Sustainability of Biomass Energy Sources – Measurement and Regional Comparison

STEFAN KOENIG and JUERGEN SACHAU
Systems and Control Engineering
University of Luxembourg - FSTC
6, rue Richard Coudenhove-Kalergi; L-1359 Luxembourg
LUXEMBOURG
stefan.koenig@uni.lu and juergen.sachau@uni.lu http://wiki.uni.lu/sce

Abstract: - Within this paper the authors are aiming to provide planning authorities, investment groups as well as policy authorities with a new method for geographical planning of renewable biomass energy systems. The key element of this work is based on the differentiation of biomass resources in consideration of their sustainability. Due to measure this sustainable character, different indicators have to be used. We propose a method where we cluster these indicators in diverse parameters and operational level according to the core aspects of sustainability. By the usage of different statistics, interviews and studies the various biomass resources can be given an individual value. We have elaborated a strategy to calculate an index for each biomass resource for comparison reasons. By using this index, entitled as Sustainable Biomass Index SBI, we offer the possibility to compare the biomass within a defined region in order to identify the most sustainable biomass for an energetic use.

Key-Words: - Biomass and Bio-energy, Sustainable Development, Biomass Energy Systems, Sustainability Measurement

1 Introduction

During the recent time period biomass resources' importance has increased enormously in the frame of energy systems. This is not only based on the current development of growth of public environmental awareness[1] and their outer appearance but also on the fact that the biomass energy is the only renewable energy achieving continuous power as a result of planning and storing the available energy resource [1]. Besides, the usage of biomass is CO2 neutral[2] and has no bearing on the global warming and climate change [2]. Moreover, in the most countries integration of biomass as a renewable energy is under constitutional law and has to be embedded in the energy policies [3]. Nevertheless, nowadays geographical planning of functional energy plants within a biomass energy system is not optimized and partially unstructured [4].

Therefore, there is a need for action regarding planning methods of biomass energy systems. Planning has to be realized on the lowest administrative level based on the bottom-up principle which is embedded in the most countries [5]. Furthermore, the local affairs is a cross-section policy and therefore responsible for the local energy policy, as well [6]. Since the famous Report of the World Commission on Environment and Development in 1987[3] [7] the local development authorities and policy maker embedded more and more the idea of sustainable development in their laws and decrees. Today, every regional planning in the European Union has to be up to the mark of sustainability [8].

Our proposed method assists the identification of the most sustainable biomass resource and, through the possibility of comparisons, the decision making will be supported regarding location, size, and type of biomass energy plants. Firstly, we refer to related works in the area of measuring the Sustainability with different focal points and introduce the Environmental Sustainability Index followed by the presentation of our approach resulting in the Sustainable Biomass Index SBI.

2 Related works

Meanwhile, there are several scientific works in the area of sustainability with almost one equal basis. This basis is the Report *Our common future* published by the World Commission on Environment and Development. This Commission was founded in 1983 by the United Nations as an independent authority on long-termed environmentally sound development with the mission to develop a perspective report. The results have been

[1] Many authors would state 'growing sustainable awareness' but due to the fact that *sustainable development* has not a unique meaning (There are more than 300 definitions) we state 'growing environmental awareness'.
[2] Assumption: sustainable behavior
[3] Nowadays known as *Brundtland Report*

published 1987 in the above mentioned report and contains the new mission statement of sustainable development: 'Meeting the needs of the present generation without comprising the ability of future generations to meet their needs' [7]. Since then, several constructive works have been elaborated. Some of them deal with the measurement of sustainability, as well. The four main important approaches are visualized in the following figure:

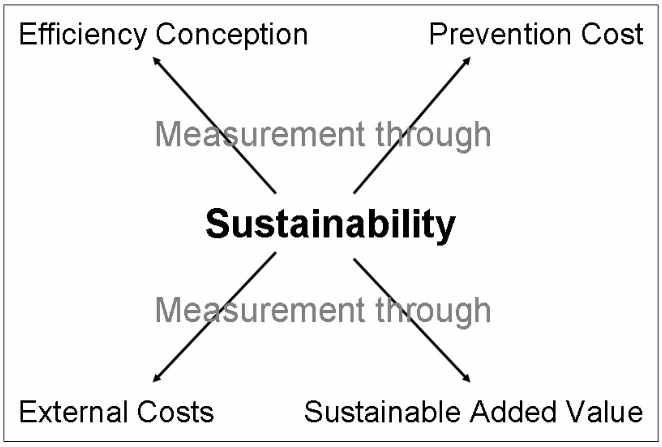

Figure 1: The four main important sustainability measurement directions

According to figure 1 the approaches are dependent on external cost (externalities), prevention cost, efficiency conception, and sustainable added value.

2.1 Measurement of Sustainability using External Costs

External Costs, or Externalities is defined as costs, which 'arises when the social or economic activities of one group of persons have an on another group and when that impact is not fully accounted, or compensated for, by the first group' [9] and are the basis for the integration of the Sustainability in the companies' balance sheet. Hence, the companies' assets have to be revised with the external cost value. Due to overview this approach the proximate figure describes the structure.

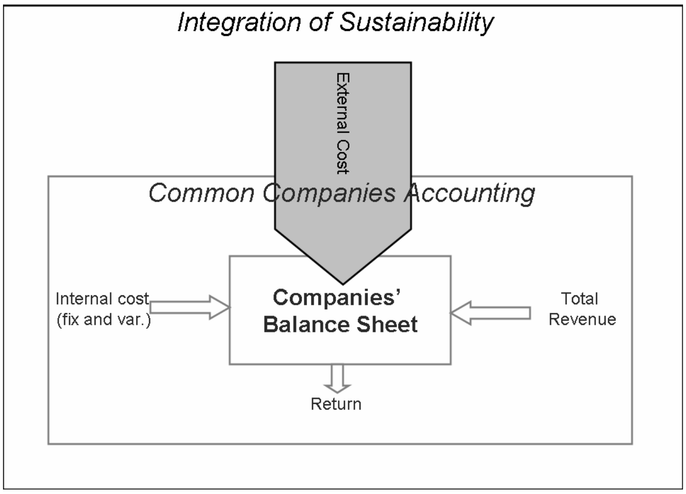

Fig. 2: Companies' Balance Sheet including Sustainability on the basis of externalities

There are two main works in this area. The first work has been elaborated by Atkinson creating the Green Value Added [10] which is defined as an indicator which 'could signal how much value-added a sector has generated after imputations reflecting environmental damage have been 'charged'.' The subsequent table gives an impression on how this value is integrated in different areas of operations.

Table 1: Environmental Damage and "Green" Value-Added [10]

	Agriculture		**Chemicals**	
	1987	1994	1987	1994
Value Added (VA)	**5600**	**8810**	**10320**	**12870**
Env. Damage	865	462	228	173
%VA	*15,4*	*5,2*	*2,2*	*1,3*
Green VA	**4735**	**8348**	**10092**	**12697**
	Food Process.		**Air Transp.**	
	1987	1994	1987	1987
Value Added (VA)	**14370**	**15530**	**2170**	**3620**
Env. Damage	241	241	212	296
%VA	*1,7*	*1,6*	*9,8*	*8,2*
Green VA	**14129**	**15289**	**1958**	**3324**
	Electricity		**Building Mat.**	
	1987	1994	1987	1994
Value Added (VA)	**5600**	**6830**	**4010**	**3890**
Env. Damage	2741	1955	341	210
%VA	*49,0*	*28,6*	*8,5*	*5,4*
Green VA	**2858**	**4875**	**3669**	**3680**

Source: [11], [12], [13], [14]

The second work in the area of including the external costs in the companies' balance sheet was developed by Huizing and Dekker working on the Net Value Added [15], which is reached if 'the benefits exceed the sum of internal and external' [16]. In consideration of biomass resources, the main problem of both approaches is the implementation because of difficulties in monetary valuation of the external effects. Therefore, the Net and the Green Value Added are both not suitable for sustainability measurement of biomass resource.

2.2 Measurement of Sustainability by integrating prevention cost

There are several works dealing with the integration of prevention costs in companies' balance sheet [17] [18][19]. According to figure 2, the balance sheet structure including Sustainability is nearly equal:

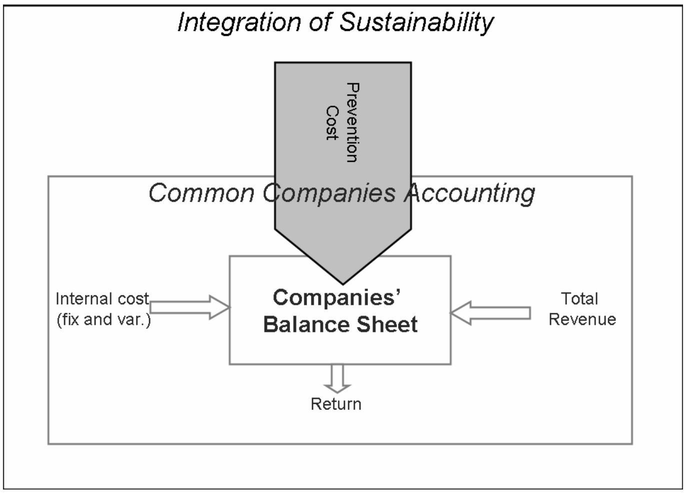

Figure 3: Companies' Balance Sheet including Sustainability on the basis of prevention cost theory

The prevention costs are defined as costs for avoiding or revoking ecological strains through the use of technical solutions [20]. Not only is the implementation of all ecological strains a difficulty of this approach but also the fragmentary understanding of sustainability. In order to include the whole sustainable costs, the socio-cultural impacts of the companies' behavior have to be implemented by reason of the definition of sustainability.

2.3 Efficiency Conception and Sustainability Measurement

The third main approach considering measurement of sustainability is the efficiency conception. With this theory by [21][22][23] the efficiency of companies' sustainable behavior can be calculated. Therefore, the value added is set into the relationship of adherent ecological impacts. These impacts are summarized in an aggregated value of the weighted relative harmfulness of different ecological elements taken out of statistics. Analog to the Prevention Costs, the Efficiency Conception does not consider the socio-cultural effects and is therefore not fully sustainable.

2.4 Measurement of Sustainability using the Sustainable Value Added

Apart from the above mentioned approaches the Sustainable Value Added approach is not burden-based. For reason of excluding the monetary weighting it is based on opportunity costs and it is worth-oriented. The weighting of ecological impacts is based on the created economical value. Additionally, the economical and social efficiency is considered resulting in a real sustainable approach [24]. One of the differences between the above mentioned Green/Net Value Added and the Sustainable Value Added is visualized in the subsequent figure:

		Benefit>Cost? (If-question)	
		considered	Not considered
Maximum benefit? (Where-question)	considered	**absolute Sustainable Value Added**	**relative Sustainable Value Added**
	not considered	**Net or Green Value Added**	**Value Added**

Figure 4: If- and Where-matrix [24]

Figge and Hahn differentiate between the relative Sustainable Value Added, which is defined as 'the size of the contribution of a company to more sustainability measured in monetary terms' [24] and the absolute Sustainable Value Added which can be calculated as follows:

absolute Sustainable Value Added =
Value Added
- *external environmental and social cost*
+ *relative Sustainable Value Added* (2.1)

However, this approach can not be used for the measurement of Biomass Resources because of the worth-orientation.

2.5 Measurement of Sustainability through defined criteria

Beside the approaches 2.1 to 2.4 which are not suitable for the sustainable measurement for biomass resources, the criteria for a sustainable development have to be pointed out in consideration of measuring the sustainability of biomass resources. Therefore, we focused on diverse criteria and their weighting in consideration of measuring the sustainability of biomass resources. In the most countries exists a set of sustainability criteria used in their spatial planning. As an example we point out the strategy for a sustainable development developed for Germany. Here, the federal government emphasizes four main coordinates: Generation justice, Quality of life, Social co-operation, and international responsibility. Every coordinate contains different action fields for the sustainable strategy, which are evaluated by using different indicators and goal-worth. The following figure describes exemplary the structure by pointing out the Quality of Life [25].

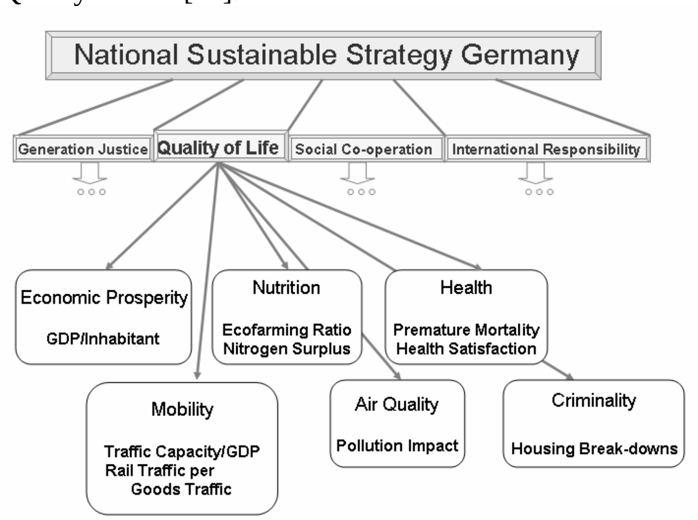

Figure 5: Quality of Life action fields of the National Sustainable Strategy Germany

There are many diverse criteria-structures elaborated by the different countries. Among others, these criteria are a basis for the proposed Sustainable Biomass Index.

Beside the different national and regional sustainability criteria, the European Union[4] has elaborated a set of sustainable development indicators. These indicators have been summarized in 10 different themes: Socio-economic development, Sustainable consumption and production, Social inclusion, Demographic changes, Public health, Climate change and Energy, Sustainable transport, Natural resources, Global partnerships, and Good governance. The main themes were subdivided into several sub-themes visualized in figure 6. The different theme indicators are subdivided into three levels structured according to their circumstantialities [26]. In comparison to the above mentioned national sustainable strategy from Germany attracts the higher number of main themes attention. However, by detailed examination we identify accordance's between the two strategies regarding the lowest level – the indicators[5]. Furthermore, different main themes of the EU strategy fit in the four main categories of the German strategy. If we consider these facts, the two strategies are different in their structure but nearly similar in their used indicators.

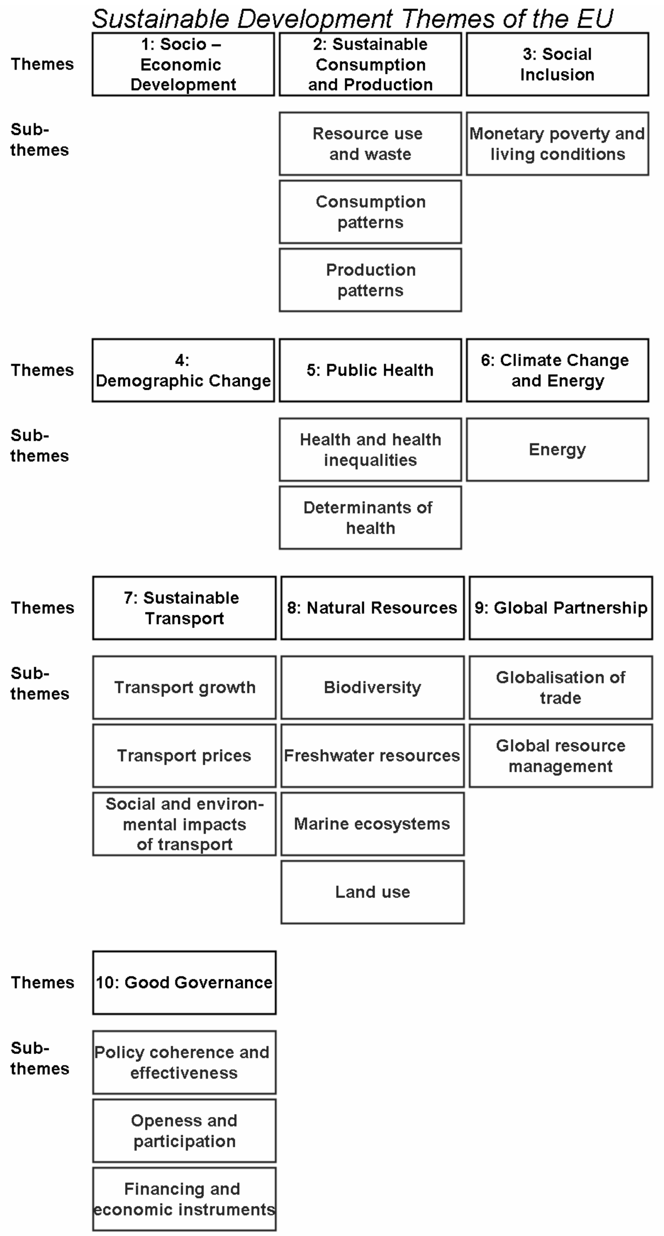

Figure 6: Sustainable development themes of the European Union

[4] Statistical Department: EUROSTAT

[5] E.g.: GDP/Inhabitant (EU-Strategy: Socio-economic development; GER-Strategy: Quality of Life – Economic Prosperity)

2.6 The 2005 Environmental Sustainability Index

The 2005 Environmental Sustainability Index published by the Yale and Columbia University is a benchmarking-index reflecting the possibility to compare countries with regard to their sustainable behavior. Therefore, five broad categories[6] have been pointed out: Environmental Systems, Reducing Environmental Stresses, Reducing Human Vulnerability to Environmental Stresses, Societal and Institutional Capacity to Respond to Environmental Challenges, and Global Stewardship [27]. Altogether 76 variables and 21 indicators are summarized in these five components. Figure 7 shows the coherency of these facts.

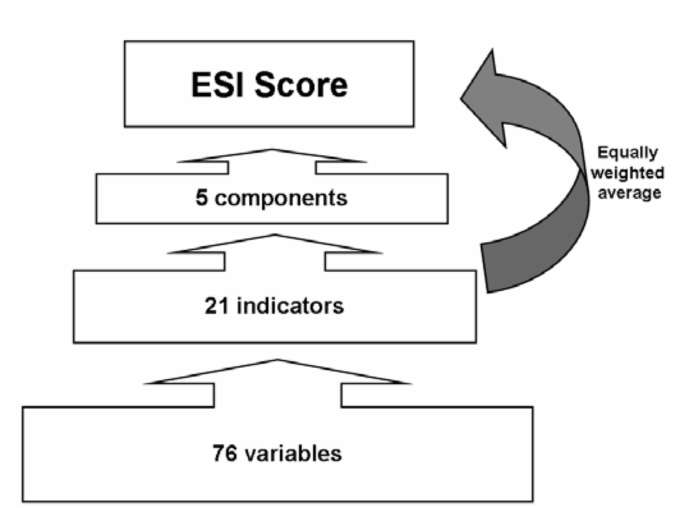

Figure 7: Constructing the ESI-Score [25]

Accordingly, table 2 exemplifies the results by pointing out the Environmental Sustainability Index ESI of the EU member countries.

Table 2: ESI Scores for EU member countries

Rank	Country	ESI	Rank	Country	ESI
1	Finland	75.1	12	Portugal	54.2
2	Sweden	71.7	13	Netherlands	53.7
3	Austria	62.7	14	Slovakia	52.8
4	Latvia	60.4	15	Hungary	52.0
5	Ireland	59.2	16	UK	50.2
6	Lithuania	58.9	17	Greece	50.1
7	Denmark	58.2	18	Italy	50.1
8	Estonia	58.2	19	Spain	48.8
9	Slovenia	57.5	20	Czech Rep.	46.6
10	Germany	56.9	21	Poland	45.0
11	France	55.2	22	Belgium	44.4

Source: [27]

This approach is mainly important for planning reasons of the observed countries with the aim of protecting their environment. Consequently, the worst evaluated countries have the ability to change their policies and general conditions in consideration of the best evaluated countries in order to advance their environmental attitude.

However, the elaborated index is only a benchmark and has no real impact on the countries' policies or behavior unless the inhabitants and/or the politician take their environmental position seriously and want to advance it.

3. Measurement of the Biomass Resources' Sustainability

Nowadays, in the field of Renewable Energy mainly the biomass energy is a fast growing market because of the above mentioned facts. Therefore, sustainable planning of this energy integration is a requirement to reach real 'green' energy. Our approach is addressed to regions with limited means but large-scaled biomass resources. Their problem is to identify the suitable biomass for an energetic use. Hence, a possibility to compare different regions biomass resources has to be elaborated. Consequently, a sustainable resource consideration should be conducted in order to involve the above mentioned mission statement of the sustainable development.

In order to answer the question on how measuring the sustainability of biomass resources, the related work in the field of sustainable measurement has to be observed and, if possible implemented. Due to the fact that we point out a sustainability index, we have to implement the mission statement of the sustainability in every step of the creation of the index. Therefore, we subdivide the Sustainable Biomass Index into three different operating levels according to the sustainability: the Socio-Cultural Operating Level, the Economical Operating Level, and the Ecological Operating Level. For balancing reasons every Operating Level gets the same weighting.

$$SBI = \frac{OL_{Socio-Cultural} + OL_{Economical} + OL_{Ecological}}{3} \quad (3.1)$$

$$\{OL \in R \mid 0 \le OL\} \quad (3.2)$$

Following the related work from Section 2 we have to consider the Externalities as well. However, this is not only because of the above mentioned difficulties in monetary valuation not possible, but also because of the fact, that we observe natural resources and not a company or a region and by reason of no production/change the external effects are incapable of measurement. Analogical, the Prevention Cost Theory is inapplicable because of no ecological strains of biomass resources. Similar to these theories, the two efficiency

[6] components

oriented approaches, the Efficiency Conception and the Sustainable Added Value are not suitable to calculate the Sustainable Biomass Index because of the incapability of measurement of biomass being a natural resource.

Hence, we concentrate on the criteria of the Sustainability and modify them in consideration of applying to biomass resources. Therefore, we point out three different levels of sustainable Measurement of Biomass Resources: The three Operating Levels (Socio-Cultural Level, Economical Level, and Ecological Level) their parameter values (Parameter Level) and their indicators (Indicator Level). The command structure of these Levels is visualized in the following figure.

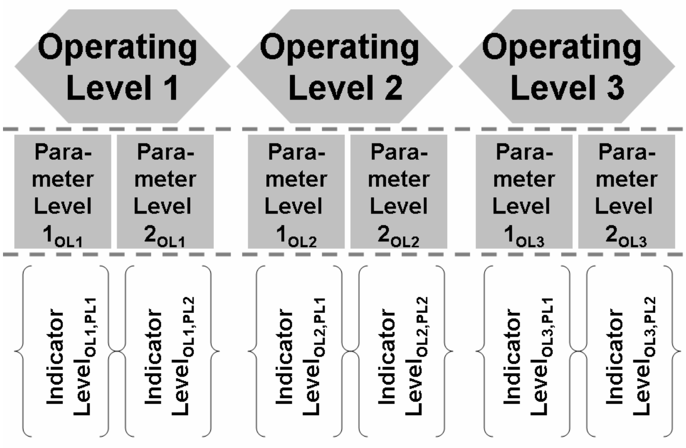

Figure 8: Level Structure of the Sustainability of biomass resources

3.1 Operating Level 1: The Socio-Cultural Measurement

In order to measure these aspects it is a requirement to define the meaning of 'socio-cultural'. Essentially, this first Operating Level consists of two terms: social and cultural. Due to the fact that these aspects are intertwined they have to be measured combined. The social component describes the surrounding area of the observed inhabitants including their employment activities and their leisure activities. Furthermore, the cruising radius is very important. Additionally, the cultural component covers the course of action and measures the behavior.

For the purpose of measuring these aspects we have to point out the different parameters according to figure 5. Intrinsically, the elaborated parameter is defined as 'Quality of Life' because of the overarching character; all different possible indicators are integrated within this parameter. Nevertheless, we have to subdivide this parameter for measuring reasons. There are two resulting parameters: the first deals with indicators created out of statistics and the second parameter is based on indicators realized by interviews of the inhabitants of the observed region.

Therefore, we termed these parameters 'Quality of Life – Strong Criteria' and 'Quality of Life – Soft Criteria'. The strong criteria are indicated by the population figure, the regions gross domestic product, the traffic performance, the ecologic cultivation, the contaminant loads, the early mortality rate, and the crime rate change. All of these criteria are taken out of the National Sustainable Strategy Germany and are modified to get in the context of biomass resources. Accordingly, the following indicators should be considered in the measurement:

- Economic change of prosperity[7]
  - ⇨ GDP/Inhabitant
- Mobility[8]
  - ⇨ Traffic Performance/GDP
- Nutrition[9]
  - ⇨ Ecological cultivation/cultivation
  - ⇨ Nitrogen surplus
- Air Quality
  - ⇨ Contaminant loads
- Physical health[10]
  - ⇨ Early mortality rate
- Crime rate change

All of these values must be derived from statistics or, in case of no suitable statistics, must be collected within the frame of studies. Due to collect data for possible changes of these indicators as a result of biomass usage, scenario analyses have to be implemented. Available data from other regions can be instrumental in creating such scenarios.

The measurement of the soft criteria must be different from the strong criteria because of nonexistence in available statistics. The soft criteria are related to the inhabitants' life and how a change in biomass resource would alter the regular course of life. Therefore, questionnaires must be created and used in representative interviews in order to measure these changes. Mainly, three impacts of change in biomass resources have to be measured:

- o Recreational activity
- o Everyday life
- o Public acceptance

By virtue of the special circumstances and the different initial situations, these questionnaires have to be specific to the interviewed region.

---

[7] Gives a first impression on the regional social satisfaction (increase: better; decrease: worse)

[8] Is an indicator for leisure and occupational activity

[9] Shows the importance of the regional biodegradation

[10] Air Quality and Physical health are indicators for the regions healthiness

Finally, the proximate figure visualizes the above mentioned parameters and indicators.

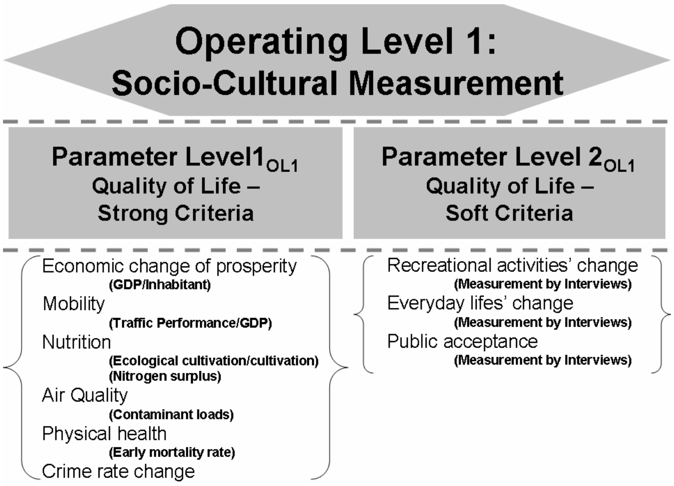

Figure 9: Socio-Cultural Measurement of biomass resources

3.2 Operating Level 2: The Economical Measurement

In contrast to the Socio-Cultural Measurement, the Economical Measurement is based on cost[11] and revenue of biomass resources. These elements represent the economical parameter level.

The Cost Analysis as the first parameter consists of at least two indicators: Newly growing biomass cost and the valuation of biomass. In order to measure sustainability these two indictors have to be considered combined. To be economic efficient, the growing cost should always be less then the valuation of biomass. If the costs are higher, outer acquisition will be the best choice.

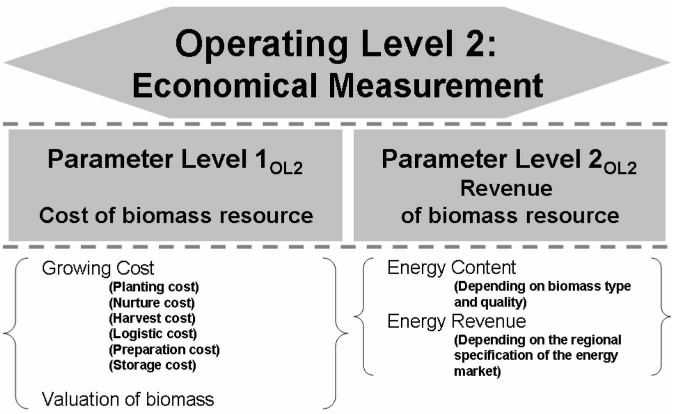

Figure 10: Economical Measurement of biomass resources

[11] No consideration of profit because of nonprofit approach (Biomass Resources)

3.3 Operating Level 3: The Ecological Measurement

In order to fulfill the sustainability criteria the ecological level has to be considered in addition to socio-cultural and economical measurements.

The most important factor regarding the ecological sustainability is that the utilized biomass has to be substituted by newly grown biomass. Only this behavior permits the usage of biomass in consideration of sustainability and CO2 neutrality.

Mainly, the ecological measurement of the biomass resources is subdivided into two parameter level: the resource oriented measurement and the ecological biomass impacts. The resource oriented aspect is about the generation justice and therefore very important for the sustainability. In order to calculate a certain value, utilized and newly grown biomass has to be considered. For specification of this newly grown biomass the second parameter, ecological biomass impacts, includes the diversity of species[12], the climate protection, and the air quality. According to the above mentioned paragraphs, the following figure describes the structure or the third Operating Level.

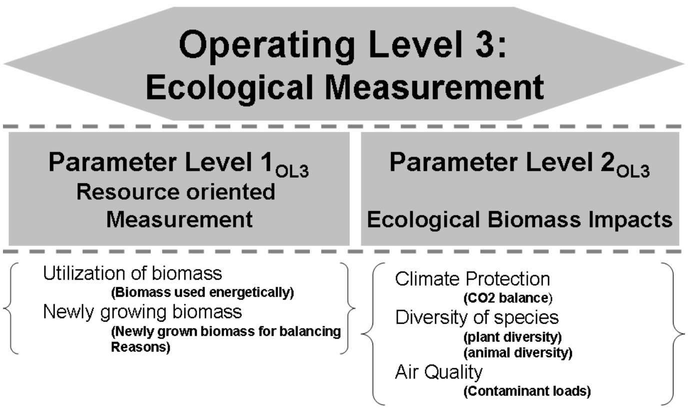

Figure 11: Ecological Measurement of biomass resources

4. The Sustainable Biomass Index

The above described Operating Levels, Parameter Levels, and Indicators are the basis for the calculation of a specific Sustainable Biomass Index SBI for each biomass/region. Mainly, for the planning authorities and investment groups the best sustainable biomass for an energetic use can be identified.

Therefore, the SBI calculation is based on equation 3.1. Each Parameter Level PL is weighted 50% of the Operating Level OL, which is described in the following equation:

$$OL_i = (PL1_{OL_i} + PL2_{OL_i})/2 \qquad (4.1)$$

[12] Plants as well as animals

The different Parameter Level has to be calculated according to the specific indicators. A sustainable minimal value per indicator has to be pointed out according to the specific region.

$PL1_{OL1}$ includes 6 indicators. Because of double-usage of the indicator Air Quality (AQ) in OL1 and OL3 it is only weighted 50 % of the other indicator from $PL1_{OL1}$. This results in equation 4.2[13]:

$$PL1_{OL1} = \frac{2(Ecop + M + N + Ph + Crc) + AQ}{11}$$

$$= \frac{2\left(\frac{\frac{GDP_e}{inh_e}}{\frac{GDP}{inh}} + \frac{\frac{\frac{vehicles}{roadnetwork}}{GDP}}{\frac{\frac{vehicles_e}{roadnetwork_e}}{GDP_e}} + \frac{\frac{cultivation_{ecol,e}}{cultivation_e}}{\frac{cultivation_{ecol}}{cultivation}} + \frac{Emr}{Emr_e} + \frac{Cr}{Cr_e}\right) + \frac{Cl}{Cl_e}}{11} \tag{4.2}$$

The indicator value is based on the nowadays situation. This value is defined as 100% and the variance by reason of biomass usage has to be added / subtracted. Typically, this value is around 1. The higher the value is, the higher is the SBI. The calculation is based on the indicators of figure 8.

Very similar to $PL1_{OL1}$ is $PL2_{OL1}$. The only difference is the type of data collection, because it is about soft criteria collected through interviews. Possible changes have to be measured negative (less than 100%) or positive (higher than 100%) dependent on the interviewed inhabitants of the observed region resulting in the value of $PL2_{OL1}$ described in equation 4.3.

$$PL2_{OL1} = \frac{Rac + Elc + Pa}{3} \tag{4.3}$$

$PL1_{OL2}$ has to be calculated on the basis of the ratio from Growing Cost and Valuation of biomass. The Growing Cost is calculated according to [28]. The valuation of biomass is dependent on the market situation of the specific region. Accordingly, the $PL1_{OL2}$ value is calculated through the following equation 4.4.

$$PL1_{OL2} = \frac{Vob_e}{GC_e} = \frac{Vob_e}{\sum_{i=1}^{n} (p_i (C_{plant,i} + C_{nurt.,i} + C_{har.,i} + C_{\log.,i} + C_{prep.,i} + C_{store,i}))} \tag{4.4}$$

The second parameter of Operating Level 2 is about the revenue of biomass resources; the biomass resource efficiency is calculated here. Therefore, the average energy revenue per biomass and the average energy content per biomass are the basis for the calculation.

$$PL2_{OL2} = \frac{\frac{\frac{EC_e}{biomass}}{\frac{\varnothing EC_e}{biomass}} + \frac{\frac{ER_e}{biomass}}{\frac{\varnothing ER_e}{biomass}}}{2} \tag{4.5}$$

The Resource oriented Measurement from the third operating level is calculated with the data from the utilization and Newly grown biomass (Ngb) in case of an energetic use. According to equation 4.4 the ratio of the used indicators Utilization of biomass (Uob) and Newly growing biomass is very important visualized in the following equation:

$$PL1_{OL3} = \frac{Ngb}{Uob} \tag{4.6}$$

$PL2_{OL3}$ is again based on possible changes of the indicators in case of energetically biomass usage. Climate Protection (CP), Diversity of species (Dos), and Air Quality (AQ) are the observed indicators. According to $PL1_{OL1}$ the Air Quality has to be weighted only 50% of the other indicators described in the following equation:

$$PL2_{OL3} = \frac{2(CP + Dos) + AQ}{5}$$

$$= \frac{2\frac{CO2repression_e}{CO2emission_e} + \frac{pd_e}{pd} + \frac{ad_e}{ad} + \frac{Cl}{Cl_e}}{5} \tag{4.7}$$

Finally, equations 4.2 to 4.7 have to be implemented in valuation of the SBI. The outcome of the calculation of this index gives the planning authorities or investment groups a possibility to compare different regions in order to generate sustainable biomass energy. The higher the value of SBI is, the more sustainable is the usage of the biomass. Generally, a biomass resource with a value higher than 1 (100%) can be called sustainable according to the definition of the sustainability [7]. Consequently, the SBI is equated as follows:

$$SBI = \frac{Pl1_{Ol1} + Pl2_{Ol1} + Pl1_{Ol2} + Pl2_{Ol2} + Pl1_{Ol3} + Pl2_{Ol3}}{6} \tag{4.8}$$

Due to give an overview of the above made assumptions and equations to calculate the SBI the subsequent figure visualizes the structure and calculation of the Sustainable Biomass Index.

[13] The abbreviations are according to the initials of the used indicators. *e* means *expected*

$$SBI = \frac{OL_1 + OL_2 + OL_3}{3}$$

$$OL_1 = (PL1_{OL_1} + PL2_{OL_1})/2 \qquad OL_2 = (PL1_{OL_2} + PL2_{OL_2})/2 \qquad OL_3 = (PL1_{OL_3} + PL2_{OL_3})/2$$

$$PL1_{OL1} = \frac{2(Ecop + M + N + Ph + Crc) + AQ}{11} \qquad PL1_{OL2} = \frac{Vob}{GC} \qquad PL1_{OL3} = \frac{Ngb}{Uob}$$

$$PL2_{OL1} = \frac{Rac + Elc + Pa}{3} \qquad PL2_{OL2} = \frac{\frac{\frac{EC}{biomass}}{\frac{\varnothing EC}{biomass}} + \frac{\frac{ER}{biomass}}{\frac{\varnothing ER}{biomass}}}{2} \qquad PL2_{OL3} = \frac{2(CP + Dos) + AQ}{5}$$

Figure 12: Equation Structure of the Sustainable Biomass Index

5. Conclusion and Future Research

Within this paper, we have shown that related works about measurement of sustainability exists and are functional for regions or companies. The difficulty of the measurement of sustainability of biomass resources, which should be a requirement for planning of biomass energy systems, is about the observation of a natural resource being a non-commercial matter. Therefore, we decided to analyze the biomass resource threefold socio-cultural, economical, and ecological according to the definition of the sustainability. The fundament of this calculation is the consideration of the recent situation and the possible changes if the biomass will be used energetically.

With the use of the SBI planning authorities as well as huge investment groups, who wants to invest in sustainable biomass energy systems are able to compare different biomass resources within a region to identify the best sustainable location of biomass energy plants. Additionally, best type and size of the planned energy plants can be identified.

Our future research based on this scientific field will be in the direction of whole system design with regards to decentralized biomass energy in sustainable surroundings using the SBI for the creation of an optimized resource planning of biomass.

References:

[1] Energy Sustainable Communities, *Experiences, Success Factors and Opportunities in the EU-25*, EREC, Brussels, 2005.

[2] EC – DG Joint Research Centre, *Options for cost-efficient use of hydrogen from biomass*, Petten, Netherlands, 2007.

[3] D. Kralj, L. Eisner, D. Goricanec, Environmental Management and its Policy in the Future, *WSEAS Transactions on Environment and Development*, Issue 3, Vol. 1, 2005, pp. 371-377.

[4] S. König, J. Sachau, Planning Alternatives for biomass production by a Strategic Cost Analysis of biomass resources, *Proceedings of the fourth WSEAS International Conference on Environment, Ecosystems, and Development*, Venice, Italy, 2006, pp.389-395.

[5] T-N. Wu, C-S. Lee, M-S. Lee, Regional Sustainable Development in Practice: A Bottom-up Participatory Approach for Lessening the Impact of Water Pollution on a Small Community, *WSEAS Transactions on Environment and Development*, Issue 6, Vol. 2, 2006, pp. 829-837.

[6] Official Journal of the European Union, *COMMUNICATION FROM THE COMMISSION TO THE MEMBER STATES of 2 September 2004 laying down guidelines for a Community initiative concerning trans-European cooperation intended to encourage harmonious and balanced development of the European territory*, 2004/C226/04, 2004.

[7] United Nations, Report of the World Commission on Environment and Development. *Our common future*, United Nations, Oxford, 1987.

[8] Commission of the European Union, *Proposal for a Council Regulation on support for rural development by the European Agricultural Fund for Rural Development* (EAFRD), COM(2004)490 final, Brussels, 2004.

[9] European Commission, *External Costs. Research results on socio-environmental damages due to electricity and transport*, Brussels, 2003.

[10] G. Atkinson, Measuring Corporate Sustainability. *Journal of Environmental Planning and Management, 43 (2)*, 2000, pp.235-252.

[11] European Commission, *Externalities of the Fuel Cycles: "ExternE Project"*, Directorate-General XII, Brussels, 1995.

[12] S. Frankhauser, Evaluating the Social Costs of Greenhouse Gas Emissions, *The Energy Journal*, 15(2), 1994, pp.157-184.

[13] Office for National Statistics, *UK Environmental Accounts 1998*, London, 1998.

[14] D.W. Pearce, J. Newcombe, *Corporate Sustainability: Concepts and Measure*, 1998.

[15] A. Huizing, C.H. Dekker, Helping to Pull our Planet out of the Red: An Environmental Report of BSO/Origin. *Accounting, Organizations and Society*, 17 (5), 1992, pp.449-458.

[16] F. Figge, T. Hahn, *Sustainable Value Added*, Gothenburg, 2002.

[17] United Nations, *Integrated Environmental and Economic Accounting*. Interim Version, New York, 1993.

[18] A. Srivstana, R. Kumar, Economic Valuation of Health Impacts of Air Pollution in Mumbai,

Environmental Monitoring and Assessment, 75 (2), 2002, pp. 135-143.

[19] D.V. Aiken, C.A. Pasurka, Adjusting the Measurement of US Manufacturing Productivity for Air Pollution Emissions Control, *Resource and Energy Economics*, 25, 2003, pp. 329-351.

[20] P. Bartelmus, Accounting for Sustainable Growth and Development, *Structural Change and Economic Dynamics*, 3 (2), 1992, pp. 241-260.

[21] M.A. Freeman, R.H. Haveman, A.V. Kneese, *The Economics of Environmental Policy*, New York, 1973.

[22] R.J. McIntyre, J.R. Thornton, Environmental Divergence. Air Pollution in the USSR, *Journal of Environmental Economics and Managemen*t, 1(2), 1974, pp.109-120.

[23] E. Carlson, M.S. Bernstam, Population and Resources under the Socialist Economic System, *Population and Development Review*, 16, 1990, pp. 274-407.

[24] F. Figge, T. Hahn, Sustainable Value Added. Measuring Corporate Contributions to Sustainability Beyond Eco-Efficiency, *Ecological Economics*, 48 (2), 2004, pp. 173-187.

[25] Die Bundesregierung, *Perspectives for Germany. Our Strategy for Sustainable Development*, Berlin, 2007.

[26] EUROSTAT, *Measuring progress towards a more sustainable Europe – 2007 monitoring report of the EU sustainable development strategy*, Luxembourg, 2007.

[27] D.C. Esty, M. Levy, T. Srebrotnjak, A. de Sherbini, *2005 Environmental Sustainability Index: Benchmarking National Environmental Stewardship*, New Haven, 2005.

[28] S. König, J. Sachau, Strategic Analysis of Sustainable Biomass Potential and Cost of Biomass Resources in Regional Spatial Planning Context, *WSEAS Transactions on Environment and Development*, Issue 10, Vol. 2, 2006, pp. 1368-1376.