Responding to Satellite Notifications from the Methane Alert and Response System

International Energy Agency

This report was prepared by the International Energy Agency (IEA), with valuable inputs and review from UNEP's IMEO.

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UNEP is the leading global voice on the environment. It provides leadership and encourages partnership in caring for the environment by inspiring, informing and enabling nations and peoples to improve their quality of life without compromising that of future generations. UNEP's International Methane Emissions Observatory exists to provide open, reliable, and actionable data to the individuals with the agency to reduce methane emissions.

Source: IEA.
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Website: www.iea.org

Abstract

In 2023, the International Methane Emissions Observatory launched the Methane Alert and Response System, the first global system to provide free satellite-based alerts on major emission events to governments. Prompt reaction to MARS notifications has led to the successful mitigation of methane leaks in several countries. However, the global response rate to MARS notifications remains relatively low, suggesting that further measures may be required to transform satellite alerts into actionable responses for governments.

The IEA, in collaboration with IMEO, has prepared this technical guidance document to assist governments seeking to improve action on MARS notifications and reduce methane emissions within their territory. The document proposes a five-step sequential process for responding to MARS notifications: (1) receive, assign and classify the notification; (2) notify the operator associated with the emission event; (3) operator responds to the notification; (4) verify the operator's response and follow-up; and (5) review and document information on the event. It also proposes indicative timelines for acting on such notifications. Recommended timelines vary according to the level of urgency assigned to the event, which is determined by the event's emission rate and whether the source is recurrent.

The IEA and IMEO are available to provide technical assistance to governments interested in adapting this framework to their jurisdiction's legal, operational and financial context. Governments interested in implementing this framework within their jurisdiction are encouraged to get in touch with IMEO and the IEA.

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Executive summary

In 2023, the United Nations Environment Programme's (UNEP) International Methane Emissions Observatory (IMEO) introduced the **Methane Alert and Response System (MARS)**, which uses satellite data (coupled with scientific expertise and artificial intelligence) to provide free notifications of large methane emission events to governments and companies.

MARS satellite alerts provide **rapid and actionable information** that can enable quick mitigation action. Swift action on major leaks or releases detected via MARS can deliver significant benefits for governments, potentially reducing gas waste, boosting sales by domestic companies and improving national energy security while simultaneously decreasing air pollution, minimising local health impacts and increasing productivity. More broadly, it may allow governments to achieve national emissions reduction objectives.

While the response rate to MARS notifications has increased since the system's introduction in 2023, overall engagement remains low: globally, only around 12% of MARS notifications received a response in 2025. This suggests that further support mechanisms may be needed to ensure satellite alerts translate into effective mitigation responses.

This **technical guidance document** is designed to assist governments seeking to improve the way they respond to MARS notifications and reduce methane emissions within their territory. It aims to support effective responses to MARS notifications, building on lessons from countries that have successfully responded to and mitigated satellite-detected emission events. The document proposes a **five-step sequential process** for responding to MARS notifications: (1) receive, assign and classify the notification; (2) notify the operator associated with the emission event; (3) operator responds to the notification; (4) verify the operator's response and follow-up; and (5) review and document information on the event.

In addition to this five-step process, the framework also proposes **indicative timelines** for acting on such notifications. These timelines are not intended to be rigid or binding but are instead meant to serve as a guideline for countries seeking to improve action on MARS notifications. Recommended timelines vary according to the level of urgency assigned to the event, which is determined by the event's emission rate and whether the source is recurrent (with the largest, most frequently detected sources receiving the highest priority).

The framework proposes **three distinct urgency levels** based on the magnitude and recurrence of emission events, each with its own proposed timeline: **urgent**

(Level 1); **fast** (Level 2); and **regular** (Level 3). The recommended timeline to complete all five response steps is 30 days for Level 1, 60 days for Level 2, and 90 days for Level 3. Ideally, any necessary mitigation action should occur within this timeframe (e.g. where the source is readily addressable). If this is not possible due to the complexity of implementing mitigation measures (e.g. cost or safety factors), the operator should develop a plan for implementing such measures, including a timeline for implementation.

Framework for responding to MARS notifications

	Level 1	Level 2	Level 3
1 • MARS focal point assigns official to the notification • Lead official classifies the notification	24h	48h	72h
2 • Lead official notifies likely operator • Other relevant authorities are informed	24h	48h	72h
3 • Operator identifies source and implements (or plans for) mitigation measures • Feedback form is filed with lead official	10 days	20 days	30 days
4 • Lead official verifies response • Follow-up activities if needed	10 days	20 days	30 days
5 • Event summary is added to government-managed database • Feedback is provided to UNEP's IMEO	8 days	16 days	24 days

Note: The timelines outlined in the framework are intended to be ambitious. While some actions may align with standard operator planning windows, recurrent emissions of this magnitude should be treated as emergencies and may necessitate responses outside typical operational procedures. Countries may adapt these timelines to reflect national circumstances and feasibility constraints. However, they are strongly encouraged to recognise the critical nature of such emission events when planning their response.

This framework can potentially serve its function as a non-binding guideline document. However, countries can strengthen the effectiveness of their response processes by ensuring that the MARS focal point and other competent authorities within the relevant jurisdiction have **clear legal authority** to request operators to take action to address large emission events. This includes the authority to require operators to respond to notifications, provide information on emission events, and implement mitigation measures. Countries should also ensure that the MARS focal point and other competent authorities have adequate resources to implement this plan and follow up on MARS notifications.

Throughout the process, countries should maintain close engagement with UNEP's IMEO. An open dialogue with IMEO allows countries to obtain targeted information to support the response process. For example, if a country or company implements a mitigation measure in response to a MARS notification, IMEO can provide information on whether the mitigation was successful or not. In addition, there is growing global attention on large emission events, and IMEO publicly releases information on whether MARS notifications received an answer and on whether successful mitigation action was taken. Engaging with IMEO may therefore allow countries to demonstrate credible emissions reduction efforts.

The IEA and IMEO are available to provide technical assistance to governments and companies seeking to improve action on MARS notifications. Governments interested in implementing this framework within their jurisdiction or in understanding the MARS programme more broadly are encouraged to get in touch with IMEO and the IEA at the following email addresses: unep-mars@un.org and iea-methane@iea.org.

Introduction

Methane abatement in the oil and gas sector is one of the fastest and most cost-effective options for reducing greenhouse gas emissions. Reducing methane emissions can deliver a range of benefits for governments and companies, including improved energy security, reduced local health impacts, and progress on achieving climate-related objectives. Among available strategies to reduce methane emissions, preventing and quickly addressing large emission events is essential.

Advances in satellite technologies have been key for detecting large emission events. While satellite technology is not perfect (with detections being more difficult offshore or in mountainous, snowy, icy, overcast and high-latitude regions), current satellites and data processing techniques can detect and measure a range of emission events, from major emissions over large areas down to smaller emissions (>100 kg/hr) at the facility level. In 2024, satellites detected nearly 5 Mt of methane emissions worldwide from very large leaks from oil and gas operations.

In 2022, UNEP's IMEO introduced MARS, the first global system to provide free satellite-based alerts on major emission events to governments, enabling them to take action to minimise waste and reduce emissions. MARS is not limited to governments: it also notifies operators regarding large emission events occurring within a facility under their control.

MARS has so far detected over 10 000 methane plumes from oil and gas activities worldwide and notified more than 5 000 actionable events in 34 countries. Prompt reaction to MARS notifications has led to the successful mitigation of methane leaks in several countries. However, the global response rate to MARS notifications remains relatively low. Only 12% of notifications received replies in 2025,[1] suggesting that further measures may be required to transform satellite alerts into actionable responses for governments and companies.

Nominating focal points is fundamental to streamlining communication and holds significant potential for improving response rates. As of early 2026, 24 countries and nine subnational governments (across all continents) have designated focal points to receive IMEO notifications. In countries that have nominated a focal point, nearly a third of emissions sources receive a response, and several countries – including Argentina, Brazil, Mexico and Yemen – have response rates

[1] Under IMEO procedures, a notification is considered to have been "answered" when the focal point responds with information on the detected event. A response does not necessarily mean mitigation action was taken.

close to 100%. This contrasts with a 2% response rate across the 14 countries that have received MARS notifications but have no focal point, nine of which have a 0% response rate.

In addition to nominating MARS focal points, following through on MARS notifications with rapid and effective mitigation action is crucial for resolving large emission events and achieving impactful emission reductions. This document sets out a step-by-step framework for governments to respond to MARS notifications and quickly address large emission events. Governments can use this framework to achieve swift mitigation action and minimise gas waste, leading to reduced emissions, improved energy security, and lower local health impacts. The framework can be embedded within, or may build upon, existing national emergency response protocols.

Operators can similarly use this framework as a starting point for their own quality, health, safety and environment systems, including standard operating procedures, incident management systems, and continuous improvement efforts. Operators can use this framework to build procedures for integrating satellite alerts within standard management protocols (e.g. process safety protocols based on the American Petroleum Institute's Recommended Practice 754).

A successful MARS response framework depends on effective mitigation of satellite-detected emission sources. Support is available for countries and operators seeking to implement policies and measures to abate energy-related methane emissions. Several programmes offer regulatory, technical, and data-related support to countries looking to improve methane monitoring and management, including IMEO's Oil and Gas Methane Partnership 2.0 (OGMP 2.0), the Climate and Clean Air Coalition's Fossil Fuel Regulatory Programme, the World Bank's Global Flaring and Methane Reduction Partnership, the Oil and Gas Climate Initiative (OGCI), and the Global Methane Hub. Countries looking for support on methane monitoring and management are encouraged to reach out to these programmes. The IEA and IMEO are also available to connect countries with these programmes.

Background on MARS process

Satellite detection approach

UNEP's IMEO uses data from 35 satellites for MARS, 17 of which are utilised for direct notification of major emission events. These satellites are equipped with methane-sensitive sensors to monitor and detect emission events in near real time and generally fall into two categories: (1) area flux mappers; and (2) point-source imagers. All detection methodologies applied within MARS are based on peer-reviewed science, and the underlying satellite imagery is publicly available, enabling independent verification of results by any stakeholder.

Through MARS, IMEO first uses area flux mappers to identify the regions where methane concentrations are elevated over time (commonly referred to as "hotspot" regions) or to detect very large methane plumes (i.e. those with an emission rate greater than 10 000 kg/hour). Further analysis is then conducted using point-source imagers (also known as high-resolution satellites, with a pixel size of approximately 30 metres), which can pinpoint specific emission sources with higher accuracy, even down to the facility level.

To process the high volume of satellite data, an IMEO-designed artificial intelligence algorithm first conducts an initial scan to detect potential methane plumes in all new available images. If IMEO's algorithm identifies a possible emission event, the candidate detection is independently reviewed and validated by at least two IMEO remote-sensing experts. To validate the plume detected by IMEO's algorithm, the IMEO experts examine additional image information and context, such as the quality of the observation (e.g. cloud cover, smoke, surface artefacts, or noise level) or the consistency of the methane enhancement with the location, wind direction and history of past observations at the same site.

Following the validation of the observed emission event, IMEO analysts compare the satellite data with visual imagery and available databases of infrastructure and ownership of oil and gas facilities. Analysts then connect emissions to facilities, and facilities to potential operators, within a country.

Notification process

Once a plume has been validated and attributed to a facility and operator, IMEO notifies the relevant country through an email alert and a report summarising key information on the detected emission event (see Annex A), including the event's coordinates, the time of detection, the estimated emission rate (in tonnes per hour), the satellite instrument used for detection and images of the plume.

Notifications are usually sent between 24 hours to 7 days after satellite detection, enabling quick action during ongoing emission events.

The notification report is always shared with the government-nominated focal point(s). If no MARS focal point has been designated by the government, the report is shared with the UNEP Permanent Representative from the concerned country, with the hope that the information will be shared with a government entity who can in turn communicate with the operator. Additionally, if the facility in question is determined to belong to a member of UNEP's OGMP 2.0, IMEO also notifies the relevant member (whether the member is an operating or non-operating partner). Entities that are not part of OGMP 2.0 may request to receive MARS notifications by joining OGMP 2.0 or by reaching out to IMEO.

Focal points are encouraged to acknowledge receipt of the notification, immediately share it with the identified operator, and provide feedback from the operator to IMEO.

Following detection of a large emission event, IMEO conducts further monitoring of the location of the emission source to assess if the source is still emitting or if any reported mitigation action has been successful. Thirty days after sharing the alert, IMEO makes the observed emissions and non-confidential data on the source publicly available on IMEO's Eye on Methane Data Platform, including information on whether feedback has been received.

Focal point nomination

Since MARS' introduction in 2022, UNEP's IMEO has worked alongside partners, including the co-conveners of the Global Methane Pledge (the European Union and the United States), to encourage governments to nominate focal points to receive MARS notifications. The nomination of a focal point has a clear effect on improving the response rate to MARS notifications and should be the first step for any effective notification response system.

Governments can adopt different approaches for the selection of focal points. Some countries have nominated multiple focal points across various government entities. Others have selected a singular individual, and many have nominated representatives directly within the country's national oil and gas company.

Ideally, governments should ensure that at least one focal point has the power to contact the oil and gas industry and request mandatory responses from operators in case of a large emission event. Focal point effectiveness can also be enhanced by nominating individuals or entities that already have responsibility for emergency response management (e.g. civil protection authorities), reducing the need to create new roles and procedures.

Jurisdictions nominating MARS focal points should ensure that the focal point is equipped with sufficient resources and personnel to carry out its responsibilities. UNEP's IMEO can also provide training to the focal point's team concerning the basics of methane detection and abatement, resulting in improved government responsiveness to satellite-detected events.

Role of the International Energy Agency

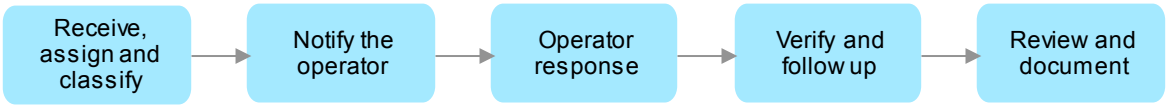
MARS is managed by UNEP's IMEO, which maintains partnerships with a range of international and intergovernmental organisations to support its mission. The IEA, through its Global Methane Engagement Programme (GMEP), provides bilateral technical support to countries and companies seeking to reduce methane emissions, including with regards to emission estimates, abatement costs and regulatory strategies.

As part of the GMEP, the IEA, together with IMEO, has prepared this response framework for countries seeking to more effectively respond to MARS notifications. The IEA and IMEO are available to provide technical assistance to governments and companies interested in adapting this framework to their jurisdiction's legal, operational, and financial context, including by providing advice on roles and responsibilities and by assisting with the creation of dedicated tools and resources (e.g. responsibility matrices). Jurisdictions interested in such support are encouraged to reach out to the IEA and IMEO to discuss options for assistance.

A step-by-step guide to respond to MARS notifications

This technical guidance proposes a five-step framework for responding to MARS notifications. It outlines a sequential process with key actions that should be taken to ensure that large emission events are mitigated and that future events are prevented. While this technical guidance is primarily aimed at governments seeking to improve action on MARS notifications, addressing and resolving large emitting events requires action from both governments and operators. Accordingly, the framework also incorporates actions that need to be taken by operators, including source identification, mitigation action, and provision of feedback to the government-nominated focal point.

A five-step framework for responding to MARS notifications



This guidance is not intended to be rigid or static. Jurisdictions that receive MARS notifications can tailor the framework so that it best corresponds to their legal, operational and financial contexts. Jurisdictions interested in adapting this framework have a range of options for how to best integrate it within their existing regulatory and operational framework. For example, it can be adopted as a regulation under existing oil and gas legislation, or it can be implemented as a non-binding guidance by government authorities.

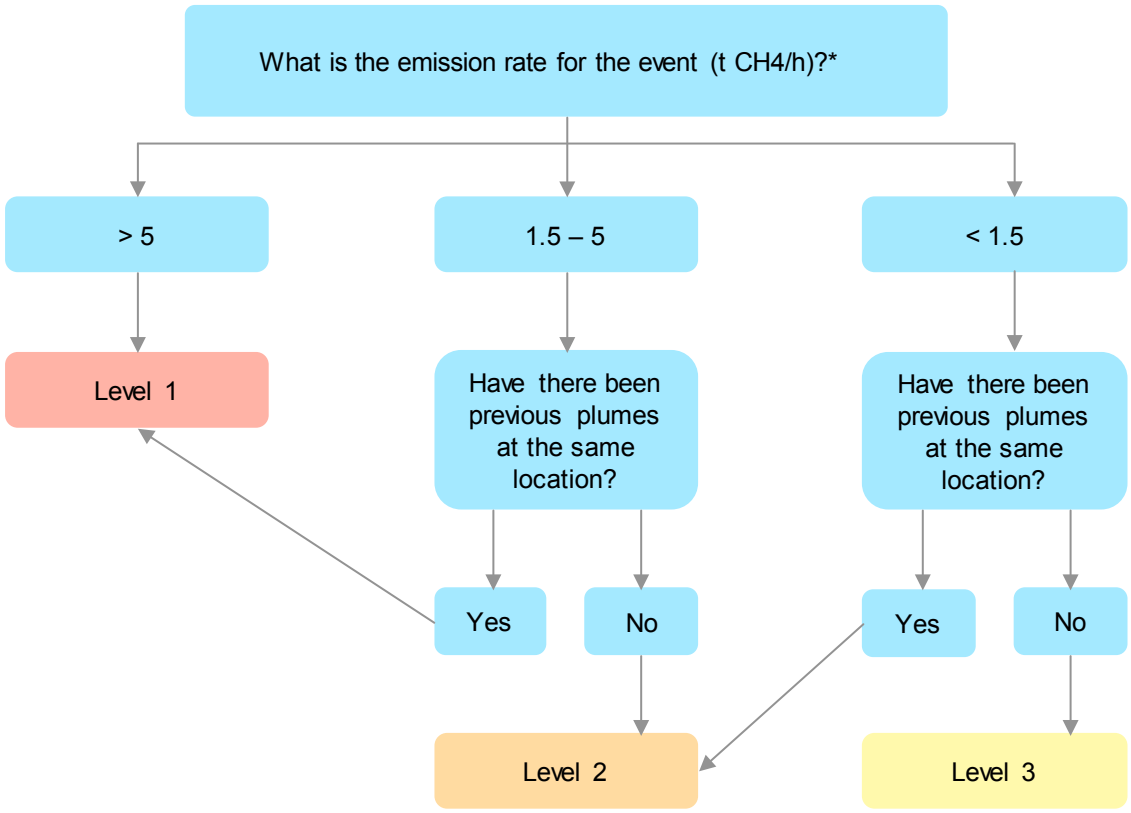
The framework is also not intended to be rigid or static from a technological perspective. The oil and gas sector is dynamic, and new technologies are constantly emerging. Retaining flexibility and the capacity to adapt is key to effective response strategies. This framework can be continuously improved and should evolve with new technological developments.

Step 1: Receive, assign and classify

The response process is triggered when UNEP's IMEO sends a notification to the government-nominated focal point. As noted, once a plume has been validated and attributed to a facility and operator by IMEO experts, IMEO notifies the relevant country through an email alert together with the report in Annex A.

After receiving the notification, the government-nominated MARS focal point is responsible for assigning it. The MARS focal point can either assign the notification to themself or to a member of their team. The person assigned to the notification (hereafter referred to as "the lead official") is responsible for overseeing implementation of Steps 1 to 5 (as described below). Within Step 1, the lead official should first classify the notification according to its level of urgency. Level assignment is done based on the decision tree set out below.

Decision tree for the classification of a MARS notification



*The plume's emissions rate and information on previous plumes are provided in the MARS notification (see Appendix I in Annex A). Estimated flux rate ranges are general examples only and can be adapted according to typical ranges observed within the jurisdiction in question. UNEP's IMEO can support the definition of appropriate ranges based on the history of detections in specific jurisdictions.

Notification levels vary according to the event's magnitude (i.e. the event's estimated emission rate) and its recurrence (i.e. whether previous plumes have been observed at the same location). The level assigned to the notification dictates

the recommended timeline over which the different steps in the response process should be completed (as described below), facilitating timely mitigation action. A tiered approach ensures that sources with the largest emission potential are addressed first, while other lower-priority sources are tackled on a longer-term timeline.

Emission rate ranges set out in the decision tree above have been selected according to global ranges observed by MARS. Events with an emission rate above 5 t/hour correspond to the top 25% of events observed since MARS' introduction in 2023, while events with a rate between 1.5 and 5 correspond to 50% of observed events. Events with a rate below 1.5 correspond to the bottom 25% of observed events.

While the emission rate ranges proposed in the decision tree are based on the distribution of globally observed events, it is important to note that such ranges are only examples. These ranges can be adapted to specific jurisdictions according to typical levels observed within the jurisdiction or according to its preferred urgency approach. Jurisdictions may also choose to incorporate additional criteria within the decision tree to elevate the urgency of certain sources (e.g. safety concerns, proximity to population centres, asset type, etc.). Other countries, particularly those with relatively few notifications, may choose to treat all notifications pursuant to a Level 1 timeline.

After assigning a response level to the notification, the lead official should open a case file for the notification with a unique identification number. The unique identification should include both the plume identification number (Plume ID) as well as the source identification number (Source ID), both of which are indicated in the MARS notification (an example of a MARS notification is available in Annex A).

As noted above, each level has its own recommended timeline for completion. Accordingly, the timeline for opening a case file varies according to the notification's level (see below). Notifications with higher mitigation potential or urgency, such as those involving large emission rates or sites with previously notified emissions, are prioritised and follow accelerated response pathways.

Response tracks and recommended timelines for completion

Level	Track	Recommended timeline to complete Step 1
1	Urgent	< 24 hours
2	Fast	< 48 hours
3	Regular	< 72 hours

Note: Shows indicative recommended timelines. The timeline for classification and assignment will vary depending on the complexity of the event and available information.

Level 1 is the most urgent response track. At this level, the lead official should aim to process the notification (classifying, opening a case file and creating a unique identification number) within 24 hours of receiving the notification from IMEO. Notifications classified under Level 2 should be processed by the lead official within 48 hours of the MARS focal point receiving the notification, while notifications classified under Level 3 should be processed within 72 hours. Completing this step as quickly as possible is preferable in all scenarios.

Glossary of key terms and definitions

Lead official: Staff member assigned by the government-nominated MARS focal point to handle the MARS notification and oversee the implementation of Steps 1 to 5.

MARS focal point: Individual or institution nominated by the government to receive direct notifications from UNEP's IMEO.

Operator: Entity operating the oil and gas facility associated with the large emission event detected via satellite. This can be a private sector company or a public sector body (e.g., the national oil company).

Jurisdiction: National or subnational government that has nominated a MARS focal point and that has responsibilities related to managing methane emissions over a given territorial area.

Step 2: Notify the operator

Once the notification has been processed, the lead official should aim to confirm the operator (or operators) that is most likely associated with the event and notify it accordingly. IMEO provides a potential operator in the MARS notification (see Annex A), which is assessed based on location information and publicly available datasets. However, this information may not always be accurate, and the lead official should strive to confirm that the potential operator identified by MARS is the correct one.

If the site is one where plumes have previously been notified, and the operator identified in the MARS notification is the same one that was involved in previous notifications, the lead official should notify that operator. If the site is one for which no previous plume has been detected, the lead official should confirm the operator by assessing the potential operator provided in the MARS notification, as well as the event's geographical coordinates and related information. Government authorities and companies should assist with this task whenever solicited.

Once the operator has been confirmed, the lead official should notify the operator based on the email template outlined in Annex B, attaching the MARS notification form (an example of which is provided in Annex A). The lead official may also notify other government stakeholders to support a coordinated response (e.g. health and safety officials). The recommended timeline and method for notifying the operator varies according to the notification's level, as set out below. These recommended timelines build upon the previous ones under Step 1, meaning they begin from the moment Step 1 has been completed (i.e. when the notification has been assigned and classified).

Notification method and recommended timeline

Level	Recommended notification method	Recommended timeline to complete Step 2
1	Phone and email	< 24 hours
2	Phone and email	< 48 hours
3	Email	< 72 hours

Note: The lead official should note in the notification case file each attempt to contact the operator and whether the notification was acknowledged.

The lead official should request confirmation from the operator upon receipt of the notification. The confirmation of receipt should be recorded and saved by both the operator and the lead official.

If the lead official assesses that the facility responsible for the emission event falls under the control of a company that participates in OGMP 2.0 (either as operator or owner), the lead official should communicate with the company to check that it has separately received a direct notification from MARS. If this is not the case, the lead official should notify the operator in the manner described above.

If the operator notified by the lead official says the facility is not under its control, the lead official should attempt to contact other operators in the vicinity. The lead official should also update any national database accordingly once the correct operator has been identified.

Facilitating identification of domestic oil and gas operators and facilities

Effective implementation of Step 2 depends on correctly identifying operators and facilities involved in the satellite-detected large emission event. Yet in some cases, the MARS focal point and other government authorities may not have comprehensive and accurate information on local oil and gas facilities and on who operates these facilities, hindering the process of notifying the relevant operator.

To facilitate the process of identifying operators under Step 2, relevant government authorities (e.g. energy or environment ministries) can request that oil and gas companies report facility locations, managers and contact means. They can also ask operators to update information upon any change (e.g. when a new facility is added or when a new manager is appointed). Government authorities can also request that oil and gas companies designate contact points to receive notifications of satellite-detected events, speeding up the process of informing operators of ongoing leaks.

Step 3: Operator response

Upon receiving the notification from the government-nominated focal point, the operator should start a procedure to identify the most likely source of emissions. In general, sources tend to be located within the plume's boundaries or within 100 metres of its edges.

To investigate the source of emissions, operators can begin by performing a desktop analysis of relevant data and records. This may include reviewing operational logs, examining recent maintenance or process activities and consulting data from control devices. In some cases, performing a desktop analysis may be sufficient to identify the source of emissions.

If the operator is unable to identify the probable source of emissions based on a desktop analysis, it should conduct a physical field visit. Operators can screen the facility through audio-visual-olfactory methods or through more advanced methane detection technologies, for example optical gas imaging cameras, aerial measurement technologies, or gas detection equipment.

To facilitate the process of source identification, operators can catalogue equipment that is susceptible of generating emissions within their facilities, proactively estimate the emission potential of this equipment, and categorise equipment according to its emission potential. When the operator receives a MARS notification, it can then focus on equipment with an emission potential that is roughly equivalent to the emission rate indicated in the MARS notification. Using an "order of magnitude" analysis of this nature can greatly accelerate the process of determining the source of emissions.

It is important to note that, even where no active emission source is identified, this does not necessarily mean that no emissions occurred; the source may simply have been short-lived or intermittent. Lead officials should recognise that MARS detections are very rarely wrong.

The recommended timeline for source identification is 5 days for a Level 1 response, 10 days for a Level 2 response and 15 days for a Level 3 response (starting from the moment when the operator receives the notification from the MARS focal point).

If a source is identified, the operator should check if it is still emitting. Some sources may be readily addressable by the operator (e.g. an unlit flare or a malfunctioning valve). Other sources may only be addressable on a longer timescale, for example because of the need for equipment shutdowns, rerouting of processes, changes in maintenance practices or operational procedures, or broader infrastructure modifications (with larger capital investment). Where the source can be readily addressed (and particularly when corrective action is within the purview of field staff to carry out), the operator should strive for a mitigation response as soon as possible. For sources that require longer mitigation timelines, operators should integrate measures within upcoming planned shutdowns or devise wider investment plans for the implementation of methane abatement measures and technologies within operations. Operators are encouraged to apply relevant best practices to mitigate emissions.

Best practices on source identification and mitigation: Examples from previous MARS notifications

Through the end of 2025, IMEO confirmed 25 mitigation actions in 10 countries following MARS notifications. These cases demonstrate the opportunity for operators to use MARS notifications to direct near-term mitigation. In Kazakhstan, for example, an operator identified the source of a MARS notification without specialised equipment, harnessing audio-visual-olfactory methods and soap foam testing to locate a leaking valve, which the operator was able to quickly repair. Similarly, MARS notifications helped the Yemen Oil and Gas Corporation (the national operator) identify several leaking valves that were collectively creating a large emission event. By repairing and replacing several of the valves with available resources, the operator was able to successfully reduce the magnitude of emissions while starting a process to secure resources for further repairs.

Even in cases where direct mitigation is not necessary (e.g. a short duration event), operators may learn from MARS notifications to avoid similar emissions in the future. For example, an OGMP 2.0 member company with operations in the Middle East received a MARS notification during a maintenance procedure. Following the event, the operator developed a poster with guidelines on how to avoid emissions during similar maintenance exercises, shared the poster with relevant teams, and held information sessions to ensure all staff were aware of applicable procedures.

In addition to taking mitigation measures or planning for such measures, the operator should perform a root-cause analysis of the event. Determining the root cause of the event can help the operator understand whether there is a risk of similar events happening again in the future, including for other sources at the same facility or for other facilities. If the operator determines that an event is likely to reoccur, it should implement measures to reduce this risk. Measures may include routine inspection and maintenance, training on leak detection and repair (LDAR), installation of automatic ignition systems, and continuous monitoring. In addition, a root-cause analysis can offer useful lessons for operators, which can be integrated within operational and maintenance plans and used to build a company-wide preventative programme. One option, for example, is to circulate lessons learned through the root-cause analysis within the company and across facilities, in order to reduce leak occurrence at different sites. Operators seeking support and training on best practices for methane management can use existing resources, including OGMP 2.0 and OGCI.

While the operator is addressing the notification, regulatory authorities may request updates on the response process, observe response procedures, and request that specific actions be taken by the operator (e.g. on-site optical gas imaging).

The next step is for the operator to complete and file the feedback form (see template in Annex C). The feedback form should be completed and returned to the lead official within 10 days for a Level 1 response, 20 days for a Level 2 response, and 30 days for a Level 3 response (starting from the moment when the operator receives the notification from the MARS focal point). The operator should complete the feedback form truthfully, accurately, and comprehensively. In addition, the form should be completed regardless of whether mitigation action has already been taken (e.g. where the source is readily addressable), is ongoing, or is yet to be taken.

The purpose of the feedback form is to provide information on whether a source was identified, what caused the event, and what mitigation action has been taken by the operator, if any. The operator should integrate the results of the root-cause analysis (see above) within the feedback form. If an emissions source has not been identified, the operator should describe how it investigated potential sources and why it was not able to identify a source. If the emissions resulted from a planned procedure, the company should provide a justification for the event and why it did not mitigate the emissions. If the emissions were unintentional, the company should describe any mitigation measures taken (including the relevant date on which action was taken), as well as plans to prevent similar events from reoccurring. If emissions were not mitigated, the operator should indicate whether future mitigation efforts are planned and provide an expected timeline.

Recommended timeline for operator response

Level	Source identification	Feedback form
1	< 5 days	< 10 days
2	< 10 days	< 20 days
3	< 15 days	< 30 days

Note: Shows indicative recommended timelines. Response time will vary depending on the complexity of the event and available information. Both timelines start from the date the operator receives the notification from the lead official. The recommended timeline for source identification is included within, and is a subset of, the longer timeline for filing the feedback form with the MARS focal point.

To maximise the effectiveness of the operator response process under Step 3, government authorities in the relevant MARS jurisdiction can implement procedures (e.g. through a regulation, legal notice, or guideline) that require oil and gas operators to develop response plans for addressing MARS notifications. Response protocols for MARS notifications can be integrated within corporate emergency response plans and be subject to government review. These corporate protocols can include provisions on how the operator will determine the source location and what corporate structure is in place to address large emission events. Drills or response exercises can also be carried out to test the response structure in place and for training purposes. Resources are available for operators looking to build an internal company process for responding to satellite notifications, for example OGCI's six-step methane detection response playbook.

Additionally, to ensure that operators are not reticent to file the feedback form with the focal point, governments can commit to protecting confidential business information contained in the form, including by refraining from publicly disclosing its contents.

Step 4: Verify and follow up

Following the operator response, the lead official should check if the operator has submitted a response form and whether it contains, at a minimum, all critical elements outlined in the feedback form (see Part 1 in Annex C).

If the operator has failed to submit a feedback form within the expected timeline (see table above), the lead official should contact the operator to determine why the form has not yet been submitted. If the lead official determines that the operator lacks a valid justification for failing to submit the form, the lead official may apply relevant enforcement procedures in accordance with applicable local laws and regulations (including by collaborating with other regulatory authorities if necessary).

Once a form has been filed by the operator, the lead official should check that it is complete and not missing any critical information. The recommended timeline for checking **response form completeness** is 24 hours for a Level 1 response, 48

hours for a Level 2 response, and 72 hours for a Level 3 response (starting from when the lead official receives the form). If the lead official determines that the form is missing critical information, they should contact the operator and assess whether there is a valid justification for failing to provide this information. If the lead official determines that the operator lacks a valid justification for omitting the required information, the lead official may apply relevant enforcements procedures in accordance with applicable local laws and regulations (including by collaborating with other regulatory authorities if necessary).

Next, the lead official should ensure that the form provides adequate information on the event's cause and on the operator's response. The operator should aim to clearly explain in the form how the source was identified, what caused the event, how the operator resolved the event (if the event was resolved), and what measures the operator has taken to prevent similar events from reoccurring (if such measures have been taken). The recommended timeline for checking **response form adequacy** is 48 hours for Level 1 notifications, 4 days for Level 2 notifications, and 6 days for Level 3 notifications (starting from the moment when the lead official has verified response form completeness).

If the lead official concludes that the operator's response form fails to provide adequate explanation about the event's cause or how the operator intends to resolve the event, verification and follow-up activities may be carried out by government authorities to ensure that the event is being properly addressed and mitigated. Situations where verification and follow-up activities may be warranted include: the timeline for completing the form has been far exceeded; the operator has failed to identify a source of emissions; no mitigation measures have been taken or are planned by the operator; or the risk of similar events reoccurring remains high. Carrying out such verification activities may require government authorities to be equipped with certain resources, such as adequate means of transport, leak detection equipment (e.g. optical gas imaging cameras) and communication devices.

Verification and follow-up activities in Neuquén province, Argentina

Upon receipt of a MARS notification concerning a large emission event within their territory, provincial authorities in Neuquén (Argentina) conducted on-site inspections, which revealed that venting had occurred without combustion, contrary to the operator's initial reports. In the province of Neuquén, companies are required to obtain a permit to vent gas.

As a result of the inspection, provincial authorities requested that the company take the following actions:

- Submit proper authorisation for gas venting within two days
- Cease venting gas without combustion and upgrade the facility and processes to eliminate gas venting within 10 days
- Install and activate the new remote ignition system for the burn pit within 10 days
- Upon being contacted by the government, the operator also shared feedback with the MARS team and committed to corrective and preventative maintenance.

Within a few weeks of the detection and notification dates, IMEO confirmed through satellite imagery that flare activity was visible and that no further emissions were detected. IMEO continues to monitor the location. This example shows how government authorities can effectively carry out verification and follow-up activities to ensure that events notified through MARS are properly addressed.

Potential verification and follow-up activities include: requesting additional information from the responsible operator; conducting on-site inspections at the event location (to conduct LDAR audits or check for evidence of mitigation measures); requesting the operator to implement best practices to resolve the event or prevent it from reoccurring in the future; and contacting other regulatory authorities to indicate the need for further action. The recommended timeline for conducting verification and follow-up activities is 7 days for Level 1 notifications, 14 days for Level 2 notifications and 21 days for Level 3 notifications (starting from the moment when the lead official has verified response form adequacy).

Recommended timeline for verification and follow-up activities

Level	Verification of response form completeness	Verification of response adequacy	Follow-up activities	Total recommended timeline for Step 4
1	< 24 hours	< 48 hours	< 7 days	< 10 days
2	< 48 hours	< 4 days	< 14 days	< 20 days
3	< 72 hours	< 6 days	< 21 days	< 30 days

Note: Shows indicative recommended timelines. The time for verification and follow-up activities will vary depending on the complexity of the event and available information. Timelines are cumulative and start from the completion of the previous verification activity.

In situations where an emissions source is not readily addressable and requires a longer mitigation timeline (see above), the lead official should conduct periodic checks to ensure that the operator is implementing planned mitigation measures according to the timeline described in the feedback form. If the operator fails to implement such measures within the indicated timeline or fails to implement them adequately, the lead official may pursue further verification and follow-up activities to ensure that the emission event is properly resolved and mitigated.

Step 5: Review and document

Once verification and follow-up activities, if any, have been completed, the lead official should review and summarise information on the event and add it to a government-managed response database, based on the template set out in Annex D. The recommended timeline for adding the event to the database is 4 days for Level 1 notifications, 8 days for Level 2 notifications and 12 days for Level 3 notifications (starting from the end of the period for follow-up activities under Step 4).

This government-managed database will serve to facilitate the response to future MARS notifications by helping to identify potential sources, sites with recurring emissions and how well operators respond to large emission events. It may also serve for reporting or inventory purposes as it will consolidate information on large emissions detected by satellites. In situations where an emissions source is not readily addressable and requires a longer mitigation timeline (see above), the lead official should periodically update the response database to reflect the latest mitigation developments.

The lead official should use the input to the response database to provide feedback to IMEO. This includes information on the source of emissions, any mitigation action taken, as well as support needed to prevent or address similar events in the future. The recommended timeline for providing feedback to IMEO is 4 days for Level 1 notifications, 8 days for Level 2 notifications and 12 days for Level 3 notifications (starting from the moment when information on the event has been added to the government-managed response database).

Following the provision of feedback to MARS, IMEO will continue to monitor the source and verify whether emissions have ceased. IMEO will provide additional information to focal points if further emissions are detected. If feedback provided to IMEO reports that mitigation action occurred, IMEO will confirm if satellite data no longer detects emissions at the source.

Recommended timeline for review and documentation

Level	Add event to database	Provide feedback to IMEO	Total recommended timeline for Step 5
1	< 4 days	< 4 days	< 8 days
2	< 8 days	< 8 days	< 16 days
3	< 12 days	< 12 days	< 24 days

Note: Shows indicative recommended timelines. The time for review and documentation will vary depending on the complexity of the event and available information. Timelines are cumulative and start from the completion of the previous action.

Conclusion

This guidance document is intended to assist governments seeking to improve their response to MARS notifications, which can reduce gas waste, enhance energy security and lower total domestic greenhouse gas emissions.

Improved response to MARS notifications starts with nominating a government-level MARS focal point, equipped with adequate personnel and resources. Once a focal point has been selected, countries can use this document to establish a protocol for responding to satellite-detected large emission events. Collaboration between government authorities and domestic operators is crucial for establishing a smooth and effective response protocol.

Governments interested in adapting this framework within their jurisdiction are encouraged to reach out to the IEA and IMEO to discuss options for assistance. The IEA and IMEO are available to provide targeted technical assistance to countries looking to build a response protocol for MARS notifications. This can include the organisation of dedicated workshops with government authorities, the preparation of a tailored response protocol that reflects the jurisdiction's context, as well as the development of country-specific templates, tools and resources for setting up a response protocol.

Summary: Five-step framework for responding to MARS notifications

Framework step	Responsible entity	Key actions	Indicative timelines
1 – Receive, assign, and classify	• Government-nominated MARS focal point. • Lead official assigned to the MARS notification.	• Assign staff to oversee response process. • Classify the notification according to decision tree. • Open case file and create unique identification number.	• 24 hours (Level 1) • 48 hours (Level 2) • 72 hours (Level 3)
2 – Notify the operator	• Lead official assigned to the MARS notification. • Operator involved in large emission event.	• Identify operator most likely associated with the large emission event. • Notify responsible operator based on email template in Annex B. • Operator confirms receipt of notification from lead official. • Operator and lead official both save confirmation of receipt.	• 24 hours (Level 1) • 48 hours (Level 2) • 72 hours (Level 3)
3 – Operator response	• Operator involved in large emission event.	• Start process to identify emission source. • Take mitigation measures (where source is readily addressable) or plan for such measures. • Document the event and assess the risk of reoccurrence. • Complete and file the feedback form (Annex C).	• Source identification: 5 days (Level 1); 10 days (Level 2); 15 days (Level 3) • Completion and return of feedback form: 10 days (Level 1); 20 days (Level 2); 30 days (Level 3)

4 – Verify and follow up	• Lead official assigned to the MARS notification. • Competent government authorities in charge of regulatory oversight for oil and gas activities.	• Check that the operator has filed feedback form. • Verify feedback form completeness. • Verify feedback form adequacy. • Conduct verification and follow-up activities as necessary (e.g. on-site inspections).	• Verification of feedback form completeness: 24 hours (Level 1); 48 hours (Level 2); 72 hours (Level 3) • Verification of feedback form adequacy: 48 hours (Level 1); 4 days (Level 2); 6 days (Level 3) • Verification and follow-up activities: 7 days (Level 1); 14 days (Level 2); 21 days (Level 3)
5 – Review and document	• Lead official assigned to the MARS notification.	• Review and summarise event information based on Annex D. • Add event information to government-managed response database. • Provide feedback to IMEO.	• Add event to the database: 4 days (Level 1); 8 days (Level 2); 12 days (Level 3) • Provide feedback to MARS: 4 days (Level 1); 8 days (Level 2); 12 days (Level 3)

Annexes

Annex A: Example of MARS notification form

UN environment programme | International Methane Emissions Observatory

Major methane emissions detected

Between [DD/MM/YYYY] and [DD/MM/YYYY], UNEP's International Methane Emissions Observatory (IMEO) detected major methane emissions in [Country A] through the Methane Alert and Response System (MARS).

UNEP's IMEO analyzed satellite imagery obtained from [Satellite/Agency] of [X] plume(s) at the sources shown in **Table 1**. UNEP's IMEO believes the emissions to be caused by the potential emissions source(s) listed in **Table 1**. **Annex I** shows the images of the detected plume(s).

We kindly request that you acknowledge receipt of this message and verify the accuracy of the potential emissions, source categories and operators. Additionally, please share any preliminary information on the causes of these emissions and mitigation efforts.

Table 1: Methane point source(s) and associated detected plume(s) in the oil and gas sector in [Country A]

Source ID	Plume ID	Oil and Gas Basin	Latitude, Longitude	Date and Time of Detection (Local Time)	Potential Operator	Potential Emissions Source Category	Total Number of Previously Detected Plumes at Source	Persistency*
XXX_S_096	XXX_126	[Oil and Gas Basin Name]	XX.XXXXX°, XX.XXXXX°	DD/MM/YYYY & HH:MM (local time)	[Operator 1]	[Potential Emissions Source Category, e.g. transmission pipelines]	0	Absent
	XXX_127			DD/MM/YYYY & HH:MM (local time)				
XXX_S_102	XXX_128	[Oil and Gas Basin Name]	XX.XXXXX°, XX.XXXXX°	DD/MM/YYYY & HH:MM (local time)	[Operator 2]	[Potential Emissions Source Category, e.g. transmission pipelines]	31	Persistent

Please note that, given that Operator 2 is a member of the OGMP 2.0, this information will also be shared directly with them.

* Persistency estimates how often emissions are detected from a specific source over time. It looks at the number of times emissions were detected compared to the number of high-quality observations over the past 6 months. Persistency is grouped into categories:

- Absent – No emissions detected over the past 6 months
- Sporadic – Detected rarely (up to 20% of the time)
- Frequent – Detected occasionally (between 20% and 80% of the time)
- Persistent – Detected almost every time (between 80% and 100% of the time)
- Undetermined – Persistency value cannot be determined due to lack of data

Mitigation support available

UNEP's IMEO and partners, including the International Energy Agency, the World Bank, and the Climate and Clean Air Coalition, offer support to countries to respond to MARS notifications and to improve methane monitoring and management broadly. These support offers may be pursued following consultation with UNEP's IMEO. **Please write to unep-mars@un.org to request an initial meeting to discuss possible mitigation support.**

Why methane emissions?

Reducing methane emissions is the fastest and most cost-effective way to limit near-term warming as broader decarbonisation efforts continue.

The IPCC highlighted in its Sixth Assessment Report the important role of methane, recognising robust evidence that drastic cuts in methane are important for near-term climate benefits, improved air quality, and achieving the Paris Agreement temperature targets.

The fossil fuel industry is responsible for an estimated one-third of anthropogenic methane emissions and has the highest potential for quick and low-cost emissions reduction, largely with technology that exists today.

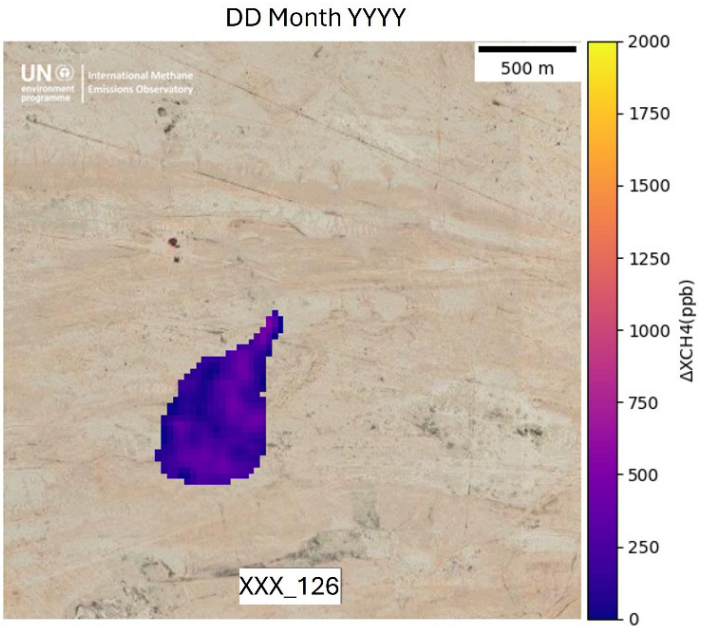
About this notification

Through MARS, UNEP's IMEO uses satellite data to identify major sources of methane emissions and rapidly share this information with relevant stakeholders. These stakeholders are encouraged to take action to address the emissions and report back to IMEO on the measures taken. IMEO will continue to monitor the source to confirm that emissions have ceased or to provide updates on any further detections that can support ongoing mitigation efforts.

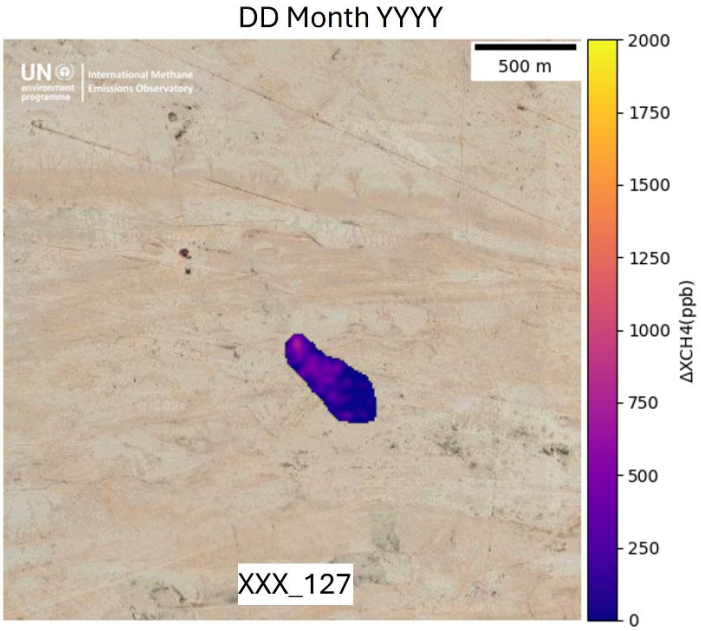
For more information, please visit the MARS website. Please contact unep-mars@un.org with any questions.

Appendix I: Detected methane plume(s) provided in notification

Source ID: XXX_S_096

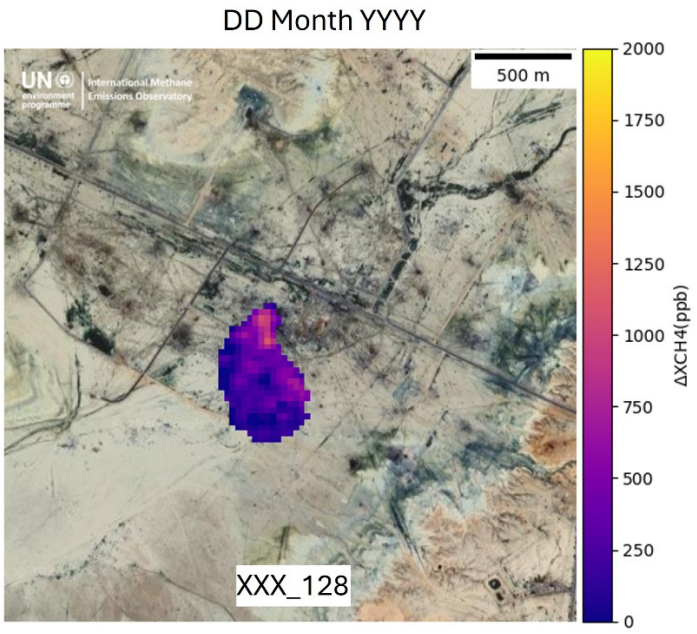


XXX_126, detected by [Satellite/Agency] on [DD/MM/YYYY] in [Oil and Gas Basin Name], Country. Emission Rate [tonnes CH_4 per hour] ± uncertainty: X.XX ± X.XX t/h



XXX_127, detected by [Satellite/Agency] on [DD/MM/YYYY], in [Oil and Gas Basin Name], Country. Emission Rate [tonnes CH_4 per hour] ± uncertainty: X.XX ± X.XX t/h

Source ID: XXX_S_102



XXX_128, detected by [Satellite/Agency] on[DD/MM/YYYY], in [Oil and Gas Basin Name], Country. Emission Rate [tonnes CH_4 per hour] ± uncertainty: X.XX ± X.XX t/h

Annex B: Email template for operator notification

From:	**[MARS Focal Point]**
To:	**[Operator]**
Email Title:	**Notification of Satellite-Detected Event (ID # [XXX]) – Level [1 (Urgent)] [2 (Fast)] [3 (Regular)]**

Dear [XXX],

The [MARS Focal Point] has been notified by UNEP's International Methane Emissions Observatory that a large methane emission event is occurring in [jurisdiction at issue]. Based on the event's geographical coordinates, the event is likely associated with a facility under your control. Additional information on the satellite-detected event is provided in the MARS notification form attached to the present email.

This is a [Level 1 / Level 2 / Level 3] event. Response to the event is proceeding according to a [urgent / fast / regular] track. To demonstrate good industry practice on methane emissions management, you are expected to complete the following actions within the indicated timelines:

- Upon receipt of this notification, immediately initiate an investigation on the event's source.
- Within **[5 / 10 / 15] days** of receiving this notification, you are expected to have identified the most likely source of emissions.
- Within **[10 / 20 / 30] days** of receiving this notification, you are expected to complete and return the feedback form attached to this notification.

Once you have completed the feedback form, please submit it by email to: [Name and Surname / Title and Position / Email Address]. The feedback form is also available at [Government Website].

Please confirm receipt of this notification by responding to [Email Address]. For any questions on the response process, please contact: [Name and Surname / Position / Phone Number / Email Address]. During the response process, the [MARS Focal Point] may contact you to obtain updates and request response measures.

(Note: Brackets include information that will need to be filled out on a case-by-case basis by the government-nominated MARS focal point.)

Annex C: Feedback form

UN environment programme | International Methane Emissions Observatory

MARS Feedback Form

UNEP's IMEO requests feedback on the source and cause of emissions detected through MARS. Please provide this feedback using the form below (or any other preferred format). **Part 1 is requested as quickly as possible. Subsequent information is valued where possible.**

Please note that the content provided in this feedback form is kept confidential. It will be used by the IMEO team to better understand emissions as well as to verify the success of mitigation measures. Please see more information on the MARS data publication policy here. Please address any questions or concerns to unep-mars@un.org.

Date of Completion of Feedback Form (DD-MM-YYYY)

Part 1: Critical Information The information below is the most important to receive regarding the emissions event. IMEO asks that this information is returned as quickly as possible.	
Source ID *(please provide the ID of the source provided in the notification)*	
Plume(s) ID(s) *(please provide the ID of the plume(s) provided in the notification)*	
Operator *(please confirm the name of the correct operator)*	
Emissions cause *(please provide any known cause for the emissions event, including the result of any on-the-ground investigation)*	
Did the MARS notification alert you to the emissions? *(please confirm whether these emissions were known, or if the notification informed you of the emissions)*	
Have the emissions ceased? Was mitigation action taken to address the emissions? *(please confirm whether the emissions are ongoing or have ceased, and if direct action was taken to stop the emissions)*	
What date did the mitigation action occur? *(when mitigation action was taken, please confirm the date(s) on which this action started and ended)*	
Executed or planned operator efforts *(where possible, please detail whether operator efforts have led to the cessation of emissions, or if future efforts are planned)*	

Part 2: Additional Facility Information	
Facility Name *(please provide the name of the facility where the emission occurred)*	
Facility Type *(please select from drop down)*	Choose an item.

Facility Contact Information *(please provide contact details for the manager of the facility where the emissions occurred)*	
Corporate Contact Information *(please provide contact details for a central corporate focal point, if appropriate)*	
OGMP 2.0 Asset Name *(for OGMP members only, please provide the name of the asset reported to the OGMP 2.0 for which this facility corresponds)*	
Part 3: Additional Emissions Information	
Emission Source Category *(please select from the drop down)*	Choose an item.
If other, please specify	
Please provide details of the specific point source within the facility that the emissions came from *(e.g. specific tank, compressor, flare)*	
Please briefly describe the root cause of the emissions event. What was the operational situation or activity that led to the emissions?	
Please select the option that best describes the operational situation or activity that led to the emission *(please select from the drop down)*	Choose an item.
If other, please specify	
Has the emission ceased or been mitigated or is it ongoing? *(please select from the drop down)*	Choose an item.
If the emission has ceased or been mitigated, please describe the actions that were taken to eliminate the emission?	
If the emission is ongoing, do you have plans to mitigate the emission? *(please select from the drop down)*	Choose an item.
If yes, please describe the mitigation plans	
Please indicate the timeline by which you expect to mitigate the emission	Click or tap to enter a date.
Are you able to quantify the emissions from this event? *(please select from the drop down)*	Choose an item.
If yes, please provide the estimate of the total emissions released *(please provide in kg methane if possible or indicate the units if not)*	
Please indicate the duration of the event *(e.g. number of hours or days)*	

Annex D: Template for response database

SUMMARY OF SATELLITE-DETECTED EMISSION EVENT	
Source ID	[ABC_S_0XX]
Plume ID	[AB_00YY]
Level	[Level 1 (Urgent) / Level 2 (Fast) / Level 3 (Regular)]
Operator	[Name of operator associated with the event.]
Date of MARS notification	[DD/MM/YYYY]
Notification	[Link or path to where notification is saved.]
Facility information	[Name, characteristics, and physical address of facility associated with the event.]
Date of operator response	[DD/MM/YYYY]
Response	[Link or path to where operator response is saved.]
Source identified?	[YES / NO]
Description of emission source	[If source was identified by operator, explain emission source (e.g. malfunctioning flare, pipeline leak, blowdown, etc.). Also indicate whether emissions were intentional (e.g. resulting from a planned procedure) or unintentional (e.g. leaking equipment).]
Emissions ceased?	[YES / NO]
Mitigation measures taken?	[Indicate whether the operator has implemented mitigation measures to resolve the emission event, and if so, what these measures are. If no mitigation measures have yet been taken, indicate this. If mitigation measures are ongoing, indicate this. If the operator has not yet taken mitigation action but has provided a timeline for implementing such measures, indicate this together with the timeline for action.]
Event duration and total estimated emissions	[Total duration of event from satellite detection to when emissions ceased, together with total estimated emissions associated with the event (based on event's emission rate). If emissions are still ongoing, do not complete this field.]
Verification activities and next steps	[Indicate whether any verification and follow-up activities were conducted with respect to the emission event (e.g. on-site inspection), as well as planned next steps regarding this event (e.g. verification of mitigation action)].

(Note: Brackets include information that will need to be filled out on a case-by-case basis by the government-nominated MARS focal point.)

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Abbreviations and acronyms

GMEP	Global Methane Engagement Programme
IMEO	International Methane Emissions Observatory
IPCC	Intergovernmental Panel on Climate Change
LDAR	Leak detection and repair
MARS	Methane Alert and Response System
NOC	National oil company
OGCI	Oil and Gas Climate Initiative
OGI	Optical gas imaging
OGMP 2.0	Oil and Gas Methane Partnership 2.0
UNEP	United Nations Environment Programme

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