TECHNISCHE UNIVERSITÄT DRESDEN

Institute of International Forestry and Forest Products, Chair of Forestry and Forest Products in Eastern Europe

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EFFICIENCY IN THE PRODUCTION AND PREPARATION OF BIOMASS FOR ENERGETIC UTILISATION

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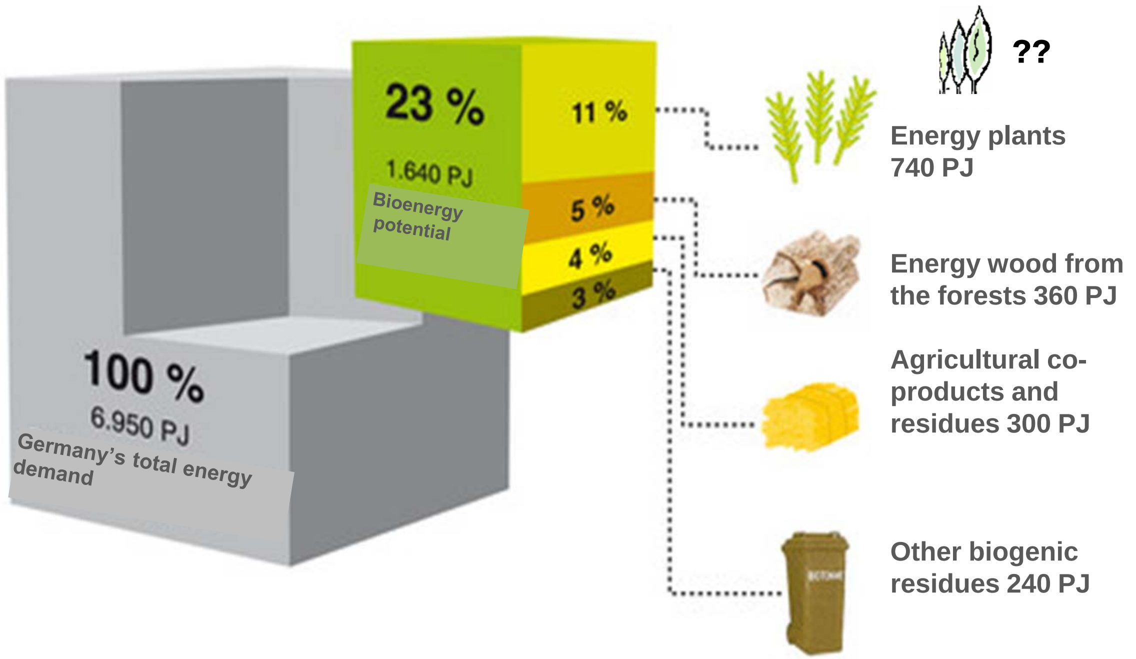


Estimated bio-energy potential in Germany in the year 2050 Source: FNR (2011)

Methods

Effectiveness

Efficiency

Efficiency **and** ***effectiveness*** **originally stem from the operations research branch of science. In the definition provided by AHN & DYCKHOFF (1997) both terms are allocated to a common system of goals:**

Effectiveness - **"do[ing] the right things"**

Efficiency - **"do[ing] the right things right."**

Effectiveness

for instance in terms of energy preparation by biomass could to define as the

difference between the energy output and the energy input

Efficiency

for instance in terms of energy preparation by biomass could to define as the

quotient of the energy output (yield) and the energy input

Output: Energy content of the product (caloric value)
Input: Sum of all forms of invested fossil energies

Efficiency in the production and supply of biomass

Product	„Energy efficiency" OUTPUT : INPUT	„Energy effectiveness" OUTPUT - INPUT GJ $ha^{-1}a^{-1}$
Rape	2 … 5 : 1	23 ….54
Silage maize	3 …15 : 1	62 … 407
Sugar beet	3 … 15 : 1	62 … 262
Wood from - Forestry (pine) - SRC (poplar)	54 : 1 60 … 64 : 1	74 177

Balance limit: Soil preparation to harvest, partial incl. transport to the storage / drying

Sources: BJÖRESSON (1996); EDER et al. (2009); KANZLER (2010); REINEKE et al. (2010); SCHOLZ / KAULFUß (1995); SCHWEINLE (2000); VENTURI (2003)

Energy efficiency and energy effectiveness for selected renewable raw materials

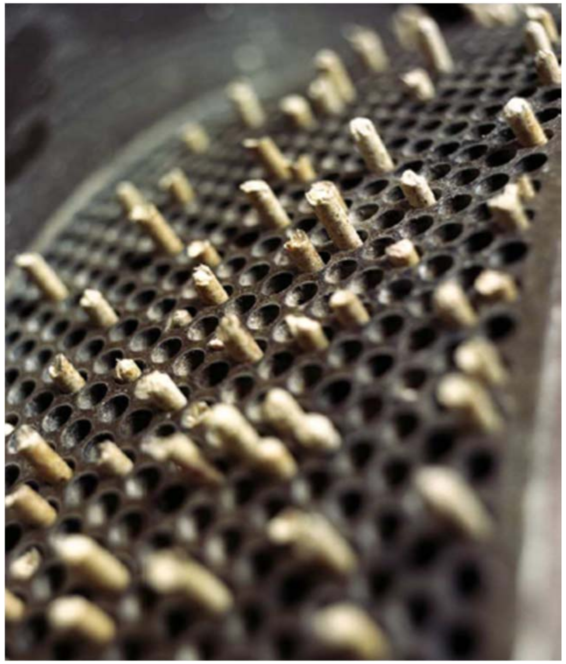
	Wood chip drying process	Output : input pre-drying w =50 %	Input MJ/t$_{atro}$	Output: input post-drying w = 25 %	Comments
1	***Cold air drying***	(7 670 MJ/t$_{atro}$: 208 MJ/t$_{atro}$) **37 : 1**	**77** 1)	13260 MJ/t$_{atro}$: 285 MJ/t$_{atro}$) **46 : 1**	**Input:** electric fan, including flow channels; Hartmann & Strehler(1995), supplemented
2	***Heated air drying***	(7 670 MJ/t$_{atro}$: 208 MJ/t$_{atro}$) **37 : 1**	**416** 1)	13 260 MJ/t$_{atro}$: 624 MJ/t$_{atro}$) **21 : 1**	**Input:** heating unit and electric aeration fan, including flow channels; Hartmann& Strehler (1995), supplemented
3	***Dome aeration process***	(7670 MJ/t$_{atro}$: 208 MJ/t$_{atro}$) **37 : 1**	**12**	13260 MJ/t$_{atro}$: 220 MJ/t$_{atro}$) **60 : 1**	**Input:** 3 domes / 8 canals, 540 m^2 protective sheet, initial values according to Brummack (2006), supplemented[1]

w =water content   SRC = short rotation coppice

1) added to the direct energy expenditure (electricity and heating) cited by Hartmann & Strehler (1995) are expenditures for the materials (energy expended in products) used in fixtures and for protective sheets of identical size to those used in the dome aeration process

Energy efficiency of various wood chip drying processes

(material: wet wood chips derived from poplar SRC) (GROßE, 2006; KANZLER, 2010)



	Energy expenditure, MJ t^{-1}	
Procedure	**Electricity**	**Heat**
Drying	85.7	4 320.0
Reduction	67.3	0
Pelleting	183.6	2.9
Cooling	7.2	0
Machinery	66.2	0
Sum	**410.0**	**4 322.9**

Source: Obernberger / Thek 2009

- The energy expenditure required for the construction and maintenance of pelleting equipment was not quantified by the authors.
- Based on WALLE et al. (2007), this accounts for 5 % of the direct energy expenditure required for pellet production, corresponding to 0.3 GJ t^{-1}. This results in an estimated energy expenditure for pellet production of 6 GJ t^{-1}.

- **Approximately one third of the calorific value of wood is, therefore, consumed solely in the production of the pellets.**

Energy expenditure in the pelleting process

(based on fresh wood with a water content of 55 %)

		Maize chaff, whole plant	Poplar (SRC)
Biomass yield	t_{atro} $ha^{-1}a^{-1}$	24	10
Gross energy yield	GJ ha^{-1} a^{-1}	435	180
Energy input	GJ ha^{-1} a^{-1}	28	3
Net energy yield	GJ ha^{-1} a^{-1}	407	177[1)]
Energy yield (electricity and heat) [3)]	GJ ha^{-1} a^{-1}	348[3)]	150 [2)]
Requirement for 740 PJ a^{-1} Basis: electricity and heat	10^6 ha	2,13	4.93
Input- Requirement for 740 PJ a^{-1}	PJ a^{-1}	148	57

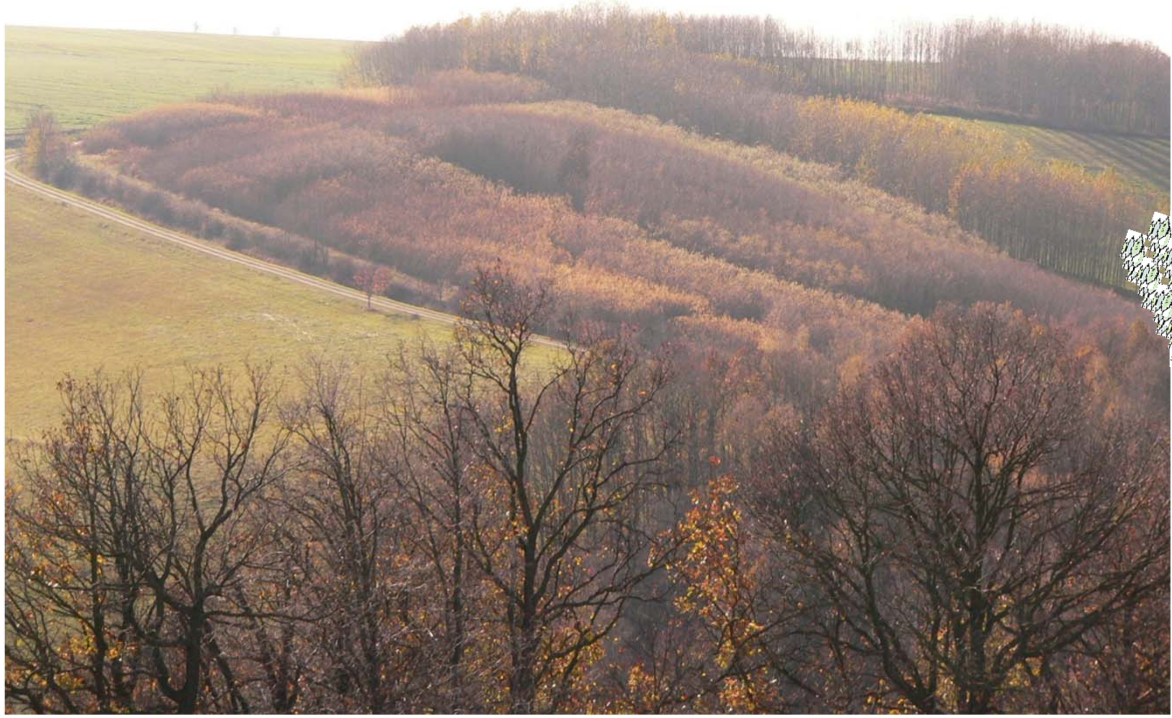
1) wood chips (w = 25 %)
2) biomass combined heat and power (CHP) plant, degree of efficiency= 0.85
3) biomethane production with centralised conversion to electricity in a CHP plant (efficiency values according to Dressler et al., 2011)

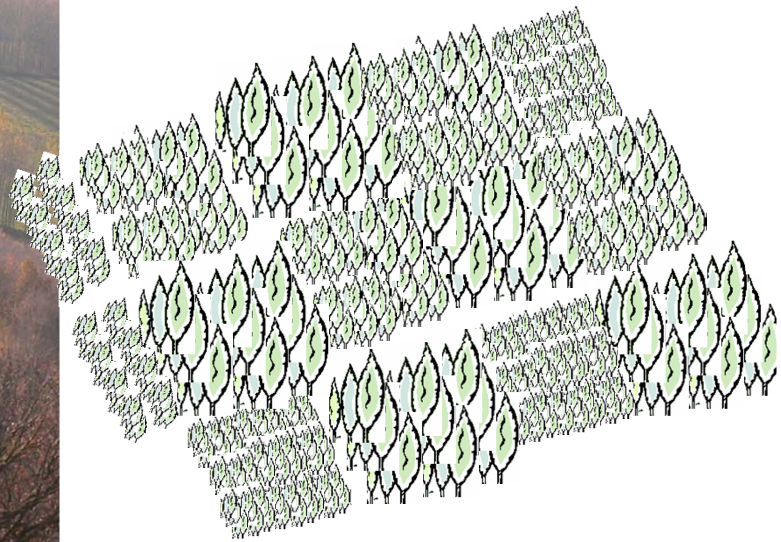
Energy balance per hectare in a comparison of central electricity and heat generation with maize (whole plant) and poplar wood chips (basic data derived from slide 2)

Conclusion

- The different plant types and the processes applied can be compared under the aspects energy efficiency and effectiveness.
- In production, preparation and conversion of biomass to heat and power the decision-making process between for the right technology should to allow for the aspect of energy efficiency absolute.
- The results, in the form of energy balances from production to the generation of electricity and heat, indicate the benefits of the use of fast growing tree species and of wood for additional energy generation.
- In comparison to maize, an agricultural crop with the highest biomass yields, heat and electricity can be obtained from short rotation coppice plantations with species such as poplar comparatively effectively and efficiently.
- With just one third of the energy input required in the production process of poplar wood chips in comparison to silage maize, it is possible to generate the same amounts of heat and electricity using 2.5 more area of land required to produce biomethane from silage maize with subsequent heat and electricity generation.

Example of a well accepted Short Rotation Plantation at the Middle Saxon Uplands





Plantation structure and landscaping aesthetics

Thank you for attention !