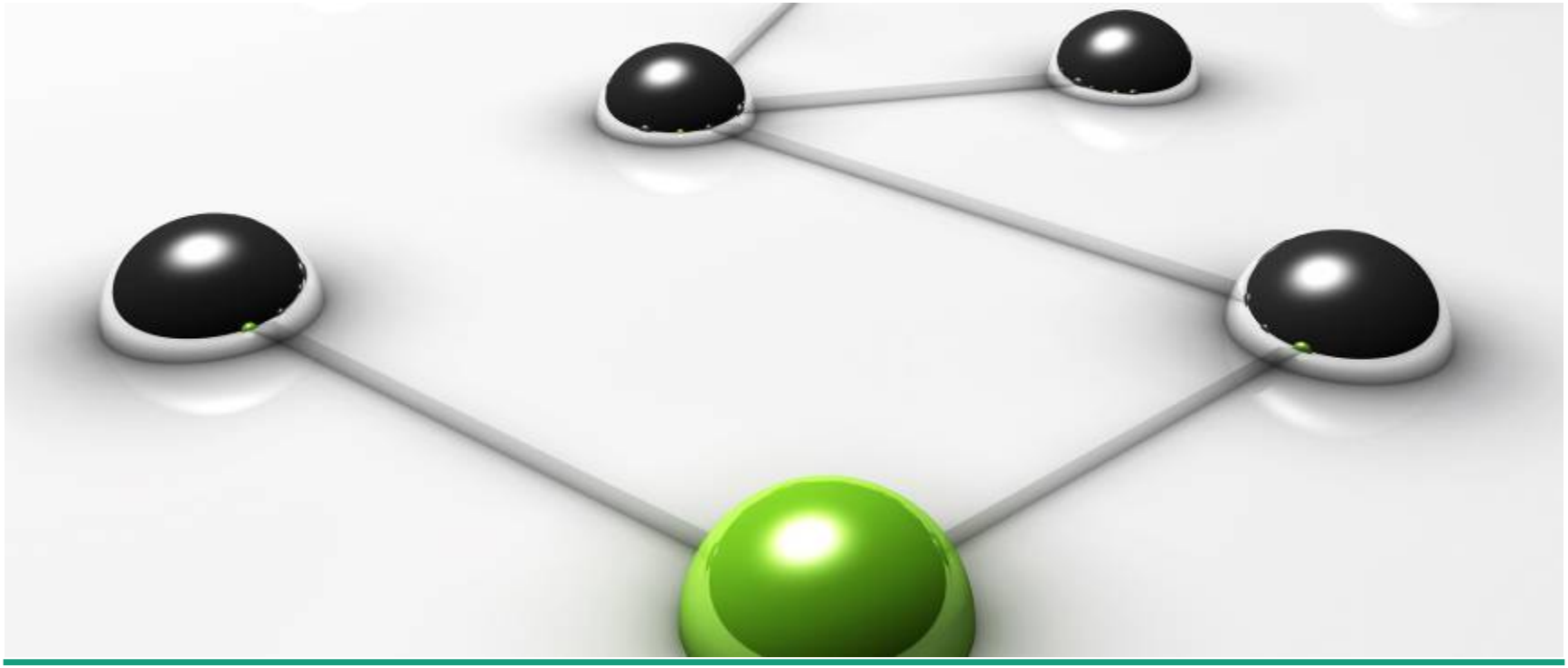
COMBUSTION OF REFINED RENEWABLE BIOMASS FUEL (RRBF) IN A BUBBLING FLUIDIZED BED

Tim Schulzke, Department Biorefinery and Biofuels
Jan Westermeyer, Catherine Hornsby



Fraunhofer UMSICHT

Outline

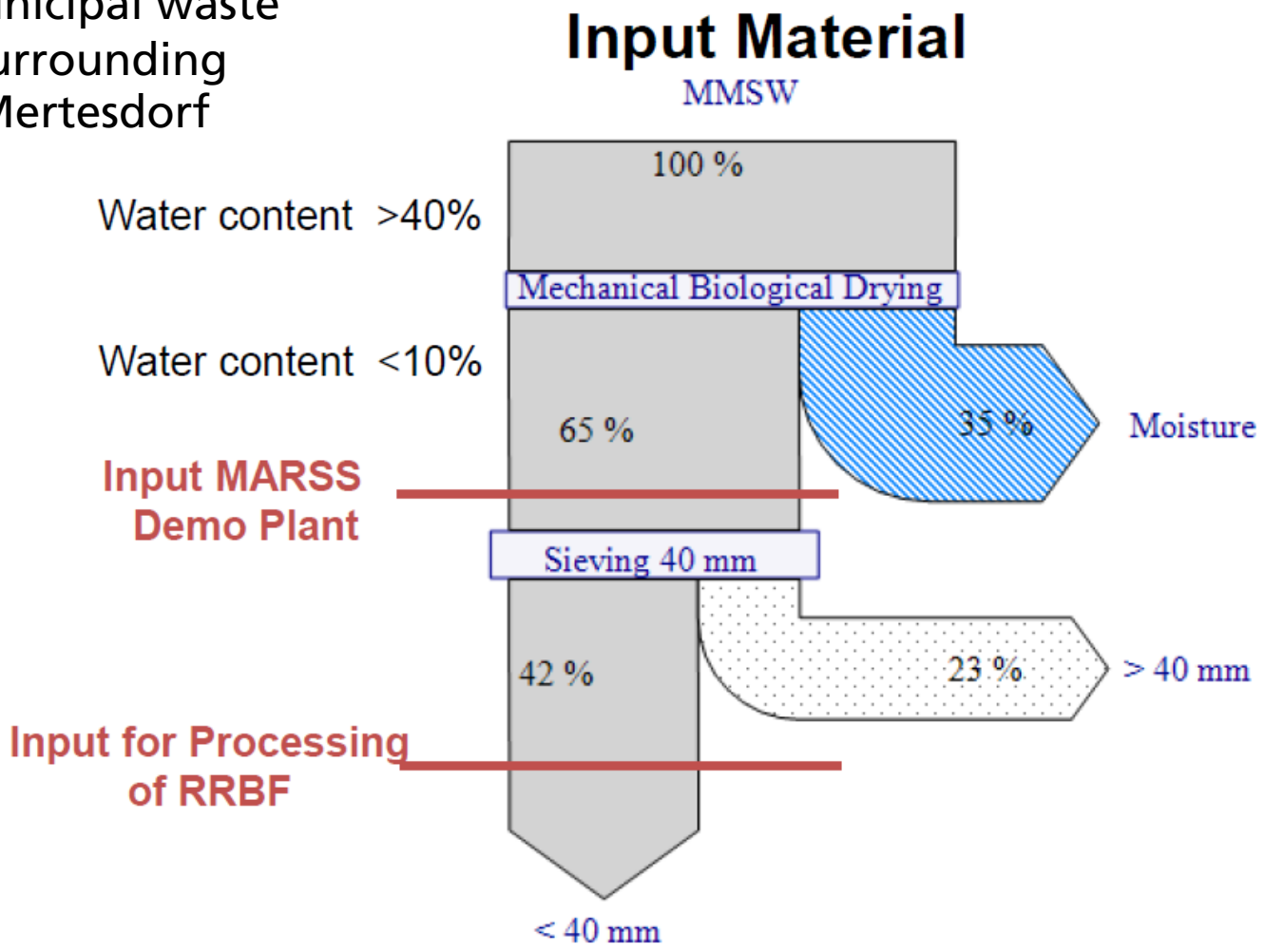
1. Background – The Project MARSS
2. Solid Fuel Characterisation
3. Fluidized Bed Test Rig
4. Combustion Test Campaigns
   - Procedure
   - Results
5. Summary

Outline

1. **Background – The Project MARSS**
2. Solid Fuel Characterisation
3. Fluidized Bed Test Rig
4. Combustion Test Campaigns
   - Procedure
   - Results
5. Summary

MARSS – Material Advanced Recovery Sustainable System

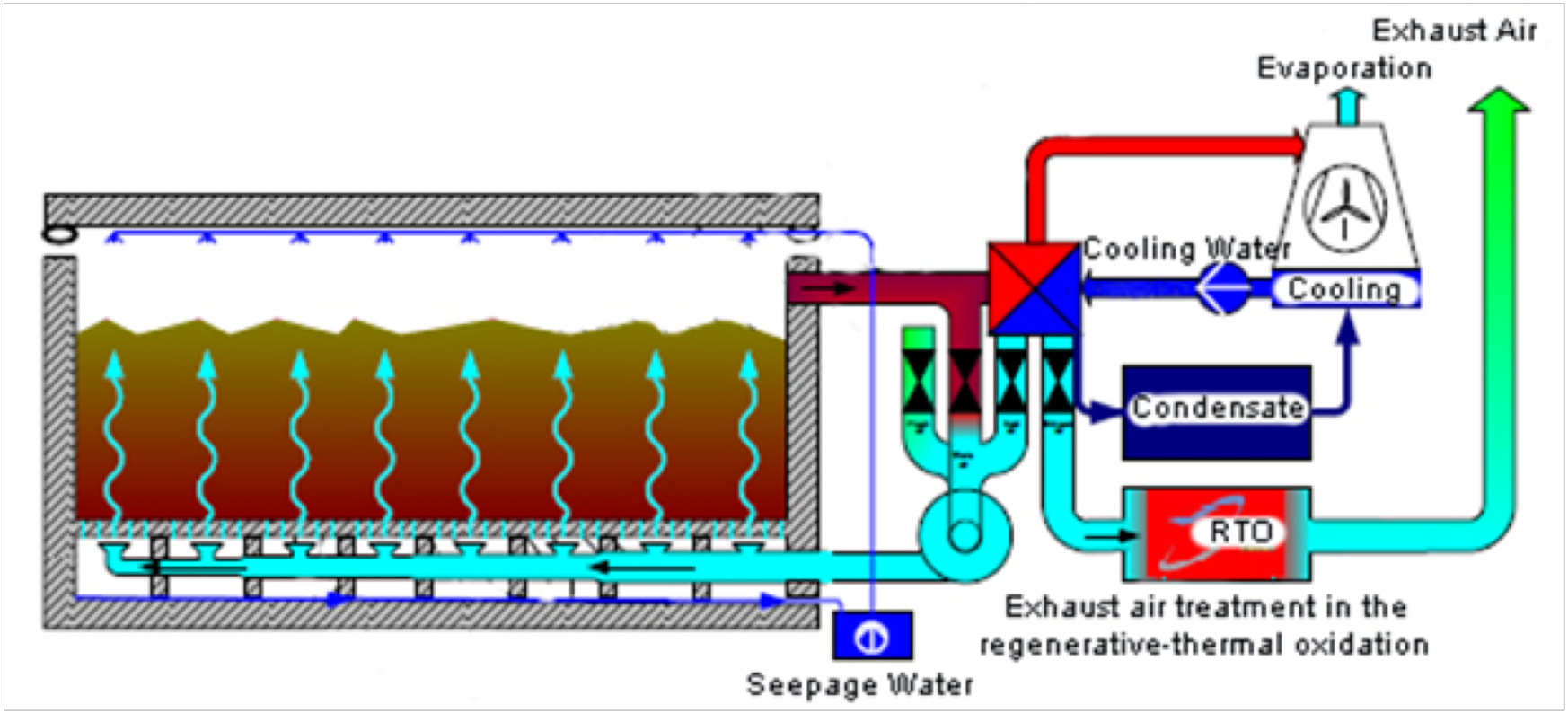
Input: mixed municipal waste
Origin: Trier + Surrounding
Location: Trier-Mertesdorf



Fraunhofer UMSICHT

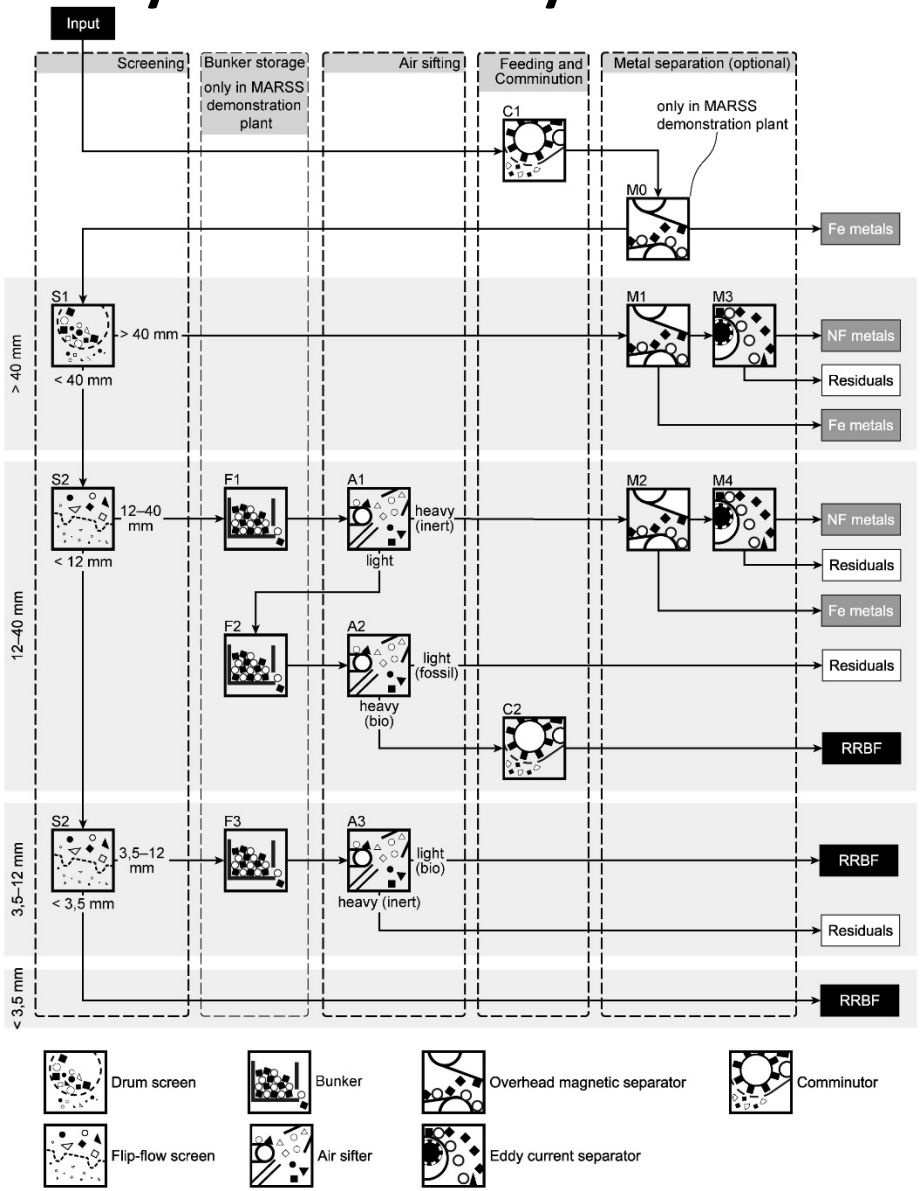
MARSS – Material Advanced Recovery Sustainable System

Principle of MBT-system (Herhof process)



Fraunhofer
UMSICHT

MARSS – Material Advanced Recovery Sustainable System



RRBF=
Refined Renewable
Biomass Fuel

Fraunhofer UMSICHT

MARSS – Material Advanced Recovery Sustainable System

Fraunhofer
UMSICHT

Outline

1. Background – The Project MARSS
2. **Solid Fuel Characterisation**
3. Fluidized Bed Test Rig
4. Combustion Test Campaigns
   - Procedure
   - Results
5. Summary

Fuel composition

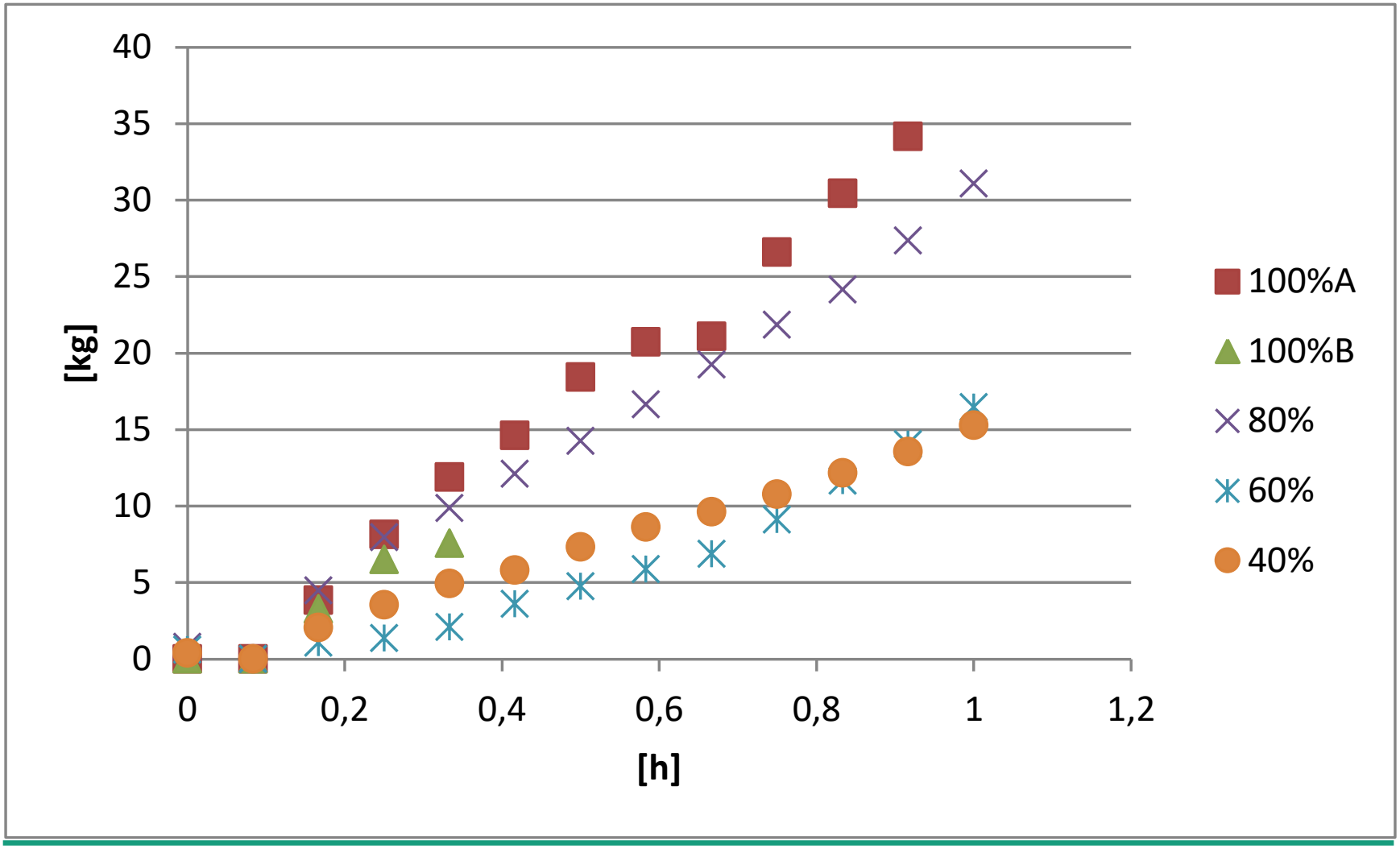
- 3 batches delivered to Fraunhofer UMSICHT
- Water content differed greatly
- Ash content differed greatly
- Heating value (dry, ash free basis) in similar range

	Original Substance			Dry Basis			Dry Ash Free		
	1. Batch	2. Batch	3. Batch	1. Batch	2. Batch	3. Batch	1. Batch	2. Batch	3. Batch
Water [%]	13.2	14.99	24.5	-	-	-	-	-	-
Ash [%]	23.3	31.88	21.74	26.84	37.5	28.8	-	-	-
C [%]	33.18	29.58	29.07	38.23	34.8	38.5	52.26	55.68	54.07
H [%]	5.55	5.58	5.89	4.7	4.6	4.2	6.42	7.36	5.90
N [%]	1.56	1.19	1.43	1.8	1.4	1.9	2.46	2.24	2.67
O [%]	35.23	29.39	41.86	27.08	18.9	26.6	37.01	30.24	37.36
S [%]	0.38	0.48	0.3	0.43	0.56	0.4	0.59	0.90	0.56
Cl [%]	0.8	0.71	0.91	0.92	0.84	1.2	1.26	1.34	1.69
Na [ppm]	6 290	5 326	5 616	7 250	6 265	7 439	-	-	-
K [ppm]	864	5 728	4 938	996	6 738	6 541	-	-	-
P [ppm]	2 150	1 471	2 103	2 480	1 730	2 786	-	-	-
LHV [MJ/kg]	12.882	10.451	11.104	15.212	12.7	15.5	20.79	20.32	21.77

Large items contained in 1. fuel batch as delivered

Fraunhofer UMSICHT

Calibration of dosing screws – 1. batch as delivered

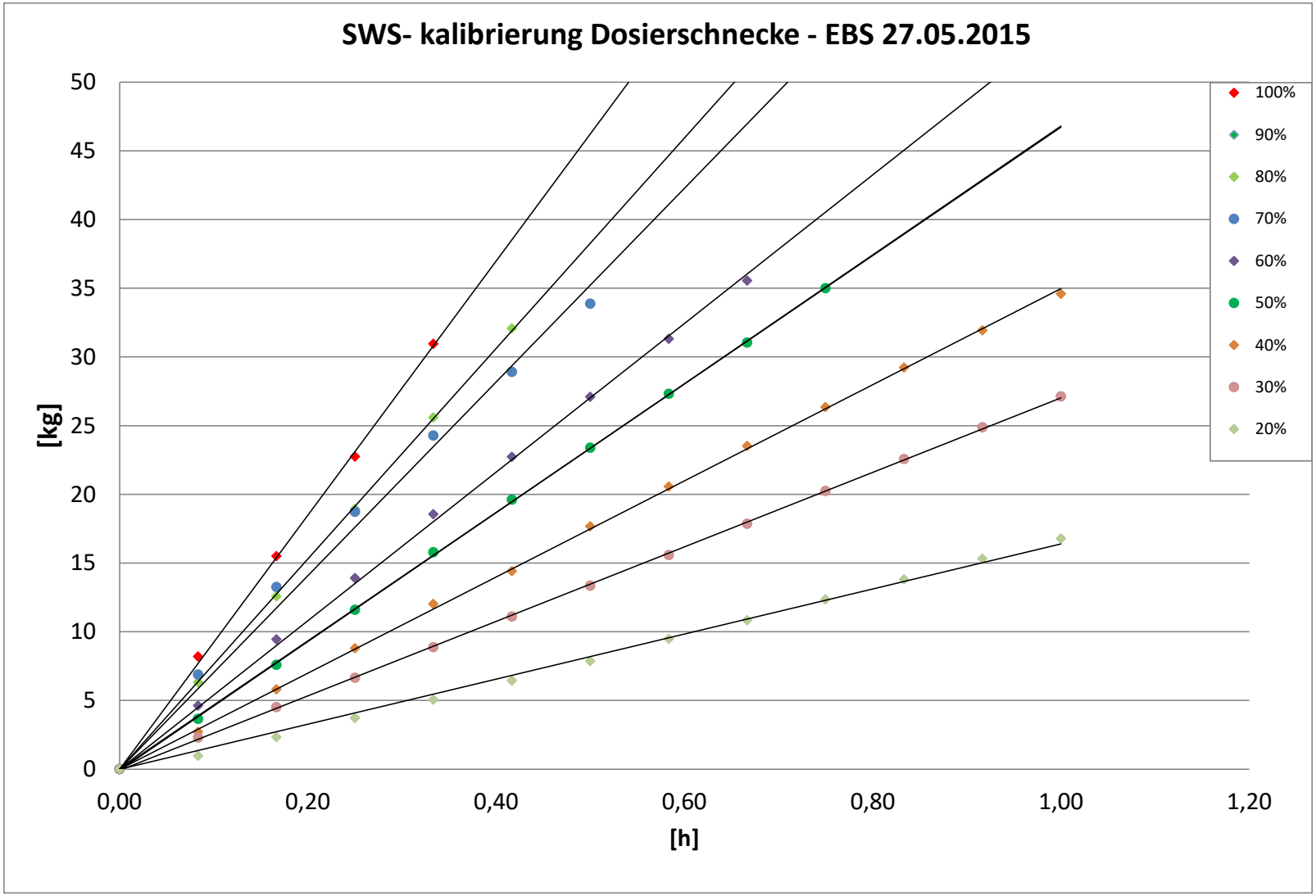


Fraunhofer UMSICHT

Large items in 1. fuel batch after additional milling single shaft shredder with 30 mm screen

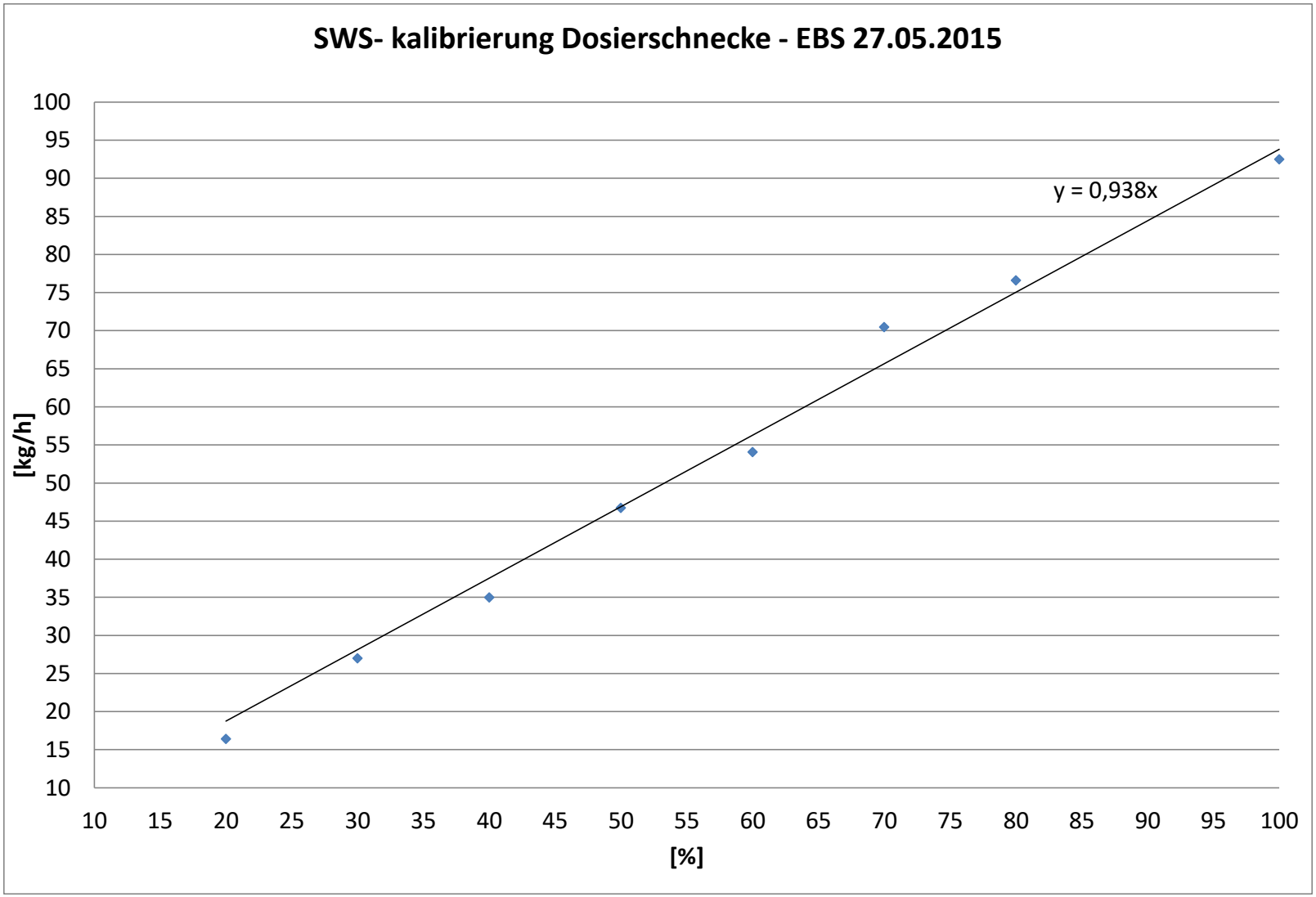
Fraunhofer UMSICHT

Calibration of dosing screws – 2. batch



Fraunhofer UMSICHT

Calibration of dosing screws – 2. batch

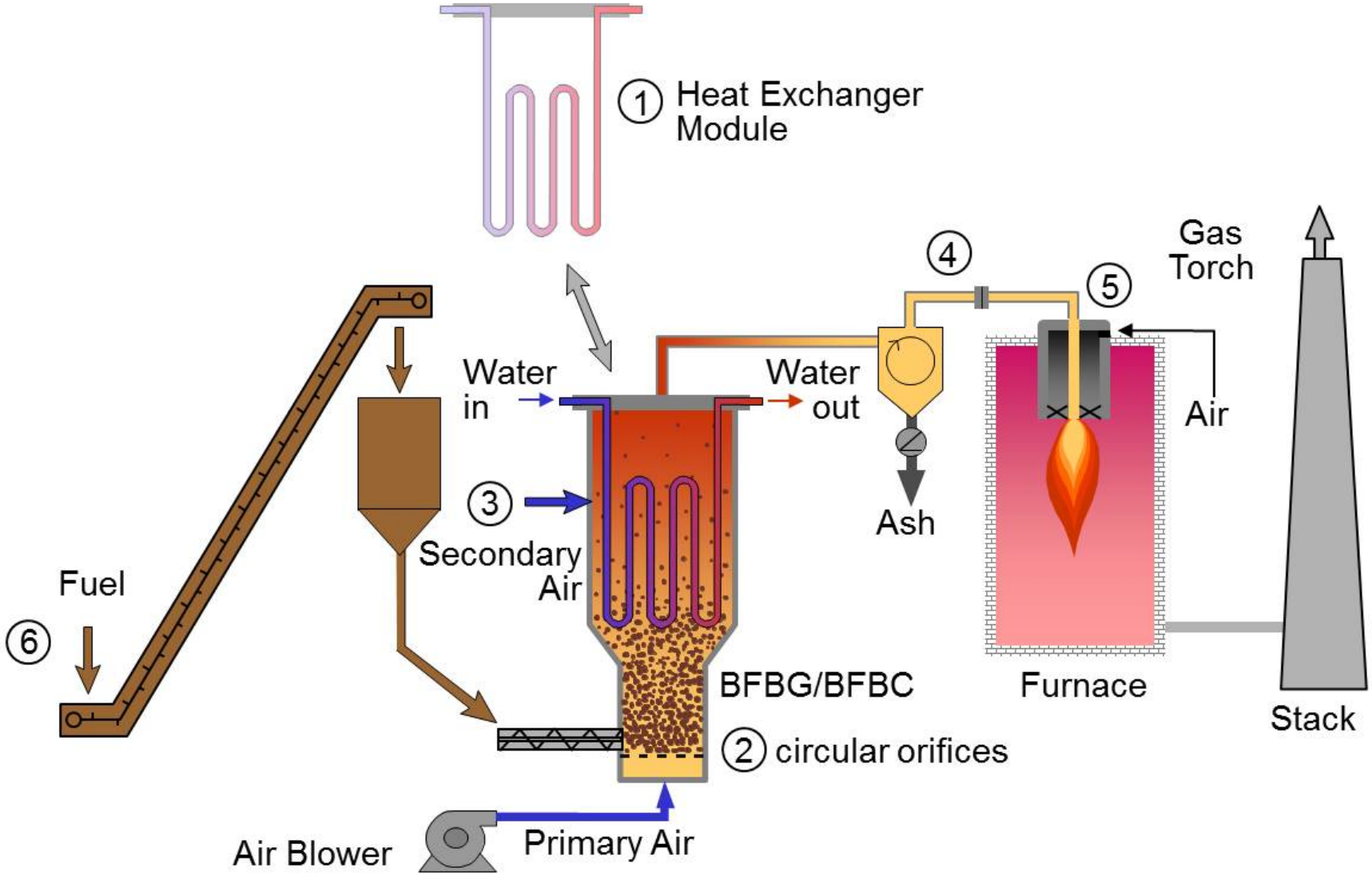


Fraunhofer UMSICHT

Outline

1. Background – The Project MARSS
2. Solid Fuel Characterisation
3. **Fluidized Bed Test Rig**
4. Combustion Test Campaigns
   - Procedure
   - Results
5. Summary

Schematic drawing of fluidized bed combustion plant



Fraunhofer UMSICHT

Photograph of fluidized bed combustion plant

Fraunhofer UMSICHT

Outline

1. Background – The Project MARSS
2. Solid Fuel Characterisation
3. Fluidized Bed Test Rig
4. **Combustion Test Campaigns**
   - **Procedure**
   - **Results**
5. Summary

Combustion test campaigns

Bed material

- 1. test run: silica sand, 0.4 – 0.8 mm
- as of 2. test run: screen underflow 1 mm from previous test run

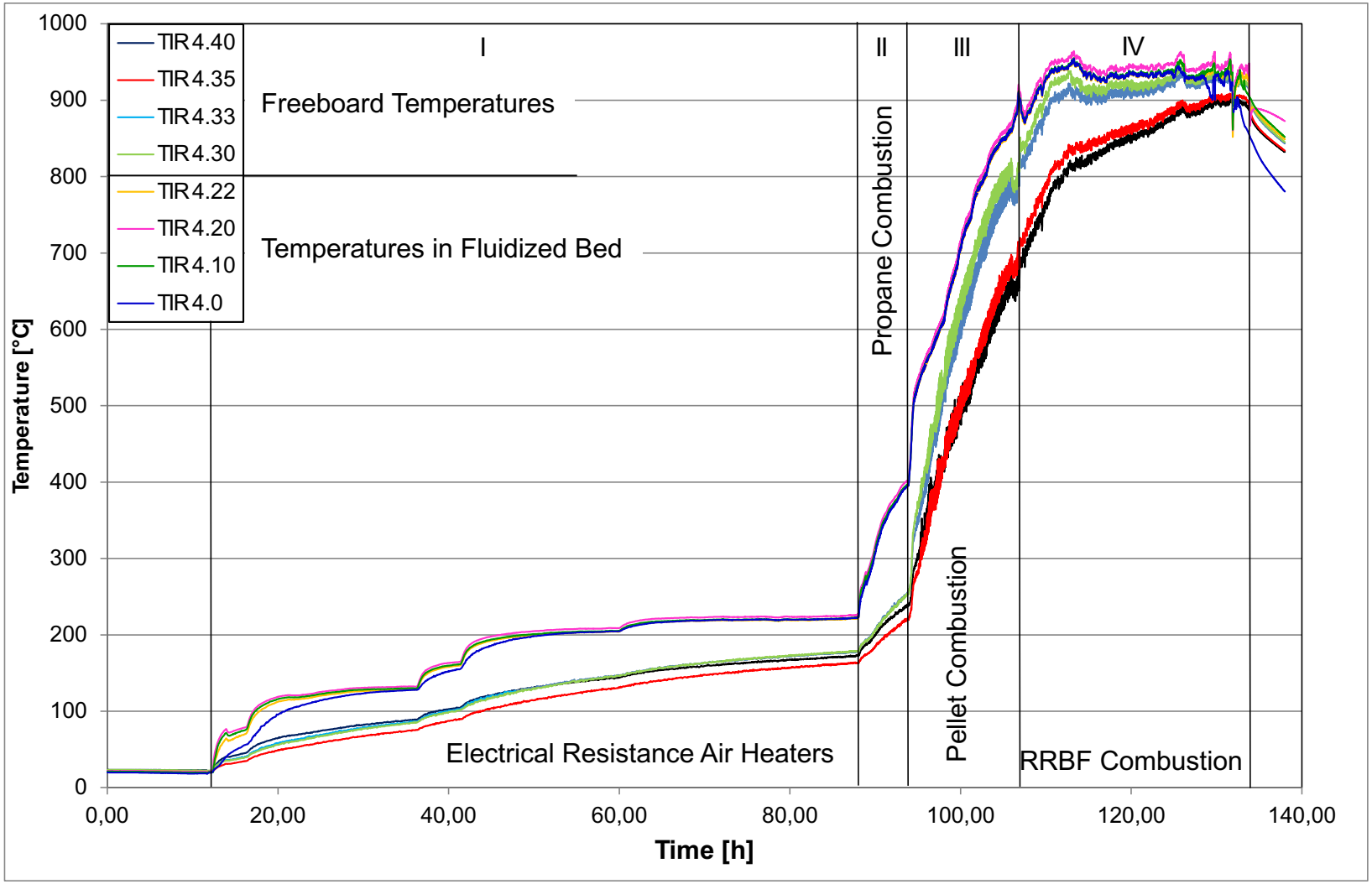
General procedure during combustion test campaigns

- Heating-up with electrical resistance air heater during weekend to ≈ 225 °C
- Heating-up with propane combustion in air flow to ≈ 425 °C
- Heating-up with wood pellet combustion in fluidized bed to ≈ 850 °C
- Duration until achievement of operating conditions ≈ 100 – 135 h

Test periods of combustion test campaigns

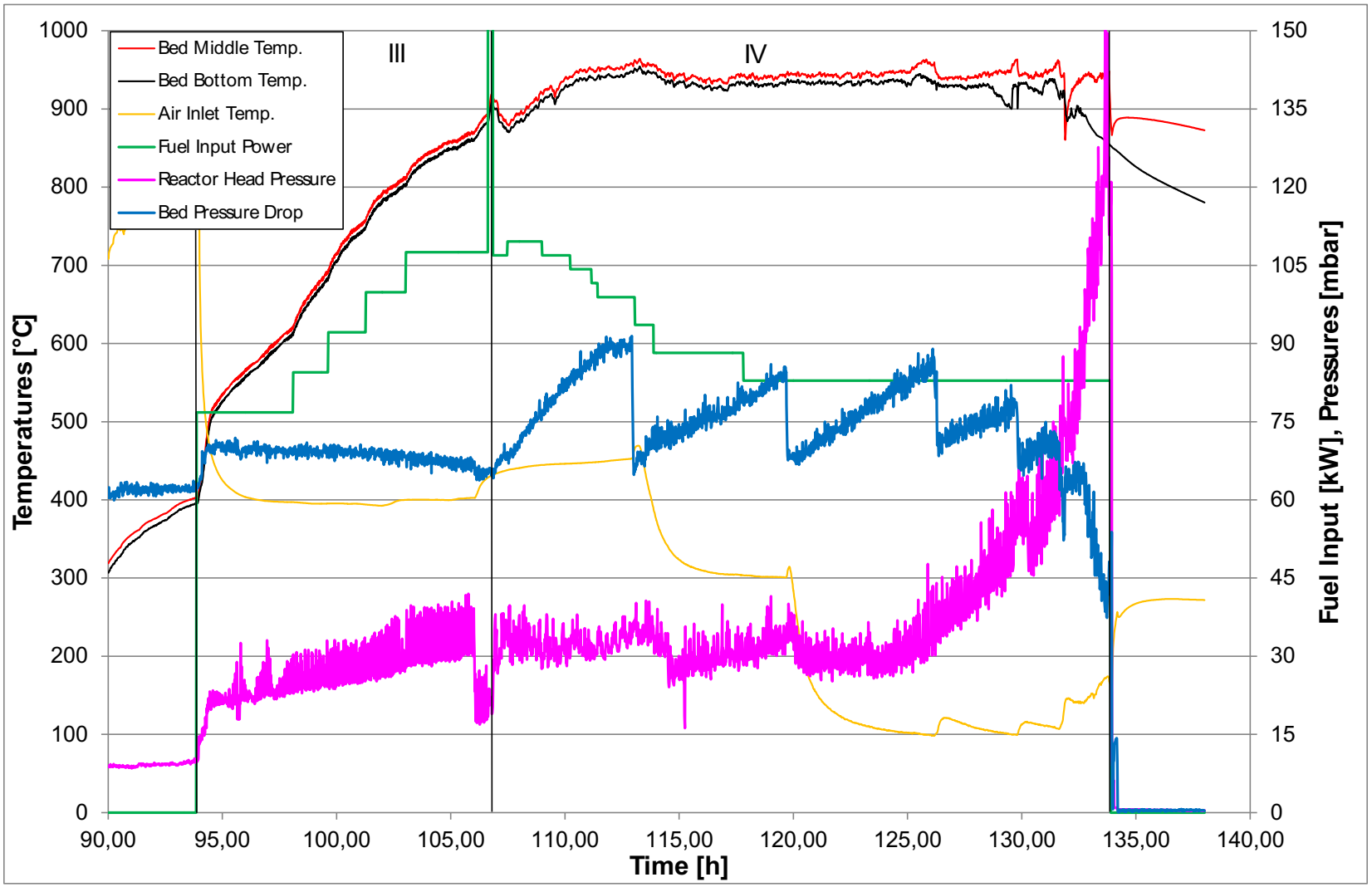
- 1. Batch: 19.-24. March 2015 09 h 48 min RRBF combustion
- 2. Batch: 09.-14. Juli 2015 15 h 07 min RRBF combustion
- 3. Batch: 04.-09. September 2015 27 h 01 min RRBF combustion

Temperature profile during 3. combustion campaign



Fraunhofer UMSICHT

Characteristic values of 3. combustion campaign



Fraunhofer UMSICHT

Findings from combustion test runs

- During combustion of wood pellets (low ash content!) nearly constant bed pressure drop (slight decrease due to bed attrition)
- During RRBF combustion (high ash content!) linear increase of bed pressure drop
- Repeated withdrawl of bed material during operation possible (only during 3. test run, after modification of bottom discharge system)
- After about 18 h RRBF combustion steap increase in reactor head pressure
  $\Rightarrow$ Deposition of fly ash in duct to combustion chamber
- After about 26 h RRBF combustion breakdown of fluidization at lowest measuring point
- Break-off of test run, when non-fluidized bed reached 2nd measuring point (directly above feeding screw)
- Reason for breakdown of fluidization:
  Amount of coarse particles in fuel larger than withdrawn bed material (and decrease of air volume flow due to increased head pressure)
  $\Rightarrow$ Accumulation of non-fluidizable particles at reactor bottom

Coarse Particles in Bed Withdrawl

Fraunhofer UMSICHT

Glass Fragments in Bed Withdrawl

Fraunhofer UMSICHT

Metal Pieces in Bed Withdrawl

Fraunhofer UMSICHT

Fly Ash

Fraunhofer UMSICHT

Ash Analysis and Ash Melting Behaviour

- Enrichment of Na, K and especially P in fly ash
- Melting behaviour of RRBF and fly ash is non-critical
  Shrinkage Start Temperature (SST) lies at least 200 °C above operating temperature

	Fly ash		
	1. Batch	2. Batch	3. Batch
Ash [%]	95.1	97.3	
C [%]	0.77	0.6	1.9
H [%]	0.05	0.1	< 0.1
N [%]	0.52	n.n.	0.1
S [%]	0.41	1.08	0.75
Cl [%]	2.03	3.23	2.0
Na [ppm]	21 567	24 600	22 300
K [ppm]	36 367	39 700	16 400
P [ppm]	11 100	14 500	10 900

	RRBF			Fly ash		
	1. Batch	2. Batch	3. Batch	1. Batch	2. Batch	3. Batch
Shrinkage Start Temperature (SST) [°C]	1 151	1 150	1 148	1 168	1 159	1 152
Deformation Temperature (DT) [°C]	1 180	1 172	1 172	1 180	1 170	1 196
Hemisphere Temperature (HT) [°C]	1 187	1 175	1 175	1 183	1 177	1 197
Flow Temperature (FT) [°C]	1 214	1 190	1 190	1 192	1 186	1 215

Outline

1. Background – The Project MARSS
2. Solid Fuel Characterisation
3. Fluidized Bed Test Rig
4. Combustion Test Campaigns
   - Procedure
   - Results
5. **Summary**

Summary

- RRBF can be dosed with screw feeders reproducible
- Despite broad variance in water and ash content easily combustible in fluidized bed, lower heating value 10.5 – 12.9 MJ/kg
- Combustion steadily possible without air preheating
- Fly ash well burnt out
- High share of coarse ash-forming compounds
  ⇒ either increase (pre-)treatment or
  increased bed withdrawl with refeed of fines
- Despite multiple metal separators in treatment a couple of metal in fuel (primarily crown caps, biro springs and nails)
- Considerable enrichment of phosphor in fly ash
  ⇒ in future usable as P source, possibly together with sewage sludge
- Ash melting behaviour below 1000 °C non-critical
  easily maintained in fluidized bed combustion

Fraunhofer UMSICHT

Department Biorefinery & Biofuels

Thank You for Your kind attention!

These Experiments were carried out as subcontract of the demonstration project MARSS with funds from EU Life+ programme.
Further Information about this project under:

www.marss.rwth-aachen.de


Quelle: photocase.de

Contact: Fraunhofer UMSICHT
Osterfelder Strasse 3, 46047 Oberhausen, Germany
E-Mail: info@umsicht.fraunhofer.de
Internet: http://www.umsicht.fraunhofer.de/en

Dipl.-Ing. Tim Schulzke
Telephone: +49 208 8598 1155
E-Mail: tim.schulzke@umsicht.fraunhofer.de

Fraunhofer UMSICHT