Project: PELLETS@LAS
(EIE/06/020)

Feasibility Study for Mixed Biomass Pellets Production

In the German Sample Region: Straubing, Bavaria

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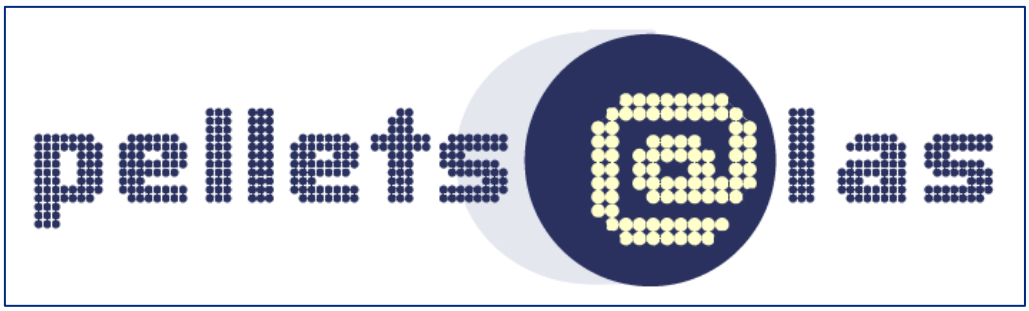

Dr. Alexander Höldrich, WIP
Dr. Christian Epp, WIP
Josef Witzelsperger

WIP Renewable Energies
Sylvensteinstr. 2
81369 Munich
Christian.epp@wip-munich.de

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Executive Summary

This document was elaborated by WIP in the PELLETS@LAS project which is supported by the European Commission under the Intelligent Energy for Europe Programme. It provides a site selection done after the basic guidance on how to select suitable sites for a mixed biomass pellets production for Germany.

For Germany the region of Straubing was selected. This region combines very intense agricultural activities with one of the best infrastructure of Germany. Large motorways and railway lines are meeting in Straubing with the large Danube industrial harbour which links Bavaria to all countries till the Black Sea. Finally, a strong competence centre for bio-energy is situated in Straubing. For all these reasons Straubing recently was selected as one of the "bioenergy regions" of Germany.

The analysis has shown that the best residue for the production should be the straw from wheat production. It was not easy to assess the free potential of straw in the region. The amount strongly depends on the soil quality and agricultural structure. Moreover, it was found out that the total amount of straw harvest varied significantly in the last years.

Still, it became clear that a production of 25.000 tons of straw pellets could be included in the agricultural structure of the region without creating any problem in the supply with straw residues.

The technical analysis that was performed together with the consortium partners brought a clear preference to Bühler technology. The largest straw pellets factory in Europe in Köge, Denmark is operating successfully with this technology. Particular advantage of this technology is that it is able to also cope with straw of different quality and humidity.

There are still very view straw pellets markets in Europe. Still, there are large power plants in Belgium, Holland and Scandinavia who already purchase straw pellets for co-firing in coal power plants. These markets could be served by the production in Germany in a first step until own domestic markets have developed. Moreover, there are some national markets in the pet and animal feeding which could be supplied as well.

In General it can be assessed that straw pellets for energy purposes currently can be sold with 90 Euro / ton. The prices for the pet and animal market go up until 140 Euro per ton. The production expenses should be around 40 Euro per ton. The current straw price is assessed to be 50 Euro as well. Thus the feasibility study shows that it will be economically feasible to produce 25.000 tons of pellets, when a certain part of the production is given to the animal and pet feed in the next years. When the prices for straw pellets in energy use will go up, the hole production can be sold in this market sector.

Acknowledgement

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Chosen Methodology

These Guidelines are based on a top-down approach which is structured into four main analysis steps as shown in Figure 1.

Step 1: **Selecting suitable regions and available raw material**

In many European countries there exist biomass potential studies which clearly define biomass quantities. Within the PELLETS@LAS project, potential studies shall be elaborated for Poland, Greece, Slovakia and Germany. The Guidelines therefore start on the basis of these potential assessments on national or regional level. The first step is to select suitable regions for the mixed biomass pellet production. Suitable regions are defined by the availability of biomass. Due to the low energy content per volume and large quantities it is economically and energetically not useful to transport agricultural feedstock further than 5 km, and stackable energy crops not more than 15 km. Thus, a mixed biomass pellets manufacturing plant should be located in a radius of less than 15 km from the available biomass sources.

Step 2: **Defining suitable neighbourhoods** within the selected region

The second step is to define suitable neighbourhoods within the selected region. Suitable neighbourhoods are defined by their access to infrastructure and logistics. Therefore, the mixed biomass pellets plant should be located in a radius closer than 5000 metres to a larger road, very helpful it is also to have direct access to a railway station or a harbour. Of course one item is for sure: the shorter the distance the better for the logistics.

Step 3: **Defining suitable sites** within the selected neighbourhood

The third step is to detect suitable sites within the selected neighbourhoods. Suitable sites are pieces of land where all devices (digesters, storage systems, CHP plants) of a mixed biomass pellets plant can be installed under favourable technical and legal framework conditions, particularly important is to have sufficient space.

Step 4: Fulfilling soft requirements for the selected sites

The last step is to optimise the soft requirements at the selected sites. This includes the mobilisation of institutional support between policy and administration and to win public support for the project.

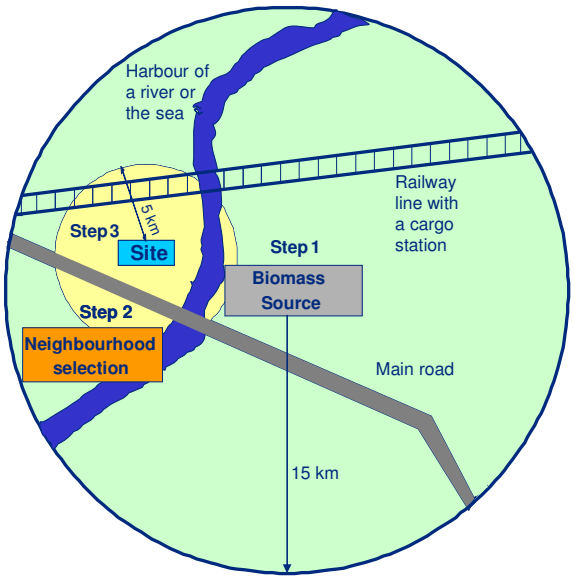


Figure 1: Site selection methodology

Description of the Target Region (Step 1)

Due to the low energy content per volume and large quantities it is economically and energetically not useful to transport biomass feedstock further than 15 km. Thus, site should be located in a radius of less than 15 km from the available biomass sources.

In the example for Germany the City of Straubing and the region administrative district Straubing-Bogen was chosen which is in Lower Bavaria.

The river Danube divides the administrative district into two parts north and south. The example regions is part of the Bundesland Bavaria as it is shown in the following pictures

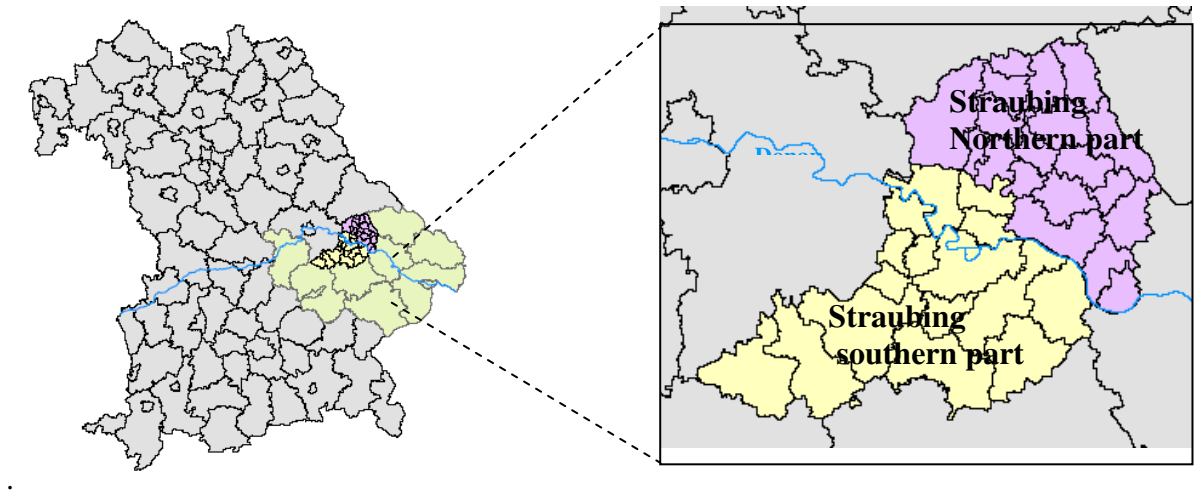


Figure 2: **The administrative district of Straubing-Bogen in the administrative region of lower Bavaria [ESRI 2005]**

The region has got a base area of 120,253 ha. 40.75 % in the northern part and 59.25 % in the southern part of Straubing [ALF 2005a, LfStaD 2005].

In the following figure 3 the land use of the northern part and southern part of the district of Straubing is shown. One can see that in the northern part the grassland together with the forests together have got a majority of 65 % of the land use [ALF 2005a, LfStaD 2005].

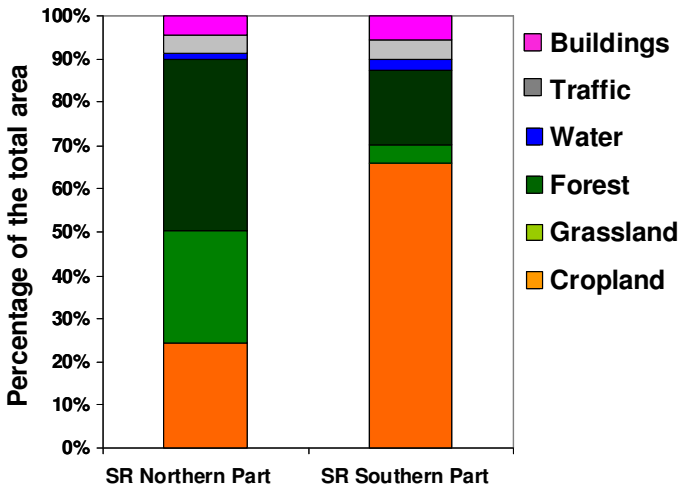


Figure 3: **Parts of the landuse in the example region [ALF 2005, LFSTAD (2005)]**

In the following table 1 the absolute values are shown.

Table 1: Cropland and grassland in the example region in average [ALF 2005a]

2000 to 2005	Cropland [ha]	Grassland [ha]
Straubing Northern Part	11,723	12,537
Straubing Southern Part	46,265	2,976
Whole Region	57,988	15,513

Biomass supply

In figure 4 it can be seen that the straw residues from corn and Tuber crop provide the largest potential for biomass in the region. Consequently, the straw potential has to be analysed in more detail.

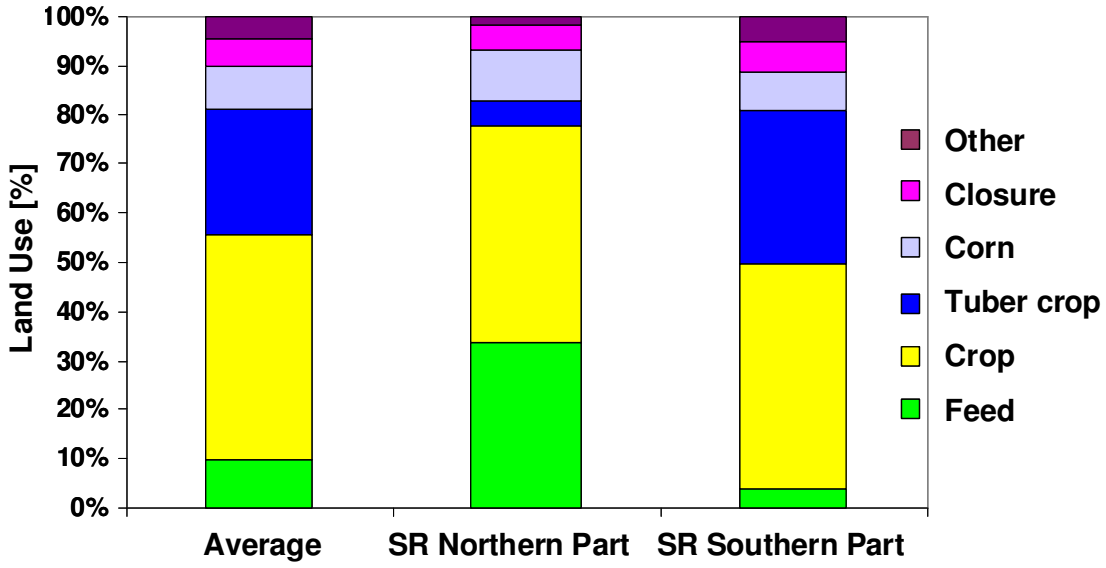


Figure 4: Land use of the crop land in the sample region [ALF 2005]

For the years 2000 to 2004 there is the total amount of available straw shown in the following table.

Table 2: Total amount of straw in the sample region [ALF 2005, LfL Bayern 2005, StMLF 2005]

Available straw [tonnes]	2000	2001	2002	2003	2004	Average
Straubing Northern Part	29,092	29,188	25,778	20,863	30,251	27,034
Straubing Southern Part	129,287	128,701	114,369	96,394	147,381	123,226
Whole Region	158,379	157,889	140,147	117,257	177,632	150,260

It is important to be aware that the total amount of straw strongly differs with the harvesting seasons. Therefore, the harvesting amount in 2003 can be considered as the minimum and in 2004 can be considered as the maximum amount. The reason for this fluctuation is seen in the different weather conditions in these years.

The volume of the grain production and the development of the harvest volume in the example region of the years 2000 to 2004 can be seen in the following graph.

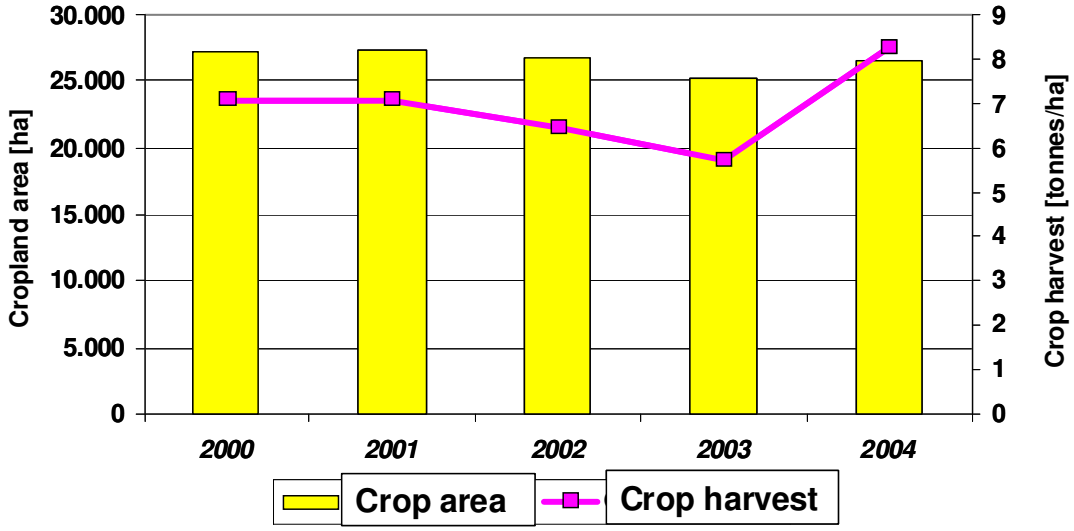


Figure 5: **Grainproduction in the example region [ALF 2005, LfL Bayern 2005]**

The harvesting quantity in the shown years is volatile. The decline in 2002 is a result of a higher rainfall. 2003 was very dry. Ideal weather conditions for a crop harvest were in 2004 [LfL Bayern 2005a, LfL Bayern 2005f].

Current use of biomass feed-stock

There are not many residues in the agricultural sector which are completely set aside because they are produced in such high quantities or have so poor qualities for any kind or recycling purpose. Many products already have a traditional use e.g. as fodder, as litter for the stables. It is very important to carefully analyse the current use of the agricultural waste. Based on this analysis it should be defined precisely, why there should be an interest of the farmers or producers of the waste to give the biomass into a new purpose.

The straw often is used as a fertilizer for the soil, in order to avoid a degradation of the soil quality. Thus, in the selected sample region a main part of the straw is to be kept on the fields.

In the following figure 6 the differences can be seen in the in the sample region of Straubing northern part and southern part. The figures show that in the Northern part 70% and in Southern part 82% of the straw residues remain on the field. This strong difference of 12% is because of the much better soil quality in the South, which enables the farmers to mainly use straw for fertilizer. In the North the prevailing poor soil quality does not improve significantly by the adding of the straw residues.

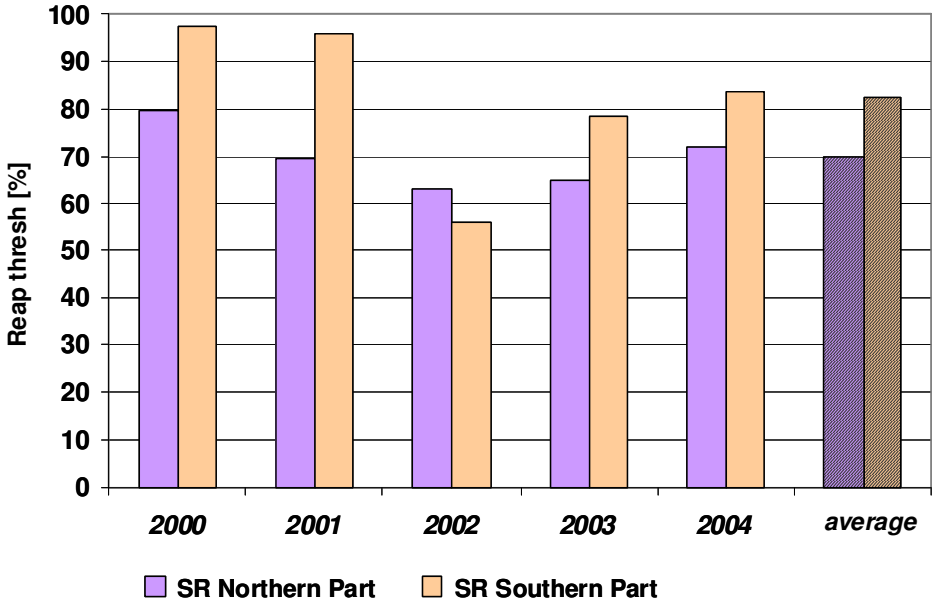


Figure 6: **Percentage of the straw volume remaining on the field in the sample region [MR 2005]**

Therefore, for the selected region of Straubing it is possible to count with the volumes of straw remaining on the field as it is shown in the following table.

Table 3: **Volume of straw remaining on the cropland in the sample region [ALF 2005a, LfL Bayern 2005a, StMLF 2005, MR 2005a]**

Remaining straw [tonnes]	2000	2001	2002	2003	2004	Average
Straubing Northern Part	23,187	20,248	16,262	13,532	21,811	19,008
Straubing Southern Part	126,236	123,097	64,358	75,467	123,268	102,485
Administrative district	149,423	143,345	80,620	88,999	145,079	121,493

It is technically possible to exchange some of these straw quantities through the implementation of Intertillage crops. Detailed studies have been implemented for assessing the possibility to replace the fertilisation with straw residues with the fertilisation through interim crops.

The following table shows the availability of straw, without the loss of sustainability in the years 2000 until 2004 in a certain scenario [Witzelsperger, 2006]

Table 4: **Volume of available straw in the sample region [ALF 2005a, LfL Bayern 2005a, StMLF 2005, MR 2005a]**

Mould balance	Intertillage [ha]	Available straw volumes [tonnes]				
		2000	2001	2002	2003	2004
± 0 kg C/ha	39	51,715	42,471	-10,293	-2,892	48,636

With an intertillage of 39 ha acreage with sugar beet, the average rises up to 26,000 tonne by a maximum of more than 50,000 tonnes.

Rivalry use of straw

As Twistel found out [Twistel 2000] the used straw percentage for animal husbandry is about 30% of the harvested volume.

It is therefore used as litter as well as animal feed. It is expected, that the use of litter will decrease because of the decline of small farms, which mainly use straw as litter. [ALF 2006].

Additionally straw is used in specialised cultivation like strawberries or flowers for covering the ground. [AID 2005].

For the cultivation of sugar beet, straw sometimes is used to cover the heap instead of using fleece. The shall prevent damages caused by frost [LMG PERKAM-KIRCHROTH 2005]

Last but not least straw is used in landscaping as a mulch substitute. Straw is cheaper than bark mulch and easier to handle. The straw demand fort his special use of tree nurseries and garden centres is about 2% of the total harvest [Twistel 2000]. Consequently, it is assessed that the main part of the used straw is mobilised through a replacement as fertiliser (through the implementation of interim crops, see above). Only in years with poor harvesting conditions additional straw has to be purchased on the free market.

Survey of the biomass availability

Biomass Region 1: Straubing-Bogen Northern Part

Biomass source	Availability per year in metric ton	Description of quality (in view to humidity, contamination)	Current use of the biomass ressource	Current market price of the ressource	Biomass available all year long or only in harvest season
Farmers	5,000	**Apparent density: between**: 80 kg/m3 to 120 kg/m3 in bales **Humidity:** < 15 % **tares**: < 0,5 gew. % **part of rest grain:** < 0,4 gew. %	litter, strawberry cultivation, sugar beet cultivation; landscaping mulch	60 to 70 €/tonne on the field in bales. (volatile from 50 to 120 per a)	Harvest season, little storage at the farmers

Biomass Region 2: Name of the region: Straubing-Bogen Southern Part

Biomass source	Availability per year in metric ton	Description of quality (in view to humidity, contamination)	Current use of the biomass resource	Current market price of the resource	Biomass availablilty of the year
Farmers	45,000	**Apparent density: between**: 80 kg/m3 to 120 kg/m3 **Humidity:** < 15 % **tares**: < 0,5 gew. % **part of rest grain:** < 0,4 gew. %	litter, strawberry cultivation, sugar beet cultivation; landscaping mulch	60 to 70 €/tonne on the field in bales.(volatile from 50 to 120 a)	Harvest season, little storage at the farmers

Mobilisation of the straw material

After the grain harvesting the straw residues are compressed in bales of rectangular shape through a contracted farming company. The bales are stored at the opening of the field (max. length 250 m). This working steps causes expenses of 19,30 Euro per metric ton. Alternatively, the bales are kept on the field and have to be collected in a separate working step. Such a collecting step would cost approximately 10 Euro per metric ton (the pressing itself would then cost 8 Euro per metric ton).

The transport to the interim storage facility is organised with agricultural machinery that is able to 16 bales of straw. The transport expenses are estimated to be around 2.07 Euro per metric ton. The storage is under open sky. Just in Time Delivery will then bring the straw to the pelletising factory.

Description of the selected neighbourhood (Step 2 of methodology)

Adequate road access

The mixed biomass pellets manufacturing plant requires a steady supply and has an outflow of large quantities. Thus, a good road access is compulsory, namely:

- Direct access to a main roads
- Safe opening to the street which is suitable for heavy vehicles
- Access to a cargo rail would be nice
- Access to a harbour would be nice

In the example region there is well built transport network (figure 7). It includes a rail network and a harbour at the river Danube. Next to the harbour there is the industrial area Straubing Sand with a total area of 218 ha. The area where it is possible to set up a manufacturing plant is 145 ha. About 80 ha already is covered by industry plants. It is therefore an excellent place for setting up a straw pellet manufacturing plant. With the harbour, the railway and the different roads you have got different possibilities for logistics.

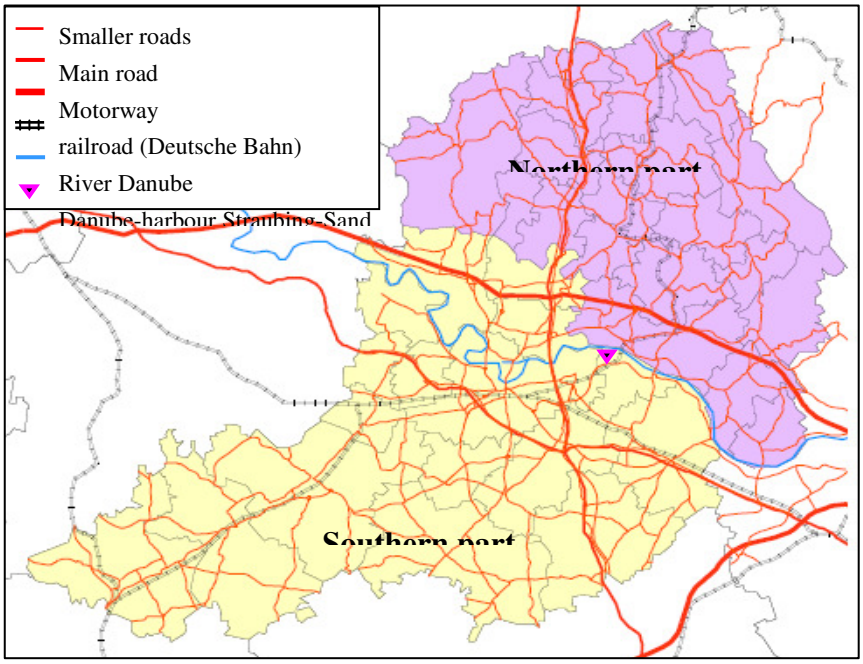


Figure 7: **Infrastructure in the sample region [ESRI 2005, StrBA 2005]**

Sufficient Access to Infrastructure

Site name:	Figure
Distance to a main road (in km)	2 km
Distance to a train cargo	0 km
Distance to a harbour	0 km

Description of the manufacturing site itself (step 3)

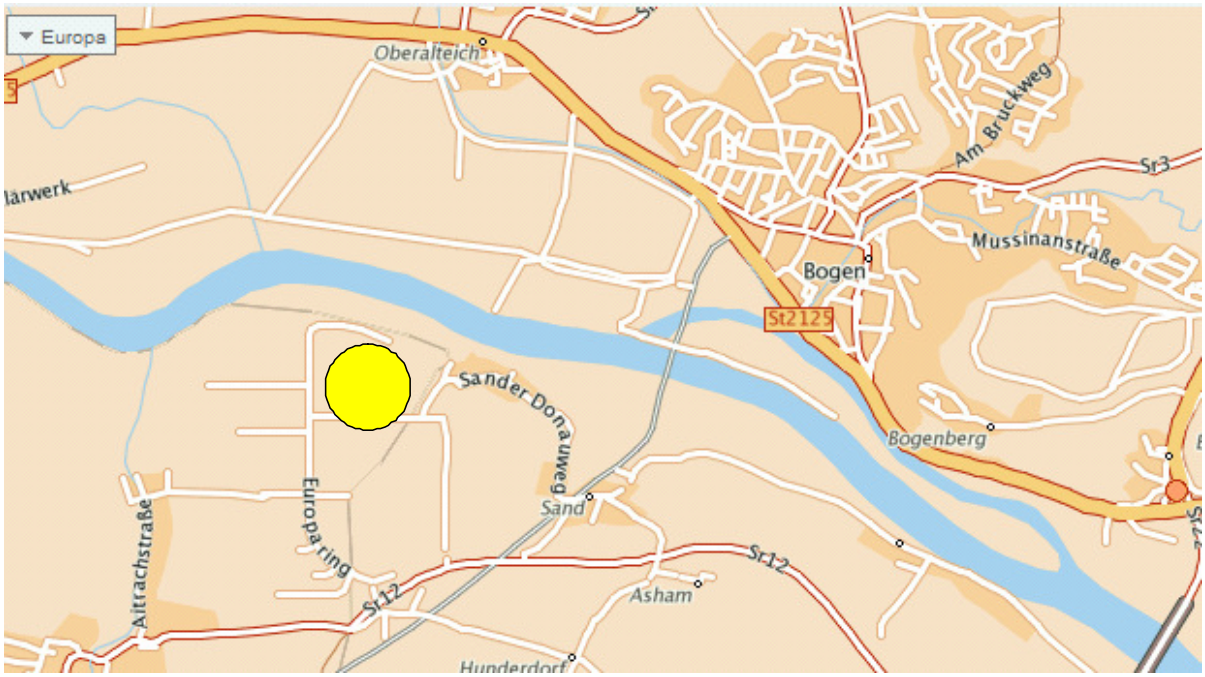


Figure 8: Possible site for a straw pellet manufacturing plant in Straubing Sand

Available space

Site name: Straubing Sand	Figure	Comments
Space for Mixed biomass pellets Plant (in m^2)	60,000	Industrial area
Space for the storage of biomass on-site:	Yes	
Space for the storage of biomass at the producer	A little	On the field and in farm buildings
Space for the manufactured pellets storage	Yes	

Additional site requirements

Site name:	Yes	No	Comments
Site access for trucks possible	X		
Soil contamination is unlikely	X		
Soil is suitable for industrial construction	X		

Planning instrument prohibits mixed biomass pellets plant on – site		X	
Planning instruments foresees residential, cultural or nature protected areas nearby		X	
Residential, cultural or nature areas exist in the proximity		X	

Ownership structure

Site name:	Straubing Sand
Who is the owner of the selected site:	The town of Straubing
Will the owner also be the operator of the mixed biomass pellets manufacturing plant	No
Is there a basic possibility to buy the land	Yes

Framework conditions for site development (step 4)

The feasibility of a selected site strongly depends on a set of so called soft requirements which cannot be overestimated in their importance.

Political support

The installation of a mixed biomass pellets manufacturing plant might be a political issue, too. It is very important for the successful project development and implementation that significant support can be found between the stakeholders on municipal and regional level.

In the region of Straubing renewable raw material is important. A centre of competence (universities and state institutes) is located in this region. Therefore it is politically wanted to build and run a plant like this.

Available know-how for mixed biomass pellets operation in the region

It is important to analyse if there are already individuals or companies in the country who have experience in successful mixed biomass pellets manufacturing plant.

Moreover, the work on-site can become much more efficient, if the plant operation can be combined with another business of similar profile, such as an agricultural association, a food processing industry or a biofuel producer.

Next to the site there is a wood pellet production site. Again centre of competence in the town (7 km away)

Committed project developer

The project development for a mixed biomass pellets plant can be long and cumbersome. For this reason it is very important to have a committed project developer in the region. This person should have a good basic understanding for the economic and technological items of a

mixed biomass pellets plant and should be well rooted in the region. Such a person can increase the chance of a successful project development significantly. This position is still vacant for the German feasibility study.

Technology Analysis

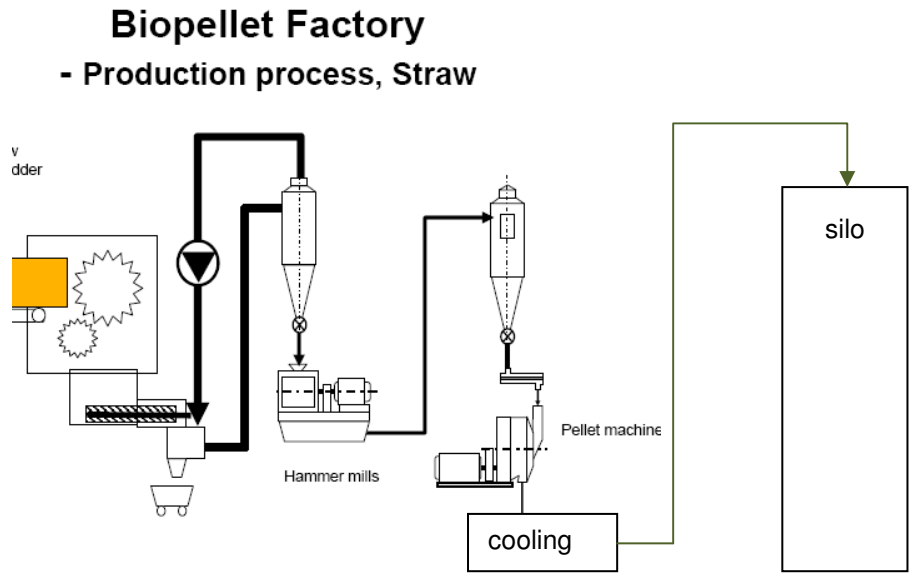
Plant Design

The pelletising site will have the following design:

- Yearly production capacity: 25,000 tons
- Hourly production capacity: 3.5 tons
- Straw input parameter: Straw in bales, with less than 18 % moisture, calorific value 14,5 GJ / t.
- Pellets output parameter: Pellets with 8 mm x 0.5 mm, with moisture of less than 8 %, calorific value 15.5 GJ / t.
- Main technology parts:
    - Shredding device
    - Hammer mill
    - Pelletising unit
    - Feeding and transport system
    - Storage silo

Some factories use heating devices to secure complete dryness of the input biomass. This heating device has to be bought additionally.

The technical scheme of a straw pellets factory can be highlighted by the following scheme:



Technology Provider

A comprehensive survey of possible technology providers has brought the following picture:

Bühler, Germany

Buhler's line uses steam and water to condition the cut straw just before pellet mill – it helps to increase the lifetime of dies and rolls and also saves the energy. Moreover, the plant in Copenhagen uses a shredding device that is able to shred and cut the straw bales of every kind (round, small and big cube bales) and is not sensitive to the moisture content. Even when this crusher technology is rather expensive and energy intense, it still can be an important advantage to secure the planned production quantity.

Reference site: Buehler pelletising technology was used in the largest straw pelletising plant of Europe in Koge, Denmark. With an original capacity of 100.000 tons per year it currently produces 60.000 tons of straw pellets p.a. The plant partly uses technology from other suppliers. It had severe starting problems particularly in the transport of the material between the different steps of the production process.

California Pelletising Machines (CPM), California

This technology is widely used for wood pellet production in Central and Eastern Europe. The technology requires comparatively high operation costs.

Reference site: The straw pellets plant with a yearly capacity of 3,5 tons per hour in Jelcz-Laskowice, Poland was constructed with CPM technology. Until today the plant has severe technology problems. These difficulties partly are caused through wrong strategic decisions of the investor.

Amandus Kahl Pelletising, Germany

Amandus Kahl is known as a very solid and high quality technology.

Reference site: One pelletising plant in Poland in Grudziadz was equipped with Kahl technology. The plant started operation in September 08. At the time of this analysis, the plant was still in the start-up phase, in which the utilisation of low-quality raw materials resulted in low plant performance. As only this data was available, the Kahl technology was not further considered in this analysis. Today, after optimisation of the raw material management by the operator, the plant reaches the required capacity and product quality.

Gama Pardubice, Czech Republic

This Czech pelletizing lines producer offers production lines with capacities between 2.6 and 3.6 mt/h to very low prices. The company founded in 1994 has supplied several straw pelletising plants in Czech Republic.

Reference site: Under investigation

Andritz

Andritz does not have any reference sites of straw pelletising. Right now they just starting with it – some investors are interested in creating one in England and the other one may rise in Poland – In Sępólno Krajeńskie the plant will be owned by Mr. Romuald Hałabuda – "Romico" company.

GEMCO, China

8mt/h pelletizing line with drying system costs 528 000 USD FOB Tianjin J.

The survey has clearly shown that Bühler technology is the most favourable one:

- Bühler is the only technology in Europe with a well working reference plant (in Denmark)
- The Bühler technology is able to handle also straw with higher humidity.
- Bühler is a technology supplier who also offers EPC Contracts

Out of these reasons the economic analysis in this report is valid for the offers of Buhler company.

Main infrastructural parts

- Production building with the hammer mill (2), pellets mill (4), the cooler (5) and the operation room (9)
- Main straw shield with the straw grinder (1), steam generator (7), and the bale storage (10)
- Straw pellets silos (6) and straw silo (3)
- Dust collector 8 under open space

A possible architectural scheme for the pellets production site can be highlighted by the following sample scheme (prepared for the CPM technology):

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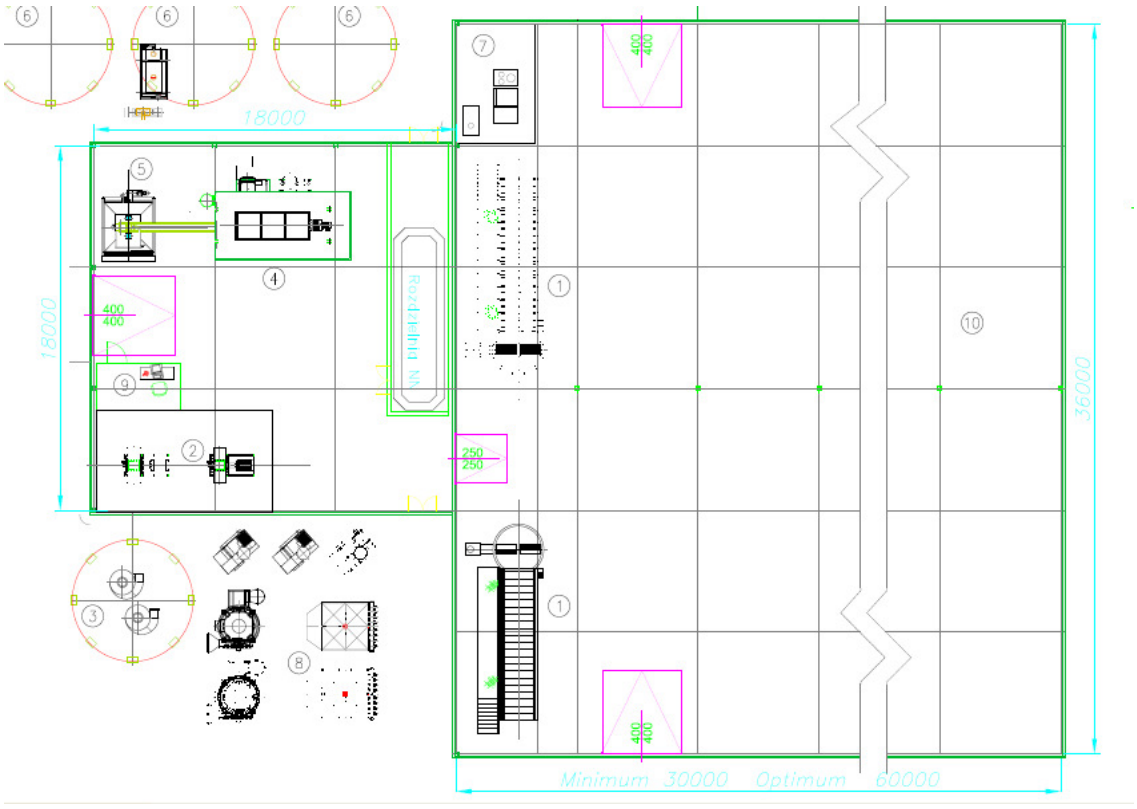

The main infrastructural parts have the following dimensions:

- Production Building: Ground space is 324 m2 (18 * 18), altitude is 8.5 meters.
- Storage Building: Ground space is 2000 m2, altitude is 8 meters. This allows a storage of 3500 tons of straw. The storage of straw could be combined with a static dryer.
- The storage for the pellets silos sums up to a total of 1500 tons
- The storage for the straw silo sums up to a total of 200 tons.

Including the periphery the entire space amount for the pelletising plant sums up to a total of 4 000 m2. Additional facilities sum up to 6 000 m2.

Investment Analysis

The following investment analysis was done based on the investigations performed on the European markets.

Investment Costs Straw Pelletising Plant		
		Euro
Technical Equipment		**1.500.000**
Pelletising equipment	3 tons / hour	
Buildings and Infrastructure		**250.000**
factory building	600 m2	200.000
fundaments		50.000
Land Purchase		**250.000**
Land purchase	10.000 m2	200.000
Land development		50.000
Transport and Logistics	Trucks	**100.000**
Project Development		**275.000**
External planning efforts	technical and legal	20.000
Preparation work		40.000
Fee for turn key construction		200.000
Bank fees		15.000
Total investment in 2009		**2.375.000**
Investment Reserve		**237.500**
Coverage of liqudity shortage first years		**100.000**
Total investment demand		**2.712.500**

Profit and Loss Assessment												
		2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	Total
Economic Yield	Index	**883.200,00**	**2.401.200,00**	**3.657.276,00**	**3.980.403,00**	**4.333.712,67**	**4.720.116,78**	**5.142.812,93**	**5.605.312,93**	**6.111.473,86**	**6.665.532,37**	**43.501.040,55**
Sale of straw pellets	-	883.200,00	2.401.200,00	3.657.276,00	3.980.403,00	4.333.712,67	4.720.116,78	5.142.812,93	5.605.312,93	6.111.473,86	6.665.532,37	**43.501.040,55**
Operation Expenses		**609.239,00**	**1.584.009,75**	**2.281.562,96**	**2.496.921,37**	**2.733.613,23**	**2.993.761,76**	**3.279.702,00**	**3.594.001,98**	**3.939.485,93**	**4.319.259,98**	**27.831.557,95**
Purchase of straw		550.000,00	1.430.000,00	2.057.000,00	2.262.700,00	2.488.970,00	2.737.867,00	3.011.653,70	3.312.819,07	3.644.100,98	4.008.511,07	**25.503.621,82**
Electricity Expenses (140 kWh / metric ton of pellets)	120,00	16.560,00	43.470,00	63.900,90	67.095,95	70.450,74	73.973,28	77.671,94	81.555,54	85.633,32	89.914,98	**670.226,65**
Electricity Price with index (Euro / MWh)	5,00%	15,00	15,75	16,54	17,36	18,23	19,14	20,10	21,11	22,16	23,27	**188,67**
Cost of spares (2,5 Euro / ton)	2,5	25.000,00	62.500,00	87.500,00	87.500,00	87.500,00	87.500,00	87.500,00	87.500,00	87.500,00	87.500,00	**787.500,00**
Machines O & M (including insurance)	2,00%	17.664,00	48.024,00	73.145,52	79.608,06	86.674,25	94.402,34	102.856,26	112.106,26	122.229,48	133.310,65	**870.020,81**
Gross Profit		**273.961,00**	**817.190,25**	**1.375.713,04**	**1.483.481,63**	**1.600.099,44**	**1.726.355,02**	**1.863.110,93**	**2.011.310,96**	**2.171.987,93**	**2.346.272,40**	**15.669.482,59**
Depreciation		**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**168.333,33**	**1.683.333,33**
Personnel Expenses	5,00%	200.000,00	210.000,00	220.500,00	231.525,00	243.101,25	255.256,31	268.019,13	281.420,08	295.491,09	310.265,64	**2.515.578,51**
Other specific cost		**35.000,00**	**35.525,00**	**36.057,88**	**36.598,74**	**37.147,72**	**37.704,94**	**38.270,51**	**38.844,57**	**39.427,24**	**40.018,65**	**374.595,26**
Office rent	1,50%	20.000,00	20.300,00	20.604,50	20.913,57	21.227,27	21.545,68	21.868,87	22.196,90	22.529,85	22.867,80	**214.054,43**
Insurances	1,50%	15.000,00	15.225,00	15.453,38	15.685,18	15.920,45	16.159,26	16.401,65	16.647,67	16.897,39	17.150,85	**160.540,83**
Simplified EBIT		**-129.372,33**	**403.331,92**	**950.821,83**	**1.047.024,55**	**1.151.517,13**	**1.265.060,43**	**1.388.487,95**	**1.522.712,97**	**1.668.736,27**	**1.827.654,77**	**11.095.975,50**
Tax	19,00%	**-24.580,74**	**76.633,06**	**180.656,15**	**198.934,67**	**218.788,26**	**240.361,48**	**263.812,71**	**289.315,46**	**317.059,89**	**347.254,41**	**2.108.235,34**
EBIT after Tax		**-104.791,59**	**326.698,85**	**770.165,69**	**848.089,89**	**932.728,88**	**1.024.698,95**	**1.124.675,24**	**1.233.397,50**	**1.351.676,38**	**1.480.400,36**	**8.987.740,15**
IRR of the overall project	-2.712.500,00	-104.791,59	326.698,85	770.165,69	848.089,89	932.728,88	1.024.698,95	1.124.675,24	1.233.397,50	1.351.676,38	1.480.400,36	**8.987.740,15**
	20,76%											

Support and additional information can be obtained from

PELLETS@LAS

c/o WIP Renewable Energies

Dr. Alexander Hoeldrich, Dr. Christian Epp

Sylvensteinstr. 2

D – 81369 Munich

Tel. + 49 89 720 12 724

www.wip-munich.de

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