Grindability of Torrefied Beechwood and Cofiring with Pulverized Lignite at Pilot Scale

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RWTH Aachen University

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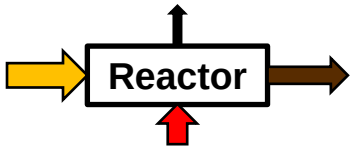
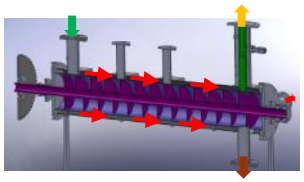
Outline

1. Torrefaction – What and why?

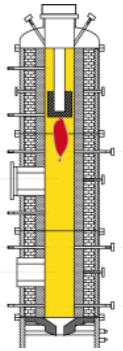


2. Torrefaction Reactor



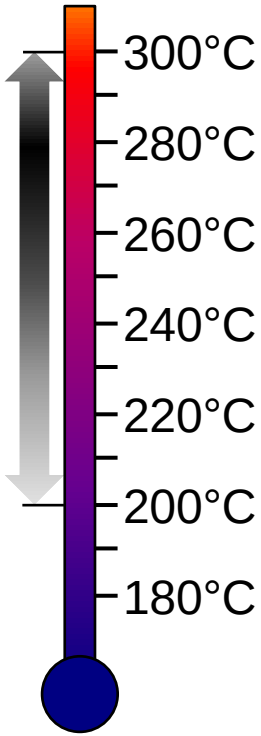
3. Grindability of Torrefied Beechwood

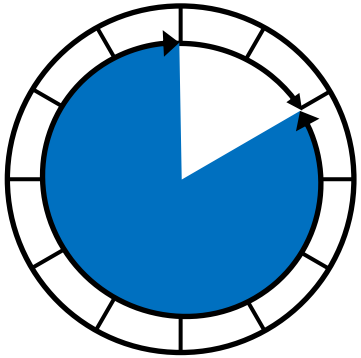
4. Cofiring in Pulverized Coal Combustion Test Rig



What Torrefaction Means

- Torrefaction
  - Thermal Treatment of Biomass





≈ 10-60 minutes

Aim: Upgrading of Biomass

- Aims of Torrefaction:
  - Improvement of Grindability

Picture sources: http://static1.essen-und-trinken.de ; http://www.dahw.de
http://picmirror.de/bild.php/8952_080308_schimmel.jpg
http://data.lustich.de/bilder/l/14003-holztransport.jpg ; http://thumbs.dreamstime.com/
http://www.heimwerker-tipps.net ; http://media.realisr.com/

Aim: Upgrading of Biomass

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  - Increase of Energy Density

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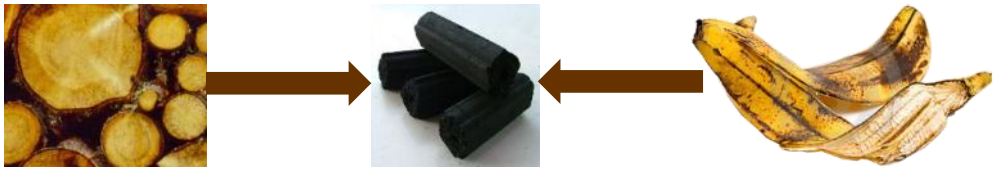
  - Prevention of Biological Decay

  - Increase of Energy Density

  - Homogenisation



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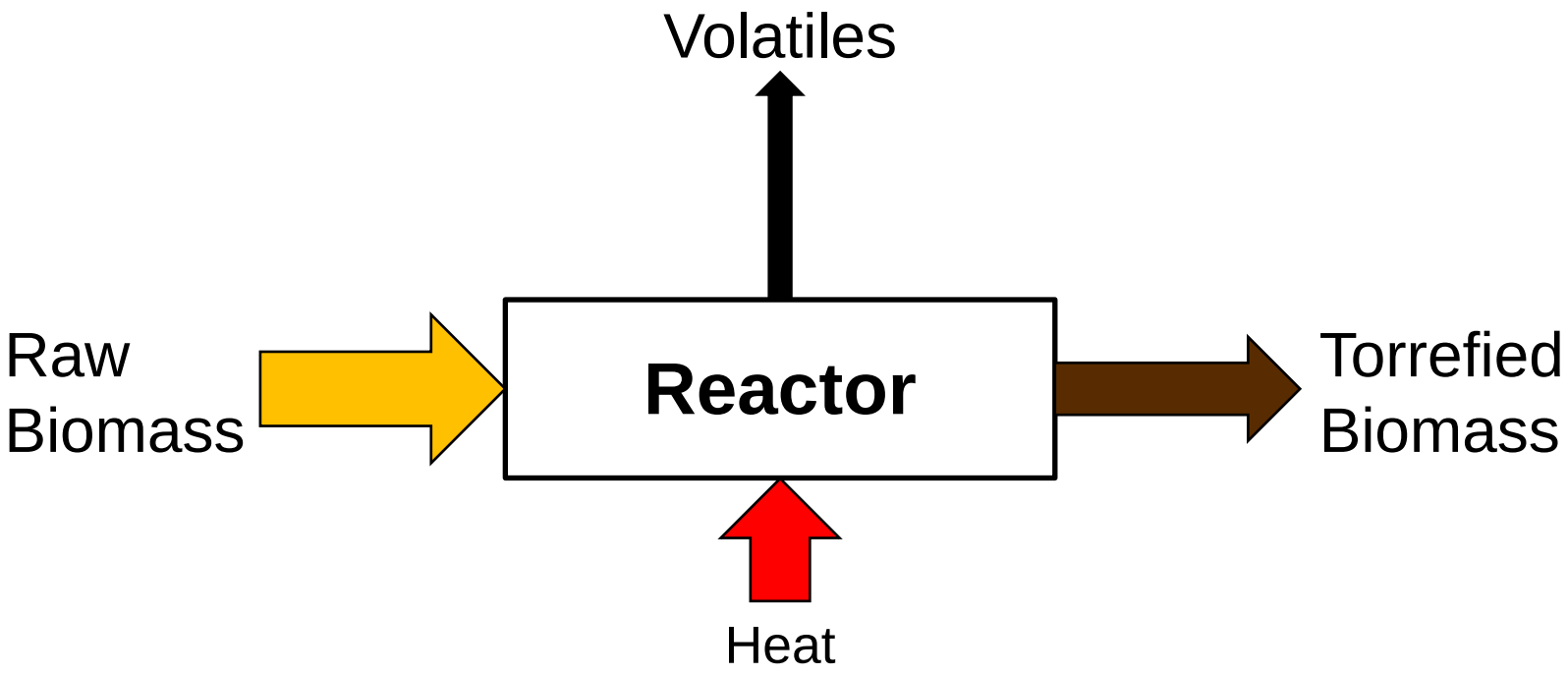
Torrefaction Process – schematical



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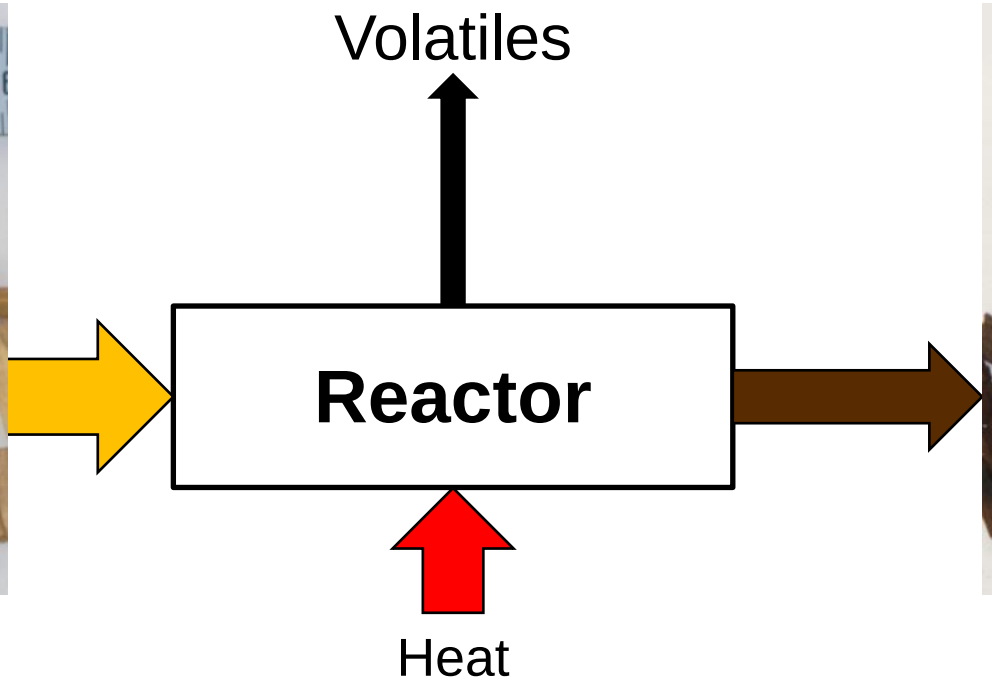

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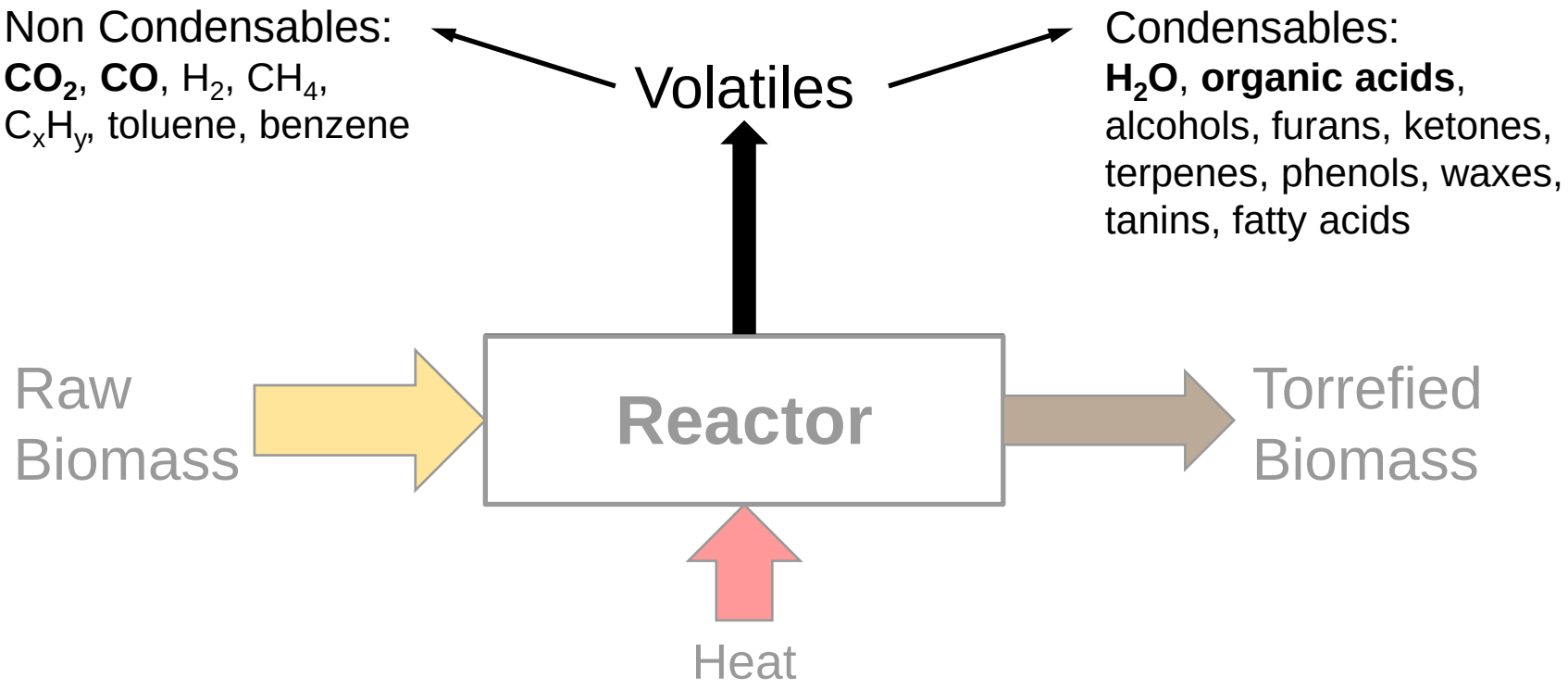

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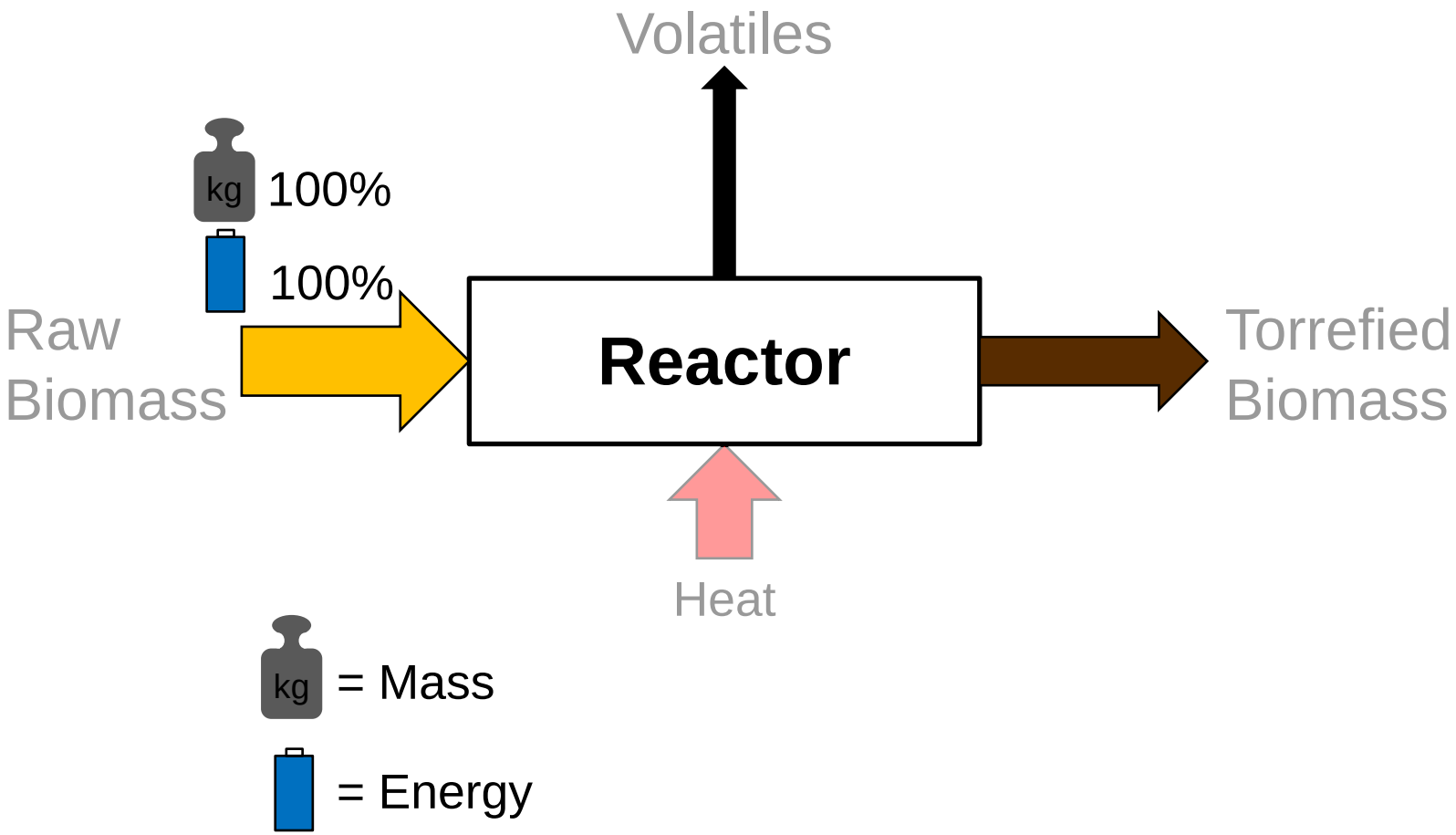
Torrefaction for biomass co-firing in existing coal-fired power stations, ECN report ECN-C--05-013, 2005

Torrefaction Process – Energy and Mass Flows



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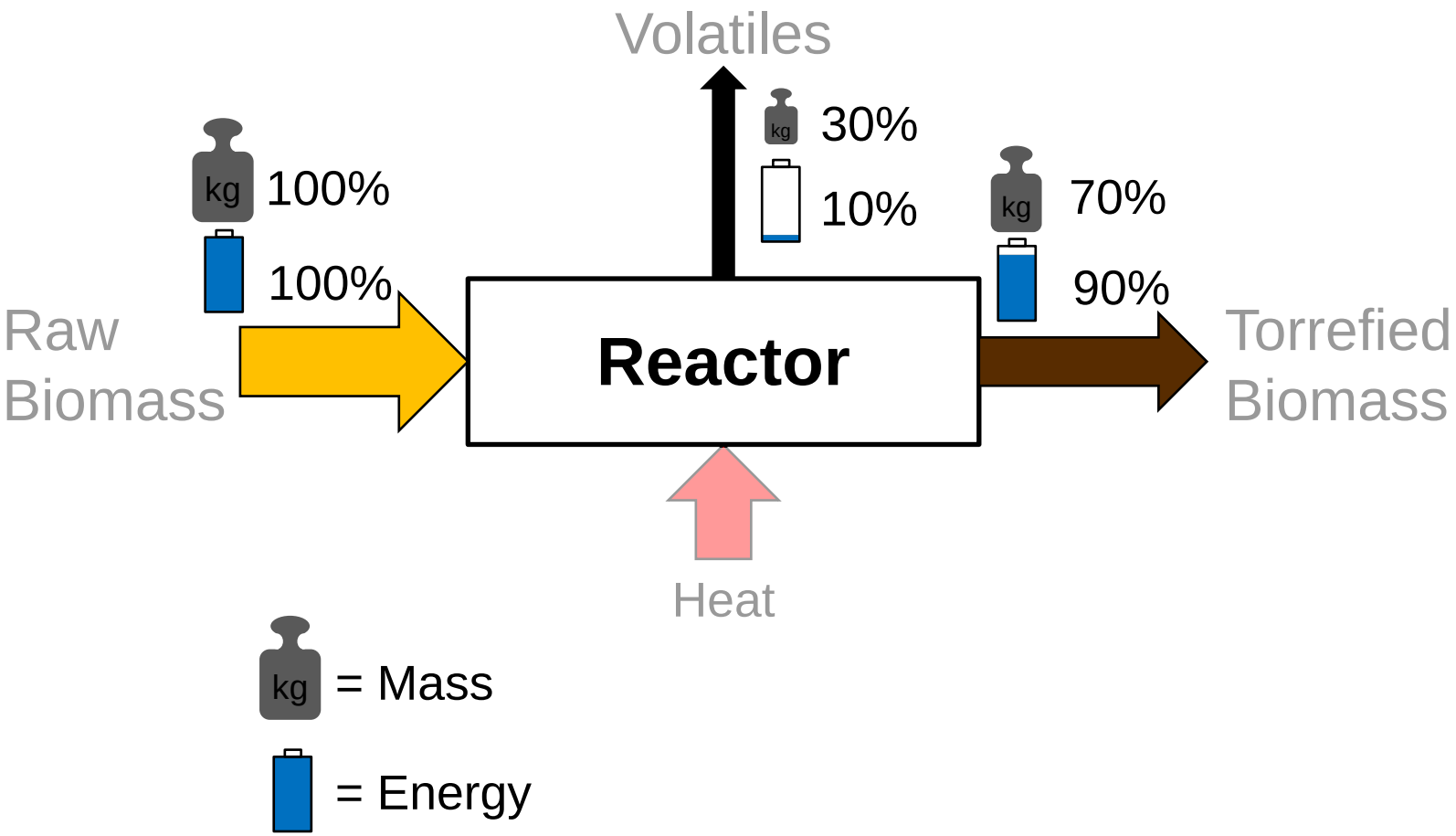

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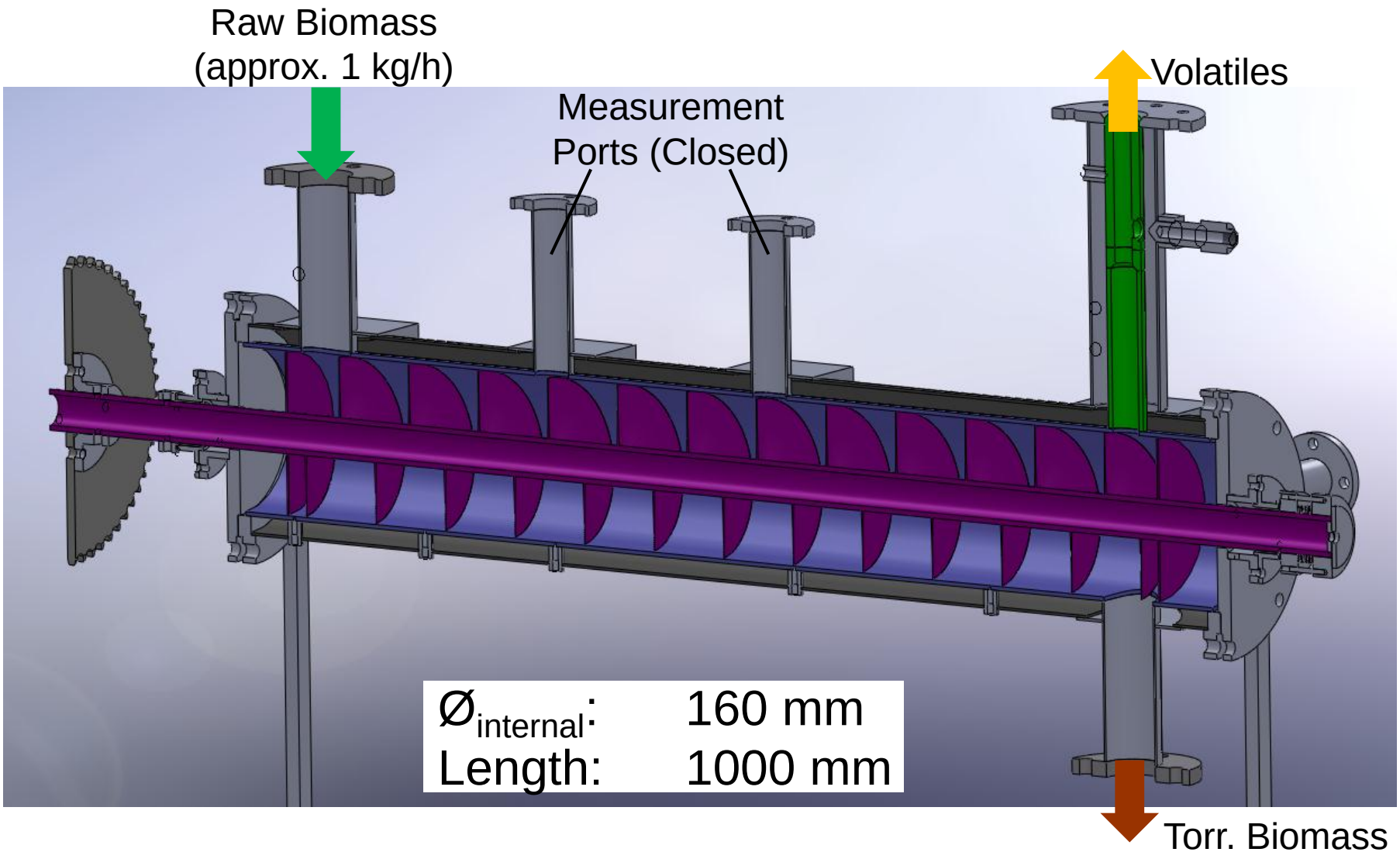
Torrefaction Reactor Used



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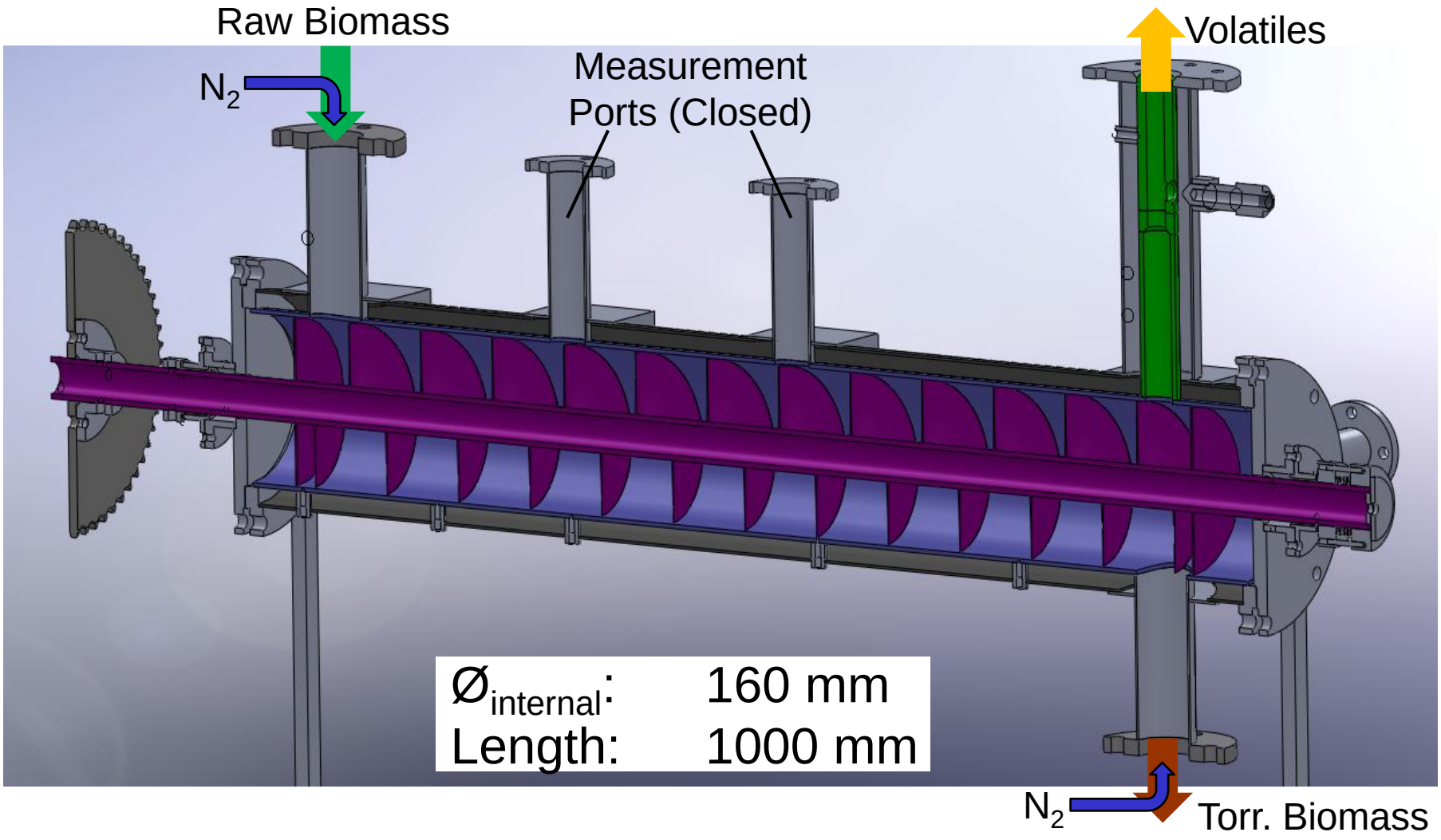

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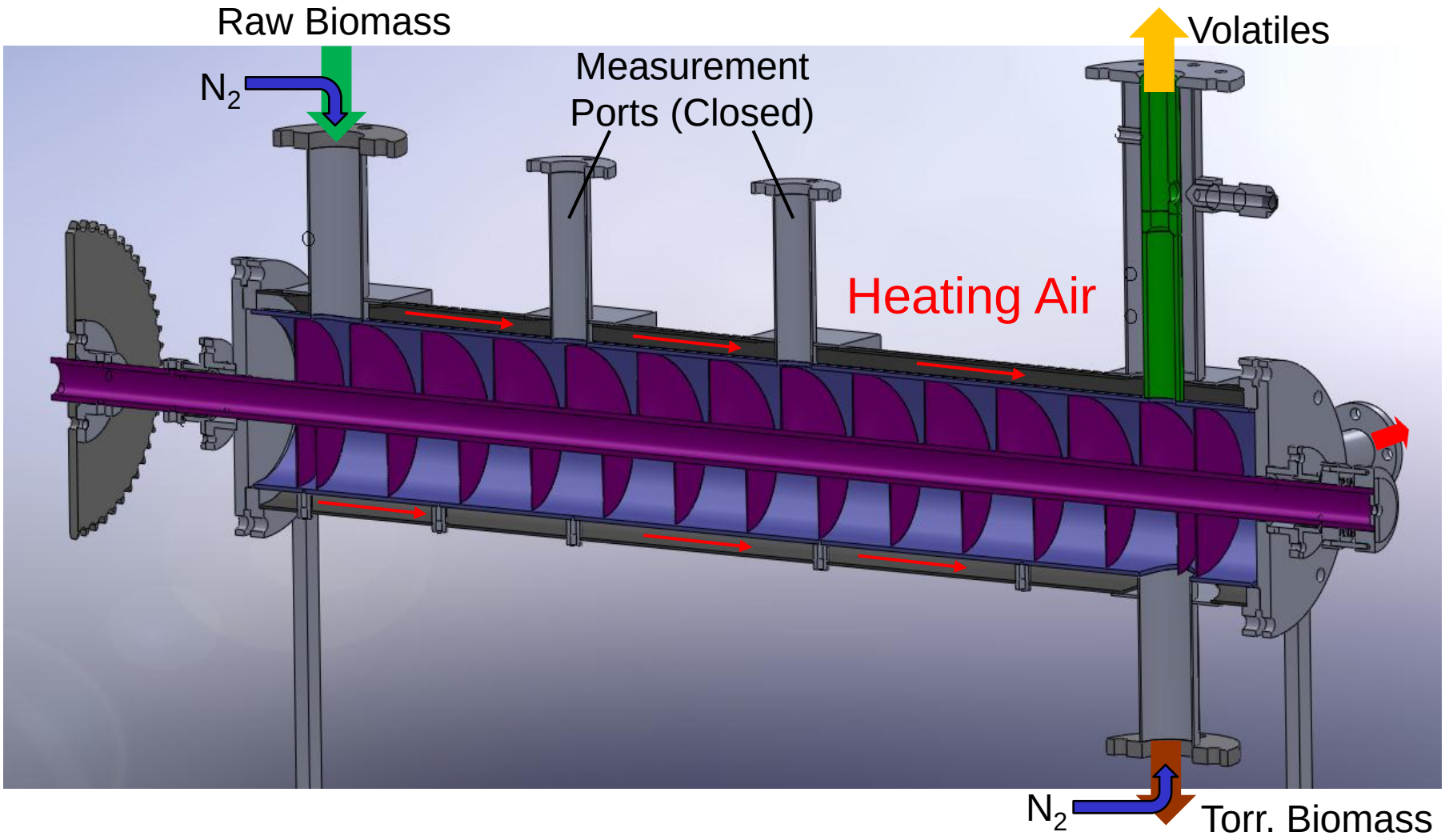

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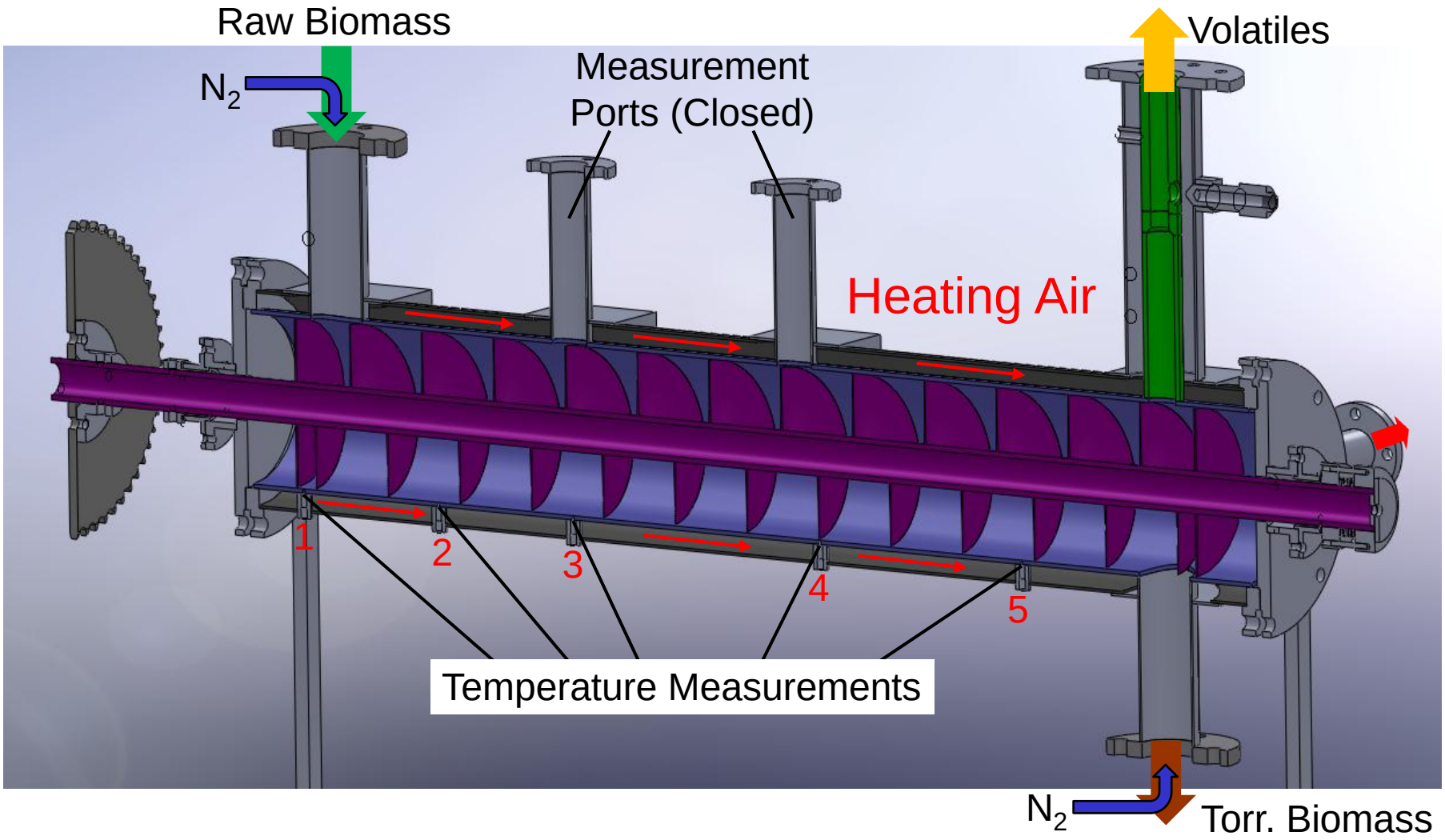
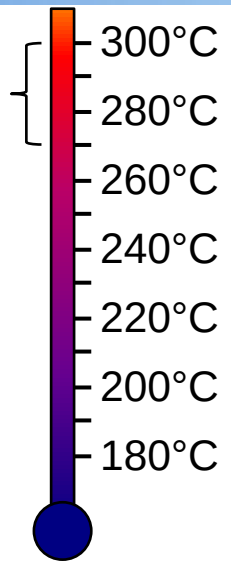
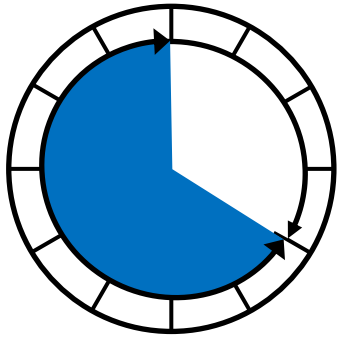


Parameters of the Study

- Temperature: 270, 280, 290, 300 °C



- Residence Time: 20, 40, 60 minutes



- Feed Moisture: 0, 10, 20 mass-%

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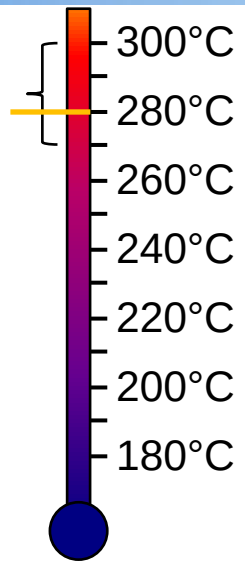
Reference Test



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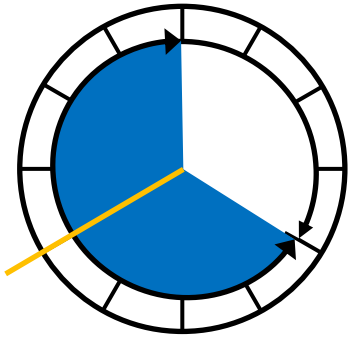

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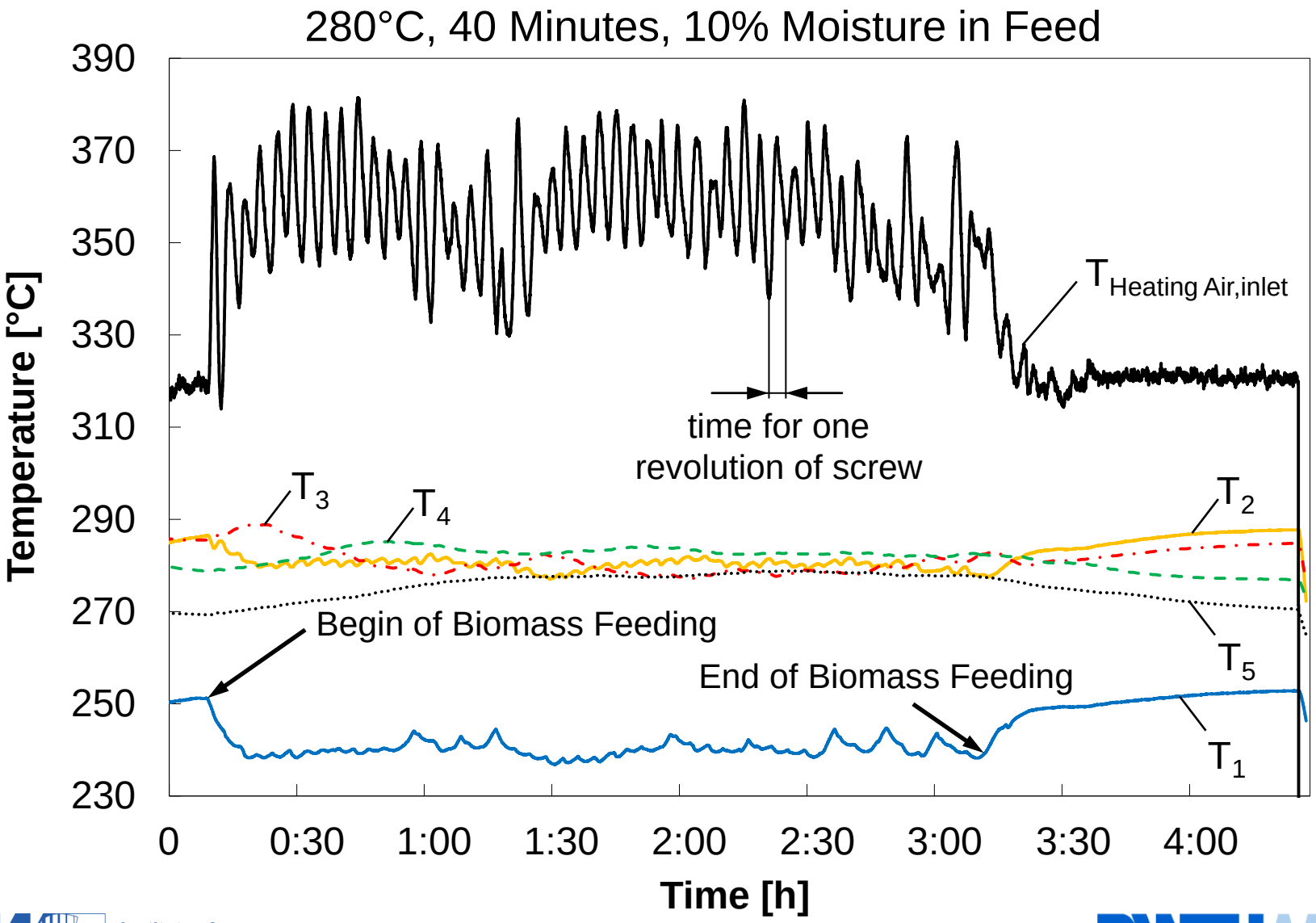
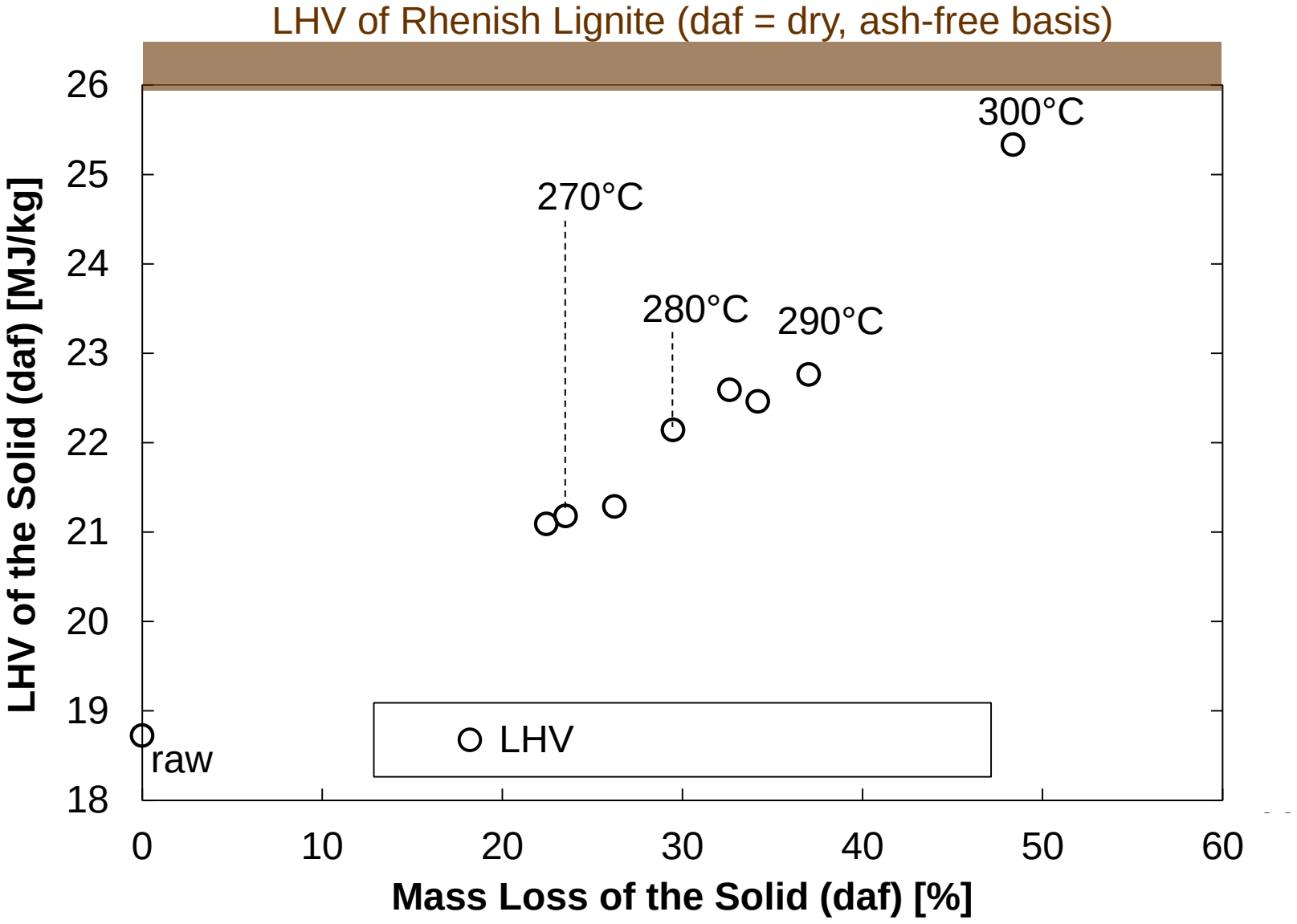
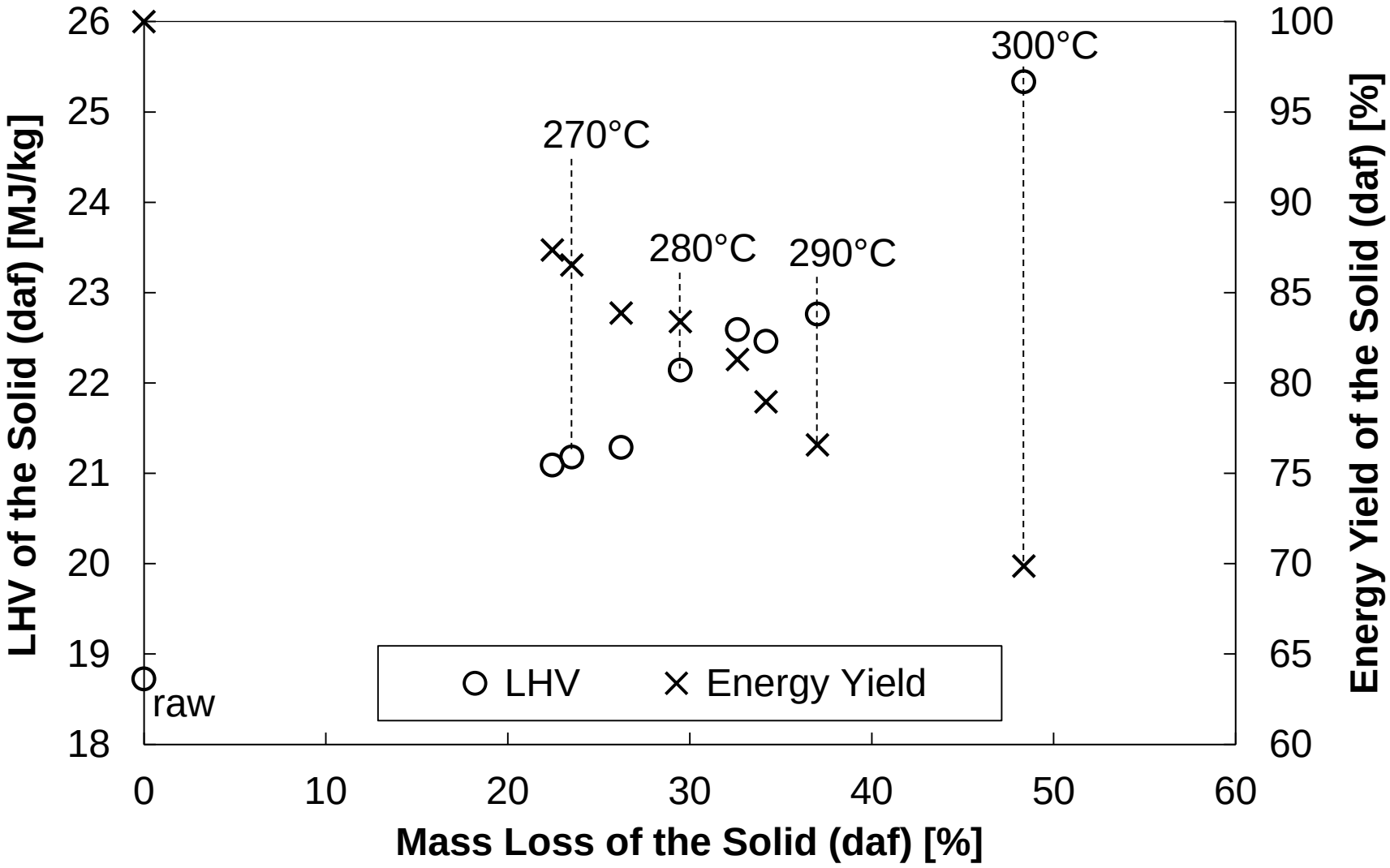
Temperature Distribution in Reactor During Reference Test



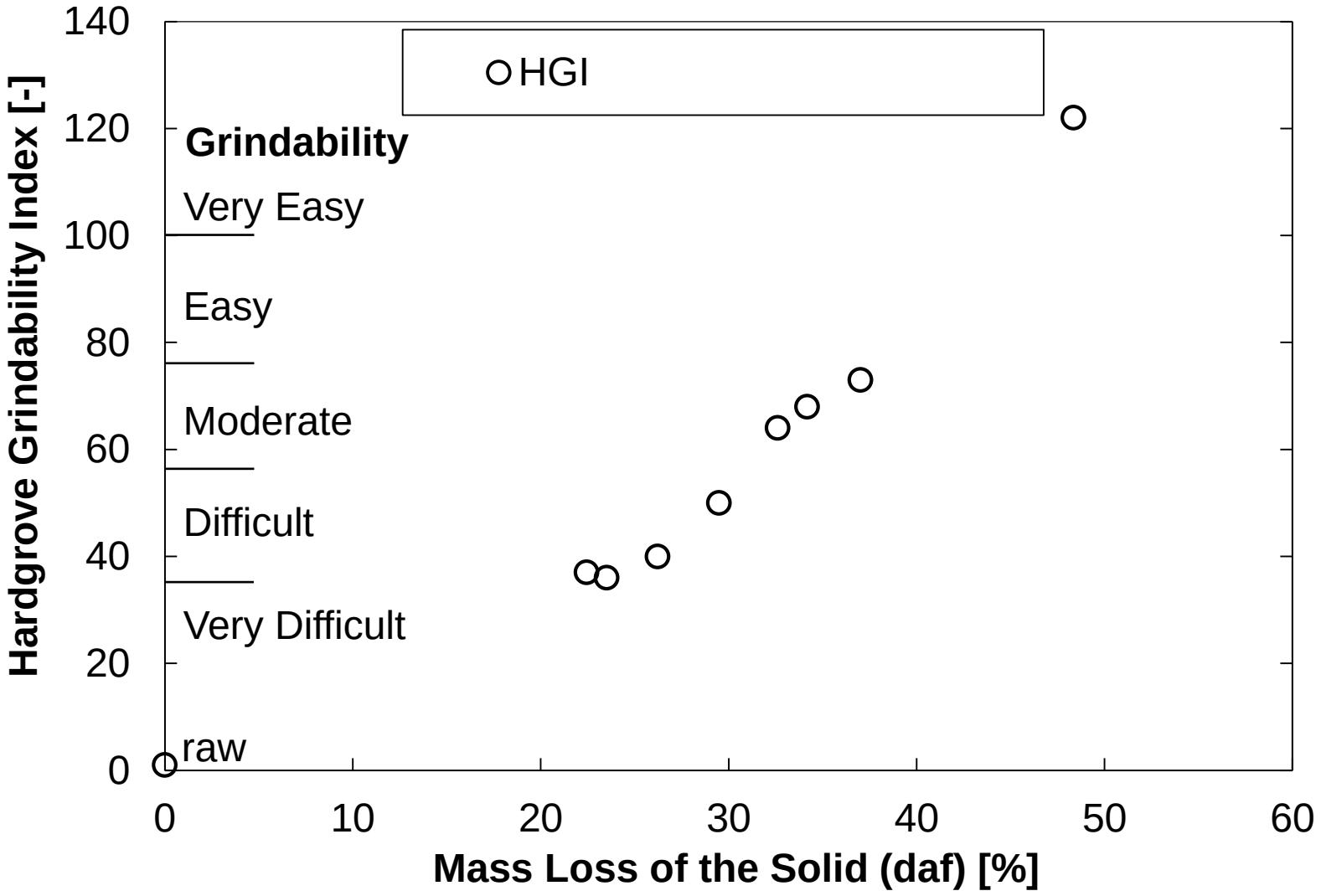
Energy Density



Energy Density and Energy Yield



Grindability of Torrefied Beechwood Chips



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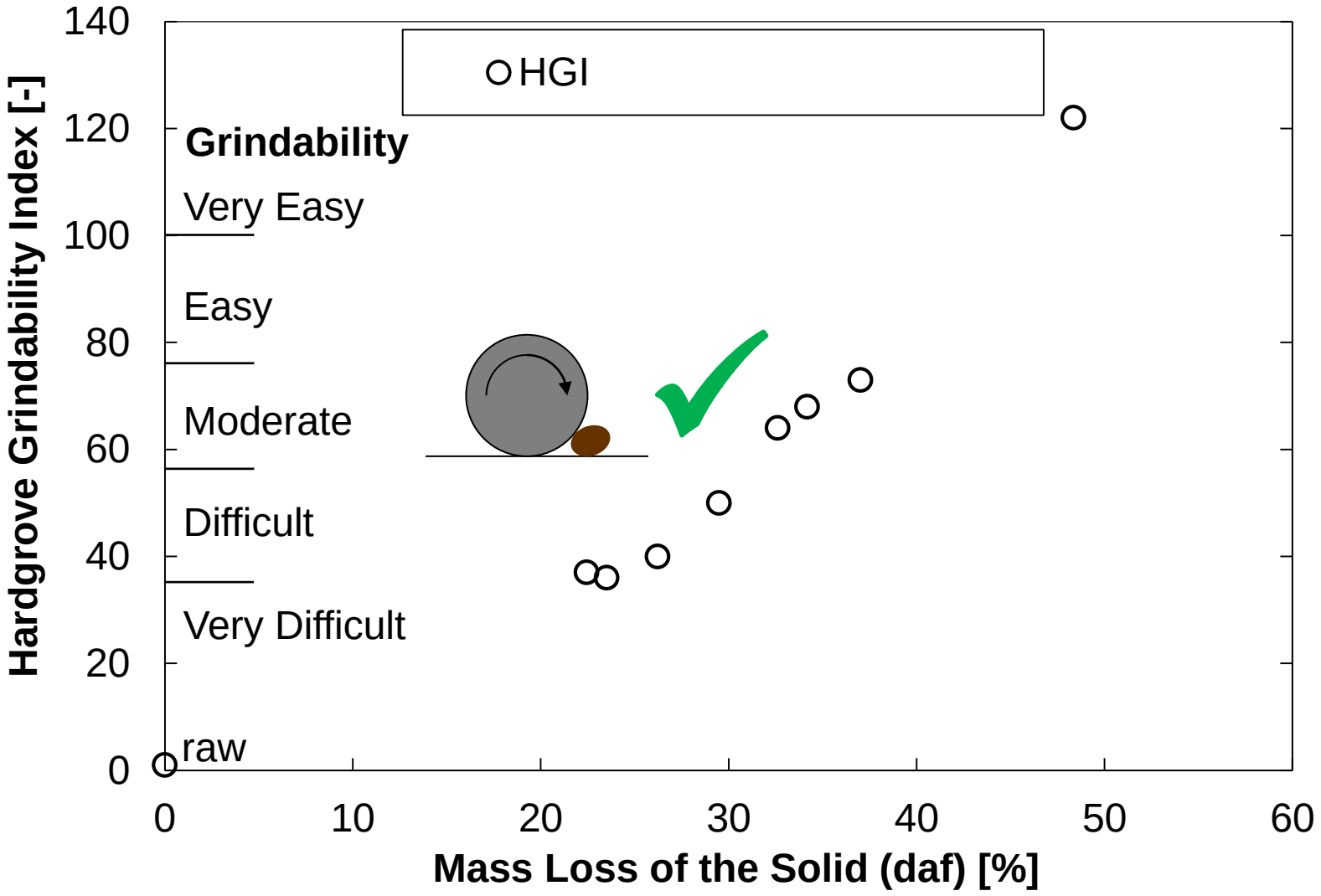

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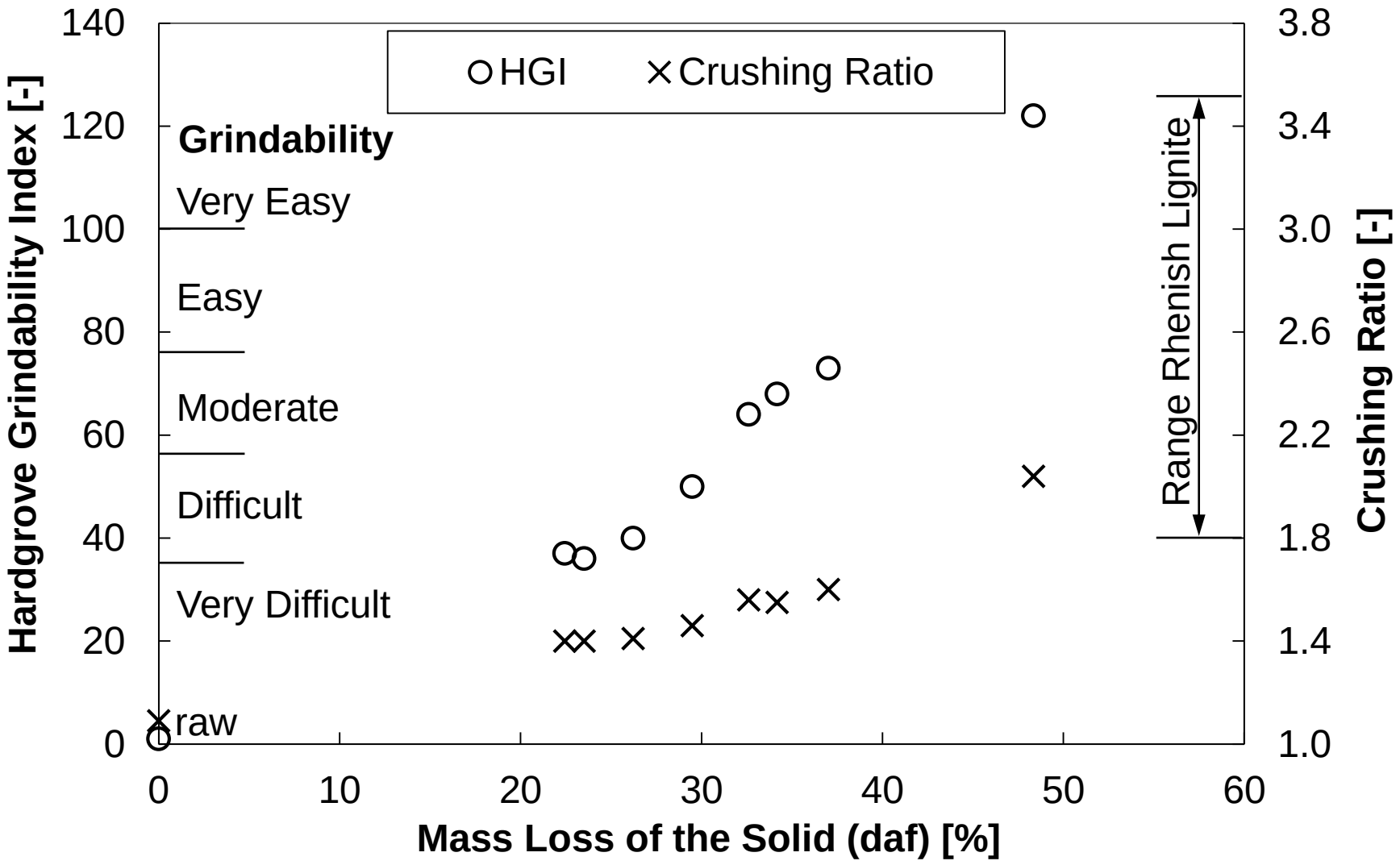

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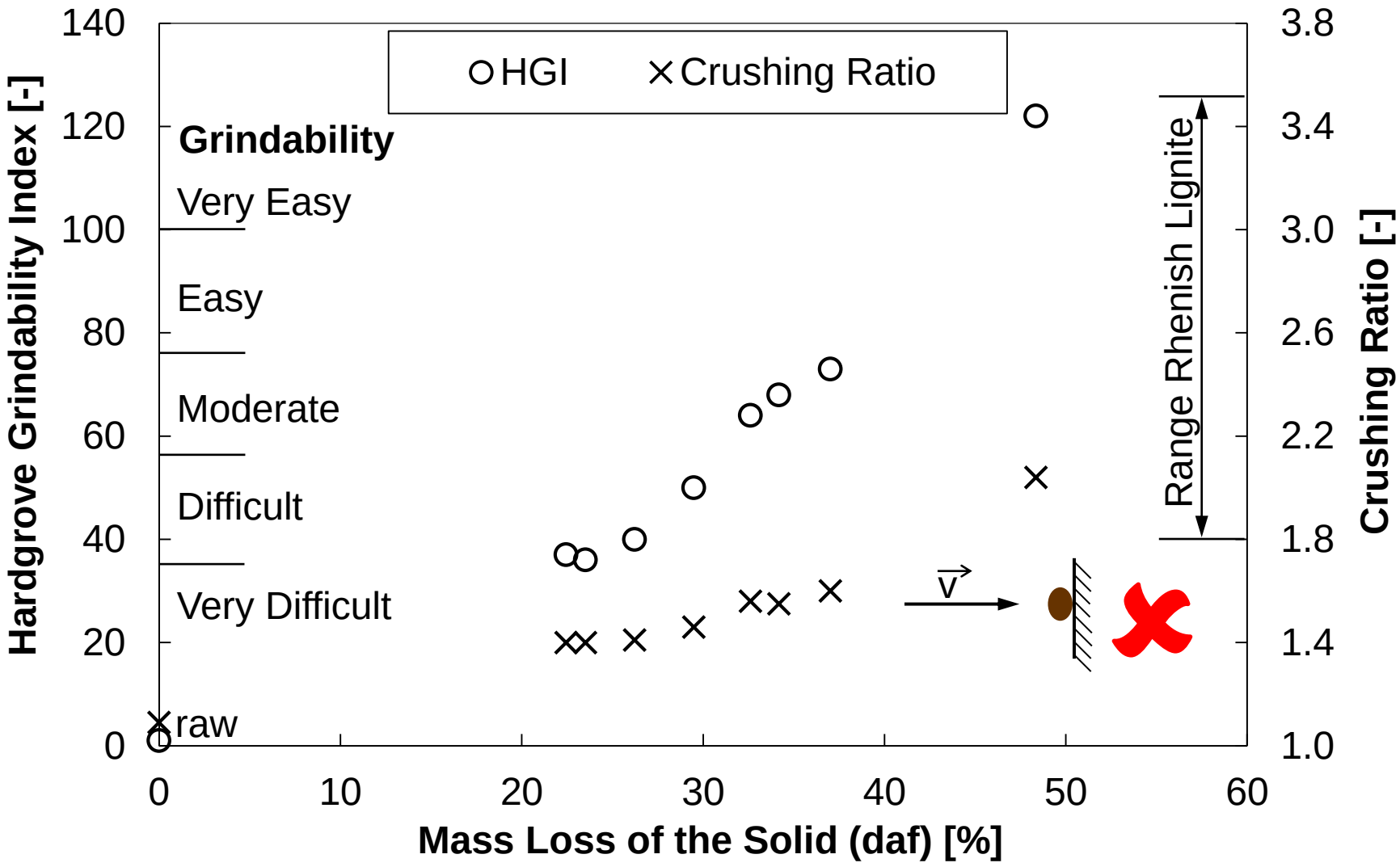
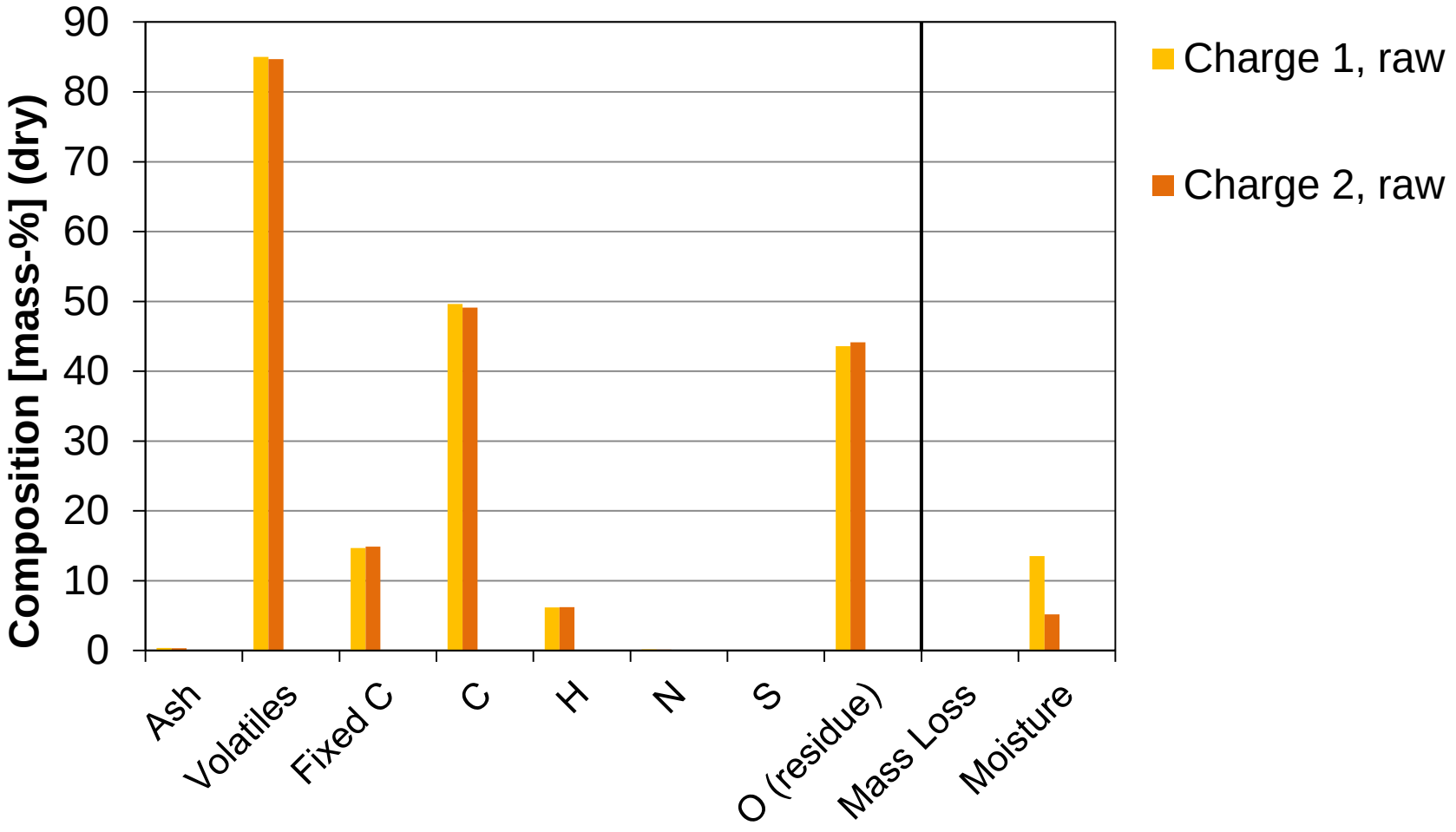
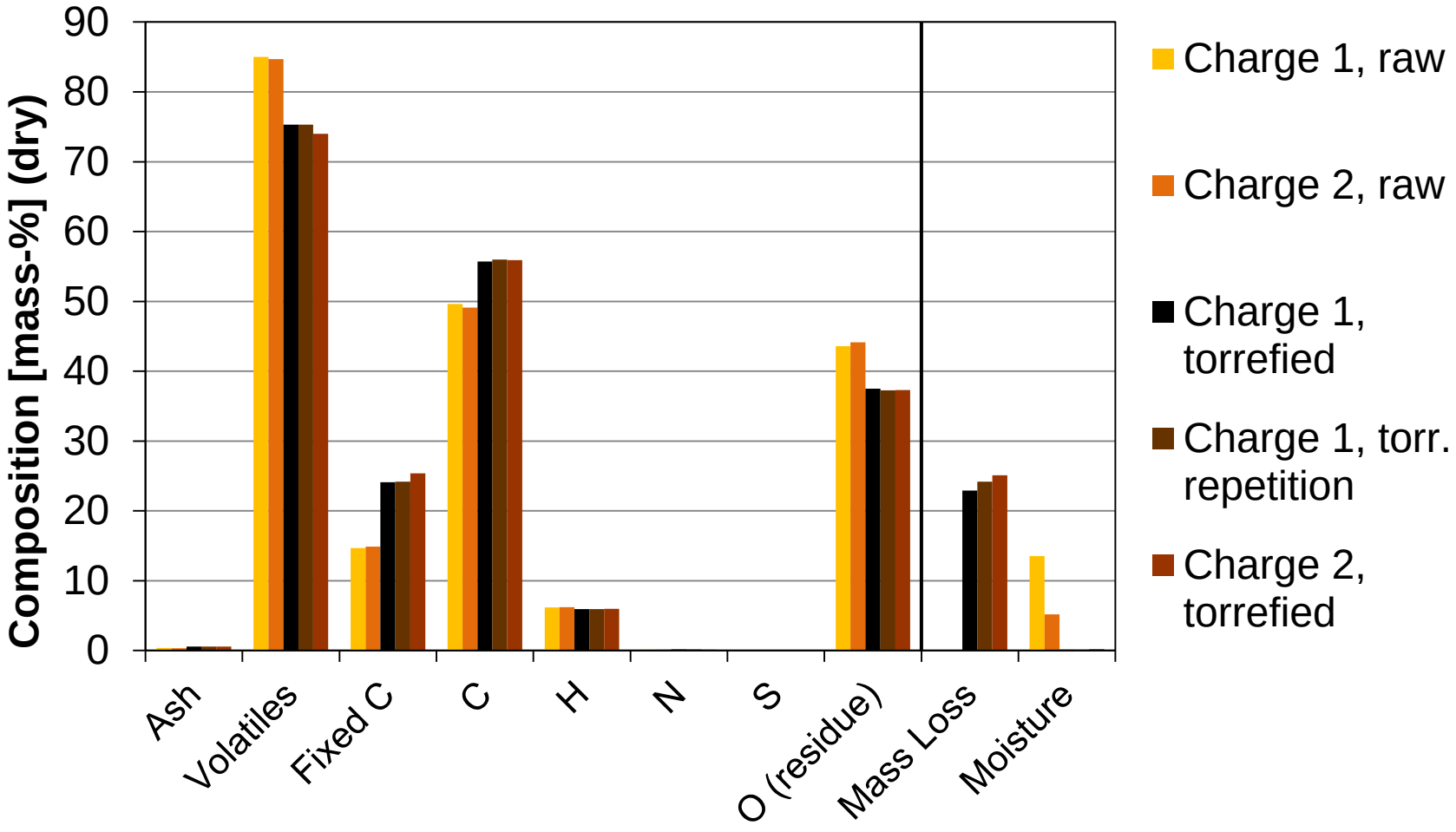


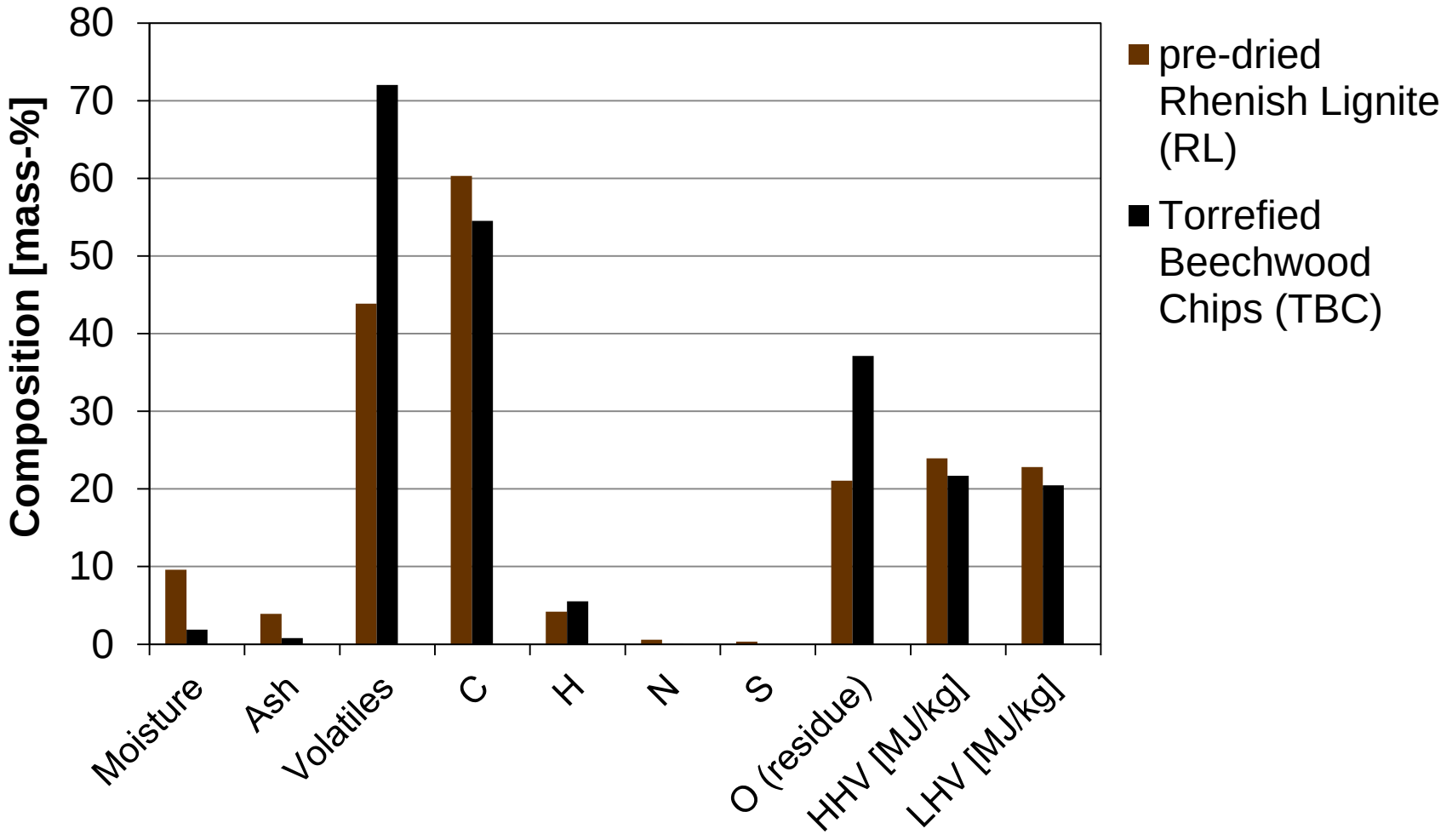
Composition of Raw Beechwood Chips



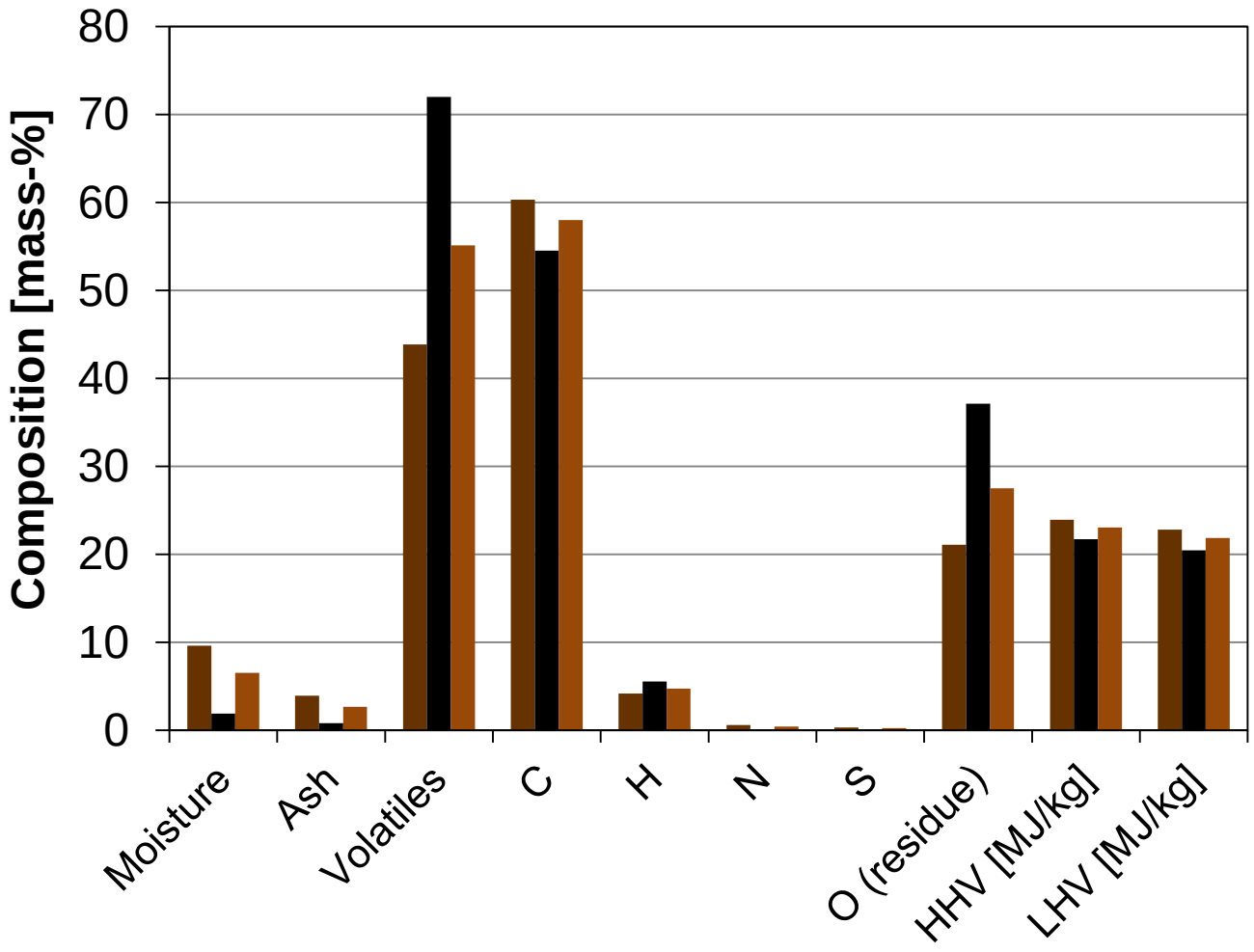
Composition of Raw and Torrefied Beechwood Chips



Comparison Lignite, Torrefied Beechwood Chips



Composition of Fuels for Cofiring Experiments



- pre-dried Rhenish Lignite (RL)
- Torrefied Beechwood Chips (TBC)
- Mixture 60/40 Mass-%

since the amount of TBC was not enough for pure combustion

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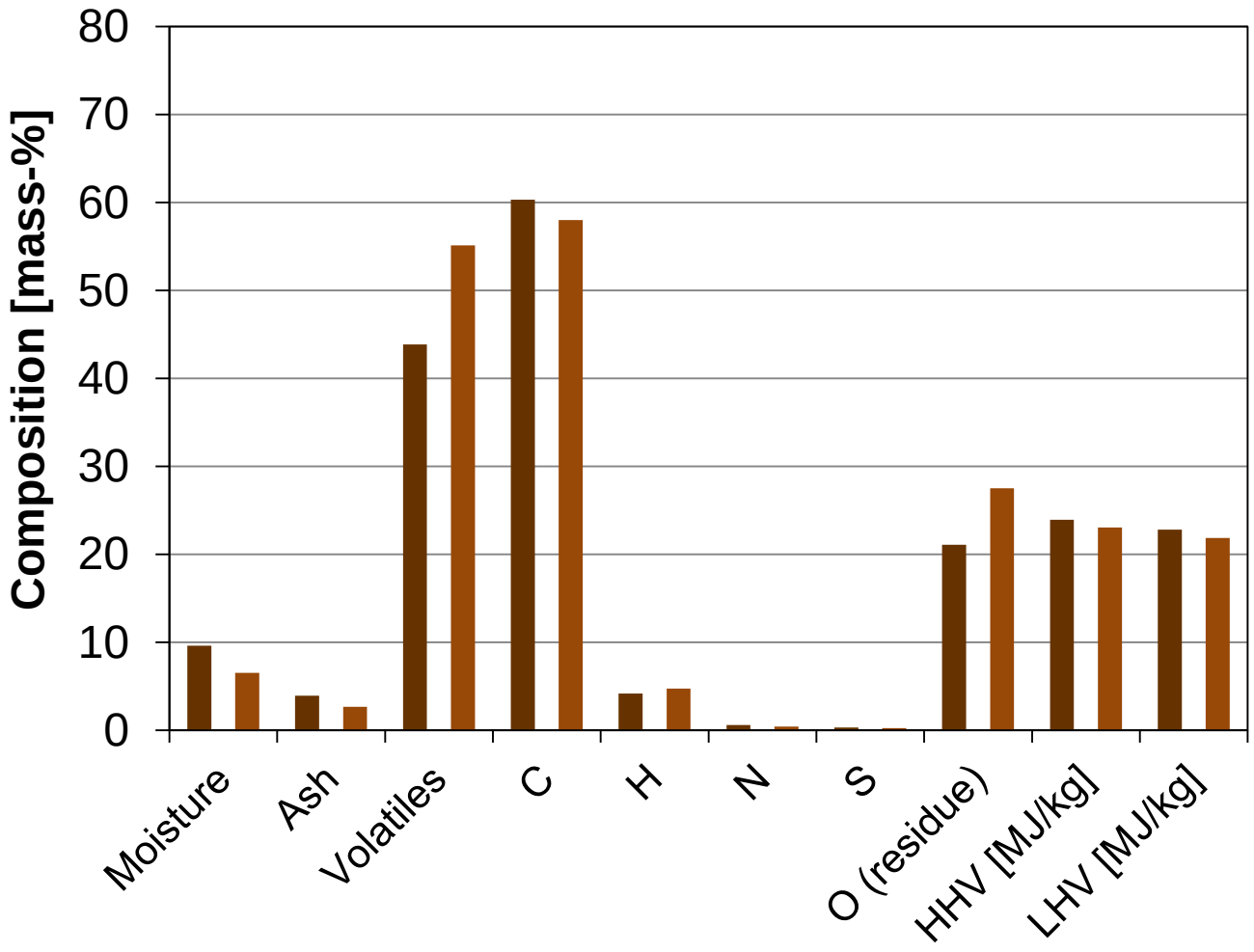

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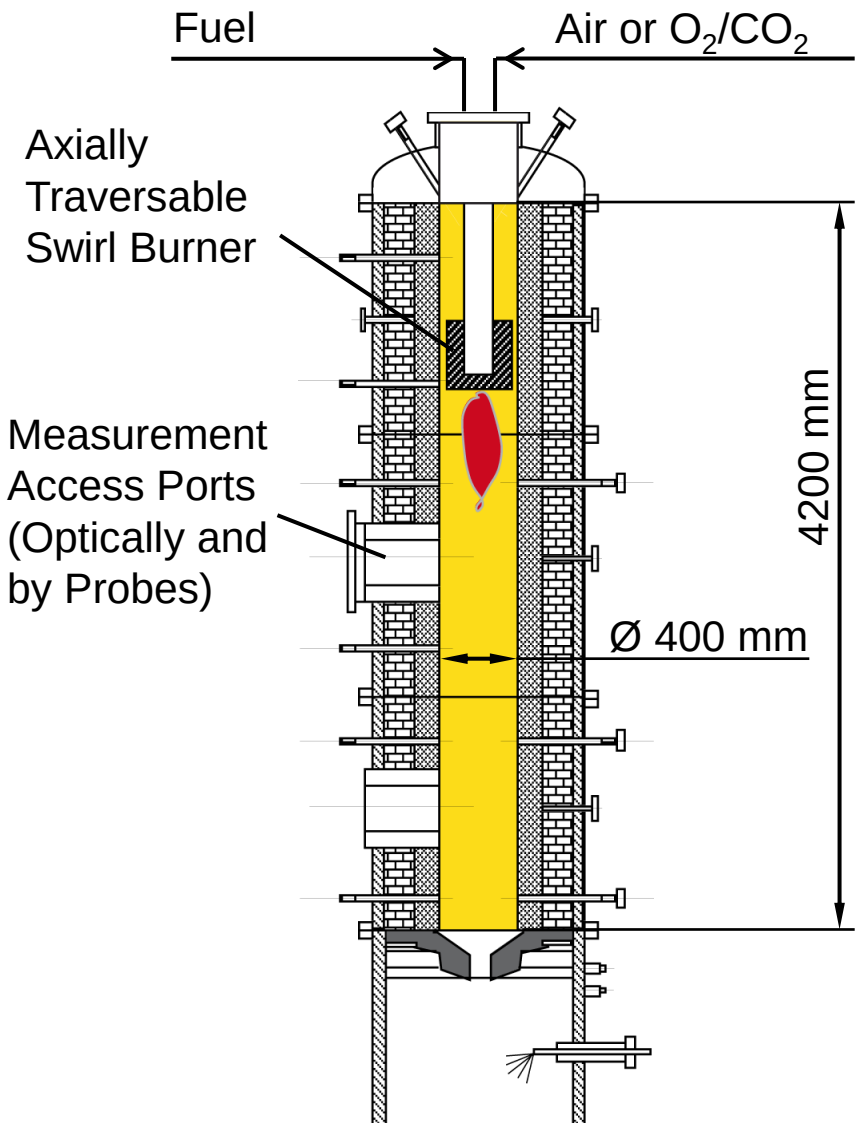
Pulverised Fuel Combustion Facility



Facility and burner have been described in detail by Stadler, H. et al.: *Experimental investigation of NO_x emissions in oxycoal combustion*. Fuel, Vol. 90, Issue 4, Pages 1604-1611, 2011

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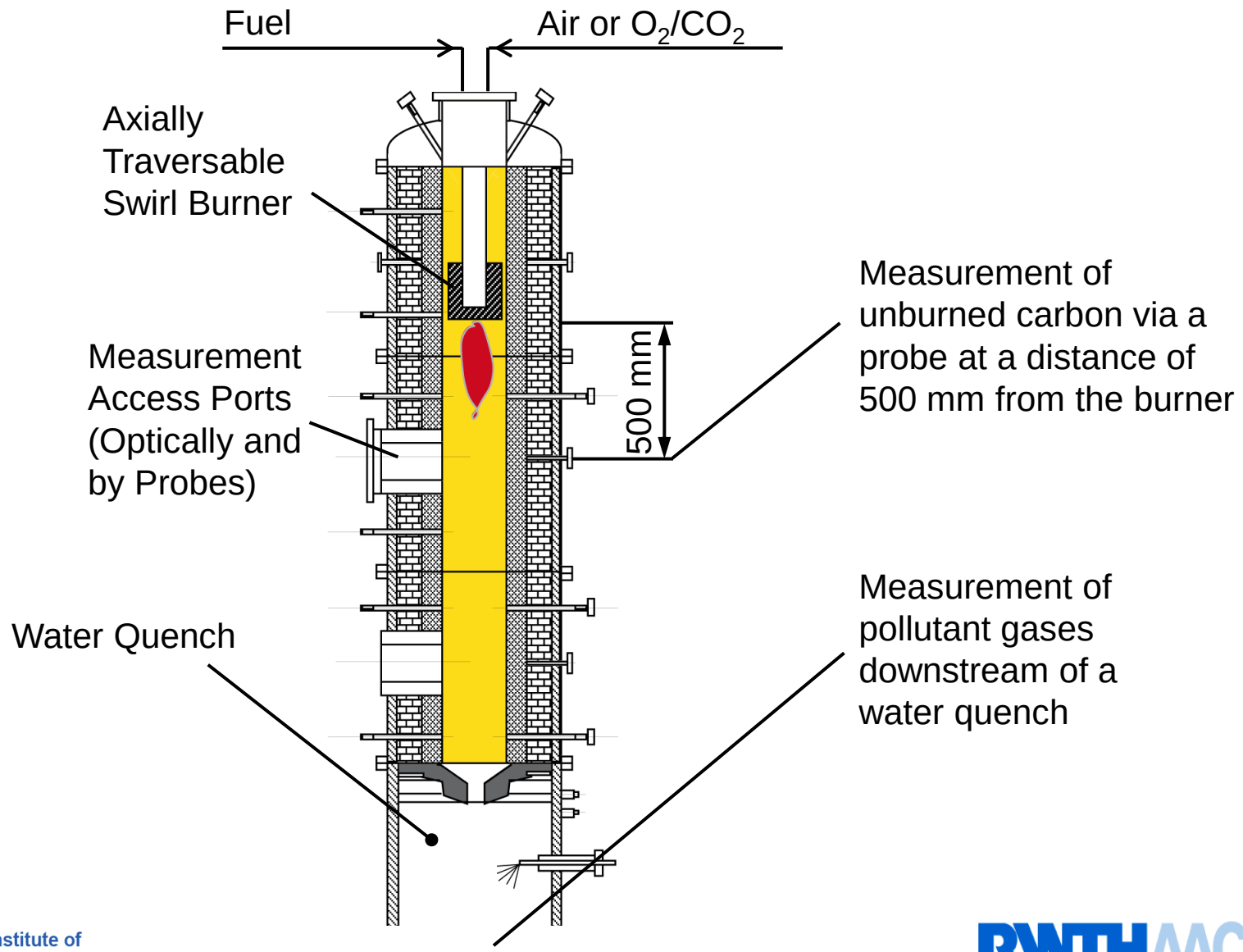
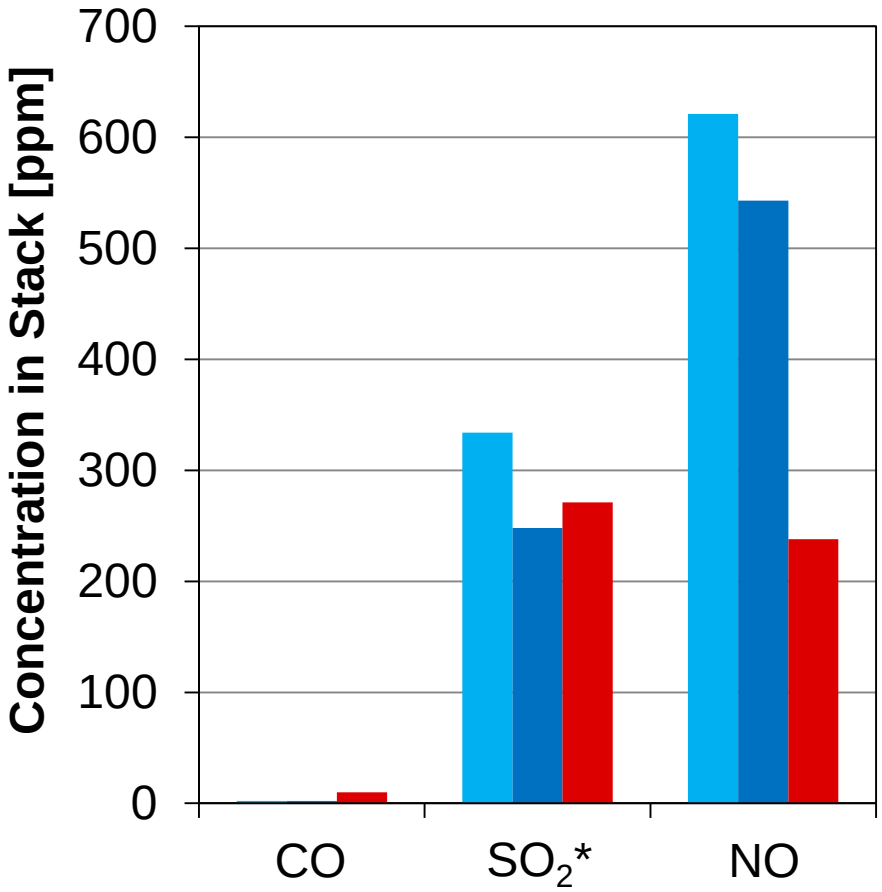


Concentration of Pollutant Gases in Flue Gas

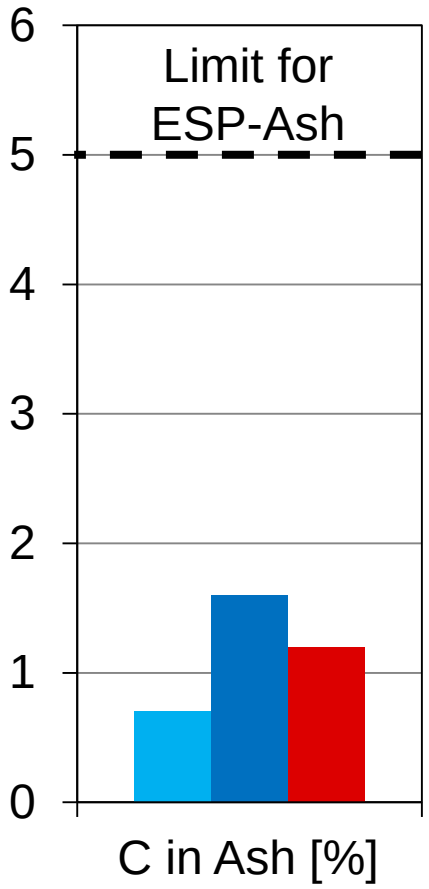


- Air, RL
- Air, RL/TBC
- 21/79 % O_2/CO_2, RL/TBC

RL = pre-dried **R**henish **L**ignite
TBC = **T**orrefied **B**eechwood **C**hips

*SO_2 values show qualitative indications since measurement is conducted downstream of a water quench

Burnout at 500 mm Distance from Burner



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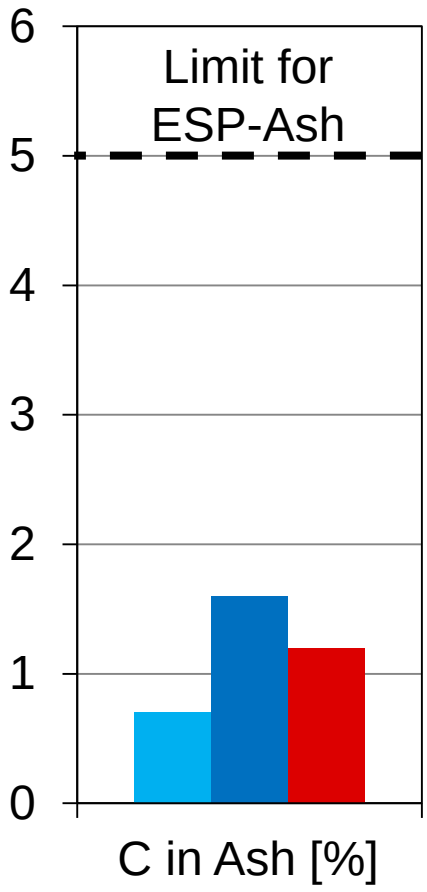

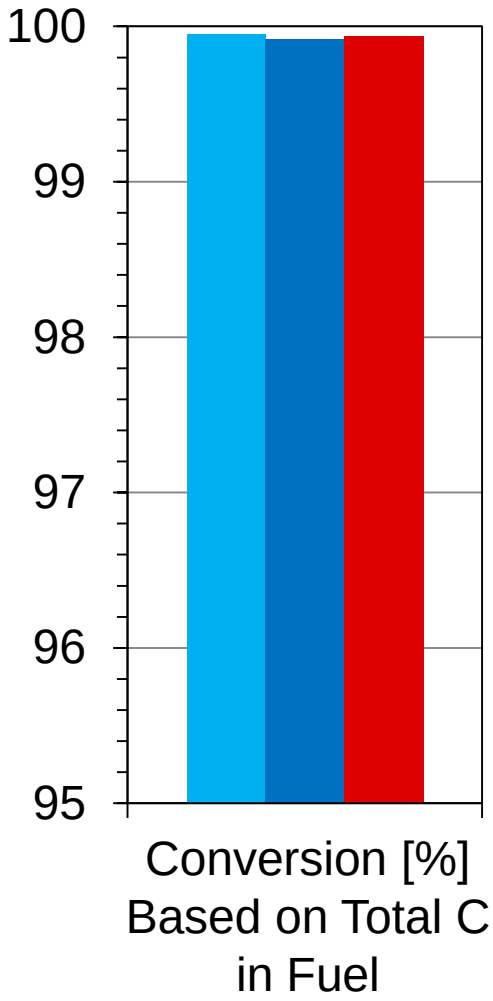

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Chemiluminescence

- Light emission due to non-thermal reason

  - Transition of a molecule from excited state (*) to ground state
  - In (gas) flames e.g.: CH*, C_2*, CO_2* (all visible), OH* (UV)

Picture Source: http://www.uv-elements.de/images/leuchtstab_big.png

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    → usage of OH*, since little thermal radiation at 309 nm

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  - Formation by: $CH + O_2 \leftrightarrow OH^* + CO$

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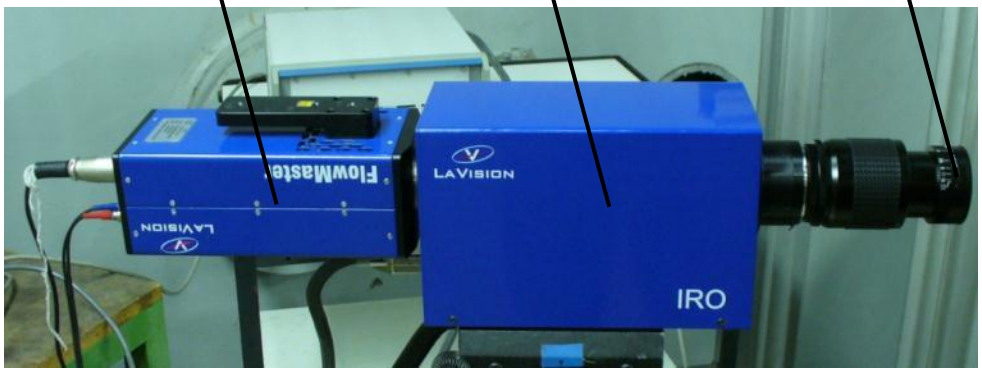
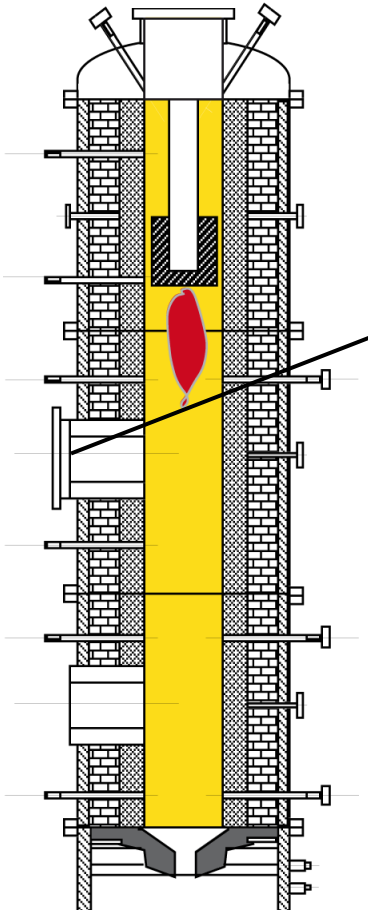
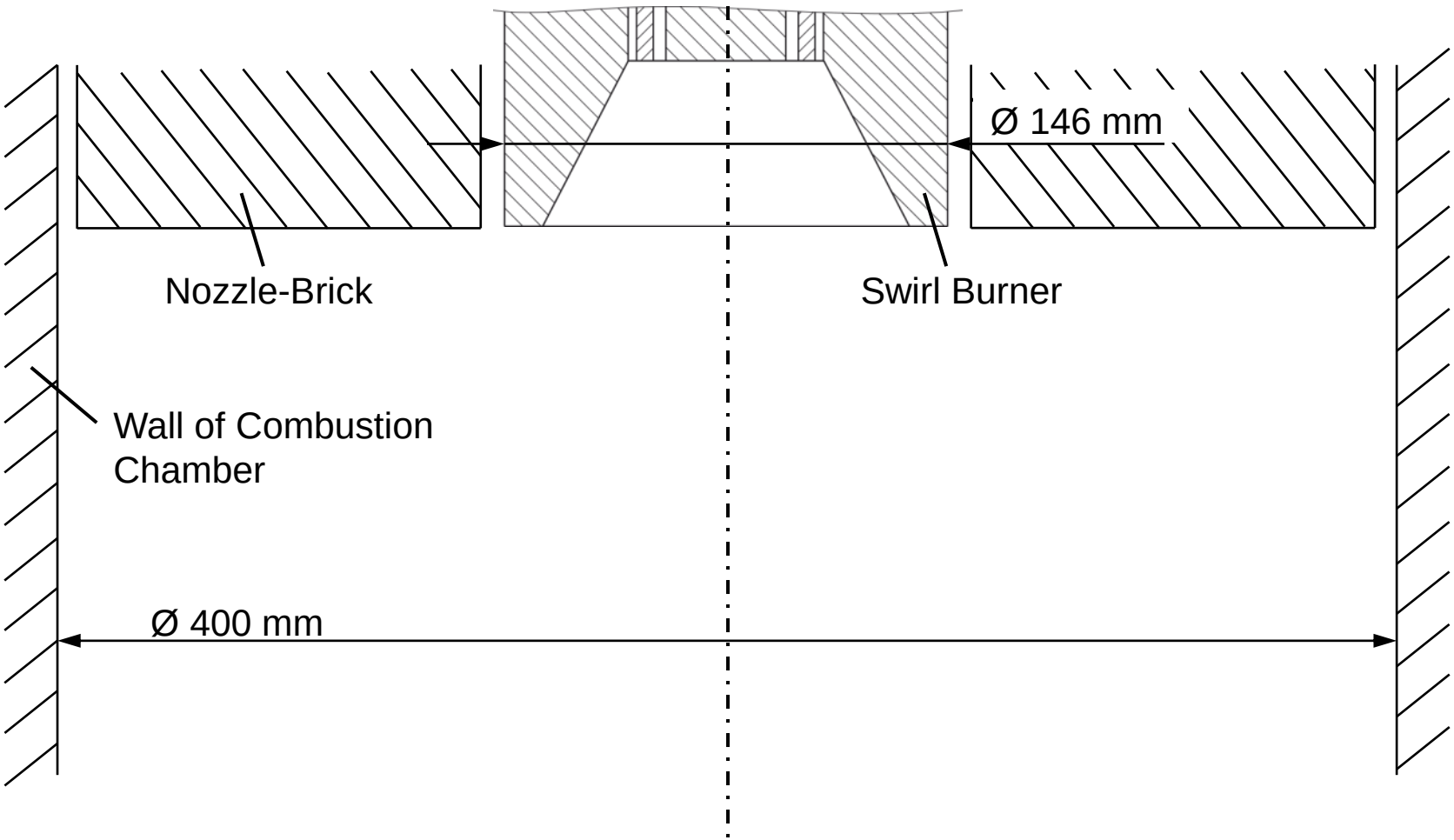
Measurement of OH*-Chemiluminescence

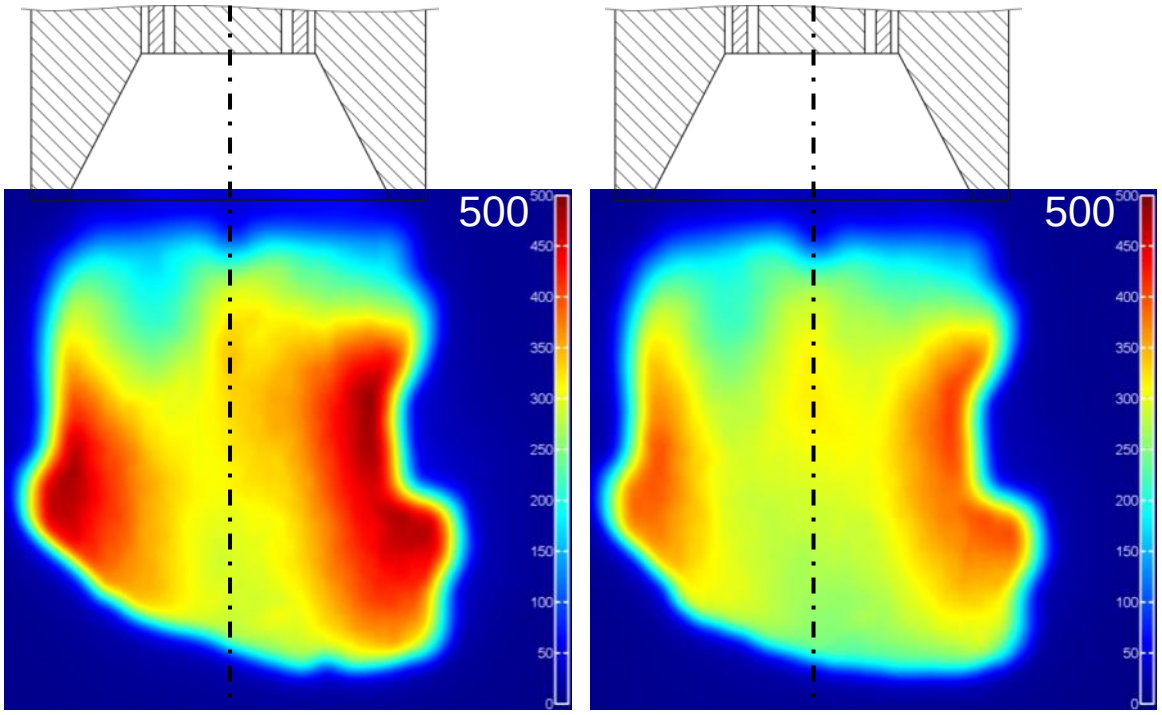




Arrangement/Position of Recorded Pictures



Chemiluminescence Results



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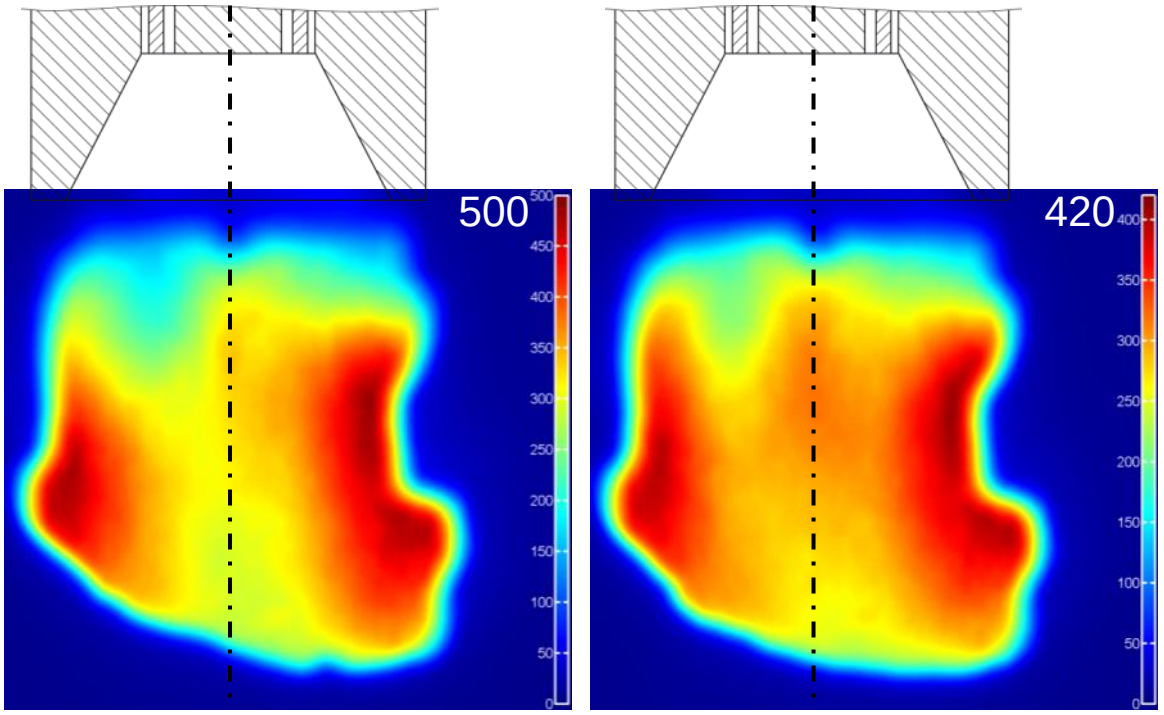

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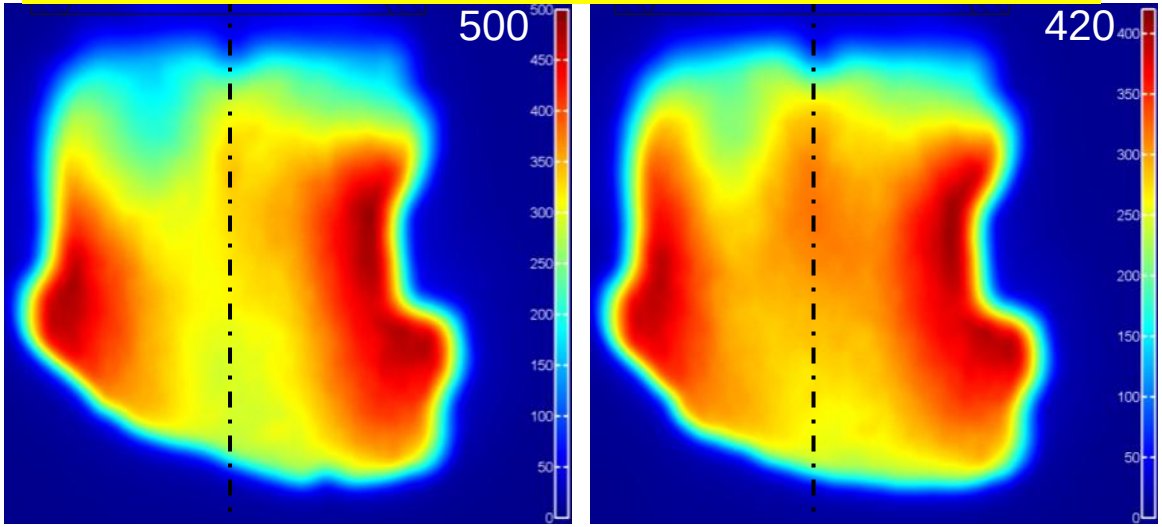
Chemiluminescence Results

Position of the reaction zone is not influenced by cofiring TBC



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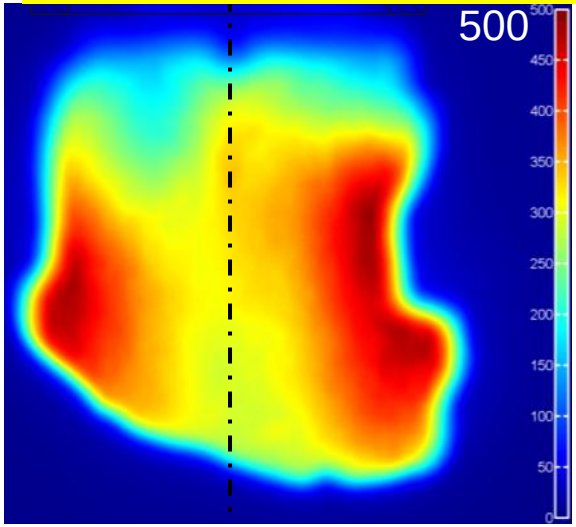
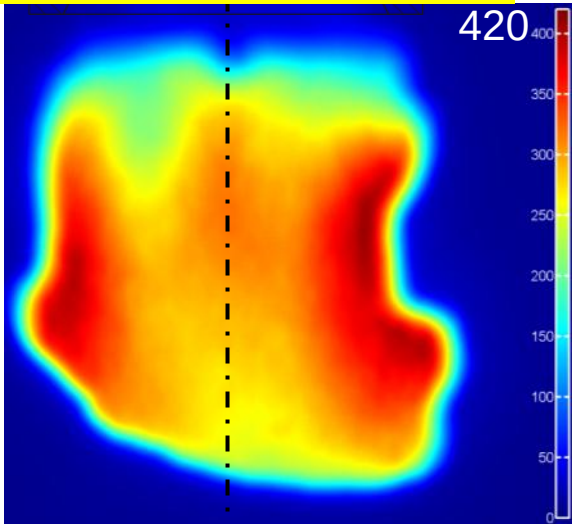
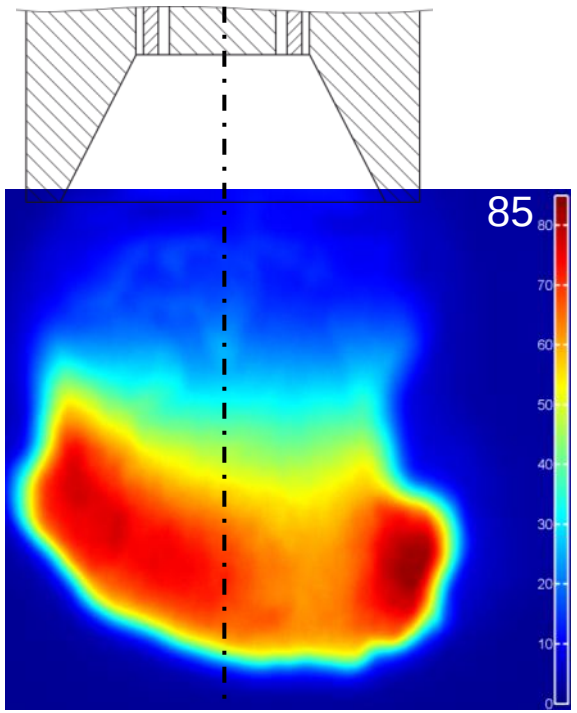


Air-RL



Air-RL/TBC



21/79 % O_2/CO_2-RL/TBC

RL = pre-dried **R**henish **L**ignite

TBC = **T**orrefied **B**eechwood **C**hips

Conclusion

- WSA's laboratory reactor → reproducible torrefaction
- Torrefaction improves grindability
- Ultimate analysis showed: wood 

lignite
- Cofiring high percentages of torrefied wood worked well

Acknowledgement for OXYCOAL-AC

Federal Ministry of Economics and Technology

BUSINESS. GROWTH. PROSPERITY.

Ministry of Innovation, Science, Research and Technology of the German State of North Rhine-Westphalia

RWE Power

E.ON Energy

Linde

MAN Diesel & Turbo

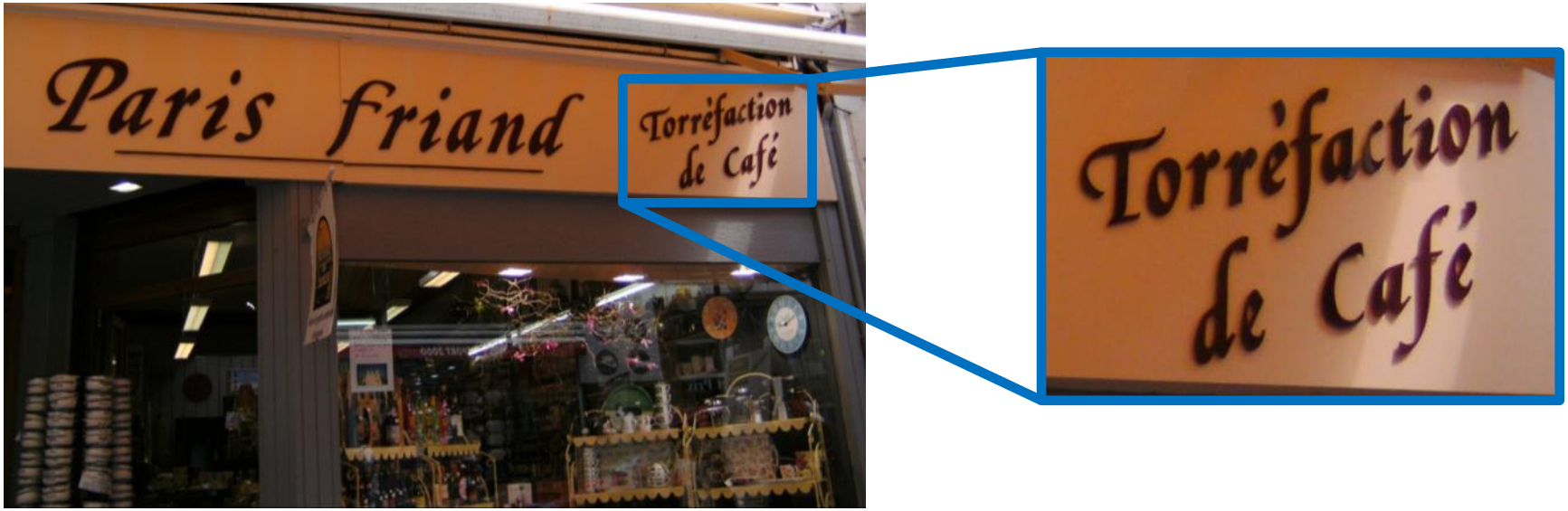
Hitachi Power Europe

WS Wärmeprozesstechnik

Backup

The Term „Torrefaction“

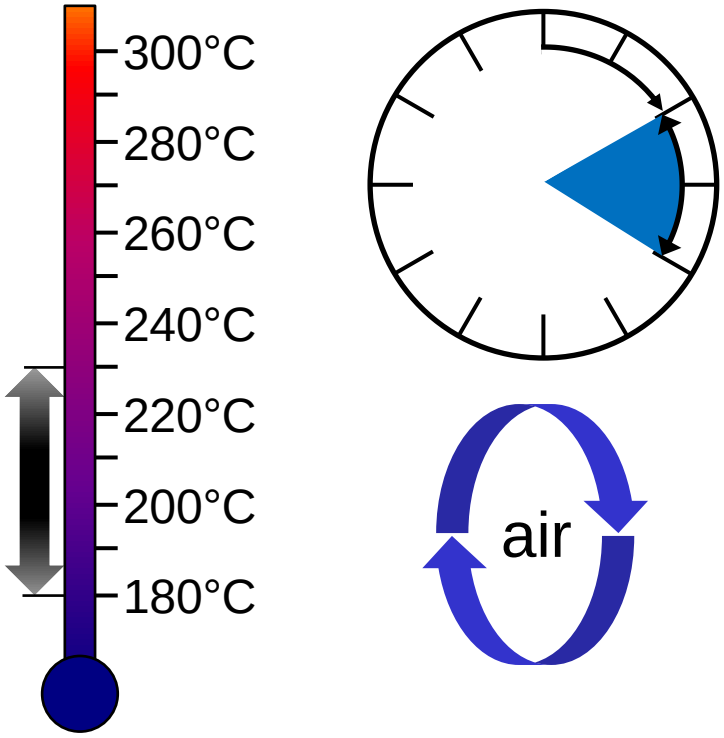
- lat. „torrere“, Meanings: roasting, baking, desiccation



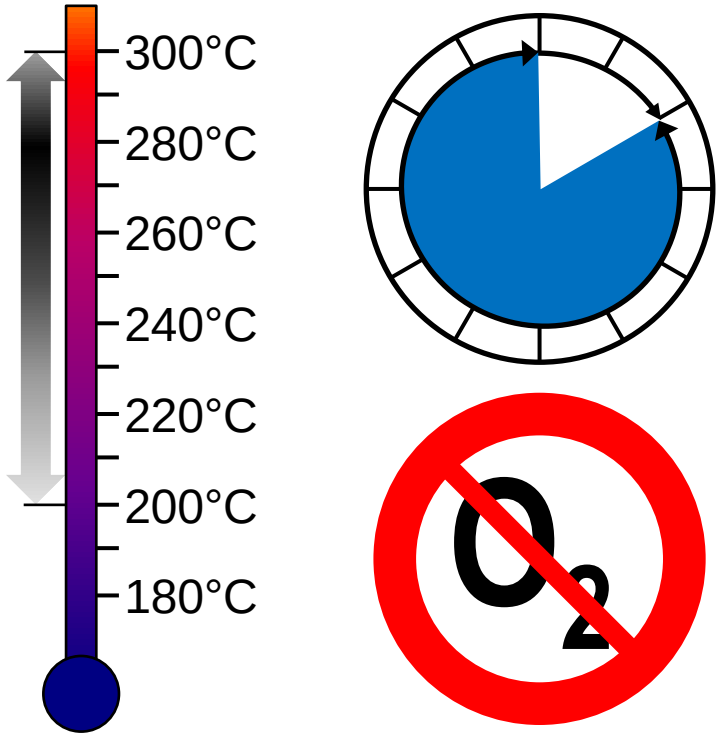
- French: torréfaction / = roasting = torrefaction
- English: roasting = torrefaction

Roasting Coffee vs. Torrefaction

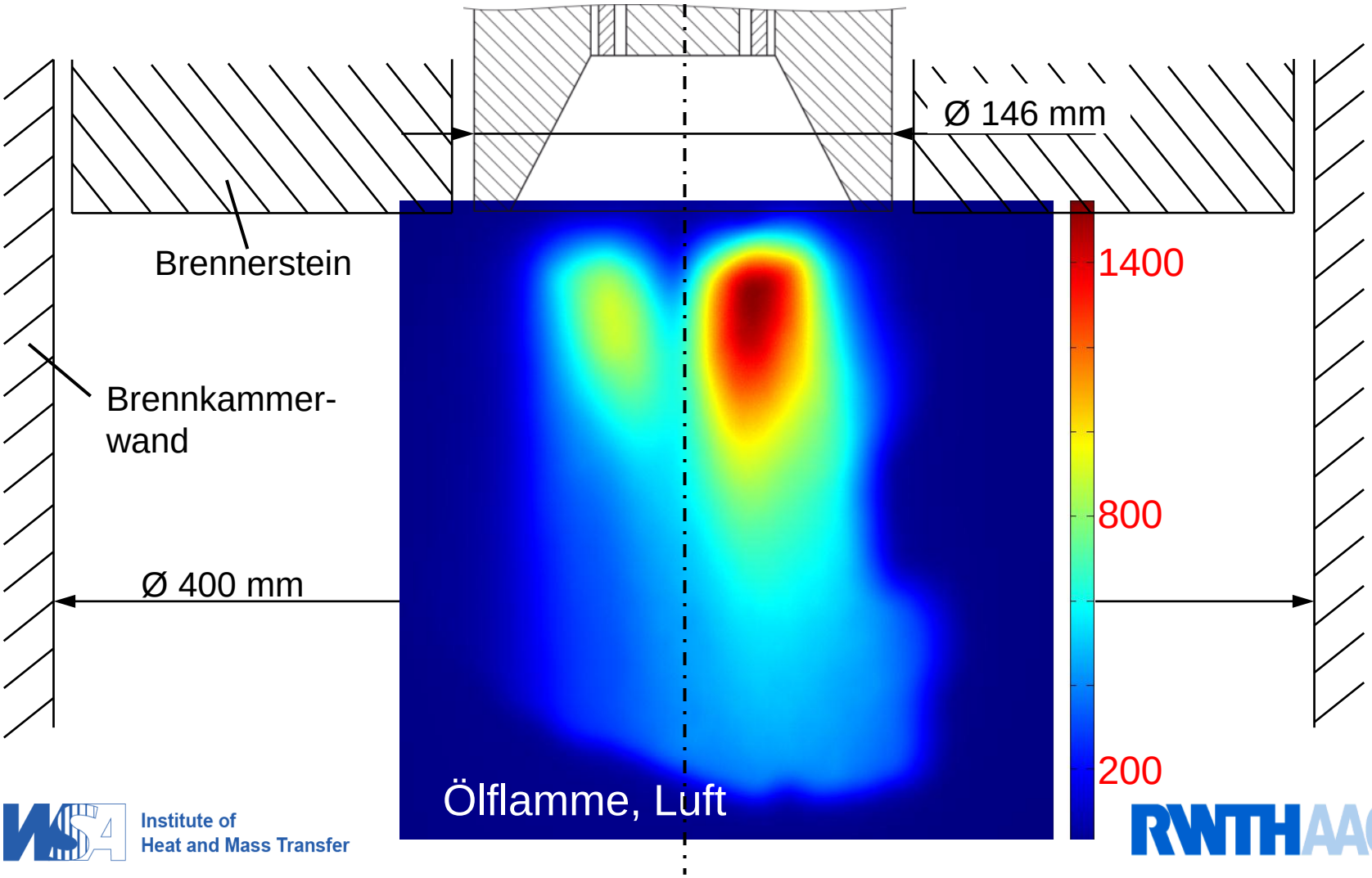
- Roasting Coffee



- Torrefaction



Position und Größe der Aufnahmen



Emissionen und Ausbrand bei Staubfeuerung

	Luftverbrennung nur RTBK	Luftverbrennung RTBK/tBS	Oxyfuelverbrennung RTBK/tBS
C in Asche [%]	0,7	1,6	1,2
CO Kamin [ppm]	2	2	10
SO_2 Kamin [ppm]	334	248	271
NO Kamin [ppm]	621	543	238