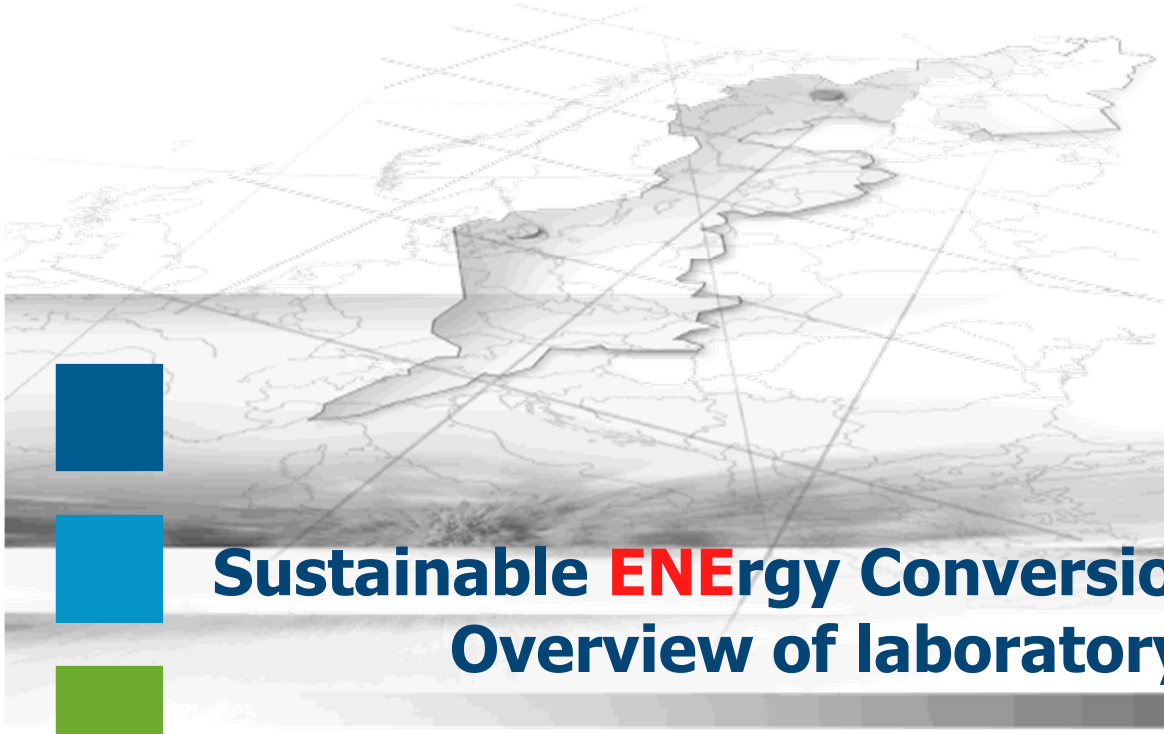
Fachhochschul
Studiengänge

Burgenland

Bildung im
Herzen Europas.



Jürgen Krail

ENEREED

# Sustainable ENErgy Conversion from REED Biomass
# Overview of laboratory and field test results

Reed as a Renewable Resource 2013; Greifswald

# Lake Neusiedl
# Facts and framework

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## ⇨ Lake Neusiedl – reed belt

- ⇨ Total area lake — 32,000 ha
- ⇨ Total area reed belt — 18,000 ha
- ⇨ Biomass potential [1] (Austria, except National park) — 84,000 $t_{(db)}$
- ⇨ Vegetation density [1] — 5 – 23 $t_{(db)}$/ha

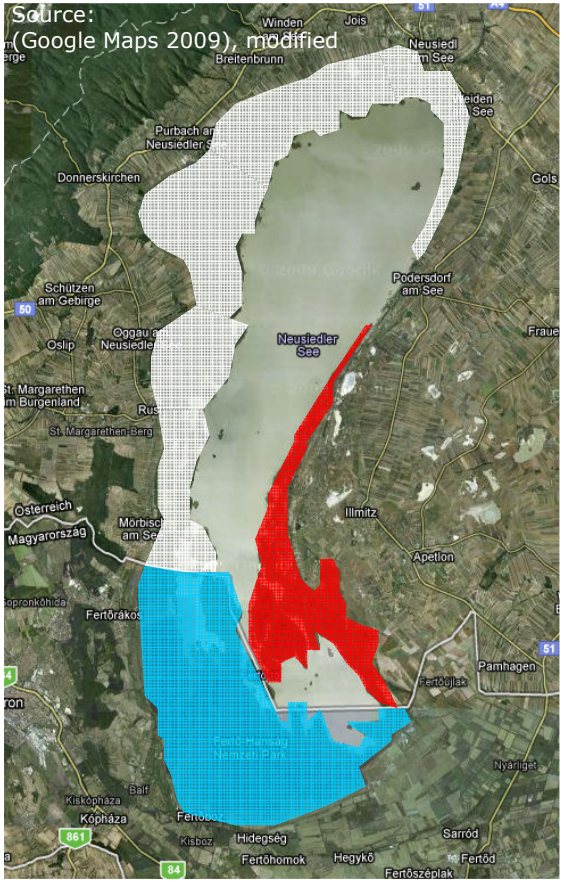
## ⇨ Nature conservation programms

- ⇨ National park Neusiedler See - Seewinkel
- ⇨ EU Natura 2000 – Landscape protection programm
- ⇨ UNESCO – World heritage site
- ⇨ UNESCO – Ramsar convention on wetlands

## ⇨ Management of ressources

- ⇨ Harvesting of reed for construction material (<10% of area)
- ⇨ No utilisation of fully grown reed at present

[1] Gamauf (2000): Satellitenbildauswertung des Schilfgürtels am Neusiedlersee zur Ermittlung von Rohstoffpotenzialen.




White area: Austrian territory, mostly available for harvesting.
Red area: Austrian territory, national park area.
Blue area: Hungarian territory.

# Aims of the project ENEREED
# Working schedule

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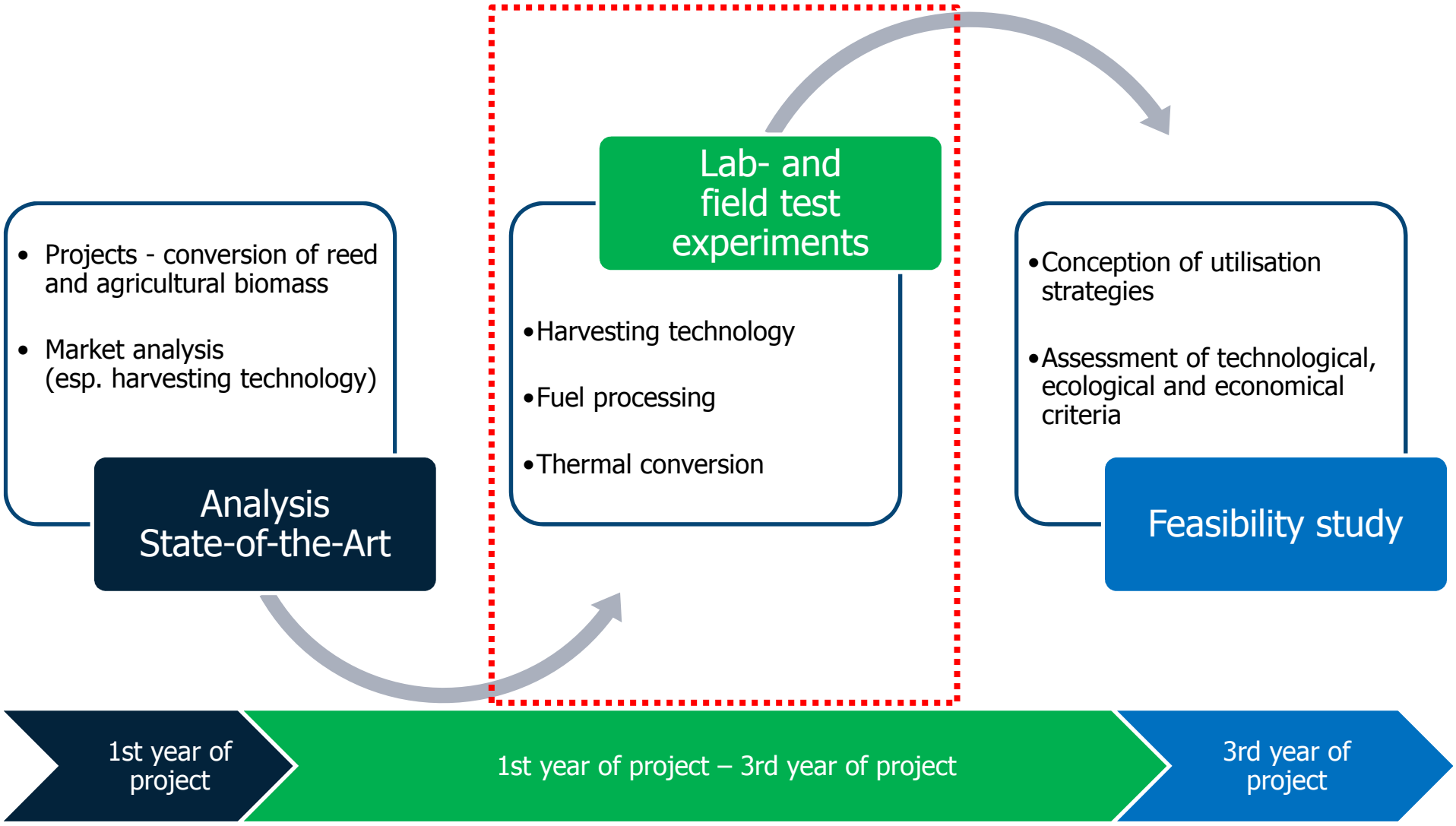

# Laboratory and field tests
# Investigated conversion paths

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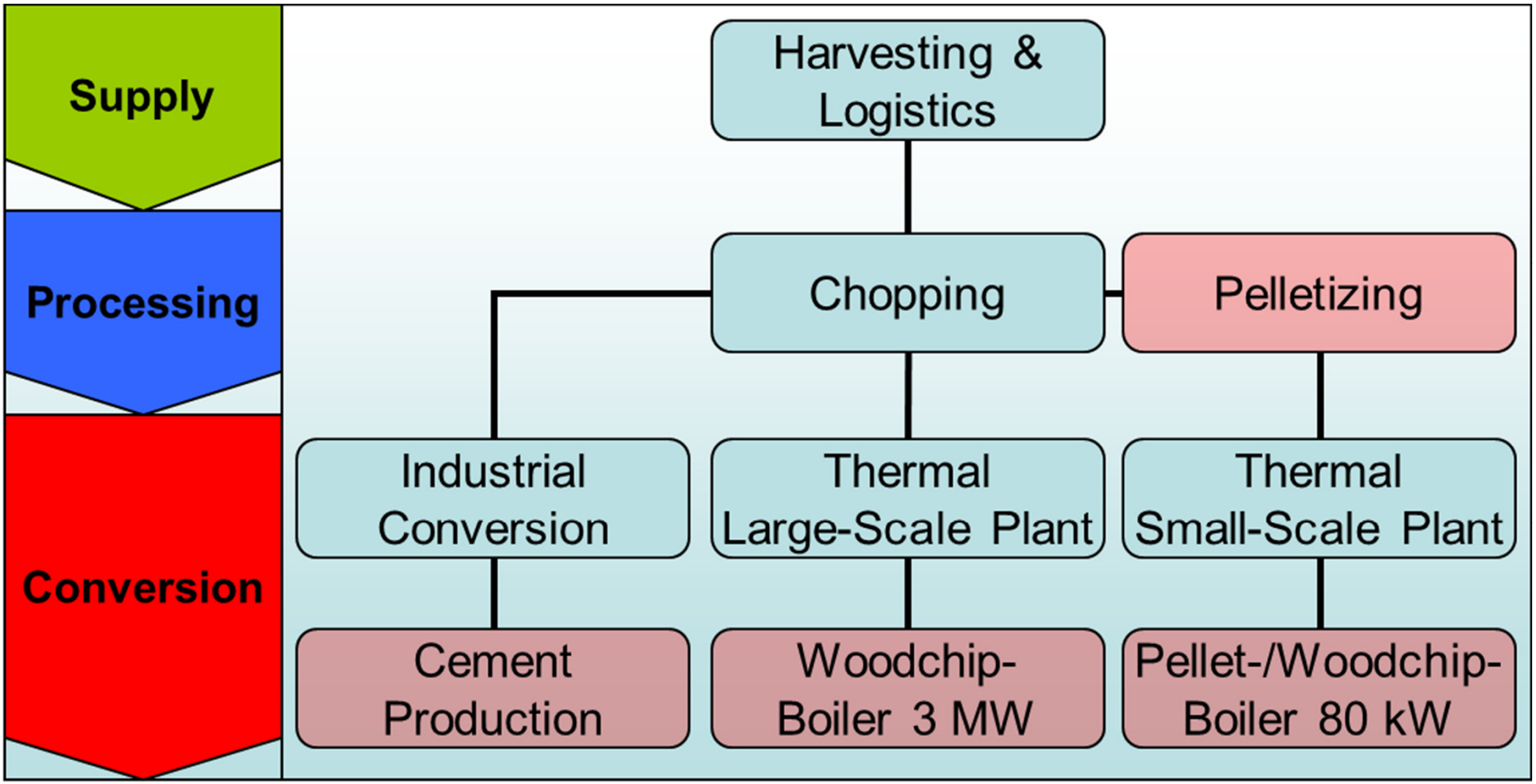

# Fuel properties of reed
# Qualitative comparison

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| | Common Reed [1,] | | Woody biomass [3,] | | Straw [3,] | | Grain whole crops [3,] | | Grain [3,] | | Grasses [3,] | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Ultimate analysis (dry mass)** | | | | | | | | | | | | |
| **C- Content [%]** | **45.48** | **[7]** | ↑↑ | [113] | ↔ | [128] | ↓ | [60] | ↓↓ | [65] | ↔ | [128] |
| **H- Content [%]** | **5.84** | **[7]** | ↑↑ | [76] | ↑ | [112] | ↑↑ | [57] | ↑↑ | [55] | ↑↑ | [158] |
| **O- Content [2,] [%]** | **40.52** | **[7]** | ↑ | [-] | ↓ | [-] | ↑↑ | [-] | ↑↑ | [-] | ↓↓ | [-] |
| **N- Content [%]** | **0.47** | **[7]** | ↓↓ | [133] | ↓ | [146] | ↑↑ | [66] | ↑↑ | [94] | ↑ | [204] |
| **S- Content [%]** | **0.07** | **[7]** | ↓ | [119] | ↑ | [141] | ↑↑ | [62] | ↑↑ | [66] | ↑↑ | [173] |
| **Cl- Content [%]** | **0.15** | **[7]** | ↓↓ | [122] | ↑↑ | [116] | ↓ | [56] | ↓↓ | [55] | ↑↑ | [116] |
| **Proximate analysis (dry mass)** | | | | | | | | | | | | |
| **Ash- Content [%]** | **7.47** | **[7]** | ↓↓ | [120] | ↓ | [145] | ↓↓ | [67] | ↓↓ | [64] | ↓ | [201] |
| **Volatiles [%]** | **76.98** | **[7]** | ↑ | [86] | ↓ | [76] | ↔ | [52] | ↑↑ | [49] | ↓↓ | [159] |
| **Lower heating value $H_{u,p,wf}$ [MJ/kg]** | **16.38** | **[7]** | ↑↑ | [115] | ↓↓ | [126] | ↓↓ | [58] | ↓↓ | [68] | ↓↓ | [218] |
| **Ash behaviour** | | | | | | | | | | | | |
| **Sintering temperature SIT [°C]** | **1409** | **[7]** | ↓↓ | [29] | ↓↓ | [48] | ↓↓ | [19] | ↓↓ | [13] | ↓↓ | [50] |
| **Softening temperature SOT [°C]** | **>1500** | **[7]** | ↓ | [34] | ↓↓ | [59] | ↓↓ | [19] | ↓↓ | [14] | ↓↓ | [62] |

↔ Basic value / equal to

↓ | ↑ Value lower (↓) / higher (↑) than basic value (basic value inside the typical range)

↓↓ | ↑↑ Value much lower (↓↓) / much higher (↑↑) than basic value (basic value outside of the typical range)

[1,] Based on a single sample – further analyses are required

[2,] Calculated value as residual value (100% minus average content ash, C, H, N, K)

[3,] Analyses from (Hartmann et al. 2000)

[###] Number of analysed samples

# Pelletizing lab scale plant
# Experimental setup

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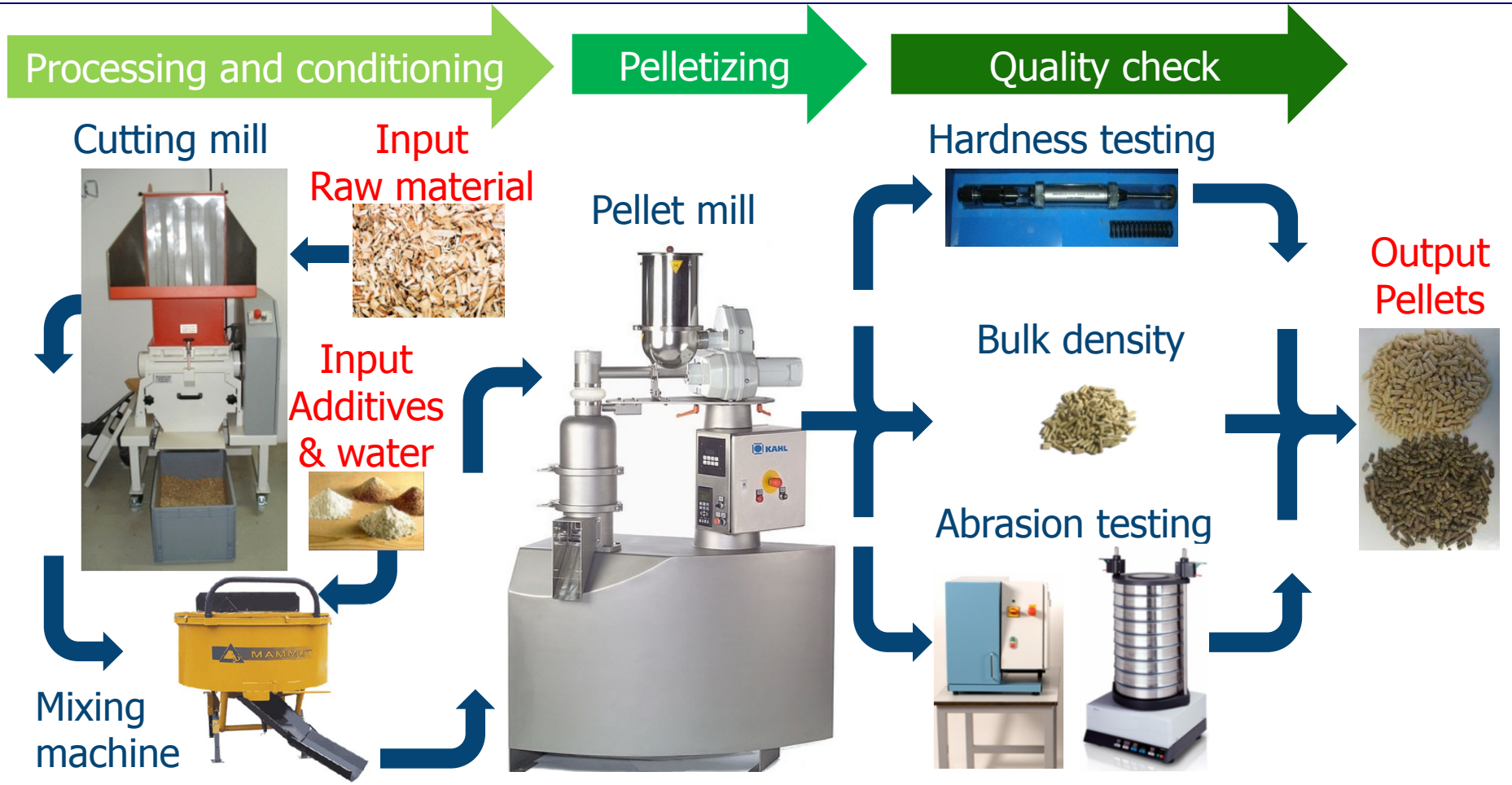


⇨ **Aim: Influence of conditioning, additives and pelletizing variables (die geometry – press ratio) to pellets quality**

# Pelletizing lab scale plant Results

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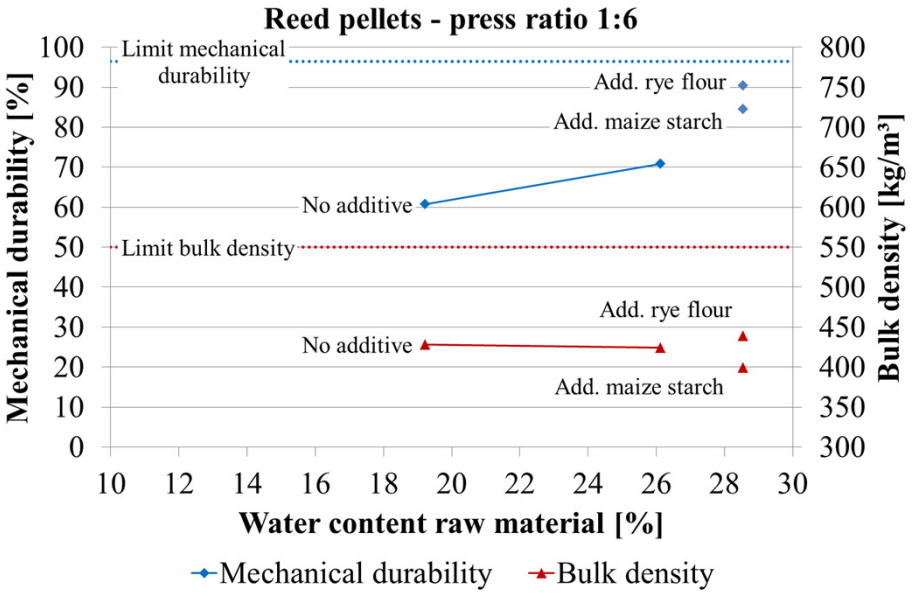


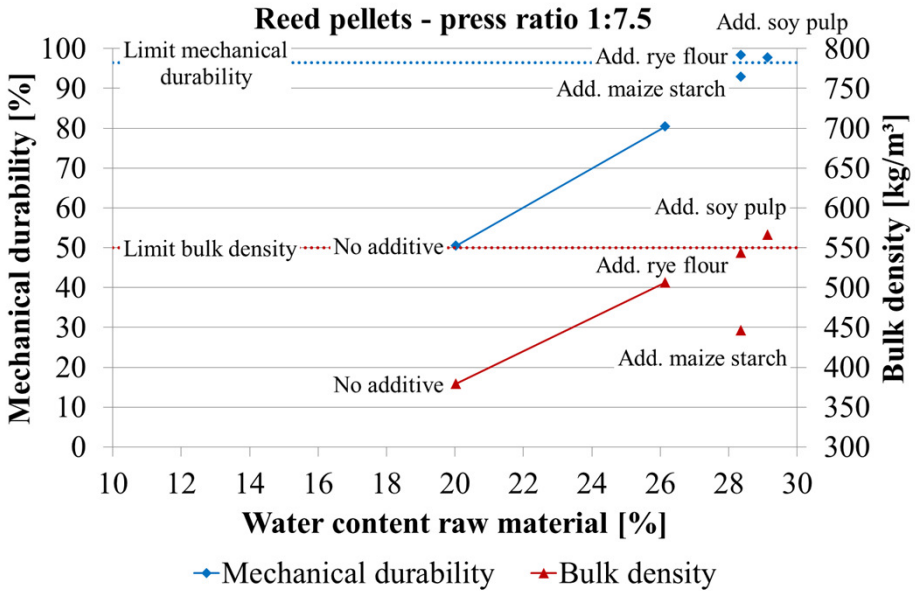


- ⇨ Reed is suitable for pelletizing under certain conditions
- ⇨ Rather high water content required
- ⇨ High press ratio improves pellets quality
- ⇨ Additive rye flour and soy pulp improves pellets quality
- ⇨ Limits of EN 14961-6 [1] for mechanical durability & bulk density can be reached

[1] EN 14961-6 (2012): Solid biofuels - Fuel specifications and classes: Non-woody pellets for non-industrial use.

# Thermal conversion small scale plant
# Experimental setup

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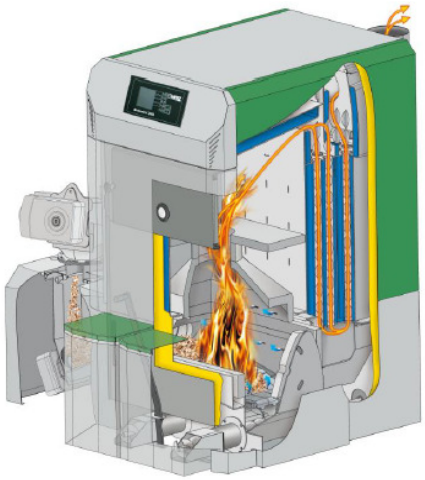
## ⇨ Combustion experiments in domestic wood-chip boiler

- ⇨ Boiler - nominal heat output 80kW with moving grate
- ⇨ Experiments with reed-/wood pellets in different mixtures, compared with wood chips
- ⇨ Boiler testing according to EN303-5[1] at boiler test stand




| 1) Boiler | 3) Flue pipe | 5) PM measuring instruments |
|---|---|---|
| 2) Biofuel container | 4) Emission measuring instruments | 6) Buffer tank |

| Measurement point | Unit |
|---|---|
| Mass flow heating circuit | kg/h |
| Mass biofuel | kg |
| Temperature heating water flow | °C |
| Temperature heating water return flow | °C |
| Temperature flue gas | °C |
| Particulate matter | $mg/m_N^3$ |
| $O_2$ | Vol. % |
| $CO_2$ | Vol. % |
| CO | ppm |
| $CH_4$ | ppm |
| NO | ppm |
| $NO_2$ | ppm |
| $SO_2$ | ppm |
| $CH_4$ or $C_xH_y$ | ppm |

[1] EN 303-5 (1999): Heating boilers for solid fuels, hand and automatically stocked, nominal heat output of up to 300 kW - Terminology, requirements, testing and marking.

# Thermal conversion small scale plant Results

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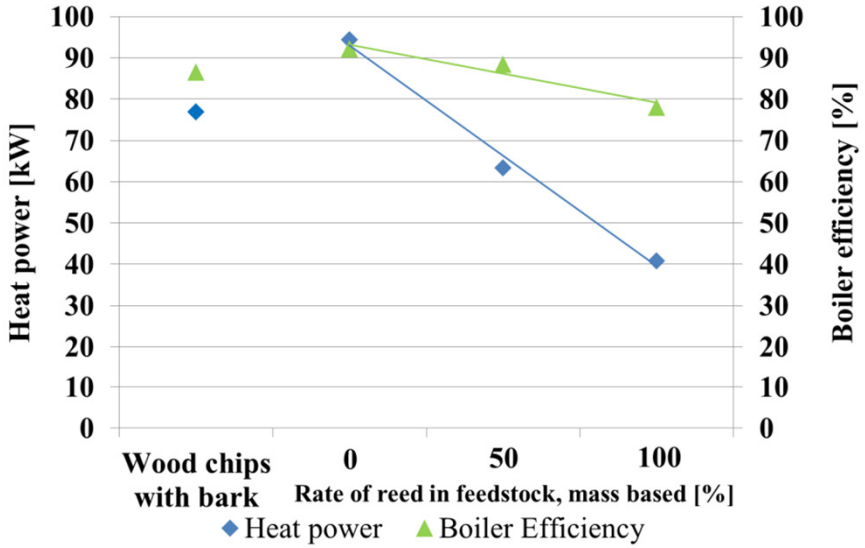


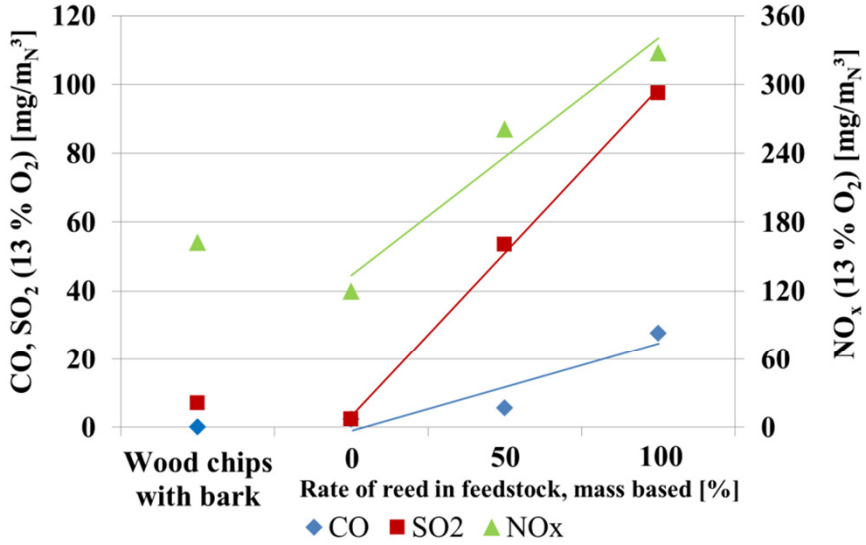


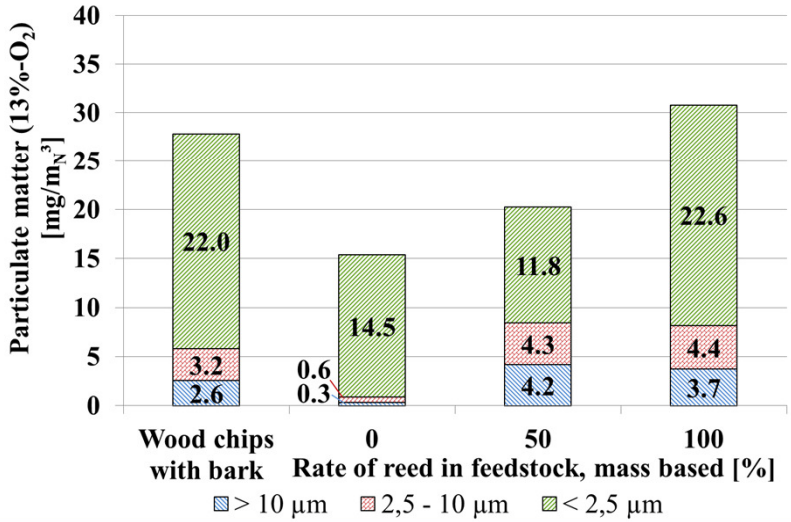

# Thermal conversion small scale plant Conclusion

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## ⇨ Boiler operation limits

- ⇨ High ash content of reed pellets requires adaption of ash discharging system
- ⇨ Increase of rate of reed in feedstock causes shorter ash discharging interval (=> unsteady conditions)
- ⇨ Rate of reed up to 75% mass portion is useful (criteria boiler efficiency)

## ⇨ Boiler emissions

- ⇨ Requirements of the federal law "Combustion Plant Regulation" (BGBl. II Nr. 312/2011) are met at all test runs

## ⇨ Measures for improvement

- ⇨ Continuously working ash-discharging system (no batch operation)
  - more steady combustion process
  - lower CO emissions (no CO peaks)
  - increase of boiler heat power output

# Thermal conversion large scale plant Experimental setup

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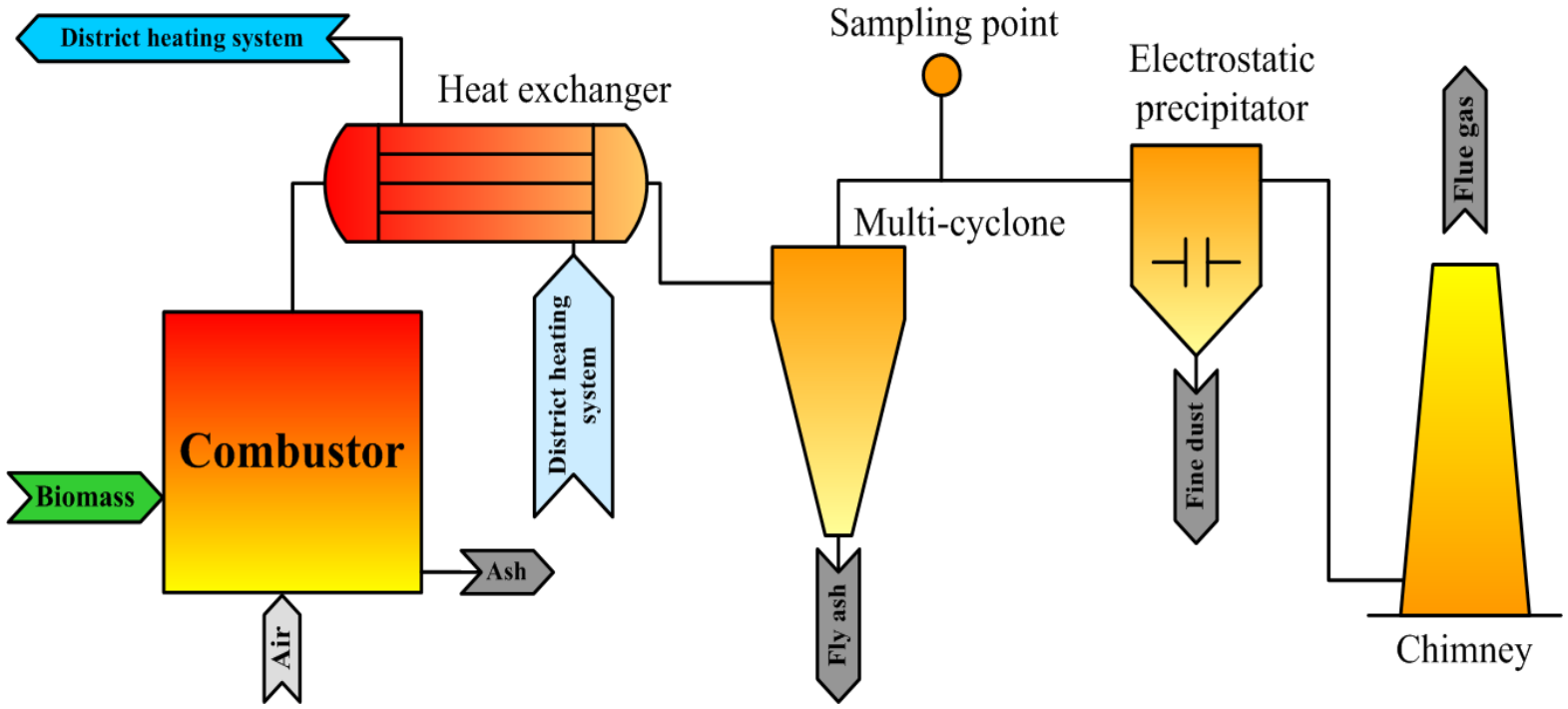
- **Combustion experiments in district heating plant**
  - Boiler - nominal heat output 3MW
  - Moving grate boiler with screw conveyors, designed for wood chips
  - Experiments with chopped reed / woodchips in different mixtures
  - Water content: reed = 12.5%, wood chips: 44%



# Thermal conversion large scale plant Results

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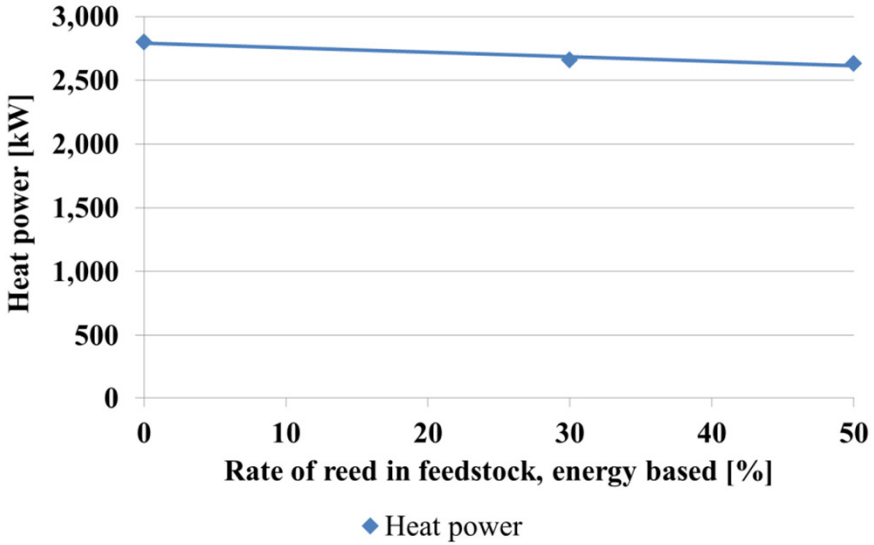


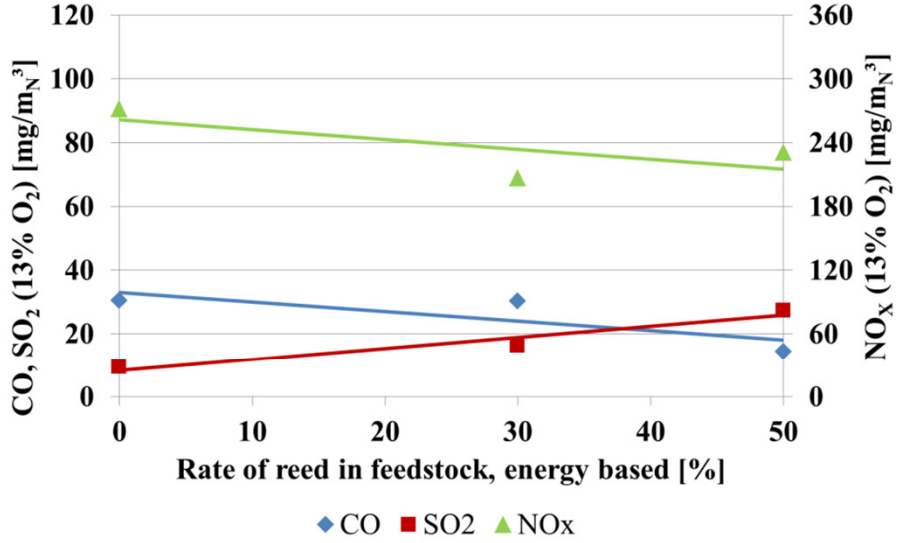


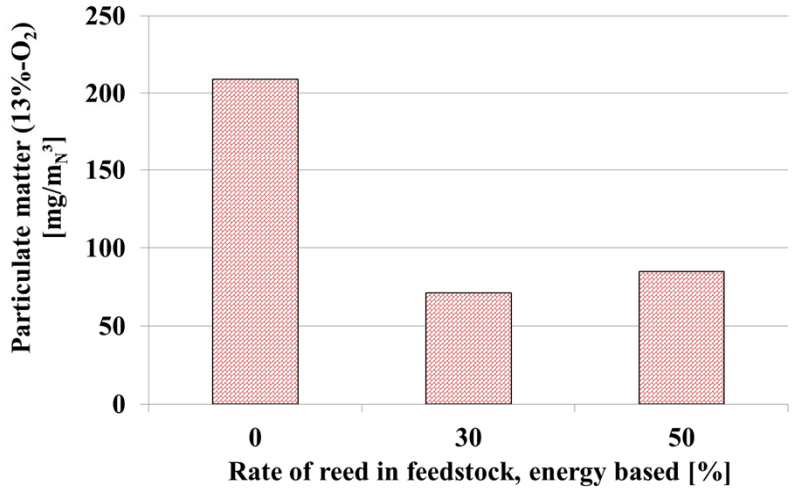

# Thermal conversion large scale plant Conclusions

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- **Boiler operation limits**
  - 100% chopped reed – short run because of feeding problems:
    - feeding problems with hydraulic push floor (designed for wood chips)
    - no operational problems in combustion process during short run
- **Boiler emissions**
  - Requirements of emission limits are met with a rate of reed up to 50% (energy based)
    - Combustion Plant Regulation (BGBl. II Nr. 312/2011)
    - Ordinance on Waste Incineration (BGBl. II Nr. 476/2010)
- **Measures for improvement**
  - Modification of feeding system

# Industrial conversion - cement industry
# Experimental setup

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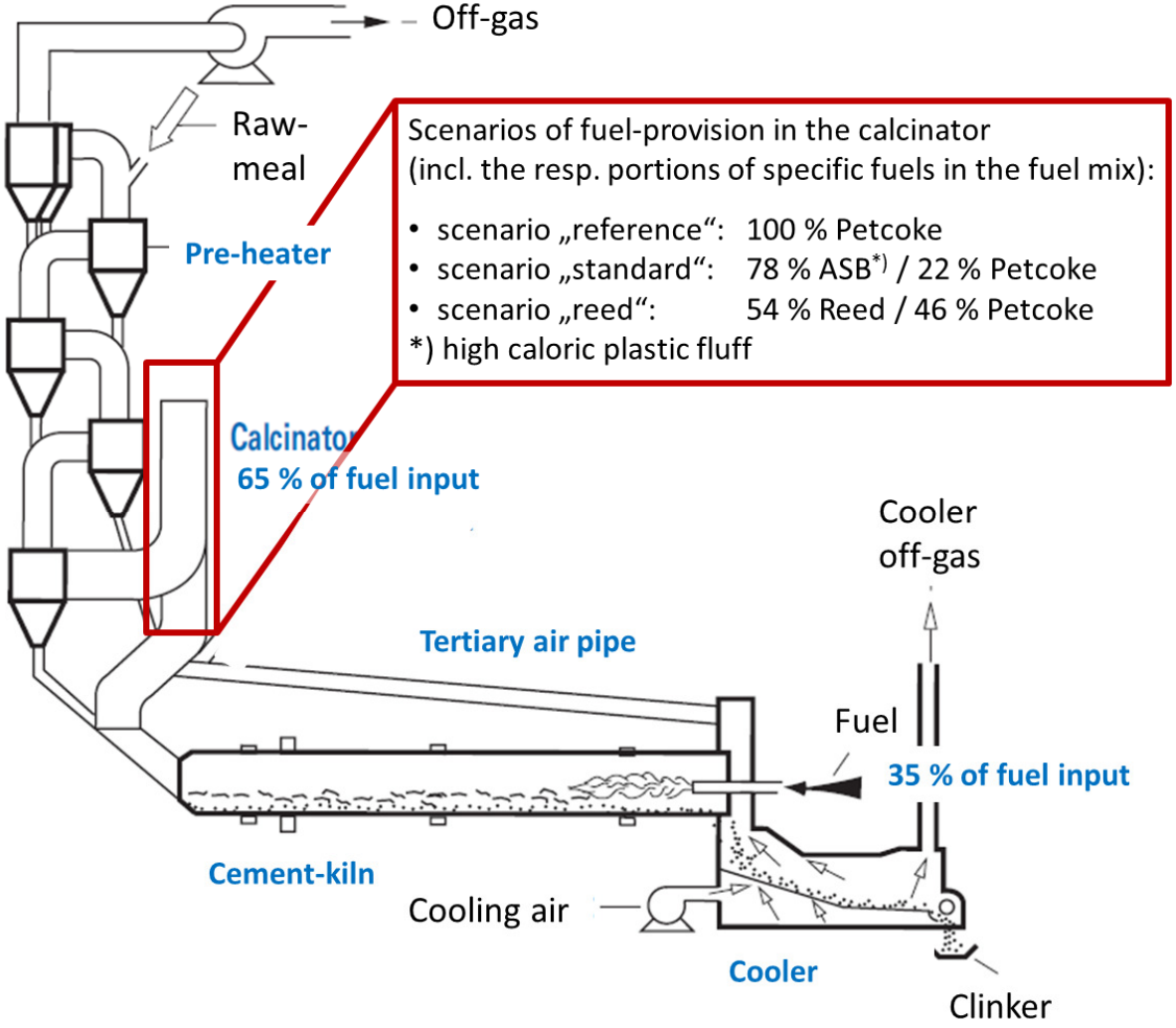


⇨ **Pre-test**

duration test run: 2 h
reed-quantity: 18.56 t

⇨ **Aim**

testing of fuel feeding installations

⇨ **Main-test**

duration test run: 30 h
reed-quantity: 252 t

⇨ **Aim**

testing of max. substitution-rate with focus on

- clinker quality
- process stability and
- emission limit values

# Industrial conversion - cement industry Results

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| | Scenario „reference" | Scenario „standard" | | Scenario „reed" | |
|---|---|---|---|---|---|
| | **PetCoke** | **ASB*)** | **PetCoke** | **Reed** | **PetCoke** |
| Energy input in calcinator [%] | 100% | 78.2% | 21.8% | 57.8% | 42.2% |
| Water content (as received) [%] | 7% | 12% | 7% | 16.7% | 7% |
| Caloric value [GJ/$t_{as\ received}$] | 33.0 | 20.5 | 33.0 | 13.7 | 33.0 |
| Emission factor [$t_{CO2fossil}$ / $t_{fuel\ as\ received}$] | 3.0 | 1.4 | 3.0 | 0 | 3.0 |
| $CO_{2fossil}$ emitted [%] (in relation to scenario „reference") | 100% | 84.3% | | 42.2% | |

*) high caloric plastic fluff

# Industrial conversion - cement industry Conclusions

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**Based on a state-of-the-art plant lay-out including most recent technology:**

- ⇨ Reed may basically be used as alternative fuel in cement production.
- ⇨ The utilization of reed as alternative fuel can reduce fossile $CO_2$-emissions significantly.
- ⇨ Reed ash remains in the product stream => material utilisation.

# Conclusion and Outlook

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- **Biomass potential**
  - Large reed potentials available:
    84,300 t total biomass potential in Austria

- **Reed for thermal utilisation**
  - Suitable for a wide range of technologies
  - Emissions limits met
  - Limiting factor: ash content

- **ToDo's for implementation**
  - Cement industry: no process-related restrictions, focus on fuel handling
  - Thermal conversion small & large scale plant:
    - long duration tests with monitoring in real plant operation
    - evaluation of maintenance intensity, reliability, risk of corrosion
  - Small scale plant: boiler- type testing for reed/mixed pellets

# Contact
# Research & Cooperation Partners


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