Ever-evolving solutions

Tools and Best Practices to Support EU Methane Regulation Compliance

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Four Distinct Service Lines

Inspection Services

Advanced inspection services for challenging pipelines and furnaces, using UT, MFL, and/or robotic technology.

Environmental Services

Global field emission measurements combined with expert knowledge and advice.

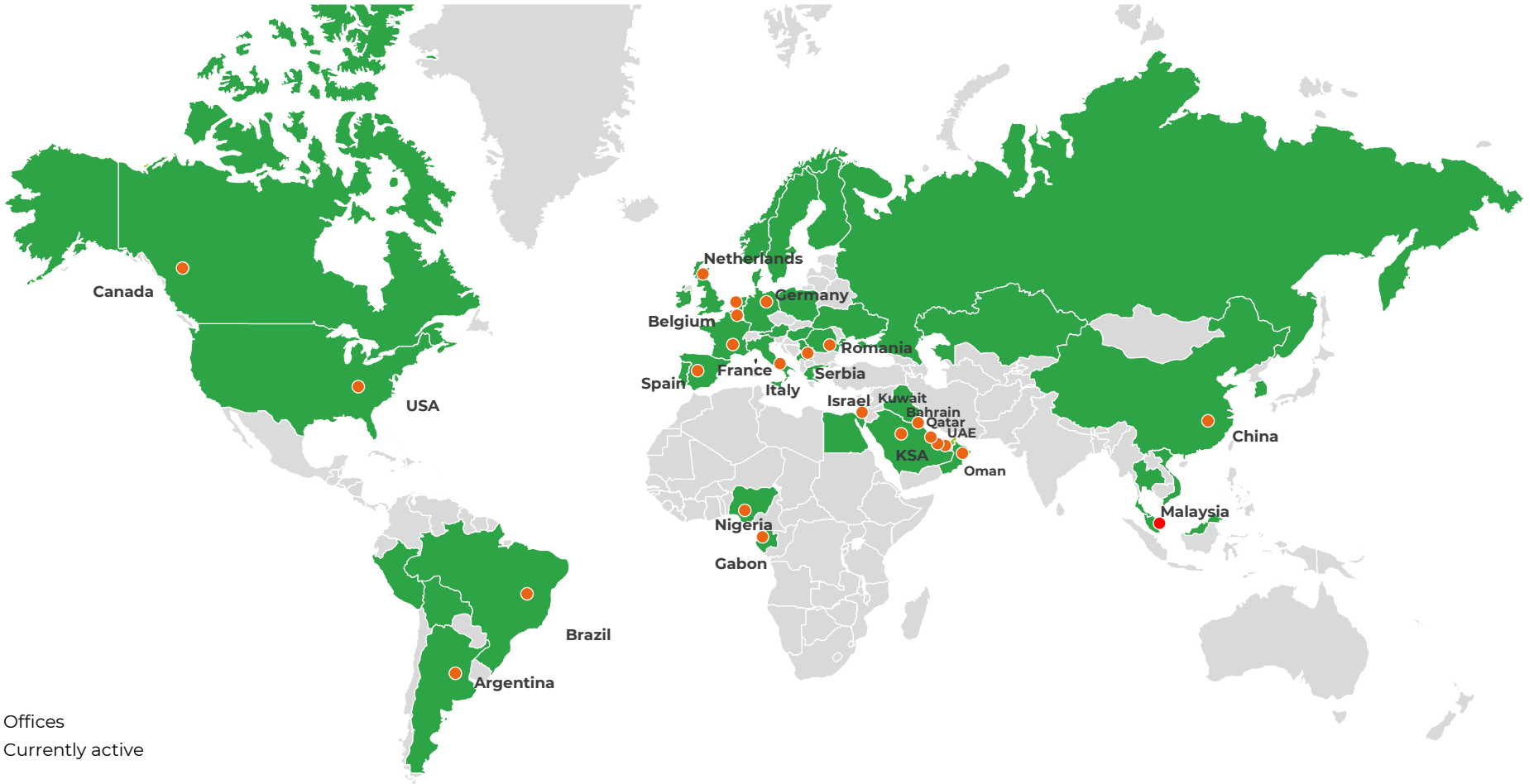
Pipeline Management

Maintaining high integrity levels of your buried pipelines, right down to detecting even the smallest leak and upcoming corrosion.

Industrial Services

Downstream cleaning (refinery, petrochemical); nitrogen-related industrial cleaning including reactor cooling, system purging, furnace cleaning, and chemical cleaning solutions.

We support clients globally



1. EU Methane Regulation

Overview

Different articles

Open points

EU Regulation Deadlines to hit

In 2024

- Create **gap analysis**
- Define **roadmap**
- Define **scope**
- Create **inventory**
- **Execute initial Type 2 LDAR program**

Before May 5, 2025

Submit LDAR program to your authorities:

- Detail your LDAR survey **approach**
- Detail your **timeline**

Before August 5, 2025

LDAR:

- **Complete Type 2 LDAR Program for all assets** (e.g. facilities, wells, pipelines)
- Submit **yearly** LDAR report

MRV:

- Quantification of source-level methane emissions
- Can be **generic factors**
- Submit **MRV Report**

Before February 5, 2026

Operated

- **Operated Asset**: Source-level quantification with source-level measurement factors
- **Based on measurements** using specific emission factors
- Submit **MRV report** containing quantification of source-level methane emissions
- Assessed by **verifier**

Before February 5, 2027

- **Non-operated Assets:** Source-level quantification with source-level measurement factors for
- **Based on measurements** using specific emission factors
- Submit **MRV report** containing quantification of source-level methane emissions
- Assessed **by verifier**

Before February 5, 2027

Operated

- **Operated Asset**: Quantification of source-level methane emissions **complemented by measurements on site-level**
- Should be **reconciled**
- Subsequent yearly **MRV reports** for **operated assets** are due May 31st
- Assessed by **verifier**
- Measurement frequency: **1/year**

Before August 5, 2028

- **Non-operated Assets:** Quantification of source-level methane emissions **complemented by measurements on site-level**
- Should be **reconciled**
- Subsequent yearly **MRV reports** for **operated assets** are due May 31st
- Assessed by **verifier**
- Measurement frequency: **1/year**

Article 12: MRV

1

Before August 5, 2025

- Quantification of source-level methane emissions
- Submit MRV report (**generic emission factors** can be used)

2

Before February 5, 2026

- Submit MRV report containing quantification of source-level methane emissions for **operated assets**

Before February 5, 2027

- Submit MRV report containing quantification of source-level methane emissions for **non-operated assets**

3

Before February 5, 2027

- Submit MRV report for source-level and site-level measurements for **operated assets**

Before August 5, 2028

- Submit MRV report for source-level and site-level measurements for **non-operated assets**

Reconciliation to elucidate reasons for discrepancies & make adjustment to the measurement plan

OGMP **Level 3** | **Level 4** | **Level 5**

- Require complete **inventory** (fugitive and non-fugitive) of all sources
- Subsequently **measurements and report every May** (e.g., 31 May 2028)
- Use **Best Available Techniques** based on **OGMP Guidance Documents**
- **Reporting template** coming by August 5, 2025 (Implementing Act) based on OGMP
- Verified by **verifier** (accredited by a national accreditation body)

Repair thresholds

Leak repair thresholds are as follows:

- In case of **Type 1** leak detection and repair surveys: **7000 ppm or 17 g/h**
- In case of **Type 2** leak detection and repair surveys:
  - **500 ppm** or **1 g/h** for **aboveground** components and for offshore components **above sea level**;
  - **1000 ppm** or **5 g/h** for the second step of **underground** components;
  - **7000 ppm** or **17 g/h** for offshore components **below sea level and below the seabed**.

Repair of found leaks

Leaks above the threshold must **be repaired immediately** after detection but **not later than**:

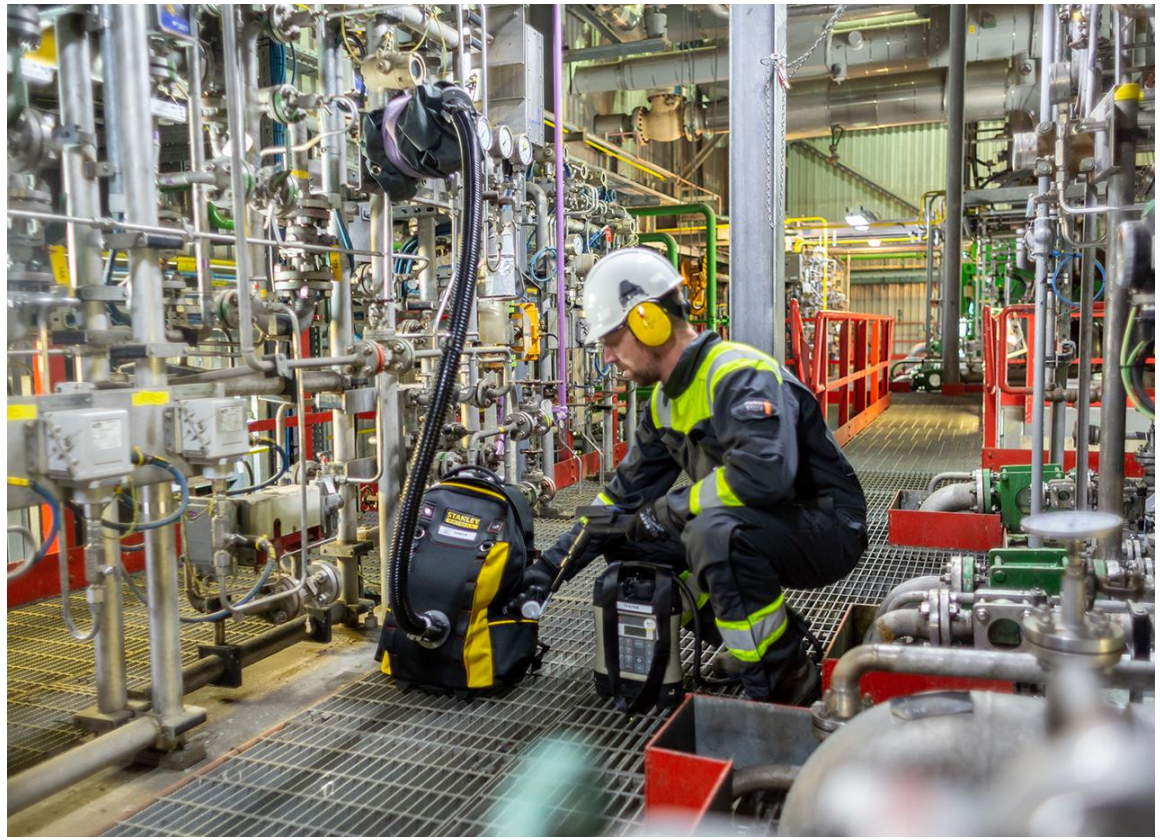
- **5 days for a first attempt**.
- If not repaired in the first 5 days, a schedule must be provided.
- **30 days for a complete repair**. If complete repair within 30 days is not possible you should minimize the leak. Large leaks always need to be prioritized.

Re-measurement

Components emitting

- **above the repair threshold** as soon as possible after the repair and **no later than 45 days**.

- **below the repair threshold** as soon as possible and **no later than 3 months.**



Our Project Methodology for LDAR programs

1

Set up LDAR program & inventory

- Kickoff meeting
- Scope clarification - Data collection
- Source Inventory from P&IDs - LEC Nrs
- Stream Identification on P&ID's
- Setup software database

2

On site data collection

- Source Identification onsite
- Measurement of all sources
- Tagging of leaking sources – create tightening list
- Maintenance assistance
- Re-measurement

3

Data processing with SFEMP software

- Import measurement data
- Data validation and Calculation (Protocol, Legislation)
- Create maintenance orders
- Create report according ISO 17025 accreditation (EPA M21)

4

Reporting

- Deliver compliant reports ready for submission
- Software training for SFEMP upon request
- Define scope next year

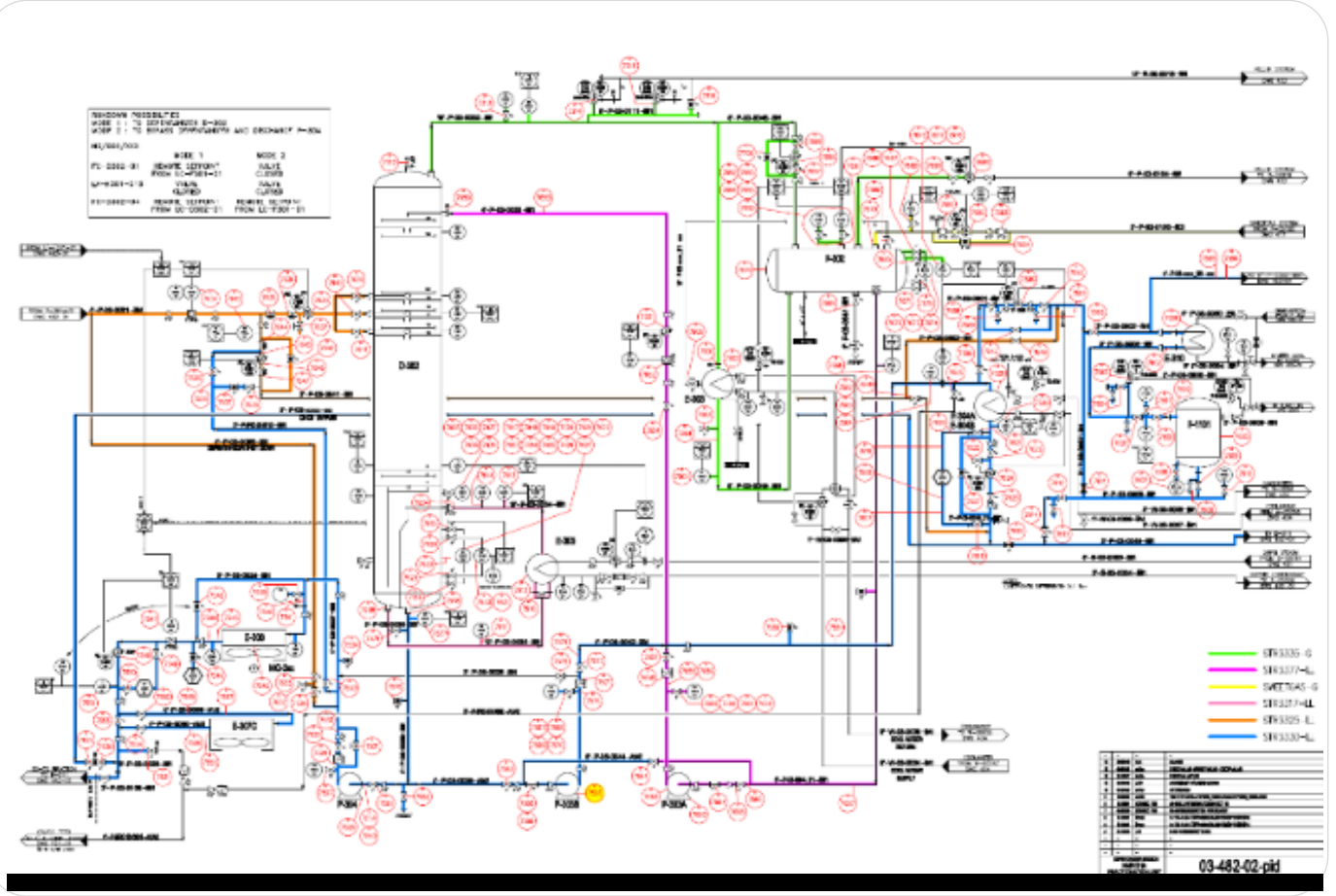
Implementation of an LDAR program

LDAR input:

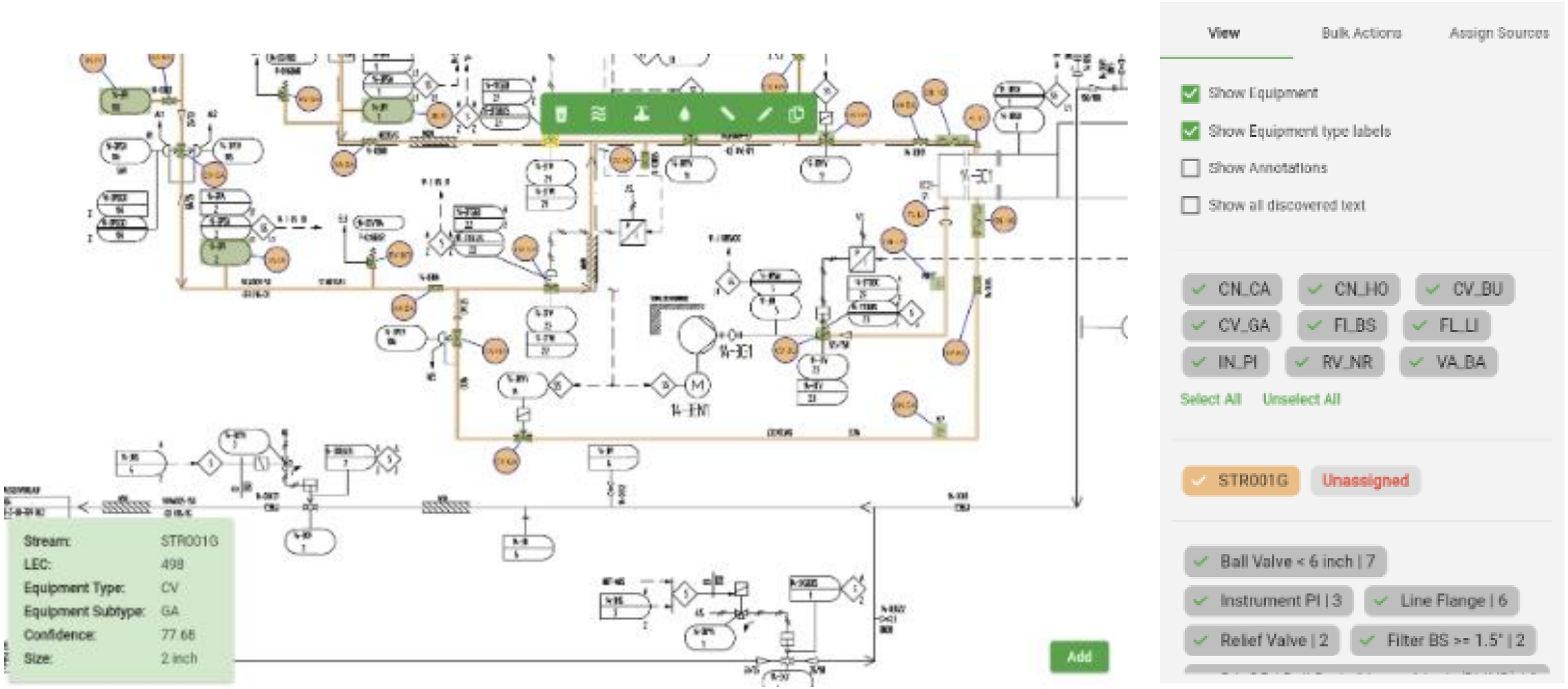
- P&IDs
- Flow Sheets
- Mass Balances / Composition info

Output:

- Source inventory
- Database, scope plan
- P&ID LDAR layer
- Response factors

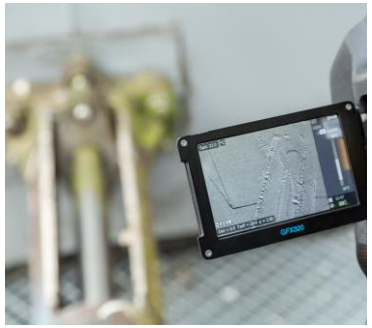


AI in Methane emission monitoring

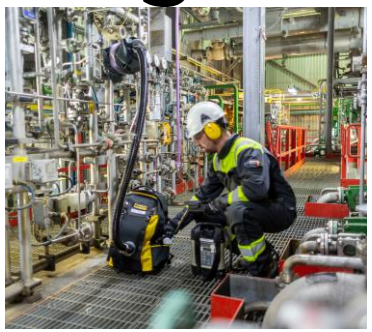


OGMP/MRV: approved bottom-up and top-down measurement technologies

FID/PID/IR/Laser



Optical Gas Imaging



High Flow Sampling
for quantification

qOGI

Acoustic measurement

RMLD

Gas leak detection on buried pipelines by car and on foot

TESTO 350
Combustion monitoring

AGNI camera
Flare efficiency

Drone measurements

Mass Emission Calculations

OGMP L4: FID

EPA Method 21
Petroleum Industry factors

Equipment Type (all services)	Default Zero Emission Rate (kg/hr/source)	Pegged Emission Rates (kg/hr/source) Mar		Correlation Equation[b] (kg/hr /source)
		10.000 ppmv	100.000 ppmv	
Leak Rates for Petroleum Industry (Refinery, Marketing Terminals and Oil and Gas Production)				
Valve	7.8E-06	0.064	0.14	2.29E-06xSV$^{0.746}$
Pump	2.4E-05	0.074	0.16	5.03E-05xSV$^{0.610}$
Other[c]	4.0E-06	0.073	0.11	1.36E-05xSV$^{0.589}$
Connector	7.5E-06	0.028	0.030	1.53E-06xSV$^{0.735}$
Flange	3.1E-07	0.085	0.084	4.61E-06xSV$^{0.703}$
Open-ended line	2.0E-06	0.030	0.079	2.20E-06xSV$^{0.704}$
Leak Rates for Synthetic Organic Chemical Manufacturing Industry (SOCMI)				
Gas valve	6.6E-07	0.024	0.11	1.87E-06xSV$^{0.873}$
Light liquid valve	4.9E-07	0.036	0.15	6.41E-06xSV$^{0.797}$
Light liquid pump	7.5E-06	0.14	0.62	1.90E-05xSV$^{0.824}$
Connector	6.1E-07	0.044	0.22	3.05E-06xSV$^{0.885}$

OGMP L3: OGI

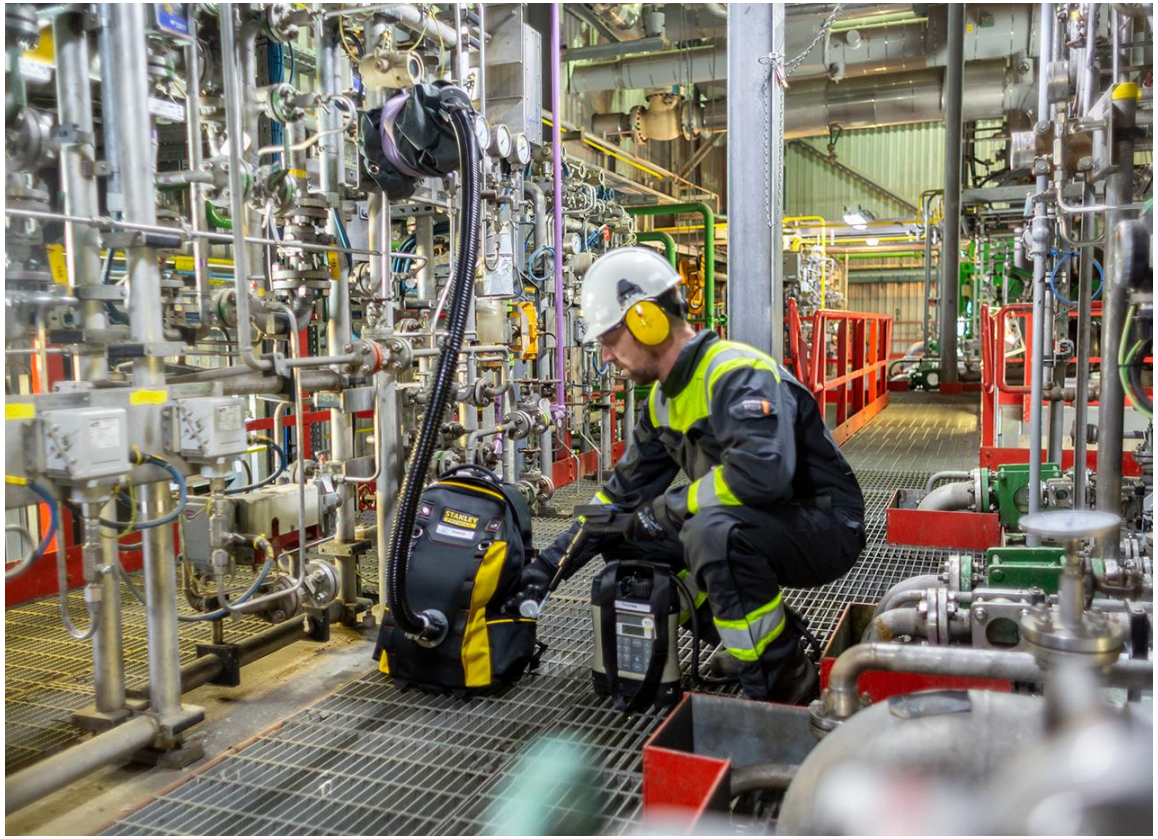
Leak/No Leak Factors

		Emission factor (g/h/component) for specified leak definition (g/h)			
Component type	**Emission factor type**	**3**	**6**	**30**	**60**
Valves	No-leak	0.019	0.043	0.17	0.27
	Leak	55	73	140	200
Pumps	No-leak	0.096	0.13	0.59	10.75
	Leak	140	160	310	350
Compressors flanges	No-leak	0.0026	0.0041	0.01	0.014
	Leak	29	45	88	120
Other components	No-leak	0.007	0.014	0.051	0.081
	Leak	56	75	150	210

- Need for new CH4 specific correlation factors
- Generally, OGI leads to higher emissions compared to FID, due to less favorable factors
- HFS or QOGI for quantification is needed

High Flow Sniffer – Quantify methane leak emission rates

- EPA Rank 1 measurement method
- In-house developed High Flow Sniffer is:
  - Portable, intrinsically safe, battery-powered
  - Determine the rate of gas leakage around various pipe fittings, valve packings, compressor seals, and underground pipelines.



Source-Based Venting Emissions

Benefits of Testo 350 for incomplete combustion

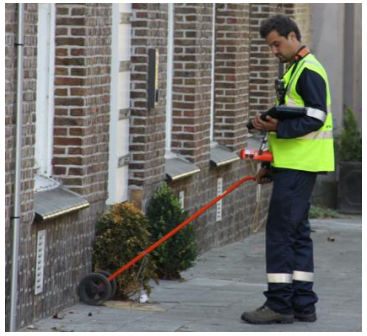
- Easy-to-use exhaust gas analyzer
- Methane-specific sensor with detection **limit up to 99,99%**
- **Usable** in difficult to reach areas
- **Test up to 6 gases simultaneously** – Select freely from sensors for CO, NO, NO_2, SO_2, H2S, C_xH_y and CO_2
- **Mass flow** and **emission rates** with pitot tube

AGNI Camera – Flare efficiency monitoring

- Use of multispectral OGI camera called AGNI camera
- AGNI camera measures CH4 and CO2 in the flare's fumes
- Can be applied to all flares including:
  - Maintenance flares
  - Emergency flares
  - Mobile flaring installations both permanently and periodically

Pipeline leak detection by car: project steps

1. **Data collection and detection of methane concentration** above threshold **by car**, which triggers an alarm
2. **Localization and verification** of gas leak indication **with handheld device**
3. **Emission quantification** of underground leaks with High Flow Sampler
4. **Registration** of the gas leak **and reporting** in the desired format

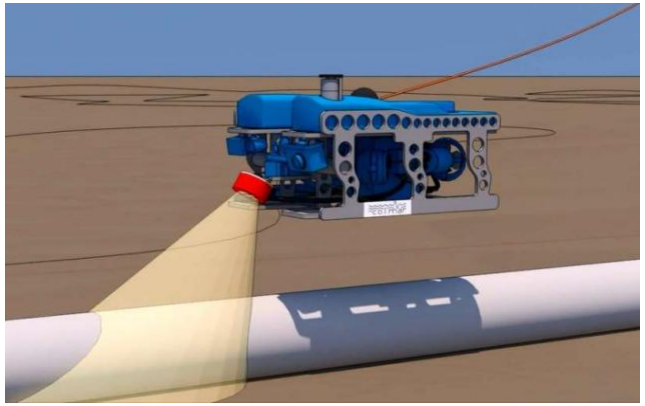


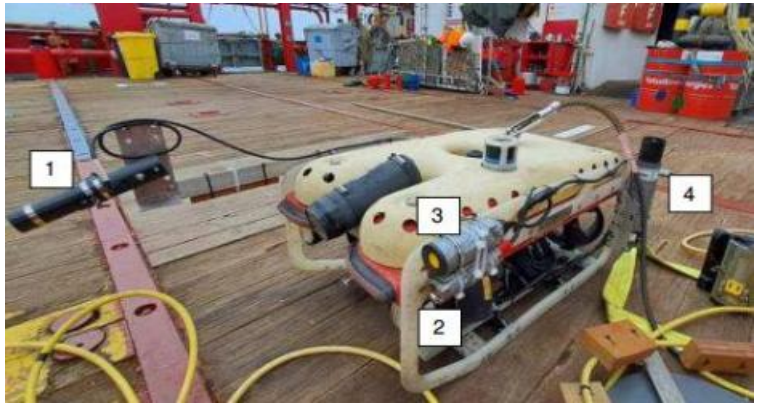
It typically takes **1 hour** to complete all project steps once a gas leak indication has been found.

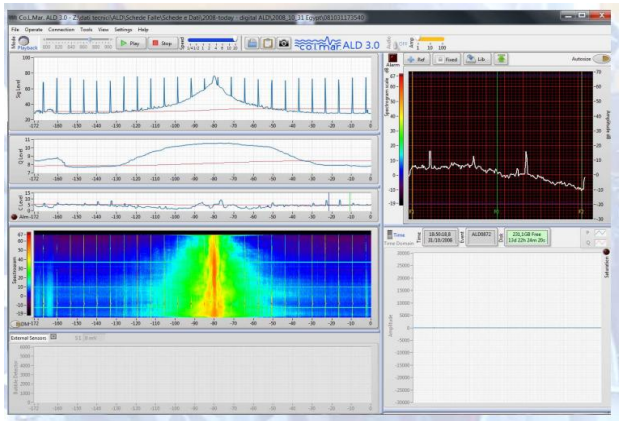
Underwater LDAR and MRV

ENVIRONMENTAL SERVICES

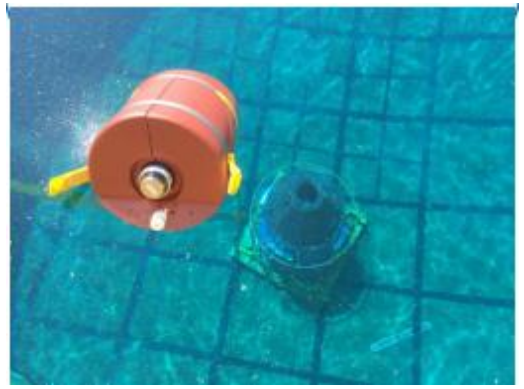
- **Pipeline**

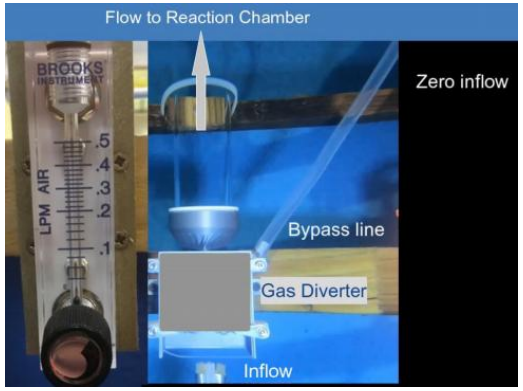


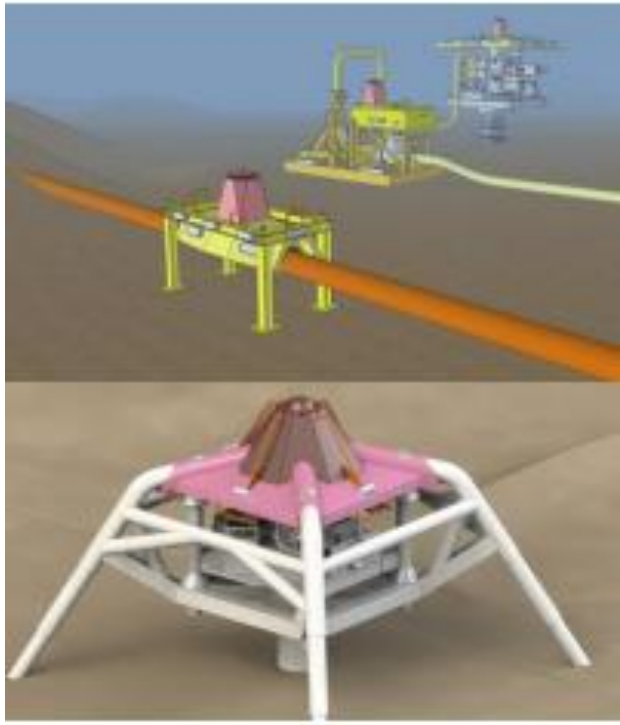




- **Inactive Wells** – passive monitoring solution
  - Utilizes passive, non-intrusive technology to detect loss of containment in subsea wells.
  - Deploys surface alert beacons triggered by detection of hydrocarbons.
  - Continuous monitoring with no External Power Required (up to 25 years)
  - Easy to install from standard offshore vessels—no in-well intervention needed.







Continuous source-level (L4) monitoring

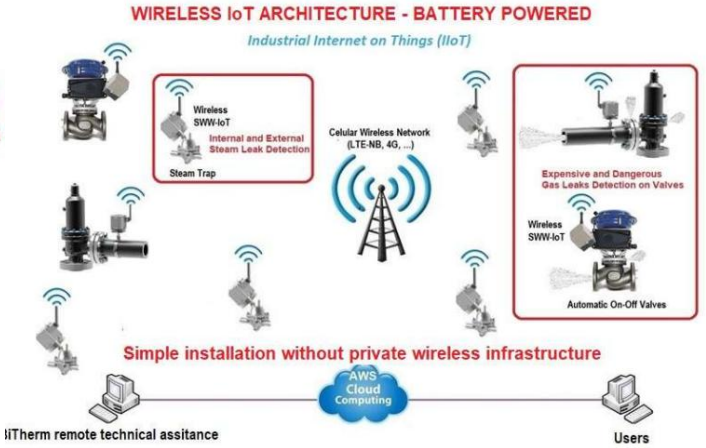
ENVIRONMENTAL SERVICES

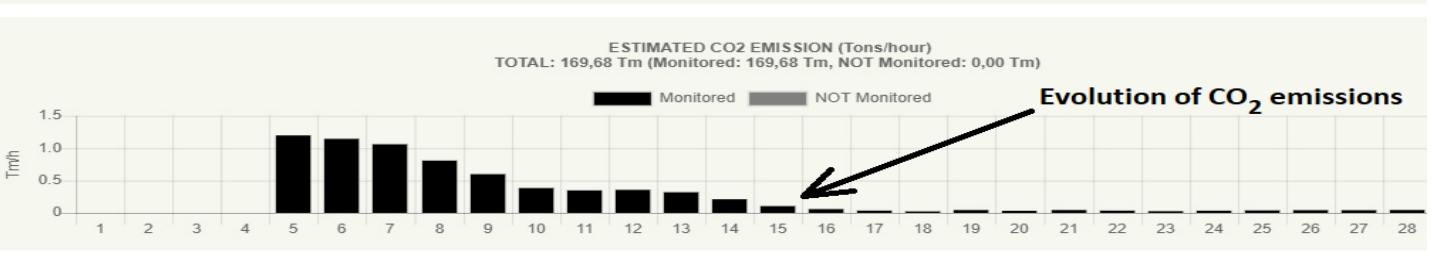
Goals:

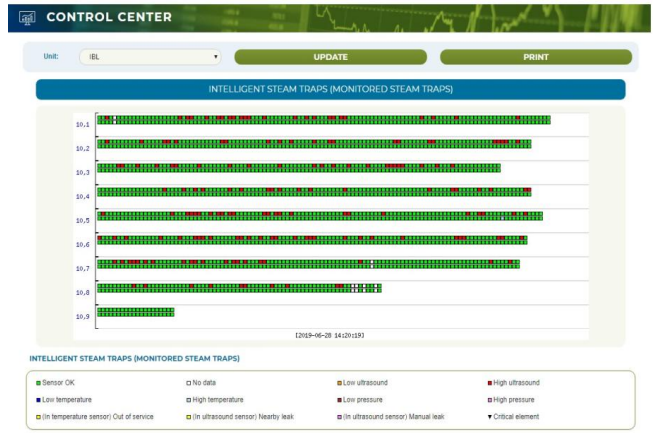
- Activity Factor (AF) - # events/hours
- Anomalies detection - open when it shouldn't be open
- Approximate quantification – require assumptions and additional calculations

Specific applications/solutions

1. PRV / steam traps:
   a. Monitor ultrasounds & temperature.
   b. Different architectures (wireless/wired; cloud/local)
   c. Approximate quantification via empirical equation





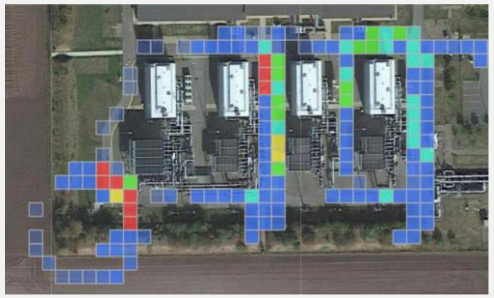


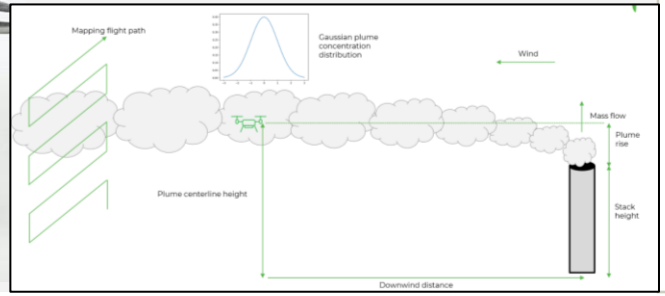
Site-level measurements for MRV/OGMP

Drones

Fugitive emissions mapping & fence line monitoring methods are utilized for the mass flow analysis.

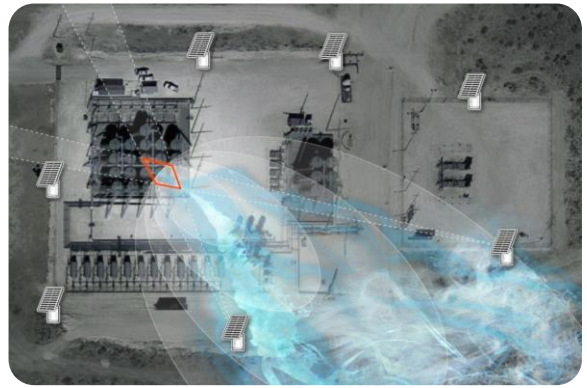
- TDLS –Laser spectroscopy
- Detection limit of 0.2 ppm
- Range 0.2 –40 000 ppm
- Highly selective



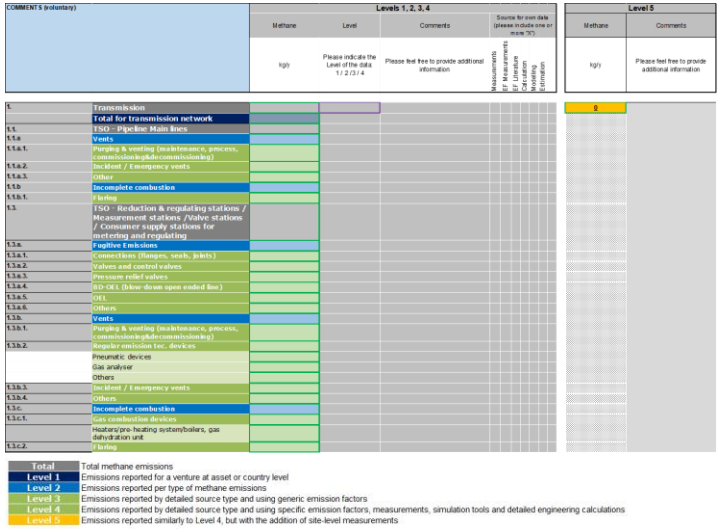


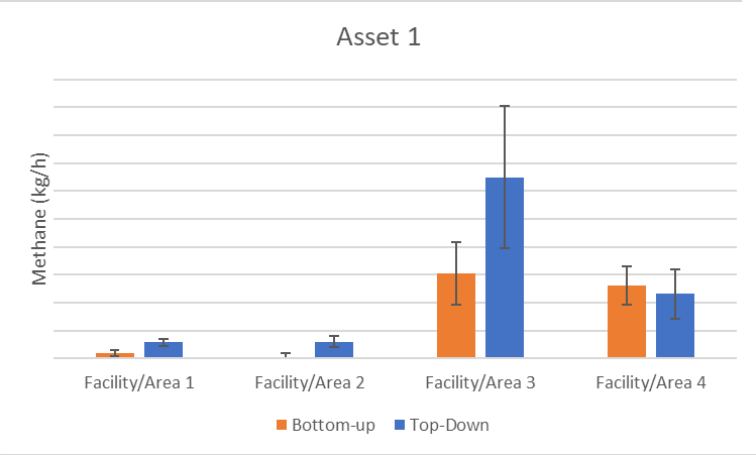
Sensor Network

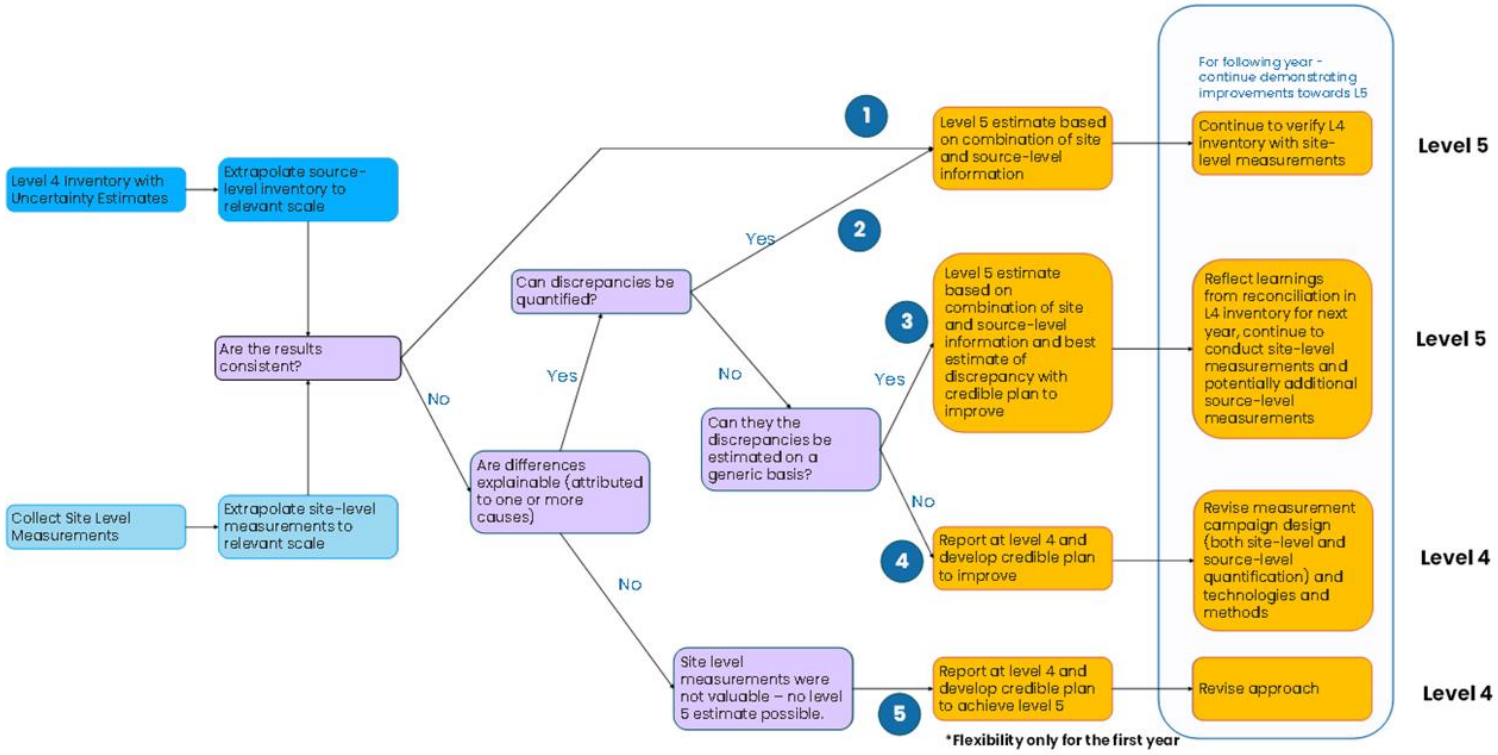
- Continuous 24/7 measurement of emission
- Solar panel powering
- Localization accuracy (± 5m)
- 90 PoD 3.6 kg/h



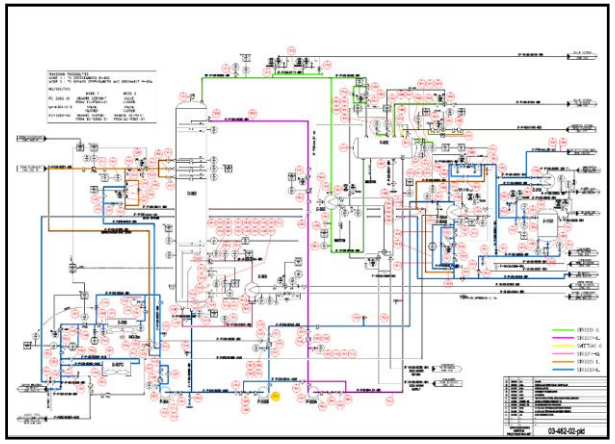
Reconciliation methodology for OGMP/MRV



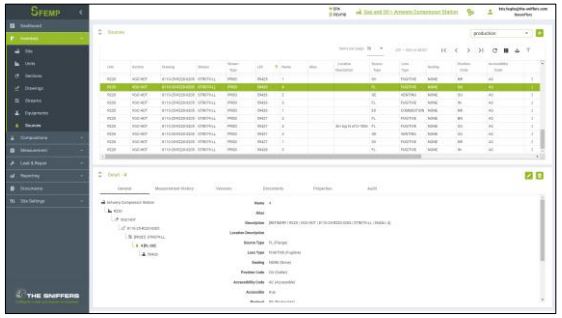




Emission management software SFEMP brings it all together

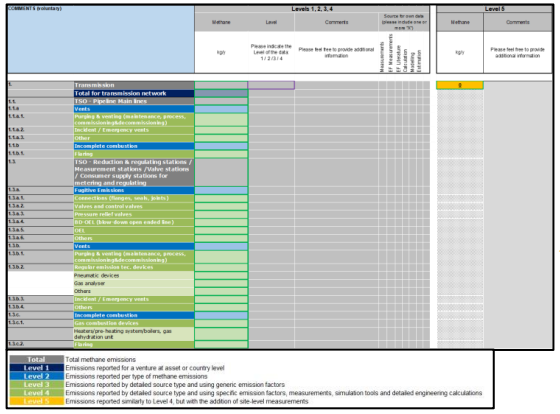


P&ID



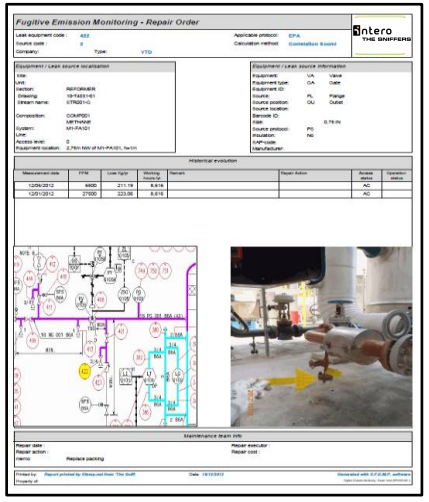
Inventory

Correlation & emission factors



Reporting template (e.g., EU/OGMP)

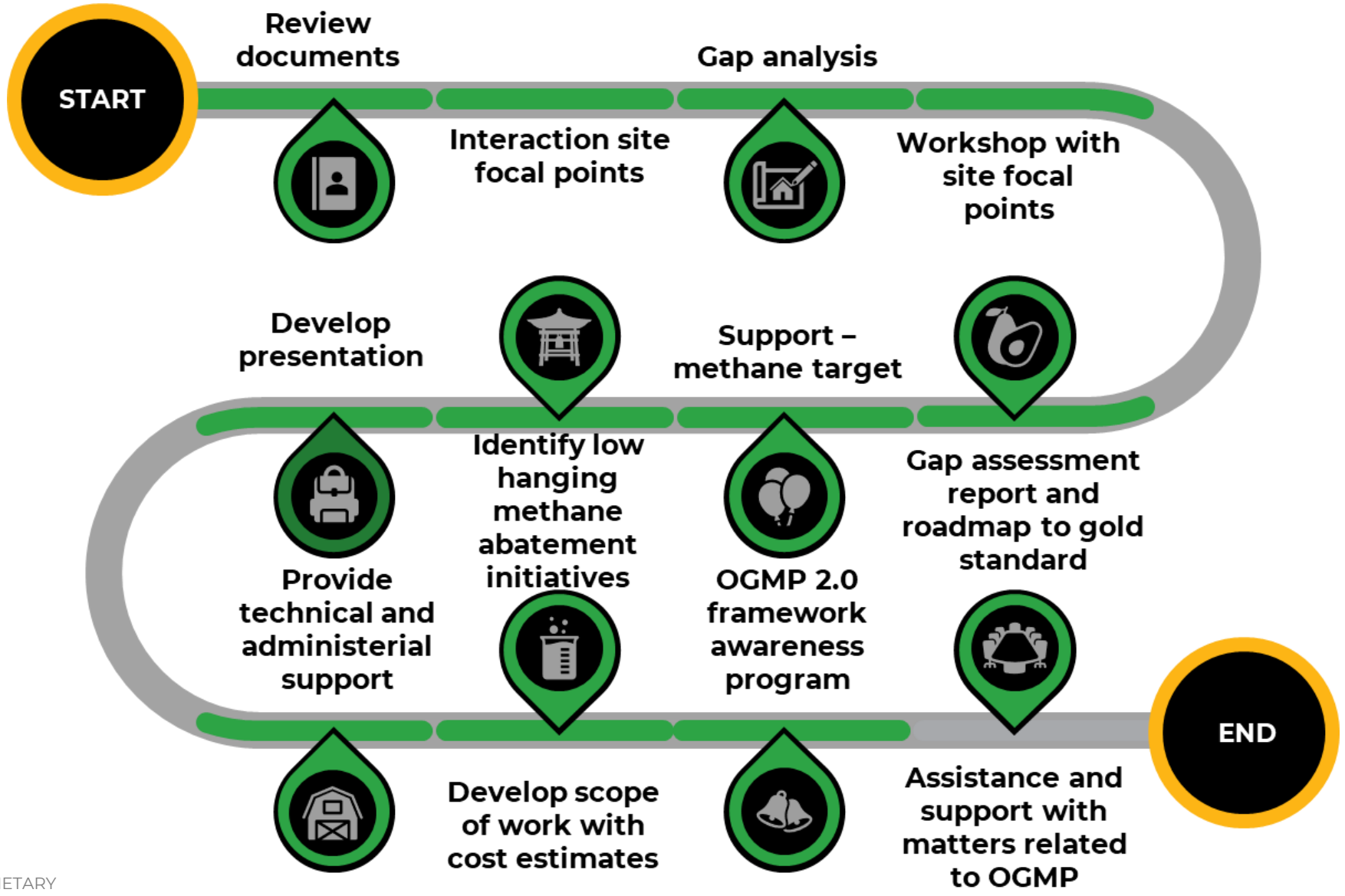
SFEMP



Repair order / maintenance follow-up

EU/OGMP Advisory

PIPELINE MANAGEMENT



Training: 4 modules

ENVIRONMENTAL SERVICES

Advisory toward OGMP 2.0

- Requirements of OGMP2.0, steps
- Identifying methane loss scenarios across your assets and asset types
- How to verify and establish a credible baseline for methane emissions
- Which technologies work best for which asset to measure, quantify, and reduce methane emissions
- Explain GAP analysis & roadmap towards the Gold Standard

Emission management training

- Theory of operation
- Measurement technologies for different emissions
- Configuration of measurement equipment
- How to operate portable equipment in the field
- Quantification of emissions
- Best-practises

Methane emission management training

- Understanding methane emissions
- Reporting emissions from a variety of sources
- How to interpret methane emissions across your assets and asset types
- How to set up a plan towards structural reduction of methane emissions year after year

SFEMP software application

- Introduction to SFEMP
- How to use the software specified for your company
- How to retrieve repair orders
- Etc.

GAP analysis

1. Assess **readiness for OGMP compliance**, including tools, resources, processes
2. Collect and **review emission data** with preliminary workshop with assets
   a. Define the scope
   b. Define the assets
   c. Send RFI
3. Perform a **desktop assessment** of the inventory of sources + **site visits** to cross check theory on P&ID and actual situation onsite
   a. Verify document information
   b. Understanding the process flow
   c. Check cross-references with other documents
   d. Verify completeness of OGMP2.0 categories
4. Identifying **all methane losses** across the value chain
5. Define **best practices and technologies** for each type of operating asset to measure, quantify, and reduce methane emissions
6. Pinpoint **GAPs** to reach OGMP Gold Standard with corrective measures

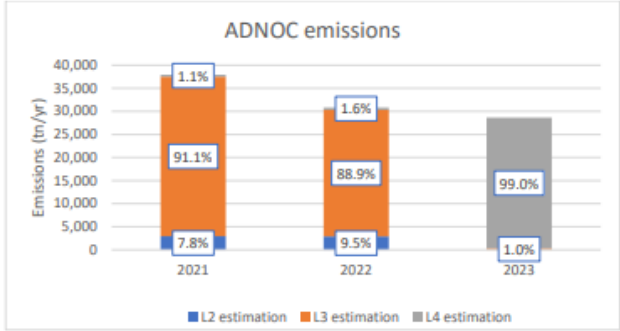
Ever-evolving solutions

Contents

Roadmap

1. Establish performance **target**
2. Establish a credible **baseline** for methane emissions across all assets
3. **Materiality** analysis for assets and sources
4. **Phasing** plan
5. Proposed **technologies** for L4/5
6. L4/5 **reconciliation** considerations
7. Create a **roadmap** and get it approved by stakeholders and the OGMP committee
8. Provide technical support during **interactions with OGMP** committee

Asset	2023 Materiality	2022	2023	2024	2025	2026
Block 9	53.5%	L2/L3	L3/L4	L4	L5	L5
Block 27	2.8%	L2/L3	L3/L4	L4	L4	L5
Block 53	27.2%	L2/L3	L3/L4	L5	L5	L5
Block 62	16.5%	L2/L3	L3/L4	L4	L4	L5



Asset	B9		B27		B53		B62		TOTAL	
Source	Emissions (tn/y)	%	Emissions (tn/y)	%	Emissions (tn/y)	%	Emissions (tn/y)	%	Emissions (tn/y)	%
Stationary combustion	378.5	9.5%	54.2	25.9%	103.3	5.1%	228.4	18.7%	764.4	10.3%
Flaring	777.2	19.6%	56.4	27.0%	990.8	49.1%	78.7	6.4%	1903.0	25.6%
Fugitives	335.4	8.4%	56.7	27.1%	67.3	3.3%	693.9	56.7%	1153.3	15.5%
Pneumatic Equipment	221.0	5.6%	0.6	0.3%	0	0%	74.0	6.0%	295.6	4.0%
Centrifugal Compressors	1,704	42.9%	0	0%	0	0%	0	0%	1704.0	23.0%
Reciprocating Compressors	177.0	4.5%	20.9	10.0%	0	0%	60.1	4.9%	258.0	3.5%
Glycol Dehydrators	176.4	4.4%	0.0	0.0%	0	0%	69.8	5.7%	246.2	3.3%
Tanks	188.4	4.7%	17.5	8.4%	157.4	7.8%	1.9	0.2%	365.2	4.9%
Well liquids unloading	0	0%	0	0%	0	0%	0	0.0%	0	0%
Well casinghead venting	12.9	0.3%	3.0	1.4%	698.2	34.6%	17.2	1.4%	731.3	9.9%
Hydraulic fracture completions	0	0%	0	0%	0	0%	0	0%	0	0%
Venting	0	0%	0	0%	0	0%	0	0%	0	0%
Other Sources	0	0%	0	0%	0	0%	0	0%	0	0%
Total	**3,970.7**	**100%**	**209.3**	**100%**	**2,017.0**	**100%**	**1,223.9**	**100%**	**7,420.9**	**100%**

3.1.2 Flaring (incomplete combustion)

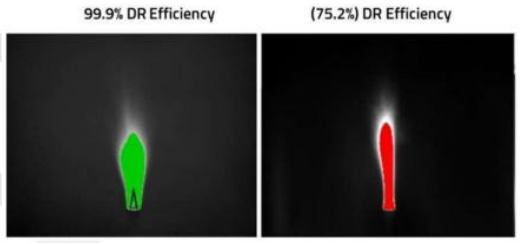
In OXY Oman there are 16 flares in B9, 3 in B27, 5 in B53 and 1 in B62.

Based on the full inventory and L3 calculation they account for **1,903.0 tn/**y and represent **25.6%** of the total emissions. They are material category for each of the 4 blocks. Table 13 presents the measurement plan for flaring emissions.

Source	Measure description	2023	2024	2025	2026
Flaring	Generic emission factors	L3			
	Direct emission measurement with SENSIA AGNI camera		33% of flaring emission sources each year for B9, B27, B53 and B62.		

Table 13: Measurements plan for flare

The flare emissions will be measured and quantified using the SENSIA AGNI bi-spectral camera (infrared) to measure Flare Destruction and Removal Efficiency (DRE) and associated flare emissions. Gas composition and gas flow to flare will also be monitored either continuously or via sporadic measurement. With these data, the emissions will be calculated.



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Thank you.

Questions?

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