

Renewable raw materials from agriculture – to produce or to save energy?

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Outline

- Introduction
- General assumptions
- Plants biomass and energy production
- Plants biomass and energy-saving potential
- Results and discussion
- Conclusions
- Outlook: Future of insulation materials

Introduction

- Eminent public discussions about efficient and sustainable land use
 - Plant varieties
 - Crops rotation
 - Soil protection
 - Biodiversity and environmental impact
- Beside the necessary provision of energy from renewable resources, efforts in energy savings are in focus.
- The use of one hectare of agricultural land for the production of energy or for the saving of energy is assessed.

General assumptions

- The total energy balance of each plants species is given per hectare and year $\text{kWh} \cdot (\text{ha} \cdot \text{y})^{-1}$
- The energy yield calculations were regarded only to the energy produced or converted



General assumptions

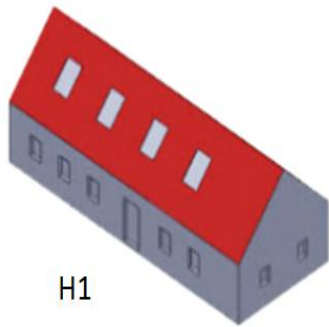
- For comparison a model family house was considered:

- total living area of 150 m²
- energy efficiency of class F

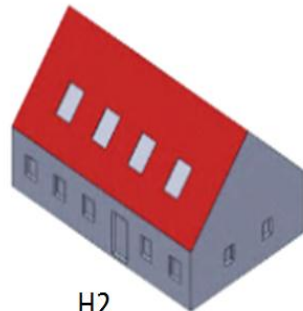
- Energy demands (3 inhabitants):

- electrical energy: 4,230 kWh·year⁻¹
- heating energy (175 kWh·(m²·y)⁻¹):
26,250 kWh·year⁻¹

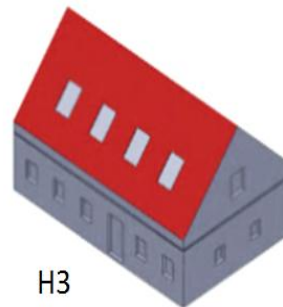
kWh/(m ² ·y)		Class
0 ... 40	New building type	A
> 40 ... 60		B
> 60 ... 80		C
> 80 ... 110		D
> 110 ... 150		E
> 150 ... 200	Old building type	F
> 200 ... 300		G
> 300 ... 400		H
> 400 ... 500		I
> 500		J



H1



H2



H3

Plants biomass and energy production: Reference: silage maize for biogas

- Fresh crop production: $44 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$



- Total biogas: $7,800\text{--}9,100 \text{ m}^3 \cdot (\text{ha} \cdot \text{y})^{-1}$
- Caloric value of biogas $5.8 \text{ kWh} \cdot \text{m}^{-3}$
- Methane content $4,394 \text{ m}^3 \cdot (\text{ha} \cdot \text{y})^{-1}$
- Electrical energy by CHP: $18,379 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 4.4 \text{ years}$
- Heat energy by CHP: $22,055 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 0.8 \text{ years}$
- Heat energy through biogas combustion:
 $43,808 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 1.6 \text{ years}$

Plants biomass and energy production: SRC Wood combustion

- Poplar fresh mass production: $12 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$
- Caloric value at 15% humidity: $4.1 \text{ kWh} \cdot \text{kg}^{-1}$
- Electrical energy by CHP: $11,070 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 2.6 \text{ years}$
- Heat energy by CHP: $30,750 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 1.1 \text{ years}$
- Heat energy through combustion:
 $49,200 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1} \rightarrow 1.9 \text{ years}$



Plants biomass and energy production: hemp combustion

- Production
 - of stems: $6 \dots 9 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$
 - of seeds: $0.4 \dots 1 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$
- Caloric value of briquettes / pellets:
 $4.72 \text{ kWh} \cdot \text{kg}^{-1}$
- Combustion energy:
 $37,778 \text{ kWh} \cdot (\text{ha} \cdot \text{y})^{-1}$
- The model house will use the
combustion energy for 1.2 years



Plants biomass and energy production: flax combustion

- Production of stems: $5...6 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$
- Production of seeds: $0.2...2.8 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$
- Caloric value: $123 \text{ kWh} \cdot \text{m}^{-3}$
- The model house will use the combustion energy for 0.2 years



Bio-Energy or Bio-insulation?

- In order to raise to an energy efficiency of class D ($105 \text{ kWh} \cdot (\text{m}^2 \cdot \text{y})^{-1}$) the model family house will need 20 cm of insulation, in sum 59 m^3
- The heat energy saved will be $10,500 \text{ kWh} \cdot \text{year}^{-1}$

kWh/(m ² ·y)			Class
0 ... 40	New building type	A	
> 40 ... 60		B	
> 60 ... 80		C	
> 80 ... 110		D	
> 110 ... 150		E	
> 150 ... 200	Old building type	F	
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> 400 ... 500		I	
> 500		J	

Saving potentials for heating energy in Germany (detached and semi-detached houses)

- Based on the statistical data* of the single family homes situation in Germany, the following saving energy potentials can be deducted:
 - Around 80% of the houses build prior to 1968 are in energy efficiency class F and their energy losses amounts to about 63,889 GWh per year;
 - If we consider all the houses build before 1990's that need insulation improvements the heating energy loses will grow to about 109,722 GWh per year.

*Weiß, J.; Dunkelberg E.: Erschließbare Energieeinsparpotenziale im Ein- und Zweifamilienhausbestand. Institut für ökologische Wirtschaftsforschung (IÖW), Berlin 2010.

Plants biomass and energy-saving potential: wood SRC insulation

- $7.8 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$ fibers with a 65% fibers extraction efficiency
 - Market wood fiber fleeces and boards densities ranging from $35 - 210 \text{ kg} \cdot \text{m}^{-3}$
 - 20 cm thick insulation panels have a density of $180 \text{ kg} \cdot \text{m}^{-3}$
 - 43 m^3 of insulation per hectare and year
 - The model family house will use 59 m^3 of insulation to raise to energy efficiency class D
- the insulation produced on one hectare will cover 73 % of the total required insulation.

Insulation panel
based on wood fibres



Plants biomass and energy-saving potential: hemp insulation

- Production of fibers : 15... 25%
- Average stem production of 7.5 t results about $1.8 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$ fibers
- Market product hemp panels have a density of $100 \text{ kg} \cdot \text{m}^{-3}$
- 20 m^3 of insulation per hectare per year
- The model family house can be covered by 34% of the insulation needed to reach an energy efficiency of class D



Insulation panel based on wet preserved hemp

Insulation panel based
on hemp fibres and
shives (Canabest)



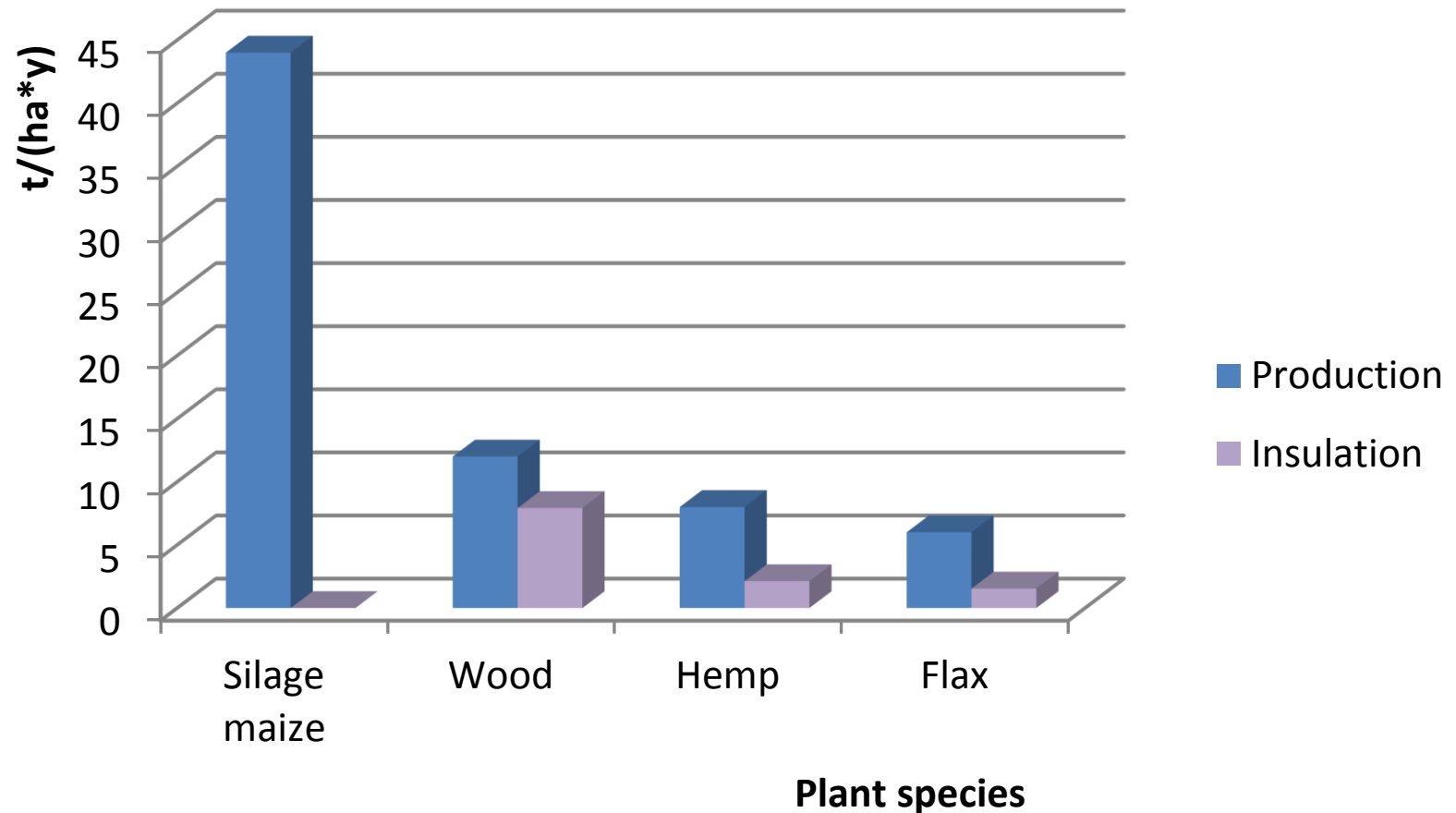
Plants biomass and energy-saving potential: flax insulation

- Production of fibers: 23 %
- Average fibers production is about $1.3 \text{ t} \cdot (\text{ha} \cdot \text{y})^{-1}$ fibers
- Market flax insulation products have a density between $30 \dots 80 \text{ kg} \cdot \text{m}^{-3}$ and 80% flax fibers.
- Flax panels with $80 \text{ kg} \cdot \text{m}^{-3}$ density will produce $19 \text{ m}^3 \cdot (\text{ha} \cdot \text{y})^{-1}$ of insulation.
- 32 % of the model family house's insulation are attained within one year

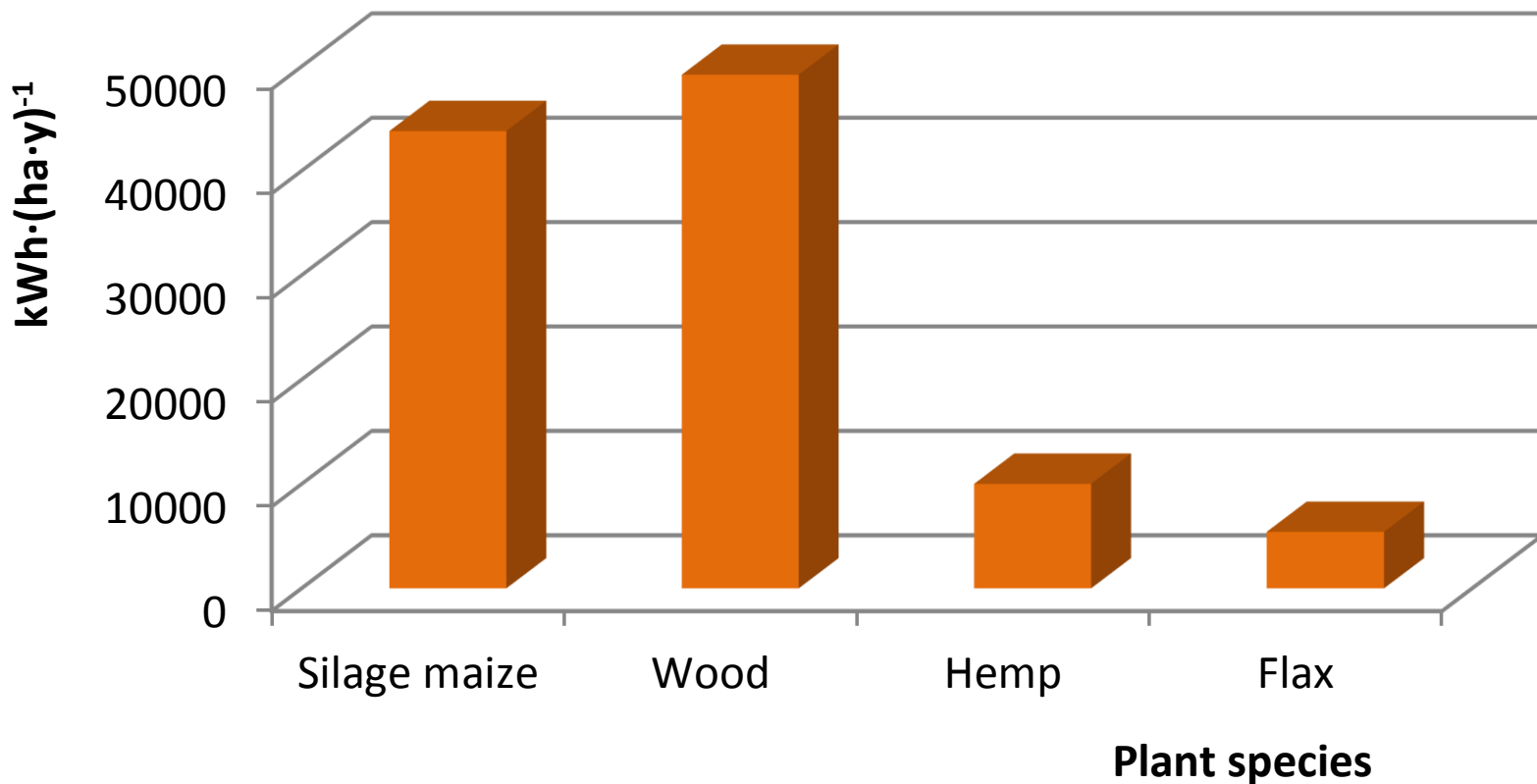


Insulation material based on flax fibres

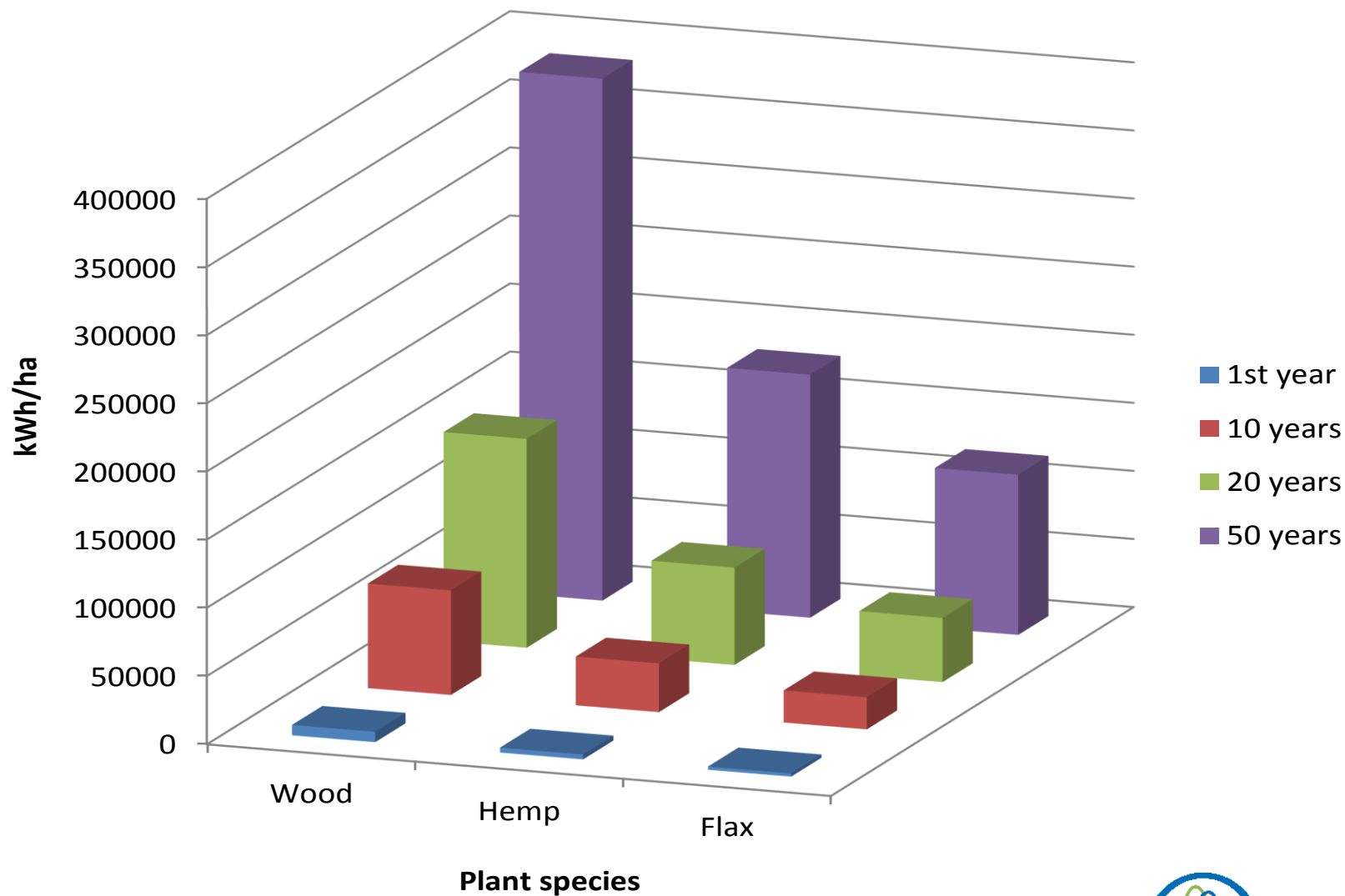
Results and discussion: Hectare-yield and insulation produced



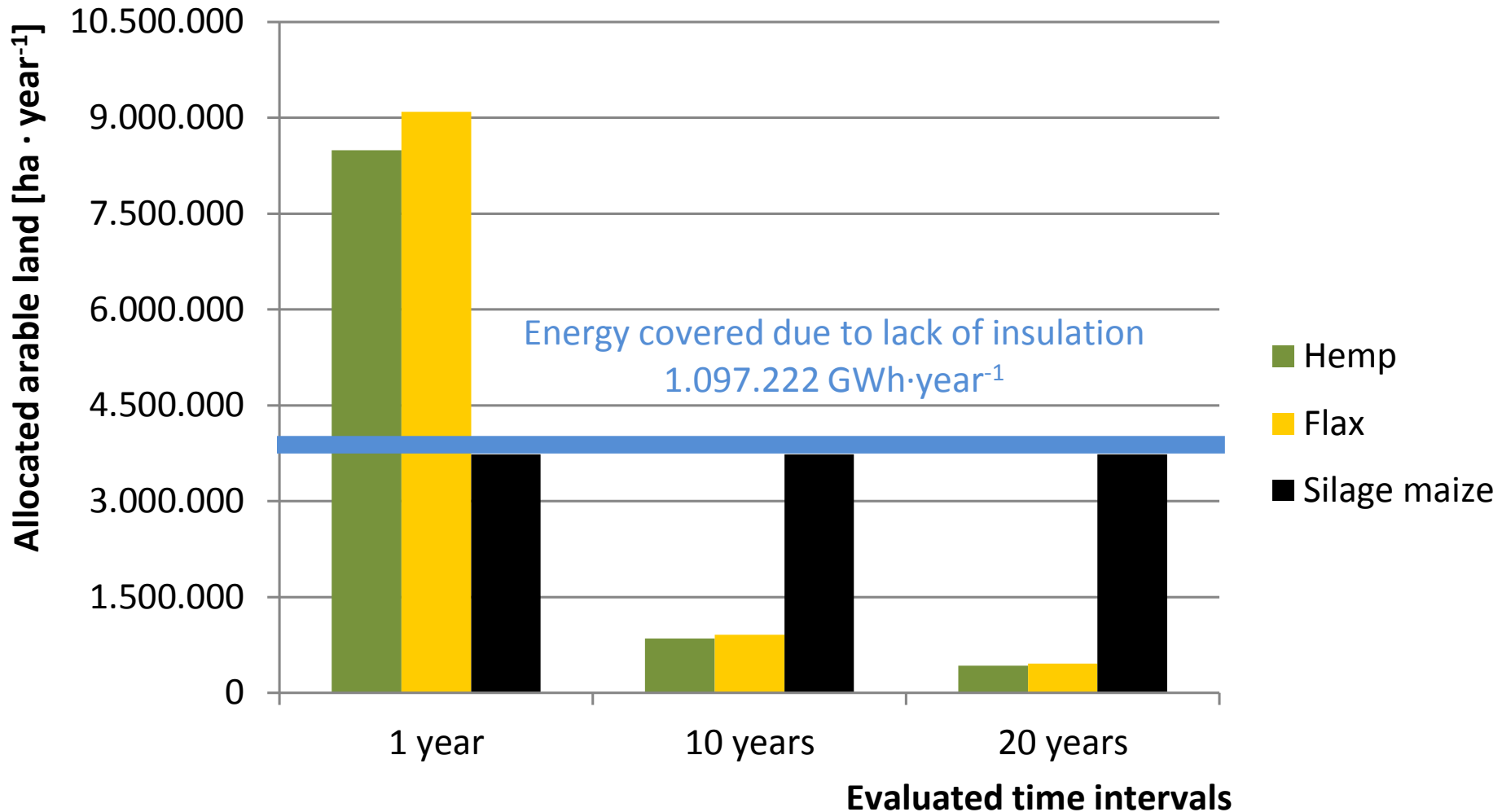
Results and discussion: Comparison of combustion heat energy yields



Results and discussion: Savings by utilization of insulation from one hectare



Results and discussion: Land-use comparison



Acreage demand for heating energy supply with biogas for a detached house (model H1, with and without exterior wall insulation)

- Calculations were made to estimate the reduction of land use for bio-energy when covering the heating demands of the model house H1 various situations:
 - with 10 cm exterior of natural fibers wall insulation;
 - with 20 cm exterior of natural fibers wall insulation.
- The acreage utilization for bio-energy when using 10 cm natural fibers insulation was reduced with 17 to 19% for the evaluation time interval of 10 to 40 years.
- The acreage utilization for bio-energy when using 20 cm natural fibers insulation was reduced with 19 to 23% for the evaluation time interval of 10 to 40 years.

Conclusions

- Bio-energy will have a necessary part within the post-fossil energy transformation/revolution, but not its solution
- Alternation from the focus “energy substitution” to “energy saving” is absolutely essential
- The renewable raw materials for energy saving purposes should have a place in the support frame of the renewable energy policy
- Local production and supply of insulation materials based on e.g. hemp provide benefits through:
 - changes in crop rotation and reduction of “maizification”
 - Rural development along the value added chain

Outlook: Future of insulation materials

- Replacement of synthetic materials for insulation
 - Drastic reduction of energy demand for primary production
 - Favorable living conditions – e.g. summer heat insulation or harmlessness in regard to construction ecology
 - Provision of healthy environment without hazardous wastes and chemicals
 - Cascade use of renewable raw materials after end-of-life as renewable energy carrier
 - Innovative solution for waste disposal problems
- Enforces new by-products such as:
 - New ecological building materials: hemp based mortars
 - Food supplements (...e.g. from seeds)
 - Pharmaceutical products
 - Basic chemicals

THANK YOU FOR YOUR ATTENTION!



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