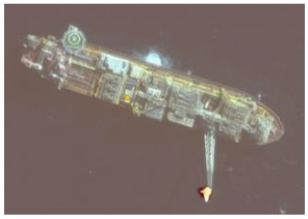
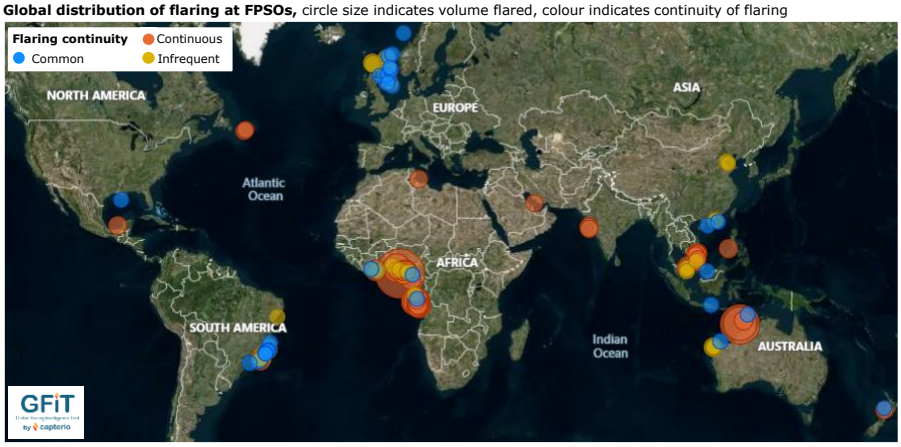
Flaring at FPSOs:

Out of sight, but not out of mind



Global distribution of flaring at FPSOs, circle size indicates volume flared, colour indicates continuity of flaring



A thought piece by capterio

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1600 words, reading time 5 minutes.

Executive summary

- **FPSOs are a significant source of gas flaring - some 4% of the global total, or 550 mmscf/d - almost $1 billion of potential revenue per year**

- **Our global dataset highlights that 16 "super-flaring" FPSOs account for 50% of this volume (and 8% of FPSOs are responsible for 80% of the flaring). Whilst these FPSOs are out of sight, they are certainly not out of mind. Capterio tracks every flare in real-time with its proprietary Global Flare Intelligence Tool (GFIT).**

- **The industry is already working very hard to reduce flaring, but there are options for improvement. In some cases, there are viable solutions to fix flaring in situ – the recent addition of booster compression modules on Total's super-flaring Ichthys FPSO is case in point. In other cases, there can be ways to debottleneck onshore facilities to create a solution downstream.**

- **By creatively finding solutions for a limited set of "super-flarers" flaring, the industry can make a real difference, reduce emissions, create value and accelerate the energy transition. With COP26 looming, its time to take the heat out of flaring.**

FPSOs ("Floating Production and Storage Offloading" facilities) have been used to develop offshore oil and gas fields since the 1990s. Today there are over 500 in operation. Operators often prefer them because of a combination of their mobility and flexibility, security, and (often) lower comparative cost.

Whilst FPSO vessels may be out of sight in remote offshore locations, they are not out of mind. Capterio's Global Flare Intelligence Tool (GFIT) uses satellite data to provide real-time intelligence on flare volumes and highlights not only some significant challenges at FPSO, but also some significant opportunities for improvement.

With today's increasing focus on net-zero ambitions and the challenges to the oil and gas industry's license to operate, it is more important than ever to tackle flaring and reduce its environmental impact. We explore flaring at FPSOs in detail in this paper.

What is the flaring landscape for FPSOs?

Today FPSOs contribute 550 mmscf/d or 4% of the world's total flaring (roughly equivalent to Libya or Mexico's total flare volumes), and 21% of all offshore flaring. Flares from 134 FPSOs were observable from satellites, suggesting that most do not flare volumes detectable by satellite (although they undoubtedly each have a small

flare, for safety reasons). Of the 134 FPSOs with detectable flaring, 8% (44 in total) contribute 80% of the flaring (400 million scf/ day), with 16 "super-flaring" vessels, responsible for 8 million scf/d.

FPSO flares are concentrated in West Africa (Nigeria, Angola, Ghana), followed by Brazil, Australia and the UK sector of the North Sea. As the map illustrates, FPSOs are frequently deployed not only in deepwater assets (e.g. Nigeria, Angola and Brazil), but also in shallow water (e.g. UK).

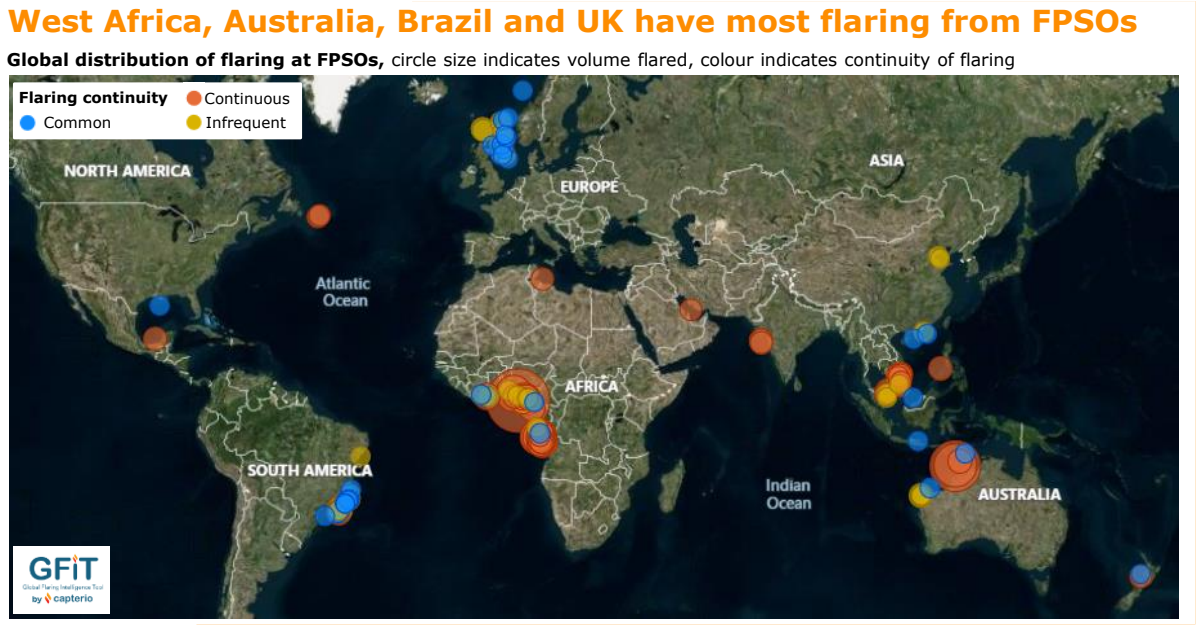


Figure 1: Map of FPSO flaring globally, in addition to volume distribution by country. Colours indicate the nature of the flares – those in red are flaring most of the time.

Australia stands out as having significant opportunity to improve. Flared volume per FPSO was, in 2019, 11 mmscf/d, with particularly high flaring due to Total and Shell. Until late November Total/Inpex's *Ichthys* FPSO regularly flared 50 million scf/day in 2019 (ironically, it flared 58 million scf/day on the day that Total announced its first so-called carbon-neutral LNG cargo into Japan in October 2020 – we doubt that these emissions are accounted for). Shell's *Prelude*, which has been beset with start-up and commissioning problems at least since January 2019, has seen many periods of dramatic flaring. As recently as late December, *Prelude* was flaring over 100 million scf/day, as Shell prepared for a resumption in LNG loadings in January 2021. The good news is that the majority of flaring at *Ichthys* and *Prelude* is now being addressed.

Figure 2 shows the distribution of flaring intensity at FPSOs. FPSOs naturally divide into 3 categories: the "super-flarers", the "average-flarers" and the "limited flarers". Most FPSOs actually have a flaring intensity (flaring volume per barrel of oil produced) one-third the global average (47 vs 176 scf/bbl). "Super-flarer" vessels are the source of most of the volumetric problem.

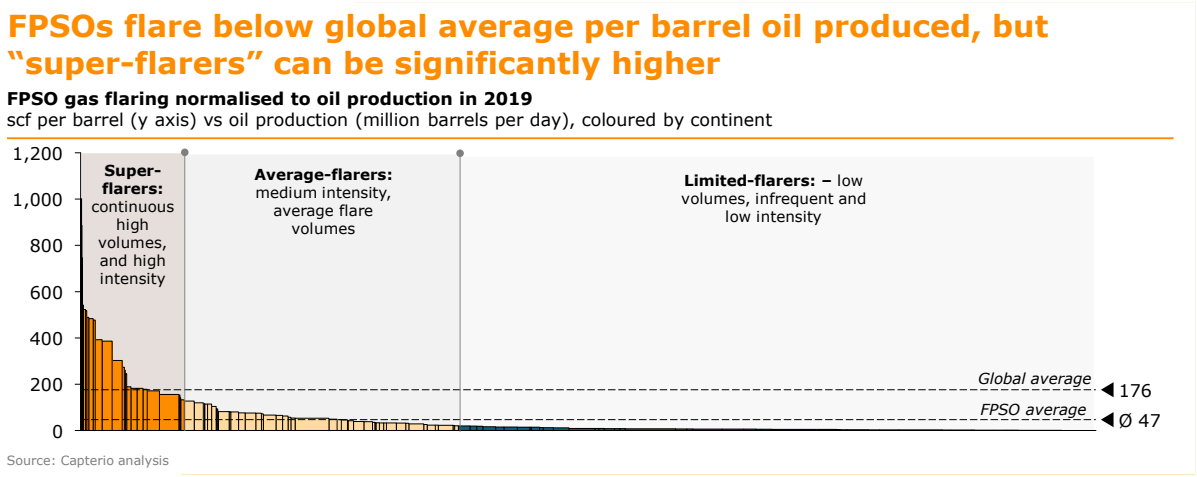


Figure 2: FPSO Flare intensity is significantly below the global average. FPSO flaring is concentrated amongst a minority of vessels.

The good news is that most FPSOs do not flare significant volumes observable by satellites. These FPSOs typically recover any waste gas and use it for on-vessel power generation, gas reinjection (to enhance oil recover), gas lift, gas disposal, pipe to shore, or (in a few cases) gas to LNG.

What drives FPSO operators to flare?

If an FPSO flares, flaring is driven by one (or more) of the following factors:

1. **Lack of local market, or lack of capacity in local markets** beyond local power requirements. Many FPSOs are physically remote with no access to gas markets. Where gas markets exist, local gas pipelines and/or downstream facilities are often bottlenecked – leaving the operator with the option to curtail their oil production or to flare.

2. **Relaxed regulators** which allow material flaring in order to maximise production and government income from royalties and taxes. Ghana is a case in point: the regulator has given special permission to Tullow to flare several tens of millions of scf of gas per day from the Jubilee and TEN fields (and the *Kwame Nkrumah* FPSO) throughout 2020 – thereby prioritising revenue over emissions.

3. **Operational challenges, especially during start up**, many of which become systemic. Examples include Shell's *Prelude* (which has had many issues, including LNG transfer, safety concerns and power trips associated with its start-up). Similarly, ExxonMobil's *Liza Destiny* had significant challenges with gas injection equipment on the new Liza field in Guyana. However, in contrast to Ghana, the Guyana regulator forced the operator to curtail production by half to avoid flaring over 15 million scf/day. Whilst starting up facilities can

often be challenging, Serica Energy has shown that it is possible to reduce such flaring by changing operational procedures.

4. **Legacy flaring from lack of original design consideration, and challenges retrofitting**. Many FPSOs were built before gas flaring was on the radar, and most super flaring FPSOs are old. Given the severe space constraints on FPSOs and the risk of interfering with ongoing production operations, it is often challenging or non-commercial to retrofit. Indeed, even FPSOs upgraded in the last ten years show significant flaring (figure 3).

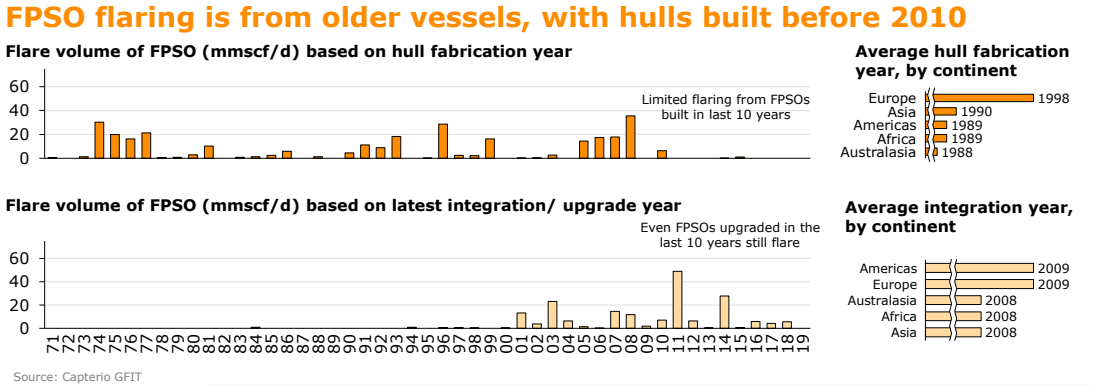
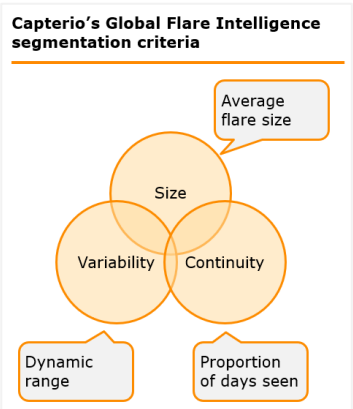


Figure 3: Timeline of flaring by hull fabrication year/ upgrade, in addition to average fabrication/ integration year by continent.

5. **Changing reservoir performance** leading to increased GOR, reduced reinjection capacity, or reservoir saturation, resulting in increasing volumes of associated gas.

What operational insights can flaring reveal?



Naturally, we do have considerable sympathy for the enormous technical challenges of operating in spaced-constrained environments. Yet our data can is often a useful diagnostic of operational performance.

To help prioritise action and support our project screening work, we have used our Global Flaring Intelligence Tool (GFIT) to segment the flaring FPSOs into "archetypes" based on the volume of flaring, the continuity of observation and the variability of the profile. We explore flaring continuity in Figure 4.

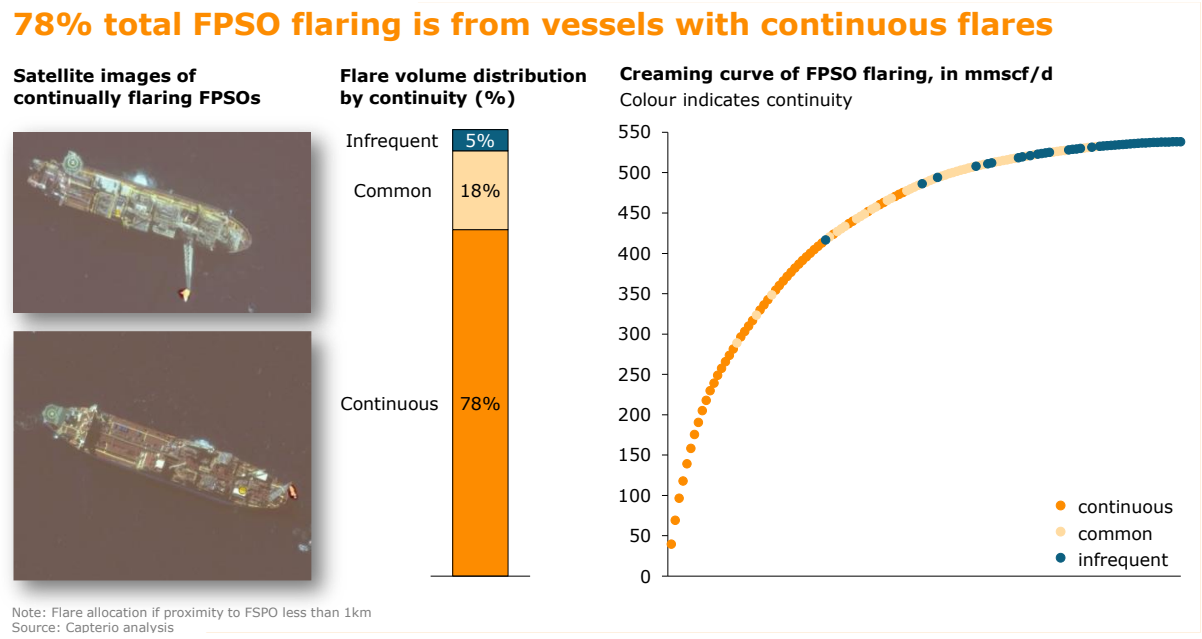


Figure 4: Satellite image of FPSO flares, distribution of volumes by flare continuity, and creaming curve of flare volumes, by flare continuity

Continuity is, of course, only part of the operational insight story. At Capterio, for our project screening work, we have developed a "variability" index to distinguish between stable flares and those with high flaring variability. FPSOs operate in one of 4 “archetypes”, based on size and variability – see Figure 5. Our tools can quickly analyse flares and their characteristics to identify the "sweet spot" where flare interventions are most likely viable – as illustrated in Figure 5.

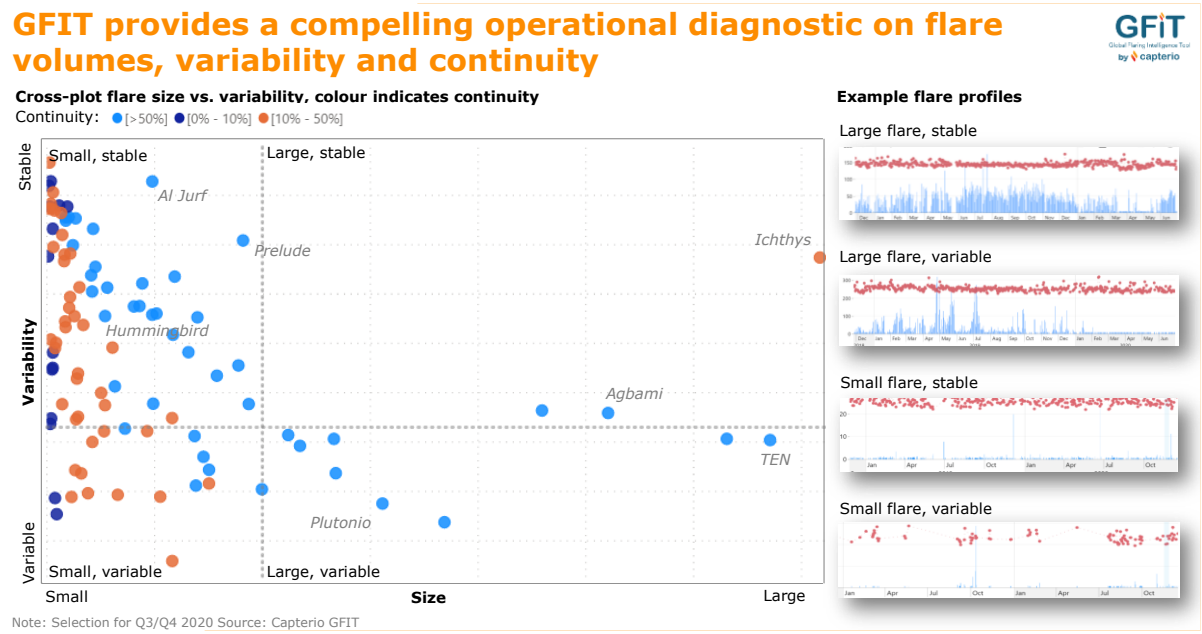


Figure 5: Capterio's flare variability matrix for FPSOs. Bottom-left quadrant is small, variable; top-right is large and stable.

What can be done to reduce FPSO flaring?

Technical solutions to flaring on FPSOs can be challenging, due to space and legacy design constraints. Yet we should at least prioritise finding solutions for at least the 16 "super-flaring" FPSOs (the source of half FPSO flare volumes). Key considerations for operators are to:

1) **Solve the intermittent issues**. Maintain proactive maintenance programmes to minimise shut-downs and keep pressures close to maximum design/safe operating limits.

2) **Upgrade the reinjection/ use for gas lift where possible**. 40% FPSOs in our dataset (for example, the Santos' *Ningaloo Vision*, one of the feature images) use reinjection for disposal or, (depending on the reservoir characteristics) for enhanced oil production) or for gas lift.

3) **Improve or upgrade equipment or pipelines**. Total/INPEX has recently installed booster compression modules on the *Ichthys Venturer* to debottleneck export lines, thereby reducing flaring. ExxonMobil managed to double its oil production after solving issues with gas compression equipment on *Liza Destiny*, also reducing flaring.

4) **Use for local power generation.** If the FPSO relies on diesel for power generation, there may be opportunity for diesel displacement – either on the facility, or for others nearby.

5) **Help to create new gas demand sinks/markets onshore**. bp has made major steps to reduce offshore flaring from the *Greater Plutonia* FPSO (and others) in Angola by capturing flared gas and sending it to their Angola LNG project, leading to reduced flaring by 44% since 2015. Other more creative solutions include (as one North Sea player is considering) using the excess gas to produce Hydrogen or Ammonia.

6) **If there are truly no utilisation options, maximise the flare combustion efficiency.** A flare with 80% combustion efficiency has 6x higher CO2e emissions than a flare with 97% combustion efficiency. Smokeless flare technologies (e.g. improving airflow at the flare, utilising flare monitoring systems) improve combustion efficiency and drastically reduce emissions. If there is space on the FPSO, a flare incinerator can deliver a much more efficient burn.

From our conversations with operators flaring at FPSOs, it is obvious that market dysfunctions and distorted incentives often limit technical fixes. To address these issues, we suggest that countries:

- Consider their gas master strategy. One West African country we know well could consider reducing imports of gas and instead stimulate the development of a local market for power.
- Reduce the complexity and cost of in-country operations and remove excessive, rigid, or redundant regulations.
- Step-up the effectiveness of their regulator(s). Encourage the metering of all flares and implement strict flaring penalties, rather than simply publishing permits.
- Enable greater "third-party" access to gas and power projects and infrastructure, so new players can deploy new technologies and operating models (see article: "Agile and Specialist Approach").

Other approaches and solutions have also been outlined in other articles. FPSOs offer a tangible "bite-size" opportunity to drive the industry towards the World Bank's Zero Routine Flaring initiative and broader alignment with net-zero ambitions. The good news is that majority of the problem lies with a select few vessels.

It's time to take the heat out of gas flaring. Capterio is a project developer that brings together assets, technologies and financing. Together, we can make it happen.

Capterio would like to acknowledge many individuals from the World Bank, the Global Gas Flaring Reduction (GGFR) programme, EBRD, IFC, OGCI, IEA, CCAC, MIQ, RMI, EDF, the Payne Institute, the Colorado School of Mines, SYSTEMIQ and many IOC and NOC companies and other institutions for many lively discussions which have contributed to this paper. The views, and any errors or omissions, are however our own.

About Capterio: Capterio is an agile and specialist project developer focused on monetising waste gas in oil & gas energy systems. We bring together assets with technologies, know-how and financing to deliver on-the-ground, real-world, safe and reliable solutions. We support our work with our unique Global Flaring Intelligence Tool (GFIT) which provides real-time insights into flaring for every asset, operator and non-operated partner worldwide.