STATIONARY LDAR

A (new) compliance tool for EU methane regulations

Susanne Pianezzi | July 14th, 2025

Energy Community

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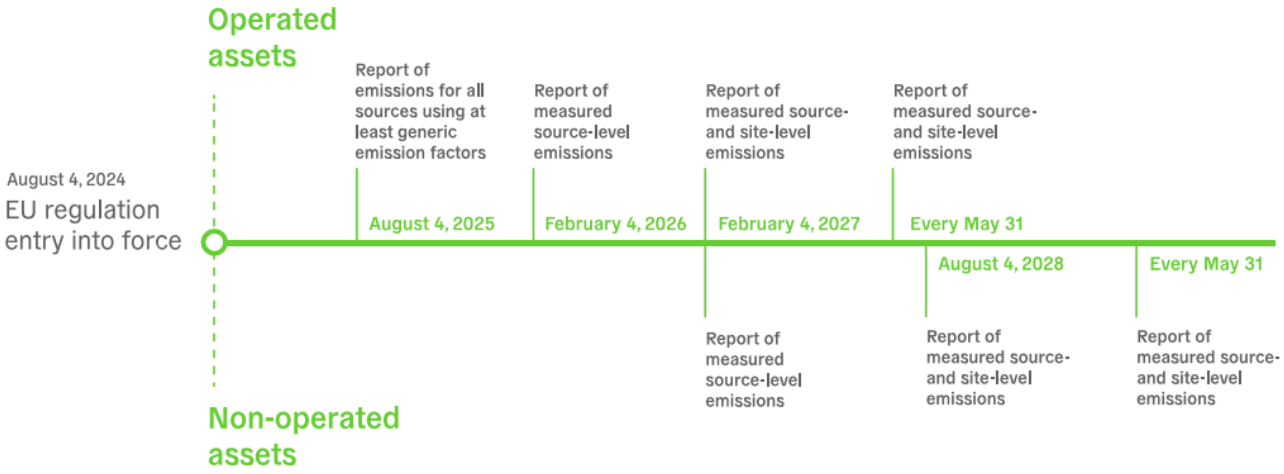
Achieve compliance with stationary LDAR

- **Challenges of the EU regulation 2024/1787** on methane emissions reduction:
  - increased LDAR survey frequencies and scope, required follow-ups
  - future reconciliation efforts

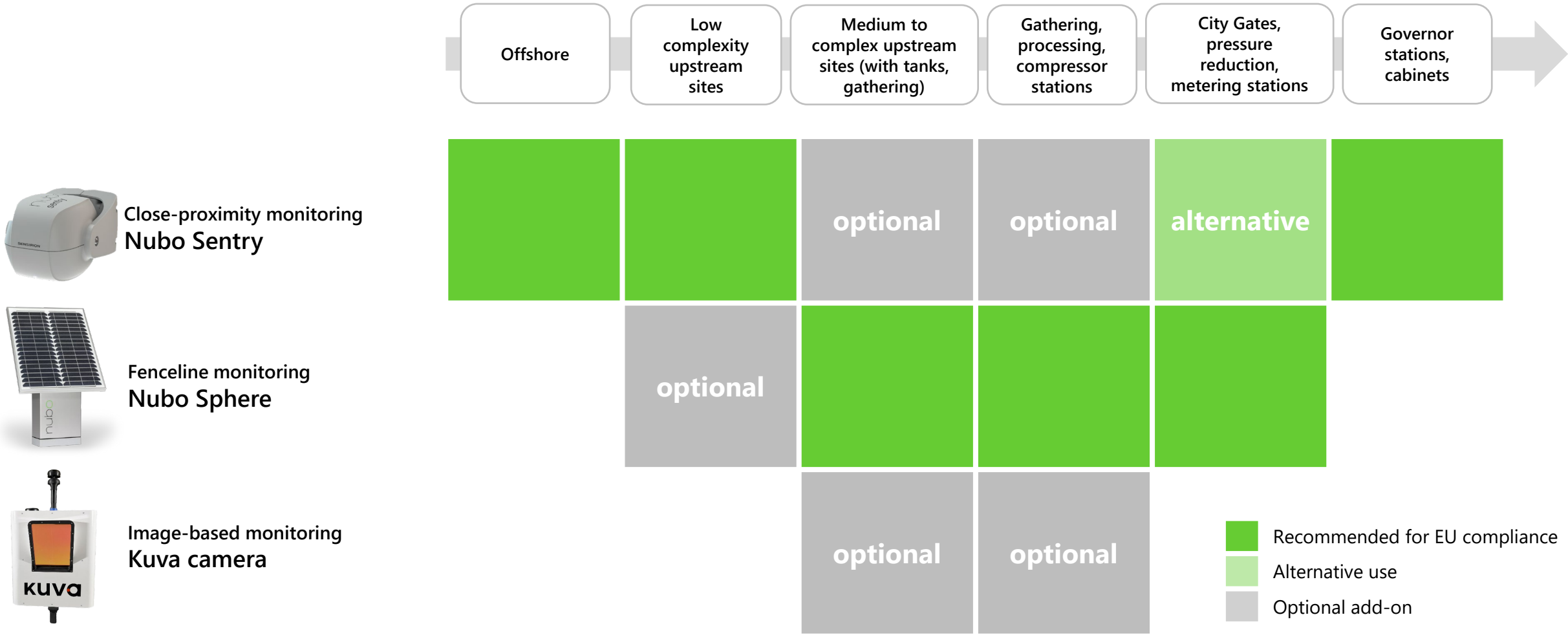
- Use **stationary LDAR technologies** to comply with EU regulation 2024/1787
  - to deploy your resources in a targeted and meaningful manner
  - to advance LDAR best practices,
  - to achieve operational excellence, and
  - to reduce emissions.

- **Be future-proof:**
  Use stationary LDAR technologies for both,
  LDAR as well as MRV compliant reporting

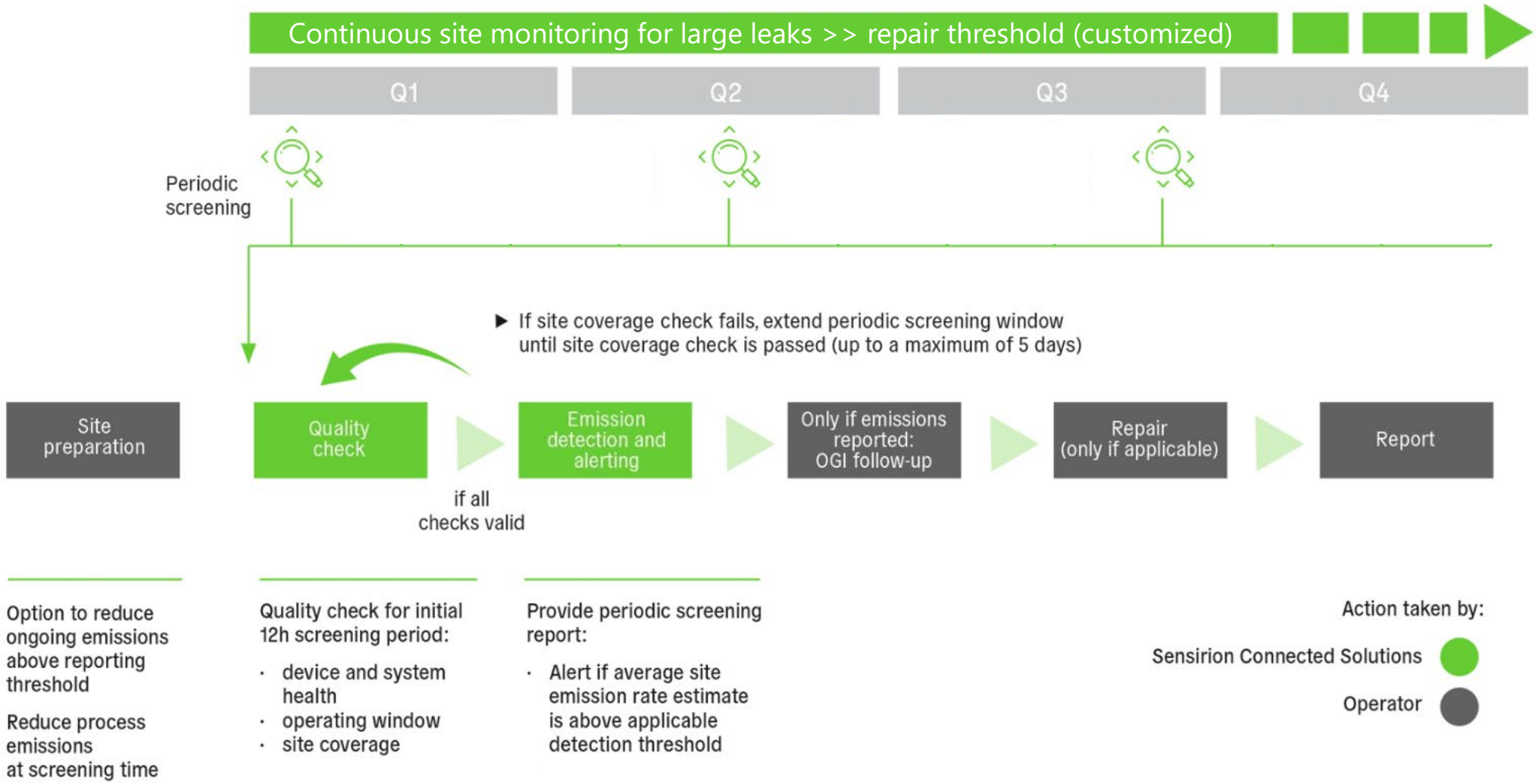


We've got you covered!

Your one-stop shop for leading stationary LDAR solutions across all assets



Workflow for periodic screening with stationary LDAR



Stationary LDAR technologies

For indoor as well as outdoor monitoring

- **Close-proximity monitoring**: ***Nubo Sentry*** *(see right)*
  - ATEX Zone 0, intrinsically-safe
  - battery operated (5 years lifetime at a measurement frequency of 1/20 sec), Lora Wan communication
  - range of 5 m for ≥ 17 g/h detection (LOD of <10 ppm)

- **Fenceline monitoring**: ***Nubo Sphere*** *(see left)*
  - Non-ATEX
  - solar-powered with battery back-up, LTE communication
  - range of 10 m for ≥17 g/h detection due to lower LOD (<1ppm)

- Both solutions are based on **mid-infrared laser spectroscopy** based on **photoacoustics**

Offshore emissions monitoring

Continuous close-proximity sensing

- **Deployment: sensor network** acting as “smoke detector”
  - Low detection limit ensures reliable and fast detection of even small emissions
  - Increasing safety due to early warning (complimentary to LEL sensors)
  - Easy to install thanks to battery operation – no need for wiring!
  - Data can remain local via LoRa communication
- **OGMP L5:** additional insights due to Nubo Sentry’s continuous nature to improve the success of your reconciliation efforts of traditional L4 campaigns with drone surveys

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Onshore emissions monitoring

maximize performance and coverage

- Get the best out of two worlds and combine:

  Nubo Sphere + Nubo Sentry

  fence line monitoring + close-proximity sensing

- Optimized coverage of relevant emission sources especially on complex sites
  - on top of tanks for thief hatch monitoring
  - at compressors for load optimization
  - at separators, inside housed structures, …
- Improved reliability and accuracy of detected methane emission events
- Speeds up root cause analysis to reduce associated costs of follow-up activities
- Increases safety through early detection of elevated methane concentrations in confined areas (complementary to LEL sensors)

Exemplary deployment

Outdoors at a valve station

- ~20x20m^2 in size

Exemplary deployment

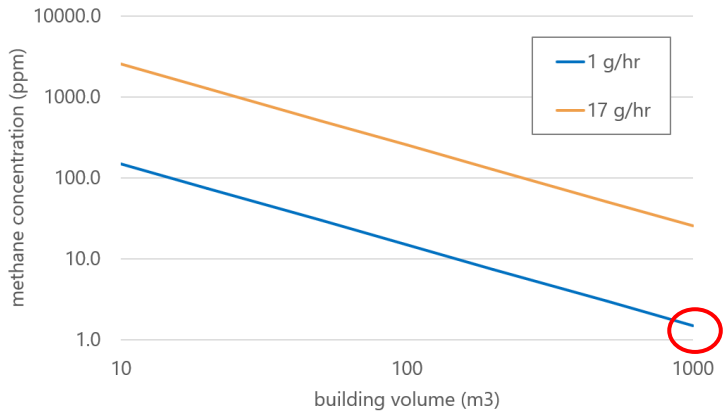
Outdoors at a valve station

- ~20x20m^2 in size
- Deploy ~**3 stationary Nubo Sentry** to cover all potential emission sources with a high probability under different wind conditions
- Each sensor covers an area of **~5 m radius** («coverage area»)
- Use of a local, solar-powered LoRa gateway or third-party infrastructure (for cost minimization)
- Use wind sensor data to avoid ambiguity, identify offsite emissions and enable quantification

Exemplary deployment

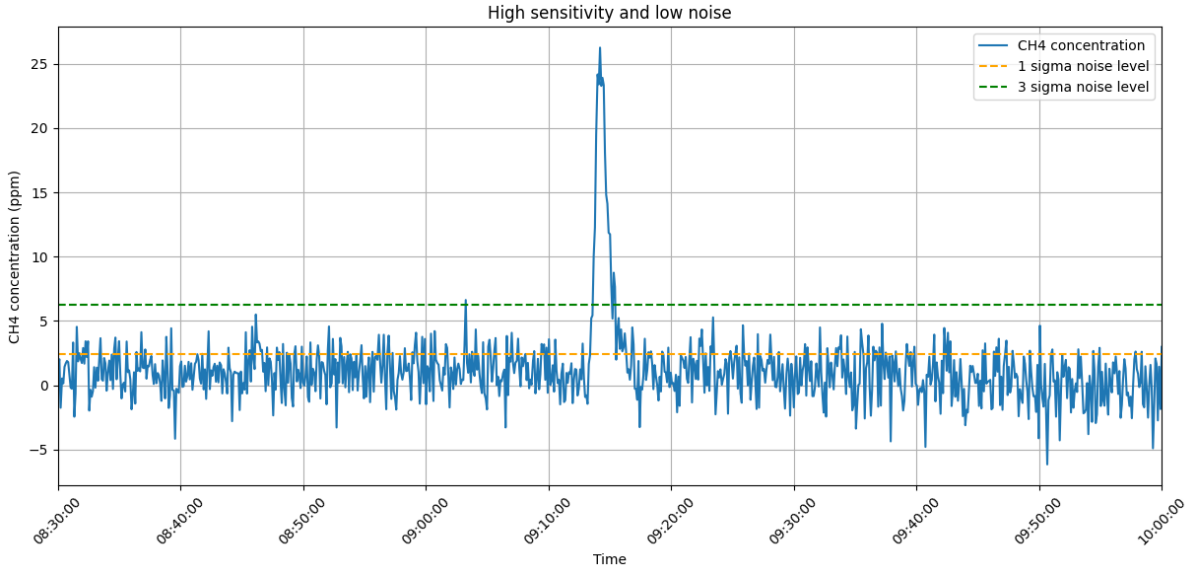
Indoor infrastructure

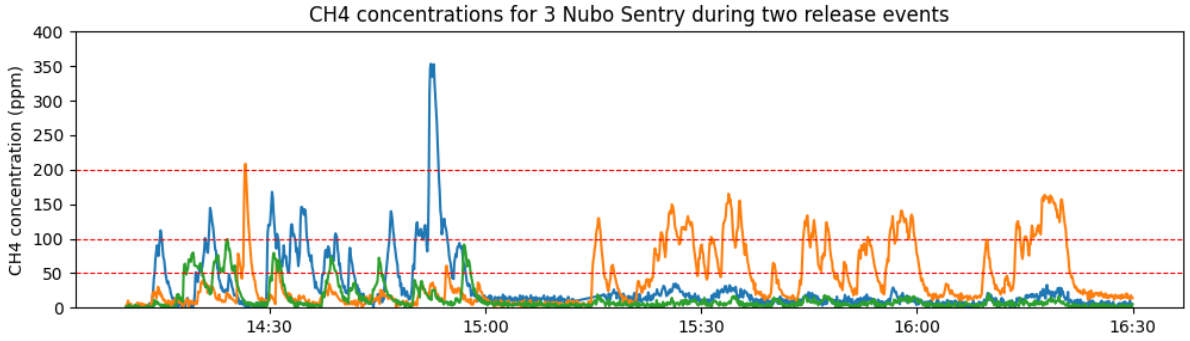
- Strategically placed to be within the flow of air
- Different conversion from g/hr to ppm: assume that methane from a persistent leak source accumulates over time resulting in a steady-state methane concentration given by
  - the leak rate,
  - the building's volume, and
  - the air exchange rate of the building through forced or natural ventilation.



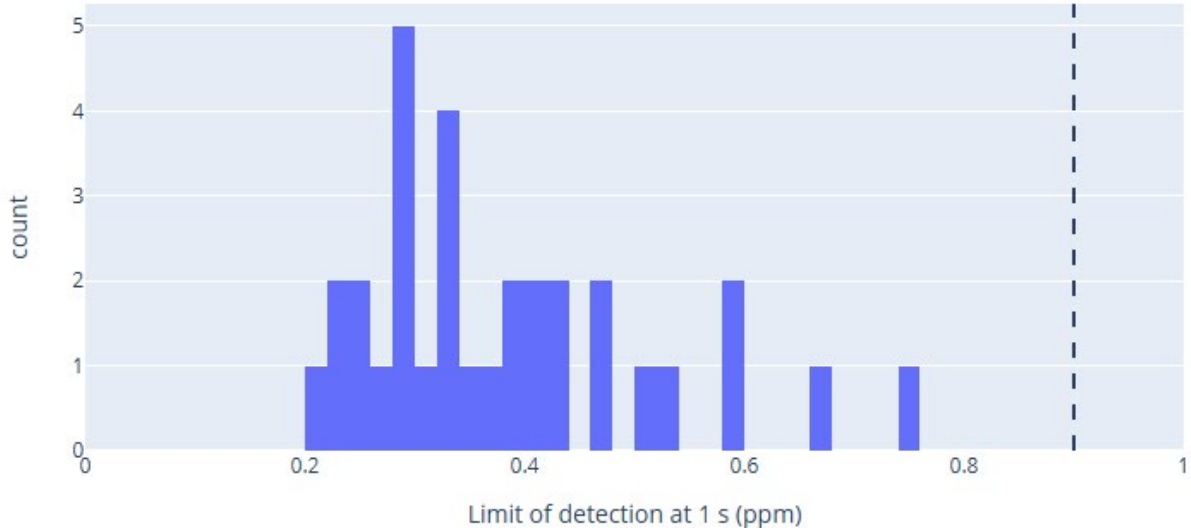
Data supporting our claimed detection limits

- **Nubo Sentry** demonstrated low detection limit < 10 ppm at TADI 2025 campaign





- **Nubo Sphere** LOD verified by
- Vito labs, BE (in 2023) confirmed detection of 17 g/hr at a distance of 20 m
- Empa (in 2025) confirmed 3-sigma LOD of < 0.9 ppm:



*preliminary results

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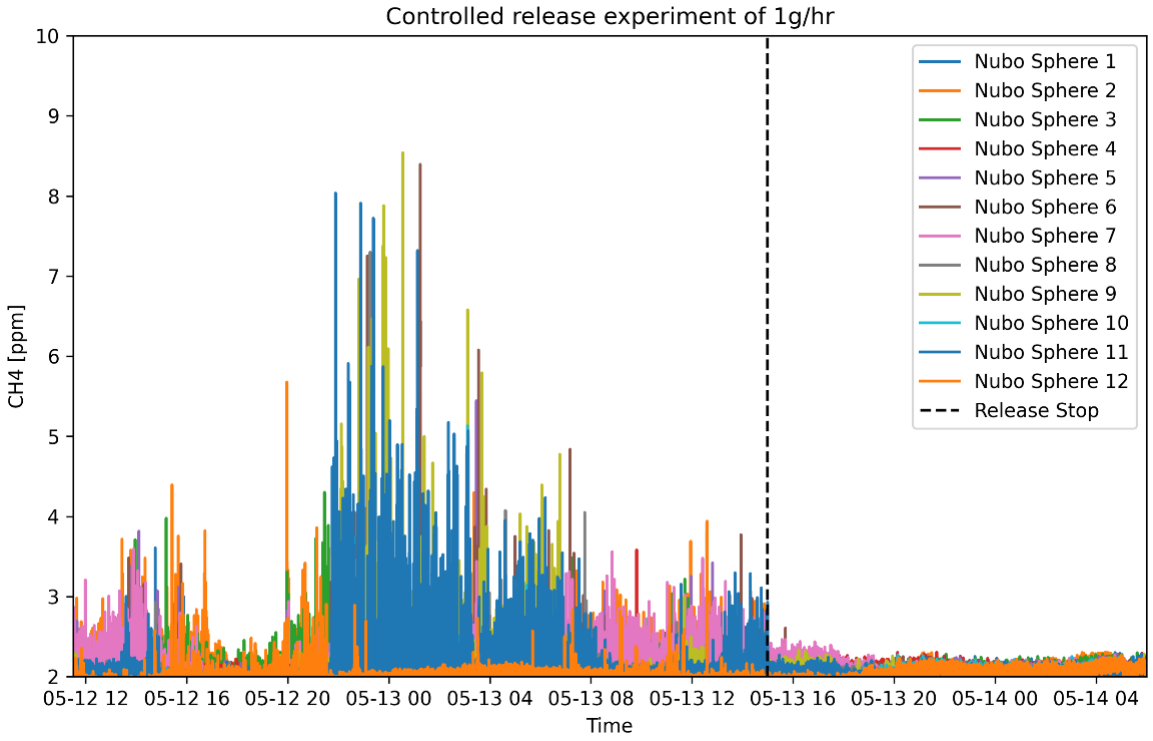
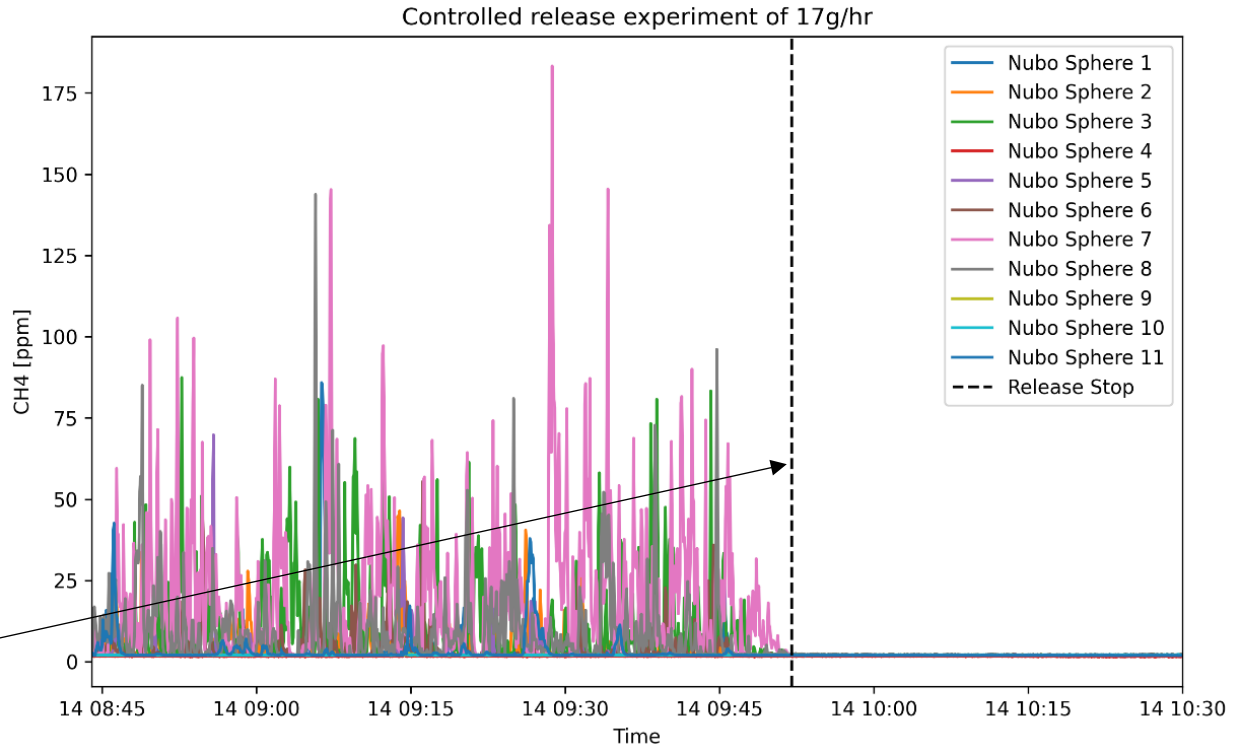
Controlled releases at Type 1 & 2 repair thresholds

- **Nubo Sphere** clearly able to detect 1 g/h in 3 m distance



Nubo Sphere easily able to detect 17 g/h in 9 m distance



end of release

Take Home Message

Use stationary LDAR to streamline your compliance efforts!

- **Stationary LDAR solutions by Sensirion meet required detection thresholds to comply with EU methane regulations**
  - Account for the specific characteristics of stationary LDAR solutions (conversion between leak rate and measured concentration at the location of the sensor based on a plume dispersion calculation; differentiate between indoor or outdoor installations)
- **Benefits of stationary LDAR**
  - Perform only targeted follow-ups, confirm repairs
  - Indoors: Increase safety through early detection of elevated methane concentrations
  - Gain additional insights to inform emissions reduction initiatives and investment decisions through more frequent monitoring
- **Be future-proof** and use the same solutions for MRV reporting requirements come February 2027

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CONTACT

Susanne Pianezzi
Director, Global Sales & Regulatory Affairs
susanne.pianezzi@sensirion.com
+41 79 540 15 89

Oliver Martin
Regional Market Manager Europe
oliver.martin@sensirion.com
+41 78 934 40 95

It was a pleasure to join you today!

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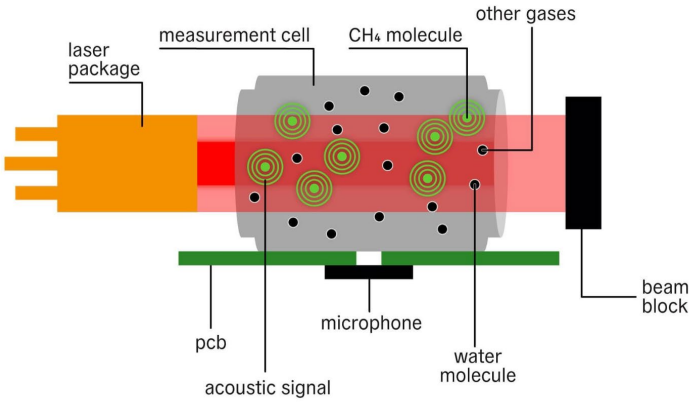
Nubo Sphere brings lab performance to the field

Unprecedented price-to-performance ratio: photoacoustic-based laser spectroscopy

Proprietary sensor technology
developed by Sensirion using 25 years of sensor expertise and specifically designed to meet the requirements of the oil & gas industry

Photoacoustic-based laser spectroscopy
probing the distinct absorption 'fingerprint' of methane molecules in a miniaturized packaging with improved power-efficiency



Combining Sensirion's patented photoacoustic sensor technology with traditional laser spectroscopy leads to:

Low total costs of ownership
thanks to 6 years lifetime, no maintenance and increased coverage

Increased quantification accuracy
thanks to high accuracy gas concentration readings

Improved detection and localization
due to fast response times on the order of seconds

Enabled site-level quantification
through absolute measurements instead of relative measurements

Reduced false positives
due to a high specificity to CH_4 (99%)

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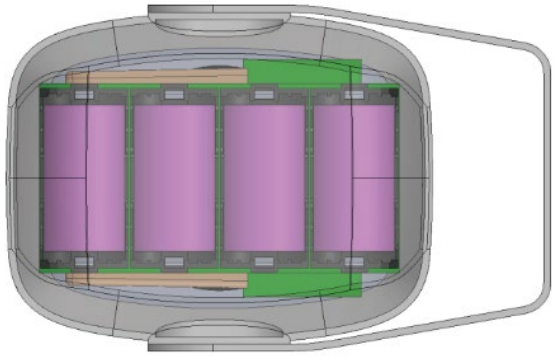
Nubo Sentry

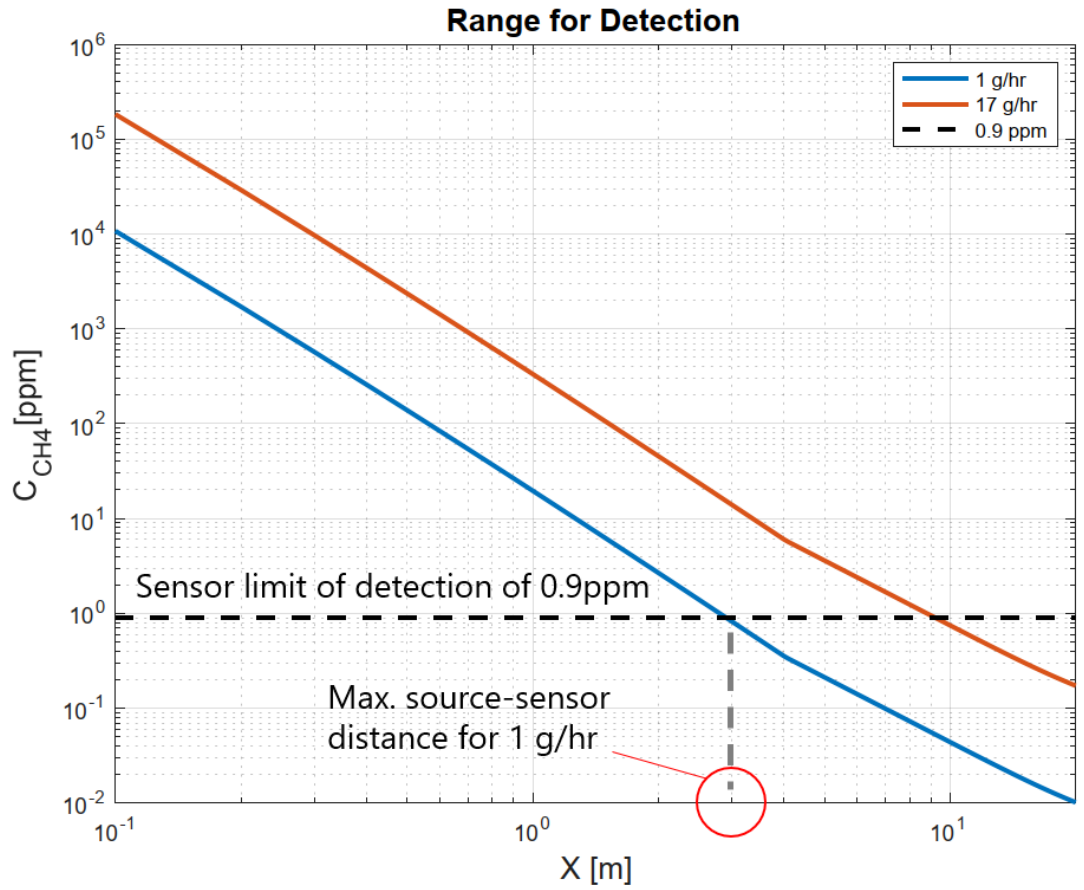
Preliminary design and specifications



- Close-proximity methane sensor
  - Low power photoacoustic spectroscopy, highly selective to methane
  - Low limit of detection: one order of magnitude below existing solutions, targeting < 20 ppm
  - Intrinsically safe
    - US/CA Class 1 Div 1, Group C, D, T4
    - ATEX/IECEx Zone 0, IIB, T4
  - 5-year battery lifetime at 1 measurement every 20 s
  - LoRa communication
  - Environmental protection (IP65 and corrosion-resistance, NEMA 4X)
  - Operating conditions: -40°C – 50°C, up to 100% RH

Conversion from g/hr to ppm

as a function of the source-sensor distance



Local plume dispersion model

- Colored lines show the methane concentration at the sensor location as a function of the source-sensor distance for leak rates of 1 g/hr (blue), 17 g/hr (red), and 1000 g/hr (yellow)
- Dashed lines indicate
  - the 3-sigma LOD in ppm of Sensirion's stationary sensor technology (black)
  - the corresponding maximum source-sensor distance of ~3 m for a 1 g/hr leak (or ~9 m for a 17 g/hr leak) (grey)

Third-party verification proving this correlation:

- 2023: Vito labs, BE confirmed detection of 17 g/hr at a distance of 20 m
- 2025: ongoing studies with Empa, CH

Sensirion's response to the LDAR questionnaire

- An explicit definition of MDL is important, which needs to be provided through the Implementing Act.
- We propose to define the MDL as the 3-sigma value of the Limit of Detection (LOD) i.e. of the noise floor of the measurement technology under evaluation.
- Because of the 3-sigma LOD definition, we propose to require an **MDL equal to the repair thresholds** defined in Article 14.8 of the EU methane regulation. The 3-sigma definition ensures a high probability that any methane concentration exceeding the repair threshold is reliably detected (> 99% probability).
- We also suggest to account for the specific characteristics of stationary LDAR technology. For this purpose, a **conversion between leak rate threshold and the required MDL at the location of the sensor** based on a plume dispersion calculation is required.
- In case stationary LDAR technologies are being deployed, we further suggest differentiating between **indoor or outdoor installations**.

Summary of Sensirion's suggested LDAR MDLs

Preliminary MDLs – work in progress!

Physical location of component	Leak threshold that triggers a requirement to repair	Suggested level of Minimum Detection Limit (MDL)
Type 1 LDAR surveys		
Onshore aboveground and offshore above sea level	7,000 ppm or 17 grams/hour (Article 14.8)	Outdoor: 17 g/hr or LOD (3-sigma) of 0.9 ppm at the position of the sensor with maximum source-sensor distance of 9 m (remark [1]). Indoor: 17 g/hr or 17 ppm at the position of the sensor for a maximum building air volume of 1000 m^3
Type 2 LDAR surveys		
Onshore aboveground and offshore above sea level	500 ppm or 1 gram/hour (Article 14.8)	Outdoor: 1 g/hr or LOD (3-sigma) of 0.9 ppm at the position of the sensor with a maximum source-sensor distance of 3 m (remark [1]). Indoor: 1 g/hr or 1 ppm at the position of the sensor for a maximum building air volume of 1000 m^3

[1] Using a sensor with a lower LOD would increase the maximum allowable source-sensor distance

Summary of Q&A

Use stationary LDAR to streamline **Type 1&2** efforts!

- There is a **correlation between ppm measured at the sensor location, sensor-source distance and emission rate**. If one of those parameters changes, the coverage area changes given a fixed LOD of the technology. Allowing either a larger area (e.g. Type 1) to be covered or a smaller one (e.g. Type 2). Same holds true if the LOD were to change.
- **Targeted follow-ups are required** upon a detection above the repair threshold (but only afterwards!) to pinpoint the leak
- **Added benefits** of a stationary LDAR technology:
  - Prepare your sites based on insights from a stationary solution prior to an upcoming survey
  - Confirm successful repairs within 45 days
  - Indoors: Increase safety through early detection of elevated methane concentrations complementary to LEL sensors
  - Gain additional insights to inform emissions reduction initiatives and investment decisions through more frequent monitoring at customizable alerting thresholds
- **Availability of the close-proximity node: end of 2025**
- **Global deployment** of the fenceline solution through a European super major

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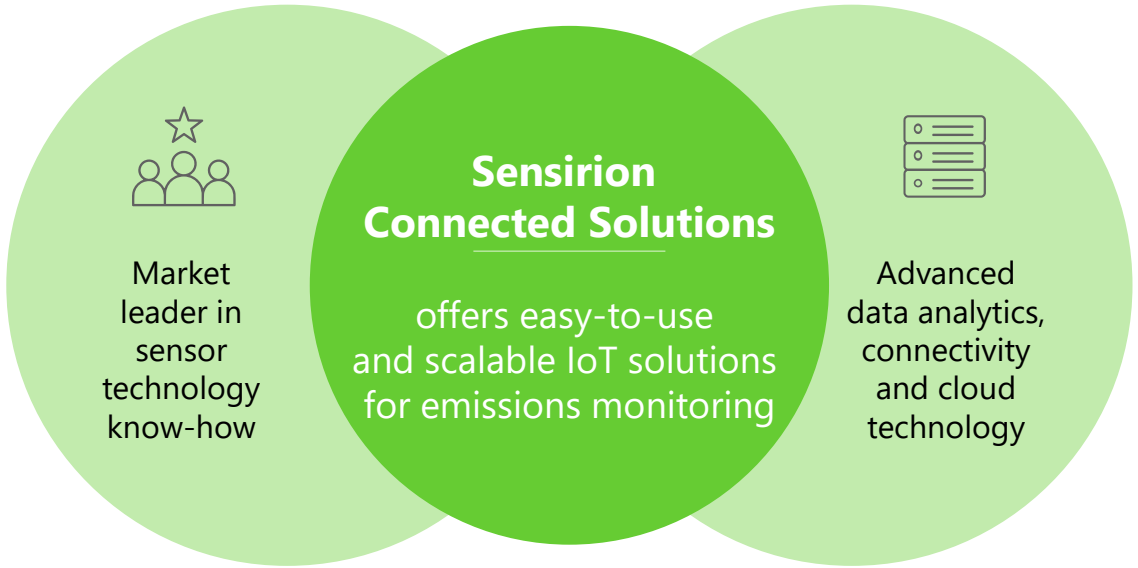
Our heritage, your advantage

Innovative, scalable, reliable, and global



Sensor expert: more than 25 years experience, innovation pioneer, publicly traded globally leading sensor manufacturer

Manufacturing prowess: scalable solutions, state-of-the art production facilities with more than 1B of produced sensors

Quality at heart: ISO 9001 and ISO 27001 certified so you don't need to worry

Global: worldwide subsidiaries, supply capability, seamless support and state-of-the-art service offering

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Demonstrates our ability to consistently provide products and services at a high quality and reliability. You buy what you get!

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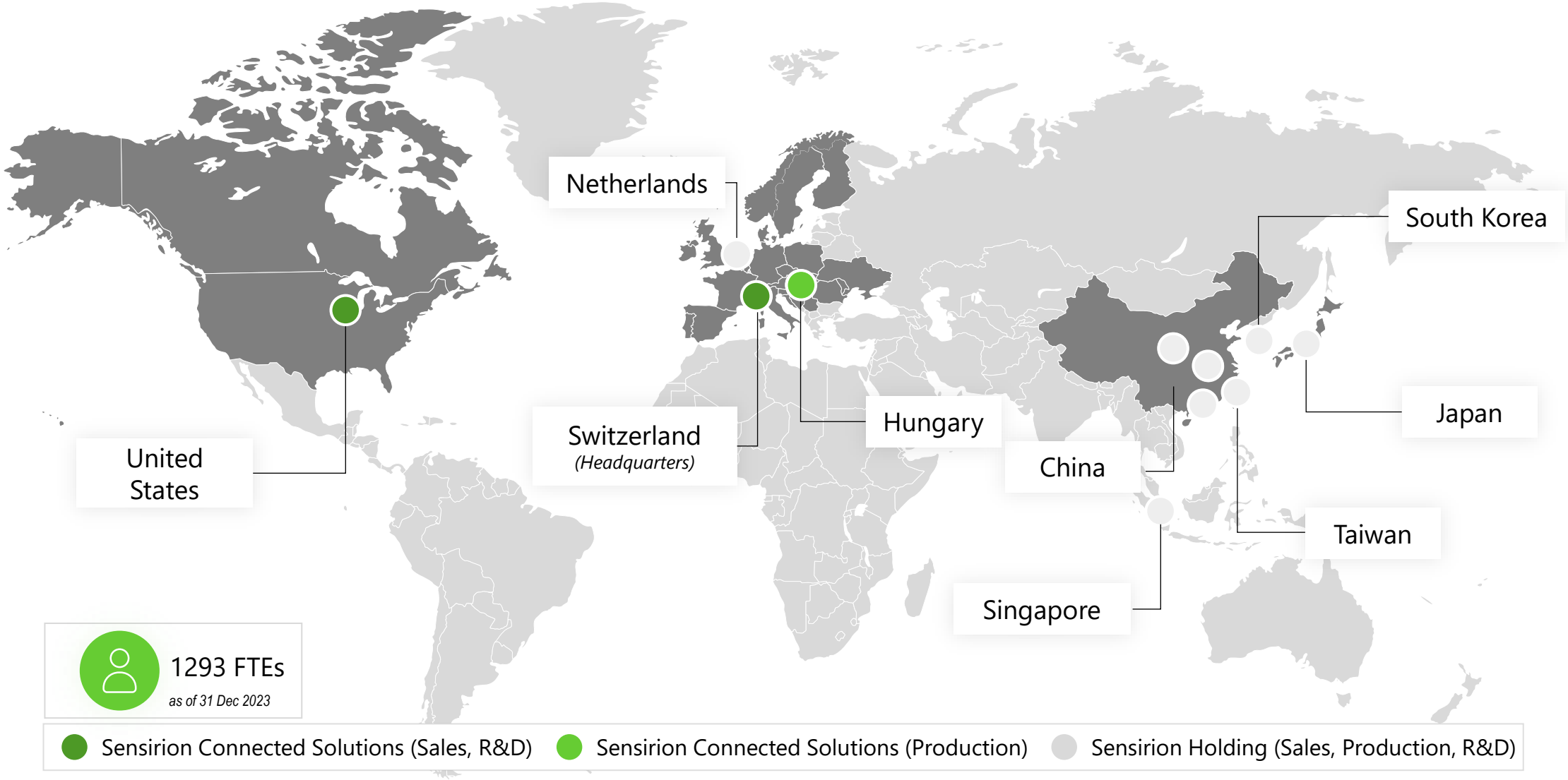
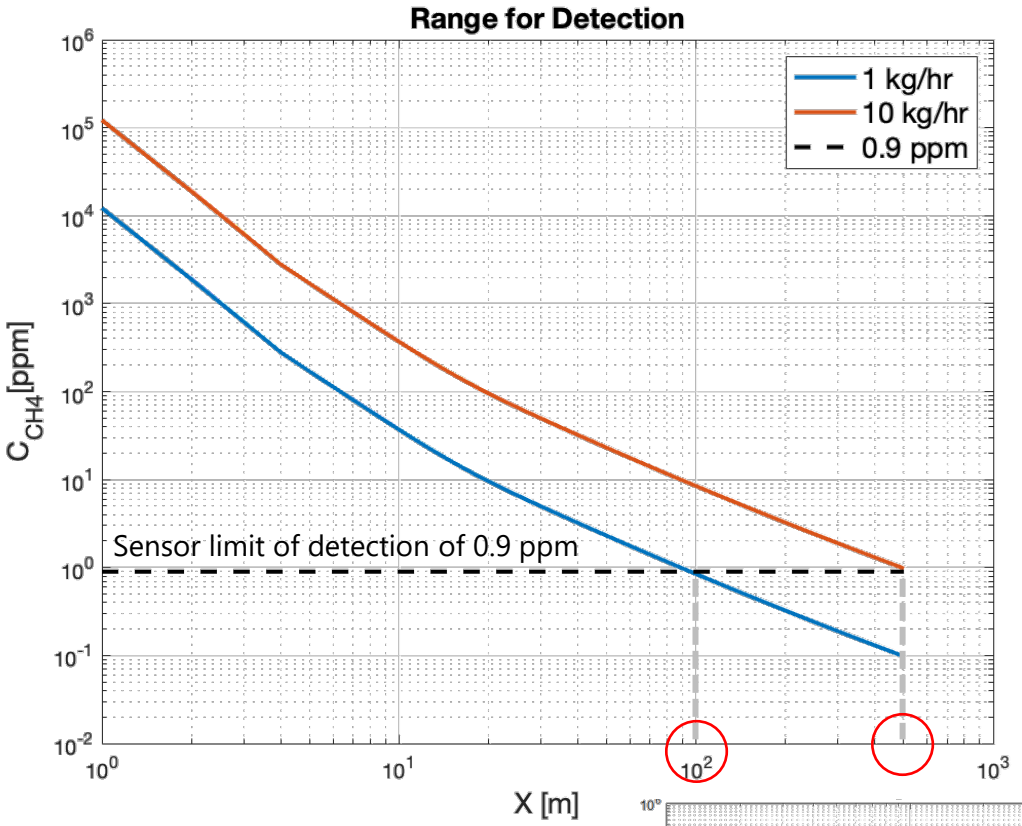
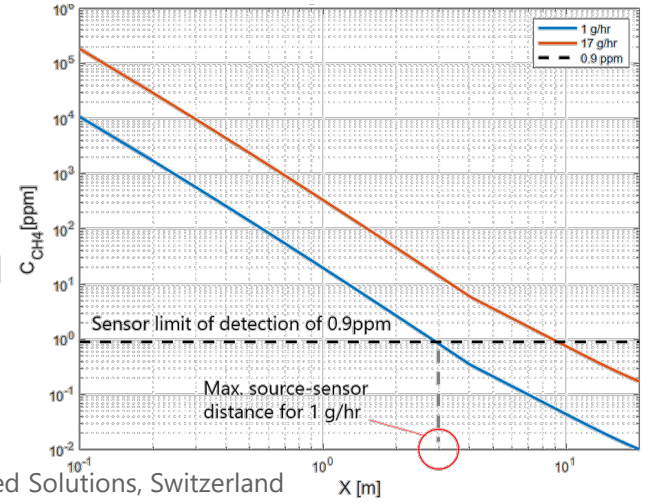
Global footprint ensures customer proximity





for very small emissions of 1 g/h and 17 g/h (as required by the EU regulation):



Conversion from g/hr to ppm

as a function of the source-sensor distance

Plume dispersion modelling

- Colored lines show the methane concentration at the sensor location as a function of the source-sensor distance for different leak rates
- Dashed lines indicate
  - the **3-sigma LOD in ppm** of Sensirion's stationary sensor technology of **0.9 ppm** (black)
  - the corresponding **maximum source-sensor** distance of **70 m for 1 kg/h, >>100 m for 10 kg/h** (grey)

Third-party verification proving this correlation:

- 2023: Vito labs, BE confirmed detection of 17 g/hr at a distance of 20 m
- 2025: Empa, CH
  (Swiss Federal Laboratories for Materials Science and Technologies)

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Marginal well sites

Cost-efficient monitoring by Nubo Sentry

- Use solely close-proximity sensors to monitor all potential emission sources
- Wind sensor to avoid ambiguity, identify offsite emissions and enable quantification
- Use of a local, solar-powered gateway or third-party gateway infrastructure (for cost minimization)
- Exemplary deployment:
  - ~80x100 m^2 in size
  - 1 well head, 1 separator, 2 tanks
  - 3 Nubo Sentry nodes (+1 wind sensor) (transparent circles indicate coverage of ~20 m and do not take wind direction into account)

Enhanced priority area monitoring

Nubo Sphere + Nubo Sentry

- Add close-proximity sensing to points of high interest e.g. emission sources with a high likelihood to emit to existing fenceline monitors
- Exemplary deployment:
  - Location: Parks TB, Midland, TX
  - ~80x90m^2 in size (excluding flares)
  - 9 tanks, 6 separators, 1 compressor (besides others)
  - 4 Nubo Sphere nodes (+1 wind sensor) as originally placed during pilot
  - Added: 3 Nubo Sentry nodes for tank and separator monitoring (transparent circles indicate coverage of ~20 m and do not take wind direction into account)

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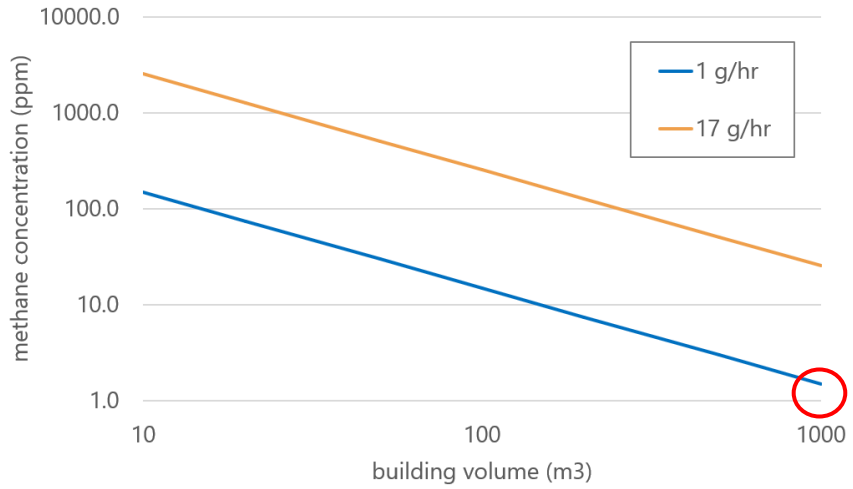
Indoor monitoring

Example of a regulating cabinet

- Different conversion from g/hr to ppm: assume that methane from a persistent leak source accumulates over time resulting in a steady-state methane concentration given by
  - the leak rate,
  - the building's volume, and
  - the air exchange rate of the building through forced or natural ventilation.



Nubo Sentry

Preliminary design and specifications

- Close-proximity methane sensor
  - Low power photoacoustic spectroscopy, highly selective to methane
  - Low limit of detection: one order of magnitude below existing solutions, targeting < 20 ppm
  - Intrinsically safe
    - US/CA Class 1 Div 1, Group C, D, T4
    - ATEX/IECEx Zone 0, IIB, T4
  - 5-year battery lifetime at 1 measurement every 20 s
  - LoRa communication
  - Environmental protection (IP65 and corrosion-resistance, NEMA 4X)
  - Operating conditions: -40°C – 50°C, up to 100% RH

NUBO SPHERE AND NUBO SENTRY

State-of-the-art sensor technology

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Our expert choice: low-power photoacoustic laser spectroscopy

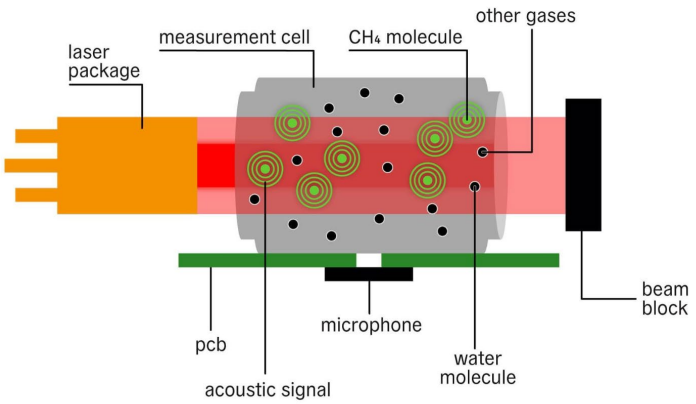
Unprecedented price-to-performance ratio

Proprietary sensor technology

- developed by Sensirion using 25 years of sensor expertise
- specifically designed to meet the requirements of the oil & gas industry

Photoacoustic-based laser spectroscopy

- probing the distinct absorption ‘fingerprint’ of methane molecules
- miniaturized packaging with improved power-efficiency



Our field-proven sensor technology, your advantages:

Long term stability and reliability
due to a laser-based measurement principle

5-year battery operation
due to laser-based reduced power consumption

Improved coverage
thanks to a lower LOD and high accuracy gas concentration readings

Low total costs of ownership
Maintenance free, no in-field calibration

Reduced false positives
due to a high specificity to CH_4

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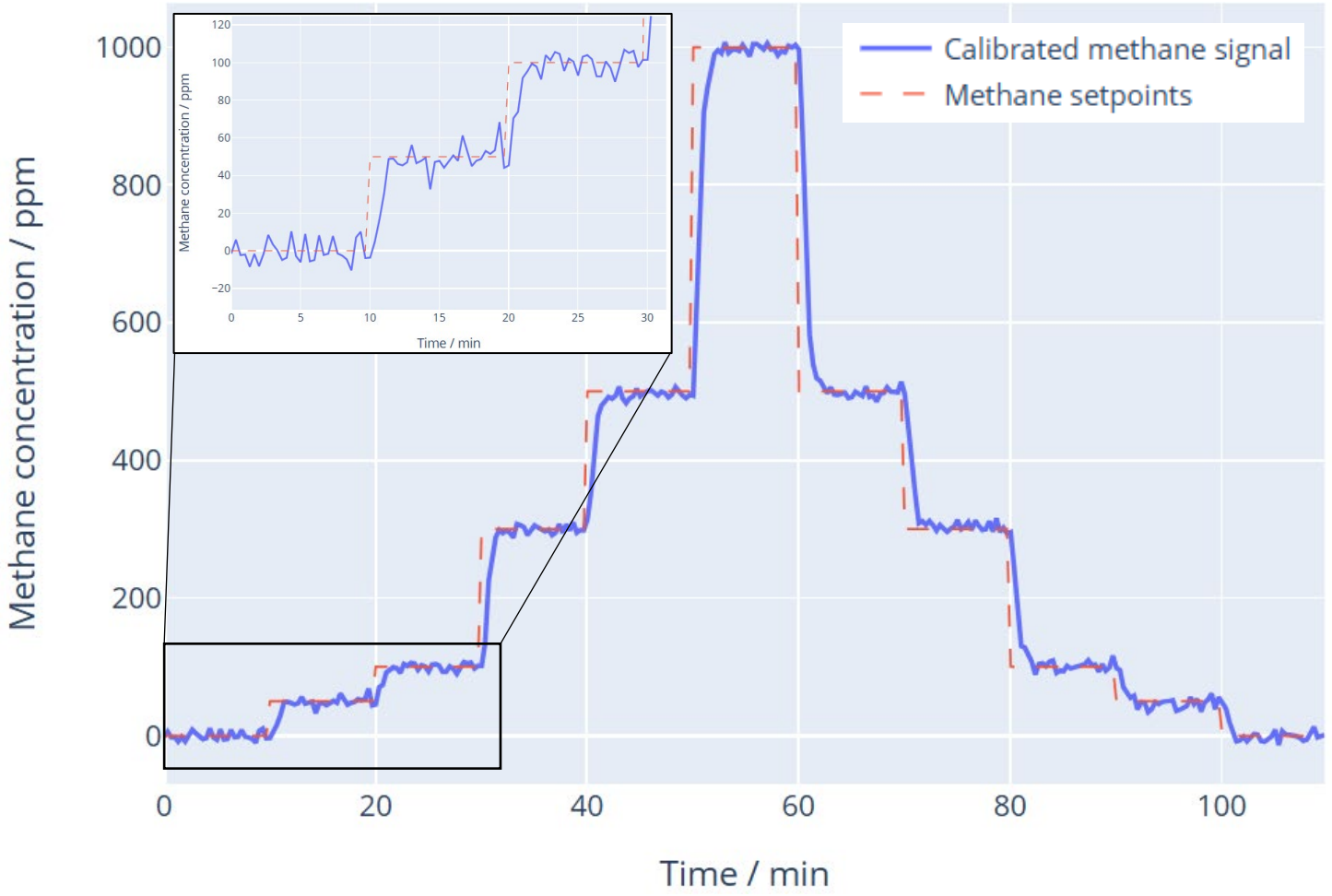
Noise level of 10 ppm demonstrated for Nubo Sentry

Prototypes confirm achieved specifications

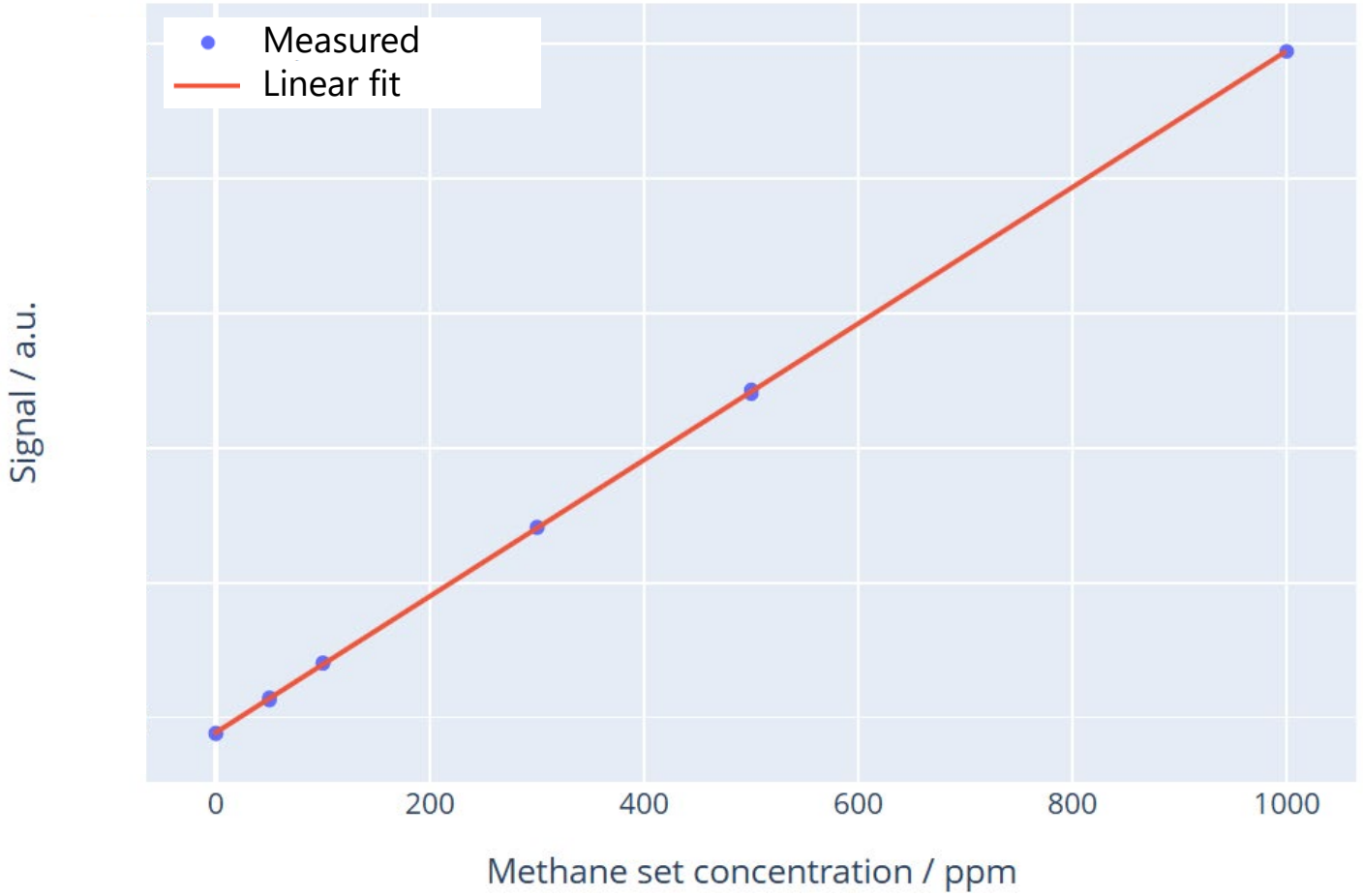
- ✓ High sensitivity and low noise level < 10 ppm
- ✓ At this performance low power consumption achieved allowing for 5-year battery life at 1/20 s measurement frequency



Noise level of 10 ppm demonstrated for Nubo Sentry

Prototypes confirm achieved specifications

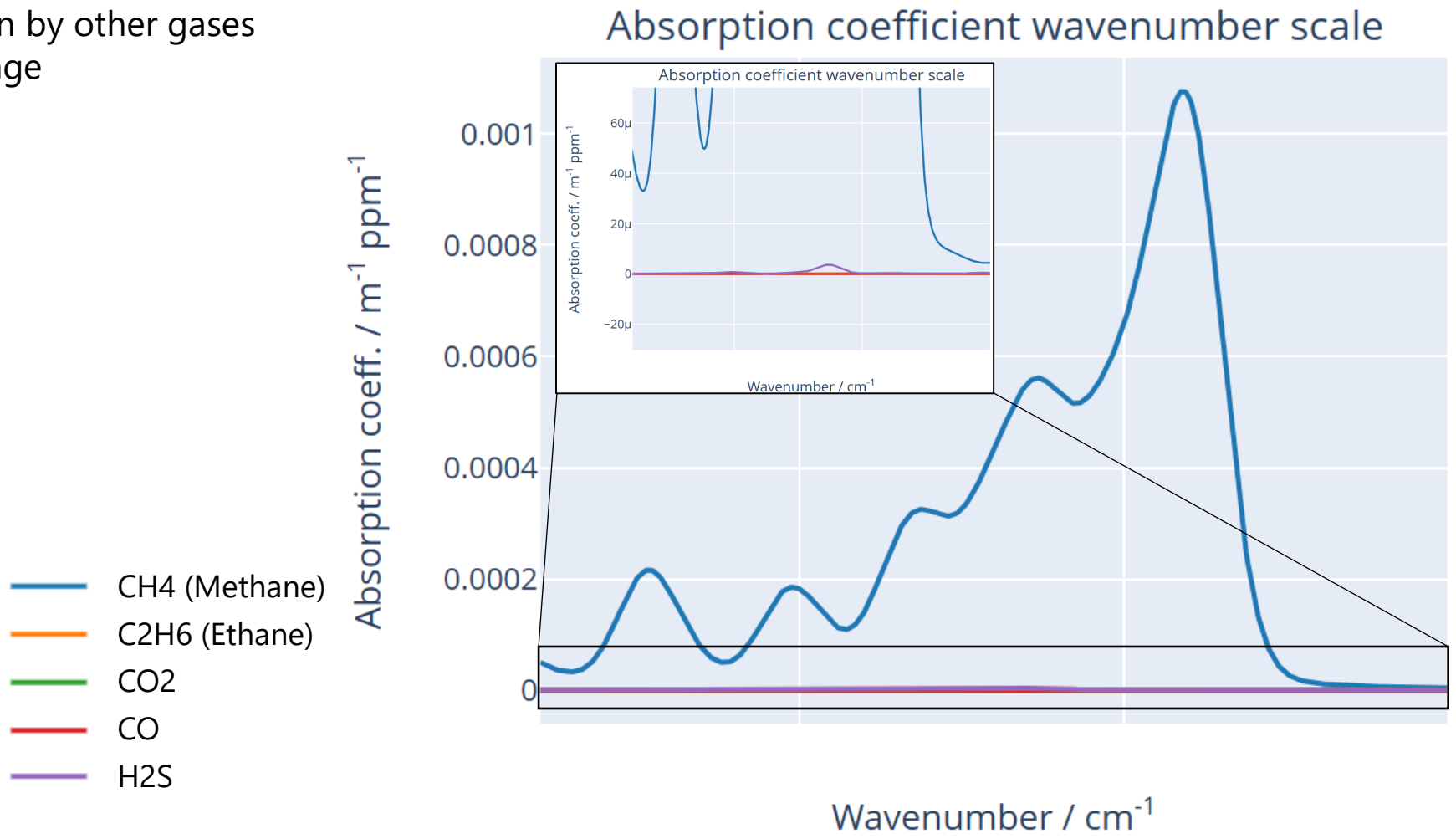
- ✓ High sensitivity and low noise level < 10 ppm
- ✓ At this performance low power consumption achieved allowing for 5-year battery life at 1/20 s measurement frequency
- ✓ Linearity of signal confirmed



Optical measurement principle = low cross-sensitivity

Nubo Sentry

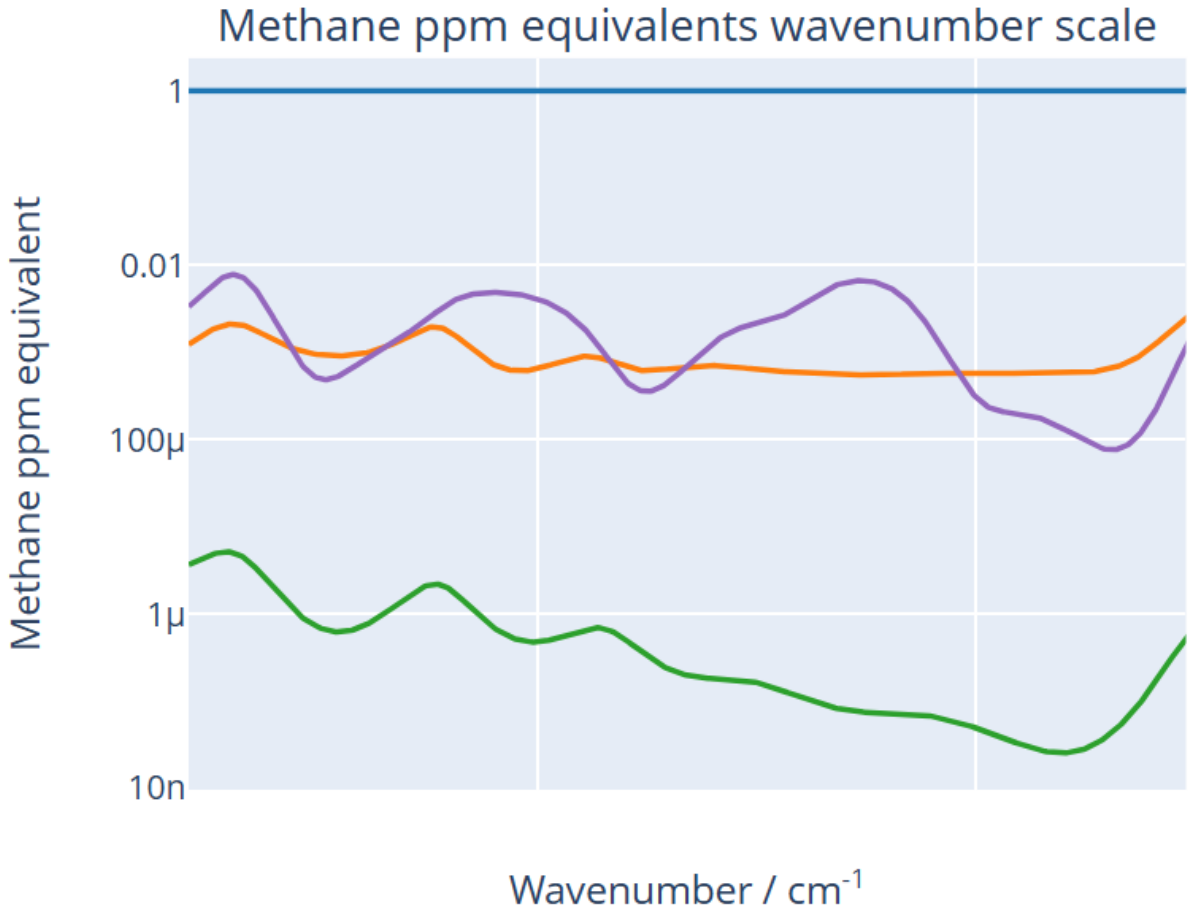
- No other significant absorption by other gases in the selected wavelength range



Optical measurement principle = low cross-sensitivity

Nubo Sentry

- Absorption of other gases scaled to absorption of 1 ppm methane
- Other gases absorb less than 1% of methane
- If same concentration of gases was present methane would contribute > 99% of the signal



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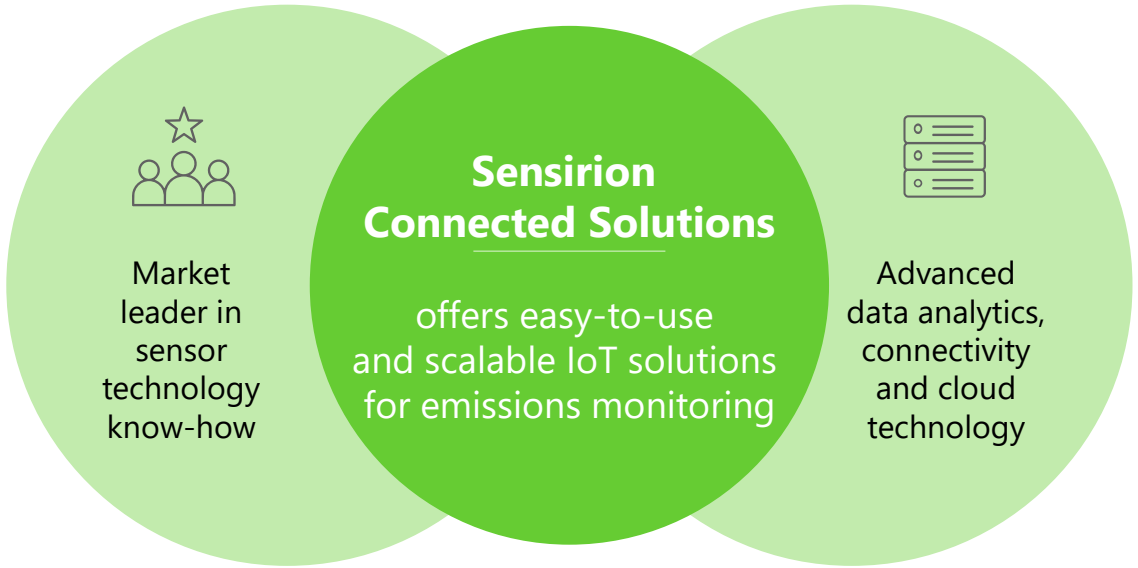

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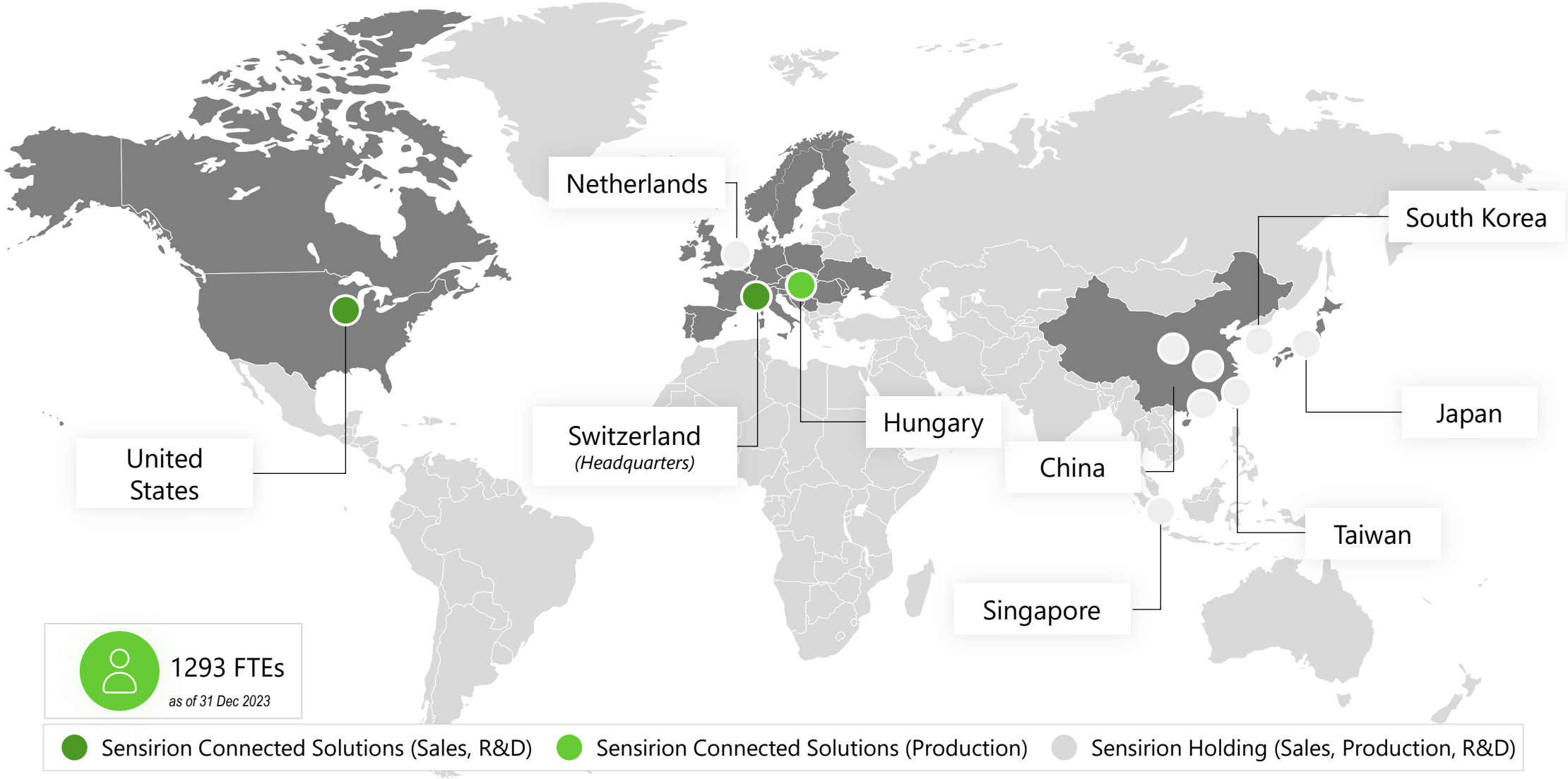
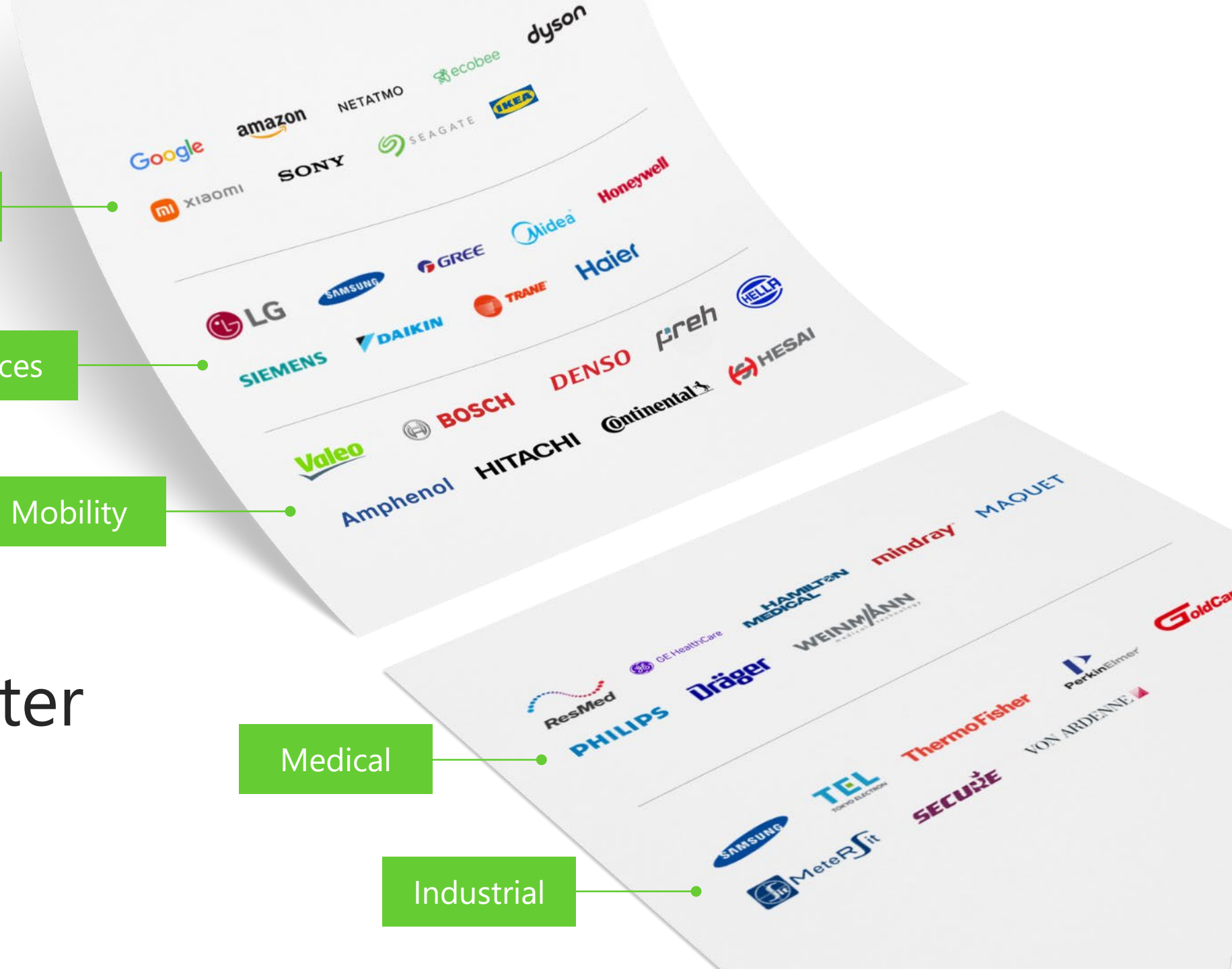


OUR CUSTOMERS

create a better world …



PRODUCTS

One-stop-shop for environmental and flow sensors

Capacitive: Humidity

Metal oxide: Volatile organic compounds

Laser light: Particulate matter

Combo modules**:** Air quality monitoring

Electrochemical: Formaldehyde

NDIR: CO_2

Photo acoustic: CO_2

Thermal conductivity: CO_2

Micro thermal: gas and liquid flow meters, differential pressure, gas metering

Gas chromatography: Gas composition

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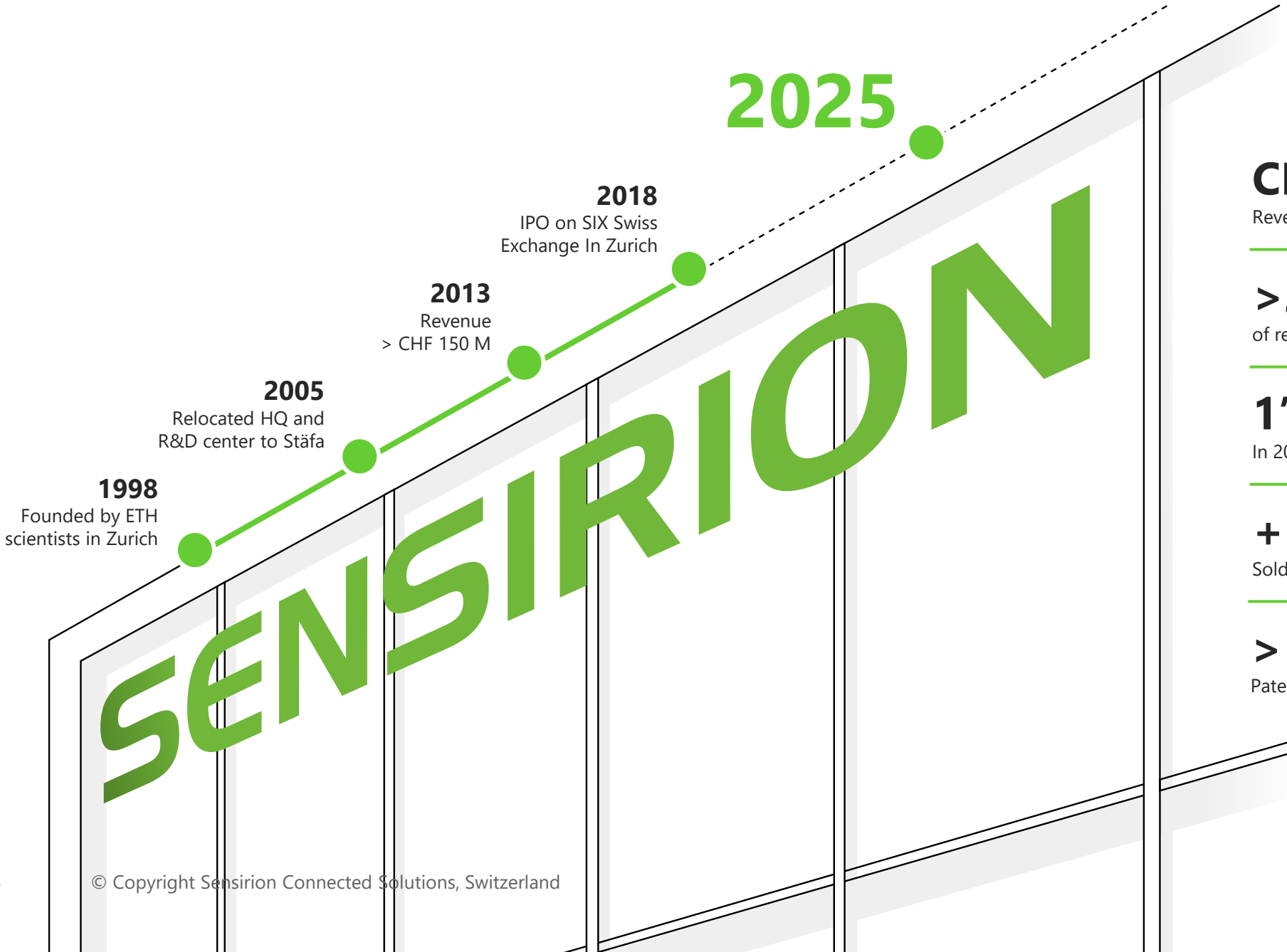

CHF 276.5M
Revenue in 2024

>23% R&D
of revenue spent in 2024

1’164 FTEs
In 2024

+1 bn sensors
Sold globally (600k produced/day)

> 200
Patent families

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