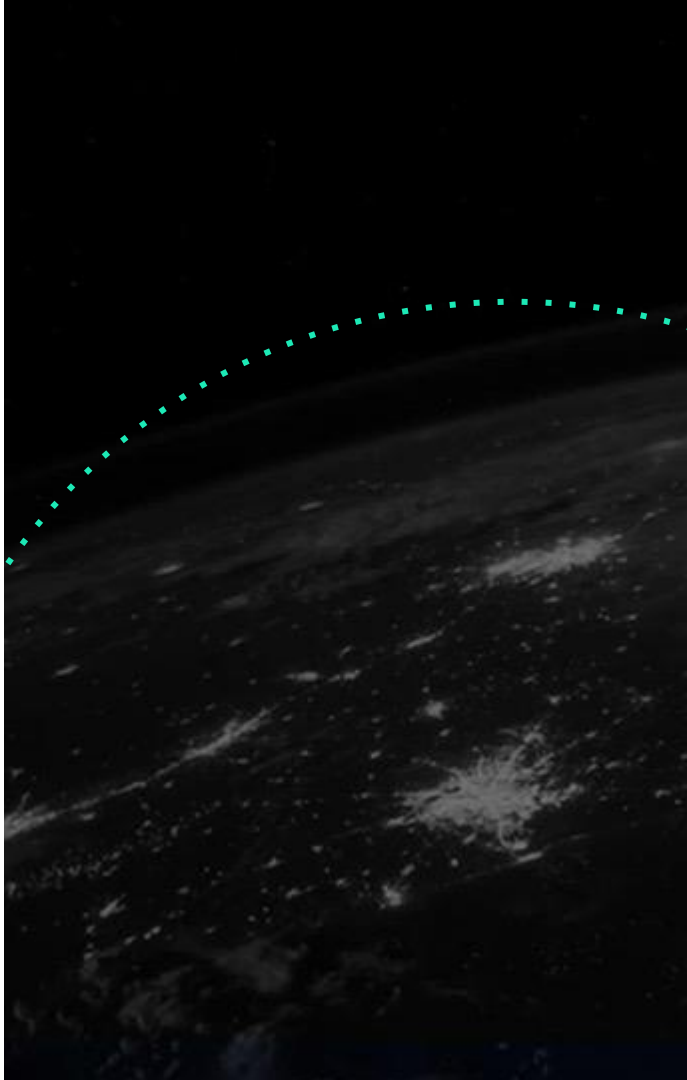
The CEO Roadmap to tackling Methane Emissions



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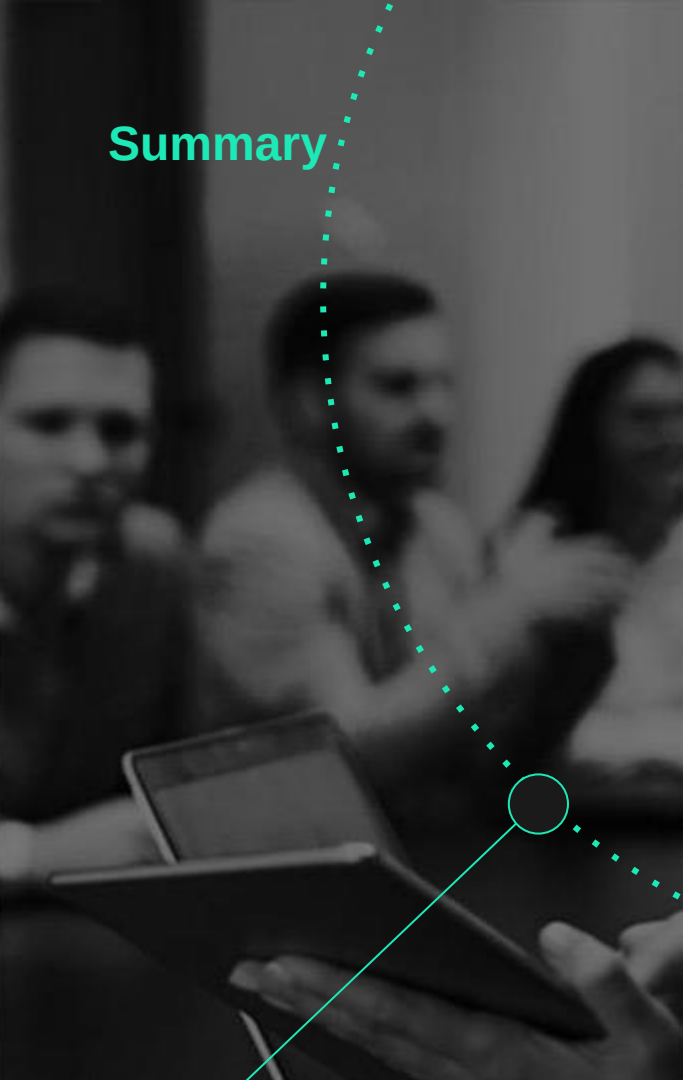
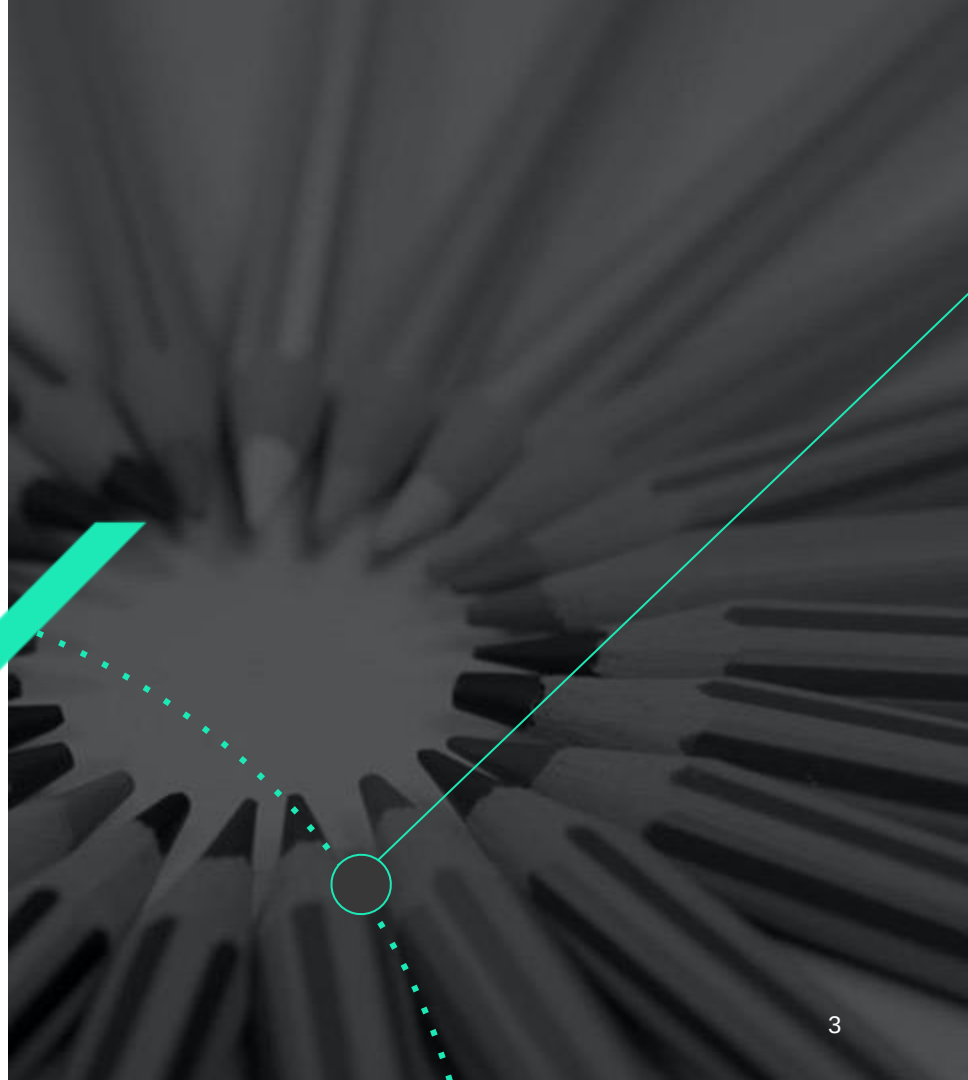


Summary

About Sia Partners



We are a next-generation consulting firm.

We are a global firm that has grown steadily over the past 20 years

2,800 Consultants

45 Offices across **19** countries

We invest heavily in tech and design to stay on cutting-edge and meet our clients' evolving challenges

5 AI centers

10 Design Centers

1000 Clients
92% returning

We cultivate expertise stemming from R&D activities and our proximity with our clients' industries

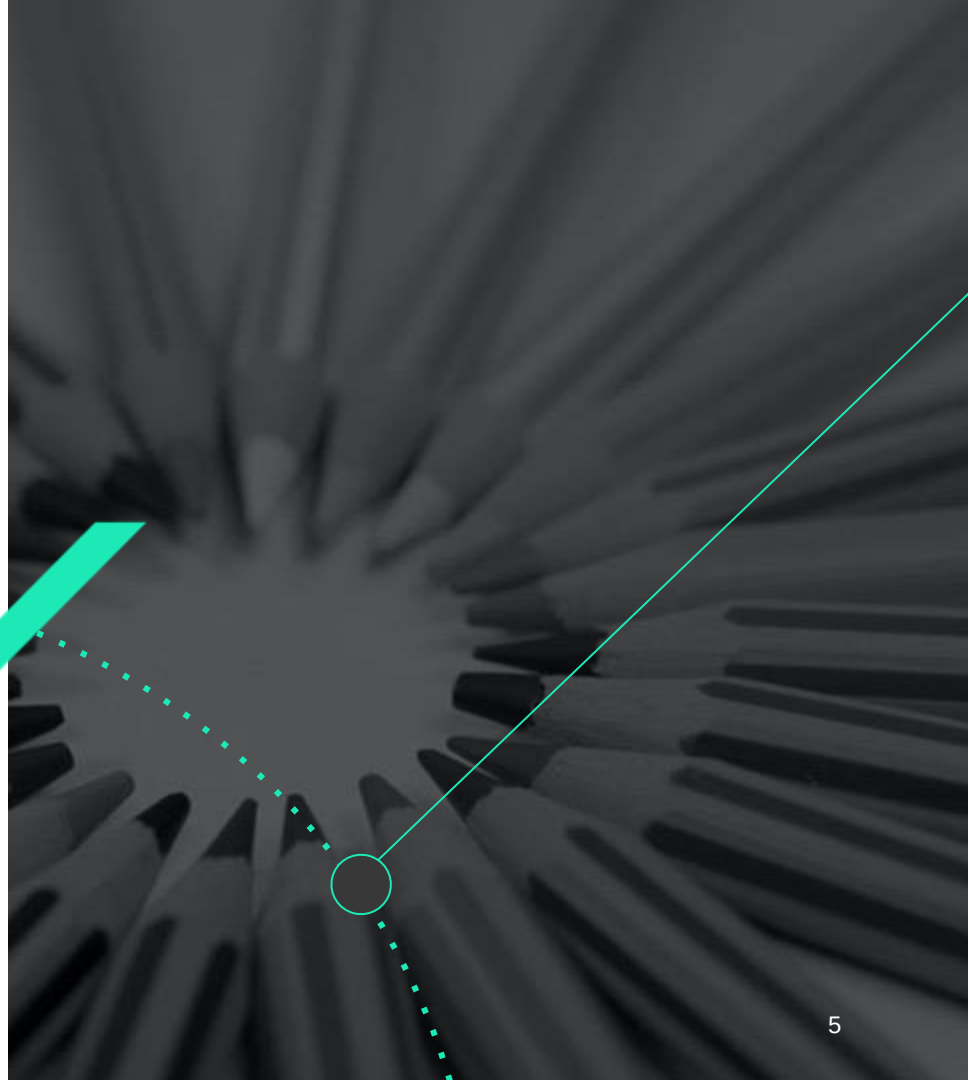
4% Of our revenue invested in R&D

Climate Analysis Center of Excellence

- Anticipating a warmer world
- Leveraging technologies
- Green financing
- Adapting public policies
- Biodiversity
- Agriculture
- Circular Economy

A next-generation consulting firm across all sectors

Why do Methane Emissions Matter?

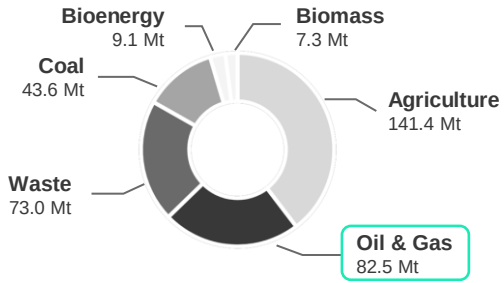


Why do Methane Emissions Matter?

Methane is responsible for around 30% of global warming

- **Methane is the second largest greenhouse gas contributor to global warming after CO_2.** Methane has a much shorter atmospheric lifetime than CO_2 – 12 years compared to centuries – but absorbs much more energy while it exists in the atmosphere. According to the latest IPCC report, the Global Warming Power (GWP) of methane is 81 times that of CO_2, over a 20-year period.
- **The concentration of methane in the atmosphere is currently two-and-a-half times greater than its pre-industrial levels.**
- **Methane also affects air quality, leading to ground-level – tropospheric – ozone, a dangerous air pollutant.**

Sources of methane emissions in the world in 2021



Sources : IPCC report and IEA figures

Methane characteristics :

- Composition: **CH_4** *(Carbon & Hydrogen)*
- Lifetime: **11.8 years**
- Global Warming Power in 20 years: **81**
- Global Warming Power in 100 years: **28**

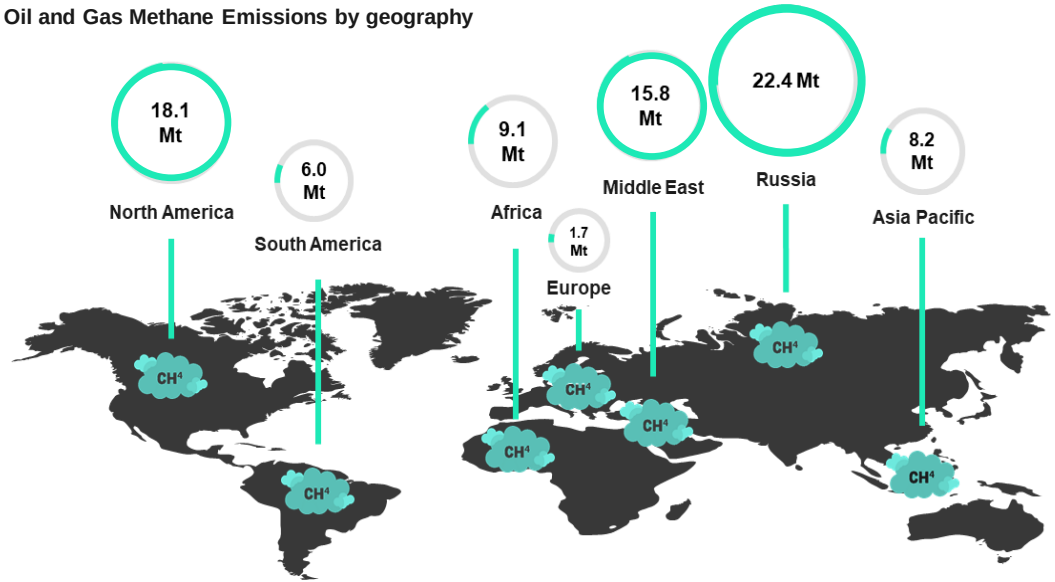
Source : IPCC report

Given the significant warming power of methane and its limited lifetime in the atmosphere, **reducing methane emissions from the energy industry represents one of the best near-term opportunities to contribute to climate change mitigation**. Of the 135 million tons of energy-related emissions, an estimated 61% are directly linked to oil and gas activities.

Understanding Methane Emissions in Oil & Gas

World View on Methane Emissions in Upstream

Oil and Gas Methane Emissions by geography

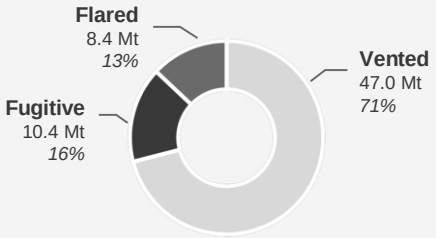


- A wide disparity can be observed between regions.
- 70% of the emissions are concentrated in the 3 highlighted areas above.
- The intensity of methane emissions varies significantly across countries and extraction points.

Upstream vs Downstream

- Upstream contributes to 80% of the oil and gas industry emissions.
- Methane emissions downstream are mainly fugitive and dispersed throughout the network.
- Upstream emissions are located on extraction spots, mostly due to intentional releases.

Upstream emission sources



The Oil and Gas industry will play a crucial part in reducing global methane emissions.
To tackle this challenge, the industry should **focus on upstream**, and **invest in innovative technologies** to tackle it.

Source : IEA Methane Tracker 2021

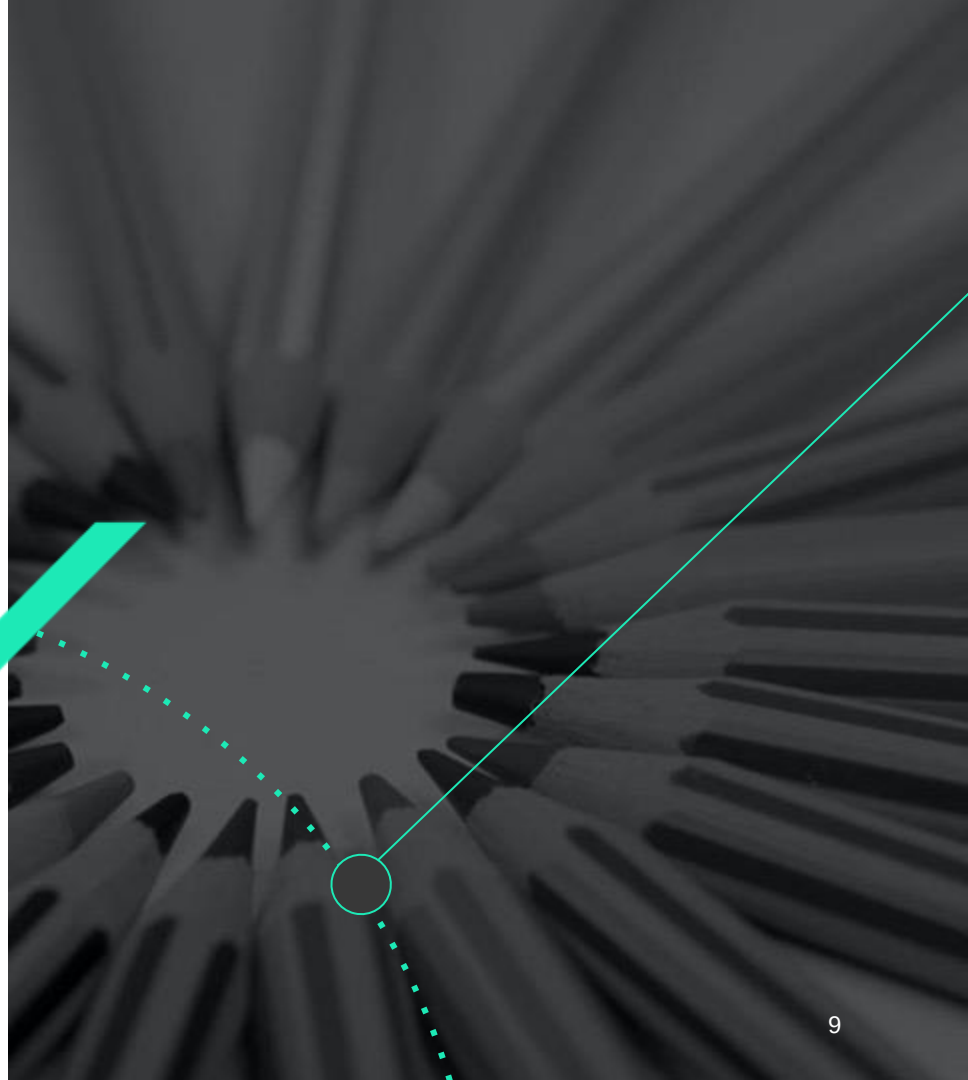
Understanding Methane Emissions in O&G

World View on Methane Emissions in Upstream Oil & Gas

Methane Emissions Category	Definition	Sources
Flaring	• Methane slip due to incomplete combustion during flaring	Upstream activities due to the following reasons: Safety, Economic & Technical, Regulatory Gas turbines (compressor drivers and generators), Gas engines and Gas-fired heaters and boilers
Venting	• Planned releases as a result of equipment design (designed to vent) • Planned venting during maintenance • Unplanned venting during incidents or equipment malfunction* • Absence of infrastructure gas can be vented as a waste by-product.	Pneumatic devices (controllers and pumps), Centrifugal compressors seal systems, Reciprocating compressor rod packing systems, Glycol dehydrators Tanks, Well liquids unloading Well casing head venting, Hydraulic fracturing completions, Purging & venting during process maintenance, Incidents, emergency stops, and equipment malfunctions*
Fugitive Losses	• Unintentional releases as a result of leaking components	Flanges, valves, connectors, open-ended lines

Source : IEA Methane Tracker 2021

The Regulatory Environment



The Regulatory Environment

Methane is a strong target for Regulations and Carbon Strategy

The Global Methane Pledge

At COP 26, **111 countries** who together are responsible for 45% of global human-caused methane emissions agreed to collectively **reduce methane emissions by at least 30% below 2020 levels** by 2030.

National Regulations

Canada has announced a target to reduce methane emissions from the oil and gas sector by at least **75% from 2012 levels by 2030**.

The EU is aiming to be **climate-neutral by 2050.**

The EPA proposes new regulations to **cut US greenhouse gas emissions by around 50%** by 2030 in order to achieve the US President's goal.

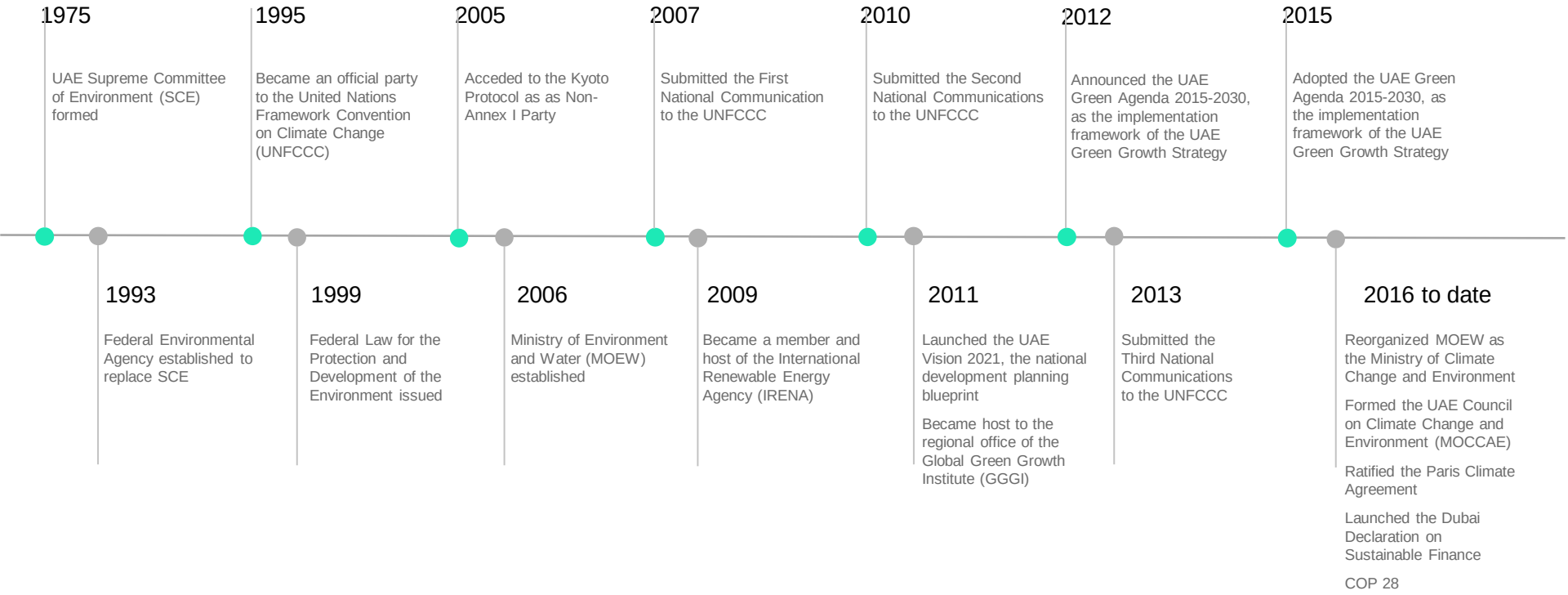
China has announced a **comprehensive and forceful plan** to reduce methane emissions.

All major oil and gas companies will have to **apply these new regulations**.
To do so, they will have to invest in **technologies** that will help them to achieve the fixed goals.

[1] UNEP
[2] IEA

The Regulatory Environment

UAE Initiatives and Commitment to Climate Change



The Regulatory Environment

UAE National Energy Strategy 2050

- **44%** from renewable energy
- **38%** from gas
- **12%** from clean fossil
- **6%** from nuclear energy

25-50%

The plan will increase the contribution of Clean energy 25-50% by 2050

70%

Will reduce carbon emissions resulting from the power generating process by 70%

40%

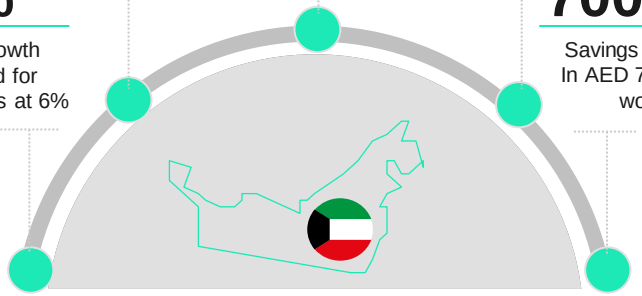
Improve energy efficiency by 40% by the middle of the century

6%

Annual growth in demand for energy stands at 6%

AED 700 BN

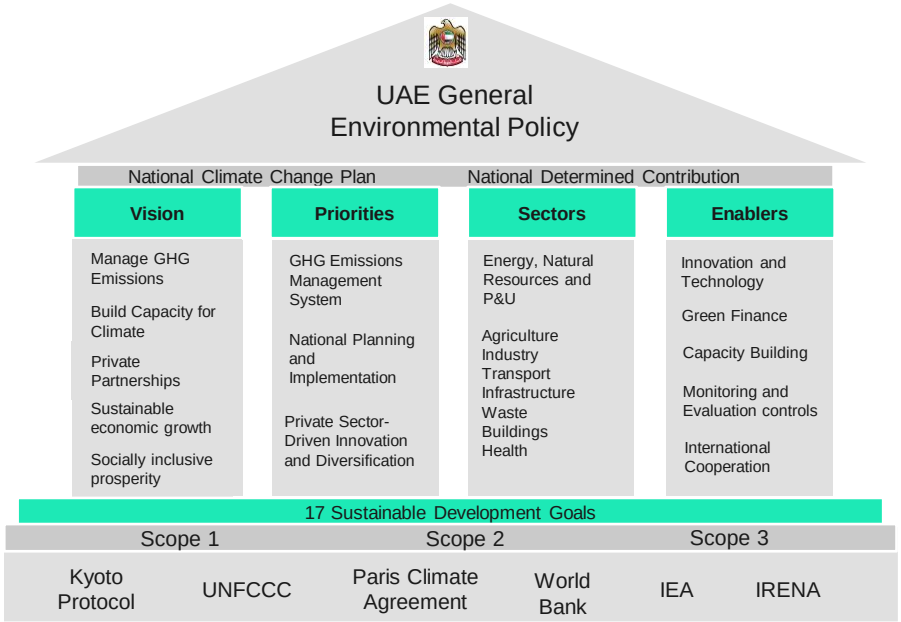
Savings resulting In AED 700 billion worth



The Regulatory Environment

The aim is to establish effective and operational policy frameworks to put the UAE on a pathway through 2030 that is compatible with achieving net zero emissions by 2050.

The National Climate Plan was launched in 2017 and built on relevant documents on green growth and sustainable development with a wide range of policies, strategies and plans, such as UAE Vision 2021, Green Agenda and National Innovation Strategy.



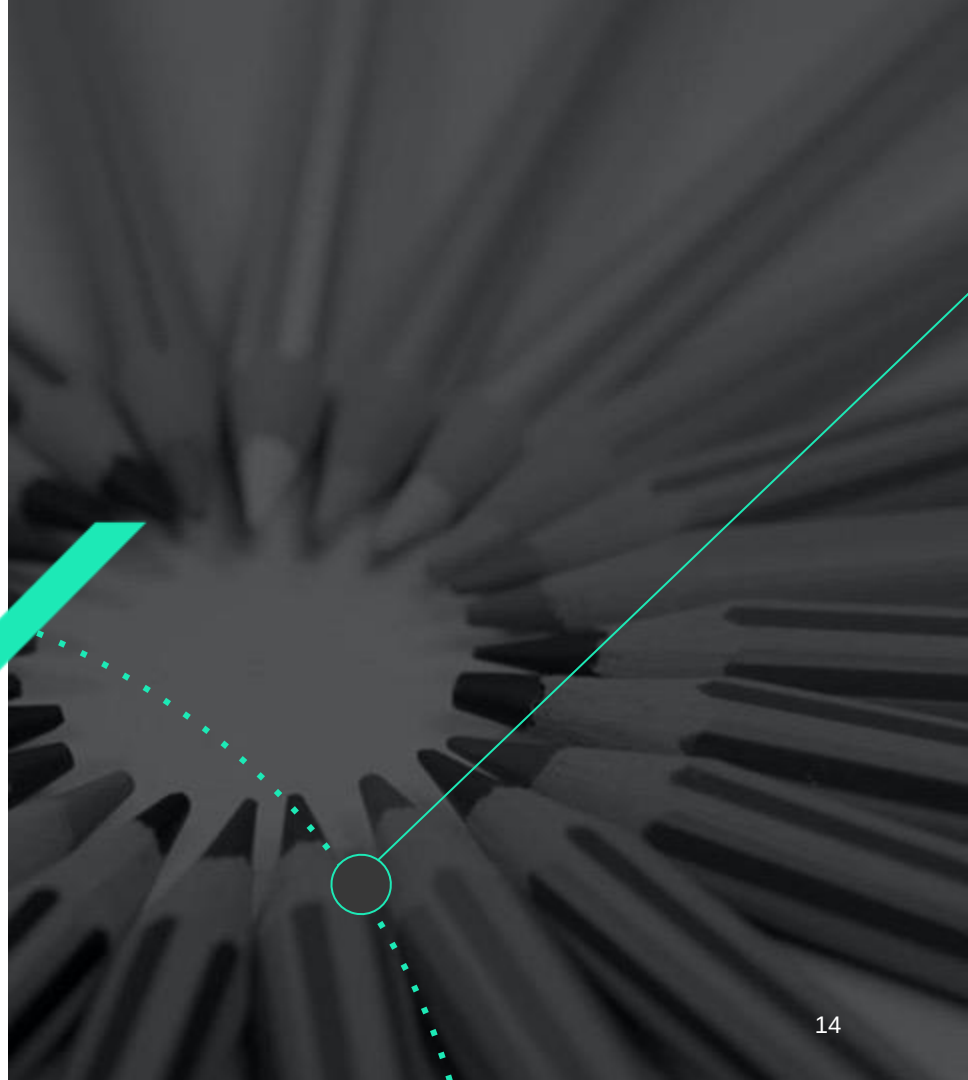
Climate Plan is not a stand-alone policy statement but rather a complementary framework of actions that specifically addresses climate change in a proactive manner

- National Energy Plan for 2050
- National Biodiversity Strategy and Action Plan
- Abu Dhabi Economic Vision 2030
- Abu Dhabi Environment Vision 2030
- Dubai Integrated Energy Strategy 2030
- Dubai Carbon Abatement Strategy 2021
- Dubai Municipality Climate Change Policy Statement

225
MtCO2e
in 2019

183
MtCO2e
by 2030

Industry Best Practice



Industry Best Practice

Methane policy recommendations for the European Union

Near-term Recommendations

Robust Monitoring Reporting and Verification	Put in place methodologies involving use of specific emissions factors, simulation tools and detailed engineering calculations towards the goal of emissions measurement at facility level, through complementary spatial scales and methods (e.g. satellite, aerial, ground based).
Improve accuracy of methane emissions data with transparency	Consistent standards across the EU. Incentivization of downstream infrastructure operators for engaging and successful implementation of MRV program. Tailored approach by O&G assets, technology enablers (LDAR*) and reporting factors as leak prevalence, leak recurrence, leak distributions, and over time emissions quantifications

* LDAR: Leak detection and repair

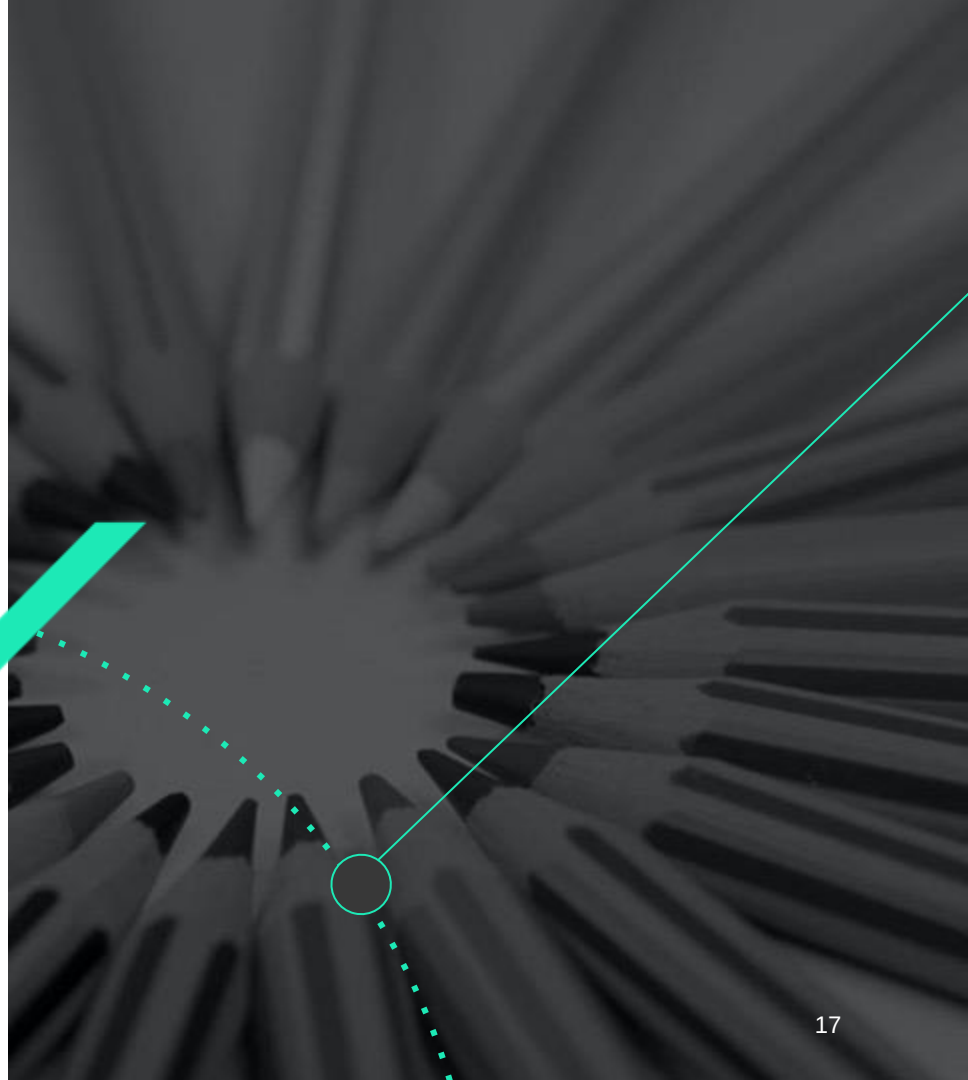
Longer-term Recommendations

Upstream supply chain Methane footprint 2025	Gas production with a methane intensity of less than 0.20% by 2025 across the global portfolio. Map supply chain segments and establish baselines and targets Continuous improvement on data quality in monitoring reporting and verification.
Procurement Standards 2025	Underlined procurement standard to procure natural gas that meets the performance standard. For the procurement standard, possible pathways for compliance include certification or the establishment of methane regulatory equivalence, underpinned by robust MRV, between the EU and third countries.

Industry Best Practice

Methane Emissions Category	Commitments	Commitments, Metrics and Target	Key Initiatives
	• Methane emissions intensity • Methane flaring monitoring • Capex allocation towards renewables	Methane emissions intensity below 0.2% by 2025. Aiming to achieve near-zero methane emissions by 2030 Zero routine flaring by 2030 Eliminate routine flaring from its Upstream operations by 2025, Planning to invest $10-15 billion across 2023 to 2025	Net carbon intensity reduction target achieved for two consecutive years In 2022 Invested $4.3 billion in low-carbon energy solutions and $3.9 billion in non-energy products Deploying drones to enhance leak detection and surveillance activities in shale operations
TotalEnergies	• Methane emissions intensity • Methane flaring monitoring • Capex allocation towards renewable	Maintain methane intensity below 0.1%. Reduce methane emissions in 50% by 2025 and 80% by 2030 Zero routine flaring by 2030	Investment towards measuring methane emissions more accurately Speeding up deployment of its drone-mounted methane detection technology
equinor	• Methane emissions intensity • Methane flaring monitoring • Capex allocation towards renewable	Keep methane intensity of operated assets at 2021 levels of 0.02%. Keep methane emission intensity close to zero by 2030 Eliminate routine flaring by 2030	Methane leak detection with aircraft-based surveys offshore >40% R&D expenditure to renewables, low carbon solutions and energy efficiency in 2025 50+% of annual gross capex* to renewables by 2030
bp	• Methane emissions intensity • Methane flaring monitoring • Capex allocation towards renewable	Methane intensity in 2022 was 0.05% Methane intensity in 2025 was 0.20% Zero Routine Flaring Initiative by 2030	To install methane measurement across O&G major sites by end 2023, publish the data and drive 50% reduction in methane intensity Annual transition growth investment reaching $6-8 billion in 2025 and are aiming for it to reach $7-9 billion in 2030
eni	• Methane emissions intensity • Methane flaring monitoring • Capex allocation towards renewables	Methane intensity in 2022 was 0.08% Net Zero Carbon Footprint UPS in 2030 and Eni in 2035 Net Zero GHG Lifecycle Emissions e Carbon Intensity in 2050	LDAR deployment (Leak Detection And Repair) Flaring down initiatives Carbon credit - MtCO2 eq Natural Climate Solutions (NCS) projects to halt deforestation Annual transition growth investment reaching $13.8 billion in 2023 – 2026.

R&D and Innovation Tackling Methane Emissions



R&D and Innovation Tackling Methane Emissions

Some companies are already addressing this issue and technology is the answer

According to the IEA, almost **¾ of methane emissions could be reduced with existing technology***, and close to half at zero net cost. Major oil companies that are then aiming for ambitious methane reduction, will then have to invest in CH4-reducing technologies and in priority in detection/measurement and data processing ones

Exploration & Development → Drilling and Well Development → Crude & Gas Transportation → Refining & Petrochemicals → Sales & Marketing → Trading

O&G companies will have to invest in technologies on three areas of the CH4 reduction technologies

Detection and Measurement

- Sensor strapped to infrastructure close to the identified source of emission
- Drone surveillance with data capture
- Satellite detection

Data Processing

- IOT
- Decision making tools
- Production and monitoring software
- Big data and Cloud

Process improvement

- IA to improve the process the data
- Reporting tools
- Dashboard to ease the data analysis

O&G companies will have to **increase their tech investment**. Sia Partners can help to **identify techs by field of action** that could be used by the O&G industrials.

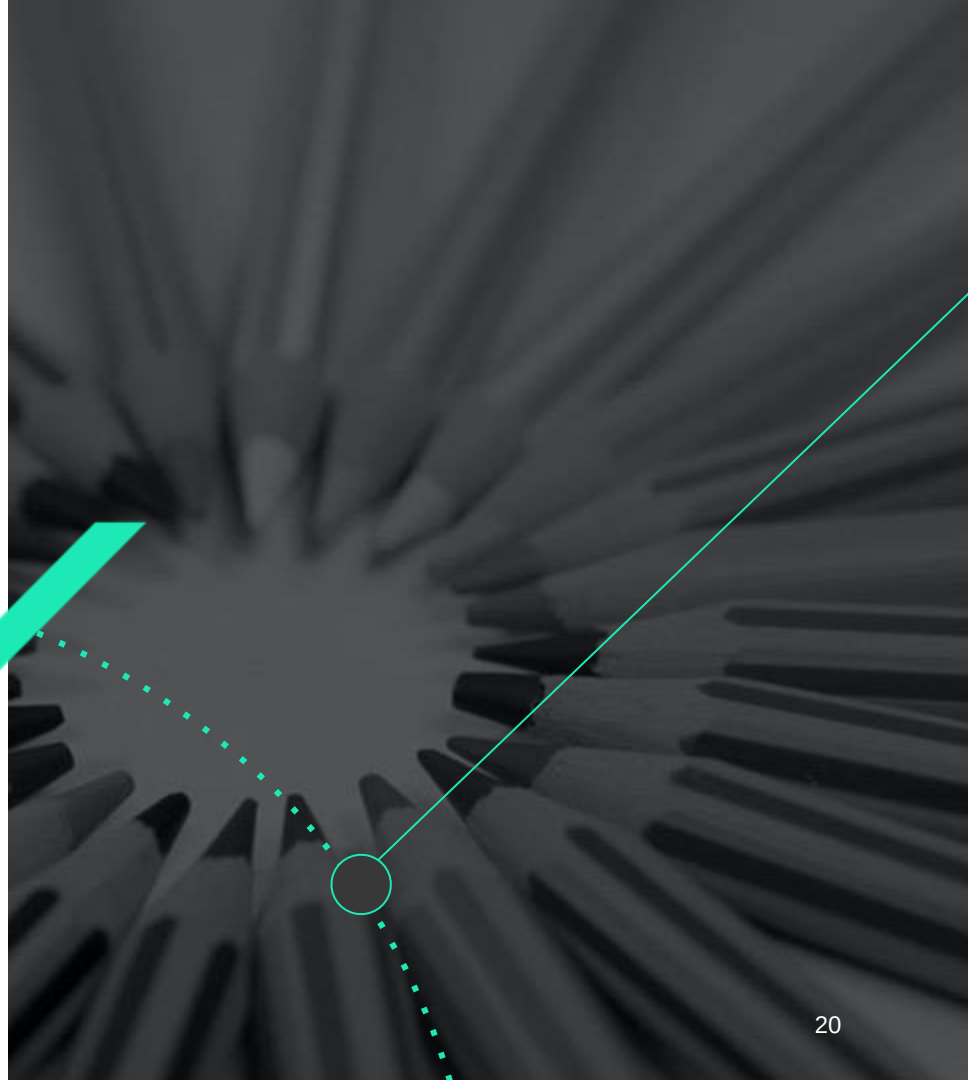
*Source : IEA Report 2021 - Curtailing methane emissions from fossil fuel operations

Research & Development

Focus on market solutions that fit the technology solutions

Example	Description	Clients
Laser Absorption Spectrometer (LAS)	A diode-infrared laser whose frequency is specifically absorbed by methane (spectrometry technology). As the laser beam from the device passes through a gas plume and is reflected to the camera, it will detect if methane is present in the beam path by comparing the strength of the outgoing and reflected beams.	
Acoustic Leak Imaging cameras (ALI)	Acoustic leak detectors capture the ultrasound signal of pressurized gas escaping a valve plug or gate that is not tightly sealed. These detectors come in both a «gun» style that detects leaks from a distance, or a «stethoscope» style that detects internal leaks through a valve plug or gate.	
Optical Gas Imaging (OGI) Camera	Hydrocarbon emissions absorb infrared (IR) light at a certain wavelength and an IR camera uses this characteristic to detect the presence of hydrocarbon gas emissions from equipment at an oil and gas facility. OGI cameras can be used with handheld units or outfitted with a drone or an aircraft.	
Imaging Interferometry (Glint Mode)	A patented imaging interferometer which merges multiple sources of light to create an interference pattern. The analysis of this interference pattern reveals the presence and quantity of methane emitted. This technology can be implemented on aircrafts or on satellites to detect methane emissions from space.	
C3 IoT	C3 IoT delivers a comprehensive platform as a service for the rapid design, development, and deployment of the largest-scale big data, predictive analytics, AI, and IoT applications. C3 IoT also provides a family of SaaS products developed with and operating on its PaaS, including predictive maintenance, sensor network health, supply chain optimization, energy management.	
Kelvin AI	AI-enabled solution to monitor and remotely manage production operations	
Process Live Data-enriched performance service	Process operations rely on complex hardware and software systems to ensure optimal hydrocarbon processing and reservoir pressure support. Equipment failures, often stemming from inlet stream changes or degradation, lead to production deferment and unscheduled maintenance that detrimentally affect operation economics.	
Viper Vision Software	Software suite designed to connect to Viper sensors allowing a continuous monitoring of the temperature. ViperVision software packages allow for real-time monitoring, data acquisition, and imaging post-analysis of the industrial processes.	

Business Cases for Methane Emissions



Business Case for Methane Emissions

CH4 emission figures in perspective

400

Approx. 400Mt CH4 emissions across all industries per year

82

82 Mt leaks from O&G facilities per year, equivalent to 155 billions MMBtu

1

Trillion US dollars
CH4 monetary leakage.

It is equivalent to the GDP of the Netherlands

* Source: Sia Partners Average gas price benchmark (HH, JKM, TTF and NBP) and World Bank

Business Case for Methane Emissions

Development concept scenarios for flaring and methane reduction projects

Smal flare = 1 mmscf/d Medium flare = 5 mmscf/d Large flare = 10 mmscf/d

1. **Gas-to-power, with power sold to the grid or other third-party off-takers**
2. **Gas-to-power, with power sold to the oil field operator for on-site use**
3. **Gas delivery to an existing pipeline network**
4. **Gas delivery to an existing gas processing plant**
5. **Compressed natural gas (CNG)**
6. **Small-scale liquefied natural gas (LNG)**

- At **10 mmscf/d**, all FMR solutions would produce positive NPVs and **double-digit IRRs**, ranging from 12% (gas delivery to a gas processing plant) to 24% percent (small-scale LNG).
- At **5 mmscf/d** flare sites, project IRRs—unlevered and pretax—range from a barely acceptable 7% (gas delivery to gas processing plant) to an **attractive 20%** (small-scale LNG).

Business Case for Methane Emissions

High-level model to monetize from flaring and methane reduction

Six developments concepts assuming small, medium and large flare sizes.

Development Concepts

(1) gas-to-power, with power sold to the grid

(2) gas-to-power, power sold to the oil field operator for on-site use

(3) gas delivery to an existing pipeline network

(4) gas delivery to an existing gas processing plant

(5) compressed natural gas (CNG)

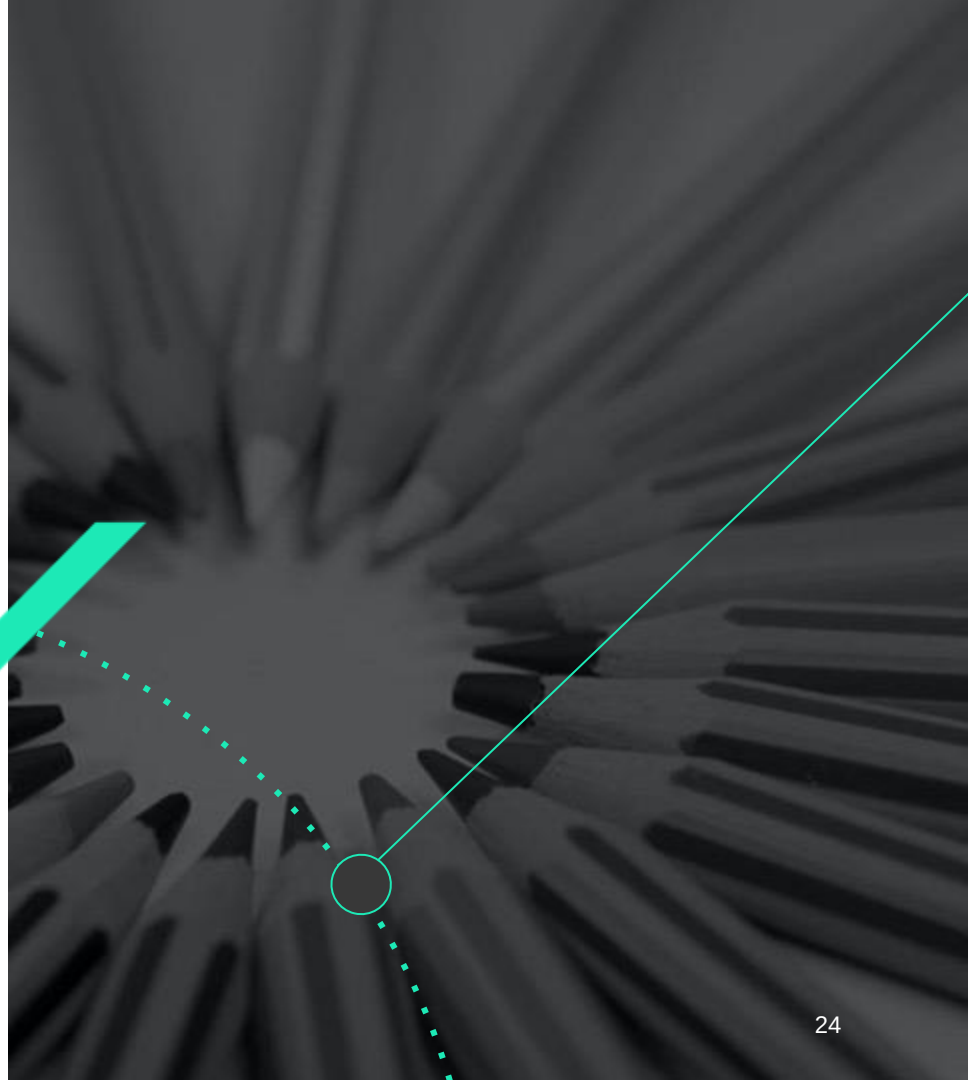
(6) small-scale liquefied natural gas (LNG)

FMR projects are seen by oil companies as unworthy diversions of capital and engineering resources.

FMR projects are more likely to be executed when FMR developers who can take care of the whole problem on behalf of oil companies.

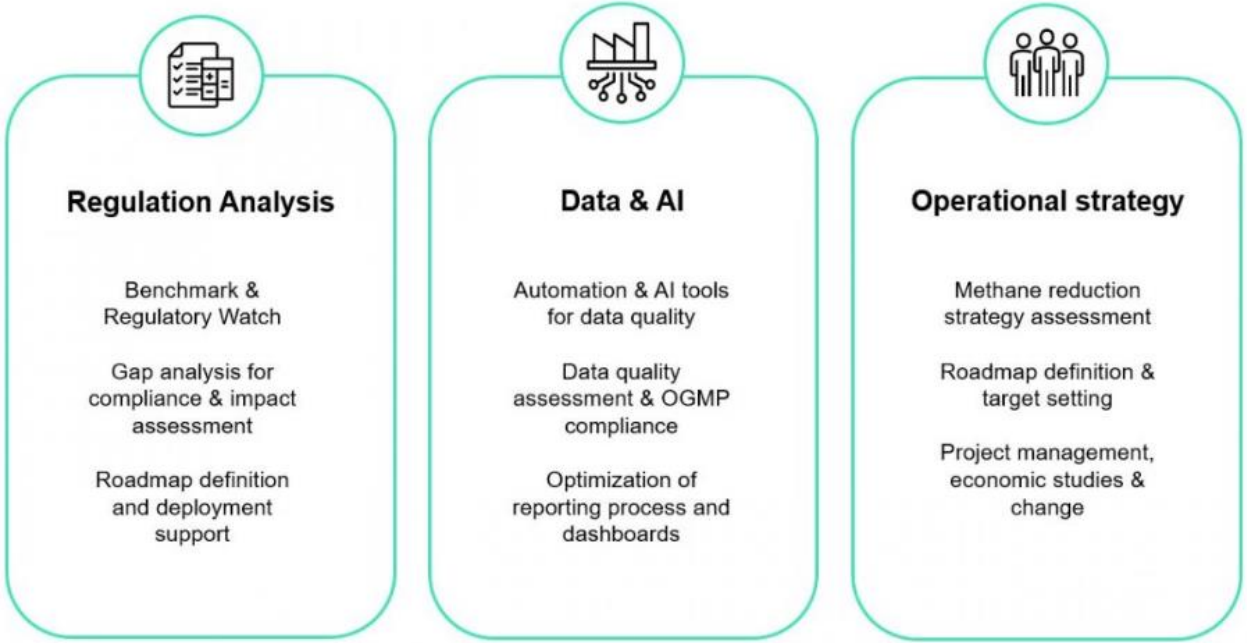
Sia Partner advise clients across the end-to-end process by building the business case to procuring and managing the right enablers with turnkey technical solutions and swift execution.

How Sia Partners Can Help?



How Sia Partners Can Help?

The approach to reduce Methane emissions



Our **approach for methane mitigation is based on these 3 core capabilities**

How Sia Partners Can Help?

Focus on the criteria of business evaluation

Size of the leaks

Measure the CH4 emitted for the volume of output produced. Give a ratio of what needs to be achieved in terms of reduction for a given plant. Indeed, it allows us to compare methane reduction initiatives on plants that are different in terms of size.

Risk analysis (human, industrial, CSR)

Identify the risks that must be taken into account to build sustainable solutions. Human and industrial risks are primordial to ensure the safety of the plant and the workers. CSR risks are more and more a concern for the companies and must then be evaluated

Location of the leaks

Allow us to locate the materials that are responsible for the leaks and to identify if there are patterns in the different leaks that occur on the client plants. It is a major criterion for selecting the right solutions and improvement plans

Business Case

Design a business case with multiple development concepts to minimize leaks and maximize valuation. Design and define technology enablers to be deployed. Assess and procure qualified vendors via the tender board. Sustainable and Green Finance Initiatives

Regulations

Identify the right regulation that needs to be taken into account to build the right target. If multiple regulations apply, need to concatenate all relevant ones to build a global response

After our business evaluation, this knowledge that we have of you will allow us to look for and present you with the technology that fits your situation.

Methodology and planning

Summary of our methodological approach

Phases	1 Business Evaluation	2 Solution Prioritization	3 POC And Generalization
Objectives	• Methane reduction business evaluation • Structuration of main improvement points	• Solution proposition • Evaluation of the proposed solutions and prioritization	• Proof of concept to validate the solution feasibility • Define the final solution and its generalization
Activities	• Develop a list of needed resources • Develop an interview guide to collect information • Analyze the business based on: ✓ **Size of the methane leak** ✓ **Location of the leaks (pipeline, wells, production site)** ✓ **Regulation in place in the country** ✓ **Risk analysis (human, industrial, CSR)** • Define improvement points	• Define a solution related to ✓ **Technology of methane emission detection and measurement** ✓ **Data-driven insight** ✓ **Digitalization** • Evaluation of maturity for each solution • Creation of the evaluation matrix and definition of the criteria • Evaluation of each solution • Prioritization and selection of the solutions	• Analysis of needs & framing of the POC (architecture, governance, choice of suppliers, monitoring KPIs, etc.). • Support for prototyping & modeling. • POC follow-up and summary. • Measure, understand, and evaluate the value of the POC on the business • Define and validate the final solution • Define a roadmap for the solution generalization
Deliverables	• Interview reports • Business evaluation report	• Solution proposal report • Solution prioritization report	• POC framing report • REX of POC report • Final solution report / business plan revision

2. Our methodology and planning

Step 1 : Business evaluation

Objectives

- Define the overall planning of the mission and the steering bodies (intermediate, final meetings)
- Validate the objectives, the proposed approach, the expected results and the formats of the deliverables
- Perform the methane emission evaluation and define improvement points

Approach

I.1 – Project framework

- Definition of the provisional work plan (schedule, key stages, sub-deliverables etc.)

I.2 – Evaluation preparation

- Identification of the main needed resources
- Develop an interview guide to collect information (see focus 1)
- Validation of the methodology that will be used for the evaluation

I.3 – Business evaluation

- Analyze the business based on:
  - ✓ **Size of the methane leak**
  - ✓ **Location of the leaks (pipeline, wells, production site)**
  - ✓ **Regulation in place in the country**
  - ✓ **Risk analysis (human, industrial, CSR)**
- Develop improvement points
- Drafting of an evaluation report

ACCELERATOR SIA

- Presence of Sia Partners internationally
- Knowledge of the role and challenges of methane reduction in the upstream O&G industry
- Proven experience in framing business evaluation
- Know-how in data research
- Good knowledge of the player's business position

OUR BELIEFS

- Importance of validating the methodology used for the evaluation
- Importance of having a wide panel of interviewees
- The evaluation is necessary in order to ensure that adequate solutions are enlightened

DELIVERABLES

- Interview report
- Business evaluation report

2. Our methodology and planning

Step 2 : Solution prioritization

Objectives

- Define the solutions and validate the prioritization matrix
- Perform an evaluation of each solution

Approach

II.1 – Solutions listing

- Define the possible solutions and its maturity based on the business evaluation report
- Relate these solutions to
  - ✓ **Technology of methane emission detection & measurement**
  - ✓ **Data-driven insight**
  - ✓ **Digitalization**

II.2 – Prioritization matrix creation

- Creation of the matrix through six criteria :
  - CAPEX
  - OPEX
  - Maturity
  - Track record
  - Implementation time
  - Field of action

II.3 – Solution prioritization and evaluation

- Evaluation of each solution through the matrix
- Prioritization and selection of the solution

ACCELERATOR SIA

- Studio, our investment fund for start-ups
- Knowledge of the role and challenges of methane reduction in the O&G upstream industry.
- Good knowledge of the possible tools used to detect methane emission in the upstream O&G industry

OUR BELIEFS

- Importance of evaluating the maturity level of each solution during the solution listing
- Importance of validating the matrix four criteria prior to starting the evaluation
- With an important possibility of solutions, a matrix is necessary to prioritize one or several solutions based on the measurable criteria

DELIVERABLES

- Solution proposal report
- Prioritization matrix
- Prioritization report

2. Our methodology and planning

Step 2: Focus on market solutions that fit the technology solutions

Detection and measurement

Technologies that allows to provide the leak data

Laser Absorption Spectrometer (LAS)

Detection of a variation of laser beam intensity after transmission along the optical path

Acoustic Leak Imaging cameras (ALI)

Capture of an acoustic signal emitted by an escaping gas.

Optical Gas Imaging (OGI) Camera

Absorption of IR light to detect the presence of hydrocarbon gas emissions.

Imaging Interferometry (Glint Mode)

Creation of interference pattern by merging multiple sources from long distance (satellite or aircraft)

Inspection services

Outsourcing the diagnostic phase with a service provider

Data Processing

Technologies that process the leak Data

Monitoring software

Integrated detection and visualization software

Production management software

Automated integrated detection, remediation and optimization solution

Process Improvement

Advanced technologies that enhance the data processing

Autonomous AI software

Big data, predictive analytics and AI solution for remote monitoring and management of operations

All these presented technologies are **relevant in the mitigation of methane emissions**. They have given industrial or prototype products that companies are now selling to the O&G actors

2. Our methodology and planning

Step 3: POC and Generalization

Objectives

- Elaborate a Proof of Concept to validate the solution feasibility
- Define the final solution and its generalization

Approach

III.1 – POC Framing	• Analysis of needs • Framing of the POC
III.2 – POC management	• Support for prototyping & modeling. • POC follow-up and summary sheet.
III.3 – Preparation for generalization	• Measure, understand and evaluate the value of the POC on the business • Evaluate the improvement points possible • Define and validate the final solution • Define a roadmap for the solution generalization

Accelerator Sia Partners

- Regularly involved in setting up POCs
- SiaXperience, a global offering based on experience design and innovation
- Expertise in gas emission

Our Beliefs

- Importance of framing appropriately the POC, based on needs
- Ensure a good follow-up in order to not deviate from the goal
- Capitalize on the return of experience from the POC to deliver the appropriate solution for the overall fuel retailer sector

Deliverables

- POC framing report
- POC REX report
- Final solution report / Business plan revision

Research & Development

Addressing Methane Emissions with Agility and Innovation in the age of Hypertransformation

01. Brief | **02. Research** | **03. Development** | **04. Testing** | **05. Sustaining**

Exploration and development | Drilling and well development | Crude & Gas transportation | Refining & Petrochemicals | Sales & Marketing | Trading

Sensor strapped to infrastructure close to the identified source of emission

Drone surveillance with data capture

Satellite detection

Internet of Things

Decision making tools

Production and monitoring software

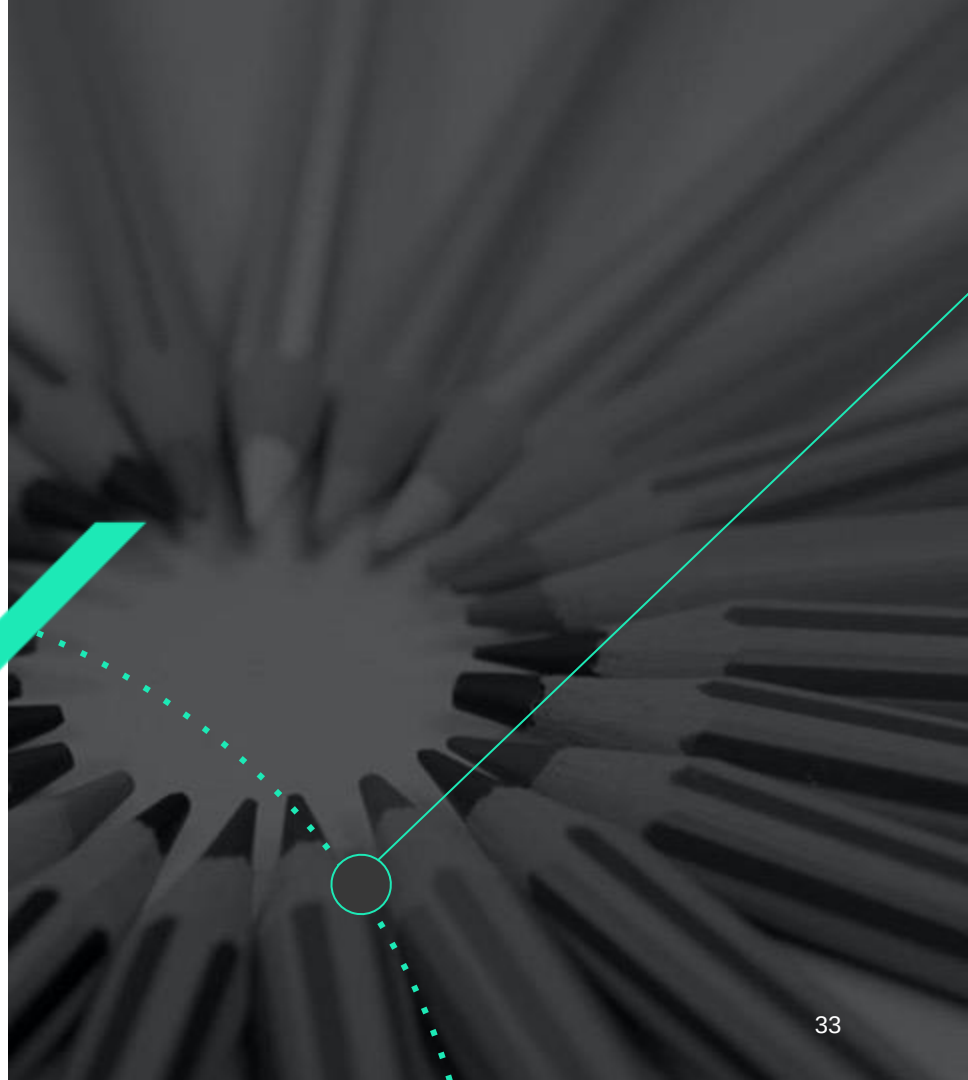
Big data and Cloud

IA to improve the process the data

Reporting tools

Dashboard to ease the data analysis

Appendices



1 Laser Absorption Spectroscopy (LAS) – handheld or aerial device

A diode-infrared laser whose frequency is specifically absorbed by methane (spectrometry technology). As the laser beam from the device passes through a gas plume and is reflected to the camera, it will detect if methane is present in the beam path by comparing the strength of the outgoing and reflected beams.

Advantages

- **Mature technology**
- **Light handheld unit, aerial possibility**
- **Immediate detection of methane only**
- **Performs well in all climate conditions**

Disadvantages

- **Detection from short distance between 30-150m max**
- **Different angles are required to identify the leak point**
- **Needs a background surface to operate => no open fields**
- **Cannot operate through clouds**

- CAPEX: device's purchase, between $10,000 and $50,000 for ha andheld device and ~$70,000 for drone technology
- OPEX: labor cost for the device operator
- Possibility of 100's of components/hour for handheld device and x3 with drone technology (depending on flight time limit)

Source : https://heathus.com/assets/uploads/RMLD-CS_122.pdf, https://www.linkedall.com/product/ailf-u10/, https://gasleaksensors.com/products/gas-trac-lz-50-laser-methane-gas-leak-detector/

1 Laser Absorption Spectroscopy (LAS) – handheld or aerial Device

Technical Data

- Sensitivity: 5 ppm·m
- Methane detection only, no false alarm
- Time response: <0,1s
- Handheld device: ~8 hours battery, recharge time 3h-5h
- For drone: max 30 min - 1h flight time
- Real-time data and Bluetooth/WIFI connections
- Graphical user interface and colour camera and display

Product examples

RMLD-CS
- Hetek Solutions Inc
- TDLAS
- ~$15,000

GAS•TRAC LZ-30/50
- Sensit
- TDLAS
- ~$13,000

U10 Drone-mounted Laser
- LinkedAll and AiLF
- TDLAS
- ~$70,000

A very mature technology used by most in Oil & Gas as their first mean to detect small and located leaks.

Source : https://heathus.com/assets/uploads/RMLD-CS_122.pdf, https://www.linkedall.com/product/ailf-u10/, https://gasleaksensors.com/products/gas-trac-lz-50-laser-methane-gas-leak-detector/

1 Laser Absorption Spectroscopy (LAS) – Aeris Technologies

A diode-infrared laser whose frequency is specifically absorbed by methane (spectrometry technology). As the laser beam from the device passes through a gas plume and is reflected to the camera, it will detect if methane is present in the beam path by comparing the strength of the outgoing and reflected beams.

Advantages

- **Autonomous once installed**
- **Locates and quantifies methane emissions**
- **Provides real-time information**

Disadvantages

- **Requires sampling ports throughout the client grid**
- **Requires battery changes (6-hour battery limit)**
- **Limited onboard memory (32 GB)**

- CAPEX: device's purchase, between $3,000 - $10,000 per year, per unit – half the price of comparable systems and 10X smaller, lighter.
- OPEX: labour cost for the device operator

Source : Scherer, J. J. (2022). Photonics and the Evolution of Ultrasensitive Gas Analyzers: Past, Present, and Future [PowerPoint slides]. https://epic-assoc.com/wp-content/uploads/2021/12/Jim-Scherer-Aeris-Technologies.pdf

1 Laser Absorption Spectroscopy (LAS) – Aeris Technologies

Technical Data

This system can be implemented on drones, handheld, or permanently fixed for continuous data. It is offered in 3 configurations:

1. MIRA PICO Series - most robust
2. MIRA Ultra Series - offers same capabilities as PICO with temperature stabilized optical core.
3. MIRA Strato Series: Drone – offers the same capabilities as PICO but smaller and lighter

Currently the only sensor with 1s resolution at 1ppb/s sensitivity. Measures in the middle infrared spectrum, meaning it's ability to detect methane is much better than competitors since it has stronger absorption.

Track records

- Currently employed in 7 countries, including the USA, Canada, Europe, and China.

A very mature technology used by most in Oil & Gas as their first mean to detect small and located leaks.

2 Acoustic Leak Imaging camera (ALI) – Handheld or Aerial Device

Acoustic leak detectors capture the ultrasound signal of pressurized gas escaping a valve plug or gate that is not tightly sealed. These detectors come in both a «gun» style that detects leaks from a distance, or a «stethoscope» style that detects internal leaks through a valve plug or gate.

Advantages

- **Easy-to-use, working comfort**
- **Time-saving**
- **Mature technology**

Disadvantages

- **Use with a drone not mature enough for now**
- **Detects all types of gas leaks, not only methane**
- **Not as useful for smaller leaks or low-pressure gas**

Economical Data

- Camera: between $35 000 and $67 000
- Drone: around $10 000-$15 000 for a drone, possibilities of packages around $84 000
- Possibilities of quantification software around $35 000
- OPEX: high labour costs

Source : Interview of Florian Perrodin, Co-Founder of Distran, global leader in ultrasonic camera manufacturing

2 Acoustic Leak Imaging camera (ALI) – handheld or aerial device

- Detection threshold: 1 L/h from 1m, 40L/h from 20m
- Working distance: 0.3 – 100 m
- Acoustic angle of view: 180° (half space)
- 124 microphones
- Rechargeable Li-ion battery
- Dimensions : 273 x 170 x 125 mm
- Weight : 980g

GE Oil & Gas

- Standard procedure since 2014
- Used in several countries worldwide

TotalEnergies

- Units deployed overseas
- Both use of visualization and quantification tools

Source : Distran Product, https://distran.swiss/en/ultra-pro/

3 Optical Gas Imaging camera (OGI) – handheld or aerial Device

Hydrocarbon emissions absorb infrared (IR) light at a certain wavelength and an IR camera uses this characteristic to detect the presence of hydrocarbon gas emissions from equipment at an oil and gas facility. OGI cameras can be used with handheld units or outfitted with a drone or an aircraft.

Advantages

- **Relatively low-cost**
- **Mature technology**
- **It can be outfitted with a drone, used by hand or used for continuous monitoring**

Disadvantages

- **Climate conditions affect the detection efficiency (temperature, wind, humidity)**
- **Darkness can be a limitation (but cameras can be equipped with lamps)**

- Camera: between $30 000 and $150 000
- Drone: around $10 000-$15 000 for a drone
- Possibilities of quantification software around $35 000
- OPEX: high labour costs
- Continuous monitoring on a fixed station or remote operations enabled (drones, aircraft)

Source : Interview of Vincent Chéret, Sales Manager at France Infra Rouge, leader company in thermography solutions

3 Optical Gas Imaging camera (OGI) – handheld or aerial device

Technical Data

- Absorption within 2 micrometers (detection of about 15 VOC gas)
- Rechargeable Li-ion battery
- Temperature of functioning: -20°C to 50°C
- Enable to scan area in real-time, capable of 100s of components/hour
- Airplanes can identify a leak source within a range of about 500 meters, can survey dozens of facilities in a day

Track records

The Environmental Partnership
- Coalition of 80 Oil & Gas companies
- LDAR programs
- Since 2019

Chevron
- Autonomous drones for oil field monitoring

Shell
- Use of continuous monitoring
- Project Quanta3 started in 2017

The most precise camera device to detect the smaller leaks

Source : FLIR product, https://www.flir.com/instruments/optical-gas-imaging/
LinkedAll product, https://www.linkedall.com/product/ogi-640/

4 Imaging Interferometry – GHGsat

GHGsat Incorporation has developed a patented imaging interferometer which merges multiple sources of light to create an interference pattern. The analysis of this interference pattern reveals the presence and quantity of methane emitted. This technology can be implemented on aircraft or on satellites to detect methane emissions from space.

Advantages

- **Effortlessly detect emissions at a world scale**
- **Measures methane and carbon dioxide**

Disadvantages

- **Can only detect large leaks, not small leaks**
- **Longer implementation time than other solutions**
- **More expensive long-term solution because of the service-providing system**

Economical Data

No data available

Source : GHGsat website, https://www.ghgsat.com/en/technology/

4 Imaging Interferometry – GHGsat

Technical Data

- 6 satellites equipped with the technology are currently orbiting the planet
- Satellites orbit the earth in 90 minutes
- Operates at an altitude of 500 kms in high-resolution

Track records

- Controlled methane release in partnership with TotalEnergies in 2019
- In 2021, an extension of the partnership with TotalEnergies for measuring the emissions from 6 offshore oil & gas platforms
- In Q4 2021, 143 MTCO2eq of methane emissions detected from 47 different countries

The most relevant solution to obtain regular reports about the larger leaks at a world scale

Source : GHGsat website, https://www.ghgsat.com/en/technology/

5 Inspection Services – Example of Kairos Aerospace

A diode-infrared laser whose frequency is specifically absorbed by methane (spectrometry technology). As the laser beam from the device passes through a gas plume and is reflected to the camera, it will detect if methane is present in the beam path by comparing the strength of the outgoing and reflected beams.

Advantages

- **Not significantly affected by degradation**
- **Immunity to electromagnetic interference**
- **Large survey area**

Disadvantages

- **High operating costs in large settings**
- **Requires sunlight for spectrometer**
- **Can only detect large leaks, not small leaks**

Economical Data

- Flat rate of $100 per well for inspection and $1000 per well (on average) for repair.
- Planes are rented close to the client's operations in order to reduce operating costs.
- Detection equipment is mounted to the strut of the wing.

Source : Ceraweek by S&P Global. (n.d.). https://ondemand.ceraweek.com/detail/video/6021450577001/kairos-aerospace-an-ogci-portfolio-company

5 Inspection Services – Example of Kairos Aerospace

Technical Data

- 12.1M tonnes of Carbon Dioxide equivalent (CO_2e) mitigated in 2021
- Operates at an altitude of 3000 feet and can cover 150 square miles per day

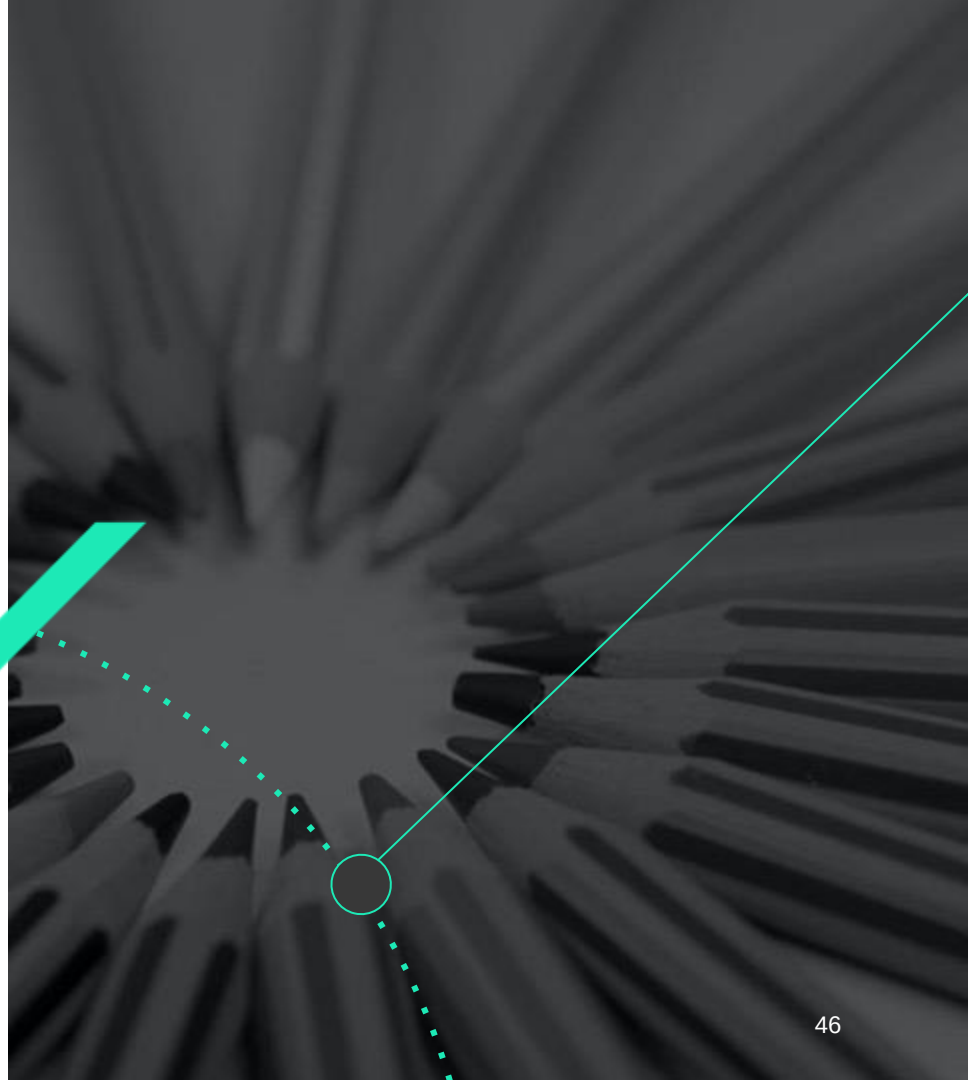
Track records

- Kairos Aerospace is currently proactively scanning upstream oil operations in order to have the data ready if clients request their services
- In 2021, Kairos Aerospace flew 13 regions in the United States and 4 internationally

A quick and easy way to have an overview of the larger leaks

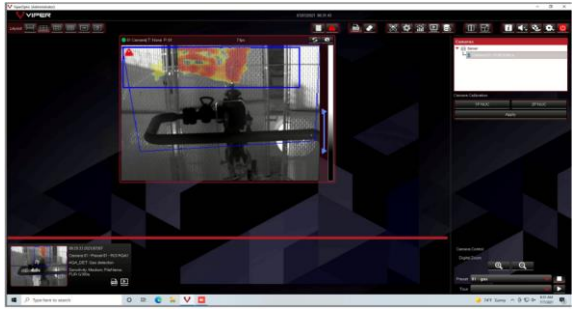
Source : Ceraweek by S&P Global. (n.d.). https://ondemand.ceraweek.com/detail/video/6021450577001/kairos-aerospace-an-ogci-portfolio-company

Data driven & digitalization technologies



6 ViperVision Software

Viper systems utilize OGI (Optical Gas Imaging) cameras and integrated ViperOptic software to detect and quantify hundreds of industrial gases. ViperOptic offers multiple capabilities from a single software platform.



Advantages

- **All-in-one solution: camera and software**
- **Modular and adaptive sensor: Fixed and portable OGI cameras**
- **Enhanced leak: ViperOptic software colorizes the gas**
- **Quantitative leak: ViperOptic quantifies the mass flow rate of the leak.**
- **Monitoring and recording videos**
- **Multiple gas type detection**

Disadvantages

- **Software needing Viper Camera's**
- **Data only gathered with OGI cameras**

Economical Data

- Total Cost: From $40,000 to $100,000 with a camera. The software license is included with the camera
- Clients: Exxon, BP, ENI, Oil field in the US, gas field in Italy

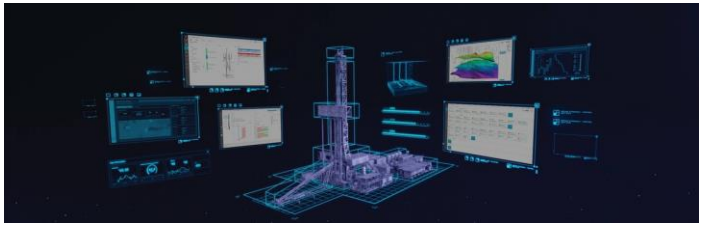
Data used

- Gas detection
- Gas quantification
- Surveillance
- Flame detection
- Spill detection

Source : Viper Imaging Sales Manager interview and documents

7 Process live data - enriched performance service

Process live data-enriched performance service provides a fully integrated detection and remediation solution. It is specifically designed to help operators manage GHG emissions and optimize production networks' overall economic performance and process facilities from the point source to the enterprise level. The service employs a data-driven approach to GHG emission management by leveraging a combination of Intelligent Internet of Things (IIoT) hardware, edge computing, and cloud-based applications



Advantages

- **End-to-end service, the service is a multifaceted offering for uptime assurance, process optimization, and greenhouse gas (GHG) control. It integrates digitally enabled equipment, collaboration with OEM experts, and maintenance to enhance asset life cycle management.**
- **Live monitoring on a secure cloud-based data environment for real-time monitoring**
- **Process modelling facilitates comprehensive emissions analysis, which enables rapid identification and mitigation processes**

Disadvantages

- **Complete solution from hardware (sensor) to software**
- **Cloud computing solution needed**

Source : https://www.slb.com/well-production/midstream/process-live-data-enriched-performance-service

Economical Data

No data available

Data used

- Any type of sensor (multipoint gas composition, flow rate, temperature, pressure, etc.)

Source : https://www.slb.com/well-production/midstream/process-live-data-enriched-performance-service

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Kelvin IA

AI-enabled solution to monitor and remotely manage production operations.

Advantages

- **Full-scale solution: process optimization, GHG control, maintenance optimization.**
- **Adaptive solution: Kelvin IA accepts all kinds of sensors and data. It can be integrated into all systems and platforms. Easy scale-up.**
- **Machine learning from human input.**
- **Entire process simulation allows us to visualize carbon emission and test operational change.**

Disadvantages

- **Cloud computing solution needed.**
- **Integration with client data and system.**
- **Operation time needed to learn from the employee in the field.**

Economical Data

- Total Cost: from $150 000 to $1.5 M depending of the scale and industrialization of the solution
- Clients: BP, Santos, funded by Oil and Gas Climate Initiative

Data used

- Any type of sensor, all the data available
- Offer expertise to assist the sensor development if necessary
- Solution very effective for venting and improving on flaring

Source : KELVIN Inc. President of Sales interview and documents

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C3 IoT

C3 IoT delivers a comprehensive platform as a service for the rapid design, development, and deployment of the largest-scale big data, predictive analytics, AI, and IoT applications. C3 IoT also provides a family of SaaS products developed with and operating on its PaaS, including predictive maintenance, sensor network health, supply chain optimization, and energy management.

Advantages

- **Full-scale solution: process optimization, GHG control, maintenance optimization**
- **Accept all kinds of sensors**
- **Machine learning and cloud computing**

Disadvantages

- **Cloud computing solution needed**
- **Integration with client data and system**
- **Optimization and maintenance focus**

Economical Data

- Total Cost: No data available
- Clients: Shell

Data used

- Any type of sensors, all the data available

Source : https://c3.ai/

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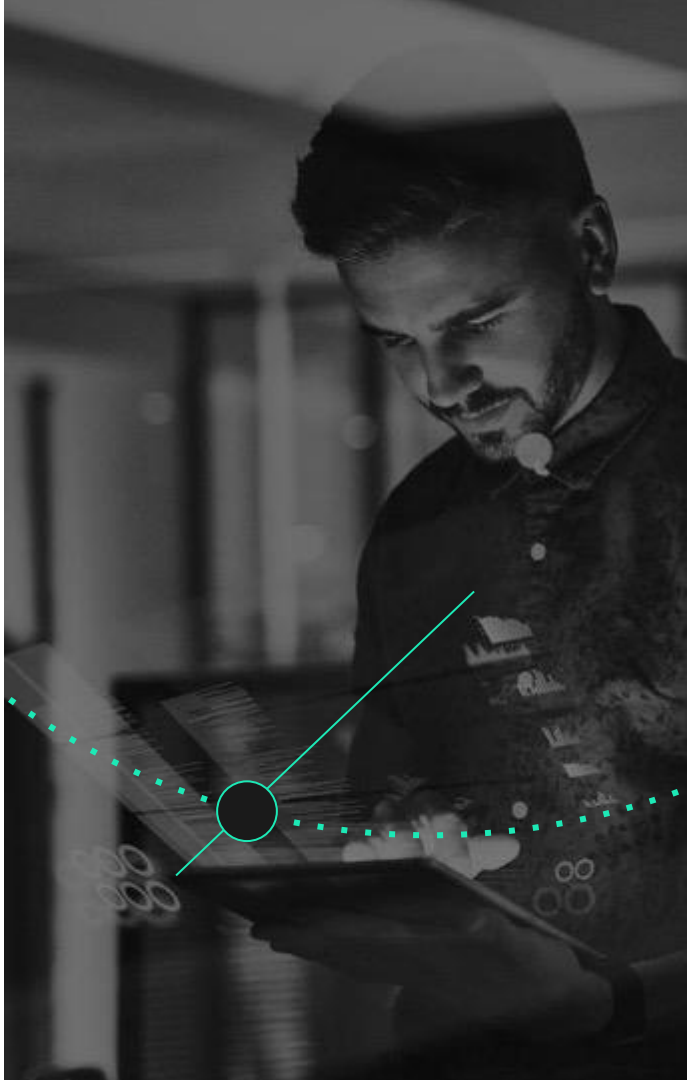

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