefaction plant and regular flaring up to 30 million scf/day at Qatar's RasGas liquefaction plant. Both plants also show periods of very high flaring (of 100 million scf/day or more) associated with shutdowns and or operational problems, such as failures to compressors processing boil-off gases or insufficient capacity. These rates of flaring can add up to 0.3 CO2-equivalent tonnes per tonne of LNG.

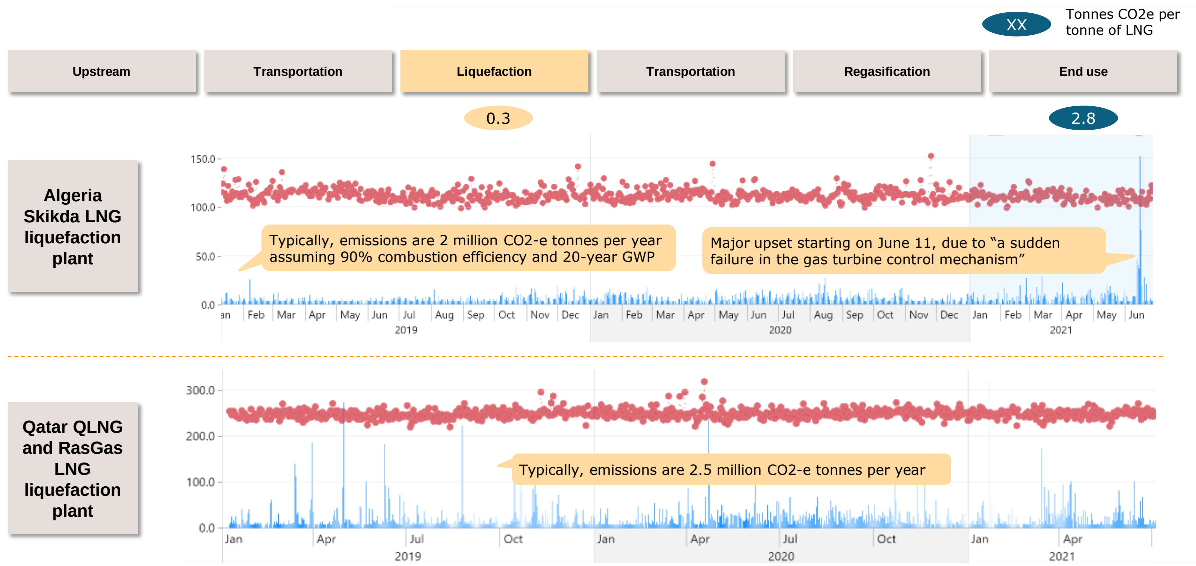


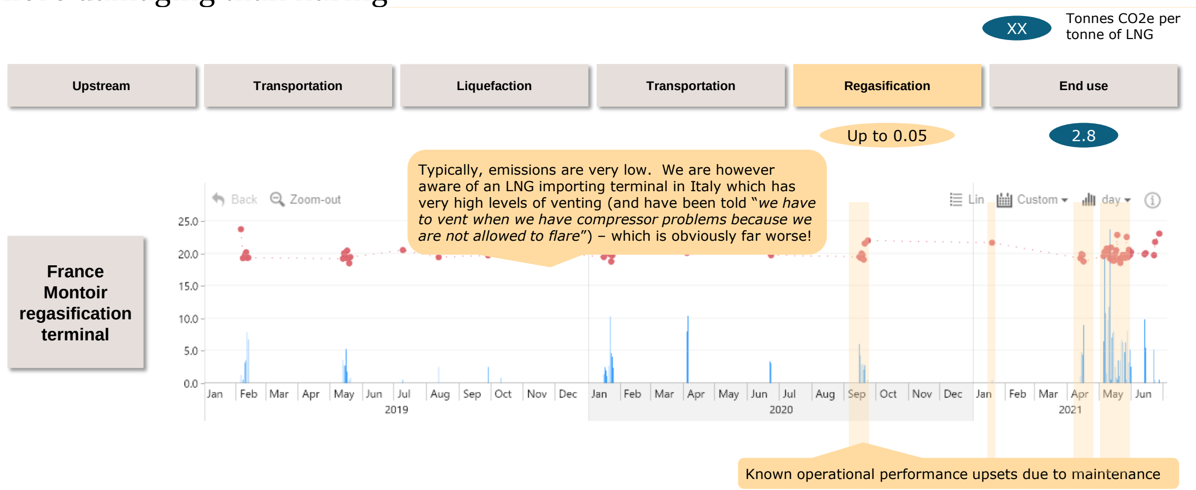
Figure 4: Flaring associated with Algeria's Skikda liquefaction plant, and Qatar's liquefaction plants. Both facilities generated around 2 million CO2-e tonnes per year, assuming 90% combustion efficiency of the flare, and a 20-year GWP. Both facilities have major periods of "upset" conditions, which are likely driven by issues around equipment maintenance.

LNG regasification plant emissions

Finally, we have also observed flaring at regasification plants. In general, flaring can happen if gasification plants don't have a boil-off gas compressor (meaning that the gas from storage tanks cannot be reintegrated into the gas transmission system), or if the LNG cargo transfer rate is too high.

Flaring at the Montoir regasification terminal (in Loire-Atlantique, France, operated by Elengy) is highly correlated to known operational performance (and is, therefore, can be used as a helpful diagnostic tool). For example, the major flaring in May was due to work being undertaken after a leak was found in gas lines and the flaring in September was due to the failure of a vapouriser. Other periods of flaring e.g. Jan 18th, April 13th 2021, all correlate with low LNG flows into the grid.

We estimate that flaring at Montoir adds some 0.05 CO2-e tonnes per tonnes of LNG (Figure 5). Interestingly, the Clean Air Taskforce (which has conducted site-level detection of methane surveys) has identified several major cases of venting. Ironically, one Italian regasification terminal chose to vent over flaring to avoid detection and to avoid breaching local regulation, despite the fact that venting is far more damaging than flaring.



Note: 84x GWP, 90% combustion efficiency assumed
Source: FlareIntel Pro

Figure 5: Flaring associated with France's Montoir regasification terminal. Whilst flaring is generally quite low, it is likely avoidable (as it is in many other regasification terminals). Flaring is, however, much more preferable than venting, which has been directly observed at an Italian regasification terminal.

How data can be used to prioritise intervention

To help operators prioritise action (and buyers to select lower-flaring cargos), we developed a methodology within FlareIntel Pro to segment flaring facilities into "archetypes" based on three parameters, namely flaring "volume", flaring "continuity" and flaring "variability". This approach has helped us to identify investment candidates for Capterio's core business (which is delivering real-world flare capture projects, by bringing together assets, technologies and financing).

Figure 6 illustrates our segmentation matrix for LNG terminals. Putting political factors aside, the easiest problems to solve, and arguable the most attractive investment cases are – in general – large, continuous and stable flares, such as the LNG facilities in UAE and Algeria (Skikda).

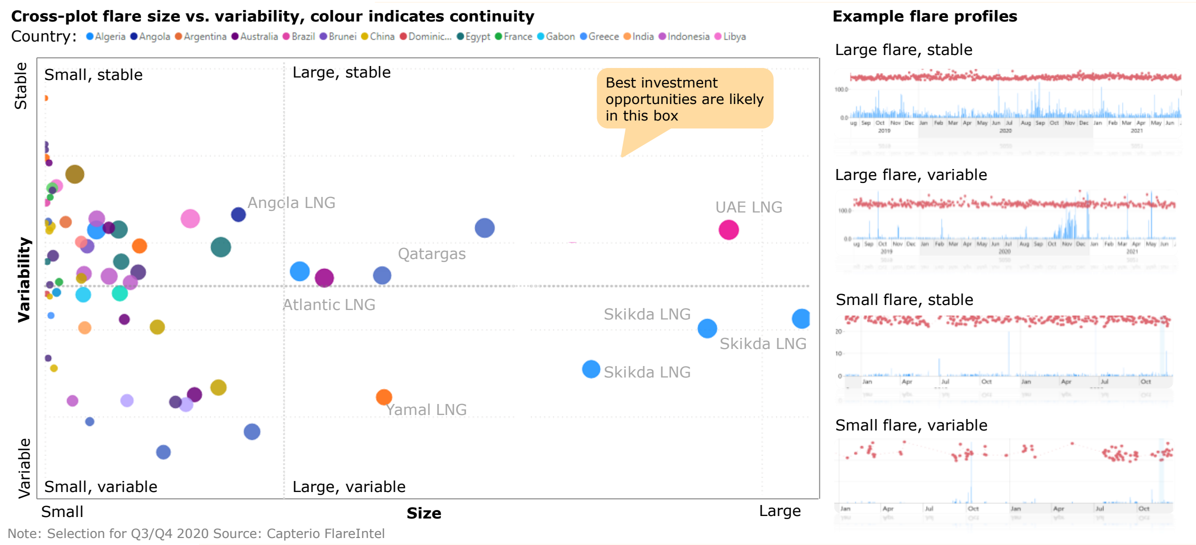


Figure 6: ***Capterio's flare project screening matrix for LNG liquefaction and regasification plants. Flares in the lower-left quadrant are small and have high variability; those in the upper-right is large and stable.***

As noted above, there are several common causes of flaring ranging from suboptimal or outdated design, lack of (or undersized) compression equipment, suboptimal operational control or poor equipment maintenance practices. We observed in the flaring data within FlareIntel, for example, a major operational upset at Algeria's Skikda facility between June 11-15 this year, which was attributed to a "sudden failure in the gas turbine control mechanism". Operators at liquefaction and regasification facilities may be able to reduce flaring either by optimising their operations or upgrading their equipment. Operators at upstream facilities may be able to reduce flaring simply by adjusting their operating pressure and temperatures. We have, for example, come across several examples of "false economies" where operators turn up their operating temperature by 10 degrees or more to assist in water separation from the gas (as a lower-cost solution to reduce the use of demulsification chemicals) without realising that this can lead to higher vapour content in product flows, leading to higher flaring. In all cases, credible measurement, monitoring and reporting is key to problem definition and delivering gas flaring solutions.

How data can drive accountability

Routine flaring needs to dramatically reduce for our industry play its role in halving greenhouse gas emissions by 2030. Almost 100 days ago, we launched our open-access tool FlareIntel to improve global awareness and transparency around flaring, improve accountability and accelerate flare reduction initiatives.

Rankings are an important part of this transparency, and in collaboration with Jefferies, the investment bank, we present in Figure 7, the "top 10" rankings along the dimensions of country, facility and operator. We also ran the analysis on IOC by equity, and by equity normalised to capacity.

As a project developer (we bring together assets, technologies and financing to deliver real-world solutions that materially reduce gas flaring), we are proud to already be working with many of the companies groups involved. The results speak for themselves and, we hope, will help operators to accelerate improvement.

- By country, most flaring comes from Algeria (some 74 million scf/day, three times higher than Qatar, despite the latter having a significantly higher export capacity). To put the volume figures in dollar terms, Algeria's flaring of 74 million scf/day is equivalent to $150 million per year of potential revenue;
- By facility, Algeria's LNG facilities, Skikda and Arzew are notably high, so too are the Qatar/Ras gas operations, Malaysia LNG and UAE's Das Island LNG;
- By operator, NOCs including Sonatrach, Qatar/Rasgas, Petronas and ADNOC dominate (based on 100% equity exposure);
- Finally, Shell, Total and bp dominate the IOC LNG flaring league table (on an equity-adjusted basis), although when also adjusted for utilised capacity, the order switches slightly. Shell's high flaring figure is driven by their exposure to assets in Qatar and Trinidad and Tobago (the latter is also relevant to bp). Total's position is driven by their assets in Yamal, Qatar and Nigeria.

The granularity of our data and our methodology goes even further, and enable us to determine many of the embedded flaring emissions at the level of an individual cargo. Such transparency would, we believe, a gamechanger for the industry.

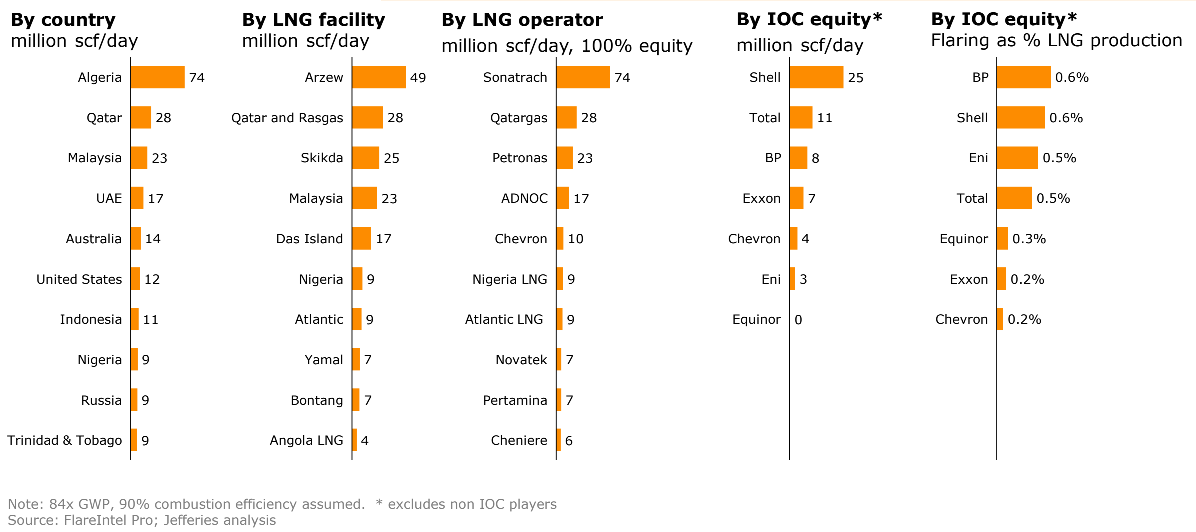


Figure 7: Rankings of LNG-related average flaring over 2018-2020 by country, facility, LNG operator (on 100% equity basis), IOC equity basis, and IOC equity flaring normalised to LNG production capacity. For the IOCs, the flaring is only associated with the liquefaction plants. We stress that this data is based on flaring only, and that emissions from flaring are only one element of the GHG emissions, and so methane from the value chain, including transportation and shipping is excluded.

Visibility on embedded emissions is increasingly important because blocks such as the EU are likely to seek to impose carbon border pricing on imported fossil fuels in due course (see our article *"gas flaring threatens Algeria's energy exports to Europe"*), and the US appears to be considering a similar direction. The impact could be material: a carbon price of $50 per tonne of CO_2 equates to a penalty of $2.5 per mmbtu, which would amount to a substantial "green premium" or penalty.

As the world becomes radically more transparent such independent, credible and verifiable approaches will become increasingly common. We are already seeing that diverse groups such as rating agencies, investors, fund managers, lenders, aggregators, consumers, citizens and governments are seeking to sharpen their understanding with better ESG metrics around flaring. And whilst this work has been focussed flaring, satellites are become increasingly adept at measuring methane, therefore enabling more precise assessments of end-to-end emissions.

Growing awareness has – for the better – led to more investigation into the credibility of so-called "carbon-neutral" LNG. Critically, consumers need standards and to be able to trust the emissions data, and buyers will increasingly seek to differentiate products based on their quality (potentially commanding "premium pricing" or higher market shares). Certification groups such as MiQ have a critical role to play to ensure the application of these standards.

Naturally, we also hope that increased awareness of company and asset performance will strengthen regulators' power, incentivise continuous operational improvements and encourage investment. Despite plenty of targets and commitments, execution to reduce flaring has been lacking. Now is the time for action.

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Capterio would like to thank Jefferies, several IOC operators, the World Bank, the IEA and the Clean Air Task Force for many lively discussions on this topic. We are grateful to the Colorado School of Mines' Earth Observation Group for their leadership.

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Suggested further reading about carbon-neutral LNG cargoes:

What is Carbon Neutral LNG? By Gavin Thompson from WoodMac

The Carbon Neutral LNG Market: Creating a framework for real emissions reductions by Erin Blanton and Samer Mosis from Colombia Center on Global Energy Policy

Methane Emissions from Natural Gas and LNG Imports: an increasingly urgent issue for the future of gas in Europe by Professor Jonathan Stern from the Oxford Institute for Energy Studies

Learn more about the underlying method of using satellite data to track flaring:

Elvidge, Christopher D., Mikhail Zhizhin, Feng-Chi Hsu, and Kimberly E. Baugh. "VIIRS Nightfire: Satellite pyrometry at night." Remote Sensing 5, no. 9 (2013): 4423-4449.