Assessing the technical feasibility of value chains for Reed based biofuels

ENEREED
Sustainable Energy Conversion from Reed Biomass

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BRINGT BESONDERES ZUSAMMEN

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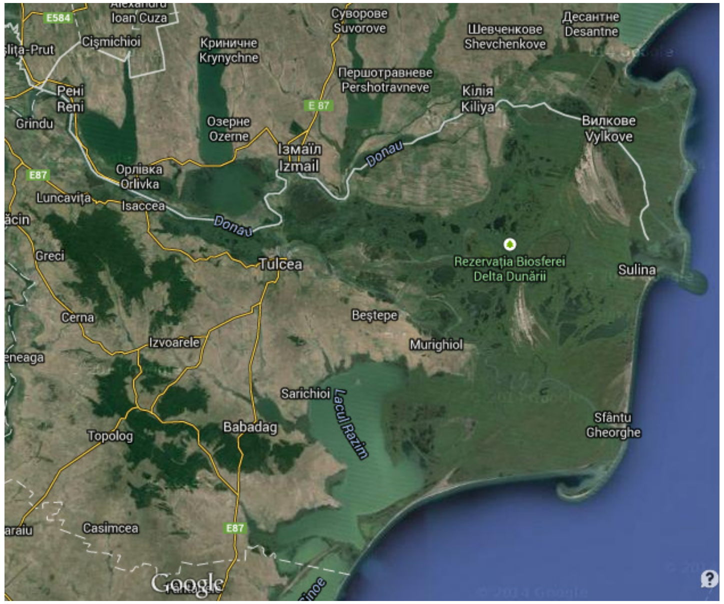
Energy from reed biomass
Reed potentials in the Danube Region

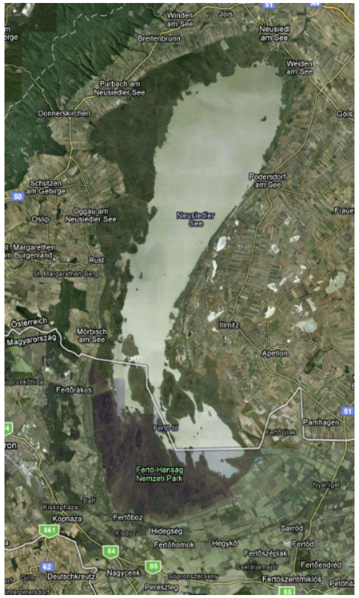
Eastern Europe – Danube Delta:

- Worlds largest connected reed area
- Total area: 200,000ha

Central Europe – Fertő/Lake Neusiedl:

- Largest reed area in Central Europe
- Total area: 18,000ha





Energy from reed biomass
Key facts, current situation Fertő/Lake Neusiedl

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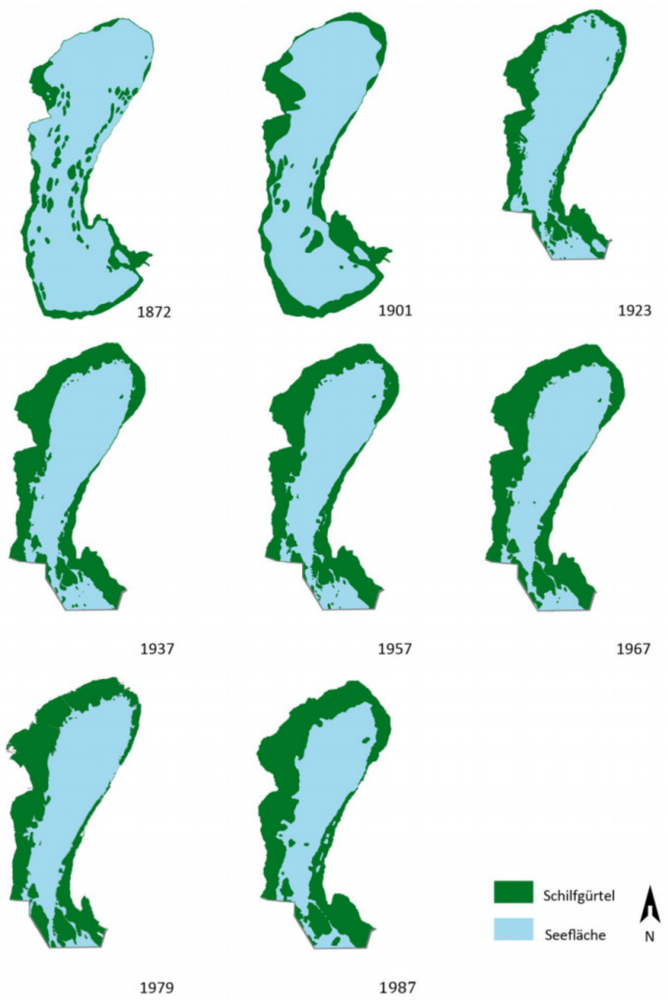
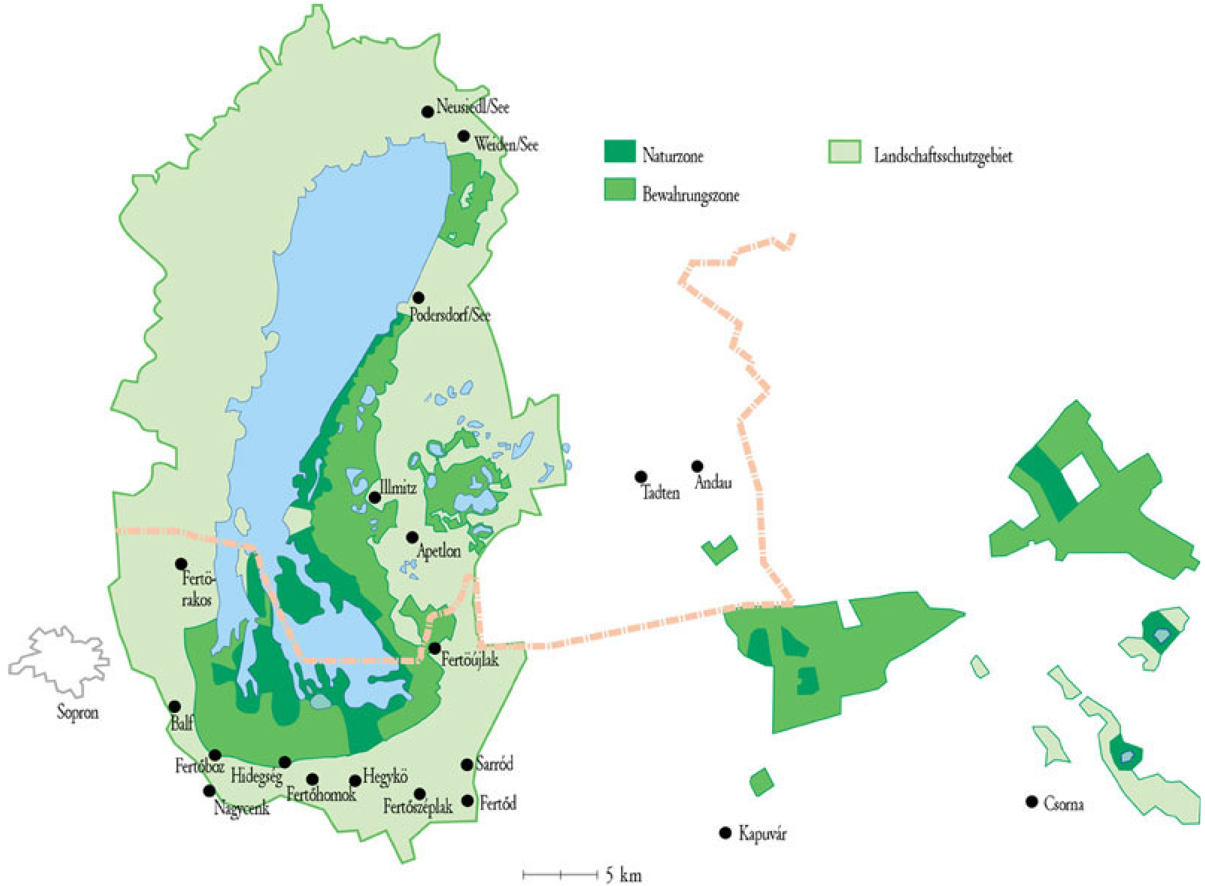
- Extension reed belt: transnational Hungary (8,000ha) and Austria (10,000ha)
- Specific area yield: 5 – 23 t_{DM}/ha
- Total biomass potential for harvesting: 84,000t_{DM} (only Austrian territory)
- Nature conservation programs:
  - Fertő-Hanság Nemzeti Park, National Park Neusiedler See - Seewinkel
  - EU Natura 2000 – Landscape protection program
  - UNESCO – World heritage site
  - UNESCO – Ramsar convention on wetlands
- Management of resources:
  - Harvesting of reed for construction material (<10% of area)
  - No utilisation of fully grown reed for heating purposes
- Environmental impacts: deterioration of water quality, silting up of the lake

Reed belt expansion at Fertő/Lake Neusiedl National Park Areas



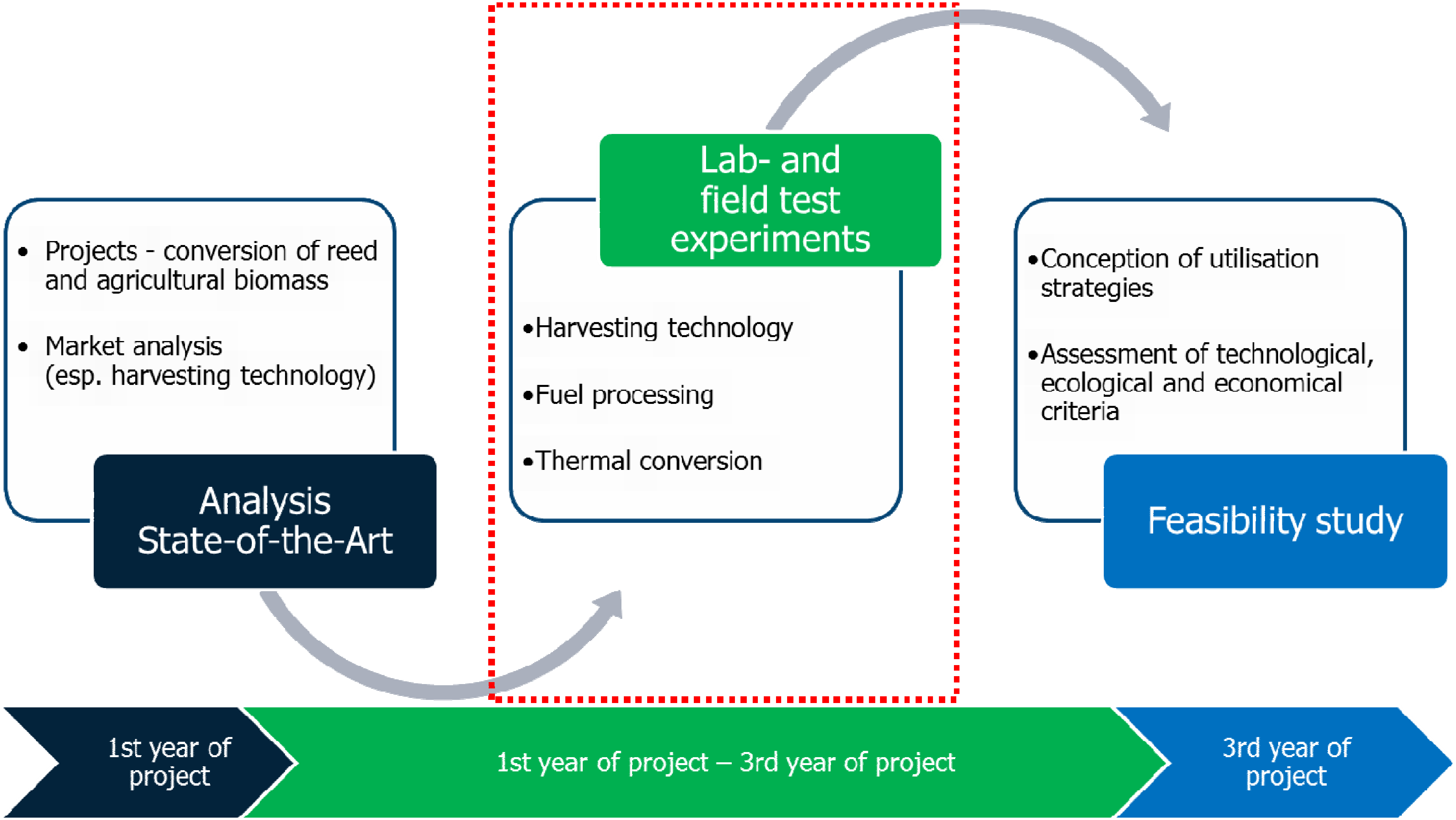
Führer, E.: Schnittpunkte der Schilfwirtschaft und des Naturschutzes am Neusiedler See, 2010

Light green area: mostly available for harvesting
Medium green area: national park, limited harvesting
Dark green areas: national park, no harvesting allowed

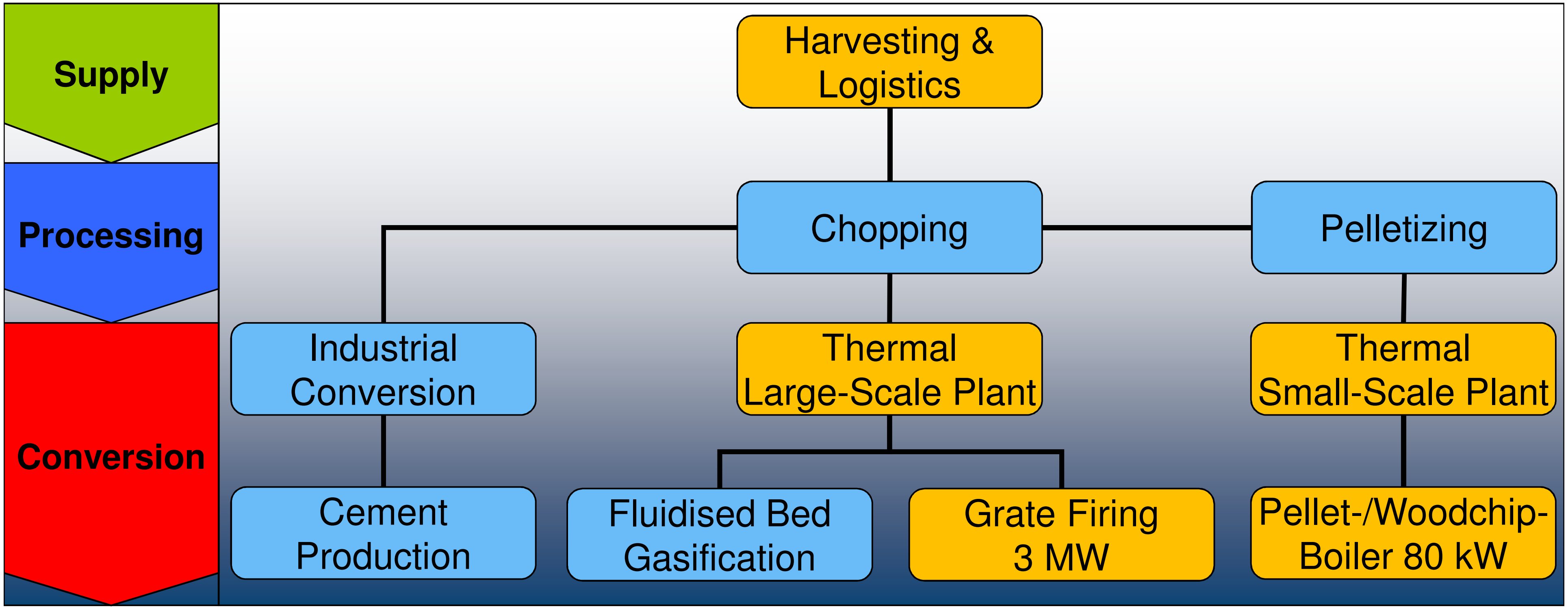


Nationalpark Neusieder See - Seewinkel (Ed.): Nationalpark Neusiedlersee Seewinkel - Eckdaten 2009

Energy from reed biomass
Project overview



Energy from reed biomass
Investigated conversion paths



Fuel properties of reed
Comparison to different biofuels

	Unit	Reed		Woody biomass [2]		Straw [2]		Grain whole crops [2]		Grain [2]		Grasses [2]	
Ultimate analysis (dry mass)													
C- Content	$\%_{db}$	45.48	[7]	↑↑	[113]	↔	[128]	↓	[60]	↓↓	[65]	↔	[128]
H- Content	$\%_{db}$	5.84	[7]	↑↑	[76]	↑	[112]	↑↑	[57]	↑↑	[55]	↑↑	[158]
O- Content[1]	$\%_{db}$	40.52	[7]	↑	[-]	↓	[-]	↑↑	[-]	↑↑	[-]	↓↓	[-]
N- Content	$\%_{db}$	0.47	[7]	↓↓	[133]	↓	[146]	↑↑	[66]	↑↑	[94]	↑	[204]
S- Content	$\%_{db}$	0.07	[7]	↓	[119]	↑	[141]	↑↑	[62]	↑↑	[66]	↑↑	[173]
Cl- Content	$\%_{db}$	0.15	[7]	↓↓	[122]	↑↑	[116]	↓	[56]	↓↓	[55]	↑↑	[116]
Proximate analysis (dry mass)													
Ash- Content	$\%_{db}$	7.47	[7]	↓↓	[120]	↓	[145]	↓↓	[67]	↓↓	[64]	↓	[201]
Volatiles	$\%_{db}$	76.98	[7]	↑	[86]	↓	[76]	↔	[52]	↑↑	[49]	↓↓	[159]
Lower heating value $H_{u,p,db}$	MJ/kg	16.38	[7]	↑↑	[115]	↓↓	[126]	↓↓	[58]	↓↓	[68]	↓↓	[218]
Ash melting 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] Calculated value as residual value (100% minus average content ash, C, H, N, K)

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

[###] Number of analysed samples

Harvesting technologies for reed

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Conventional harvesting | vs. | Harvesting with increased degree of mechanisation

- Reaper-binder (bundles)
- Harvesting for construction purposes

\- Higher demand of staff- resources (5 workers needed)

\+ Lower ground pressure: 980 kg/m²

\+ State-of-the Art technology

- Reaper-baler (round bales)
- Harvesting of reed for energy purposes

\+ Lower demand of staff- resources (1-2 workers needed)

\- Higher ground pressure: 1,220 kg/m²

\- Prototype with development demand

–Harvesting at water depth < 40cm or frozen ground

Harvesting technologies for reed
Operational Characteristics

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Conventional harvesting	vs.	Harvesting with increased degree of mechanisation

- Power of diesel engine: 118 kW
- Fuel consumption: 6.3 l/h

- Storage capacity (bundles): 1,850 kg

- Surface related yield (base): 5.5 t_{WB}/ha
- Duration of mowing route: 1.0 h/route
- Distance of mowing: 1,180 m

- Hourly harvesting output: 1.4 t_{WB}/h

- Power of diesel engine: 142 kW
- Fuel consumption: 10.0 l/h

- Storage capacity (bales): 760 kg

- Surface related yield (base): 6.2 t_{WB}/ha
- Duration of mowing route: 0.55 h/route
- Distance of mowing: 430 m

- Hourly harvesting output: 1.1 t_{WB}/h

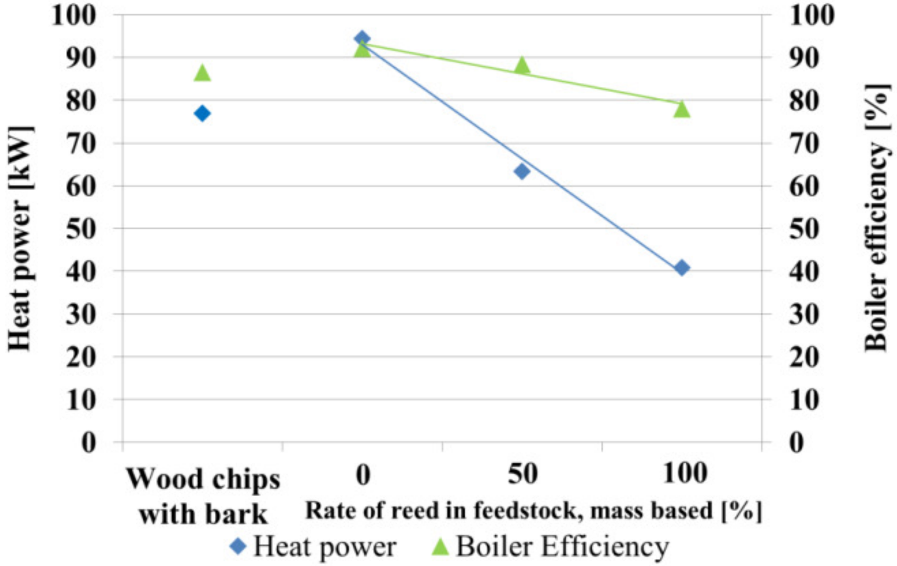
Energy conversion small scale plant
Domestic heating - Pellet/wood chip boiler

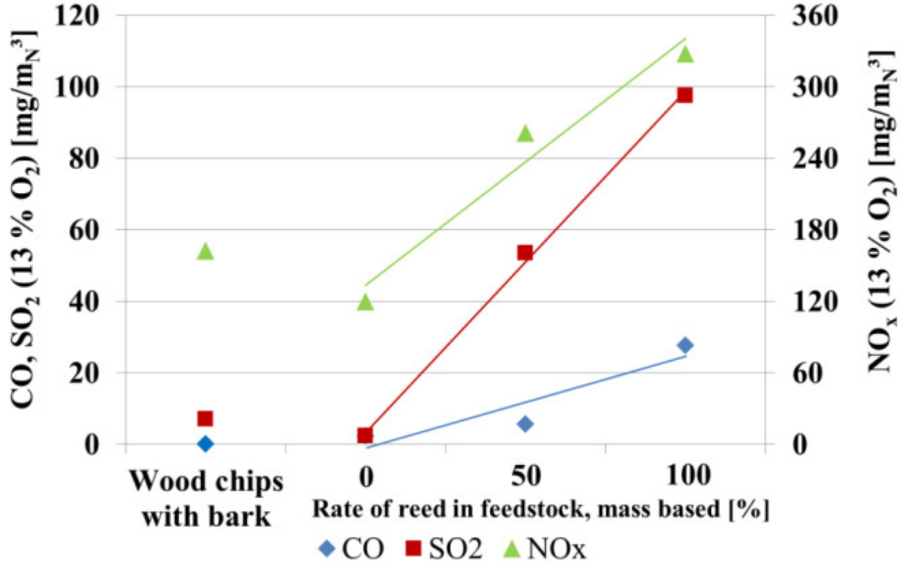
- Pellet/woodchip boiler: HERZ firematic 80
- Test procedure: ÖNORM EN 303-5 (1999)
- Objective: Maximum heat power output under complete combustion conditions

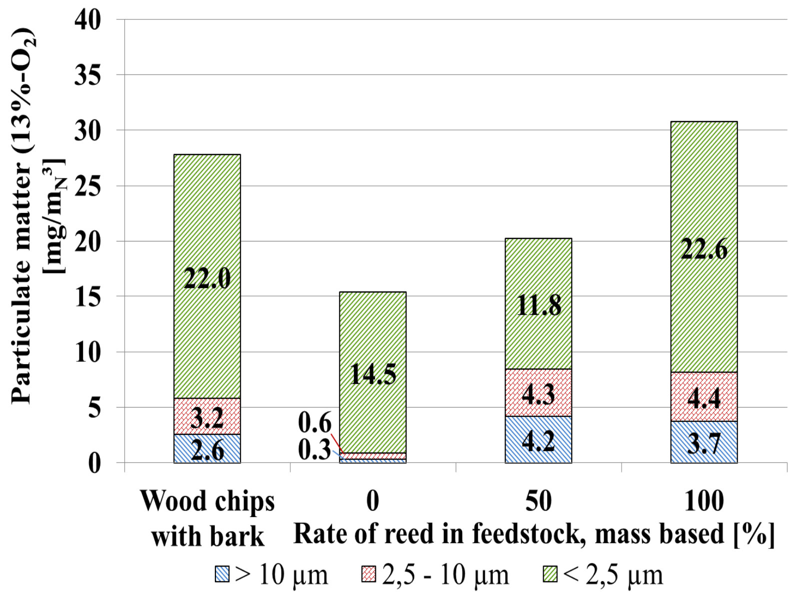
- Tested biofuels:
  - Reed pellets
  - Wood pellets
  - Wood chips with bark

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

Energy conversion small scale plant
Domestic heating - Results of test runs





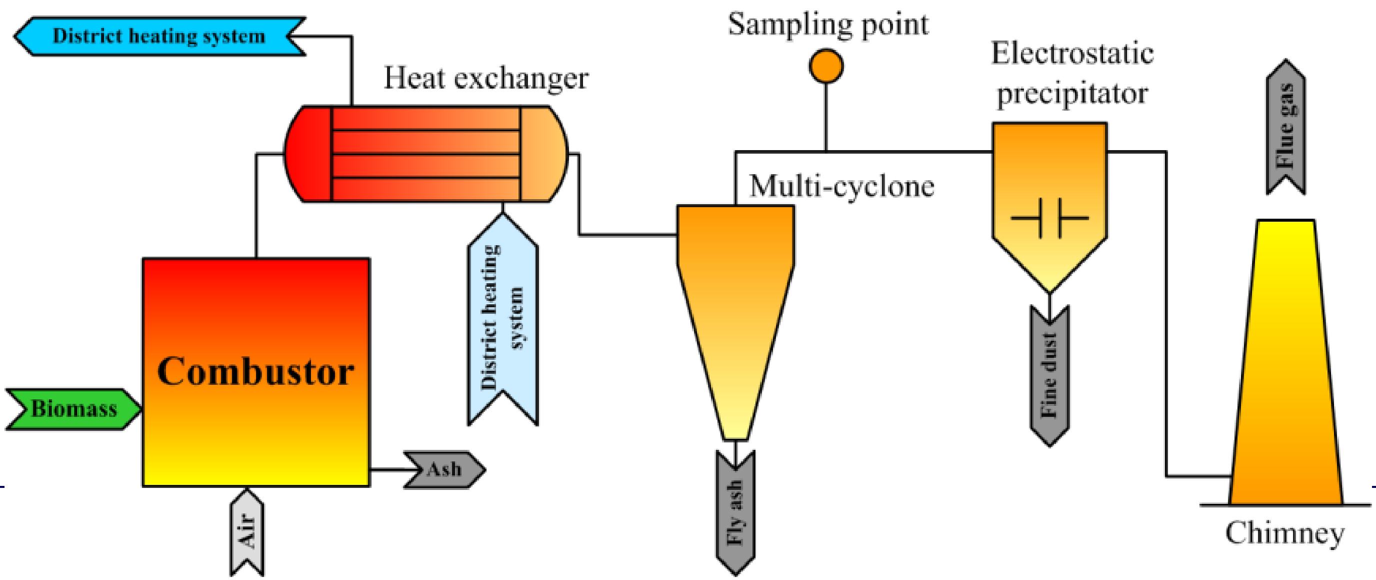


Energy conversion small scale plant
Domestic heating - Conclusion

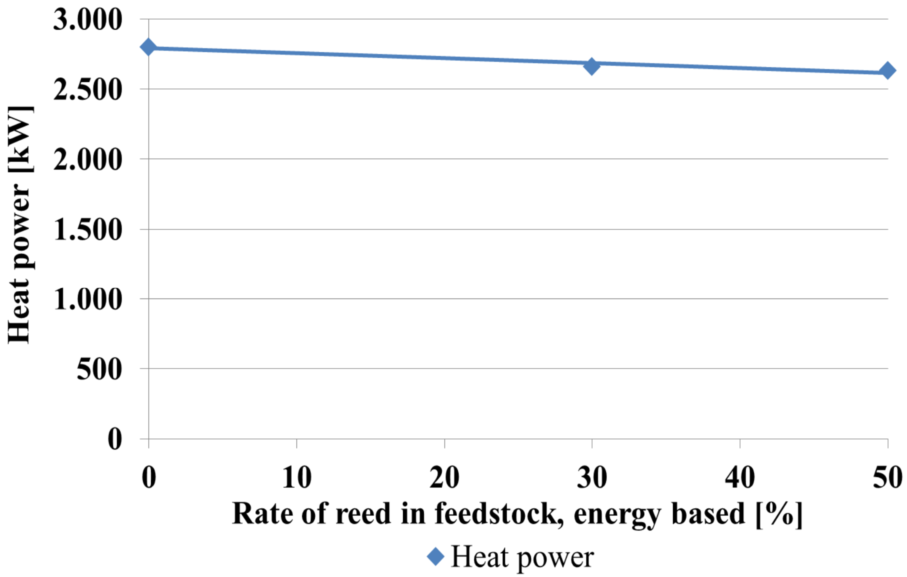
- Fuels with high ash content can cause
  - shorter ash-discharging interval
  - unsteady combustion process (→ CO-peaks)
- Ash content is limiting factor in combustion → adaptions on the ash-discharging system
- When mass fraction of reed increases
  - lower heat power output
  - higher emissions
- Boiler efficiency: maximum 75 % mass portion of reed pellets combustion is recommended
- Emissions meet the requirements of the Austrian federal law "Combustion Plant Regulation (BGBl. II Nr. 312/2011)"

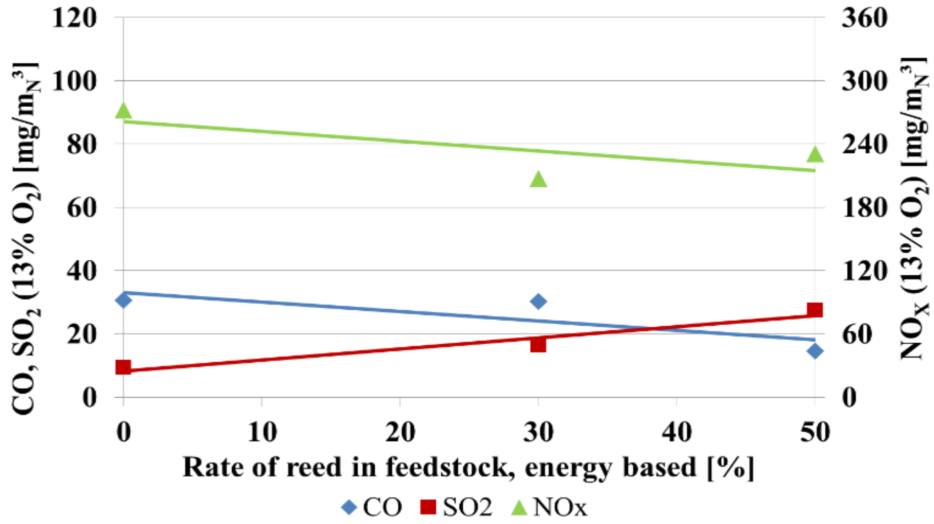
Energy conversion large scale plant
District heating – boiler with grate firing

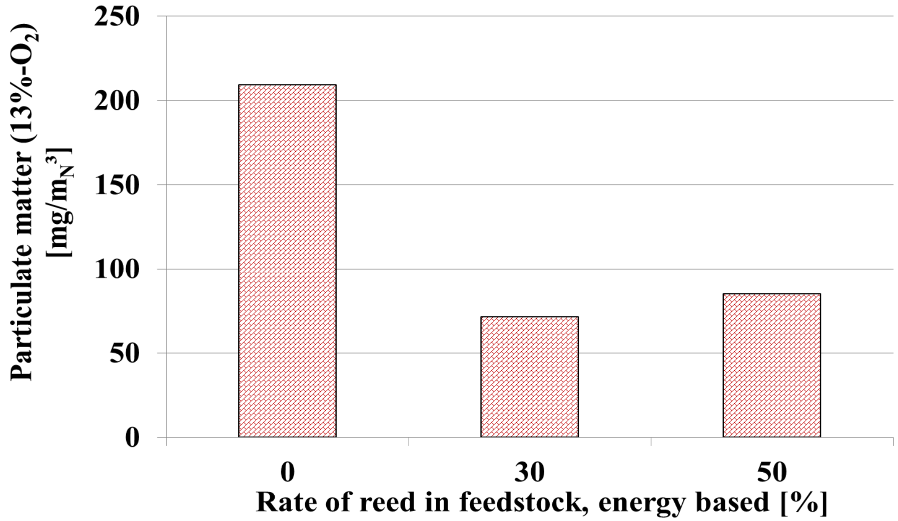
- Woodchip boiler, nominal power 3MW
- Fuel transport system: pusher-floor transport
- Tested biofuel: wood chips, chopped reed
- Water content: wood chips 44%, reed 12.5%
- Fuel mixtures: 100% wood chips (reference fuel)
  30% reed/70% wood chips (energy based)
  50% reed/50% wood chips (energy based)
  100% reed



Energy conversion large scale plant
District heating – Results of test runs







Energy conversion large scale plant
District heating - Conclusion

- Fuels with low volumetric energy density (chopped reed) can cause feeding problems in fuel supply
- Low energy density of chopped reed is limiting factor in fuel transport system → adaptions on the fuel feeding system
- When mass fraction of reed increases
  - thermal output constant, slightly decreasing
  - CO and NO_x – emissions decreases, SO_2 emissions increases
  - dust emissions decreases
- Emissions meet the requirements of the Austrian federal law “Waste Incineration Ordinance (BGBl. II Nr. 476/2010)”

Conclusion

- Potentials:
  Large reed potentials are available for energetic utilisation
- Harvesting:
  Further developments in technology are necessary for reliable harvesting machines
- Energetic utilisation:
  Reed as alternative fuel can be used in a wide range of conversion possibilities

  Co- combustion with wood is recommended; large scale plants lead to less problem in combustion; adaption of feeding/discharging system may be necessary

  Measured emission meet the emission limits in both cases

Acknowledgment
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Project Management
Industrial Conversion
Thermal Conversion Small Scale

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