Supplementary Materials

Likely underestimation of reported methane emissions from UK upstream oil and gas activities

Supplementary Material Section 1 - Offshore oil and gas extraction processes

Offshore production platforms extract an oil/gas/water mixture from beneath the seabed and pass this mixture into 2-phase separators, where gas is mostly separated from oil and water. Oil and water are then separated from each other and the remaining gas in 3-phase separators (Figure SM1). Natural gas from the 3-stage separator (flash gas) is injected into the export line via a vapor recovery unit (VRU), the gas then passes through export compressors (typically around ten 1,000 hp dry seal, electric start centrifugal engines) and a glycol dehydrator before being transported to shore in high pressure (> 100 psi) pipelines. Flash-gas is spontaneous vapor produced from the depressurization of the extracted oil mixture during separation. Ideally, all gas lost through the seal vents of the compressors and the dehydrators is sent to a low-pressure (LP) flare. When any of the export compressors are blown down or the VRU is offline, gas is sent to the high-pressure (HP) flare. In the event of excessive pressure, pressure release valves will also route gas to the HP flare.

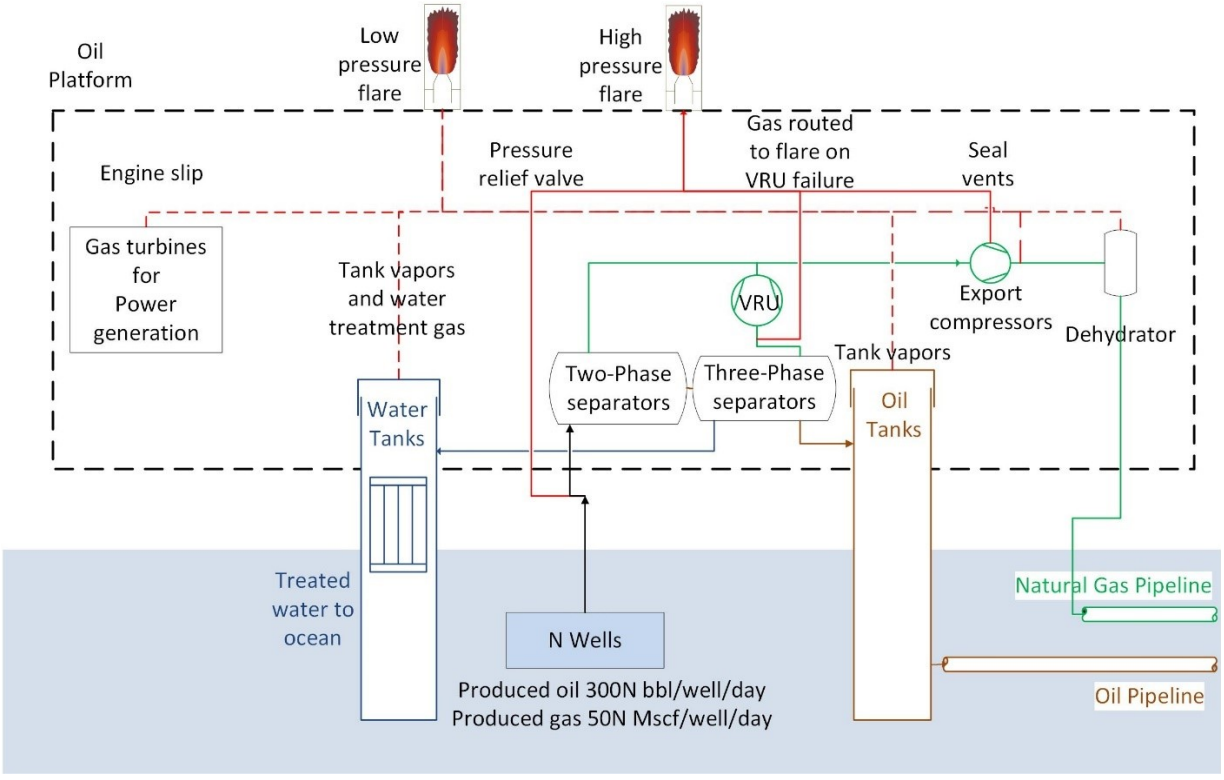

Figure S1 Production platform schematic. Shown here are major equipment components which can be sites of potential emissions.

Produced oil and water are stored in separate tanks that act as ballast for the platform. Oil is generally transported to shore via pipeline, while water is treated and then transferred back to the ocean. Any gas in the tank headspace is routed to the LP flare. Ideally, all pneumatics are controlled by compressed air instead of NG and any combustion slip from the gas turbines used to power the platform is also routed to the LP flare. Combustion slip is where unburned CH_4 is entrained in exhaust from natural gas-fired compressor engines

Supplementary Material Section 2 – NAEI emission factors in 2019

Table S1

NFR Code	Source	Fuel Name	Emission Factor (kilotonnne)	Activity Units
1B2b4_Gas_transmission_and_storage	Natural Gas leakage	Transmission	0.818141698	kt NG leaked
1B2c_Flaring_Oil	Upstream Oil - flaring	Combustion	1.08E-05	t
1A1cii_Oil_and_gas_extraction	Upstream Oil - fuel combustion	Gas oil	2.44E-06	TJ (net)
1A1cii_Oil_and_gas_extraction	Upstream Oil - fuel combustion	Natural gas	1.83E-05	TJ (net)
1B2a3_Oil_transport	Upstream Oil - Onshore Oil Loading	Crude oil	6.57E-09	t
1B2a3_Oil_transport	Upstream Oil - Offshore Oil Loading	Crude oil	4.48E-08	t
1B2c_Flaring_Gas	Upstream Gas - flaring	Combustion	1.08E-05	t
1A1cii_Oil_and_gas_extraction	Upstream Gas - fuel combustion	Gas oil	3.40E-06	TJ (net)
1A1cii_Oil_and_gas_extraction	Upstream Gas - fuel combustion	Natural gas	2.84E-05	TJ (net)

Supplementary Material Section 3 - Global distribution of offshore facilities in 2018

Table S2

Region	2018 Number of offshore platforms[1]
Gulf of Mexico	175
North Sea	184
Southeast Asia	152
Far East Asia	155
Persian Gulf	159
Mexico	88
Brazil	51
Western Africa	75
Venezuela	46
Caspian Sea	37
Rest of US	28
Mediterranean	26
Rest of South America and Caribbean	30
Black Sea	18
Australia	11
Red Sea	17
Canadian Atlantic	7
Alaska	5
Rest of Africa	5
Eastern Europe	3
Canadian Arctic	1
Canadian Pacific	1

Supplementary Material Section 4 – Regional variability in offshore venting and flaring and LDAR regulations

Table S3 Regional variability in offshore venting and flaring and LDAR regulations. P(%) refers to the percentage of global offshore platforms, R is if there a requirement for reporting of gas flared, Per - require permission to flare, Res - flaring restrictions, Pen - flaring penalties, V - Venting regulations , and LDAR – is leak detection and repair required.

Region	P (%)	R	Per	Res	Pen	V	LDAR	Category
Asia & Australasia	31	No	No	No	No	No	No	3
North & Central America	24	Yes	Yes	Yes	Yes	Yes	Yes	1
Europe	17	Yes	Yes	Yes	Yes	Yes	Yes	1
Middle East	12	No	Yes	No	No	No	No	3
South America	10	No	Yes	Yes	Yes	No	No	2
Africa	6	No	Yes	No	No	No	No	3

REFERENCES

1. Statistica. Number of offshore rigs worldwide as of January 2018 by region. https://www.statista.com/statistics/279100/number-of-offshore-rigs-worldwide-by-region/. Accessed 28/12/21. (2021).