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# Fiber-Optic Sensing for Field Development Asset Integrity & Optimization Workshop

24–25th March 2026  
Ardoe House Hotel,  
Aberdeen, UK

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# New Energies DFOS Applications: From O&G Upstream to Energy Diversification



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# Agenda

- Motivation
- DFOS Monitoring for New Energy Applications
  - Case Studies
- Takeaways & Discussion



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# Motivation

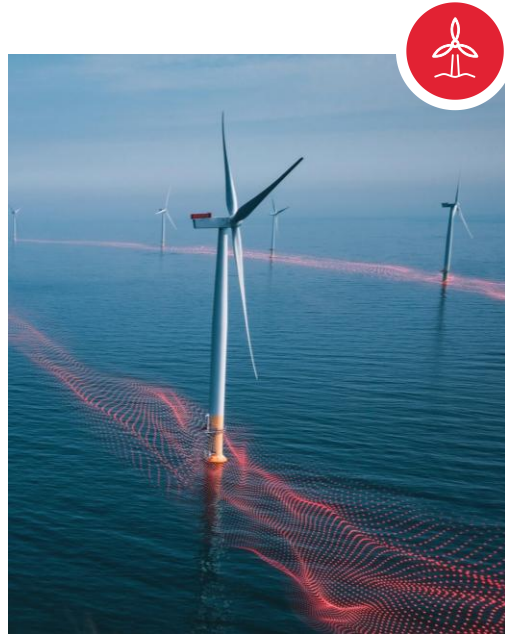
## Why monitoring matters in the shift to New Energy?

- Energy systems are rapidly expanding beyond traditional oil & gas
- Similar challenges to upstream O&G:  
subsurface uncertainty, asset integrity, complex conditions
- Many assets in remote / hard-to-access environments
- Growing need for continuous, long-distance monitoring
- Fiber optic monitoring enables real-time insight where direct access is not possible



# Motivation

## Expanding Energy Applications





# Monitoring Solar Infrastructure

## Early Hot Spot Detection Using DTS

- Solar energy is becoming an important part of the renewable energy mix.
- Large-scale PV installations introduce new monitoring challenges.

### Case study – IKEA installation:

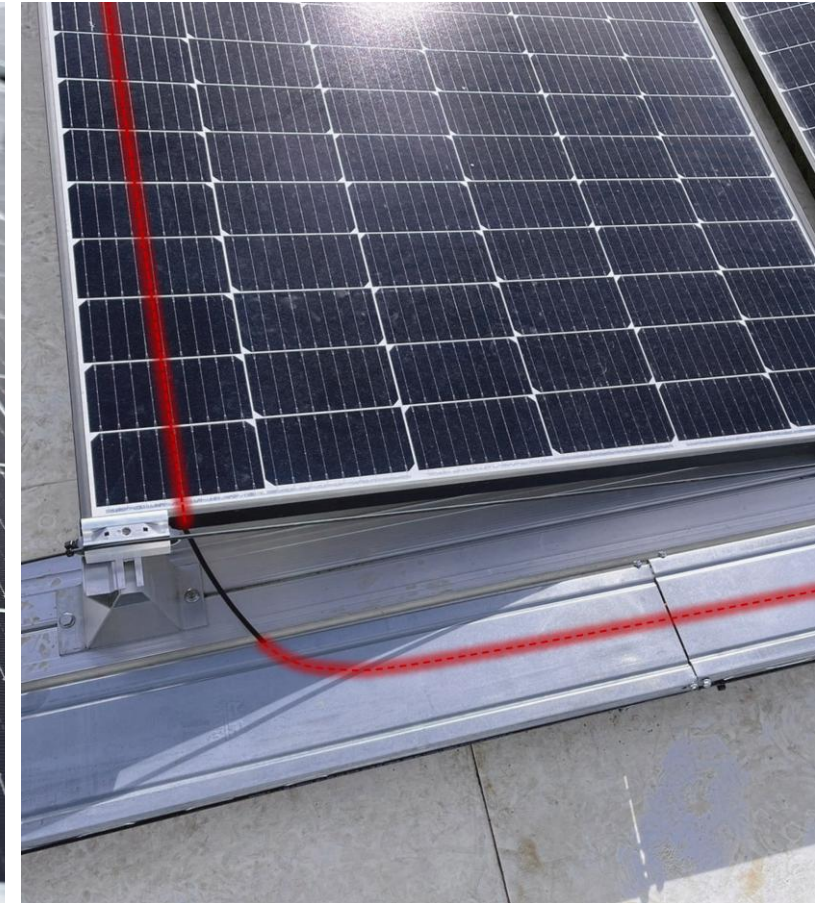
- Solar panels installed on facility rooftops and car park canopies.
- The installation covers tens of thousands of square meters of solar panels.
- The system produces enough electricity to power around 3,000 homes.
- Reduces CO<sub>2</sub> emissions and supports local renewable power generation.



# Monitoring Solar Infrastructure

## Advantages of DFOS

- ~20-25% of PV system damages is related to fire incidents
- Early detection of overheating is difficult in large installations
- Rooftop fires are challenging to manage due to:
  - building height
  - water may not reach the ignition source
  - smoke can be drawn into the building's AC system
- Conventional fire detection systems are often not suitable for large PV installations



\*Source: AP Sensing



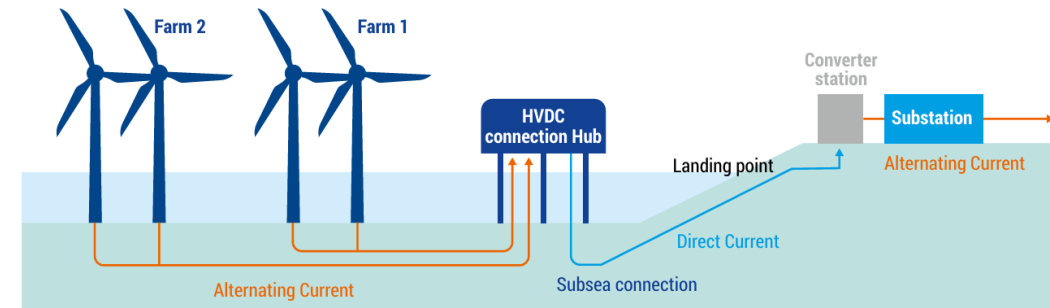
# Monitoring Offshore Wind Infrastructure

## Cable failures: Just a question of time

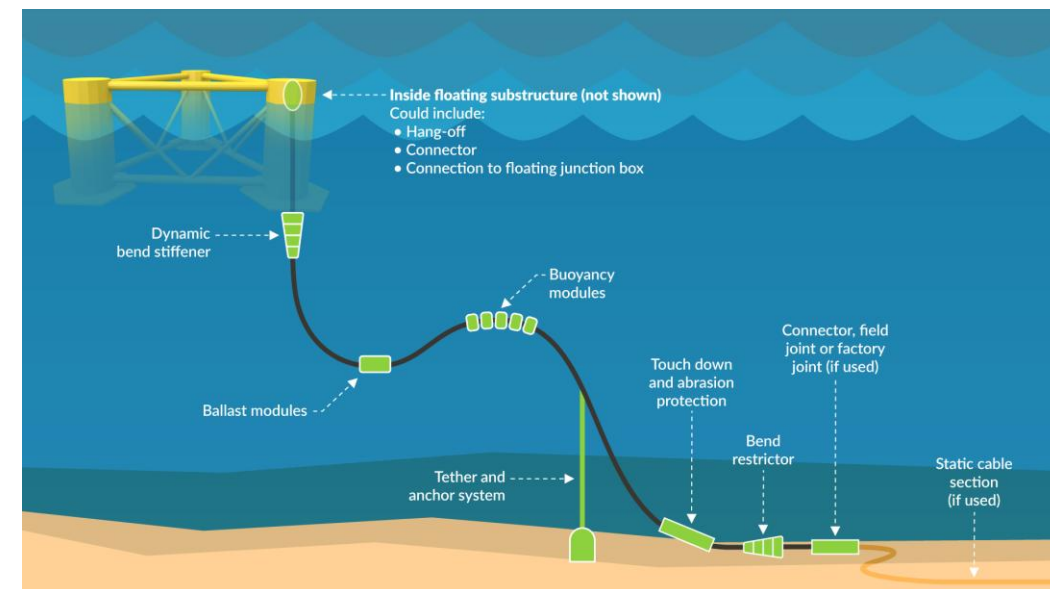
- Cables are critical to offshore wind farms – fixed-bottom or floating
- Include static subsea and dynamic cables
- DFOS enables condition monitoring through:
  - Thermal cable rating and depth of burial state monitoring
  - Fatigue monitoring
  - Detection of third-party damage



\*Source: Nexans



\*Source: Offshore Network Development Plans / Pan-European Summary, 2024



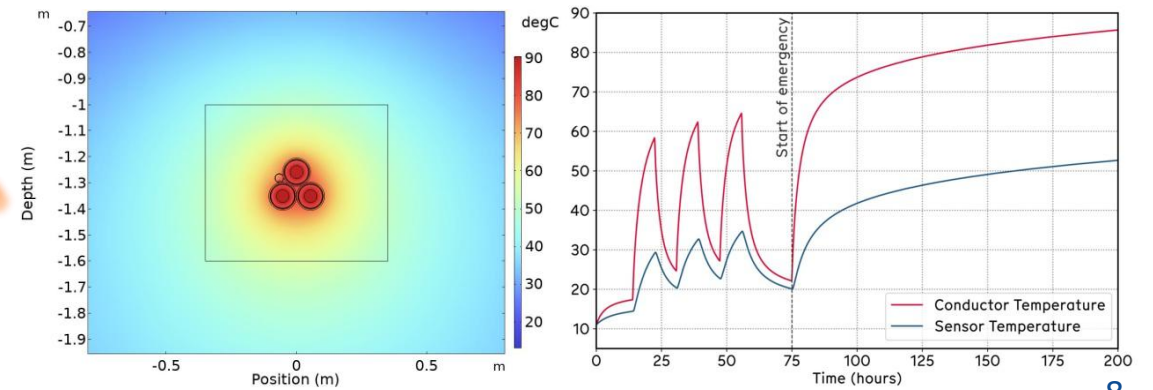
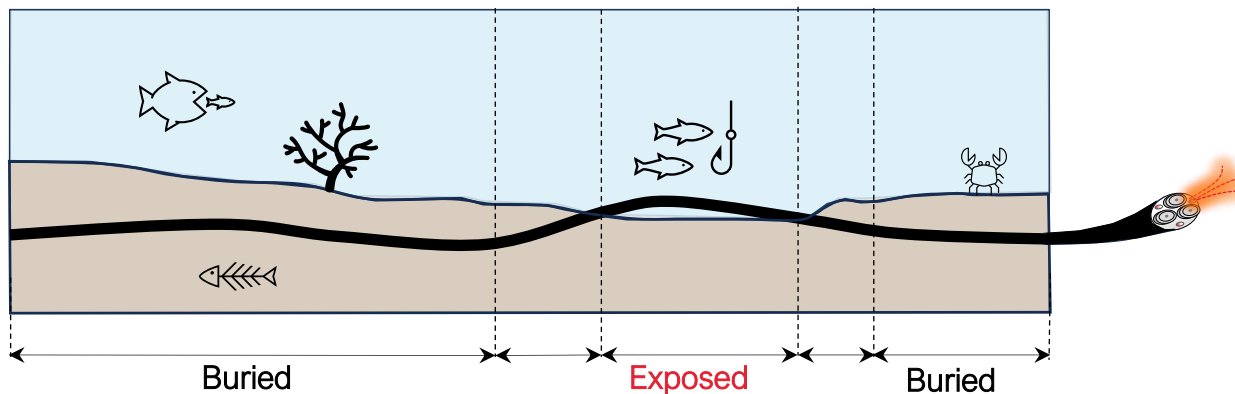
\*Source: guidetofloatingoffshorewind.com

# Monitoring Offshore Wind Infrastructure

## DTS-based insights

- What drives the temperature in the power cables:
    - Electrical load (power carried by the cable)
    - Seabed properties
    - Depth of cable burial
    - Seawater conditions
- DTS measurements  
 Measured load
- Depth of burial

- ✓ DTS measurements
  - ✓ Measured load
  - ✓ 1D thermal network model
- Dynamic Cable Rating

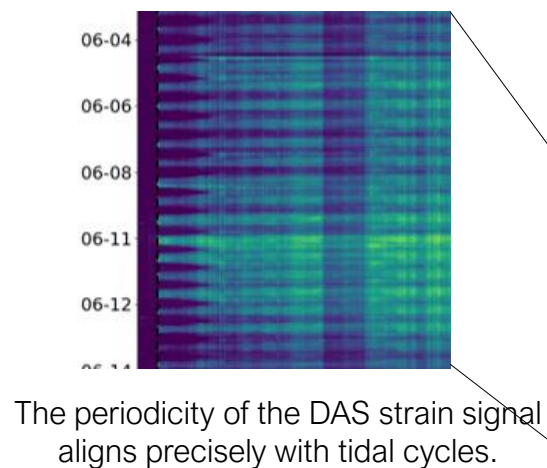
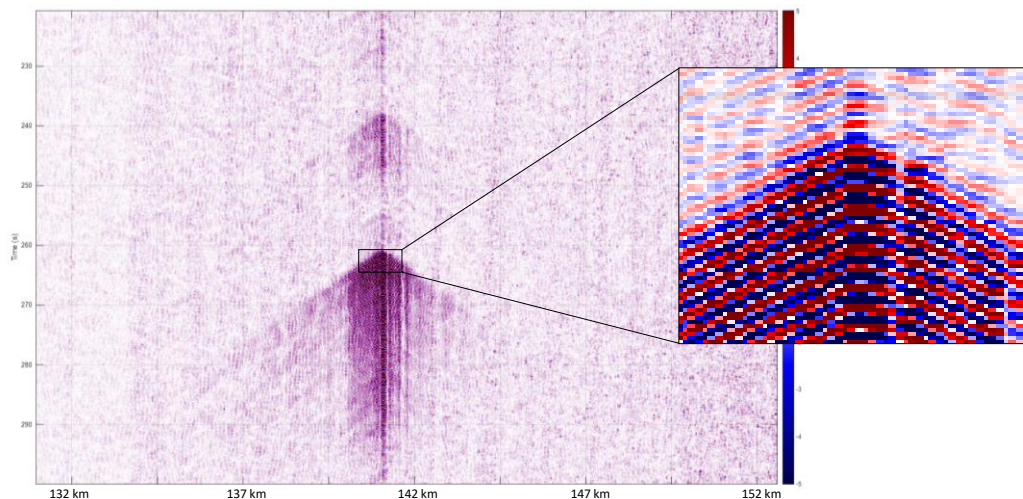
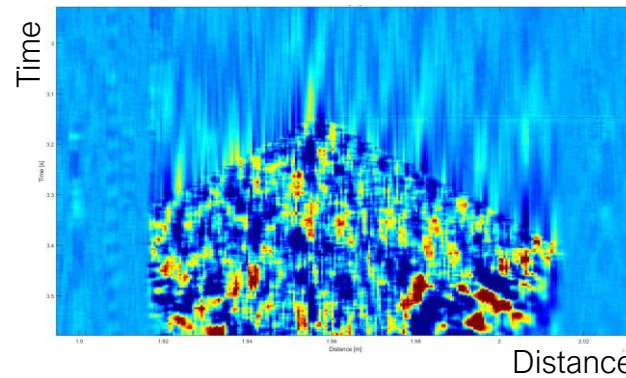


\*Source: AP Sensing

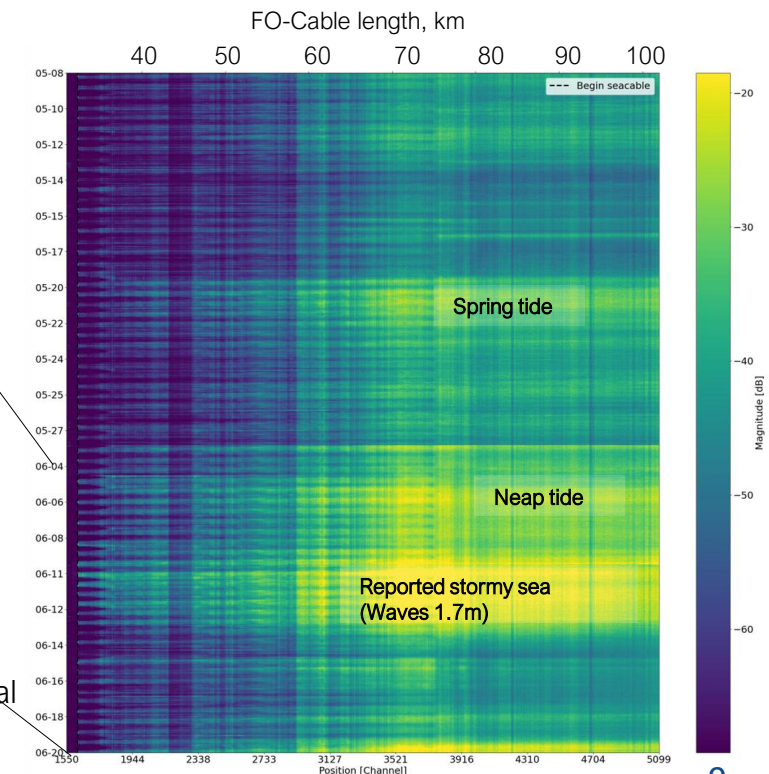
# Monitoring Offshore Wind Infrastructure

## DAS-based insights

- Cable faults
- Third-party activities, e.g. anchor drop
- Ocean-induced cable motion



The periodicity of the DAS strain signal aligns precisely with tidal cycles.



\*Source: AP Sensing

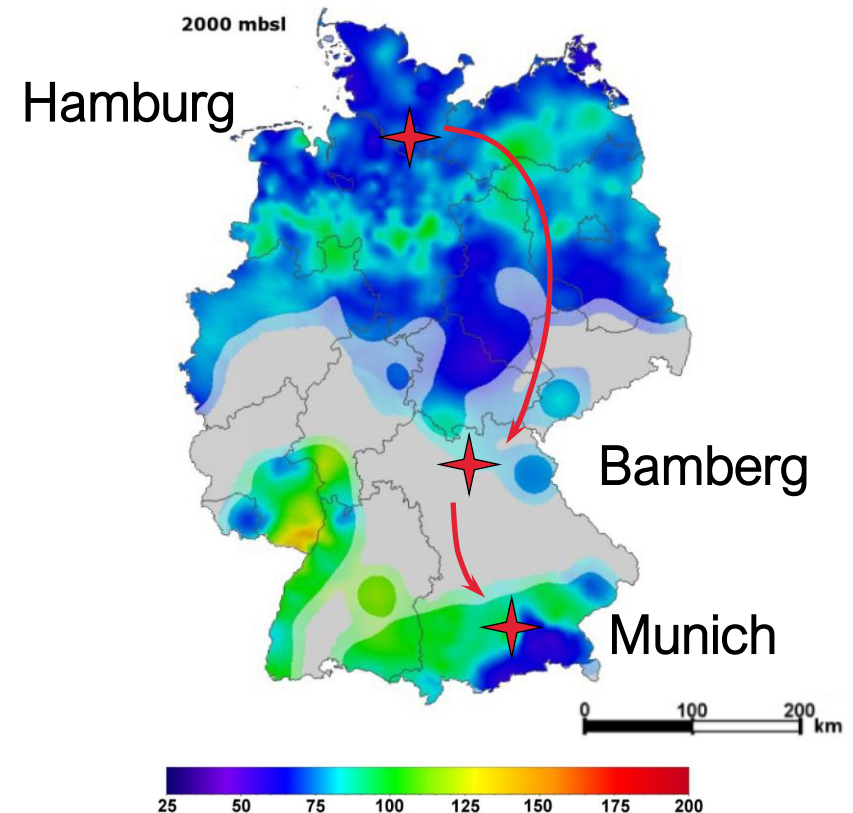


# Monitoring Geothermal Energy

## Example from Germany

- Case Study locations:
  - Hamburg (North)  
Borehole heat exchangers (~13 m)
  - Bamberg (Central-South)  
Borehole heat exchangers (~120 m)
  - Southern Germany (Munich region)  
Deep geothermal (> 3 km)

Map of subsurface temperature distribution @ 2000 meters below sea level

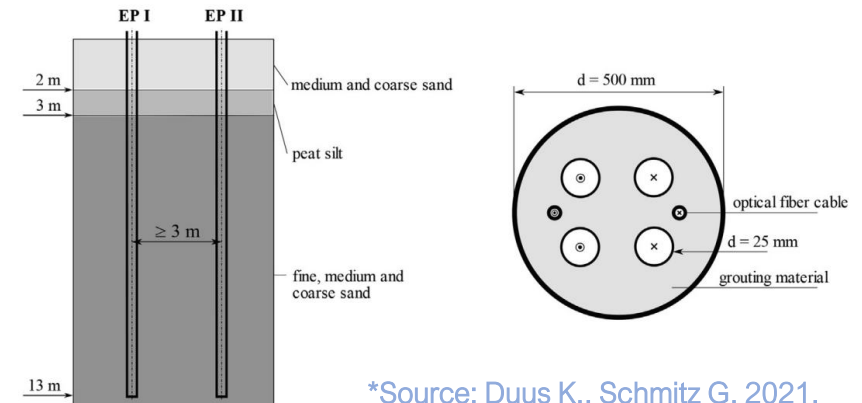


\*Source: Agemar T. et al. 2014. Deep Geothermal Energy Production in Germany.

# Monitoring Geothermal Energy

## Shallow geothermal energy

- Energy-efficient building project in Hamburg
- Building foundation includes ~1600 piles, ~950 used as energy piles
- Energy piles contain double U-tube borehole heat exchangers
- Ground temperatures: 10-12 °C
- DTS monitors temperature evolution in soil and piles (17 energy piles and 13 observations boreholes were equipped with FO)
- Enables evaluation of thermal performance and system efficiency



\*Source: Duus K., Schmitz G. 2021.



## Monitoring Geothermal Energy

### Shallow geothermal energy

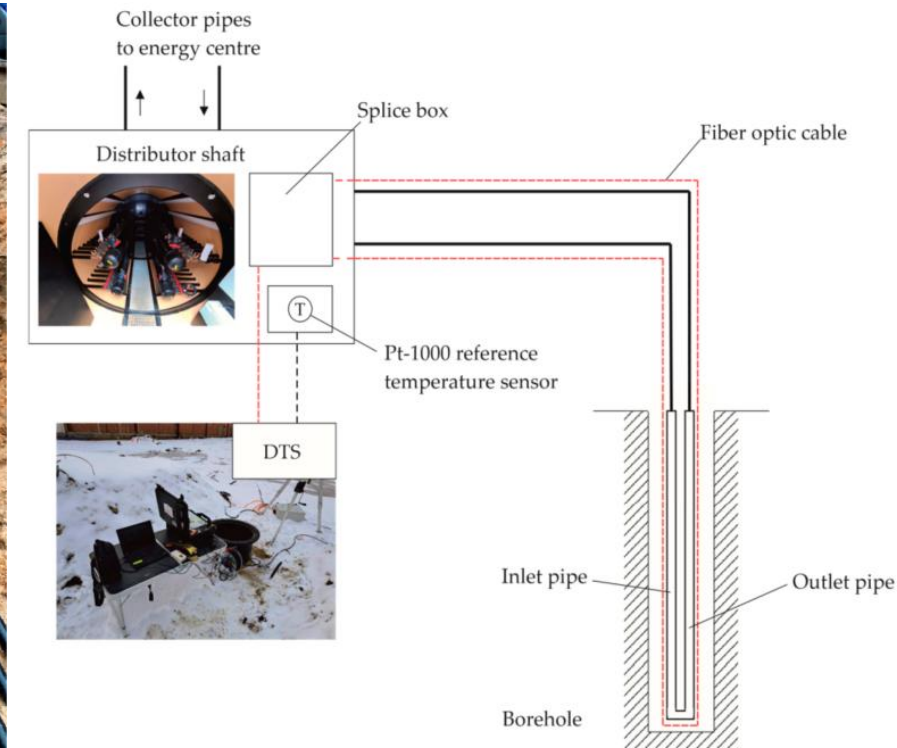
- Shallow geothermal systems provide renewable heating for urban area

#### Case study: Bamberg, Bavaria – Lagarde Campus:

- Residential district using borehole heat exchanger fields
- 54 boreholes, each 120 m deep
- System supplies ~1,200 MWh of renewable heat annually
- Example of large-scale geothermal deployment in dense urban environments



Surface trench installations

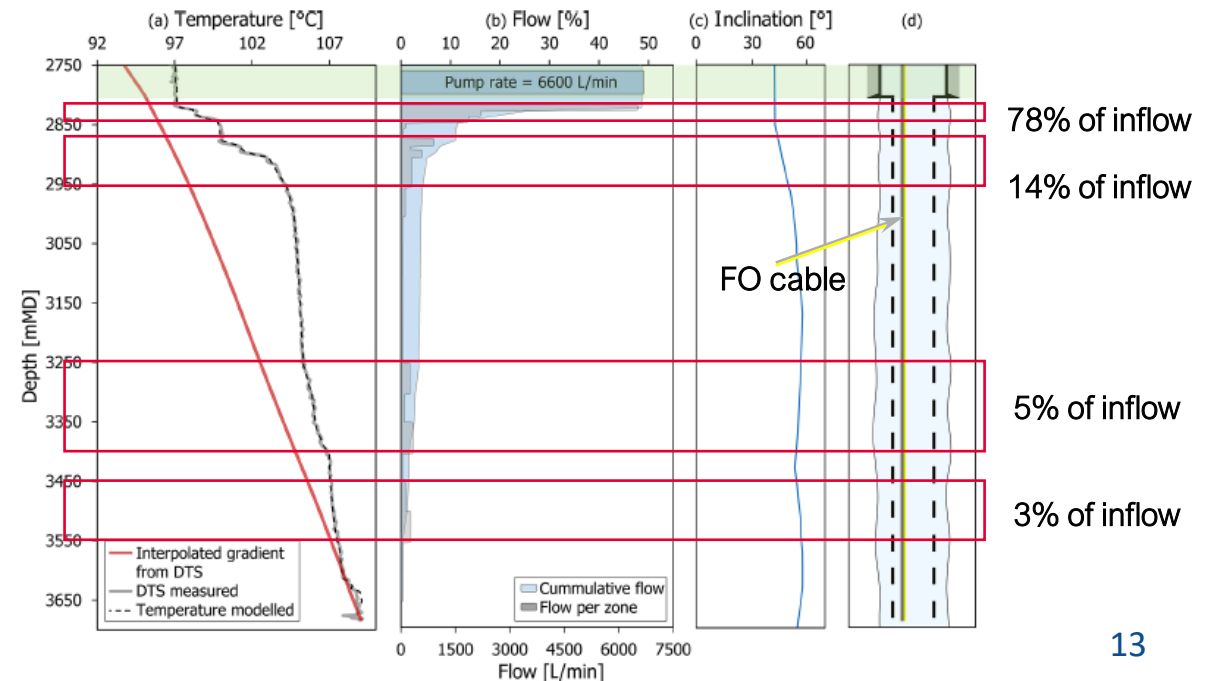
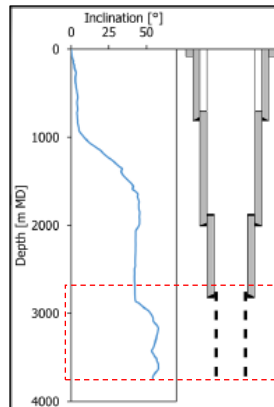
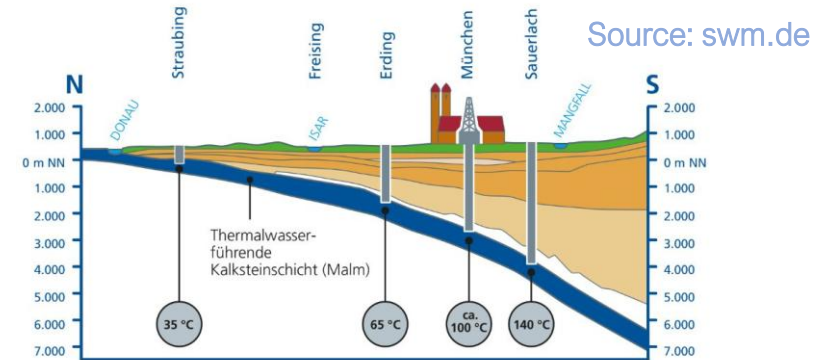


Schematic configuration of the boreholes and DTS

# Monitoring Geothermal Energy

## Deep Geothermal

- Munich and the surrounding region sit above a vast deep geothermal reservoir, with hot thermal water at 2 – 3 km depth
- Municipal utility company uses this resource to generate climate-friendly heat and electricity
- Fiber-optic cable installed along the production well
- Supports monitoring of long-term production stability



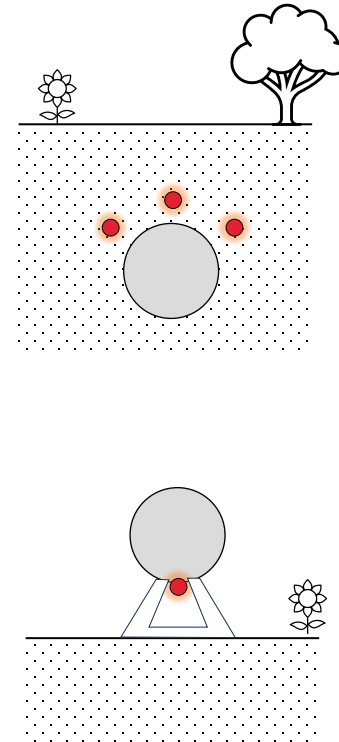
\*Source: Schöderle at al., 2023



# Monitoring Pipeline Infrastructure

Pipelines – part of new energy infrastructure

- New energy systems rely on transport pipelines for CO<sub>2</sub>, hydrogen and ammonia
- Pipelines can be buried or above ground
- Fiber-optic installation methods vary depending on pipeline design and environment
- Monitoring strategy depends on the physical properties of the transported gas



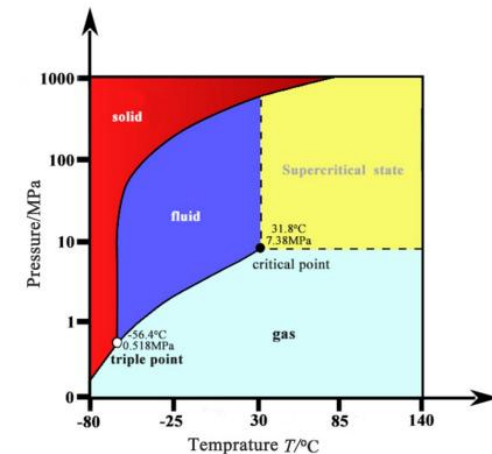
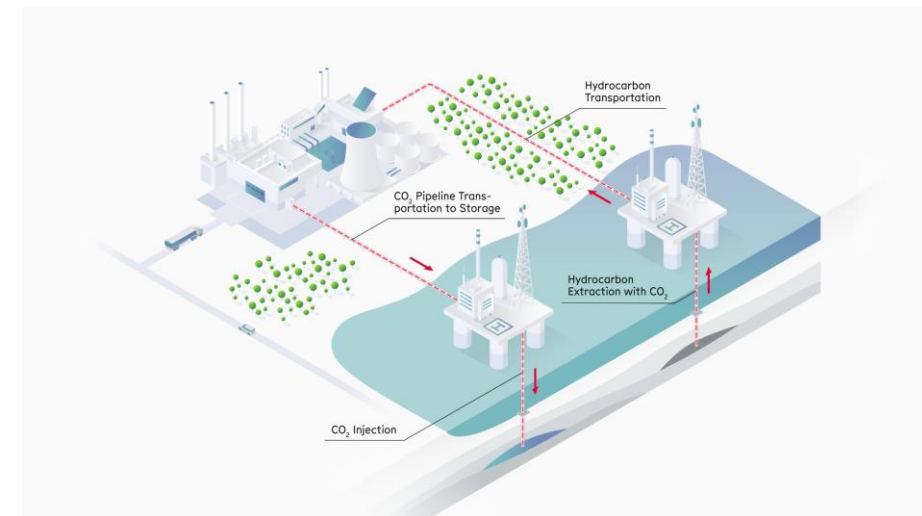
CO<sub>2</sub> pipeline with FOC



# CO<sub>2</sub> Transportation Pipelines

Part of decarbonization infrastructure

- CO<sub>2</sub> has unique thermodynamic behavior compared to natural gas
- Depending on P and T° CO<sub>2</sub> can exist in multiple phases
- Pressure strongly influences its state – gaseous at lower pressure, dense/liquid-like at higher pressure
- It is typically transported in the dense or supercritical phase.
- Pressures above 80-100 bar
- Rapid decompression can accelerate crack propagation
- CO<sub>2</sub> leaks can compromise the integrity and effectiveness of CCS projects.



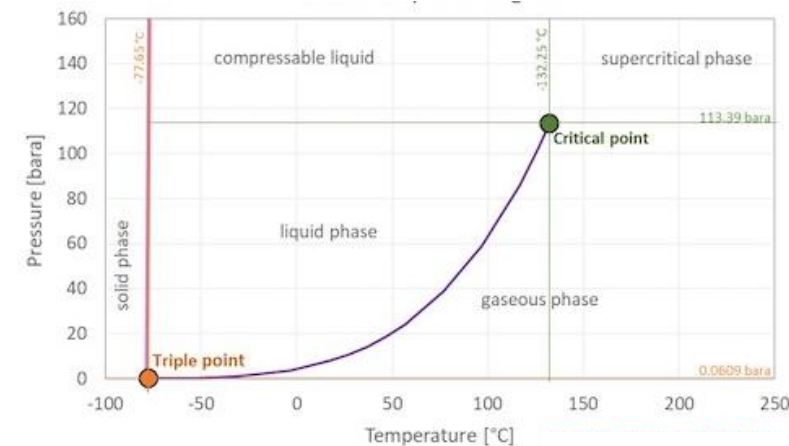
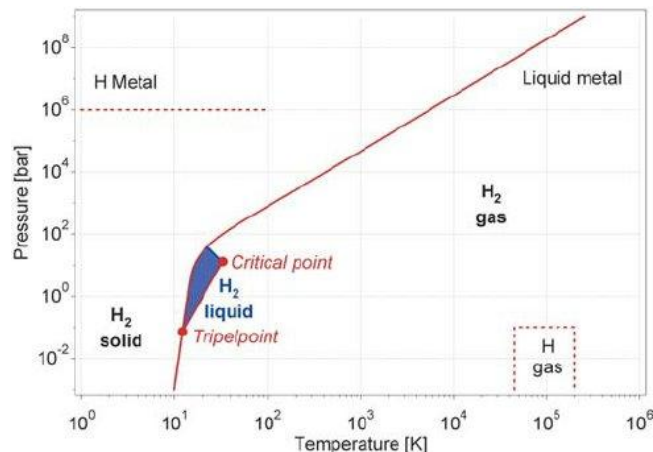
\*Source: Wikipedia



# Hydrogen & Ammonia Pipelines

H<sub>2</sub> & NH<sub>3</sub> Pipelines as a part of energy transition infrastructure

- Hydrogen molecules are extremely small, increasing leakage risk through micro-defects
- Hydrogen is typically transported as a compressed gas through pipelines
- Hydrogen pipelines show different thermodynamic behaviour (no Joule-Thomson cooling)
- Ammonia - Increasingly used as a hydrogen carrier
- Often transported through lower-pressure pipelines



## Power Behind Digital World

### Data Centres and Energy Transition

- Rapid growth of cloud, AI, digital services
- Data centers becoming major electricity consumers
- Large electrical loads are distributed through bus duct systems
- Temperature is a key indicator of bus duct health
- Conventional approach relies on periodic infrared thermography

IR cameras – incomplete coverage  
Point sensors – discrete point only





# Key Takeaways

## DFOS Across the Energy System

- Energy transition is driving the expansion of new and diverse infrastructure:
  - renewable generation (solar, wind, geothermal)
  - energy transport (CO<sub>2</sub>, hydrogen and ammonia pipelines)
  - critical infrastructure (data centers)
- These assets share common monitoring challenges:
  - long distances
  - remote environments
  - need for continuous monitoring
- DFOS provides continuous insight along entire assets
- One sensing technology can support monitoring across all of these.
- Distributed sensing for diversified energy infrastructure!



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Many thanks to my colleagues at AP Sensing  
for their support and collaboration.

# Thank You for Your Attention!

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