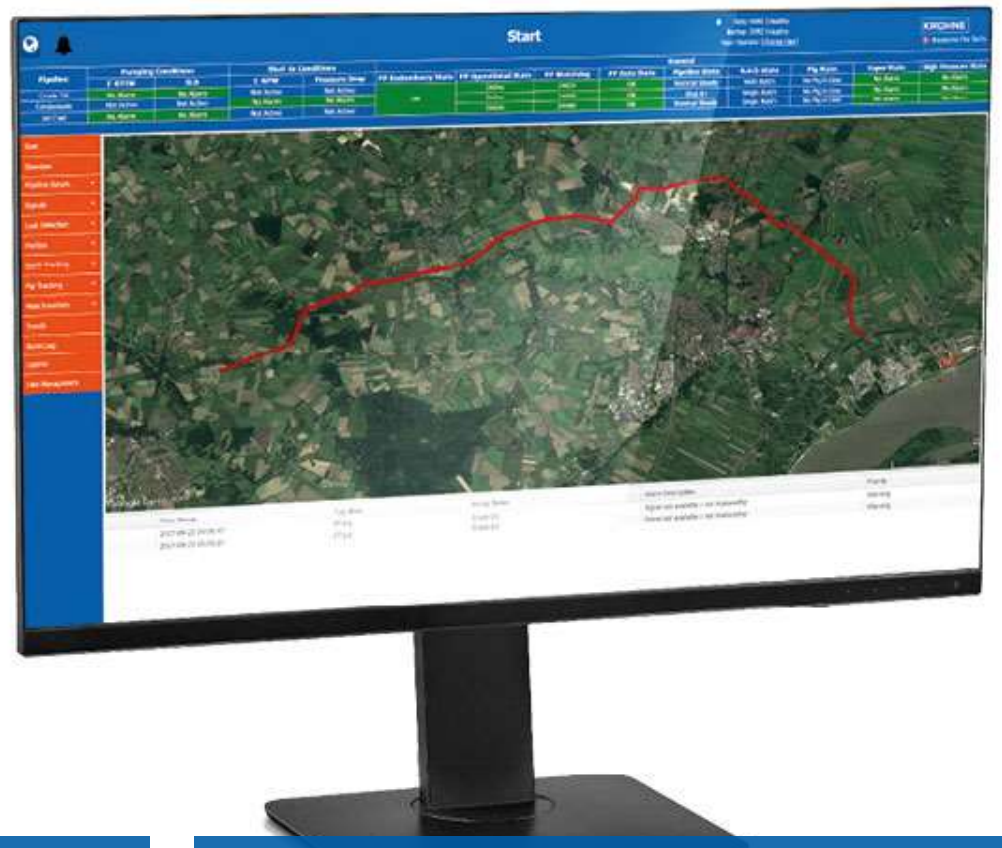
KROHNE
measure the facts



Smart Monitoring of Pipelines in the Energy Transition

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2022-05-24

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- KROHNE

KROHNE Group

A leading international supplier of process measuring technology

- Founded 1921 in Duisburg, Germany
- 100% family-owned
- 2021 turnover: 652.4 MEUR (incl. joint ventures)
- >4,100 employees
- >350 employees in R&D
- 16 production facilities in 11 countries
- Local presence in over 100 countries

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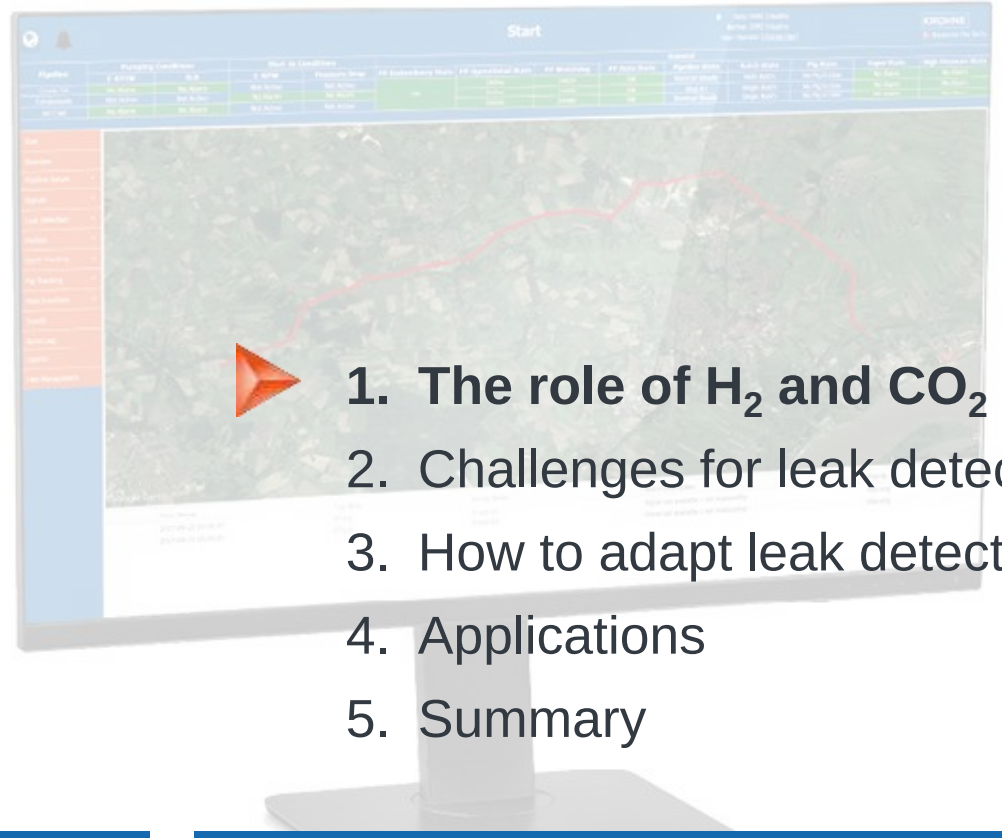


1. **The role of H_2 and CO_2 in the energy transition**
2. Challenges for leak detection
3. How to adapt leak detection to handle the requirements
4. Applications
5. Summary

Smart Monitoring of Pipelines in the Energy Transition

Agenda

Role of hydrogen and carbon dioxide in the energy transition

- Reduce **carbon dioxide** (CO_2) emission to meet the goals of the Paris climate agreement
- Main trend is **electrification** of the energy system

- Supply:
  - Solar panels (PV)
  - Onshore/offshore wind energy

- Demand:
  - Electric cars
  - Electric heating / cooking
  - ….

Role of hydrogen and carbon dioxide in the energy transition

Hydrogen & Carbon Capture and Storage

- Reduce **carbon dioxide** (CO_2) emission to meet the goals of the Paris climate agreement
- Main trend is **electrification** of the energy system
- Green electricity is not the answer to ‘everything’, e.g.:
  - Not all energy can be provided by electricity; fuels are still needed (planes, ships)
  - High temperature processes cannot be heated by electricity (steel, cement, …)
  - Renewable energy is intermittent → energy storage and buffering needed

Hydrogen
Energy carrier

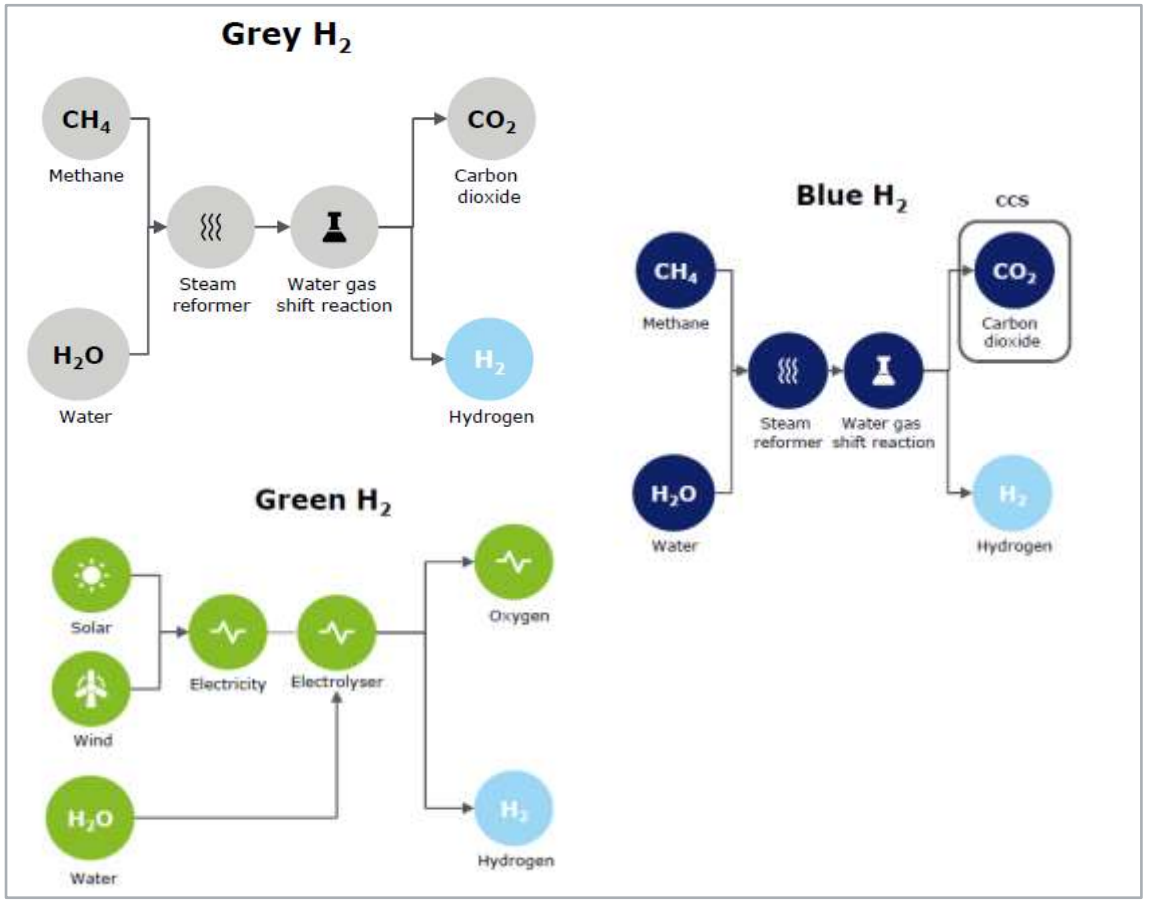
  - Not all CO_2 emission is released in combustion of fossil fuel (e.g. cement production)
  - Large cost (and depreciation) involved in transforming existing industry/infrastructure to green electricity, e.g. refineries, powerplants (coal and gas)

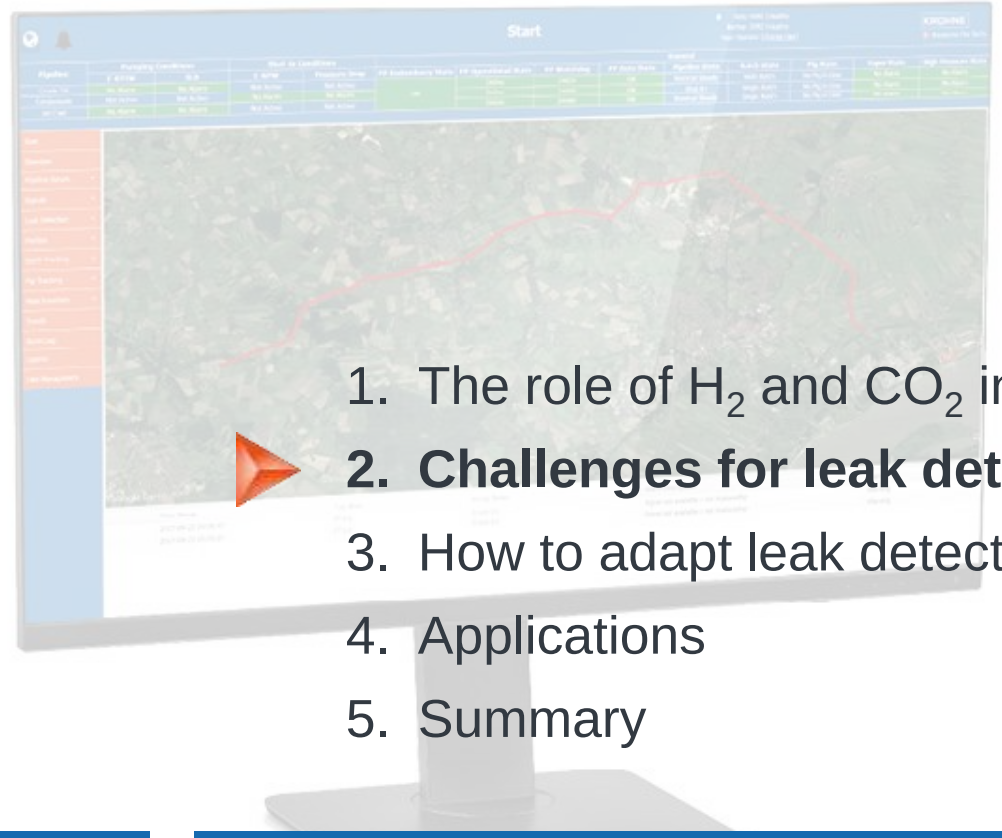
CCS
Carbon capture and storage

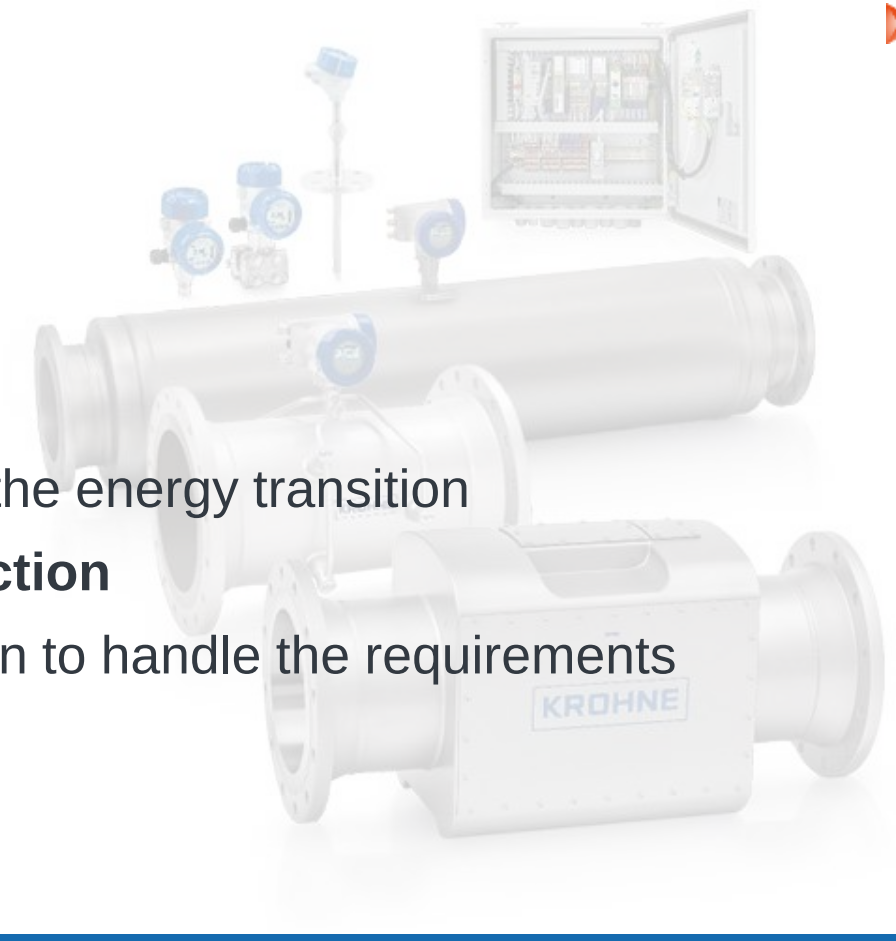
Role of hydrogen in the energy transition

Hydrogen production

- **Grey hydrogen**:
  - Steam Methane Reforming (SMR) resulting in CO_2 emission
  - By far the largest production method for hydrogen
- **Blue hydrogen**:
  - Carbon Capture to reduce CO_2 emission
- **Green hydrogen**:
  - Water electrolysis powered with green electricity
  - Decomposing water in to H_2 and O_2
  - No CO_2 emission (when renewable energy is used)







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Challenges for leak detection

Hydrogen

Hydrogen will in many cases be transported as a gas via pipelines.

Leak detection required since:

- Hydrogen is a small molecule (easy leakage)
- Hydrogen is an explosive gas (safety)

100% H2

- Example: Power to gas plants producing pure hydrogen which is distributed via dedicated hydrogen pipelines.

H_2 blended with natural gas

- Example: Blending 20% percentage of hydrogen

Challenge: different compositions of the gasses in the pipeline

Challenges for leak detection

Carbon Capture and Storage (CCS)

Capture

- CO_2 is captured at (industrial) emission sites

Storage:

- The CO_2 is injected in depleted gas reservoirs or used for enhanced oil recovery (EOR), where most of the CO_2 stays in the reservoir.

Transportation:

- The captured CO_2 is transported to sites where the CO_2 is stored or utilised
- CO_2 can be transported as gas, liquid or in supercritical state

Leak detection needed since leakage of CO_2 has a negative effect on the climate (green house gas)

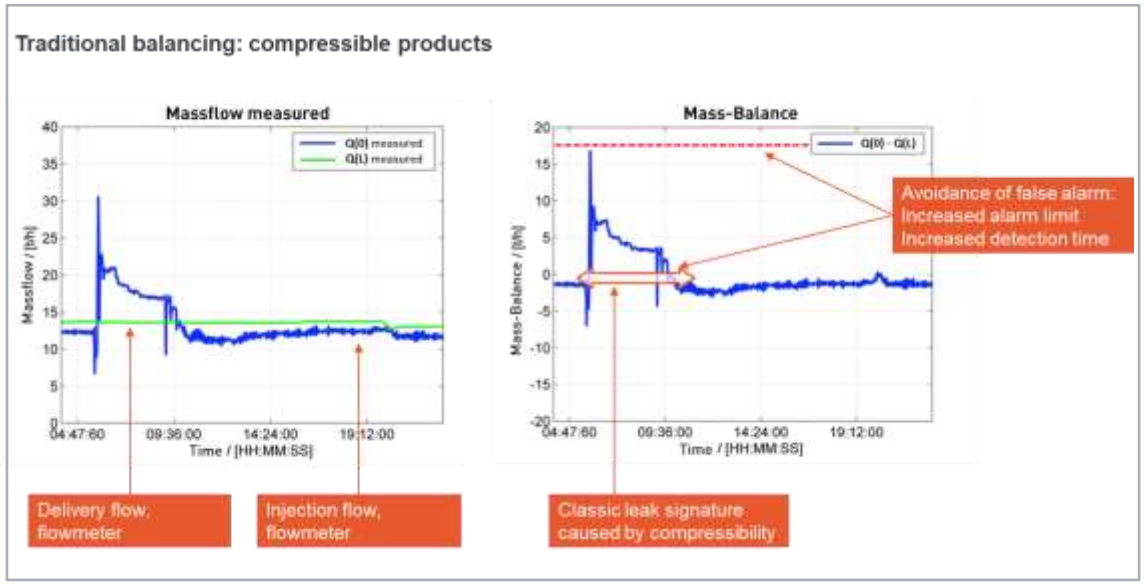
Challenge: different fluid states of CO_2 in the pipeline

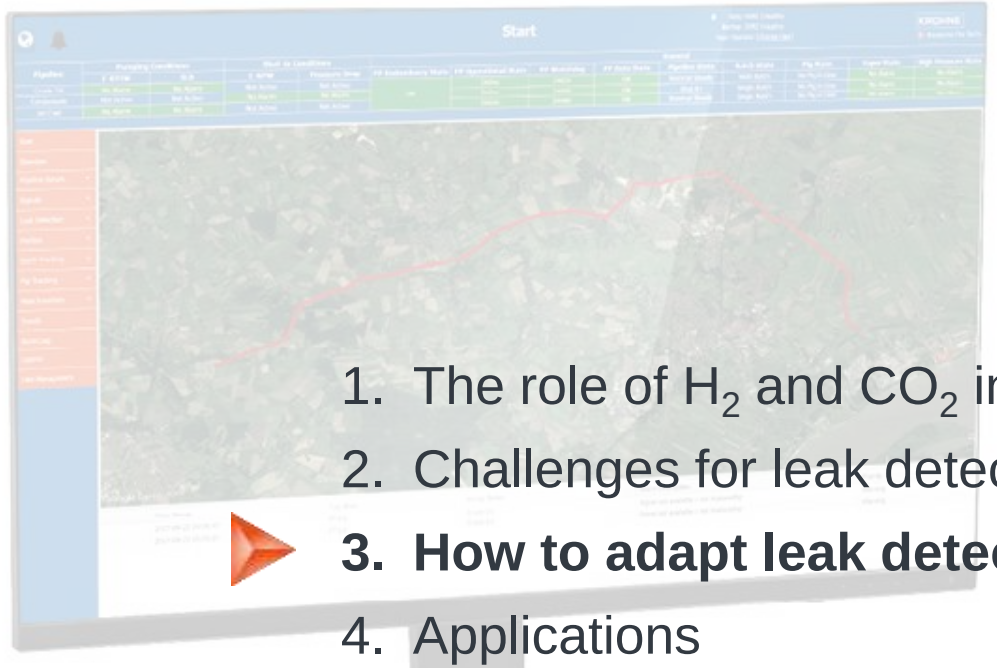
Classical Systems

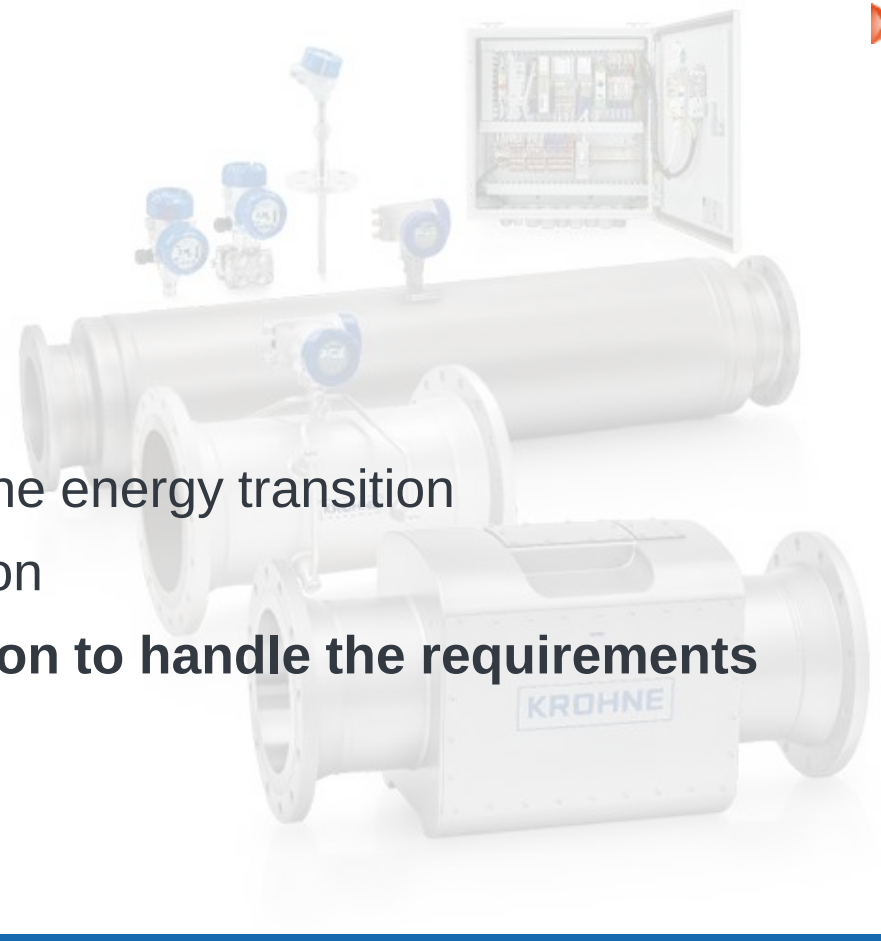
Leak detection

- Negative Pressure Wave based leak detection systems are affected due to damping in gas
- Mass balance, but also classical statistical systems are affected due to compressibility and linepack changes

➔This leads to long detection times or high thresholds. The systems will react with a loss of sensitivity or in the worst case with false alarms.







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How to overcome the challenges

Extended – Real Time Transient Model

Based on principle of statistical pattern recognition

Stage 1: RTTM

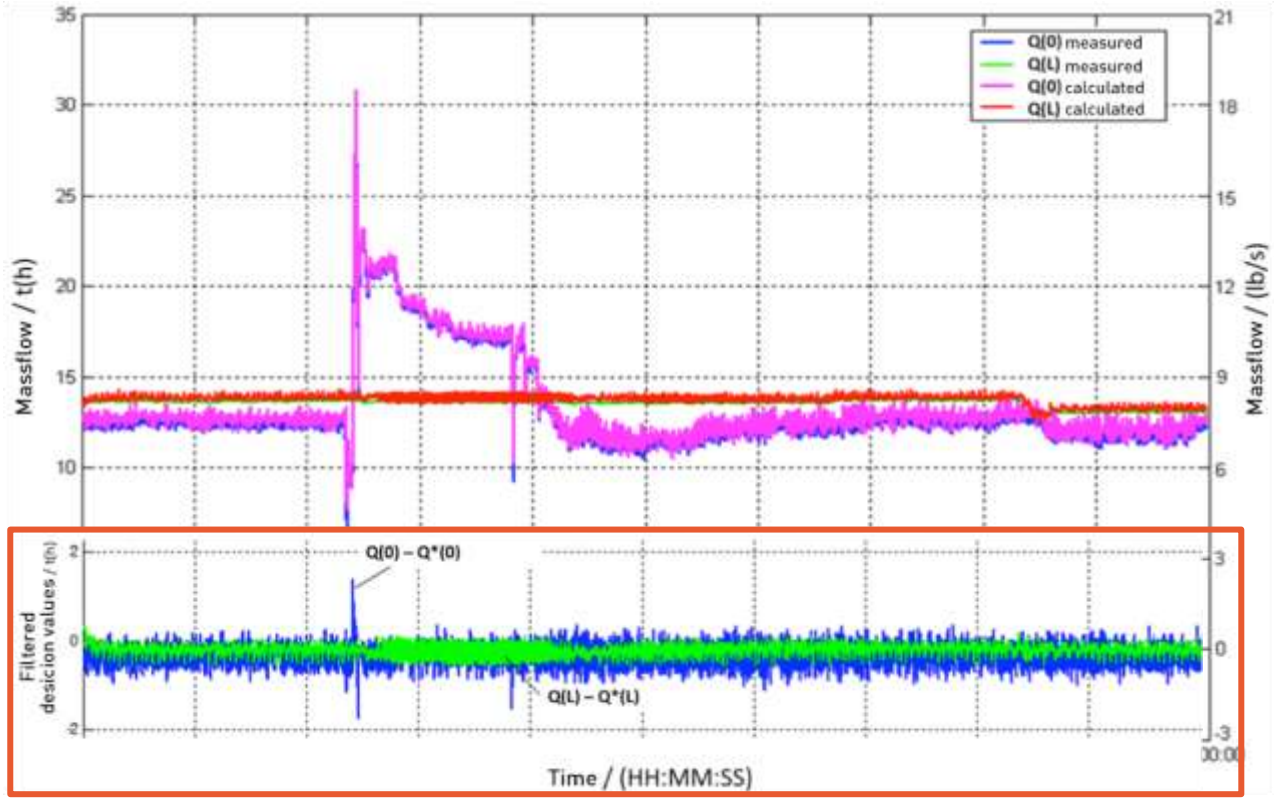
- Create a digital twin of the pipeline (virtual pipeline)
- Include fluid properties and pipeline properties in the model
- Uses process model to create pattern
- Compare digital twin (calculated) values to real measured process data

Stage 2: E, Extended

- In case deviation exceeds the threshold do not automatically raise alarm
- Addition of signature analysis to detect leaks and avoid false alarms
- Leak alert, leak rate, leak position

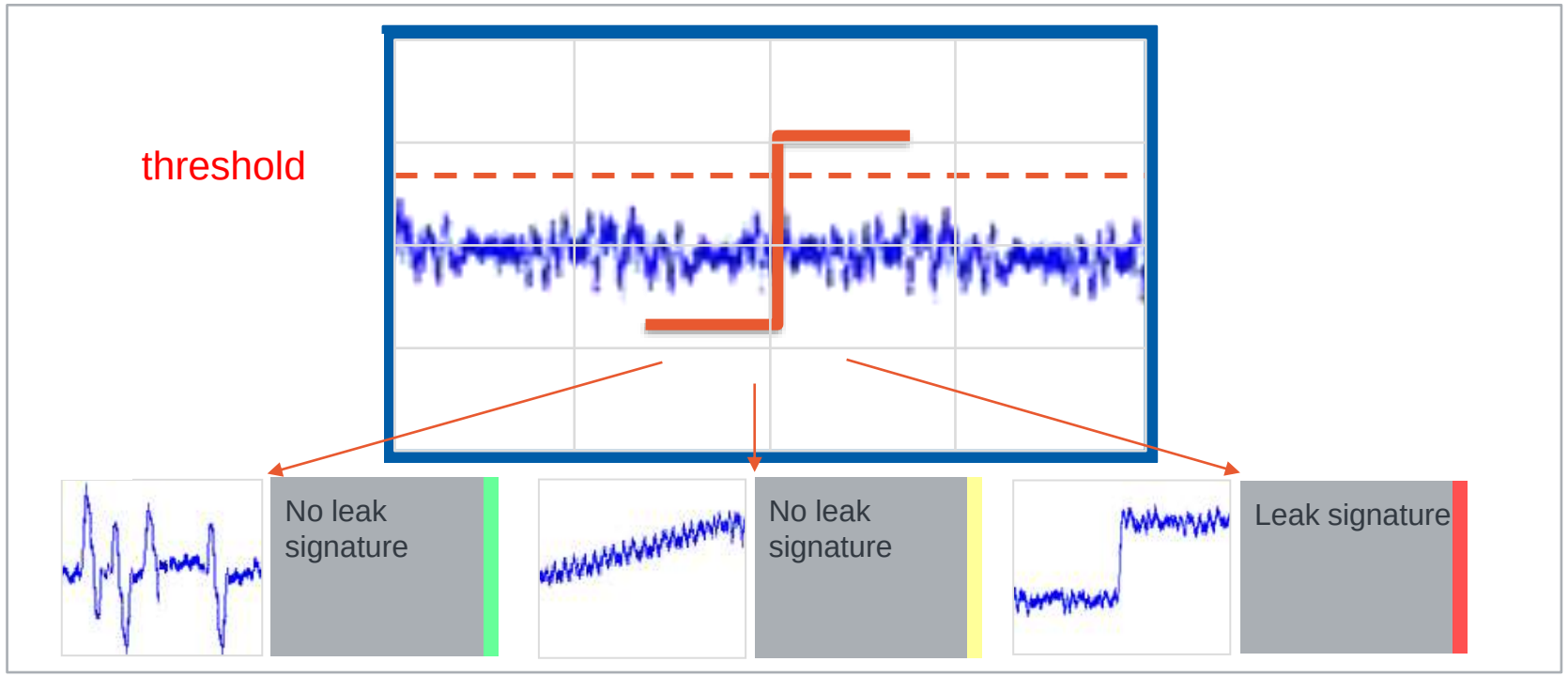
How to overcome the challenges

Dynamic filtering using RTTM



How to overcome the challenges

Leak Signature Analysis



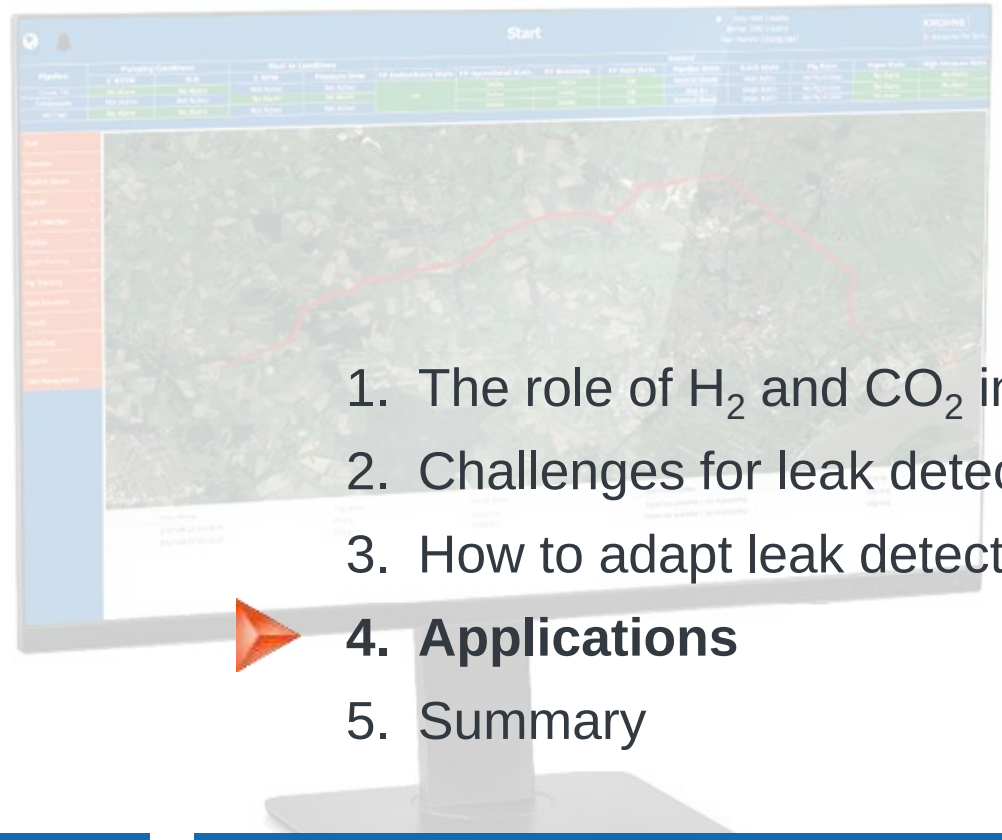
How to overcome the challenges

Leak Signature Analysis

Benefits of “Leak Pattern Recognition”

- Trained to application during initial setup process
- Long term stability and reliability
- No self-learning required as Leak Pattern Recognition remembers the **leak signature**
- Improves overall robustness as it **accepts different compositions and mixtures related imbalance and errors**

E-RTTM
pipeline leak detection



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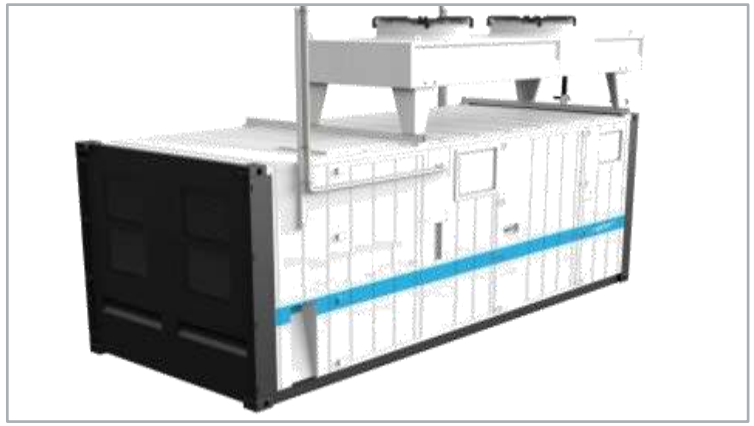
Application Overview

Leak Detection System for Hydrogen

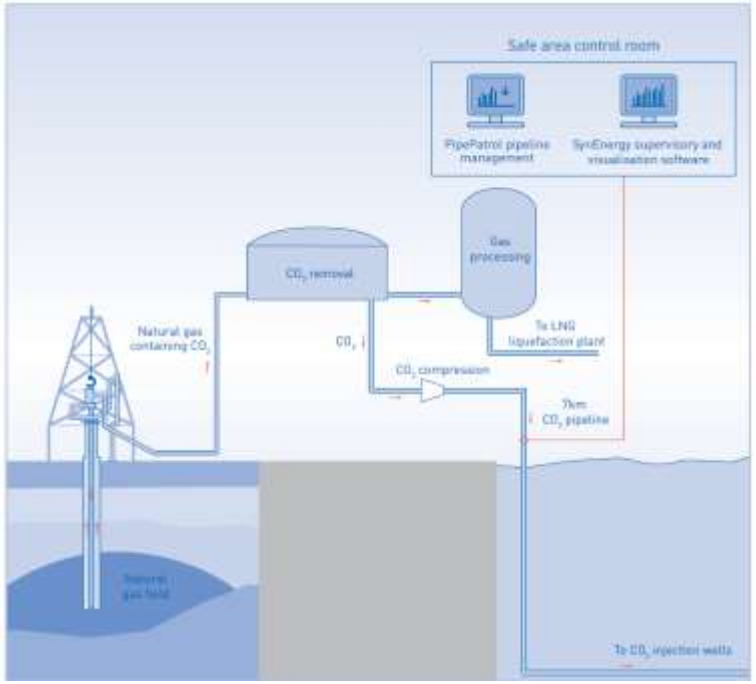
Location	Germany
Year of supply	2013
Application	Power to Gas
Medium	**Dense Phase Hydrogen**
Project details	The leak detection system was installed on a hydrogen Power-to-Gas project in Germany which was the world's first demonstration plant for storing wind energy in the natural gas grid. The plant stores electricity generated by wind turbines. Around 360 Sm^3/h of hydrogen is generated by means of electrolysis and fed via a 1.6 km hydrogen pipeline into the gas grid. A leak test was done under 3rd party review of TÜV, resulting in a swift leak alarm from PipePatrol. Since beginning of operation, the system has secured the transport of over 10 million kWh of hydrogen fed into the grid.

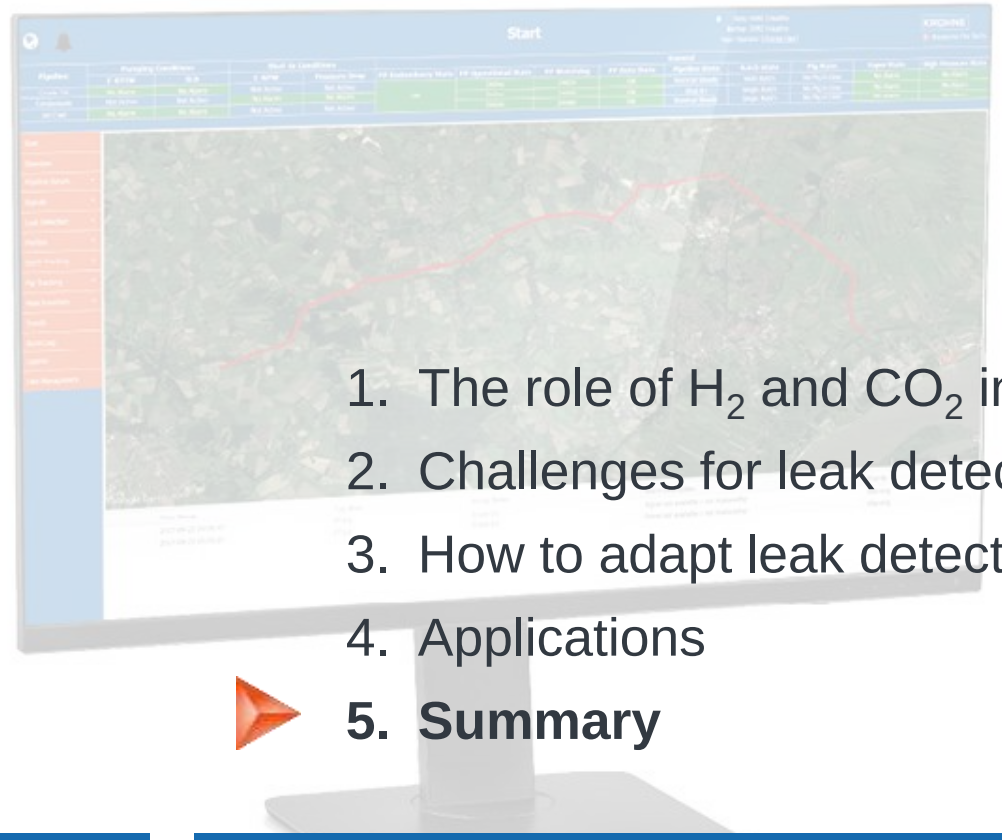


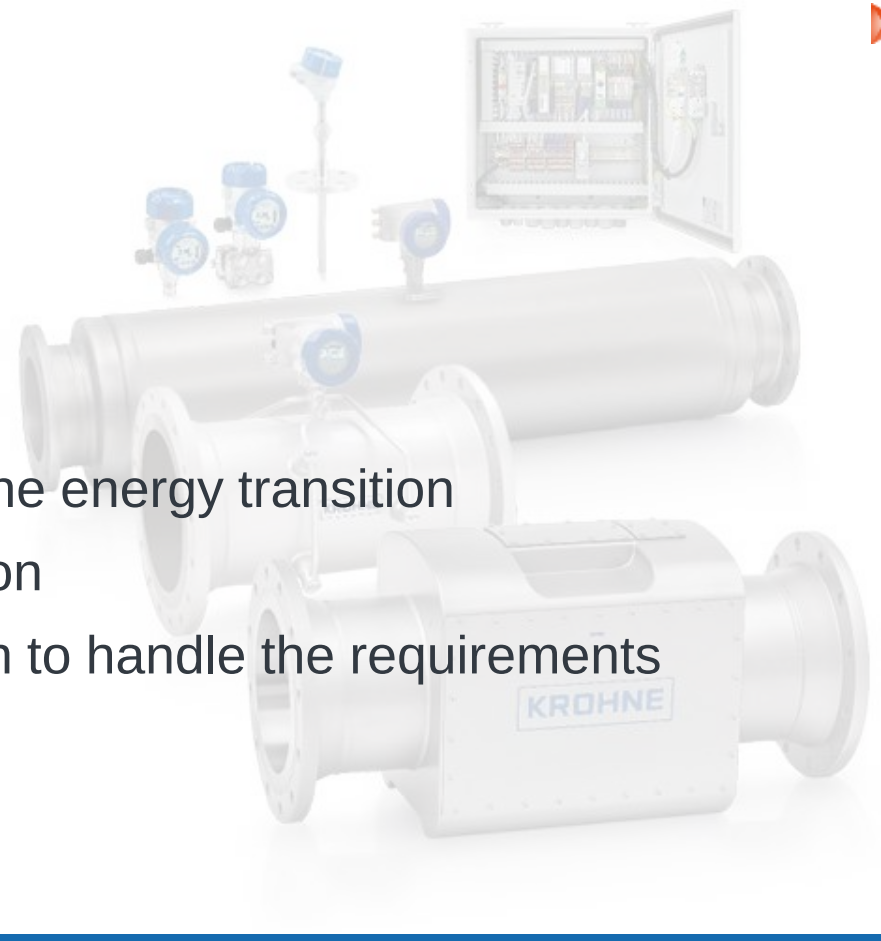
Application Overview

Leak Detection System for Carbon Capture

Location	Australia
Year of supply	2014
Application	Carbon capture CO2 injection
Medium	**Dense Phase CO2**
Project details	Natural gas from the Gorgon gas field in Western Australia contains around 14% naturally occurring CO2. Prior to converting the natural gas to LNG by cooling it to -162°C / -259.6°F, the CO2 is removed. To minimize the environmental footprint, the separated CO2 is not vented but injected in a storage formation. The CO2 is transported in supercritical phase at elevated pressures. The underground pipeline has a diameter of 300 mm / 12”. Three compressor modules feed CO2 in the pipeline that transports it to nine injection wells at three drill centers.







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Summary

Leak Detection for Energy Transition

Reliable leak detection using Model Based Technology

- Digital twin of pipeline network combined with model that incorporates fluid properties and pipeline properties
- Model based technology (E-RTTM) compensate disadvantages of other leak detection technologies
- Signature Analysis makes the system less sensitive against inaccuracies in RTTM calculations.
- Thus challenging pipeline conditions, product parameters or mixtures, e.g. hydrogen blends, leading to these inaccuracies become less important.

➔ No false alarms, still reliable detection

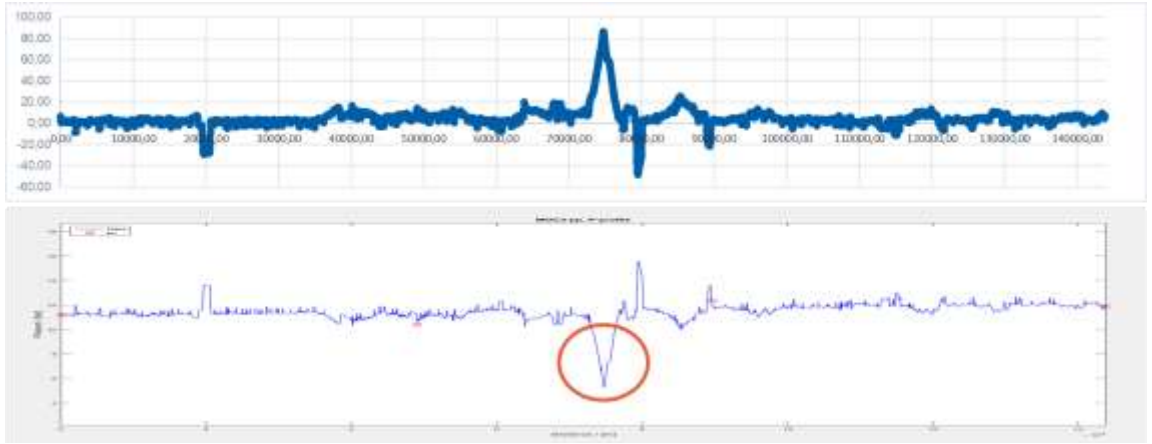
E-RTTM
pipeline leak detection

Summary

Functionalities of model based systems

Standard information

- Detection and localization of a leak



Additional information

- Composition Tracking
- Profiles
- State detection
- Virtual Instrumentation and Validation

Summary

Pipeline Management Solutions

Smart monitoring and protection of pipelines

- Comprehensive suite of modules for leak, theft and line break detection as well as monitoring of tightness and lifetime stress
- Complete and sensitive protection of oil, gas, water and multiproduct pipelines
- From single software applications to full packages including instrumentation, cyber security and field data acquisition

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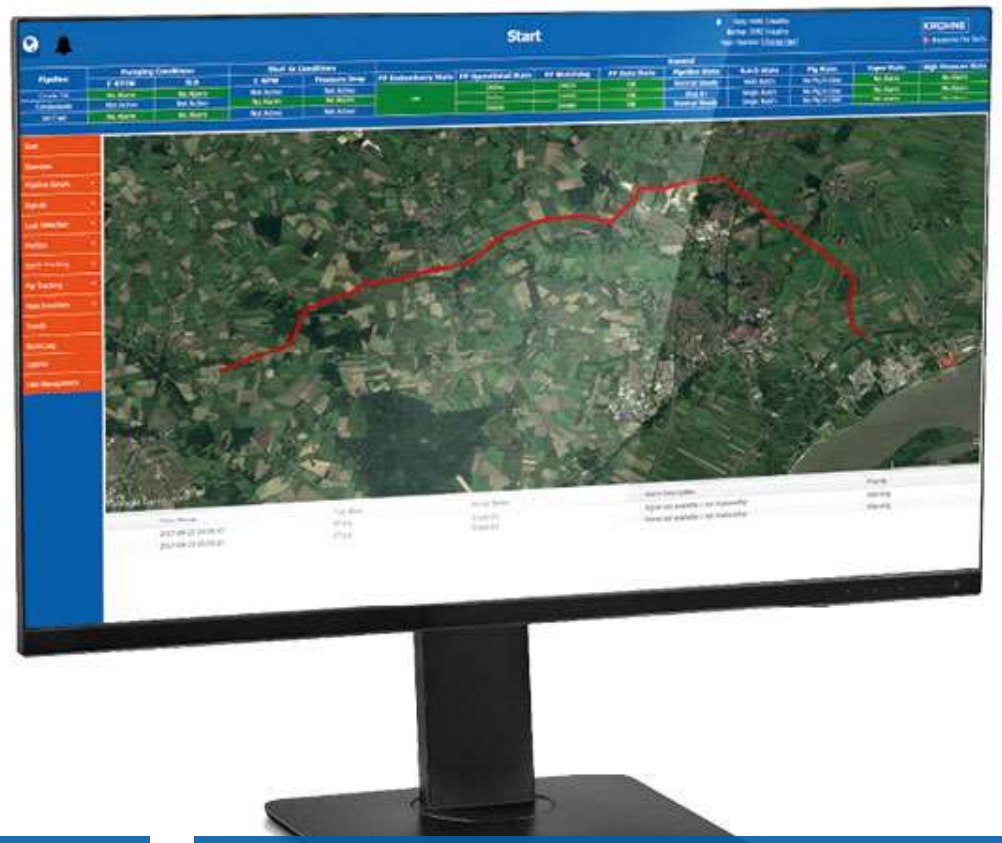

#readyforthetransition