“Burning Skies” Investigation Methodology

Our “Burning Skies” investigative series relied on a methodology developed by the environmental journalism consortium EIF, in partnership with the European Investigative Collaborations (EIC) network and their twelve media partners.

In order to reveal the toll of gas flaring across Africa and the Middle East and assess the responsibilities of western oil and gas majors, our consortium spent over a year investigating flaring locations across 18 countries during a eleven year period, from 2012 to 2023.

To achieve this, we cross-referenced yearly data about the geographical boundaries and ownership of more than 650 hydrocarbon infrastructures with flaring signals obtained from the organisation Skytruth. This flaring data was provided to Skytruth by the Earth Observation Group of the Payne Institute for Public Policy, from the Colorado School of Mines (see section 3.1).

Geographical scope and hydrocarbons licences:

Our geographical scope focused on the 18 countries listed below. These countries were selected based on data accessibility on oil and gas licences geo-data and flaring volume presence.

Countries that featured low levels of observable flaring emissions, such as Tanzania, were excluded from the research. Countries that had significant flaring emissions levels, but no supporting cadastre for hydrocarbon licences, were also excluded, such as Libya.

For each country, we retrieved oil and gas geo-data from either governmental sources or specialised scientific or corporate sources, such as The Energy Year.

The main sources used on a country-level, for licences geo-data, were:

- **Iraq:** Governmental source used: Ministry of Natural Resources, Regional Kurdistan Government (2013)
- **Algeria:** Governmental source used: The National Agency for the Valorization of Hydrocarbon Resources (ALNAFT), 2024
- **Nigeria:** Multi-stakeholder governance source used: Nigeria Extractive Industries Transparency Initiative, 2024
- **Angola:** Corporate source used: The Energy Year, 2023
- **Egypt:** Governmental source used: Egyptian Ministry of Petroleum and Mineral Resources, 2024
- **Oman:** Governmental source used: Oman’s Ministry of Energy and Minerals, 2023

- **United Arab Emirates:** Corporate sources used: The Energy Year, 2021 The Oil & Gas Year, 2019
- **Qatar:** Governmental source used: Qatar Energy, 2023
- **Gabon:** Industry source used: The Energy Year, 2022
- **Congo:** Governmental source used: Hydrocarbon Ministry of Congo, 2023
- **Cameroon:** Governmental source used: Hydrocarbon Ministry of Cameroon, 2019
- **Tunisia:** Government source used: ETAP (Entreprise Tunisienne d'Activités Pétrolières), 2023
- **Equatorial Guinea:** Governmental source used: Ministry of Mines & Hydrocarbons of Ghana, 2023
- **Chad:** Governmental source used: Republic of Chad, 2015
- **South Africa**: Governmental source used: Petroleum Agency South Africa, 2023
- **Ivory Coast**: Governmental source used: Ministry of Mines, Petroleum and Energy of Ivory Coast, 2022
- **Mozambique**: Governmental source used: INP - National Petroleum Institute of Mozambique, 2022
- **Ghana**: Governmental source used: Petroleum Commission of Ghana, 2021

Outdated maps were updated and fact-checked on an asset-by-asset basis, using numerous news and corporate sources, in order to ensure the accuracy of the geo-data we retrieved.

Oil and gas infrastructures and ownership details

We researched each oil and gas licence individually for every single year between 2012 and 2022. For each year, we included the name of the known "operator" in charge of running all operations included on a given licence. We recorded every change of operators we could identify during this period.

This information was retrieved from corporate press releases from the companies themselves, oil and gas governmental maps and cadastres and official journals from the countries involved in this research.

We tried our best to isolate flaring sources whenever they appeared to be linked to a distinct infrastructure (refinery, petrochemical facility, LNG terminal) within an oil and gas licence, in order to avoid the misattribution of flaring signals.

ENI asked to access our data and were presented with the opportunity to correct it, but did not request any modification.

3. Flaring sources and conversion factor

3.1 EOG's data and Skytruth's data

Our partners retrieved flaring data signals from Skytruth. This flaring data is attributable to the Earth Observation Group (EOG) of the Payne Institute for Public Policy, from the Colorado School of mines.

EOG's data uses the NASA's Visible Infrared Imaging Radiometer Suite (VIIRS), a sensor that "observes and collects global satellite observations that span the visible and infrared wavelengths across land, ocean, and atmosphere", in order to locate and assess flaring estimates on a global scale.

Relevant sources and credits for the EOG's methodology can be accessed here:

- Zhizhin, M.; Matveev, A.; Ghosh, T.; Hsu, F.-C.; Howells, M.; Elvidge, C. Measuring Gas Flaring in Russia with Multispectral VIIRS Nightfire. Remote Sens. 2021, 13, 3078. https://doi.org/10.3390/rs13163078

- Elvidge, C.D.; Zhizhin, M.; Baugh, K.; Hsu, F.-C.; Ghosh, T. Methods for Global Survey of Natural Gas Flaring from Visible Infrared Imaging Radiometer Suite Data. Energies 2016, 9, 14. https://doi.org/10.3390/en9010014

- Elvidge, C.D.; Zhizhin, M.; Hsu, F.-C.; Baugh, K.E. VIIRS Nightfire: Satellite Pyrometry at Night. Remote Sens. 2013, 5, 4423-4449. https://doi.org/10.3390/rs5094423//

EOG's team members informed us that observed flaring data had an interval confidence value of +/- 20%, due to several satellites overpassing the same location in some instances. Skytruth clusters some of this data in order to mitigate such "false positive" possibilities, which is why our consortium selected Skytruth's results for our lead publication.

3.2 Methane to carbon dioxide equivalent values

EOG and Skytruth's data are expressed in billion cubic metres (BCM) of burned methane (CH_4). We converted these values in tons of carbon dioxide equivalents ($MtCO_2e$), using the following conversion factor, communicated to us by the World Bank, which assumes a 98% burning efficiency rate:

(BCM)*2579000 = tons of CO_2e

We chose this burning efficiency rate as the most conservative one, despite recent studies stating that observable burning efficiency rate could actually be as low as 91% in some occasions, as mentioned in our lead publication article.

3.3 Attribution of emissions for comparative results

Oil and gas majors have various reporting methodologies, as there is no single and definitive industry standard for reporting flaring-related emissions.

For comparative figures and results, our consortium set a conservative and yet comprehensive standard in order to rank oil and gas majors emissions. We did so by using the most common approach used by companies such as ENI, BP, Shell and TotalEnergies, which typically attributes emissions rates to an operator, rather than, instead to the shareholders, of an asset.

Whenever more than one operator was found, or when we identified an operating joint-venture composed of various companies, emissions were divided according to the respective shares held by each company in a joint venture.

Example of emissions attribution for a joint venture:

> *Licence A is operated by Company A and Company B through an equity joint-venture and has flared 1BCM of flared methane.*
>
> *Therefore, Company A and Company B have each been attributed 0,5 BCM of flared methane.*

3.4 Attribution by year

As Skytruth's Flaring Volume data is provided in a yearly format, we had to account for changes of operators by attributing yearly emissions signals based on the duration of ownership during a given year.

This means that whenever a change in licence operator occurred within a single year, its emissions were attributed to the company that held the licence's operating rights for the longest period.

We set a threshold of 75% of ownership duration requirement (9 months) under which the licence's flaring amount was left unattributed.

Example of attribution by year during a change of operator:

> *Licence A changed operator from Company A to Company B between 1st of January and 31st of March → Company B was attributed the entire amount flared during the year.*
>
> *Licence B changed operator from Company A to Company B between 1st of April and 30th of September → The amount flared during the year was not attributed to any company.*
>
> *LIcence C changed operator from Company A to Company B between 1st of October and 31st of December → Company A was attributed the entire amount flared during the year.*

This means that our methodology tends to under-estimate the flaring volumes attributed to some operators, an approach we selected as the most conservative and fairest one.

3.5 Tailored attribution scenarios for Shell, TotalEnergies and ENI

Our partner newsroom NRC relied on EOG's data for their article on Shell in Nigeria, also including the year 2023 to their research.

A separate scenario was created for our partner newsroom Domani regarding ENI. This scenario is based on the company's own methodology, which reports full emission volumes of any given operated asset, regardless of shares of operating rights.

Under-reporting for BP and ENI was assessed based on all declared and non-declared years for the period from 2012 to 2022 compared to our own findings. To be noted that ENI did not provide any flaring data for the years 2012 and 2013.

Mediapart used two additional scenarios for TotalEnergies. First by calculating the flaring emissions using the exact same methodology as TotalEnergies (100% of emissions attributed to operated assets, 0% to all other assets), in order to be able to compare these figures with the ones published by the company.

In a second scenario, destined to take into account the responsibility of TotalEnergy in its non-operated assets, Mediapart attributed to the company the percentage of emissions equal to the percentage of shares held in these assets.

Nacional has used the latter scenario to calculate responsibilities of INA and MOL in non-operated assets too.

3.6 Attribution by country and region of origin of the operators

To attribute the amount of emissions to the country or region of origin of the operators responsible for these emissions, we identified the origin of each operator based on the registered address of their main offices.

We then summed the emissions attributed to all operators from a given country or region.

In the case of binational operators, the entire amount of emissions was attributed to both countries.

3.7 Attribution by country regulations

To attribute the amount of emissions to different types of regulations, we compiled the current and past flaring regulations in our 18 countries of interest, retrieved from governmental sources and public regulating bodies documentation.

We defined ‘prohibited’ regulations as any country and period during which a national law prohibits flaring - including in cases where operators are allowed to bypass this prohibition by obtaining a waiver.

We defined “unregulated” regulations as any country and period during which we could not find any applicable law in place to regulate flaring.

For any question regarding this methodology, please contact team@eiforum.org