Planning Alternatives for biomass production by a Strategic Cost Analysis of biomass resources

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Abstract: - Biomass energy systems are the only uniform sustainable systems achieving continuous power on a high level. Any other uniform sustainable energy system is dependent on sporadic energy inputs [1]. The contribution of this paper is situated within the frame of an exemplary designing of optimized regional type, quantity and location of biomass energy facilities based on an economic efficiency calculation. Several requirements have to be implemented in this calculation. Being one of these requirements and the contribution of this paper, the Strategic Cost Analysis of biomass resources has to be established. In order to analyze the costs, the biomass types and the cost categories have to be defined in a strategic context. This elaborated Strategic Cost Analysis results in Planning Alternatives on the topic of long-termed planning decisions, e.g. the external processing of biomass production vs. supervision of the planning authorities or purchase vs. rental vs. external processing of agricultural machines.

Key-Words: - Biomass and Bio-energy, Urban and Rural Development, Strategic Cost Analysis, Biomass Energy Systems

1 Introduction

Nowadays the energy problems are more obvious than in any other time before. The increasing energy costs are only the beginning of effects caused by the pollution of the environment. Beside the decreasing nonrenewable energy resources, e.g. coal and oil, the external effects, e.g. the global warming process, show the topicality of the energy problems. By including these external effects in the Economic Efficiency Calculation (EEC), the economic benefits will be more obvious [2]. The problem considering a substitution of fossil and nuclear energy sources is not caused by the utilized techniques, but by the decentralized strategic management. The different energy facilities have to be combined to a whole system and this system has to be specific to the observed region. Systems are not tapping their full potential, even though they could be more effective, economic and ecologic in nearly every region. As a consequence of the constant output[1] and the good possibilities to plan the long-termed output[2], we have specialized in Biomass Energy Systems.

The following work is embedded in an exemplary model using different tools and methods to optimize the planning in every geographical region. Particularly, this Strategic Cost Analysis of biomass resources will be used in the EEC together with the Potential of Biomass for a sustainable energetic use, the possible Energy Facilities, the Regional Energy demand and the Energy Production cost [3]. After the presentation of related works in section 2, the Strategic Cost Analysis will be the contents of section 3 followed by the Planning Alternatives in section 4 and the Conclusion (section 5).

[1] Wind and solar sources are not constant
[2] E.g. planting

2 Related works

There are several previous works dealing with the theme of a cost analysis. First of all, we briefly want to present a research report from the Wuppertal Institute for Climate, Environment and Energy together with the German Aerospace Centre about long-term scenarios for a sustainable energetic use in Germany. In this context they have evaluated the manufacturing cost of the different biomass energy output fuel types and put them in the context of the CO_2 output. The following figure visualizes the results.

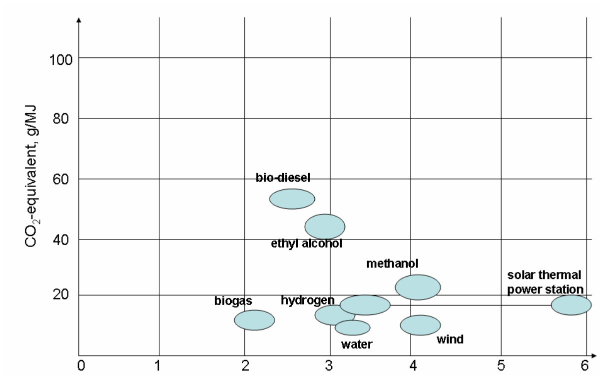

Fig.1: Production cost of new fuels based on [4] p.67

The results of the production cost analysis include the resource cost as well as the whole production cost. Due to the fact, that our work is based on an exemplary framework[3] a constitutive approach is not possible.

Ancillary, there are several other studies on the operational level including the whole production costs, exemplified by R. Carapellucci [5], M. Hoogwijk [6] and A. Kumar et.al. [7]. P. Hagström has centralized these works in a detailed listing of the different studies in his doctoral thesis [8]. All these studies are specific to a region and/or the technical circumstances and are therefore not includable in this Strategic Cost Analysis.

Beside these operational cost analyses, there are some theoretical frameworks calculating the cost of the biomass resources. There exists an approach established by the EECInetwork[4]. In their opinion the residue cost is zero, if the biomass residues from industry or agriculture will be utilized energetically at the same place by the industrial or agricultural manufacturer themselves [9]. This approach can only partly be considered in the Strategic Cost Analysis because of the integrated sight from the strategic planning towards the complete regional biomass energy system. Accordingly, biomass energy facility locations have to be sustainable, which is, beside of our environmental awareness, a requirement for the European Energy policy being part of the European Regional Policy [10]. Simplified, the Sustainability urges the planning to be economically efficient, ecologically maintainable and consistent with the socio-cultural aspects in every planning step [3]. For this reason, it is important to consider that the biomass facilities might not only be located close to the residue sources because of the lower biomass cost, although this is an advantage of location.

Another theoretical framework was established by the Institute for Energy and Environment in Leipzig/Germany. In their final report about the biogas extraction from liquid manure, organic residues and cultivated biomass, they describe the anticipated cost categories. These categories are the liquid manure[5] (lm), working hours (wh) for planting, nurture, harvest, ensiling, and logistics and possible closure premiums (cp) [11]. These closure premiums have to be included unless it is not utilized worldwide. The total cost (tc) structure in the context of this study will be as follows:

$$tc=lm+wh_{(planting+nurture+harvest+ensiling+logistics)}-cp \quad (1)$$

In consideration of the self-financing supply of liquid manure this cost factor could be left out. The main problem concerning this equation is the unconsidered real assets costs[6].

Lastly, we want to refer to a study directed by the Institute for Energy Industry and Rational Use of Energy about the total economic evaluation of the production of energy in consideration of external and macroeconomic effects. They have pointed out a framework to calculate the bio-energy source cost. Basically, they perform a full costing for the whole production and preparation process. The combustible cost is the addition of all costs (c) of the process parts (n) which are included in the supply chain visualized in the following equation.

$$tc = \sum_{i=1}^{n} c_i \quad (2)$$

This supply chain is dependent on the different frameworks resulting from the biomass production, the energy demand, and the technical and administrative frameworks [12]. Generic parts, which are a requirement for the strategic analysis, are not included in this conceptual methodology and therefore, the results are not useable in the context of our Strategic Cost Analysis.

3 Strategic Cost Analysis

Due to the fact that the related works in the context of a Strategic Cost Analysis do not suffice, we want to diversify and emphasize them in order to fit in the above mentioned exemplary model. Firstly, we point out the different biomass resource types. Ensuing, we identify the diverse cost factors. By joining these two factors together the miscellaneous cost of the biomass types will be the result.

3.1 Biomass Types

This section about the types of biomass is very important because of the various different costs of the types. These types of biomass could lead to a kind of cost-cluster depending on the regional surroundings. Therefore, it could not be pointed out exemplary.

There are several studies using different types of biomass. The Institute for Applied Material Flow Management (IfaS) has pointed out at least four different types of biomass for an energetic use shown in the table below [13].

[3] Monetary production cost implicates an operational level
[4] European Energy Crops InterNetwork
[5] Assumption: self-financing supply

[6] Seeds, Machines for nurture, harvest, ensiling and transport, work equipment etc.

Wooden Biomass	Other solid Biomass	Fermentable Biomass	Oily Biomass
- Split logs - Wood chips - Wood pellets	- Straw - Miscanthus	- agricultural plants and residues - organic waste	- vegetable oil

Table 1: Biomass Types based on IfaS

By reason of different possible categories[7] of these types, this classification of biomass is not utilizable in the context of the Strategic Cost Analysis.

Another categorization of biomass was established by the Institute for Future Energy Systems (izes) in the scope of a regional study about energetic utilization of biomass. They subdivide the whole biomass for an energetic use in five categories and several subcategories. These categories are: *Wooden Biomass* (Subcategories: *forestal residues*, *fast growing energy plants*, *matured timber from industry* and *used wood*), *culm shaped biomass* (Subcategories: *straw*, *grass*, *whole cereal plant*, and *fiber plant*), *Oily biomass*, *Sugary and Starchy Biomass*, and *Residual Biomass* (*landscape conversation residues*, *agricultural residues*, and *organic residues*) [14].

Further to these studies, an additional aspect is not considered. In the planning context, the long-termed biomass value is more significant than the actual value [3]. For this reason, an additional biomass for an energetic use has to be added to the biomass types. We define these types as *closured agricultural land* and *additional agricultural land from undeveloped areas*. Ancillary, the *landscape conversation wood* has to be included in the *Wooden Biomass*. By involving the above mentioned studies, the subsequent categorization of the important six biomass types will be displayed in the following table.

[7] For instance, the "Wooden Biomass" could be of forestal, agricultural, industrial or edificial origin with all different costs.

Wooden Biomass	Additional long-termed Biomass	Culm Shaped Biomass(III)	Other organic Biomass(IV)
- Forestal Residues (**Ia**) - Fast growing energy plants (**Ib**) - matured timber from industry (**Ic**) and used wood (**Id**) - landscape conversation wood (**Ie**)	- Biomass cultivated in closured agricultural land (**IIa**) - Biomass cultivated in additional agricultural land (**IIb**)	- straw - grass - cereal plant - fiber plant	- landscape conversation residues - agricultural residues - Organic Residues
Sugary / Starchy Biomass (V)		**Oily Biomass (VI)**	

Table 2: Biomass Types for the Strategic Cost Analysis

3.2 Categorization of costs

Beside the different biomass types we have to observe different cost types of biomass resources in order to create a basis for the Strategic Cost Analysis.

Simplified, the total cost will be subdivided into *real assets* and *services* [15] with several subcategories. Because of the strategic approach we subdivide the total cost according to the time flow in *planting*, *nurture*, *harvest*, *logistics*, *preparation*, and *storage* described in equation (3).

$$C_{total} = C_{planting} + C_{nurture} + C_{harvest} + C_{logistics} + C_{preparation} + C_{storage} \quad (3)$$

These categories are not mandatory for every biomass type but the possibility is given. The following equations will give a detailed description of the above mentioned cost categories[8].

$$C_{planting} = C_{seed} + C_{planter} + C_{HR} + C_{area} \quad (4)$$

$$C_{nurture} = C_{upkeep} + C_{HR} + C_{area} \quad (5)$$

$$C_{harvest} = C_{harvester} + C_{HR} \quad (6)$$

$$C_{logistics} = C_{transporter} + C_{HR} \quad (7)$$

$$C_{storage} = C_{area} + C_{depot} \quad (8)$$

The costs for *area* and *human resources* can be shared and combined if they appear repeatedly in the total cost analysis dependent on the utilization and the regional surroundings.

[8] HR ≙ human resources

Consequently, it is possible to subdivide the cost into *fixed* and *variable* costs. Costs for *seed*, *human resources*, and *upkeep* are a function of the output and therefore, they can be classified as variable costs. The fixed cost categories are the *area* and the *depot* because of the long-termed orientation of the agricultural business. Accordingly, in the long-termed sight these two cost factors could be defined as variable. A very special situation comes along with the different used machines. The costs of *planter*, *harvester*, and *transporter* are dependent on the type of finance. There are three different possibilities, being the essential factors for the below mentioned planning alternatives (See Subsection 4.2). The first possibility is, to purchase the machine. Hence, this purchase is independent from the output quantity and so it will be a fixed cost. The second possibility is to rent a machine. This cost factor could be fixed or variable dependent on the rental duration. If it's short-termed the cost will be variable dependent on the output quantity, if it's long-termed it will be a fixed cost. The last possibility is to pass the whole work step to an external contractor. For instance, the planting cost will be the *seed* and the *area* and the external contractor will cover the *HR* and the *planter*. In consequence of the payment by output, these costs are variable.

3.3 The Strategic Costs of Biomass Types

Accordingly to 3.1 and 3.2, this subsection will packetize the different biomass types and the cost categories in order to allocate a strategic value for each biomass type. Analogical to the theories pointed out above, this approach is exemplary, too. Therefore, it deals not with real costs, as they are all different and dependent on the observed region.

The following table presents a detailed cost overview of the biomass types based on table 2.

	Ia	Ib	Ic	Id	Ie	IIa	IIb	III	IV	V	VI
Planting	-	-	-	-	-	$	$	-	-	-	-
Nurture	-	-	-	-	-	$	$	-	-	-	-
Harvest	-	-	-	-	-	$	$	-	-	-	-
Logistic	$	$	$	-/$	-/$	$	$	$	-/$	$	$
Preparation	-	-	-	$	-	-	-	-	-/$	-	-
Storage	$	$	$	$	$	$	$	$	$	$	$
Biomass	-	$	-/$	-	-	-	-	$	-	$	$

Table 3: Cost overview of biomass types

Obviously, there are several biomass types with the same cost factors. We have consciously waived a clustering of these types, by reason of the different intensity of the cost factors [11]. In the case of IIa and IIb we made the assumption that the whole supply chain is supervised by the planning authorities of the observed region. The biomass types Ib, III, V, and VI are planted, nurtured, and harvested by agriculturists and put on the energy market. Based on the consistence of the residues, the *wooden biomass*[9] (Ia, Ic, Id, and Ie) does not have to be planted, nurtured, and harvested. These residues have to be transported to a biomass energy source and stored there. Due to the fact that the *matured timber from used wood* (Id) and the *landscape conversation wood* (Ie) have to be transported in any case, there accrue only costs if the route of transport towards the biomass energy source is longer than the regular route. Depending on the nature of the biomass and the industrial sector, the *matured timber from industries* (Ic) may be liable to pay costs. The *Other organic residues* (IV) consist of a variety of different kinds of biomass. Some are ecological damaged and had to be prepared in order to have the possibility to generate energy from them. According to Id and Ie, there is the possibility of a no-charge transportation, if the common route of transportation is longer than the route of transportation to the biomass energy source.

By using equation (3) to (8) the cost factors of every biomass type can be displayed. The human resources and area factor can be consolidated by reason of the non-operational approach. The following equation exemplifies the results with the *Starchy and Sugary biomass*.

$$C_V = C_{biomass} + C_{transporter} + C_{area} + C_{depot} + C_{HR} \quad (9)$$

Additionally to the purchase and the production of biomass, the main cost factors are the *logistics* and the *storage*[10]. The storage is dependent on the shelf life of biomass and the concerned biomass energy facility. The logistic costs of the biomass resources have been analyzed in several studies and works. Therefore, we refer to the study from the Institute for Energy and Environment [16] and the work from de Mol et.al. [17].

4 Planning Effects of the Strategic Cost Analysis

This section deals with the possible planning alternatives, emanating from the assumptions made in chapter 3.2 concerning the different cost opportunities of the utilized machines in the Strategic Cost Analysis. Another basic factor concerning these planning effects is the knowledge about the potential of biomass within the observe region. It is very important to include the sustainability in this context, because of our growing environmental awareness and the steady inclusion in the Regional and Energy Policies. The following equation describes the exemplary calculation of the Tangible Biomass Potential by König and Sachau [3]. This

[9] Exclusion: Ib
[10] See Table 3

calculation frame will be used in the following chapters.[11]

$$P_{tangible} = P_{theor} - P_{tech} - P_{sustainable} + P_{additional} \quad (10)$$

Generally, the Strategic Cost Analysis of the biomass resources may reach three planning decisions: The external processing of biomass production, the decision about the purchase, rental, or passing the whole work step to an external contractor and the planning relevant action possibilities.

4.1 External Processing of biomass production

This planning alternative is mostly dependent on the biomass types IIa and IIb (See subsection 3.1). The basic assumption towards these types from table 3 is, that planting, nurture, and harvest is supervised by the planning authorities. With the use of the following figure the decision *supervision vs. external processing* will be reached.

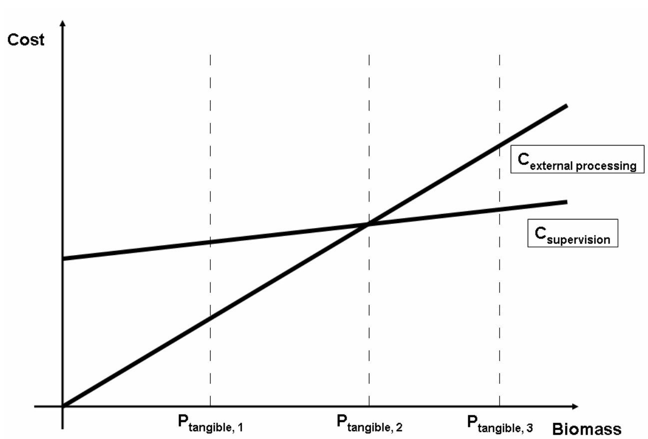

Fig. 2: Decision Supervision vs. external processing

There are three different biomass potentials shown in the figure above. In the first case, the tangible potential calculated by the equation (10) is comparative low ($P_{tangible,1}$). As a consequence of the single dependency on the variable costs, the external processing will be preferred. The supervision by the planning authorities is not economically because of the higher costs deduced from the accrued fixed costs. In the second possibility ($P_{tangible,2}$) the costs for external processing ($C_{external\ processing}$) and costs for supervision of the planning authorities ($C_{supervision}$) coincide. Due to the higher risk in the case of the supervision by the planning authorities, the external processing will be the best choice. A higher difficulty is given, if the tangible Potential somewhat exceeds $P_{tangible,2}$. Here, a risk analysis has to be elaborated in order to find the best possibility. In the case of $P_{tangible,3}$ the supervision by the planning authorities should be the best economical choice. Only if the risk analysis expect a proportional high risk in the case of $C_{external\ processing} < C_{supervision}$ the decision will be in favor of the external processing.

4.2 Purchase, Rental, or External Processing of agricultural machines

This chapter deals with the three exertion possibilities of the agricultural machines according to the assumptions made in chapter 3.2. As a consequence of the continuous use of machines, this decision has to be done for every biomass type. The following figure visualizes the three different possibilities with the assumption, that the external processing cost growth will be relative lower by the growth of the biomass potential.

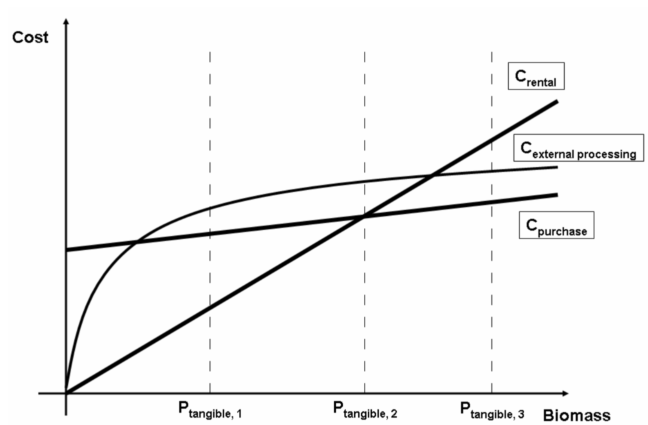

Fig. 3: Purchase vs. Rental vs. External Processing

In the case of a comparatively low regional tangible biomass potential ($P_{tangible,1}$) the agricultural machines have to be rented. There is nearly no risk and the costs are relatively low. In a region with a tangible biomass potential $P_{tangible,2}$ the decision of the best possibility is based on a risk analysis. The *purchase* is more risky than the *rental*. The costs are in $P_{tangible,2}$ the same and so the choice would be the *rental* of the machines. As a consequence of the higher risk in the case of *rental* opposite to the *external processing*[12] it depends on the risk analysis if the *rental* or the *external processing* will be the best choice. At the biomass potential $P_{tangible,3}$ the problem is nearly the same but with different cost factors. The machine *rental* is uneconomic and not advisable. The *purchase* is the lowest cost factor but it is more risky than the slightly expensive *external processing* with the least risk. The decision is dependent on the risk analysis to be undertaken. If the *external*

[11] P ≙ Potential; theor ≙ theoretical; tech ≙ technical

[12] The external processing includes the manpower (variable cost); for the rental machines the manpower is a fixed cost

processing uses economies of scale[13] and/or economies of scope[14] the cost schedule graph of the *external processing* could run below the graph of *purchase* cost. In this case the only possible decision is the *external processing* of the agricultural machines used in the biomass production process.

4.3 Planning relevant action possibilities

In 4.1 and 4.2 several decisions about the usage of machines and external processing have been elaborated. To get them in the planning context, the potential of biomass has to be viewed in a long-termed sight, as well as the cost factor. The following two equations describe these long-termed strategic cost and potential analysis.[15]

$$P_{prob,t} = \sum_{i=1}^{n} (p_{i,t} P_{i,t} + p_{i,t} P_{additional,i,t}) \quad [3]\ (11)$$

$$C_{prob,t} = \sum_{i=1}^{n} (p_{i,t} (C_{planting,i,t} + C_{nurture,i,t} + C_{harvest,i,t} + C_{logistics,i,t} + C_{preparation,i,t} + C_{storage,i,t})) \quad (12)$$

The basis for these calculations is the creation of at least 3 scenarios[16] (n) with different possibilities p.

The resulting cost and potential value has to be included in the figures 2 and 3. The planning decisions will be elaborated on the basis of the results from 4.1 and 4.2.

5 Conclusion

By the usage of the Strategic Cost Analysis within the typing of biomass resources and categorization of the cost factors, the exemplary approach of this method allows the planning authorities to design planning alternatives at the basis of the biomass resource costs. As a consequence of this, the method and the planning alternatives are applicable to every geographical region in the world and are not limited to any special regional surroundings.

The analysis of regional tangible biomass potential must be considered with high importance generating valuable input for planning alternatives. The most essential factors in the context of this biomass analysis are the integration of the sustainability and the exemplary approach [3]. Beside the consideration of the biomass potential analysis the above mentioned exemplary approach is a limitation on the operational level. Consequently, the regional activities, e.g. giving every cost factor the correct value or the creation of the potential analysis, are very important, longwinded and sometimes expensive. Therefore, this approach is called a Strategic Cost Analysis.

The considered application of this work is the usage in a strategic framework with the aim to point out exemplary a certain regional biomass energy plan within the best considered locations of the different possible energy facilities and the different types of biomass. Simplified, we want to design the optimized regional biomass energy system. Another application area of this work is in a political or planning framework. By the deployment of these planning alternatives, best planning decisions in the case of the production of biomass will be detected. Finally, the inclusion of a target costing system [18] leads to the achievement of pre-defined political aims.

[13] Larger machines ->economy of time

[14] Machine placement in different working fields

[15] Assumption: $\sum_{i=1}^{n} p_i = 1$

[16] Minimum, maximum and basis scenario

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