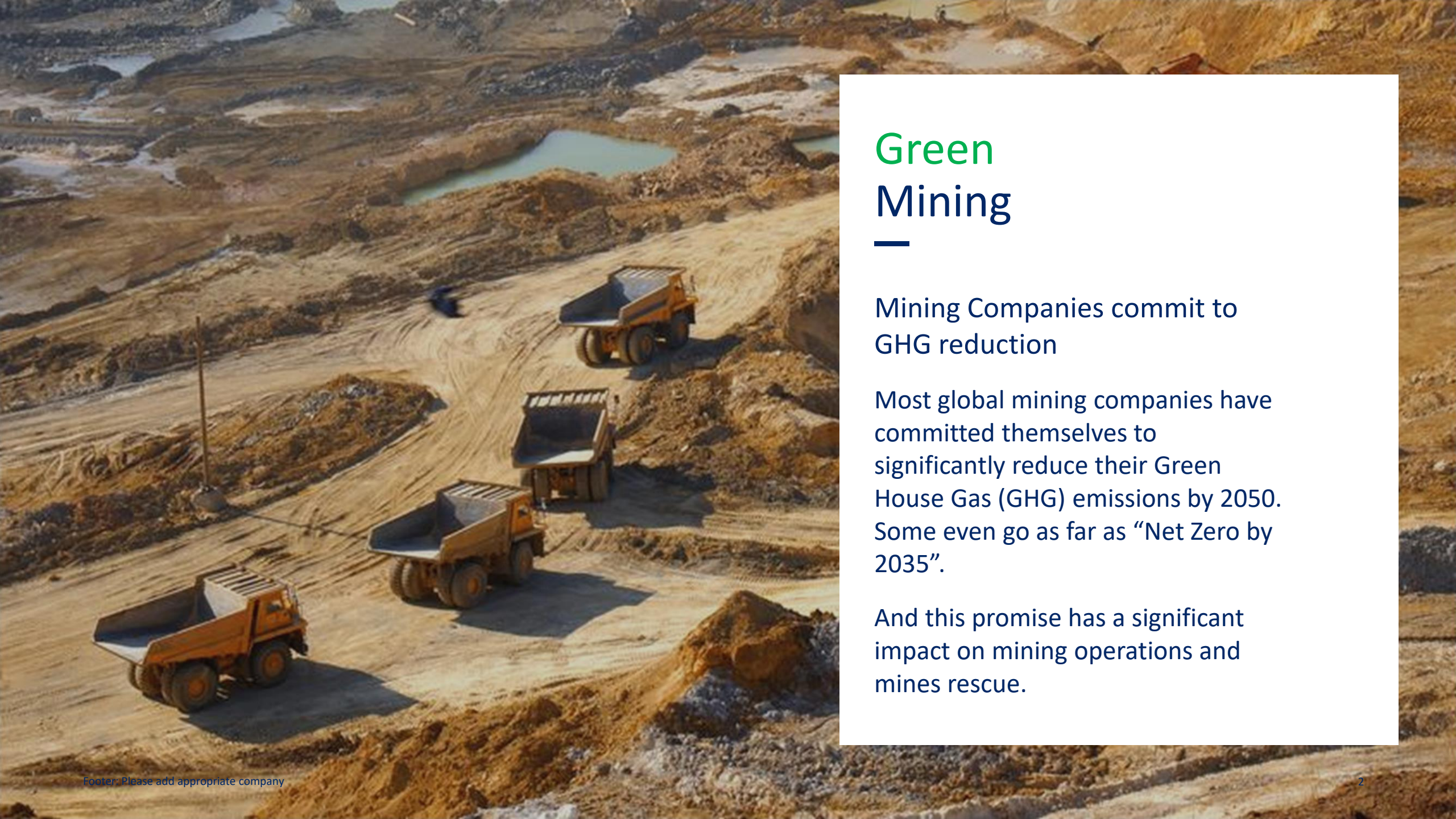
Every Coin has 2 Sides: Green Energy and Mines Rescue

Presentation by Axel Bahr, Dräger Safety



Green Mining

Mining Companies commit to GHG reduction

Most global mining companies have committed themselves to significantly reduce their Green House Gas (GHG) emissions by 2050. Some even go as far as “Net Zero by 2035”.

And this promise has a significant impact on mining operations and mines rescue.

Clean Energy
in the Mining Industry

"There are five focus decarbonisation technologies in the mining industry, and a range of energy transition technologies will need to be deployed to decarbonise mining operations" (Alex Phillips, energy transition analyst at GlobalData)

1. Electrification
   of mining equipment, especially haulers and diggers
2. Hydrogen
   for use in Fuel Cells or direct combustion (e.g. smelters)
3. Renewable Energy
   from Solar and Wind farms
4. Alternative Fuels
   such as Green Methanol for combustion engines
5. Carbon Capture, Utilisation and Storage
   to reduce CO_2 release

Clean Energy
Safety Solutions

Item 01

What is Clean Energy and what are the risks?

Item 02

What is Dräger’s safety approach for Clean Energy?

Item 03

Hydrogen

Item 04

Recommendation

01
What is Clean Energy and what are the risks?

Clean Energy Hazards

Hydrogen (H_2)

- Highly flammable
- Invisible flame
- Odorless / colorless
- High risk of leakages

Batteries (HF, CO, CO2, HCN)

- Highly toxic
- Highly flammable
- Frostbite

CCUS (CO_2)

- Very toxic
- Strong green house gas

Methanol (CH_3OH)

- Very toxic
- Highly flammable
- Almost invisible flame

Clean Energy
Hydrogen (H_2) Hazards

Explosion

A H2-air-mixture is highly flammable in a wide range between 4%Vol and 77%Vol.

The energy needed to ignite this mixture is 0,017mJ which further increases the risk of explosions or even self-ignition.

Invisible Flame

In daylight H2 flames are nearly invisible. In addition they hardly radiate heat and are odorless making them extremely difficult to notice.

Leakages

Due to its small molecules and low viscosity, H2 is prone to leak from seals and valves.
High pressure leaks pose a significant risk of self-ignition

Clean Energy
Batteries (HF, CO, CO_2, HCN) Hazards

Explosion

Battery-cell thermal runaway leads to high risk of explosion where gases and vapors can accumulate in poorly ventilated areas

Flammability

During incidents, clouds of flammable gases and vapors are released from the cells. These flammable vapor clouds can be sometimes mistaken for smoke or steam.

Toxicity

Toxic and irritant emissions during thermal runaway or fires (e.g. CO, HF, HCl, HCN, SO2, NO2, and PAHs)

Clean Energy
Methanol (CH_3OH) Hazards

Toxicity

Methanol is very toxic and exposure can damage specific organs and the central nervous system.

Flammability

With a lower explosion limit of 6%Vol. an upper limit of 50%Vol, a flash point of 9°C and an ignition temperature of just 440°C, Methanol is considered to be a highly flammable substance.

Invisible Flame

The flame of a Methanol fire is very pale and nearly invisible in daylight. Unlike Hydrogen, the flames emit radiant heat and can be felt from a distance.

Clean Energy
CCUS (CO_2) Hazards

Toxicity

Breathing in high concentrations of CO2 leads to intoxication resulting in sleepiness, loss of concentration and ultimately respiratory arrest.

Greenhouse Gas

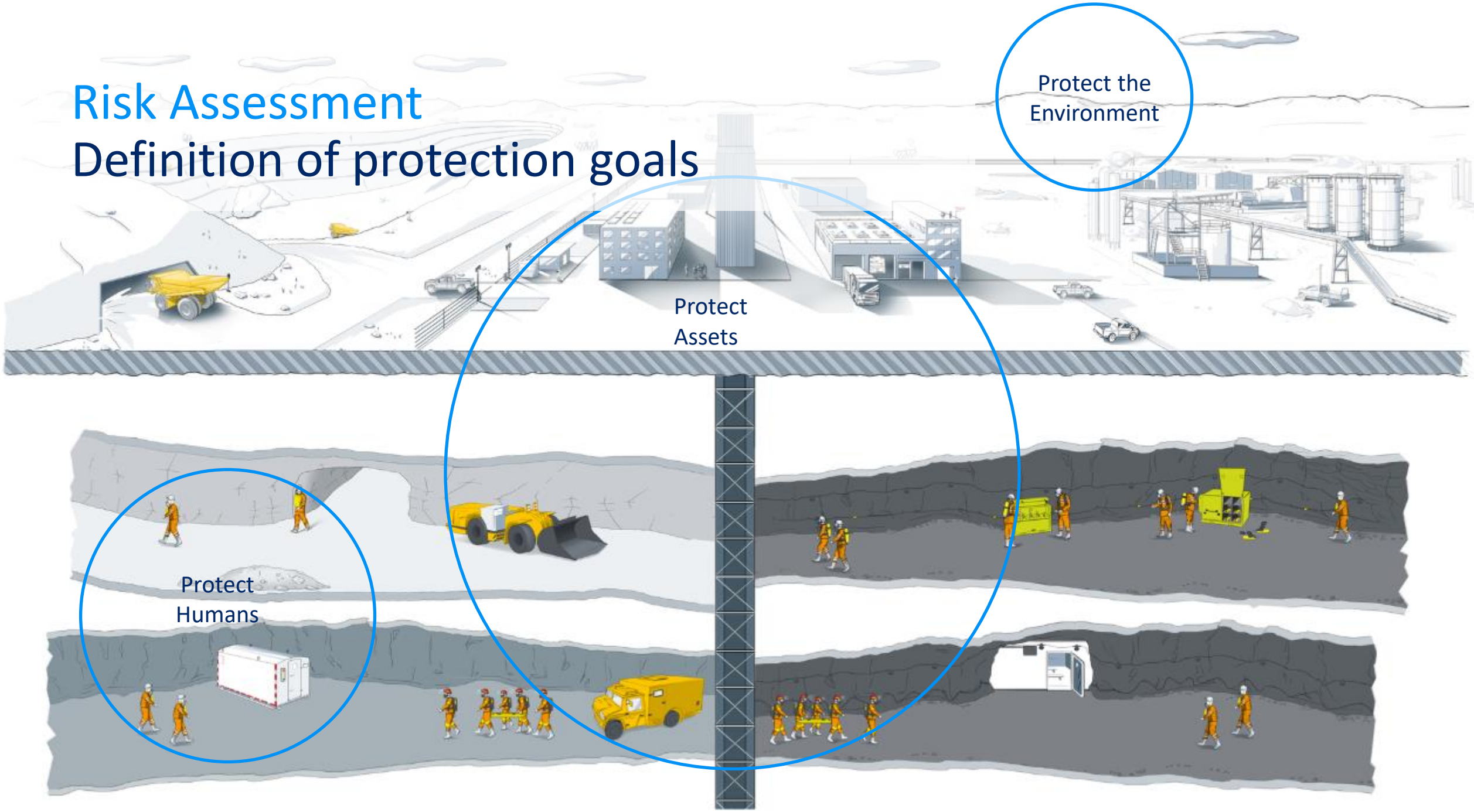
CO2 is the most significant long-lived greenhouse gas in earth's atmosphere.

The rapid increase in its concentration lead to global warming.

02
What is Dräger’s safety approach for Clean Energy

Risk Assessment

Definition of protection goals

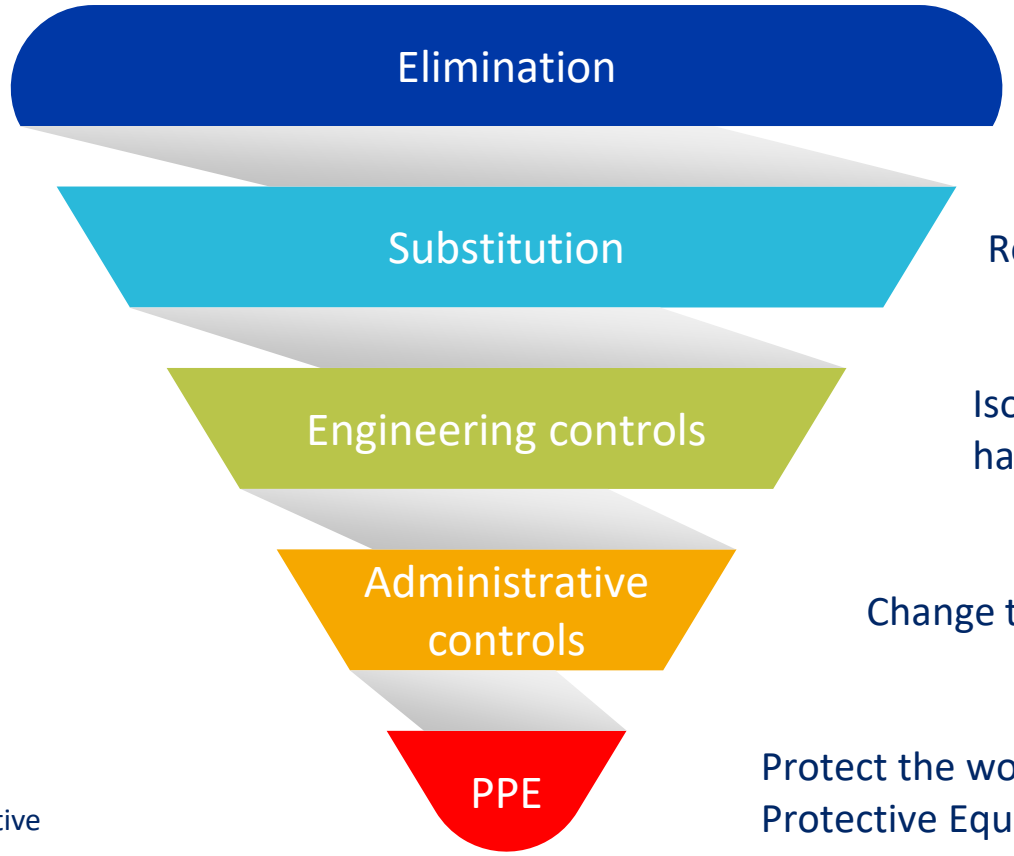


Risk assessment
Selection of protective measures

Hierarchy of controls

Most effective

Least effective



Physically remove the hazard

Replace the hazard

Isolate people from the hazard

Change the way people work

Protect the worker with Personal Protective Equipment

Fire and Gas Detection System
- Explosion-proof electrical equipment
- Technical safety (e.g. TPRD)
- Ventilation equipment

Breathing protection
- CCBA
- SCBA
- Masks & Filters

03
Hydrogen

Safety Challenges
Hydrogen

Education
Threats from H_2 should neither be overrated, nor underestimated.

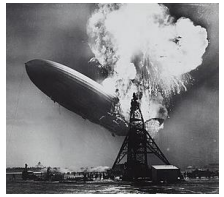
Permeation
H_2 is the smallest of all molecules and can permeate through and embrittle materials. The right choice, handling and maintenance of materials is critical.

Leaks
Due to its small molecular size and low viscosity, H_2 can quickly leak from its pipelines.

Gas pockets
H_2 is less dense than air and forms gas pockets at indoor ceilings.

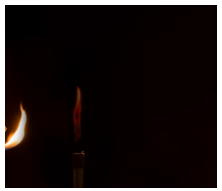
Odorless
Not only is H_2 colorless, it is also odorless. Therefore, a person cannot detect hydrogen.

Ex-protection
The biggest threat from hydrogen is that it leads to an explosion. Equipment in Ex-areas must be suitable and certified.



Invisible for IR
IR sensors in gas detection devices cannot detect H_2 because of missing C-H bonds.

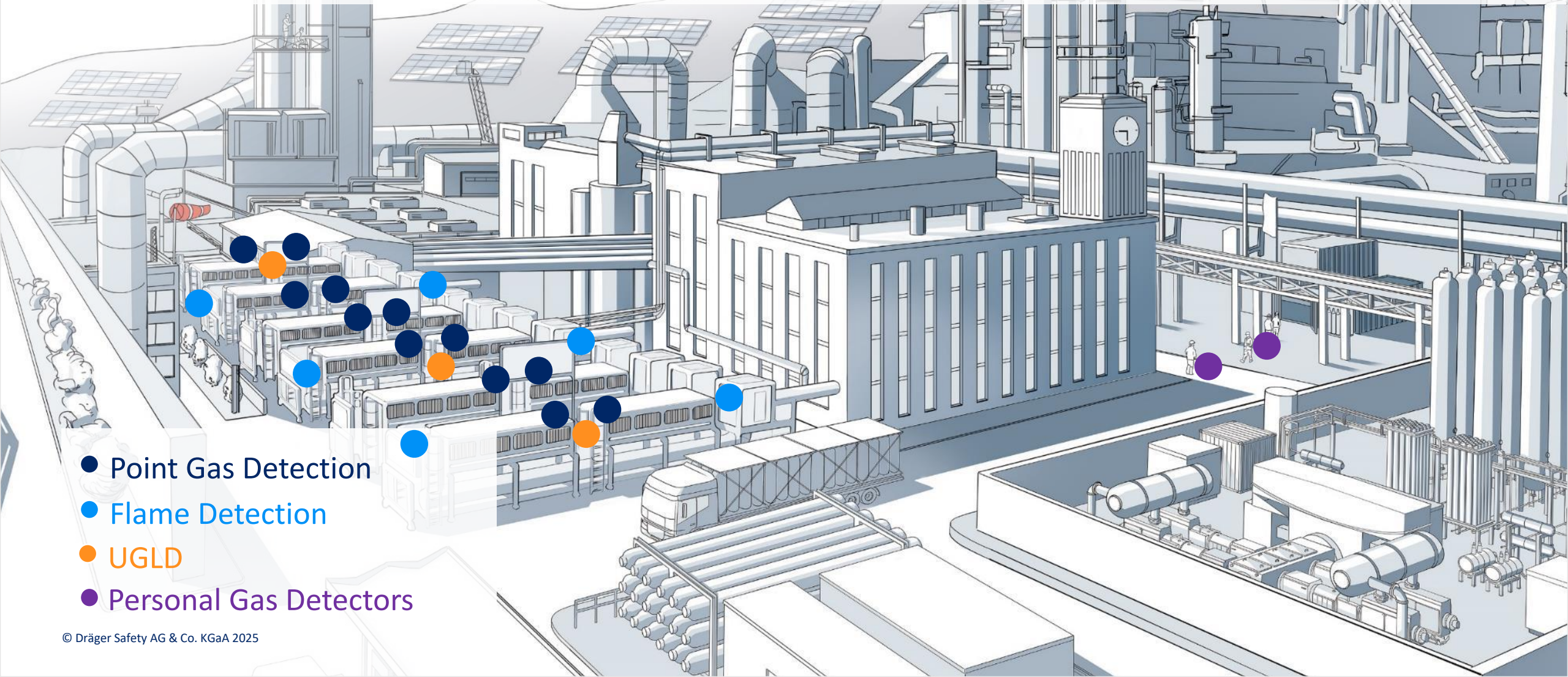
Invisible Flame
The hydrogen flame is very pale and not visible in daylight.



Dräger's Detection Matrix approach

In order to ensure the fast and reliable detection of Hydrogen, Ammonia, Methanol or Carbon Dioxide, we recommend a matrix of different detection technologies to combine each technology's strength and eradicate its weakness.

Detection Matrix
Combination of Technologies



Fire and Gas Detection System
Senses vs. Sensor Technologies

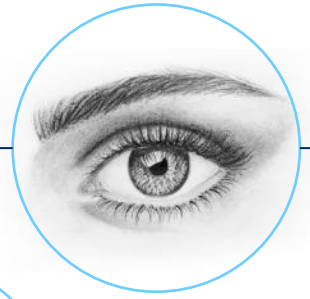
Point Detector

Flammable IR
Gas Detector

Toxic
ElectrochemicalGas
Detector

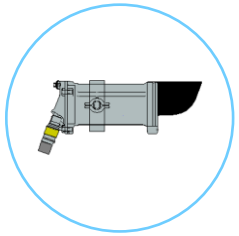
Flammable
Catalytic Gas
Detector

Area Monitoring / Line of sight

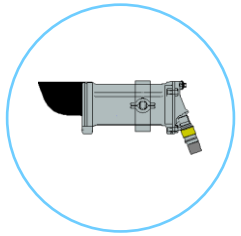


Flame Detector

Gas Camera



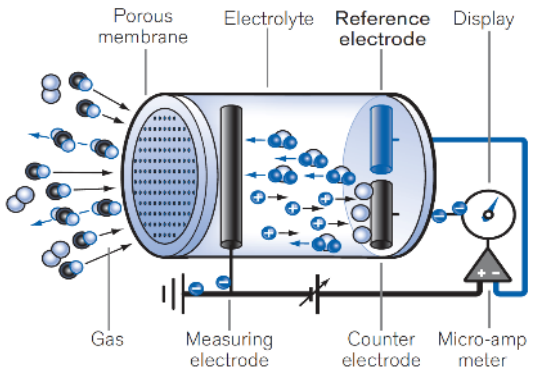
Open Path
Gas Detector

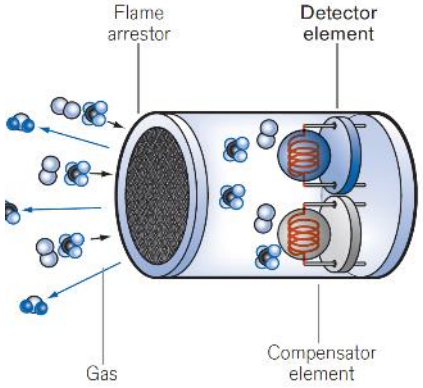


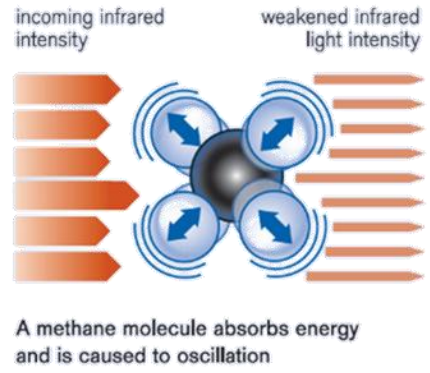
Ultrasonic Gas Leak Detector

UGLD

Basic gas detection technologies
Point gas detectors







Electrochemical sensor (EC)

EC sensors function **similar to batteries** and detect gases in **ppm concentrations.**

- Target substance **reacts chemically** and generates an **electrical charge** between two electrodes.
- The signal strength is proportional to the gas concentration.

Catalytic bead sensor (CatEx)

CatEx sensors **oxidize combustible** gases, releasing heat.

- A **suitable temperature-controlled catalyst** material is used, which is additionally heated measurably by the reaction heat.
- This small increase in temperature is a measure of the gas concentration.

Infrared Sensor (IR)

IR sensors measure the **change in intensity** of infrared radiation absorbed by target materials.

- Infrared is weakened by C-H, but not by H-H bonds.
- Methane can be measured, **but hydrogen cannot.**

Portable Gas Detection
H_2 Sensor Technologies

NEW

Dräger Pac 8000 H_2
Personal Air Monitoring and Protection

- DrägerSensor XXS H_2 HC:
  0 – 4 Vol% / 0 - 100 % LEL

Dräger X-am 5800
Personal Air Monitoring and Protection

- Ex-protection by CatEx sensor
  up to 100 % LEL
- DrägerSensor XXS H_2 HC:
  0 – 4 Vol% / 0 - 100 % LEL

Dräger X-am 8000
Leak Detection and Clearance Measurements

- Ex-protection by CatEx sensor optimized for H_2 with 3 measurements ranges: up to 40,000 ppm, 100 % LEL and 0 - 100 Vol.-% (NEW)
- DrägerSensor XXS H_2: 0 - 2,000 ppm
- DrägerSensor XXS H_2 HC:
  0 - 40,000 ppm / 0 - 100 % LEL

Fire and Gas Detection System
Senses vs. Sensor Technologies

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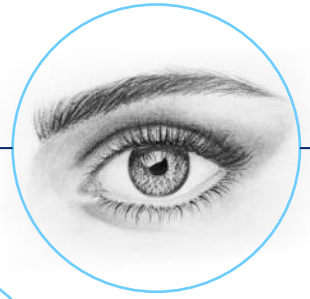
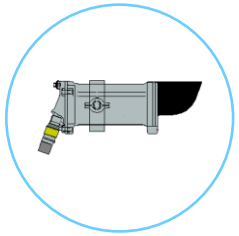
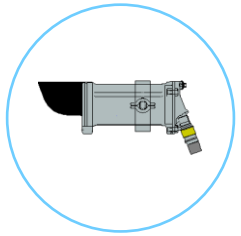


Flame Detector

Gas Camera



Open Path
Gas Detector



Ultrasonic Gas Leak Detector

UGLD

Fire and Gas Detection System
Hydrogen Flame Detection

To the human body and all our senses hydrogen and its flames are almost undetectable.

Hydrogen flames

– are invisible in daylight
– emit very little radiant heat
– are odorless

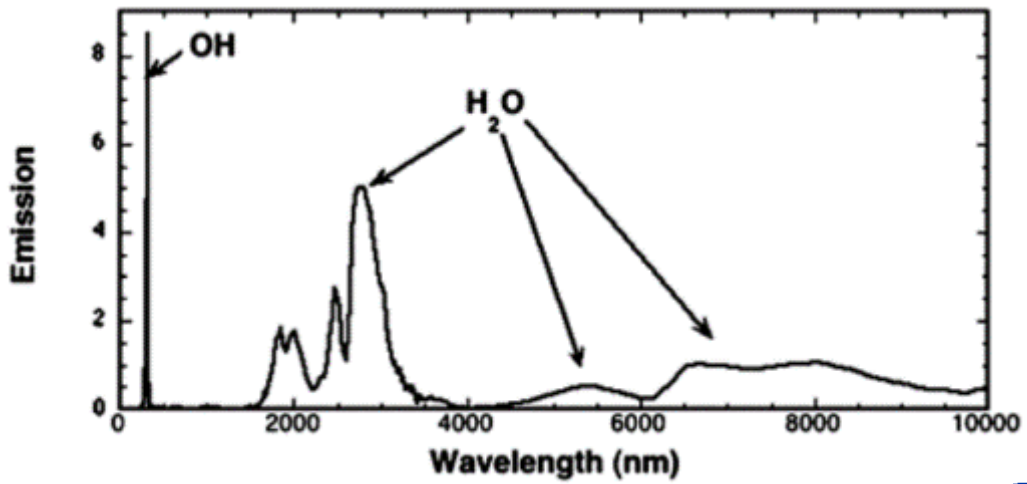
In addition, Hydrogen has the following unique characteristics that make it more hazardous than other substances:

– LEL at 20°C is 4 Vol%
– UEL at 20°C is 77 Vol%
– Ignition energy is 0,017 mJ

Fire and Gas Detection System
Hydrogen Flame Detection

- Hydrogen flames do NOT emit CO_2
- Hydrogen flames only emit hot H_2O

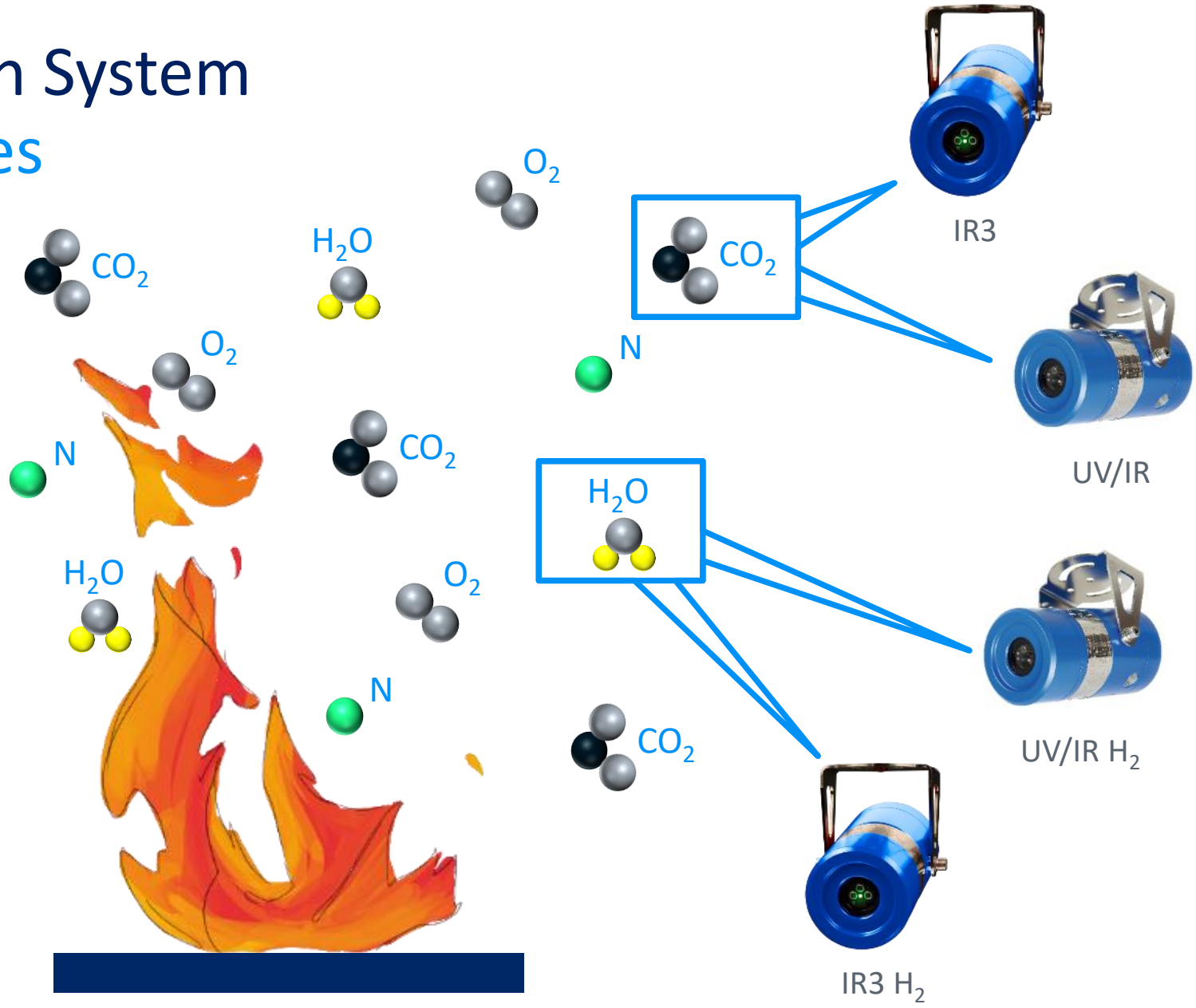
$$2\ H_2 + O_2 \rightarrow 2\ H_2O + \text{Energy}$$



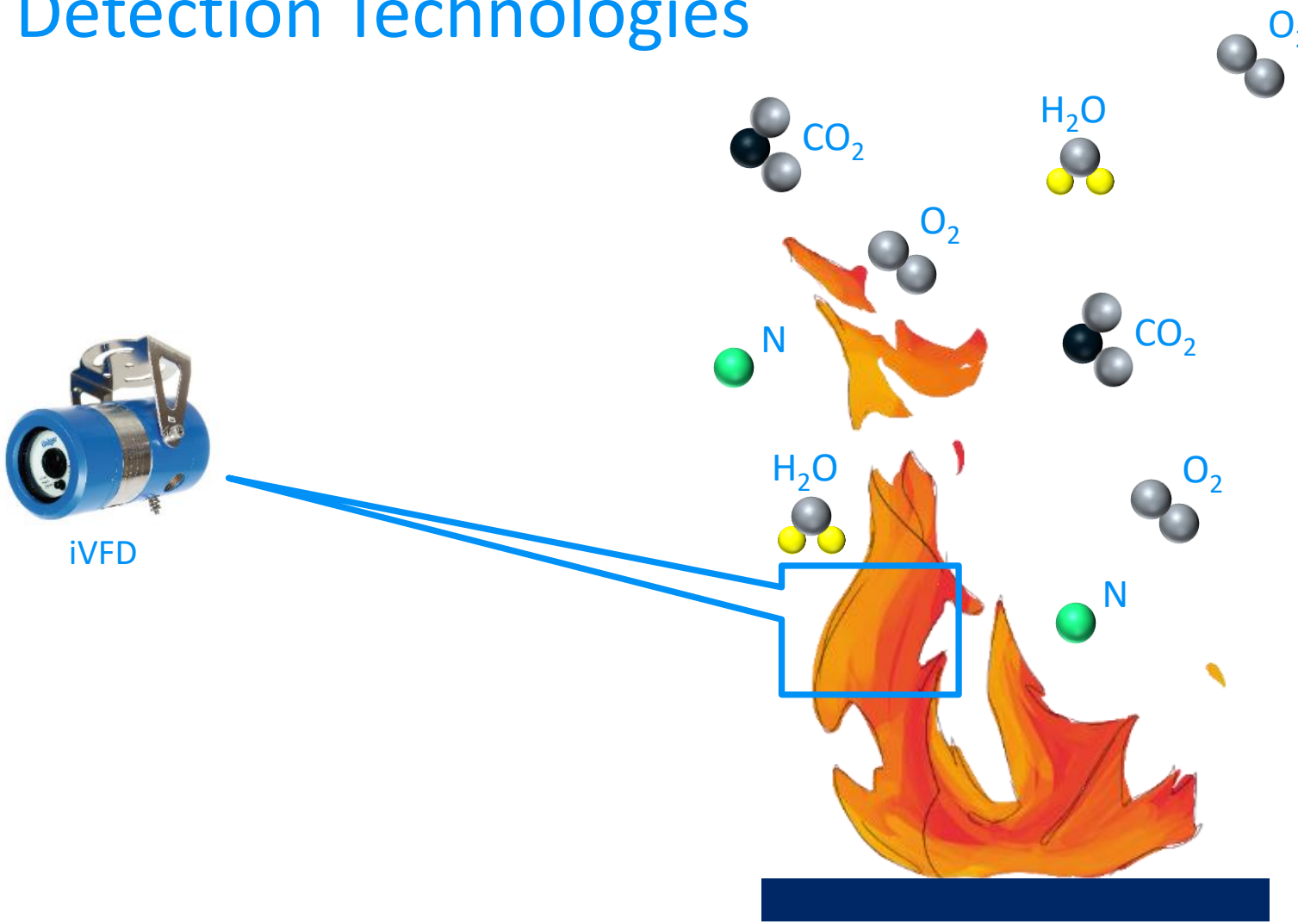
Fire and Gas Detection System
Detection Technologies

- Radiant flame detectors

do NOT see the flame itself. They only see the electromagnetic radiation emitted by the combustion products. Their frequency spectrum depends on the chemical composition of the reaction products.



Fire and Gas Detection System
Detection Technologies



Visual flame detectors

see the flame itself. Their processor analyses each pixel of the video picture taken by their camera for signals indicating a flame such as shape, color, and flicker.

Fire and Gas Detection System
Electromagnetic Radiation

Reaction products in combustion processes:

Methanol	$2\ CH_3OH + 3\ O_2$	→	$2\ CO_2 + 4\ H_2O$	+ Energy
Hydrogen	$2\ H_2 + O_2$	→	$2\ H_2O$	+ Energy
Ammonia	$4\ NH_3 + 3\ O_2$	→	$2\ N_2 + 6\ H_2O$	+ Energy

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Senses vs. Sensor Technologies

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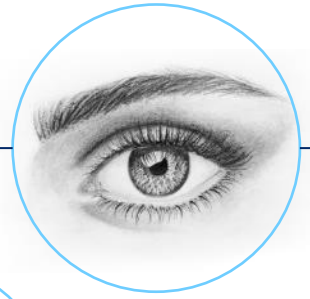

Flame Detector

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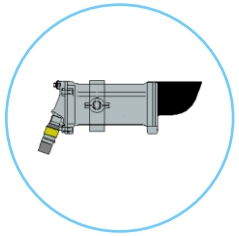

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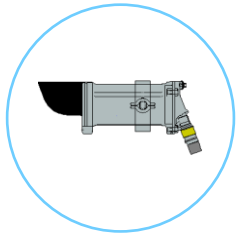
Gas Detector



Ultrasonic Gas Leak Detector

UGLD

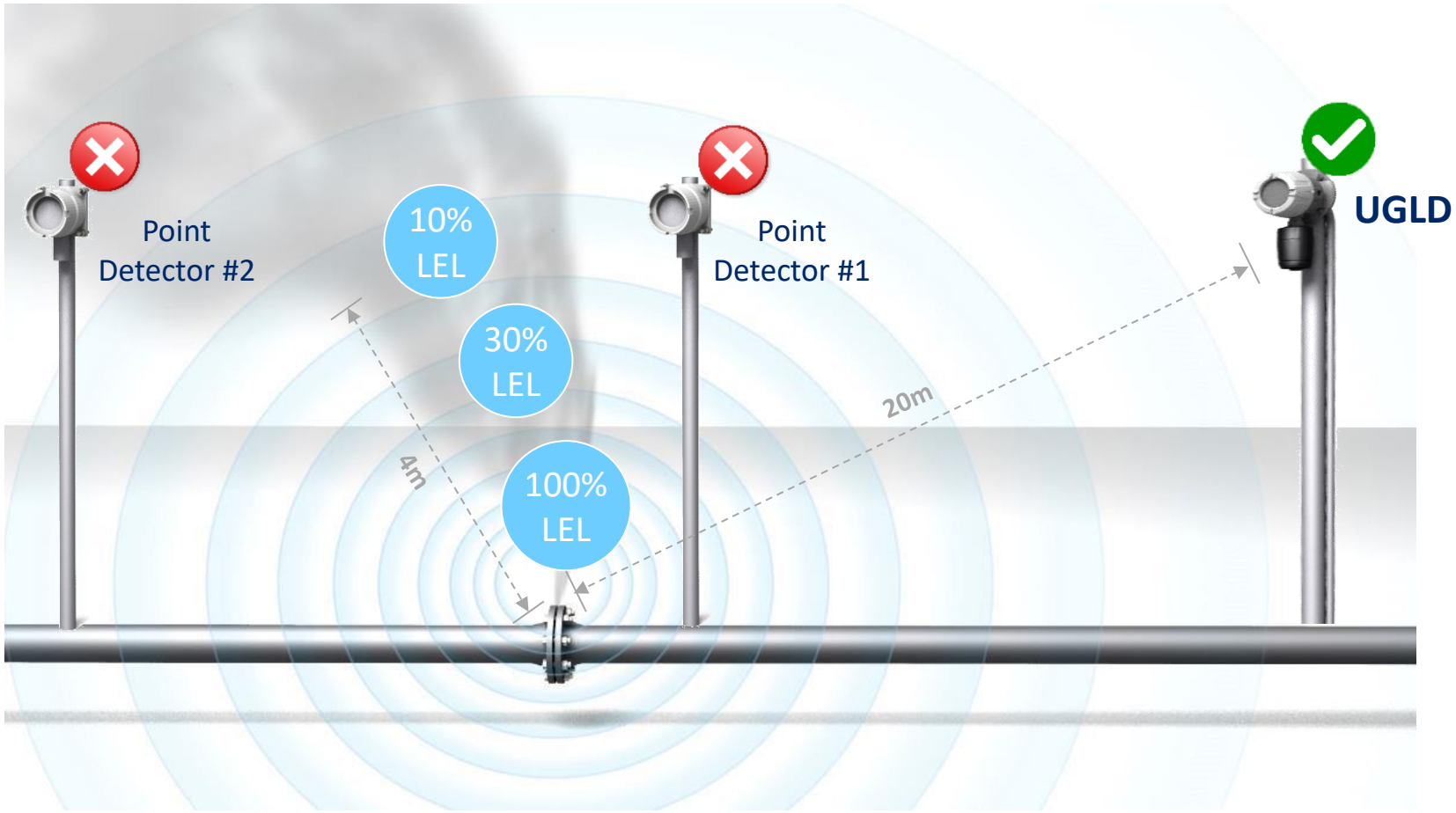
Fire and Gas Detection System
Ultrasonic Gas Leak Detection

Why Ultrasonic Gas Leak Detection?

Approximately 36% of major gas releases and 69% of significant gas releases are undetected by gas detectors.

Source: Health and Safety Executive (HSE) Offshore Hydrocarbons Release database (2001 – 2008) – (McGillivray and Hare, 2008)

Fire and Gas Detection System
Ultrasonic Gas Leak Detection



Acoustic sensors are robust against wind and gas dilution and offer advantages that cannot be covered by other technologies

04
Recommendation

Portable Gas Detection
Recommendation

Disclaimer: Please check for local rules, regulations and (mining) approvals, they might require different special certification or equipment or require different parameters (such like alarm levels or LEL factors).

Portable Gas Detection

Recommendation for scenarios with H_2

Dräger X-am 2800

Personal Air Monitoring and Protection

- CatEx SR sensor calibrated for Methane with equal sensitivity to H2
- Dräger Sensor XXS O2 PR (Poison resistant)
- Dräger Sensor XXS CO LC (cross sensitivity with H2)

Portable Gas Detection

Recommendation for scenarios with H_2

Dräger X-am 5800

Personal Air Monitoring and Protection

- CatEx SR sensor calibrated for Methane with equal sensitivity to H2
- Dräger Sensor XXS O2 PR
- Dräger Sensor XXS H2 HC (does not show Methane, but 0-4 Vol% H2)
- Dräger Sensor XXS CO H2 cp (H2 compensated; shows less than 15 ppm CO with 1000 ppm H2 present)

Outlook 2026

- Dräger Sensor IR Ex or IR Ex/CO2 available (no cross sensitivity to H2)

Portable Gas Detection

Recommendation for scenarios with H_2

Dräger X-am 8000

Personal Air Monitoring, Leak Detection and Clearance Measurements

- Dräger Dual Sensor IR Ex/CO2 (no cross sensitivity to H2)
- Dräger Sensor CatEx H2 100 calibrated for H2 (measures 0-4 Vol% or 0-40.000 ppm (no cross sensitivity to CH4)
- Dräger Sensor XXS CO H2 cp cp (H2 compensated; shows less than 15 ppm CO with 1000 ppm H2 present)
- Dräger Sensor XXS O2 / H2S LC
- Dräger Sensor XXS NO2

- (DrägerSensor XXS H_2 HC: 0 - 40,000 ppm / 0 - 100 % LEL)