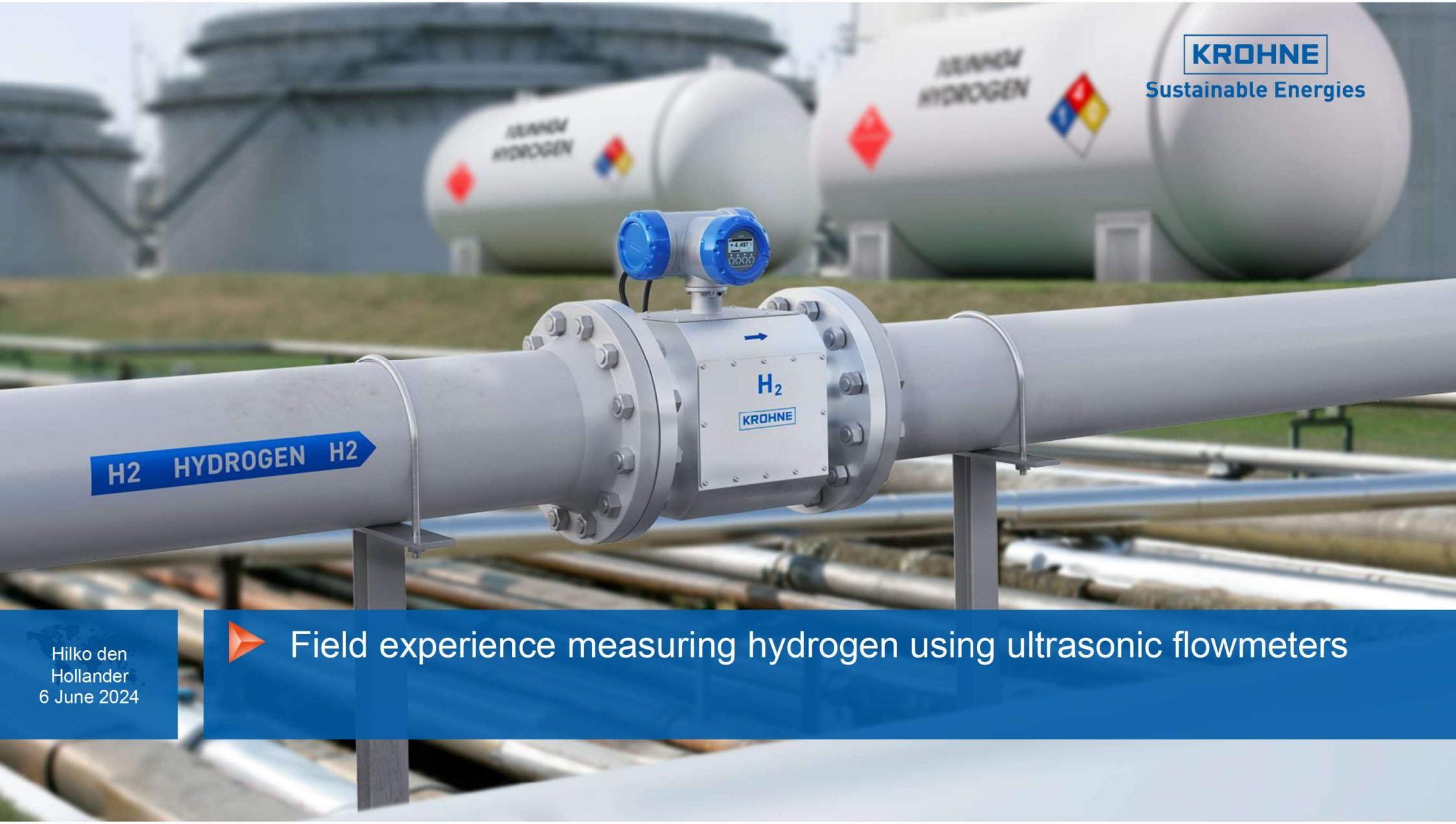
Krohne Belgium



Field experience measuring hydrogen using ultrasonic flowmeters

Hilko den Hollander
6 June 2024

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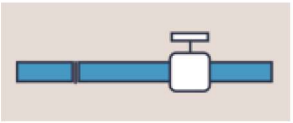
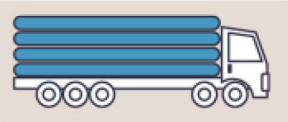
Transport of hydrogen

- **Gaseous hydrogen**
  - Pipelines
    - Blend with natural gas
    - Pure hydrogen



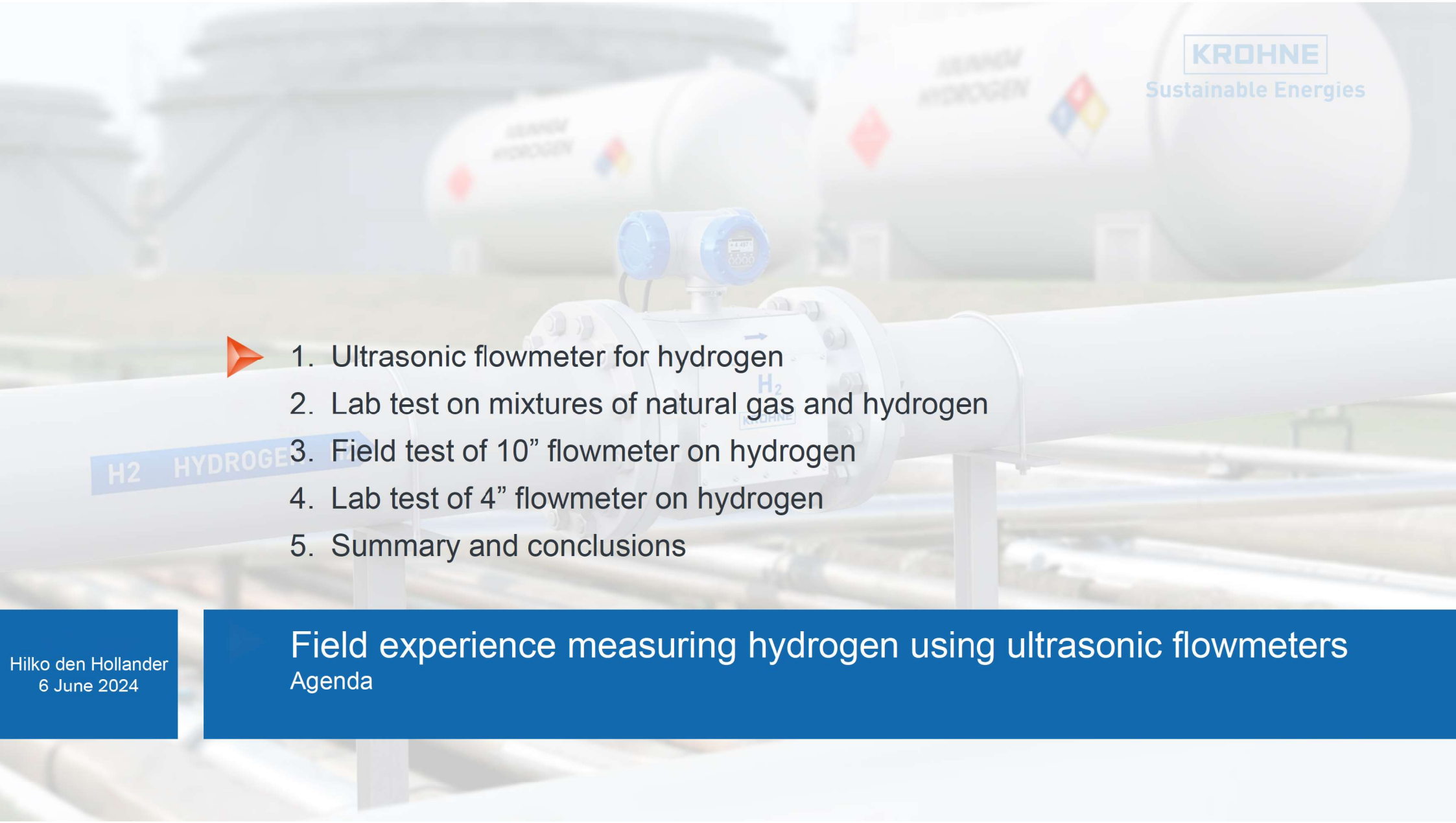
  - Tube trailers
    - Compressed hydrogen



- **Liquid hydrogen**
  - -252°C
  - Long distance transportation
  - NH_3 / Methanol / LOHC /……

Ultrasonic flowmeters

Focus of todays presentation



1. Ultrasonic flowmeter for hydrogen
2. Lab test on mixtures of natural gas and hydrogen
3. Field test of 10” flowmeter on hydrogen
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5. Summary and conclusions

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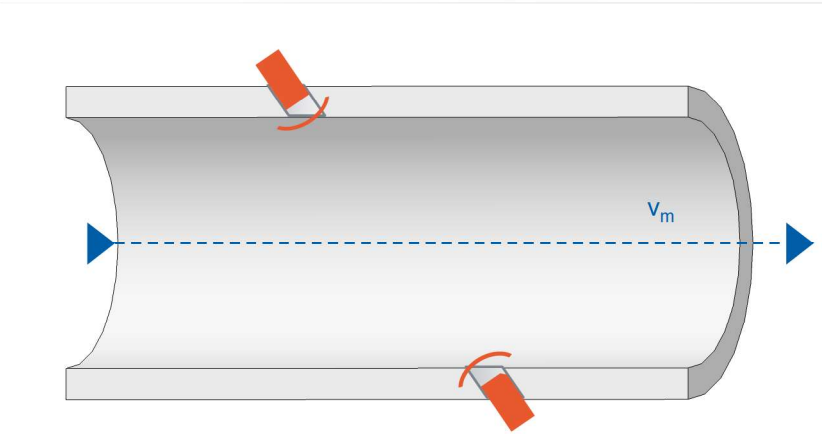
Ultrasonic flow measurement principle

transit time measurement



- Ultrasonic signal
- Transit time difference downstream vs. upstream
- Difference in transit time is related to flow velocity
- Volume flowrate is calculated

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Measurement Challenges for H_2
ultrasonic technology

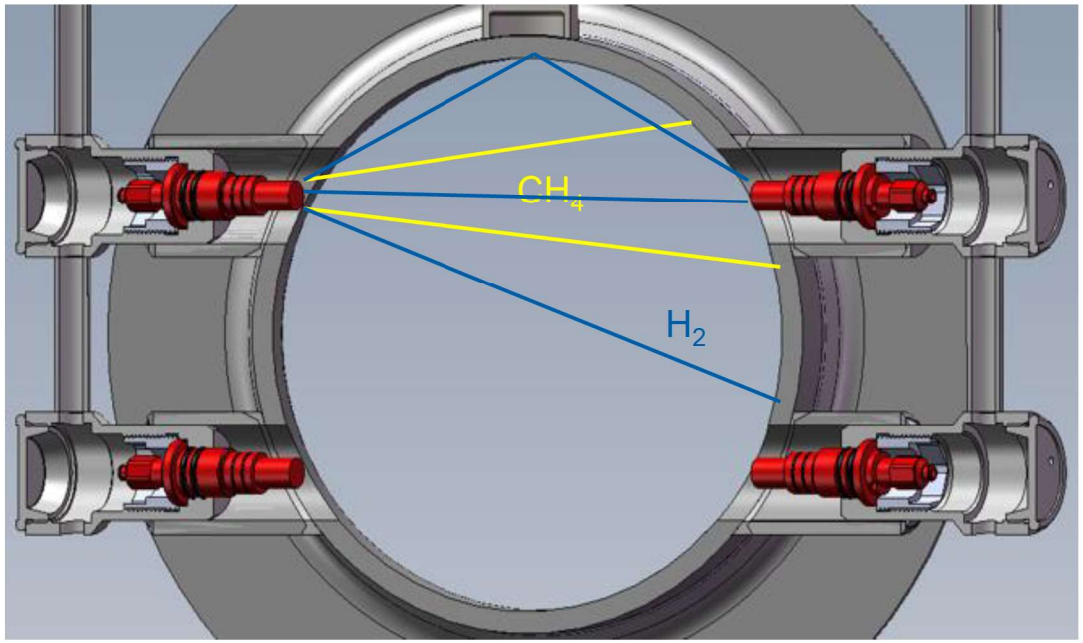
Low density (8 times lower than natural gas)

- *Impacts SNR*

Speed of sound (3 times higher than natural gas)

- *Short transit time*
- *Larger opening angle*

(un)-Availability of calibration facilities



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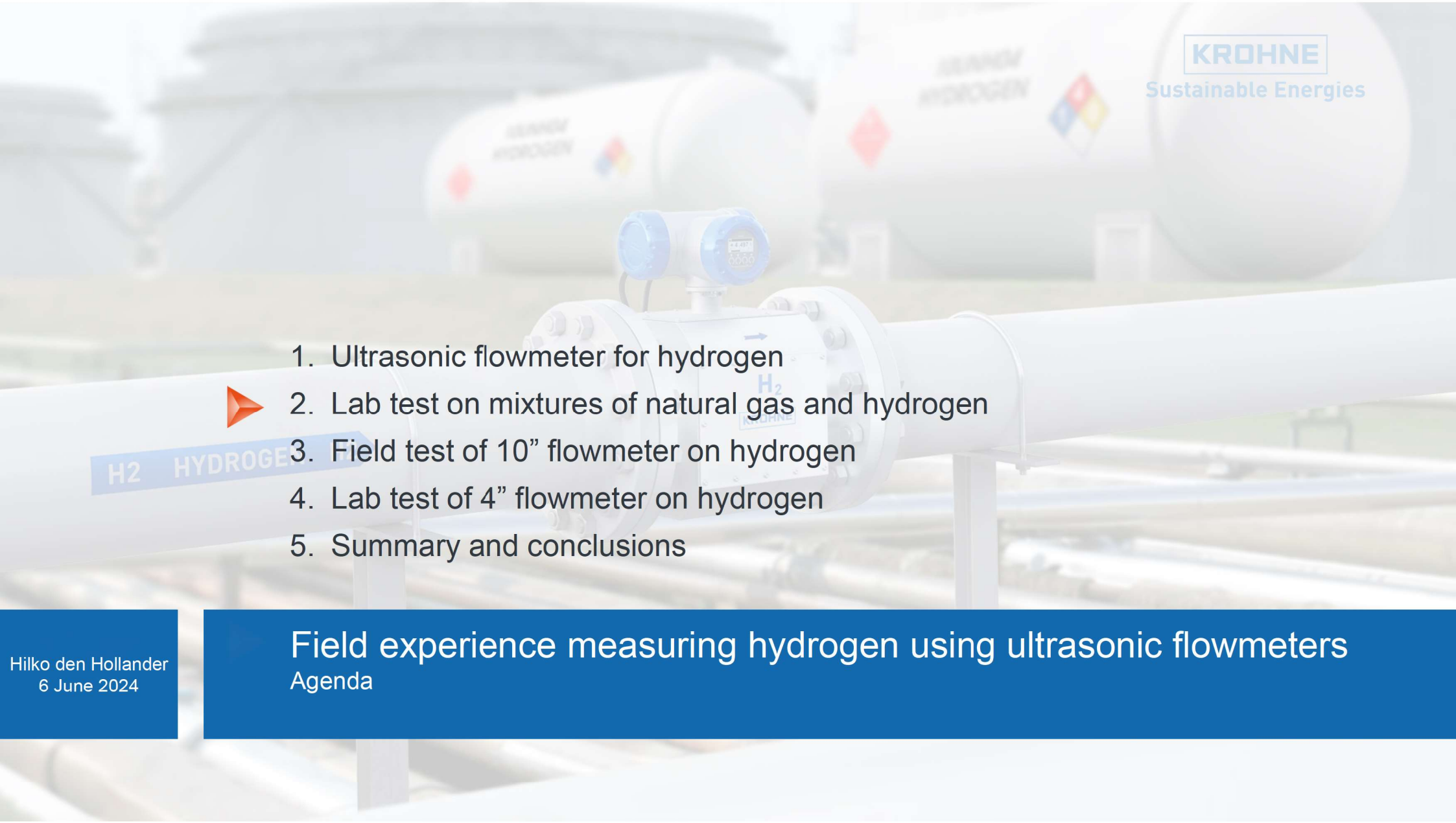
Ultrasonic flow measurement principle

ALTOSONIC V12 – ultrasonic custody transfer gas flowmeter

- Transit time measurement
- Time difference between upstream and downstream signal
- Flow velocity and speed of sound
- Multiple paths combined for high accuracy



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Mixture of natural gas and H_2

Mixing H_2 with natural gas

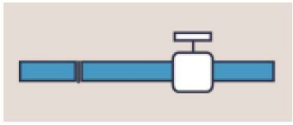
- Low volume of H_2 / no dedicated H_2 network
- Reuse existing infrastructure
- Decarbonizing NG use

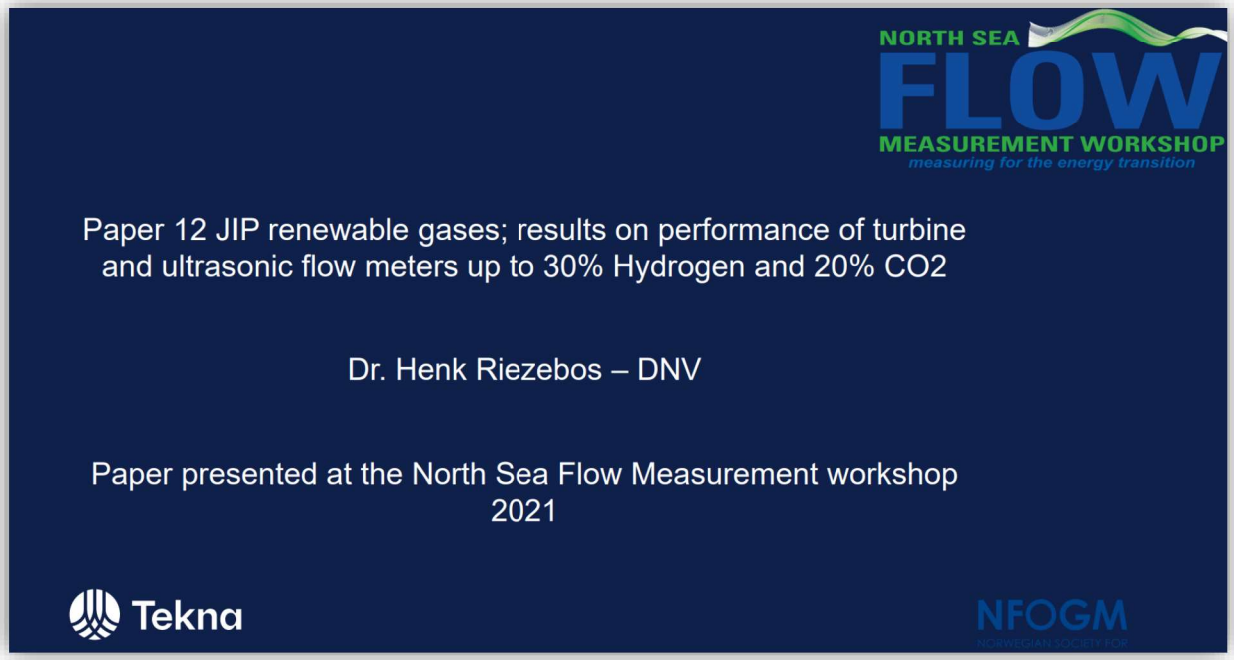
DNV JIP renewable gases

- 10 TSO's
- 9 manufacturers

Results presented NSFMW 2021

- 4 turbines
- 5 CT ultrasonic flowmeters
- 4 process ultrasonic flowmeters





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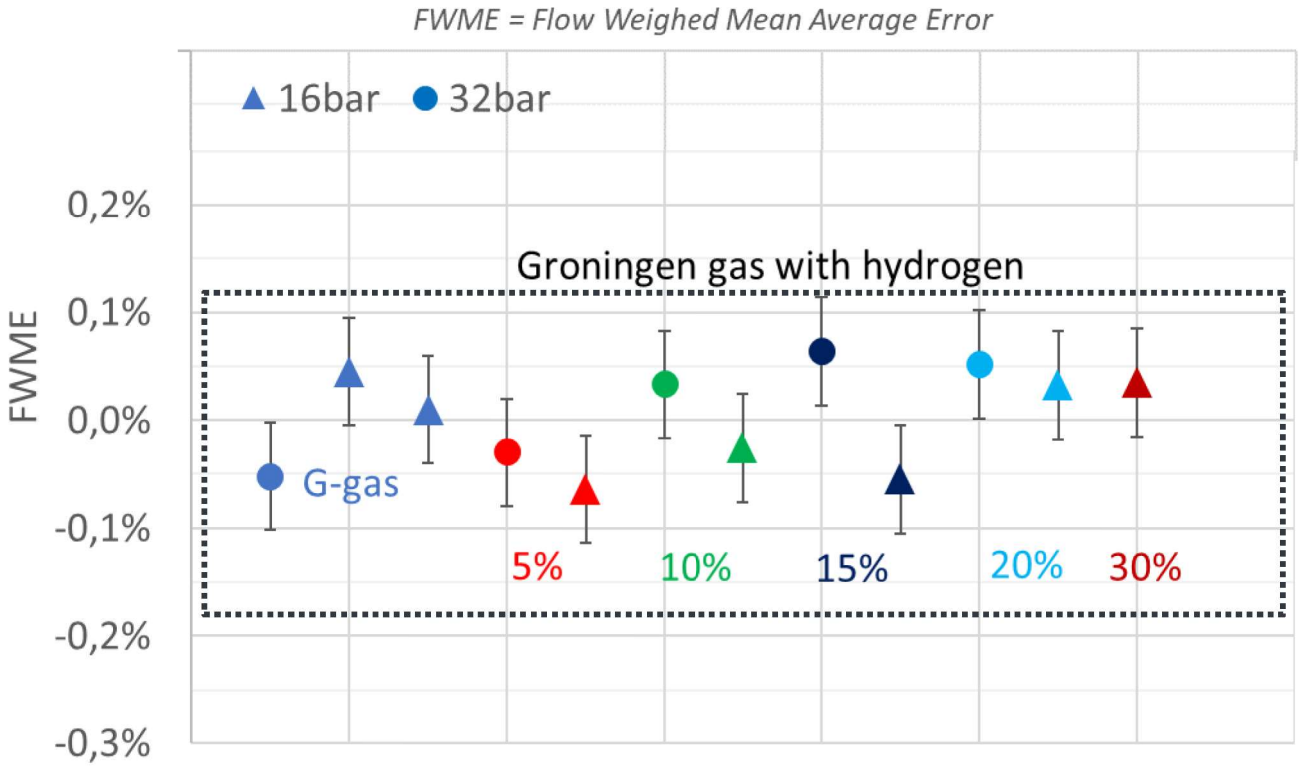
Mixture of natural gas and H_2

Results for ALTOSONIC V12 – DNV JIP renewable gases

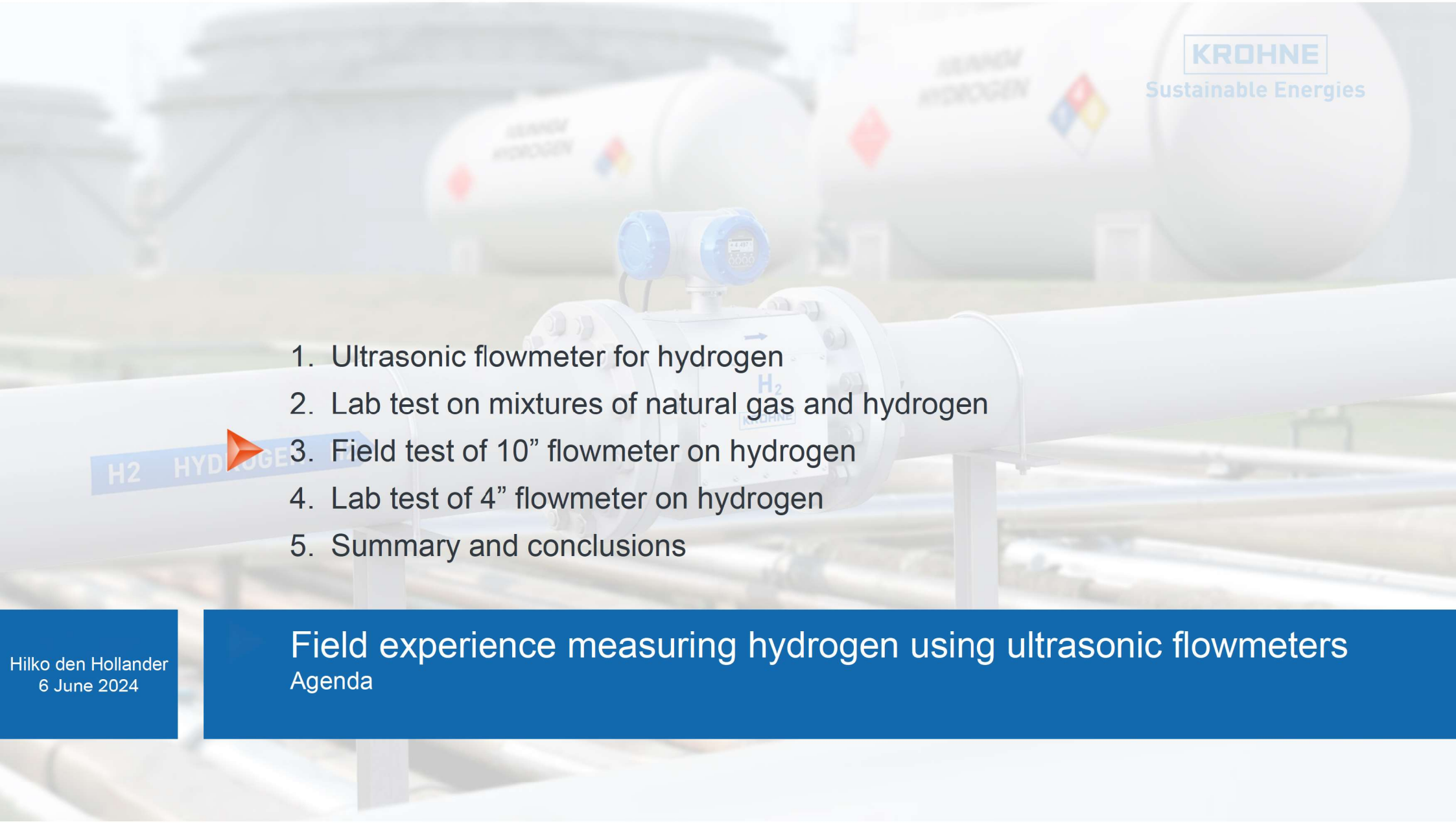


8” Flowmeter **calibrated** and certified for **natural gas**

Flowmeter output compared to reference system of flow lab

Tested in laboratory with blends of hydrogen and natural gas

Performance of the flowmeter is not impacted by mixing hydrogen



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Field test 10” UFM on hydrogen

2021 fieldtest initiated by OGE and EVONIK

Chemical park Marl in Germany

Hydrogen pipeline network (19 bar)

10” ALTOSONIC V12 (ultrasonic) is compared against turbine meter *(already installed at field)*

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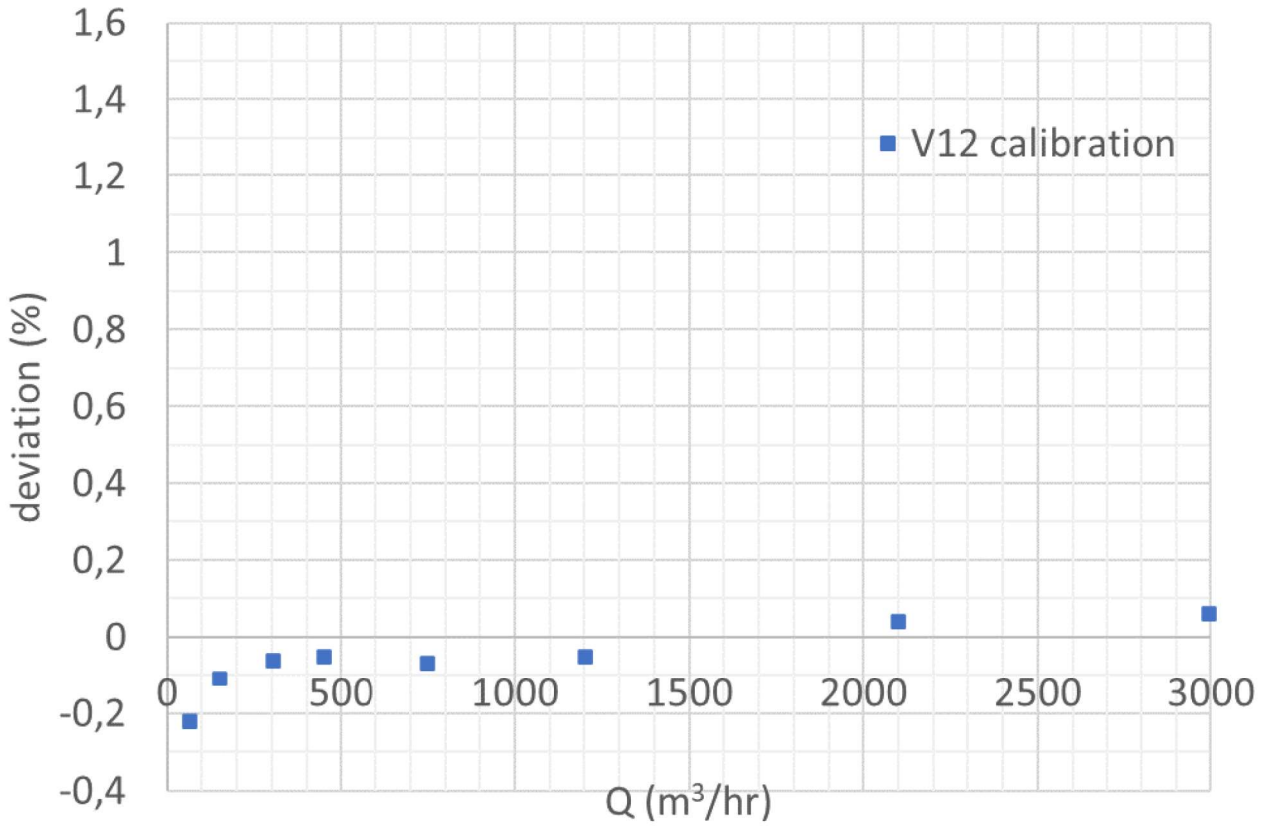
Field test 10” UFM on hydrogen

step 1: calibration of UFM on natural gas at Pigsar lab



ALTOSONIC V12 in spec on natural gas

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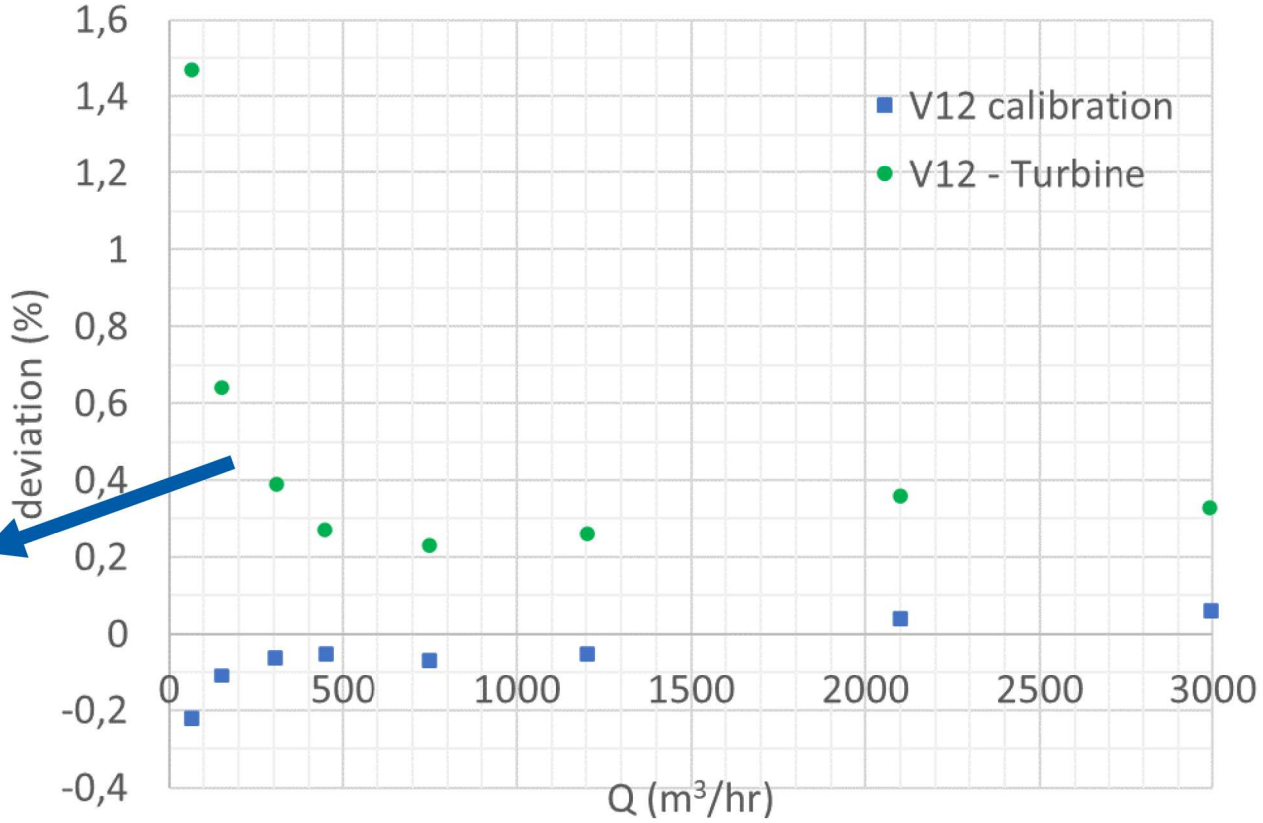
Field test 10” UFM on hydrogen

step 1: calibration of UFM on natural gas at Pigsar lab

step 2: comparison (UFM vs Turbine) on natural gas at Pigsar lab



Turbine:
Qmin=200m3/hr

Baseline curve determined for deviation of Turbine vs. V12 on natural gas

ALTOSONIC V12 in spec on natural gas

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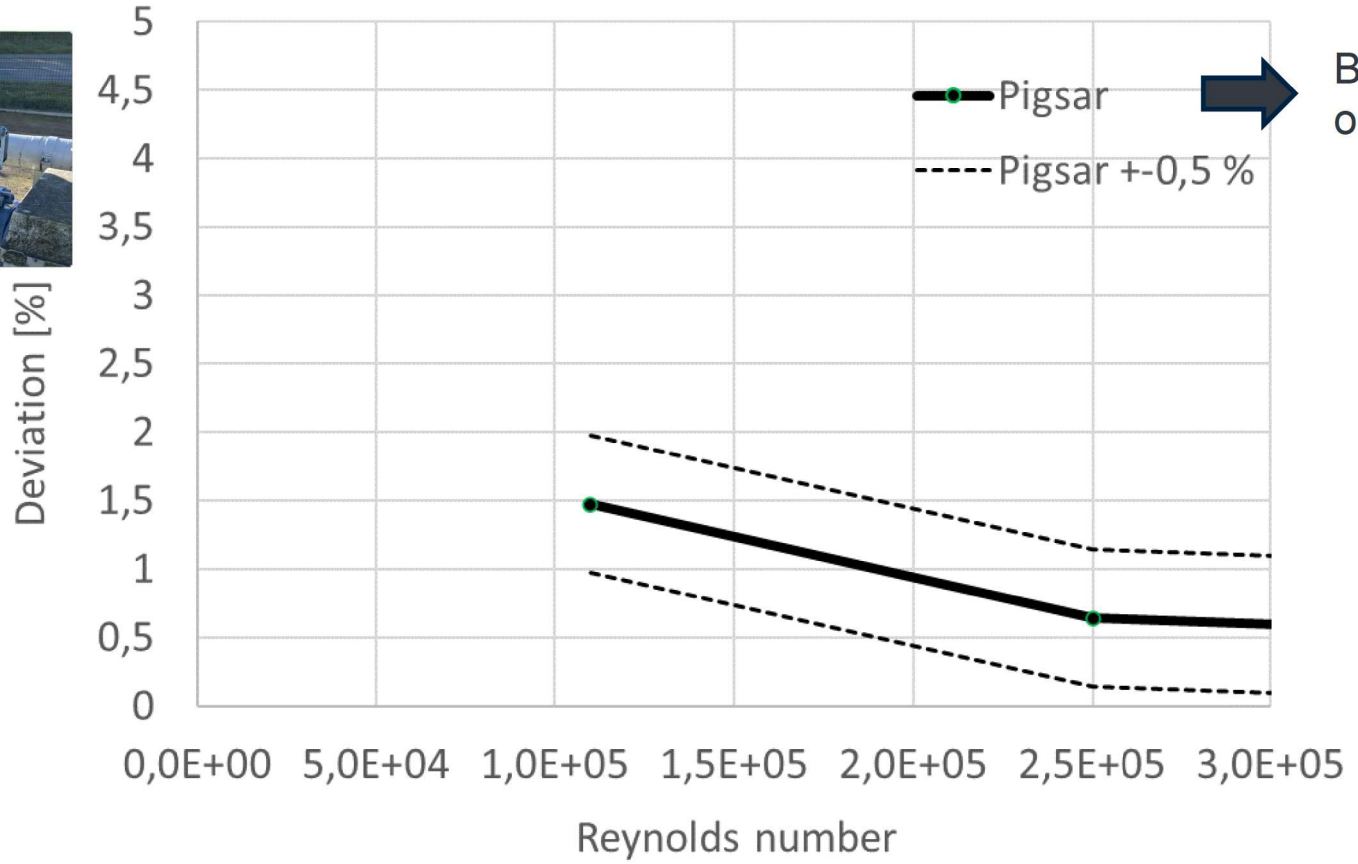
Field test 10” UFM on hydrogen

step 3: comparison (UFM vs Turbine) on hydrogen in the field

Field test 10” UFM on hydrogen

step 3: comparison (UFM vs Turbine) on hydrogen in the field



Baseline curve obtained on natural gas

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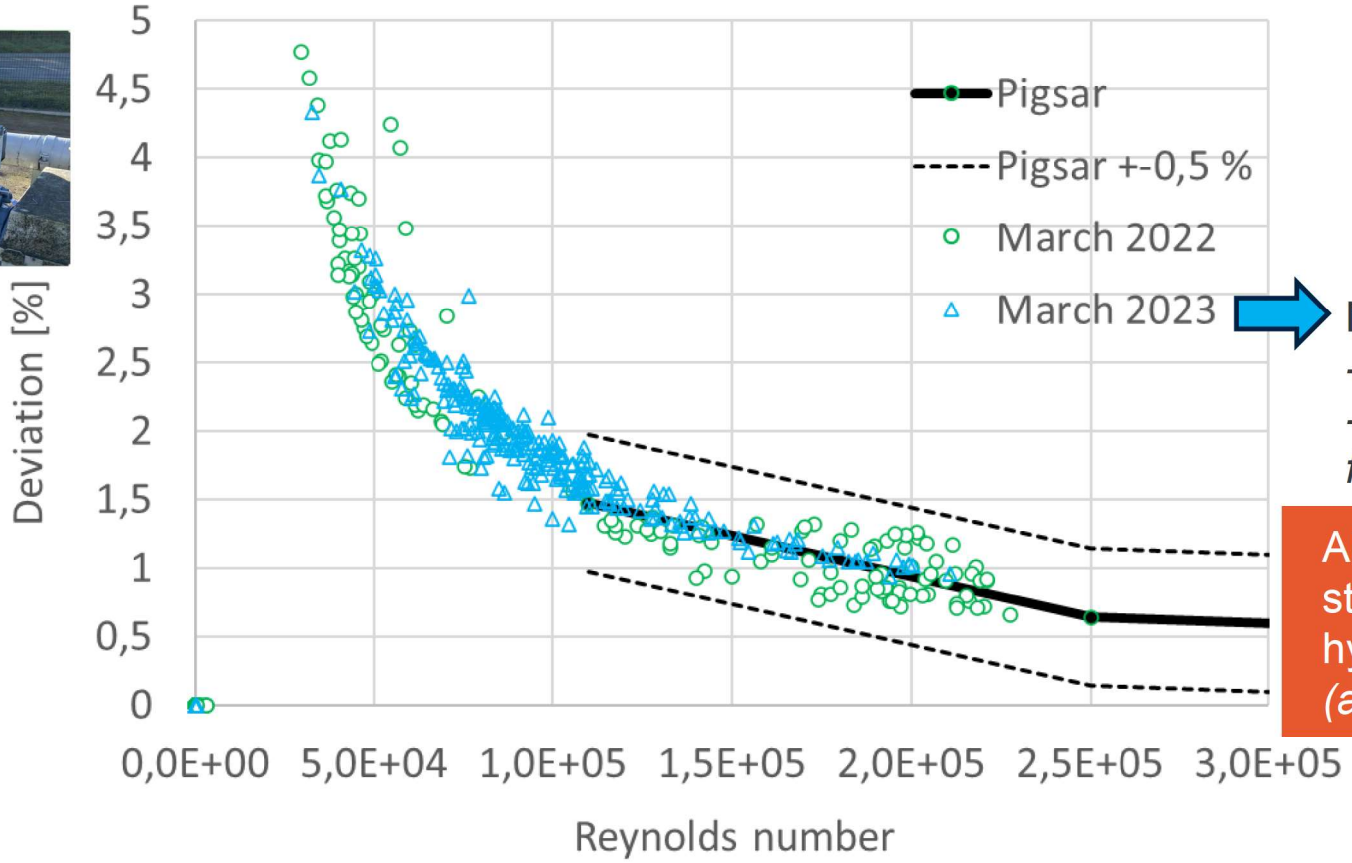
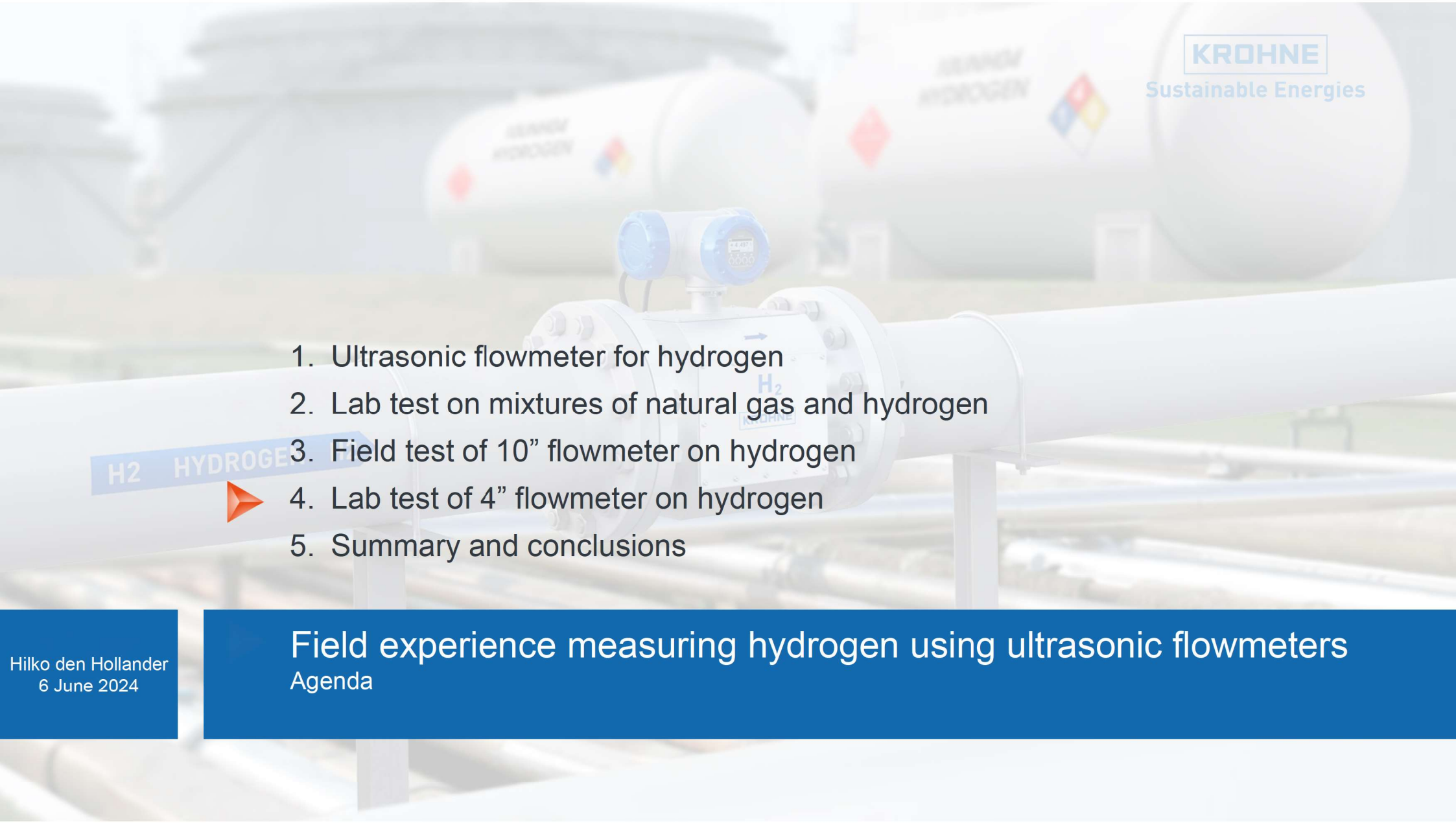
Field test 10” UFM on hydrogen

step 3: comparison (UFM vs Turbine) on hydrogen in the field



New field data.
-one year later
-unchanged settings of flowmeter

ALTOSONIC V12 showing stable performance on hydrogen in the field.
(already for 18 months)



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Lab test of 4” UFM on hydrogen

Tests executed in September 2023

Hydrogen flowloop at DNV (Groningen, the Netherlands)

Turbine meter is applied as reference

- Calibrated on air at DNV and natural gas at PTB
- PTB turbine meter model is applied for corrections
- Flow rate 20-400m3/hr
- Estimated uncertainty 0.3-0.5% for Re>10,000

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Lab test of 4” UFM on hydrogen

- 4” ALTOSONIC V12 is tested at DNV
- tests have been performed in September 2023
- Lessons learned from fieldtest (10”) have been applied
- Optimised signal processing chain settings as determined for H_2 have been applied
- Reynolds correction curve for natural gas has been applied
- Meter factor is determined on H_2

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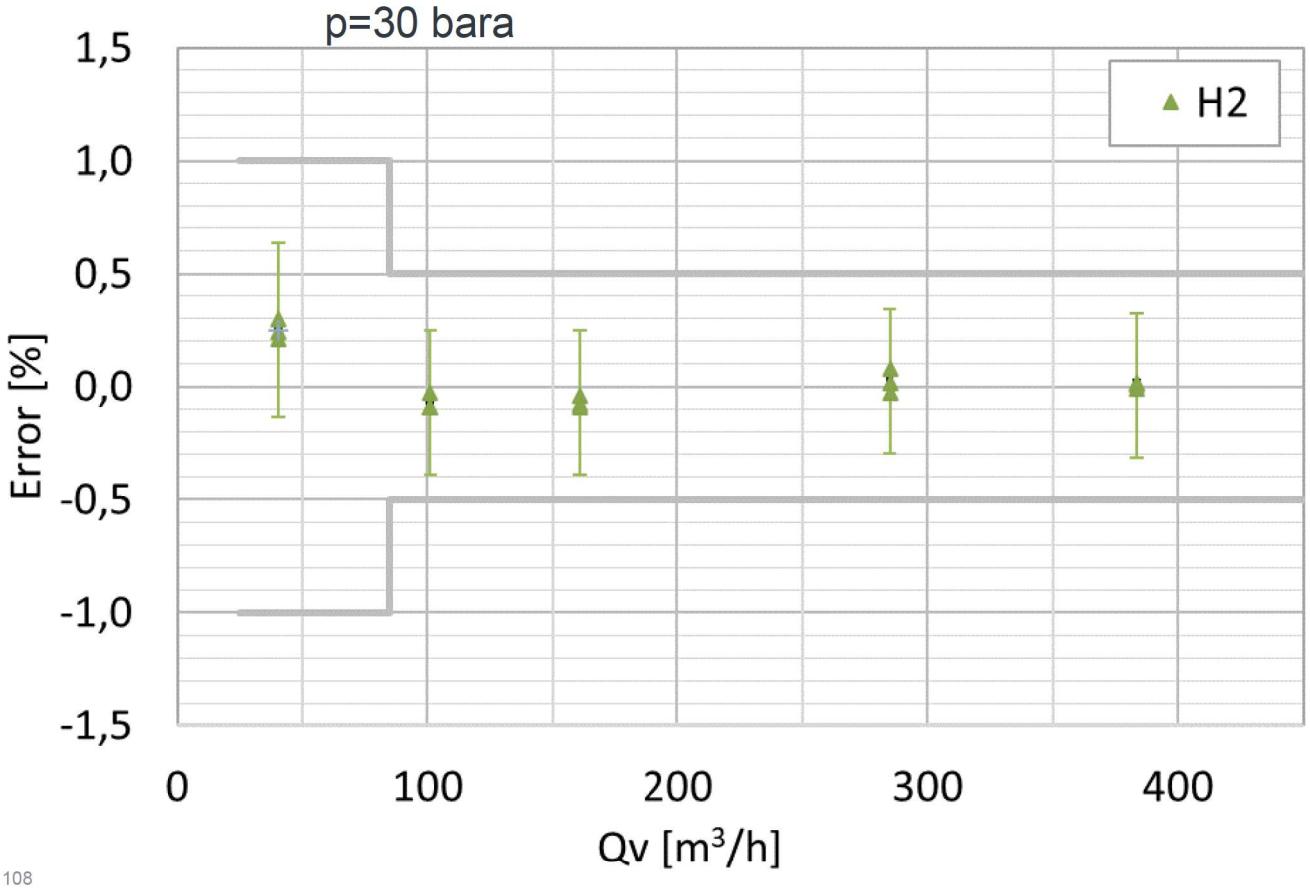
Lab test of 4” UFM on hydrogen

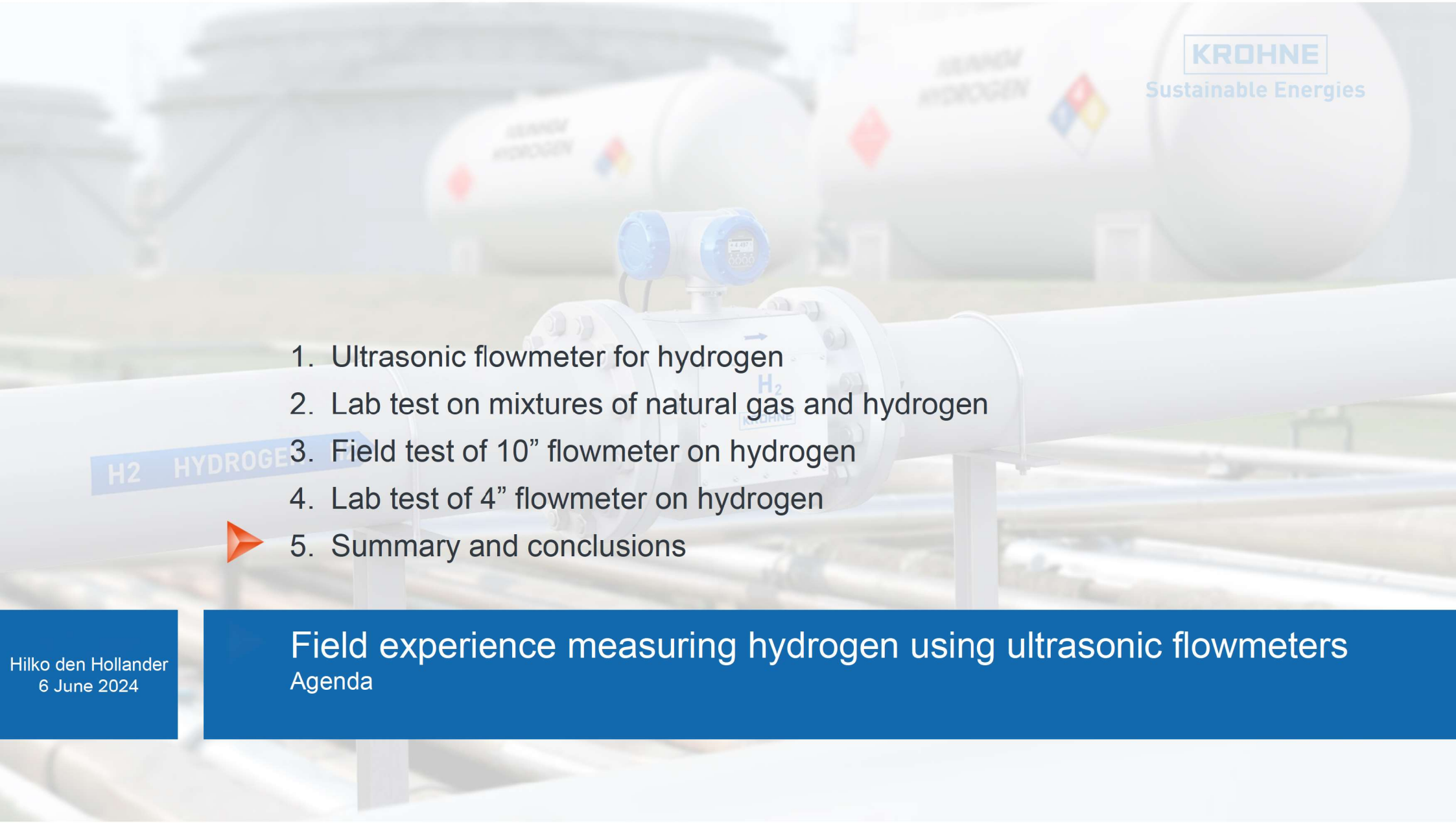


3 repetitions per flowrate (good repeatability)

Error bars denote total uncertainty (dominated by test circuit)

Linearity similar to natural gas application

Individual measurement paths meet expected and desired quality



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Summary and conclusion

- ALTOSONIC V12 ultrasonic gas flowmeter keeps its performance when mixing hydrogen to natural gas (tested up to 30%)
- 10” ALTOSONIC V12 shows stable and good results in field test on pure hydrogen (run time > 18 months)
- 4” ALTOSONIC V12 tested at H_2 loop of DNV and shows performance similar to typically achieved on natural gas
- Speed of sound can also be used to determine purity of Hydrogen and KOH concentration

Thank you for your attention!
Questions?