Delivery of sustainable supply of non-food biomass to support a resource-efficient Bioeconomy in Europe

S2Biom summer school, Athens, Greece, 17-20 May, 2016

Case study of supplying large scale Biofuel production plants in North-East Germany and North West Poland with lignocellulosic feedstock from the region

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This project is co-funded by the European Union within the 7th Frame Programme. Grant Agreement n°608622.

Investigation of regional drop-in transportation fuel production chains

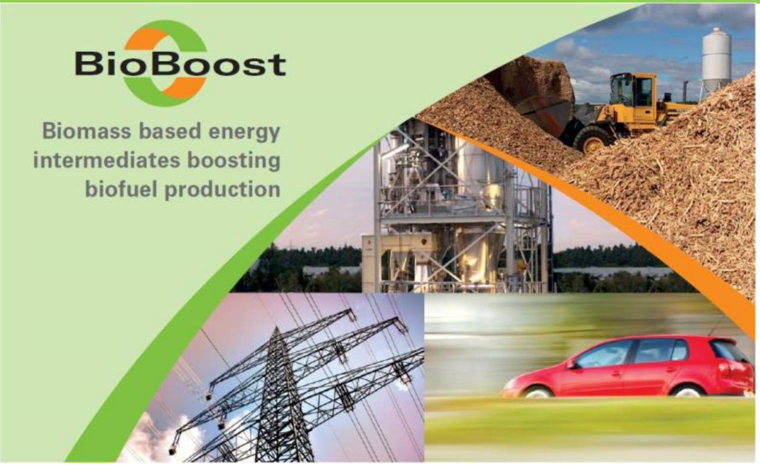
Case study Biofuel production in North-East Germany – North-West Poland

Optimizing cost of biofuel production for two drop-in biofuel pathways:

1: straw -> transport-> fast pyrolysis-> transport of energy carrier -> new built gasification and fuel synthesis plants

2: forestry residues -> transport-> catalytic pyrolysis-> energy carrier -> transport -> existing refineries

Biomass based energy intermediates boosting biofuel production



Project Acronym	BioBoost
Project Reference	282873 in FP7
Theme	ENERGY.2011.3.7-1: Development of new or improved sustainable bio-energy carriers
Contract type	Collaborative project
Coordinator	Karlsruher Institut fuer Technologie (KIT)
Consortium	13 Beneficiaries from 6 countries
Start	01/2012
Duration	42 month
Budget	7.3 Mio €
Funding	5.1 Mio €

Consortium

The feedstock potential assessment for EU-27 + Switzerland in NUTS-3

1.Agricultural residues

1.1 Straw

1.2 Residuals of pruning

1.3 Livestock residues

1.4 Hay from permanent grassland

1.5 Perennial crops

2. Forestry residues

3. Natural conservation matter

3.1 Green urban areas

3.2 Hay and shrubs

4. Roadside vegetation

5. Urban and industrial waste

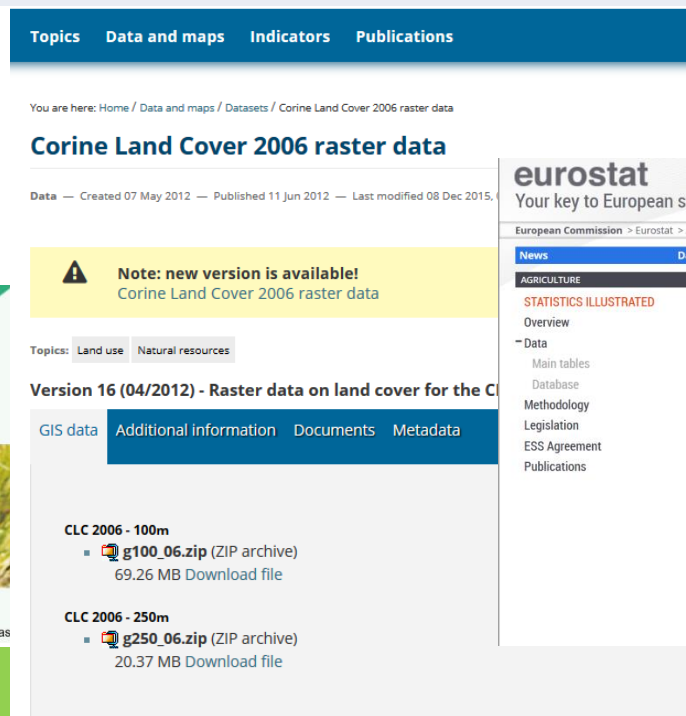
5.1 Biodegradable municipal waste

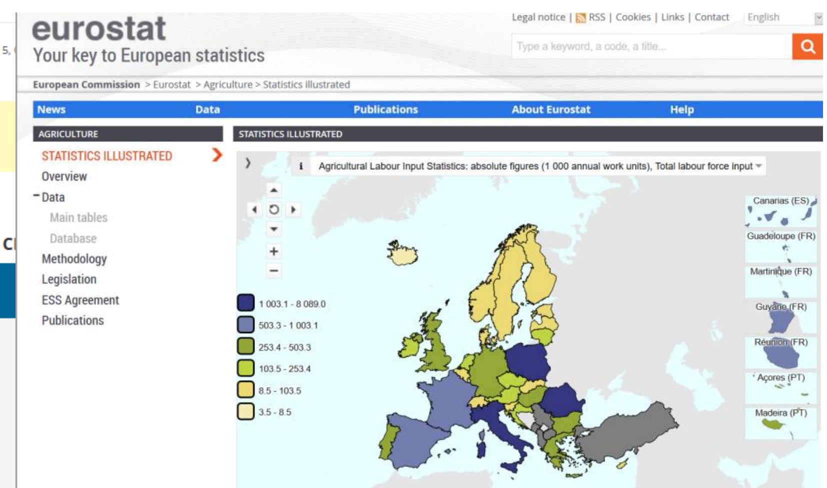
5.2 Bio-waste of food industry

5.3 Bio-waste of wood industry by-products

Methods, approaches and data

Source	Location
RENEW Project	http://www.renew-fuel.com/fs_documents.php
EEA: CORINE	http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2006-raster-2
Eurostat	http://ec.europa.eu/eurostat/web/agriculture/statistics-illustrated



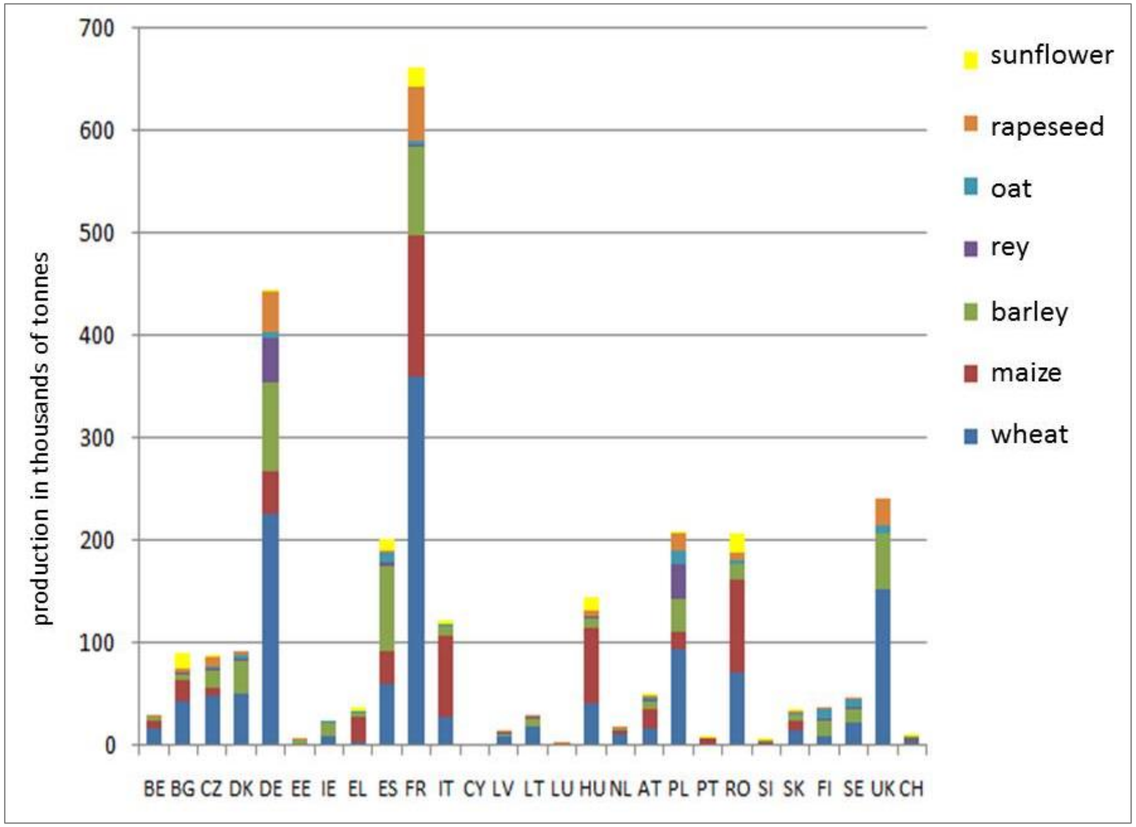


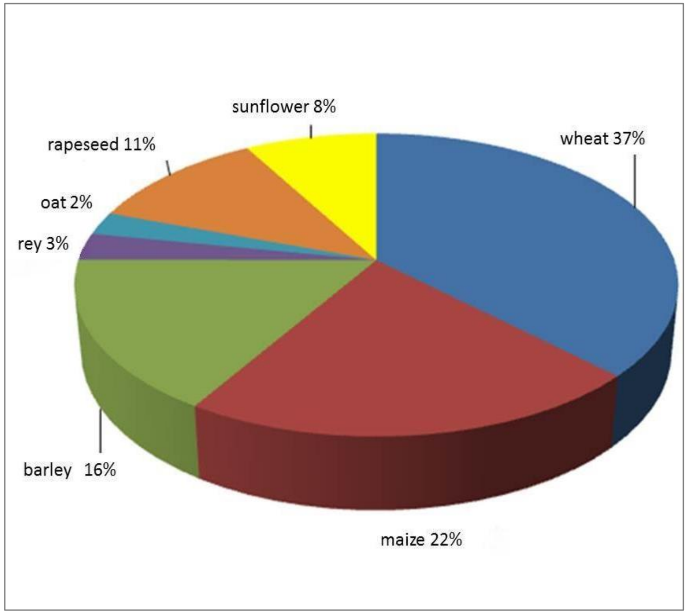
Straw surplus was modelled by using followed scenario for assessment:

Step 1. Average grain yield for NUTS-2
Step 2. Straw potential
Step 3. Theoretical straw potential
Step 4. Technical straw potential

Methods, approaches and data

Step 1. Average grain yield for NUTS-2





Crop production in EU-27 +CH (yield in kt). *Sources: Eurostat*

Methods, approaches and data

Step 2. Straw potential

Crop	Algorithm: Straw to grain ratio
Wheat and barley	Yield*(0.769-0.129*ATAN((Yield-6.7)/1.5))
Maize	-0.181*LN(Yield)+1.337
Rice	-1.226*LN(Yield)+3.845
Rape seed	-0.452*LN(Yield)+2.0475
Sunflower	- 1.1097*LN(Yield)+3.2189
other cereals: oat, triticale, mixes of cereals, etc.	0.9

Sources: Edwards (2005) for wheat and barley,
Scarlat (2010) for maize, rice, rapeseed and sunflower

Step 3. Theoretical straw potential (TeoSP)

TeoSP=

$$\sum_{i=1}^{i}(Yield * ratio\ straw - to - grain)$$

Where:

Yield = yield of i (i = wheat, barley ...) in ton per NUTS-2

Ratio = straw to grain ratio

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Step 4. Technical straw potential TechSP (NUTS-3)

TechSP = TeoSP/ – //in loop according to 3 steps !

first step (soil protection): 100% oilseed rape and turnip rape straw [OT_S]
+ 50 % maize stalks [MS_S]

second step (soil protection): while [OT_S]+ 50%[MS_S] < **30% of TeoSP** then
- remained MS_S – sunflower straw (if needed)
- other cereals straw (if needed) – wheat and barlay straw (if needed)

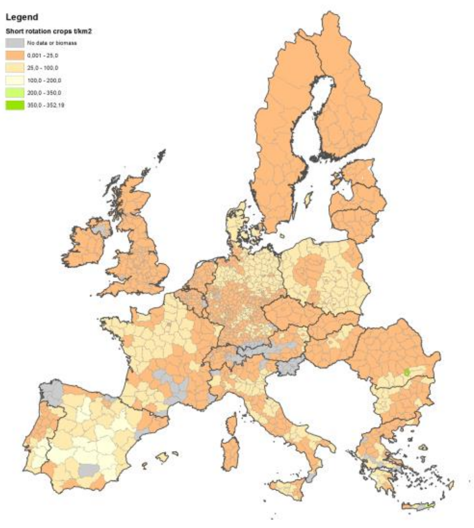
end

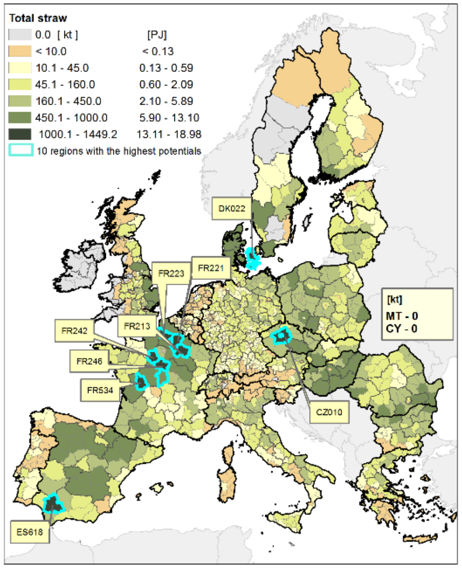
third step (feeding and beding): while **STRAW > 0 and STRAW (needed for animals) > 0** then
- cereals straw (if exist and if needed)

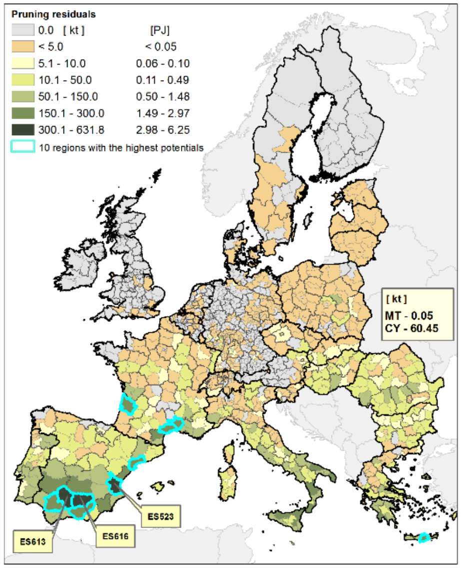
end

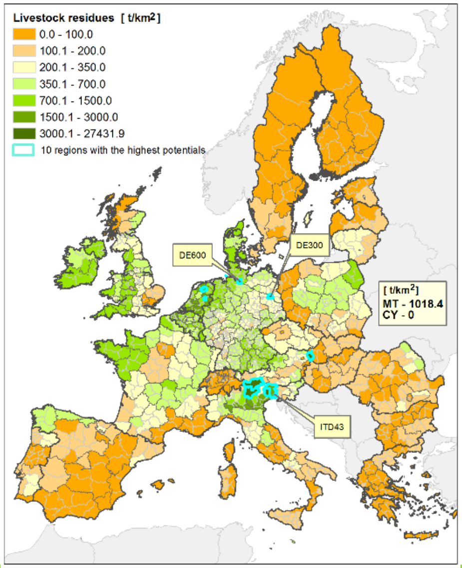
We do not assume import/export of straw in case of straw deficit in the region (NUTS-3)
In case of deficit the technical straw potential = 0

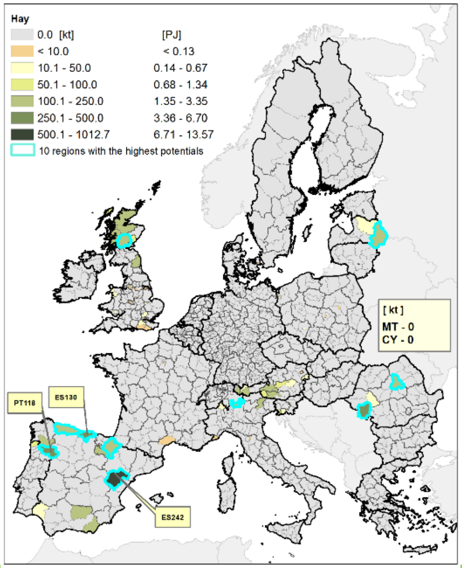
Methods, approaches and data

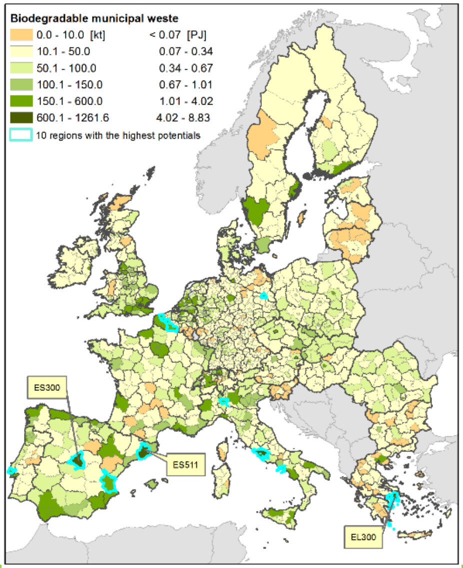






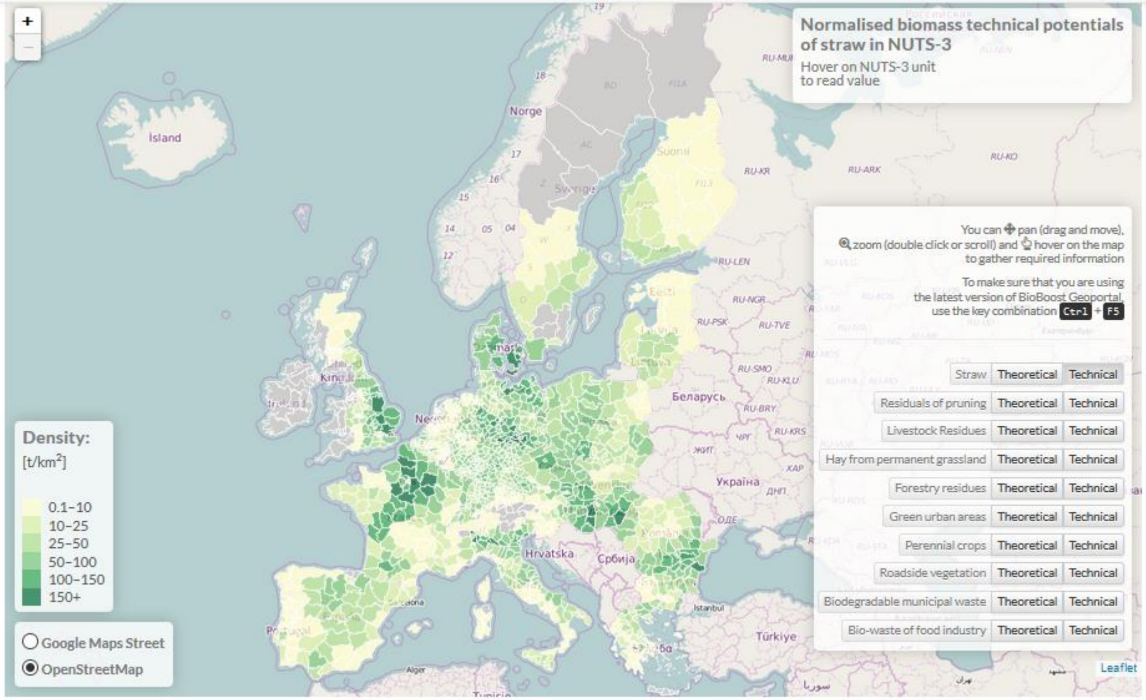






Methods, approaches and data

BioBoost Geoportal | BioBoost Navigator | BioBoost Add-on for HeuristicLab | Knowledge Base | Request a data | Contact



To view the technical potential statistics, enable calculating, then click any units on the map and "Sum values in columns" button

Enable calculating | Number of selected NUTS 0 | Remove all | Sum values in columns

NUTS name	Straw	Residuals of pruning	Livestock Residues	Hay from permanent grassland	Forestry residues	Green urban areas	Perennial crops	Roadside vegetation	Biodegradable municipal waste	Bio-waste of food industry	Total

Map description

The map present technical straw potential that was assessed by subtraction of the amount of straw necessary for animal bedding and feeding in addition to the part of straw that is needed for incorporation into the soil. Straw for energy purposes was defined as a total production minus from the straw used in the production of animal feed and bedding, which is necessary in the maintenance of soil.

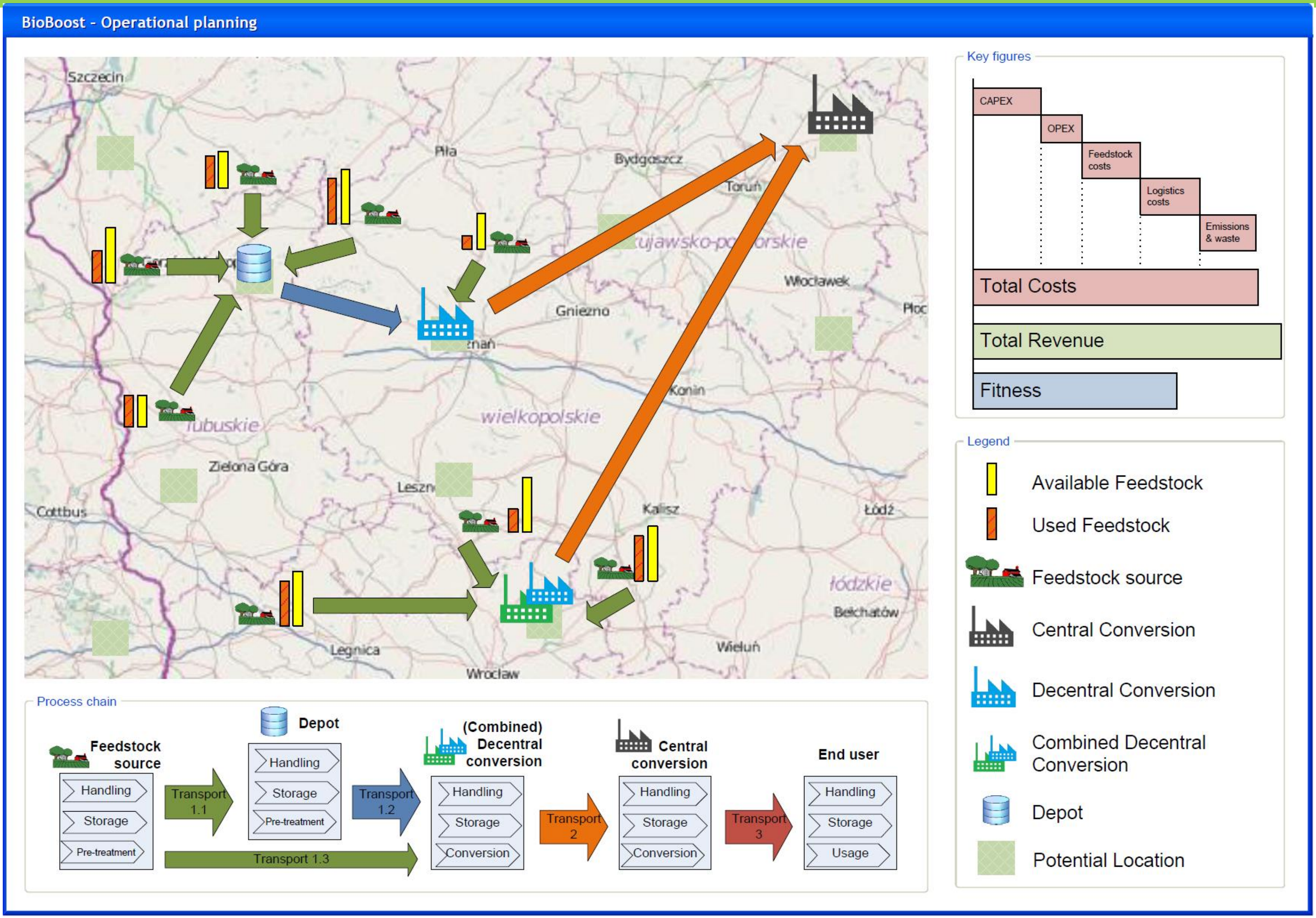
Simulation based optimization model

HeuristicLab: BioBoost module

Developed by University of Applied Science Upper Austria

- Simulation-based optimization to construct an optimisation scenario for feedstock usage, plant location selection, and transport route selection
- Mixed-integer optimization problem for finding optimal biomass networks with respect to economic and ecologic objectives

Methods, approaches and data



HeuristicLab

A Paradigm-Independent and Extensible Environment for Heuristic Optimization

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wiki: BioBoost

Strona początkowa | Indeks | Historia

Within the BioBoost project we developed a simulation model for the evaluation of processes for 2nd generation bio-fuels. A customized algorithm optimizes locations and capacities of plants as well as biomass and energy carrier logistics. On this page you can download the software as an add-on for HeuristicLab. Using this add-on helps to analyse which regions in Europe would be ideal for first implementation of industrial-scale plants for 2nd generation bio fuels. You can also easily analysis the profitability of such plants.

Of course the simulation model can be easily adapted to other bio-fuel production processes and technologies, other regions and more fine grained regional analysis. It is only necessary to provide the necessary data. We are happy to help you when adapting the simulator to your needs!

Download HeuristicLab
Download BioBoost Add-on
Download HL Demo File (Scenario: Austria)

- Technologies: Fast pyrolysis, catalytic pyrolysis, hydrothermal carbonization
- Simulation-based Optimization
- Regional analysis on NUTS-3 level over EU-27
- Multi-echelon logistics
- Optimize locations for plants
- Optimize logistics
- Profitability analysis

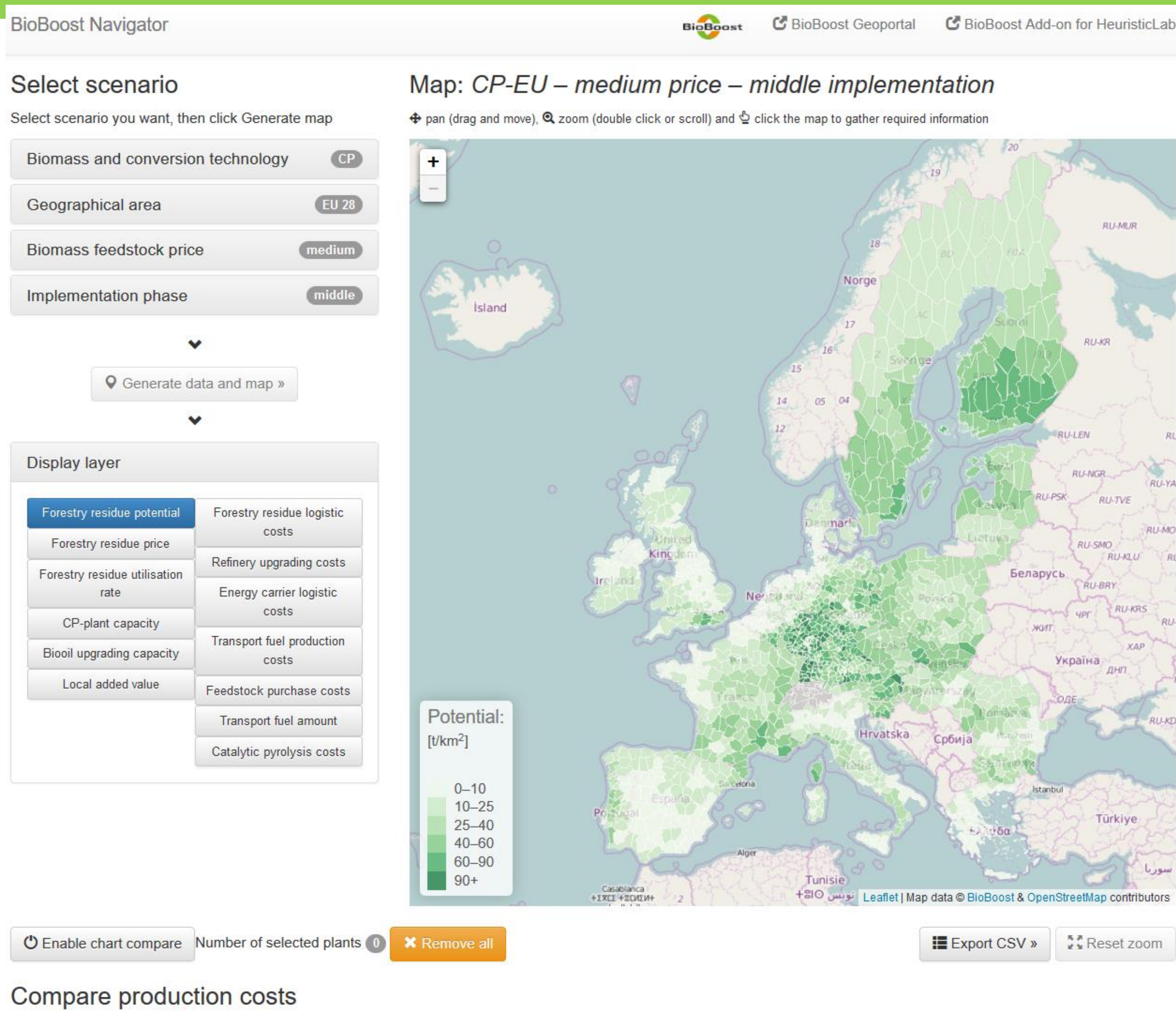
Installation instructions

1. Download HeuristicLab main application HeuristicLab.zip (daily trunk build) and unpack to a convenient location. Installation and administrative rights are not necessary.
2. Download BioBoost add-on HeuristicLab.BioBoost.zip (daily build) and unpack the files into the same folder.
3. Start HeuristicLab-3.3.exe
4. Launch "Optimizer"
5. Load an existing BioBoost simulation model or create a new one with "File -> New -> BioBoost Problem"

Documentation and Publications

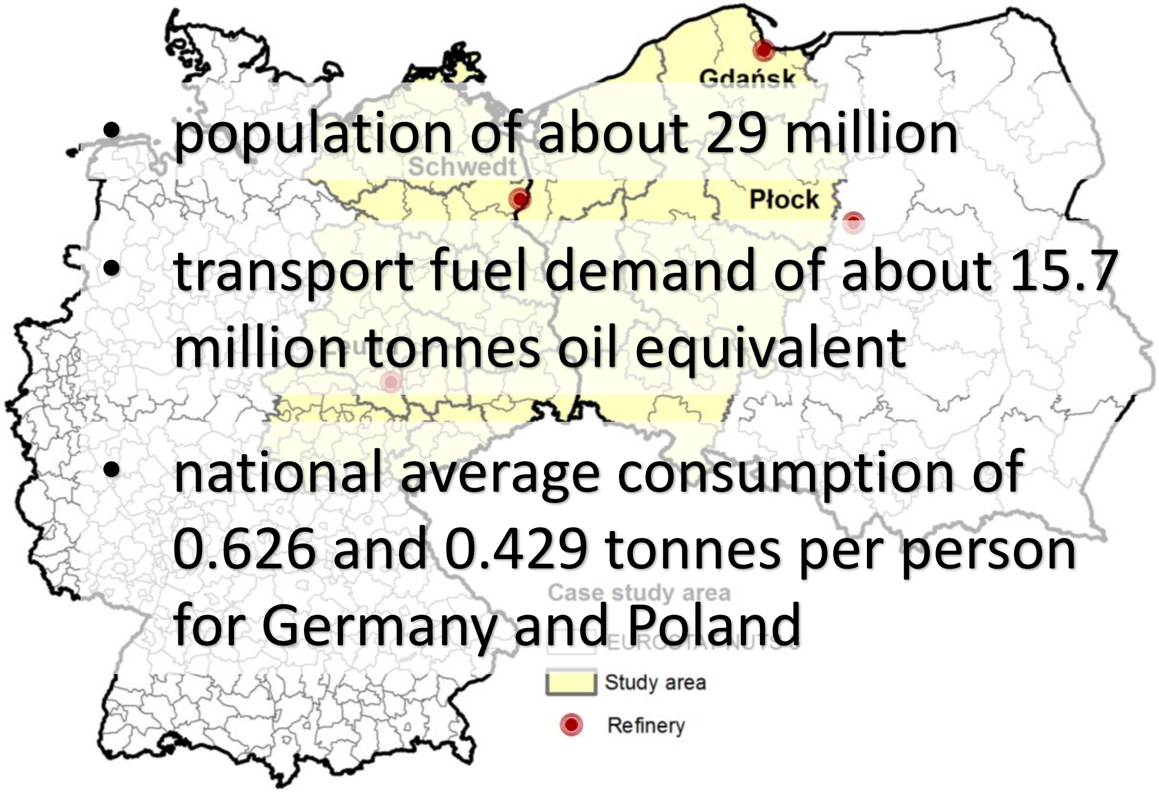
We have presented the software at multiple occasions

Methods, approaches and data



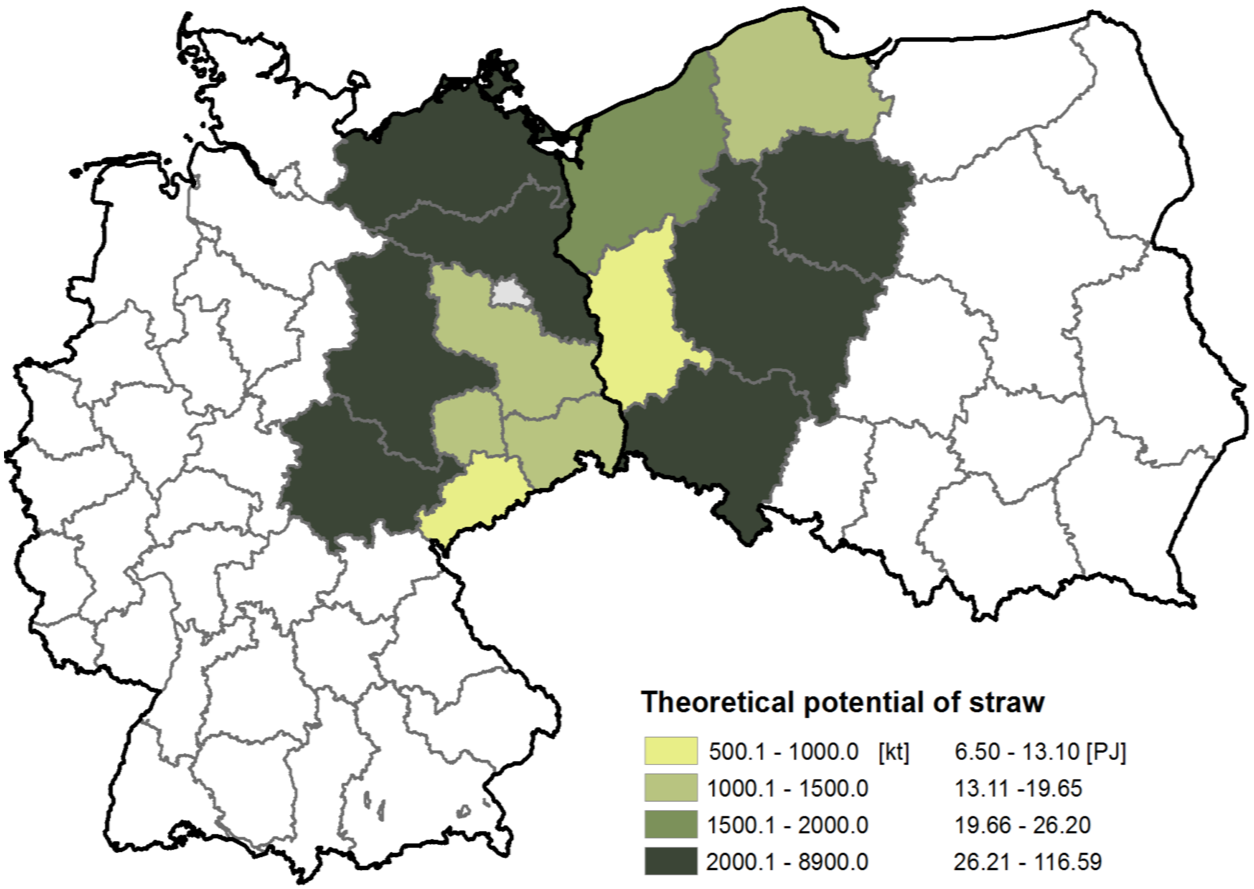
Case study area

- population of about 29 million
- transport fuel demand of about 15.7 million tonnes oil equivalent
- national average consumption of 0.626 and 0.429 tonnes per person for Germany and Poland

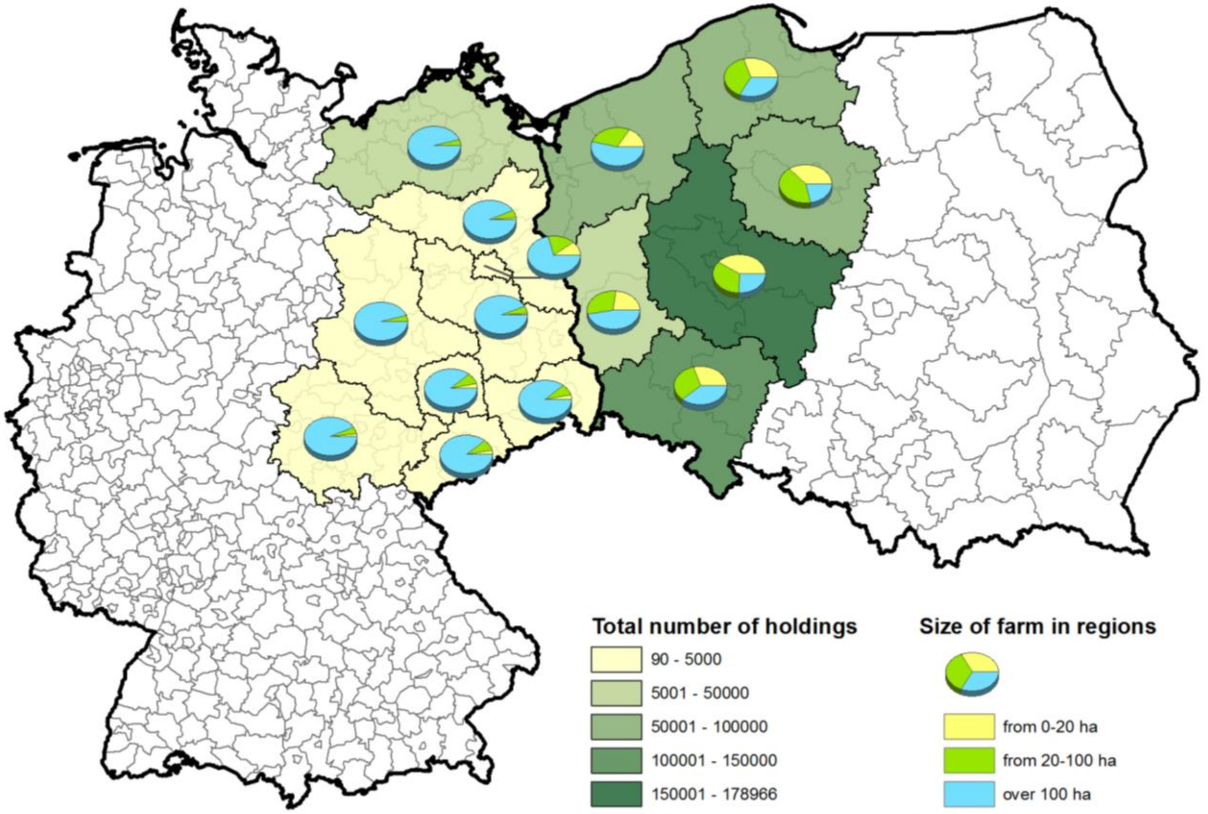


Location of the case study area (highlighted) in Germany and Poland. Large NUTS 3 regions were split up to areas of less than 7500 km² (thin straight lines) to increase the performance of the optimisation model. Locations of refineries relevant for the study area are indicated by red dots.

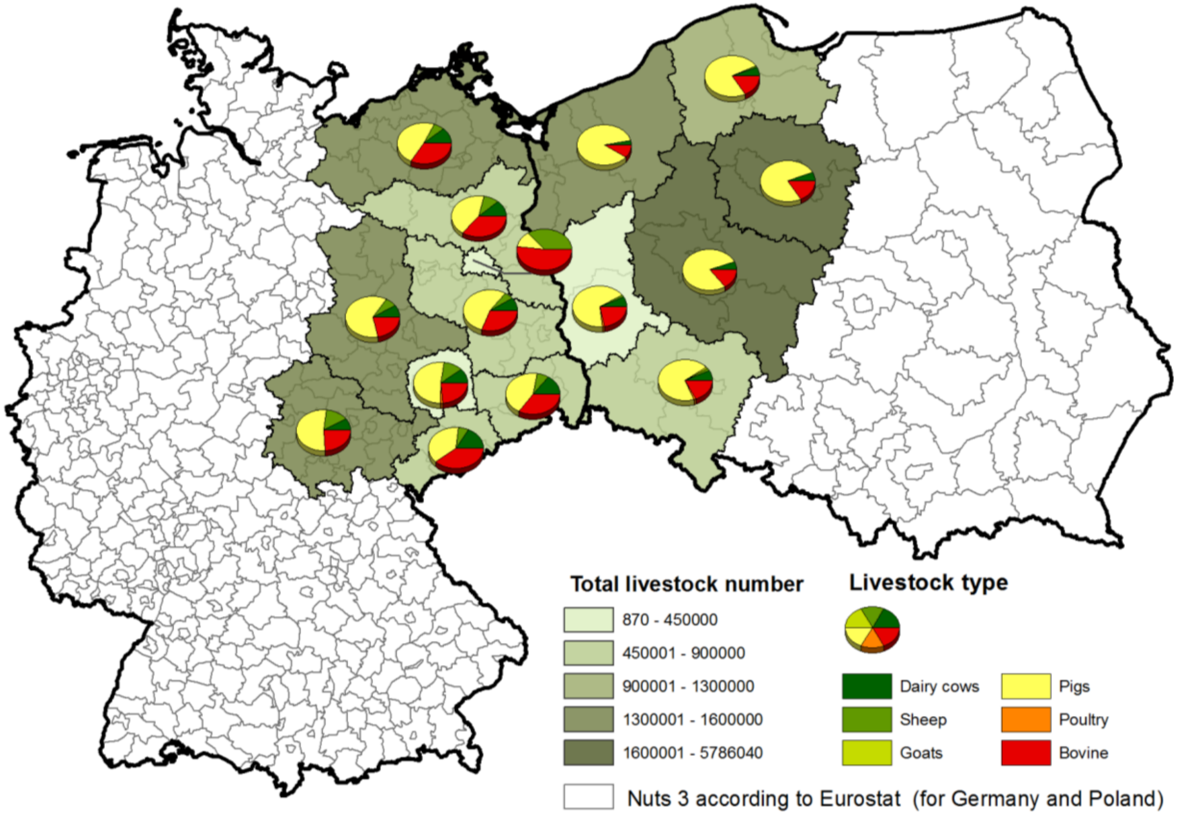
Theoretical straw potential



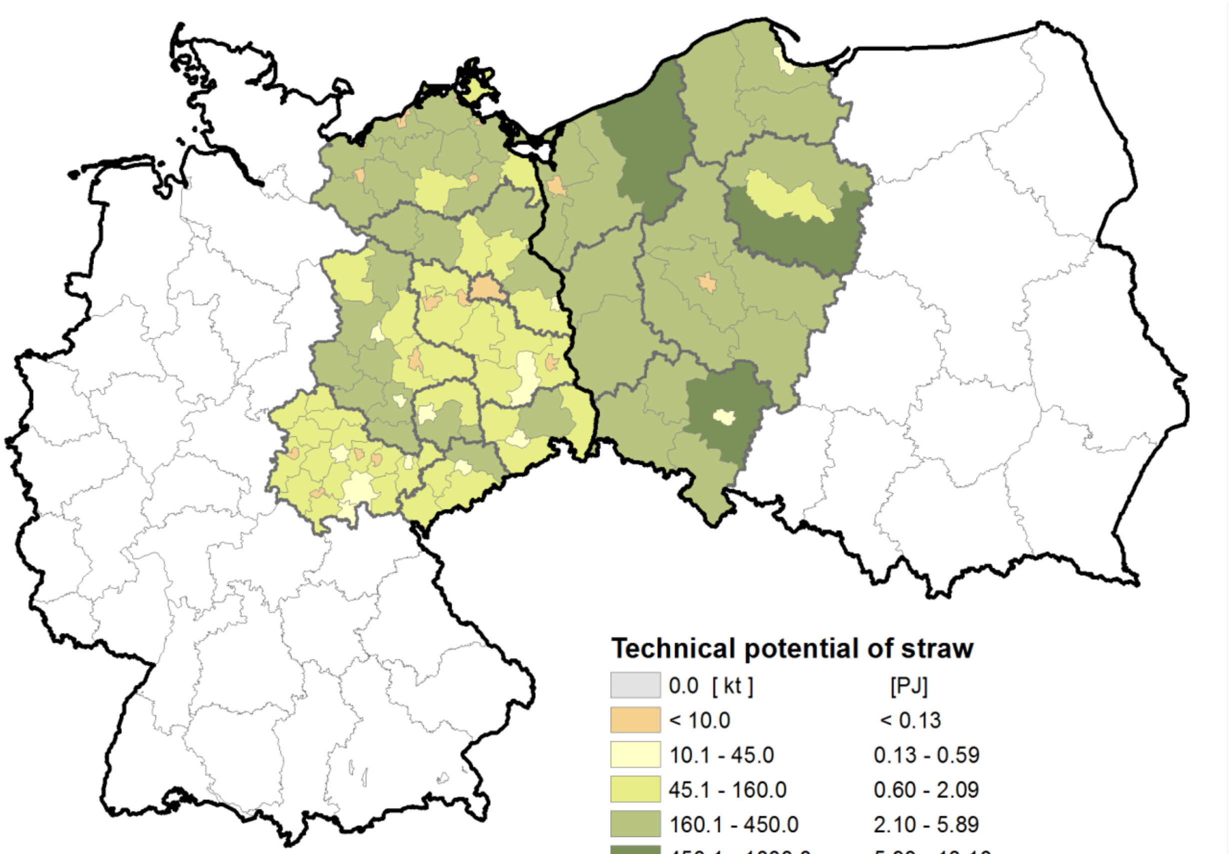
Farm holdings and avarage farm size



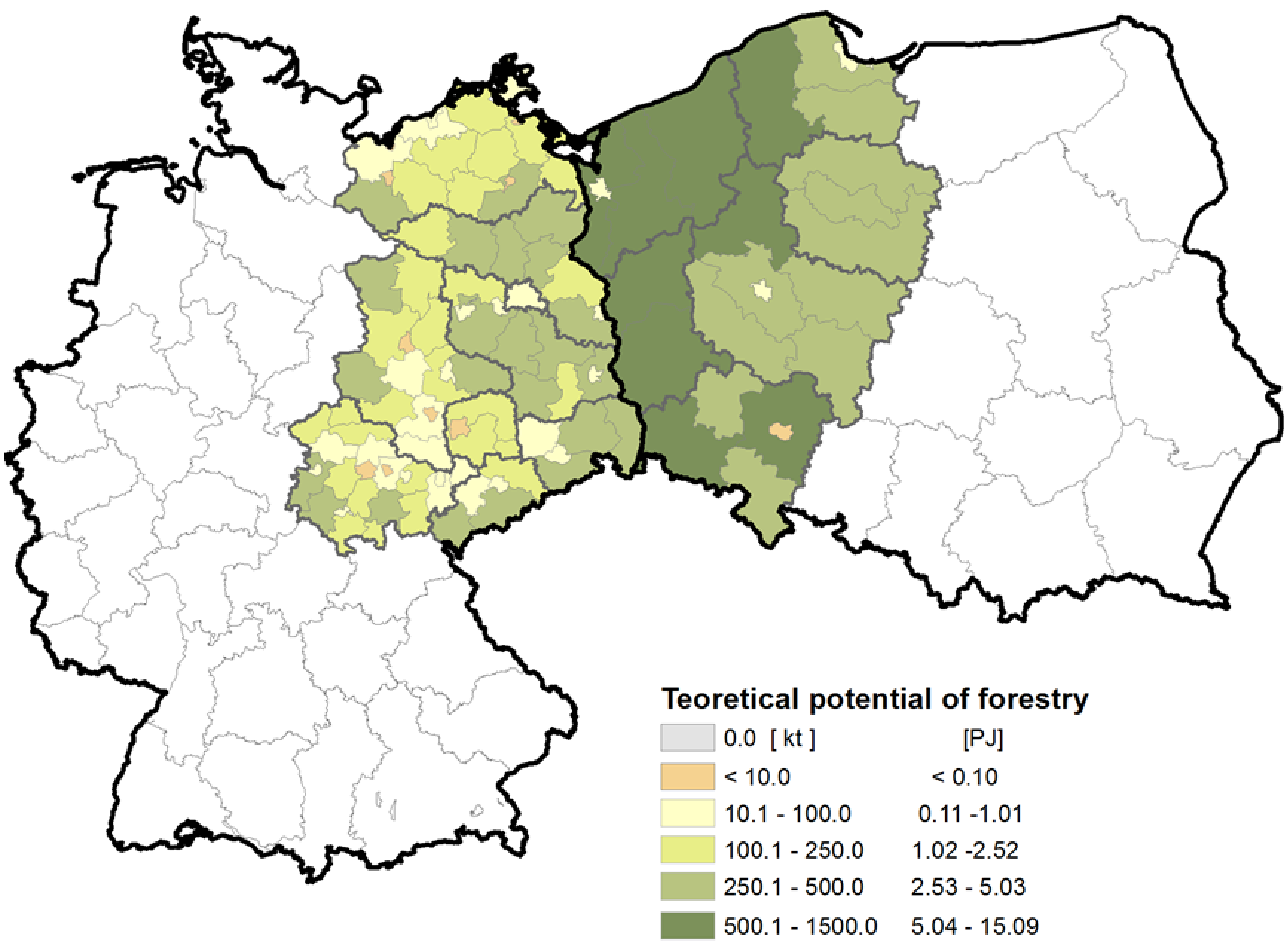
Deduction of competing use



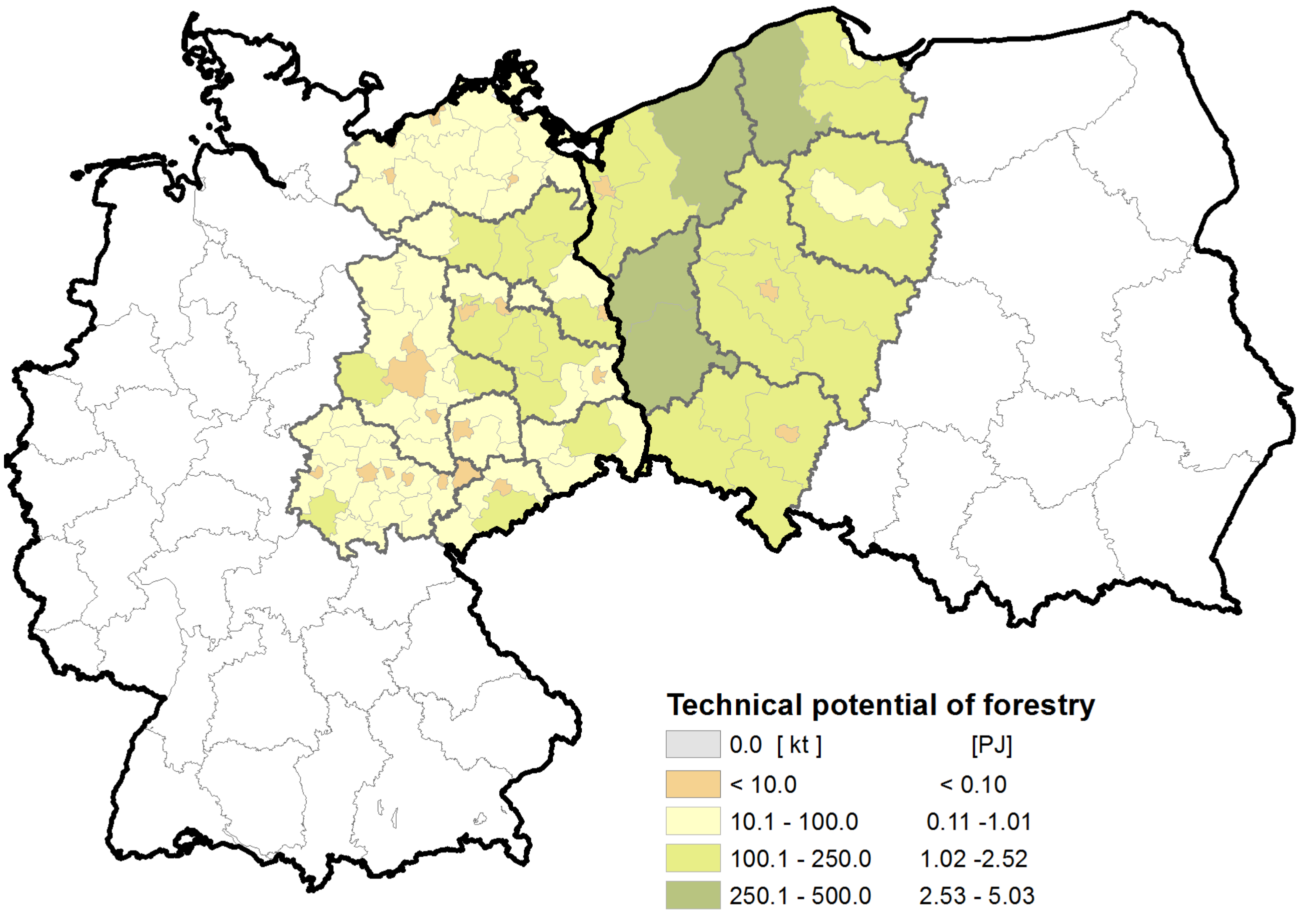
Technical straw potential



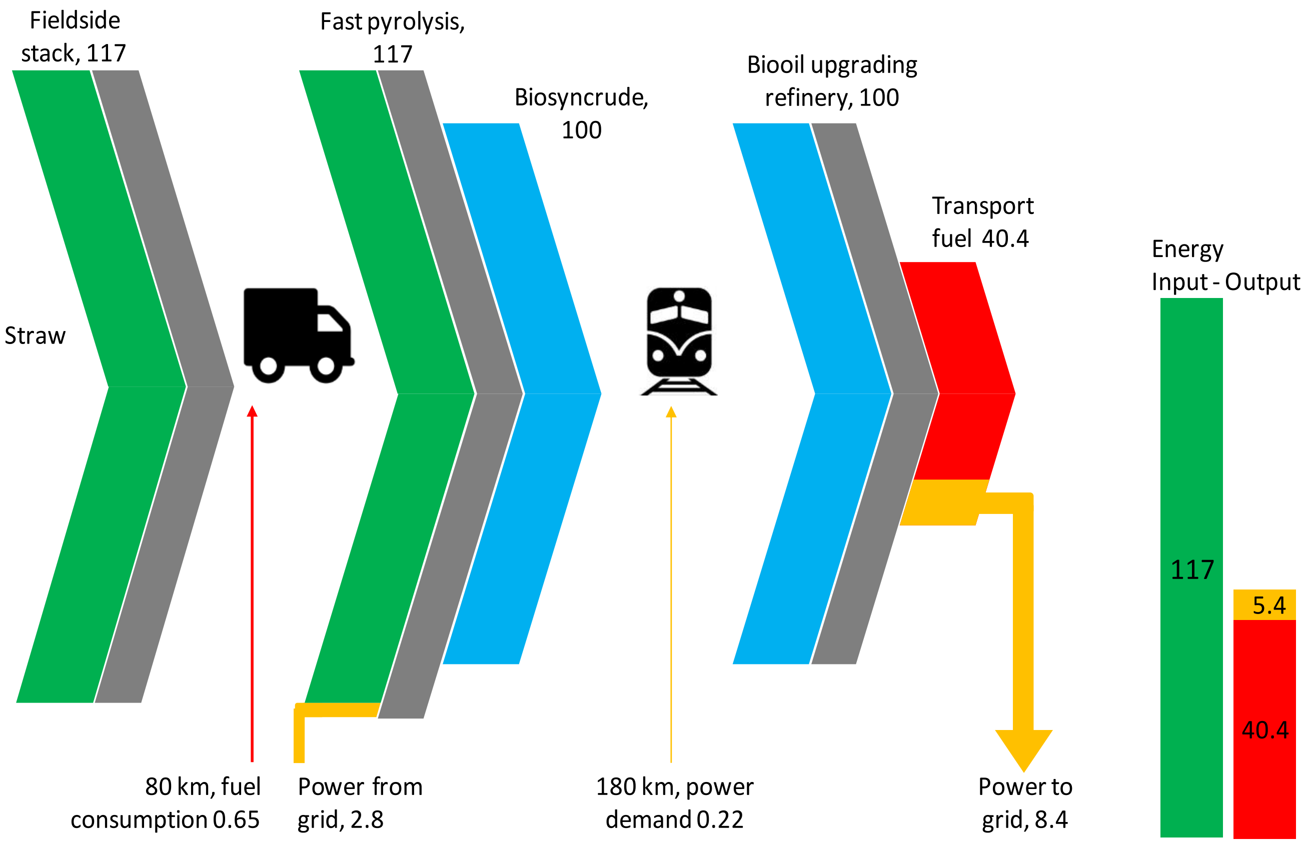
Theoretical potential of forestry



Technical potential of forestry

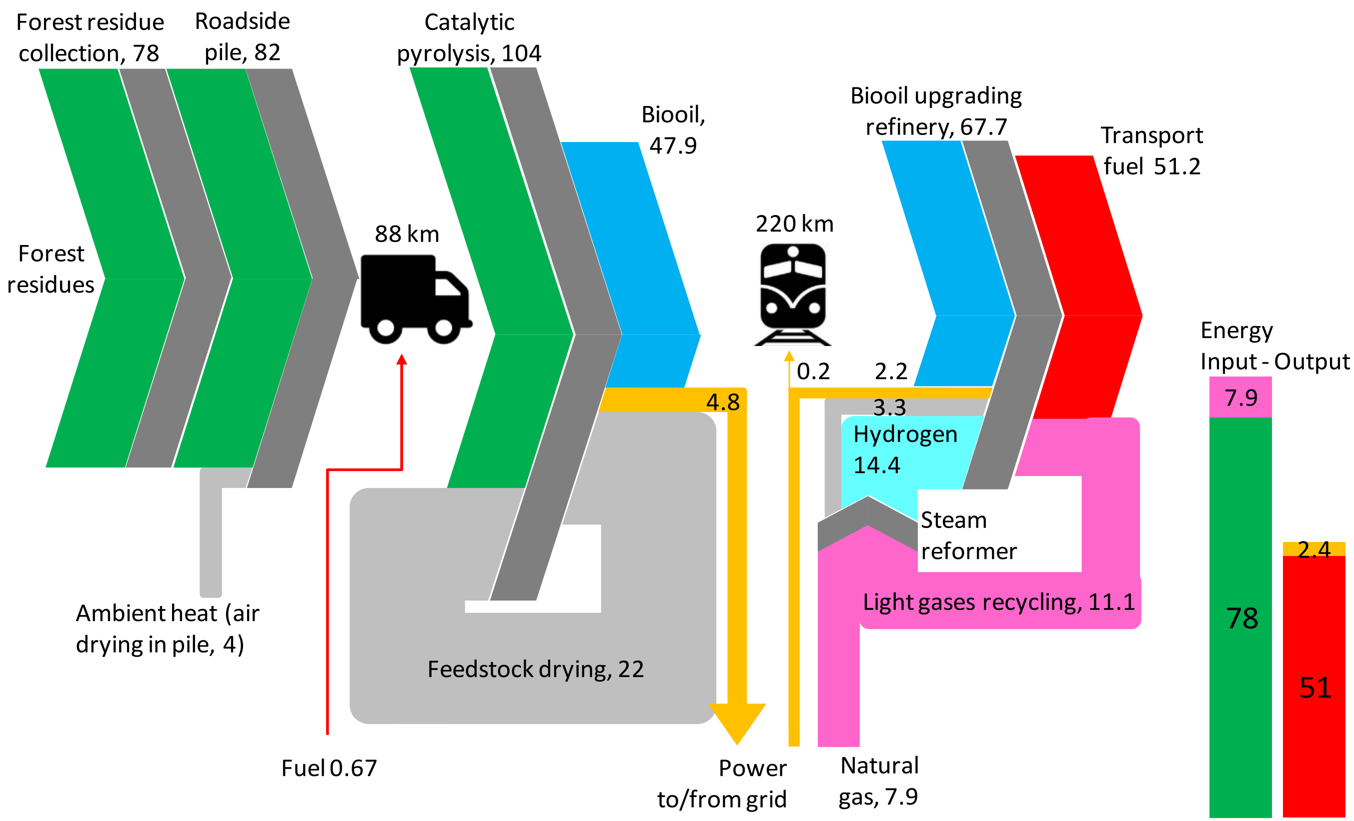


Energy flow of Fast Pyrolysis



Sankey-diagram on energy flows of a design-size (100 MW) catalytic fast pyrolysis plant and respective upgrading capacity in a refinery (67.7 MW instead of design size 260 MW). Numbers indicate the energy flow in MW. Transport efforts are given for reference case. (S. Kühner, SYNCOM)

Energy flow of Catalytic Pyrolysis



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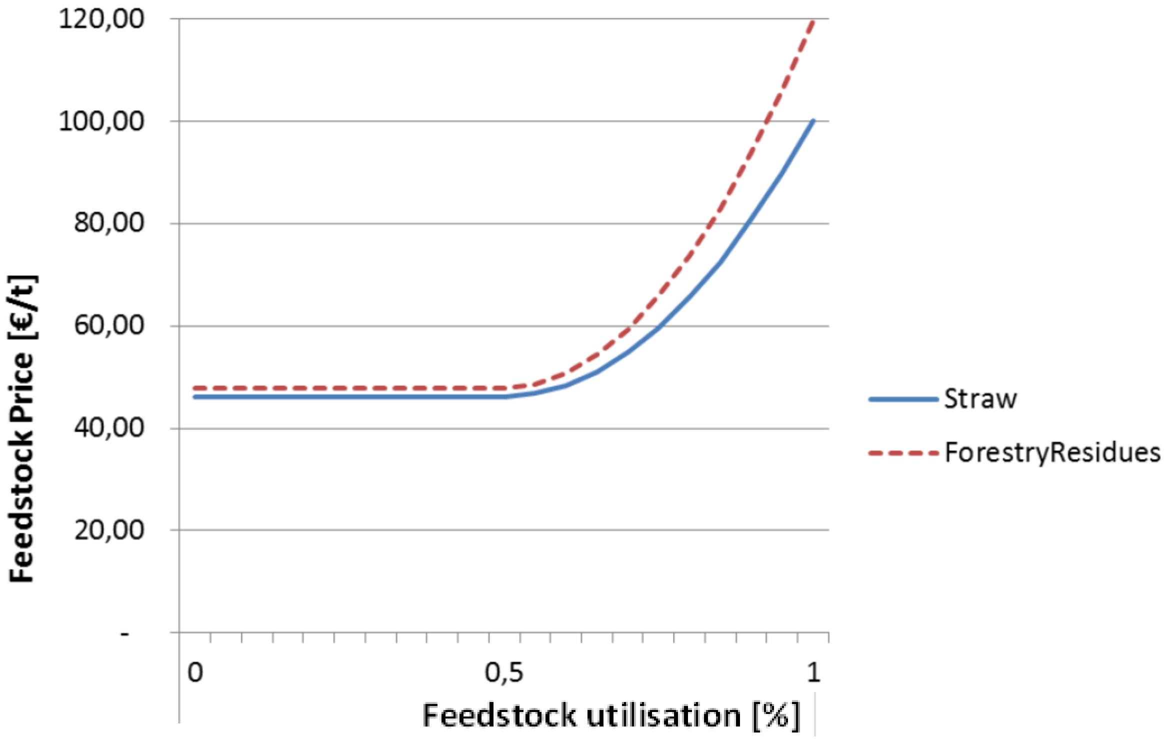
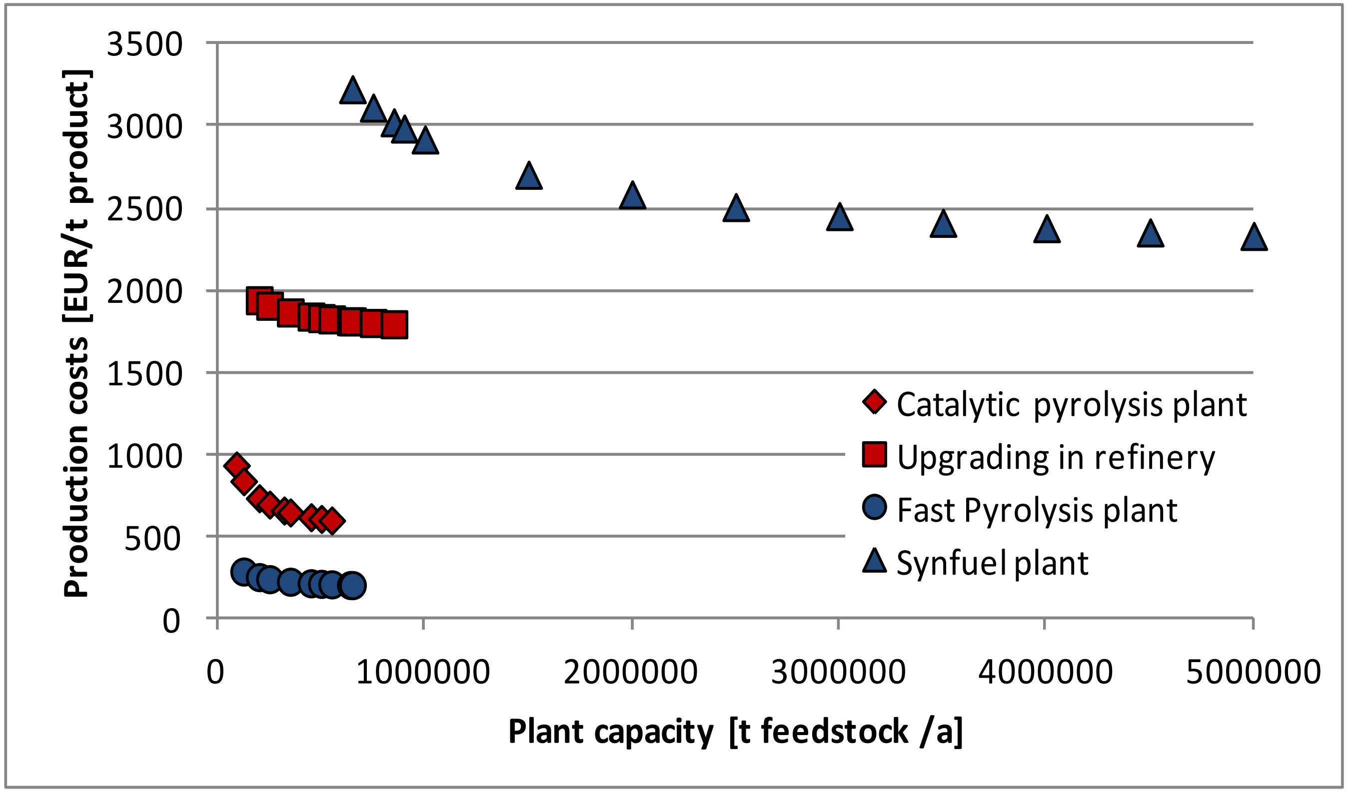
Feedstock cost supply/demand



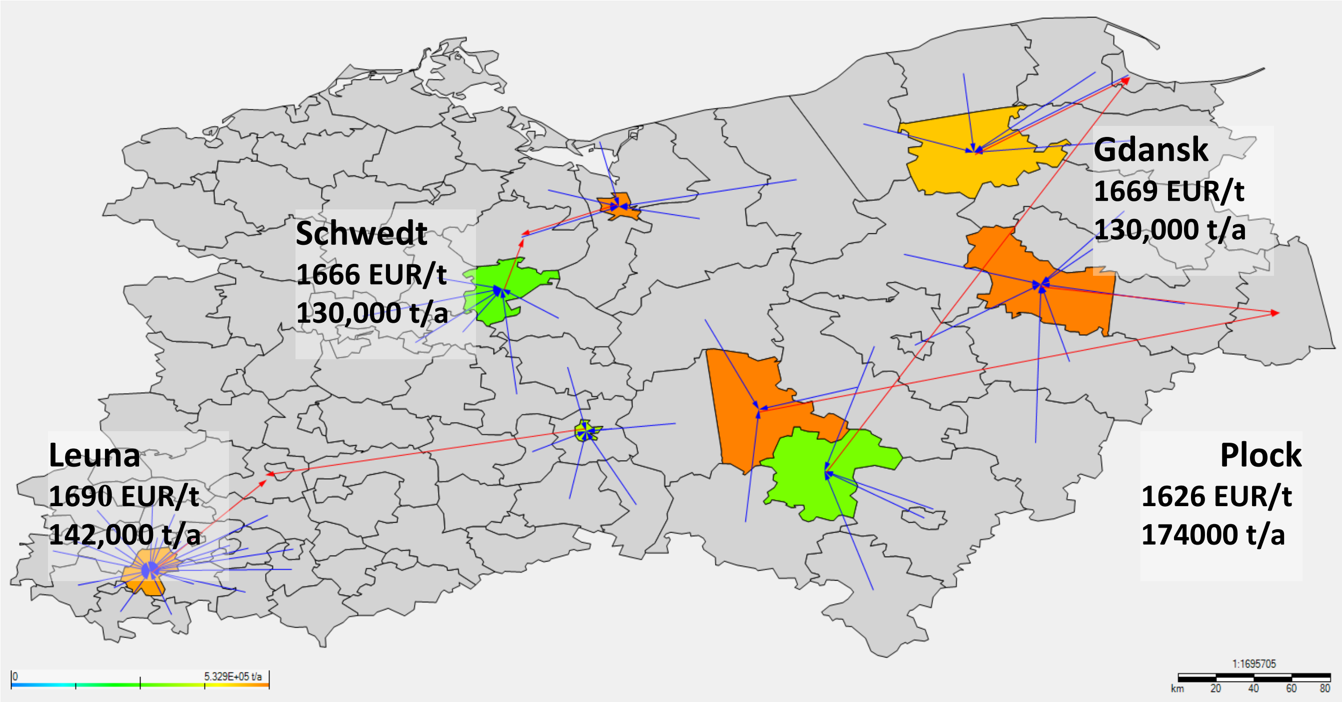
The feedstock prices (y-axis) depend on degree of utilization (x-axis). Increasing prices were assumed, if more than 50% of the available residue and waste feedstock is marketed.

The influence of plant scale on production costs per unit



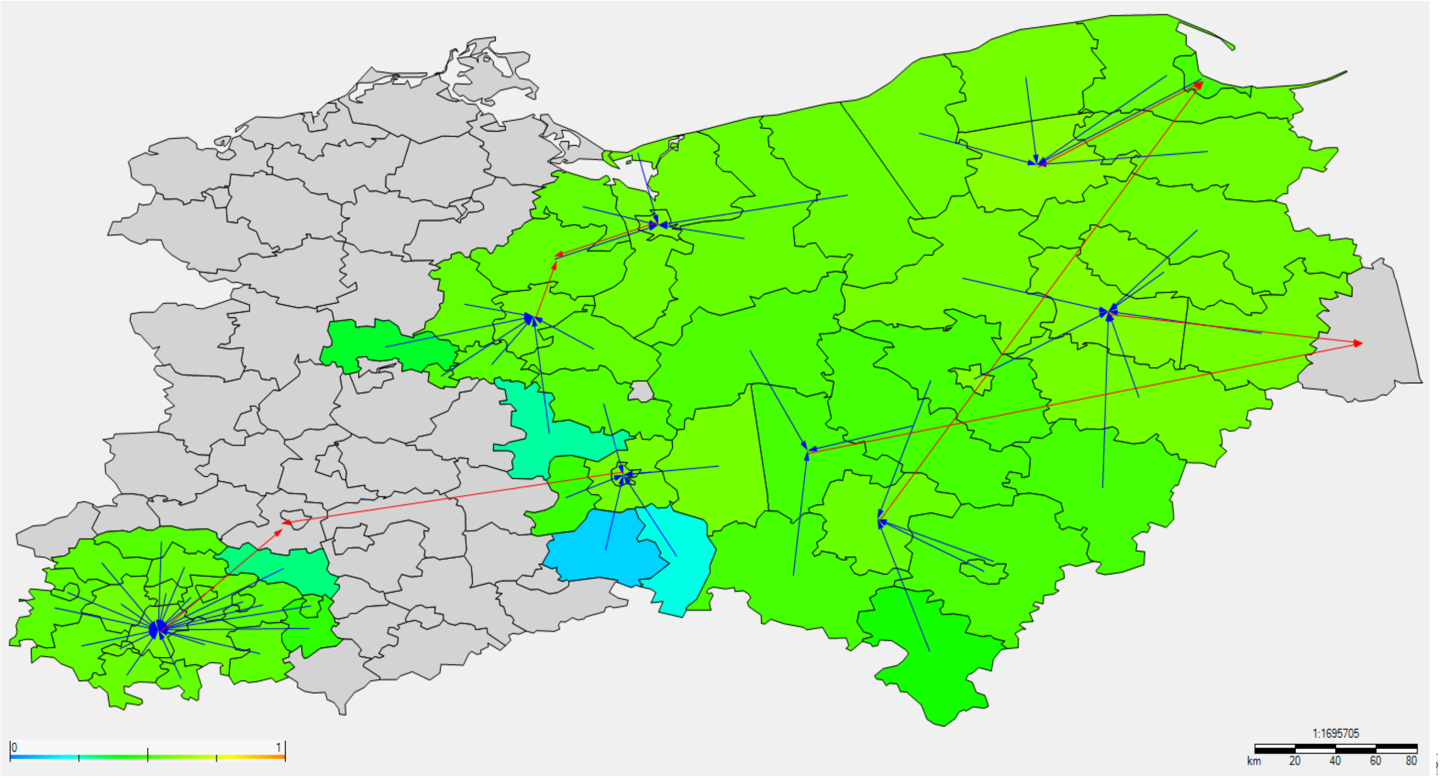
Production cost per unit vs plant production capacity

Costs and transport fuel amounts



Regions with CP-plants and their size in tonnes forestry residues conversion capacity per year (green-290,000 t/a; orange-533,000 t/a). Forest residue procurement is indicated by the blue arrows, red arrows indicate biooil transport for upgrading at existing refineries. Total transport fuel production costs and amounts are given for the refineries as yielded in this best of 6 parallel optimisation runs.

Regional forest residue utilisation



Regional forest residue utilisation in best run. Blue shading: 5-20%; green: 40-60%, red: 100% utilisation; blue arrows: forest residue transport to CP-plant; red arrow: biooil transport to refinery.

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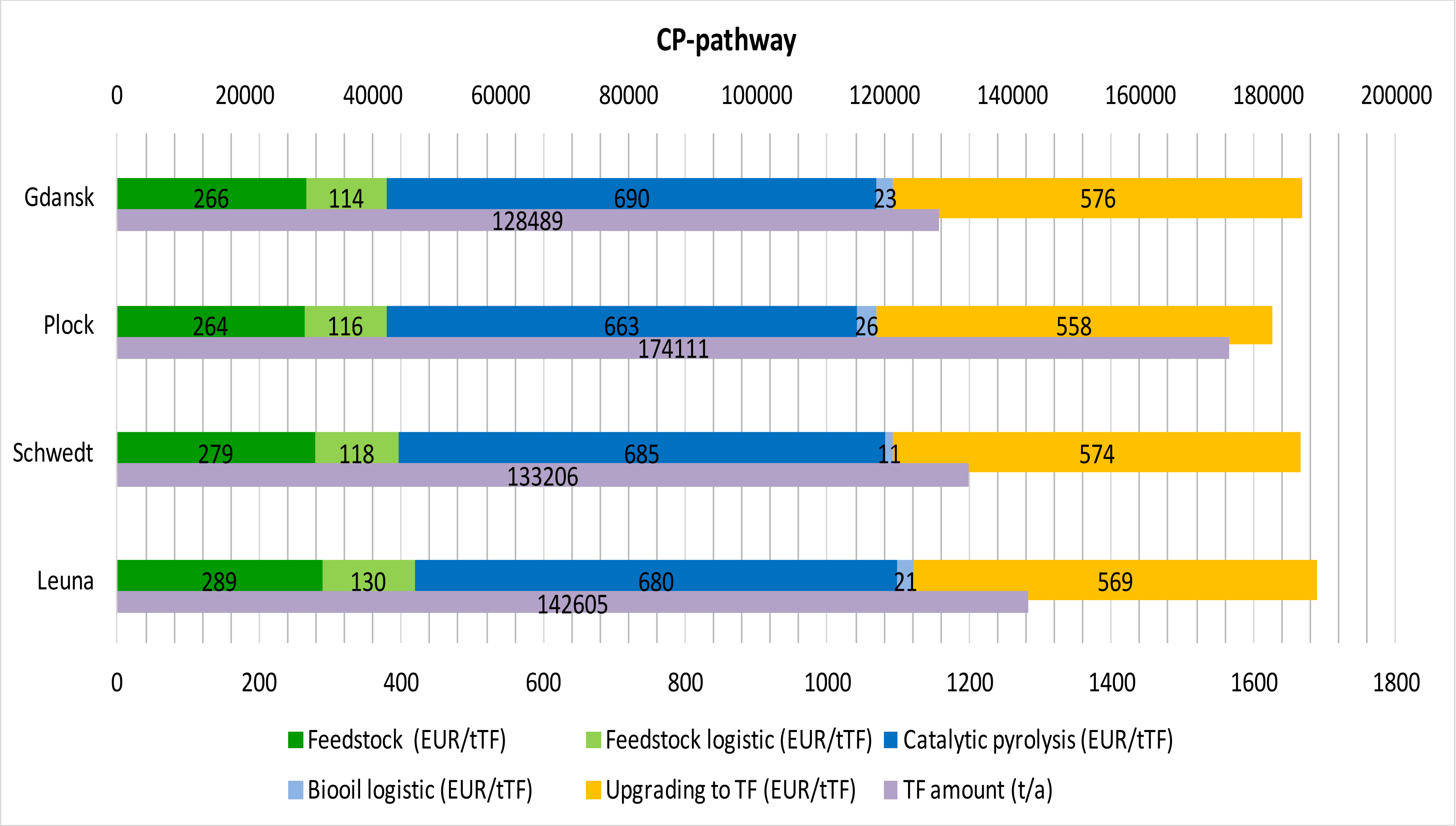
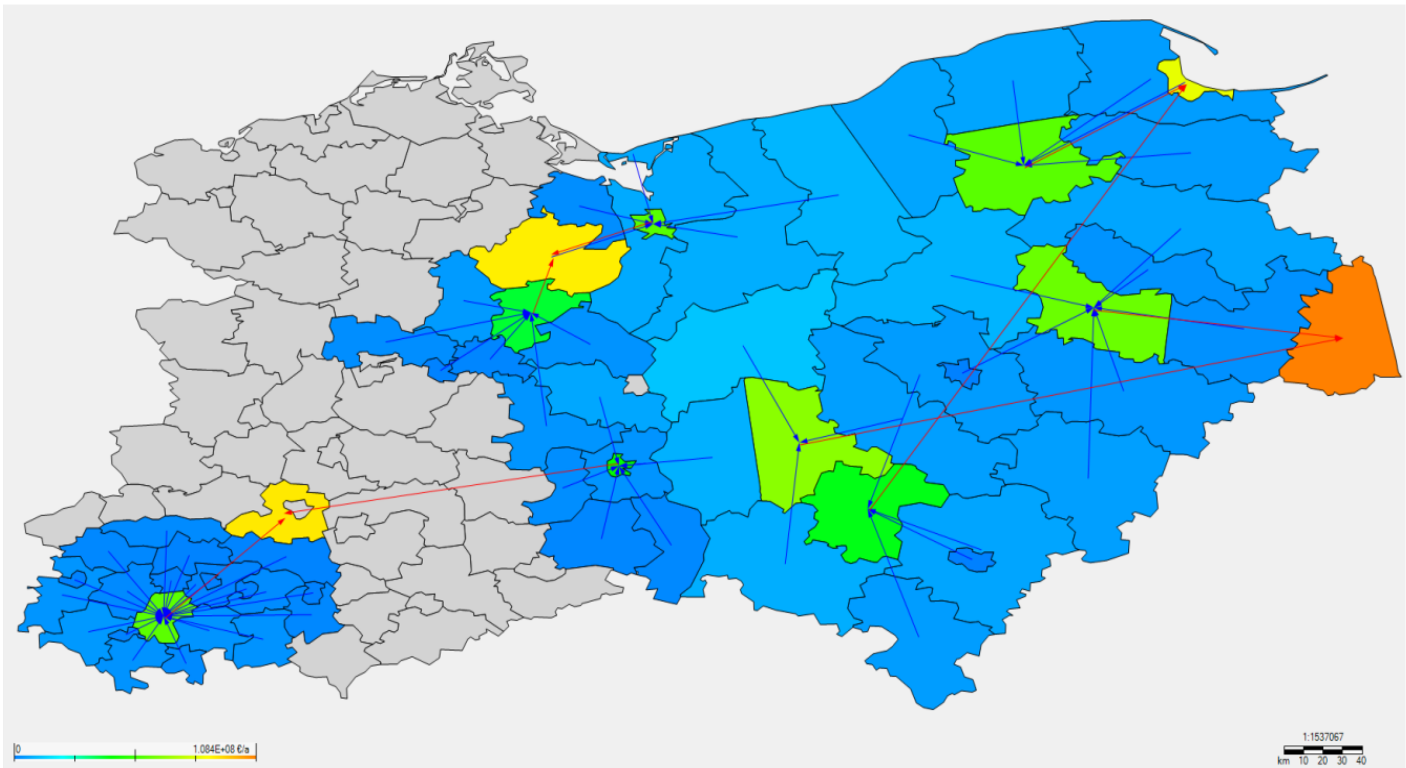
Cost components of the final fuel



Composition of fuel production costs and amount of Catalytic Pyrolysis-based transport fuel in the four refineries of the case study area.

Added value in the regions



Added value in the regions of the study area. Blue shading: Up to 11 MEUR/a; green: 40 to 60 MEUR/a; yellow: 80 – 90 MEUR/a; red: 110 MEUR/a

The case study conclusions

1. In the study area the available and sustainable exploitable potential of straw and forest residues amounts to 300 PJ or 7.1 million tonnes oil equivalent per year.
2. Fully implemented the CP- and FP-biofuel value chains converts about 50% of the available straw and forest residue biomass to 1.5 million tonnes of transport fuel.
3. The CP- and FP-biofuel potential covers about 10% of the annual transport fuel demand in the study area.
4. At a GHG-avoidance of about 80% and assuming local consumption of the CP- and FP-biofuels the CO_2-emissions of the transport sector would be reduced by 7.7 %. This is 25% more than required by the present regulations.
5. The investment required for full implementation of the CP- and FP-value chains in the study area amounts to about 23 billion EUR. Specific measures to support and back these investments would be needed.
6. The conversion technology of both, the CP- and FP-value chain is currently not commercial available. Further efforts for development and demonstration of these technologies are needed prior to commercialisation.

References & further reading

- http://bioboost.eu/project/facts.php
- http://bioboost.iung.pl/
- http://iung.neogis.pl/navigator/
- http://dev.heuristiclab.com/trac.fcgi/wiki/BioBoost

Thank you for your attention !!

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