University of Stuttgart
Institute of Combustion and Power Plant Technology
Prof. Dr. techn. G. Scheffknecht

Syngas measurement at IFK

Whats our status? What are we interested in?

Gas Analysis Workshop, 16 June 2017, Stockholm

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Fluidized Bed Processes

- ✓ Gasification
- ✓ Combustion
- ✓ Calcium Looping (CaL)
- ✓ Chemical Looping (CLC)

Fuels

- ✓ Biomass, Residues
- ✓ Coal

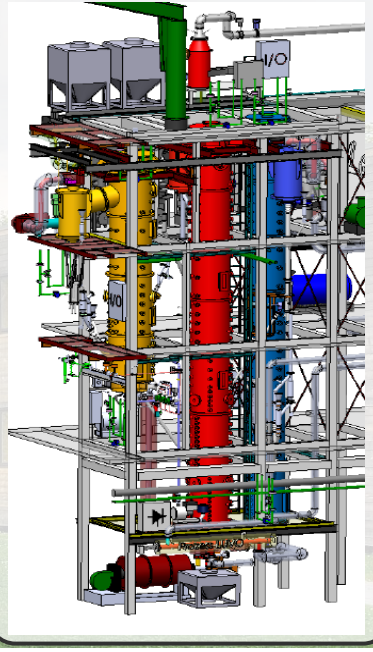
Gas measurement

- ✓ Permanent gases
- ✓ H_2S, NH_3, HCl
- ✓ tar

20 kW_{th} electrically heated DFB System

Tar generator test rig

200 kW_{th} DFB Pilot Facility



Flameless oxidation

- ✓ Liquid fuels
- ✓ Producer gas

Gas/ Tar Analysis

Cold Model Analyses

Modelling and Simulation

Fuels used in the experimental work

Wood pellets

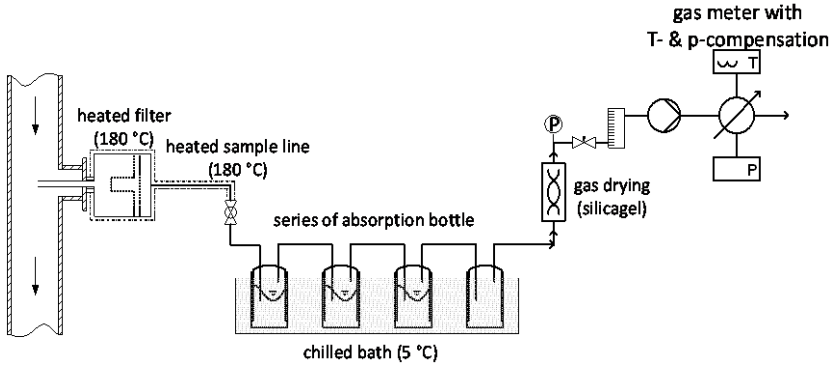
Straw pellets

Dried sewage sludge

in wt-%	proximate analysis		elemental analysis waf					
	moisture	**ash wf**	**C**	**H**	**O**	**N**	**S**	**Cl**
wood pellets	9.8	0.1	50.8	6.3	42.9	-	-	-
straw pellets	10.3	5.7	49.3	6.4	42.8	0.8	0.2	0.5
dried sewage sludge	6.5	47.6	51.0	6.9	32.1	7.5	2.4	0.2

Measurement techniques at IFK

- IFKs Online FID Tar Analyzer

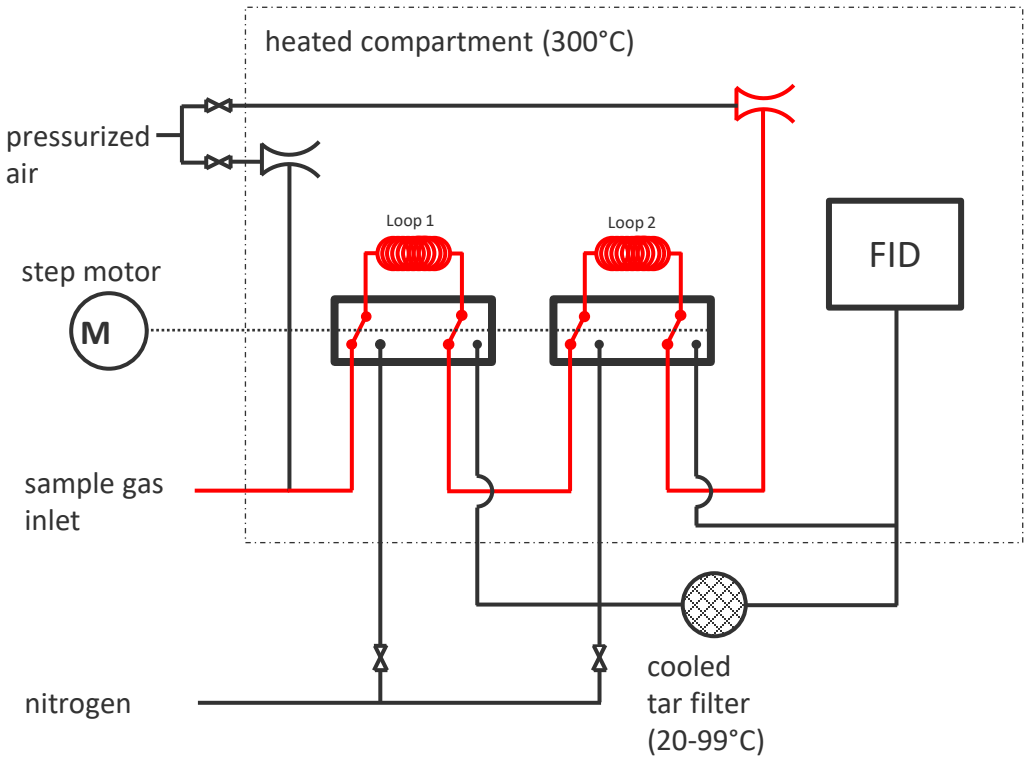


- Wet chemical H_2S, NH_3, HCl
- Tar protocol

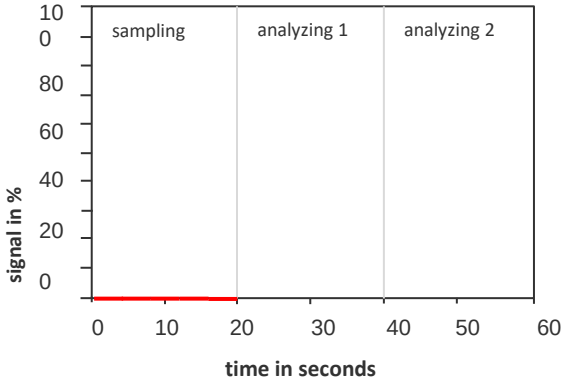
- Gasmet FTIR Analyzer

Final device

Measurement principle

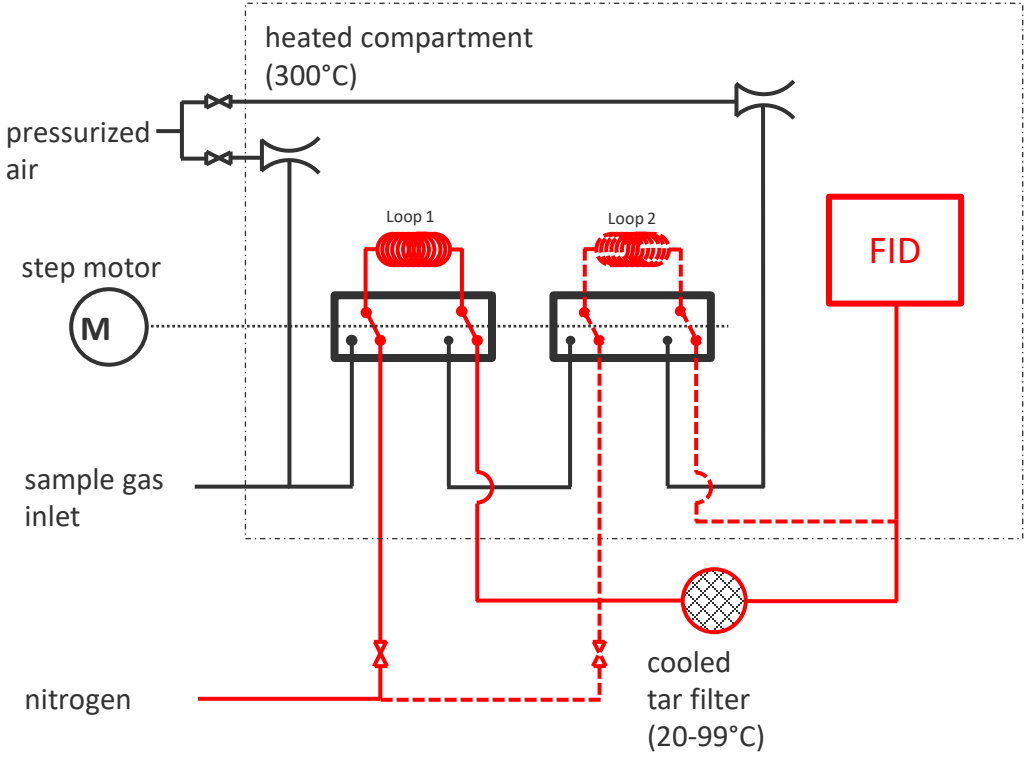


sampling phase

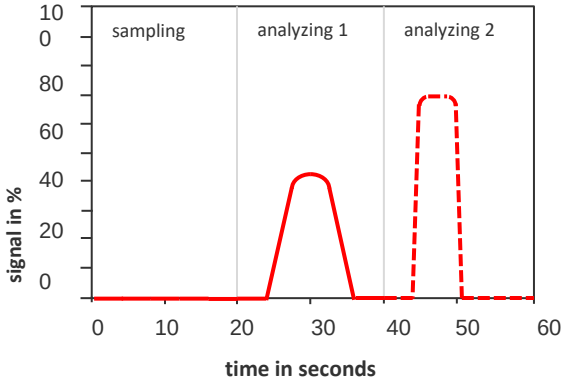


- Sample gas is sucked through sample loops with venturi nozzle.
- Both sample loops are filled consecutively.
- Detector signal is zero during loading phase.

Measurement principle



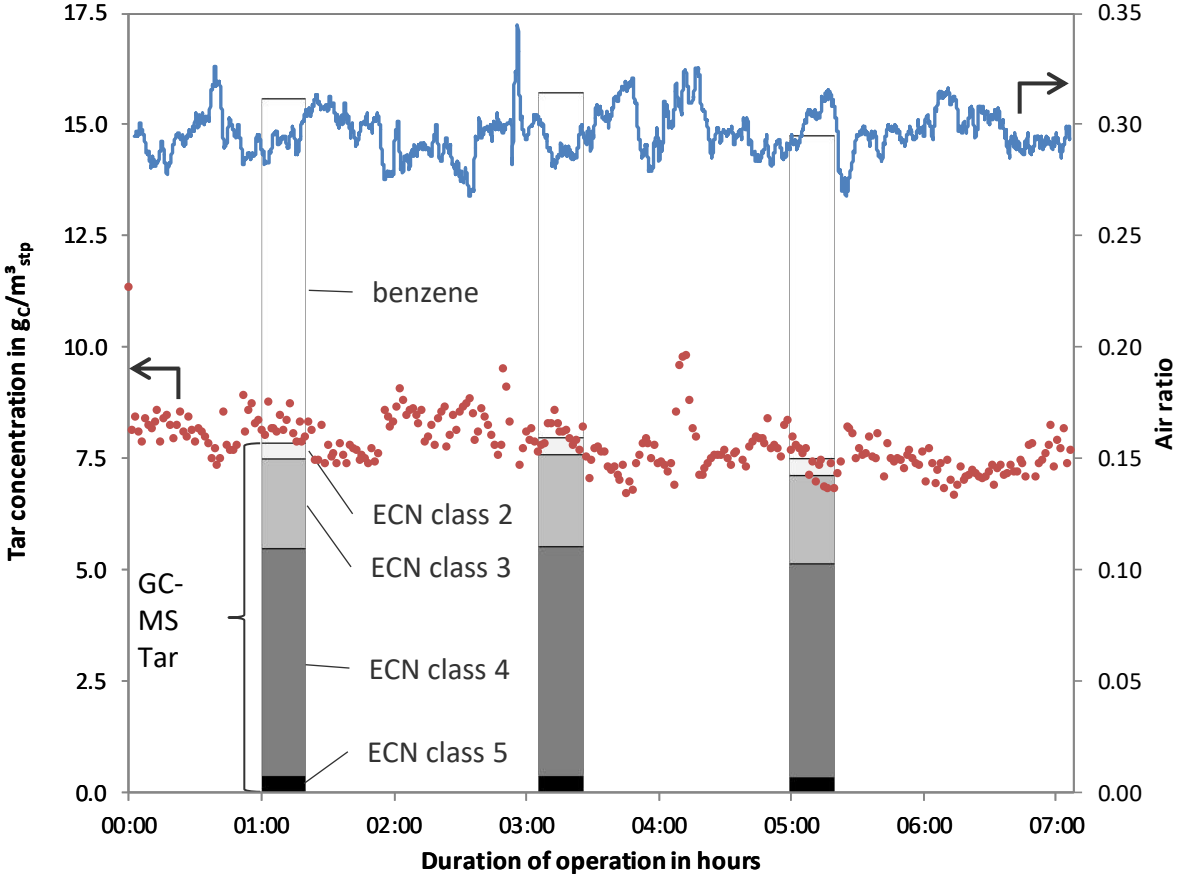
analyzing phase



- Gas in sample loops is flushed to the detector consecutively.
- Tars of sample loop 1 are condensed/separated on a cooled filter.
- Measured components:
  - Total hydrocarbon
  - Non-condensable HC
  - Tars (condensable HC)

Comparative measurements - Results base case

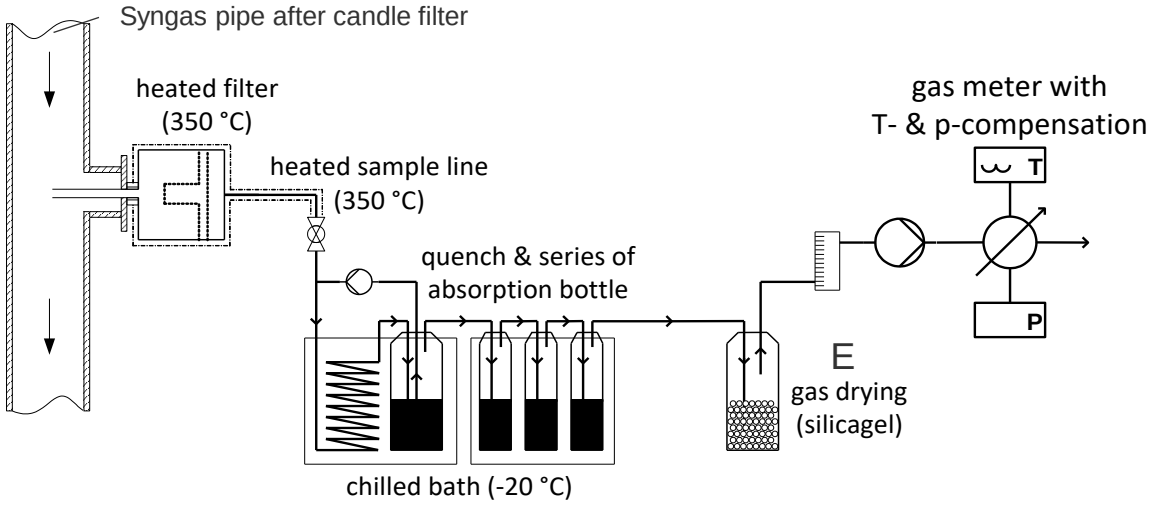
Base case at 800 °C and an air ratio of 0.3



- Time of operation of more than 7 hours.
- 3 comparative measurements.
- One online measurement cycle had a duration of around 84 seconds (300 cycles).
- Online measured tar concentrations follow the wet chemical comparative measurements very close over the total time of operation.
- Air ratio fluctuates little because of the volumetric dosing system.
- Heavy fluctuations in air ratio result from refill of dosing system.
- If heavy fluctuations of air ratio present, online measurements increase/decrease immediately.

Methods – wet chemical impurity and tar measurement

Tar measurement arrangement



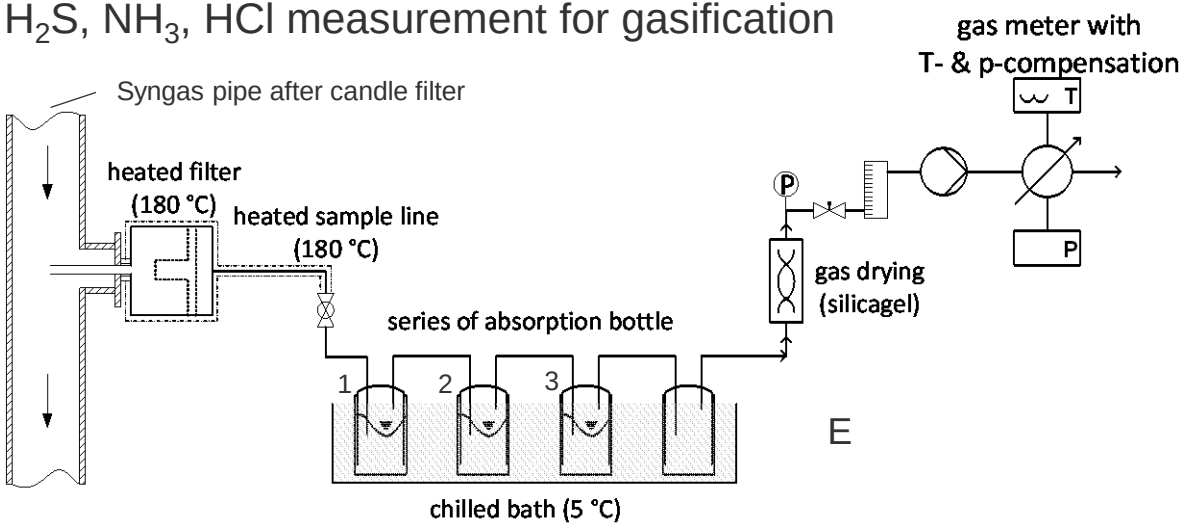
DIN CEN/TS15439 (tar protocol)

- Absorption liquid: Isopropanol
- Liquid is sampled and analysed
  Gravimetrically (GC-MS also possible)

Further explanations:
Visual Presentation 2CV.3.31
D. Schweitzer, M. Schmid, A. Gredinger, R. Spörl., G. Scheffknecht: Gasification of waste biomasses: Measurement of pollutants in product gas, EUBCE 2017

Methods – wet chemical impurity and tar measurement

H_2S, NH_3, HCl measurement for gasification



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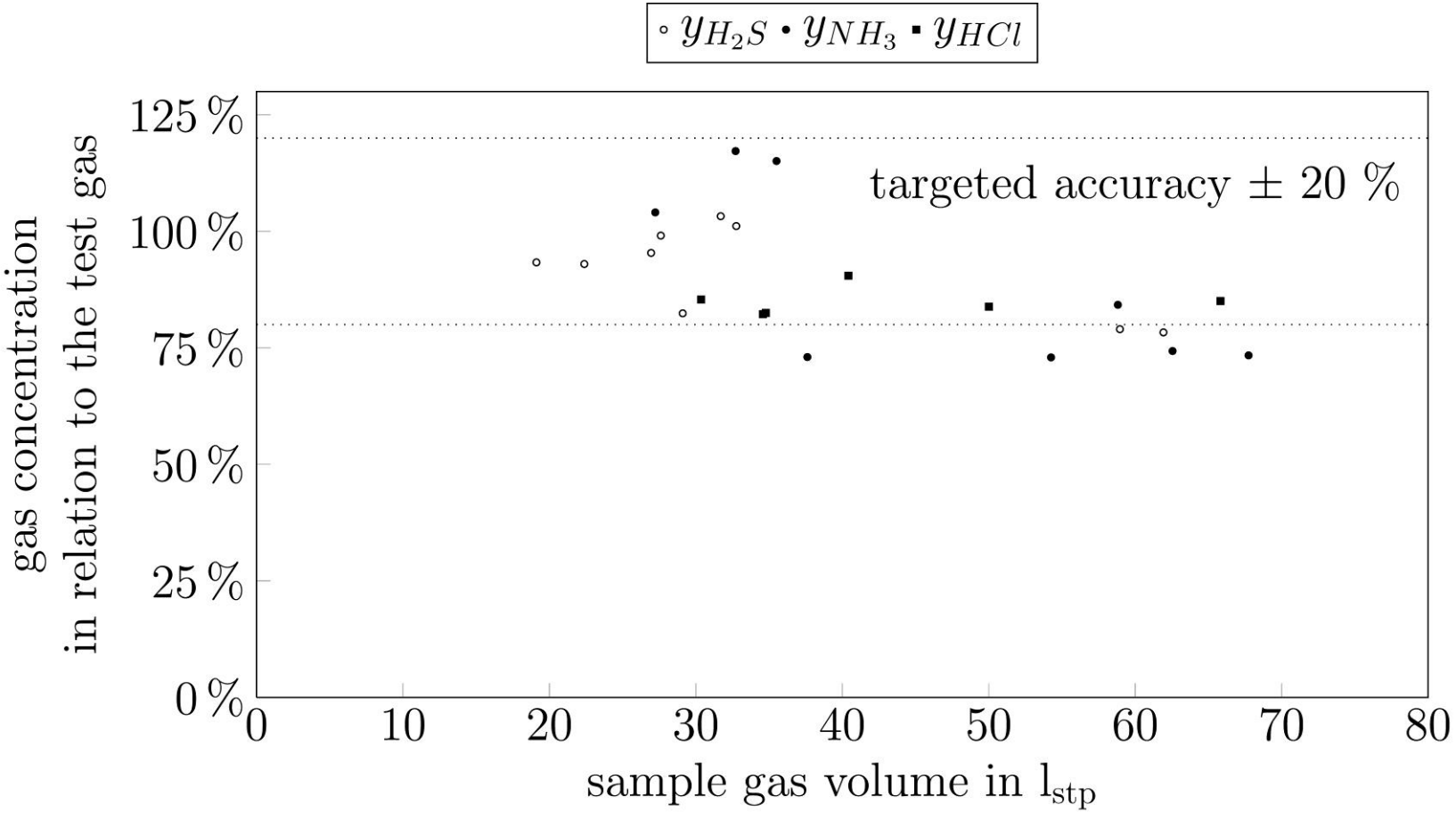
- H_2S: DIN 51855-4 (iodometric titration)
- NH_3: DIN EN ISO 11732 (indophenol method)
- HCl: Coulometric analysis

	H_2S	**NH_3**	**HCl**
Tar removal solution *bottle 1*	Isopropanol, H_2SO_4	Isopropanol, NaOH	-
absorption solution *bottle 2+3*	Zinc acetate	1 mol/l H_2SO_4	H_2O

Accuracy of wet chemical measurement techniques



FTIR experience for syngas/offgas analysis
Gasmet DX4000

Gas	Measured species	Result quality
Synthetic flue gas	HCl, N_2O, standard gases	Very good
Flue gas	HCl, N_2O, standard gases	good in accordation to other analyzers
H_2O, tar model compounds, N_2 from test gas generator	H_2O, phenole, xylene	Very good
Catalytic reforming of test gas from test gas generator	H_2O, phenole, xylene All possible reforming products	promising / ? Values make sense, but higher residual values, some hydrocarbons have odd values (to high)
raw syngas from fluidized bed gasification	H_2O, permanent gases, hydrocarbons, tars, pollutants	Not so good / ? Permanent gases do not fully match with other analyzers, some spezies have odd values, high residual values *Positive: device was not damaged!*

What is IFK interested in?

- Tar measurement
  - Joined comparison measurements
  - Improving the handling of the tar protocol
  - How to deal with heteroatoms (S, N, Cl) in tar analysis
    - Gravimetric: What about the salts?
    - GC-MS: how to detect S, N, Cl containing tar species?

- FTIR
  - Experience exchange
  - How to evaluate data from raw syngas measurement

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Thank you!

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