Biomass Energy Europe

Summary Report on Illustration Cases

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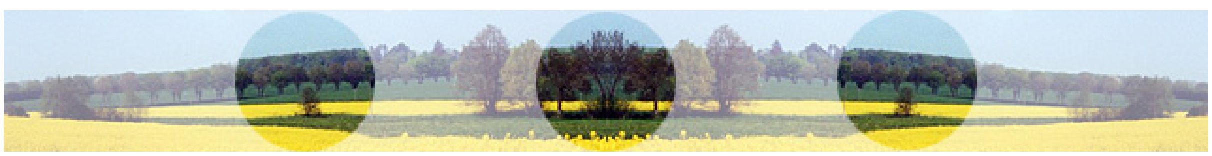

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1 Introduction

1.1 Purpose and scope

The overall objective of the Biomass Energy Europe (BEE) project was to improve the accuracy and comparability of future biomass resource assessments for energy by reducing heterogeneity of terms and definitions, increasing harmonisation of data and calculations and exchanging knowledge on methods and approaches. The BEE method (BEE 2010b) and data (BEE 2010c) handbooks summarise approaches and methods and harmonises assumptions of biomass resource assessments based on existing studies. It does not propose just a single method to fit for all purposes but rather describes and documents various alternative approaches and methods in a comparative way. The alternative methods proposed still lead to different estimates of current and future biomass potentials. This is the logic nature of an application of alternative methods. Still the alternatives might require different input data, they assess different types of potentials or differ in their degree of integration. However, following the guidelines of the BEE handbooks shall increase comparability among estimates in a way that differences can be easily be referred to different input data and approaches.

In the annexed series of reports the methodological recommendations for biomass resource potential for energy (provided in the BEE method and data handbook) are illustrated and validated in their applicability by implementing the proposed methods and data to specific cases. The illustration cases are carried out at different geographic scales:

- Pan European (individual EU27 plus a few non-EU countries)
- Croatia
- Finland
- Ukraine
- FYR Macedonia

Each illustration case describes biomass assessments of a set of biomass types in combinations with specific methods. Table 1 lists these combinations. The main illustration case is implemented at the European level and provides estimates for individual EU27 and a few additional countries. All types of biomass for bioenergy are analysed at this level. This case study covers not only different biomass types at one time but also applies alternative assessment methods. This makes comparisons across methods, potentials and biomass types possible. Illustration cases at the national level are targeting specific sources of biomass. For Croatia there is a focus on willow as an energy crop. The focus of Finland is on advanced spatially explicit methods for estimating biomass potentials from forestry and forestry residues. Finally the case of Ukraine covers all biomass sources in a country under economic transition and with low actual use of biomass for energy production. An example of a country with lacking basic statistical information for carrying out biomass assessments is FYR Macedonia, a BEE illustration case that highlights data needs and issues of data consistency.

Table 1: Coverage of illustration cases.

Geographical focus	Biomass types	Methodological focus
Europe (EU27)	Forestry	Resource-focussed statistical method
	Forestry	Resource-focussed spatially explicit method
	Energy crops	Resource-focussed statistical method
	Agricultural residues	Resource-focussed statistical method
	Waste	Resource-focussed statistical method
	Energy crops	Resource-focussed spatially explicit method
	Forestry and energy crops	Integrated assessment methods
Croatia	Energy crops (willow)	Basic resource-focussed spatially explicit method
Finland	Forestry	Advanced resource-focussed spatially explicit method
Ukraine	Forestry, energy crops, agricultural residues and waste	Resource-focussed statistical and Integrated assessment method
FYR Macedonia	-	Descriptive

These illustration cases provide not only information on European and national biomass potentials, but also demonstrate how a biomass resource assessment using a harmonised approach can be performed. Thus, regional differences in data availability and access, as well as the latest methodological achievements are considered.

The results of the illustration cases and the methodological recommendations for harmonising biomass assessments were presented to specific users of these products. Users were asked to evaluate and qualify both the utility and benefits of the assessments based on the developed harmonised approach. The results are presented in a separate validation report (BEE 2010h).

1.2 Structure

This document is the Summary Report of the BEE Illustration Cases. It provides some general information on the purpose of the illustration cases, summarises the individual cases for EU27, Croatia, Finland, Ukraine and FYR Macedonia and draws some general conclusions from the work package findings. The structure of reports reflects the organisation of the work package tasks. All reports of individual illustration cases follow the same outline and address the same questions:

Introduction
- Introduction to the country/region, the biomass types analysed
- What is special about the biomass type addressed in this report?
- What is special about the region/country?

Methodology
- Description of methods and approaches used and references to the BEE handbooks
- Documentation of changes to methods described in the handbook

Potential for biomass
- Presentation of results

Analysis and discussion
- Data gaps and methodological challenges
- Current status of biomass utilisation
- Implementation issues
- Sustainability issues

Conclusion and recommendation
- What are the conclusions from the illustration case?
- What can be recommended for the region/country?
- How could unresolved harmonisation issues be overcome?

The individual reports on illustration cases and a Validation report on conclusions from users are released as Annexes to this summary report in the following way:

Annex I (European illustration case)	BEE (2010a). European illustration case. H. Böttcher, M. Dees, S. M. Fritz, K. Gunia, I. Huck, M. Lindner, T. Paappanen, C. I. Ramos, U. Schneider, J. Torén, A. Thebaud, J. v. Brusselen, M. Vis, A. Woynowski and S. Zudin. IIASA, Laxenburg.
Annex II (Illustration case for Croatia)	BEE (2010d). Illustration case for Croatia. D. Kajba, J. Domac and V. Segon. FFZG, Zagreb.
Annex III (Illustration case for Finland)	BEE (2010e). Illustration case for Finland. A. Lehtonen, P. Anttila and P. Puolakka. Metla, Helsinki.

Annex IV (Illustration case for Ukraine)	BEE (2010g). Illustration case for Ukraine. P. Lakyda, R. Vasylyshyn, S. Zibtsev, T. Zheliezna, C. I. Ramos, U. Schneider, I. Huck and H. Böttcher. NUBiP, Kiev.
Annex V (Illustration case for Macedonia)	BEE (2010f). Illustration case for the Former Yugoslavian Republic of Macedonia. K. Popovski. MAGA, Skopje.

1.3 Acknowledgements

The series of reports of the BEE illustration cases has been produced by the *Biomass Energy Europe project*, which was supported by the European Commission under the 7th Framework Programme (FP7) and coordinated by the Albert Ludwig-Universität Freiburg. The illustration case reports form the deliverables (D6.1 and D6.2) of Work Package 6 *'Illustration Cases'* of the BEE-project. The International Institute for Applied Systems Analysis (IIASA) was work package leader.

All BEE participants of Work Package 6 have contributed parts to the different illustration cases. Below the authors and organisations responsible for the different reports are listed.

Table 2: Authors and contributors to the reports on the BEE illustration cases.

Report	Responsible organisation	Authors
Summary	IIASA	Hannes Böttcher
Illustration case for Europe	IIASA	Hannes Böttcher
Forestry - Resource-focussed statistical method	ALU	Matthias Dees, Alicia Woynowski
Energy crops and agriculture - Resource-focussed statistical method	VTT	Teuvo Paappanen
Waste - Resource-focussed statistical method	BTG	Martijn Vis, Alexandre Thebaud
Forestry - Resource-focussed spatially explicit method	EFI	Katja Gunia, Jo van Brusselen, Sergiy Zudin, Marcus Lindner
Energy crops - Resource-focussed spatially explicit method	IIASA	Hannes Böttcher
Integrated assessment methods	Uni HH	Ingo Huck, Ivie Ramos, Uwe Schneider, Johan Torén
Illustration case for Croatia	FFZG	Davorin Kajba, Julije Domac, Velimir Segon
Illustration case for Finland	Metla	Aleksi Lehtonen, Perttu Anttila, Paula Puolakka
Illustration case for Ukraine	NUBiP	Petro Lakyda, Roman Vasylyshyn, Sergiy Zibtsev, Tetiana Zheliezna, Chrystalyn Ivie Ramos, Uwe Schneider, Ingo Huck, Hannes Böttcher
Illustration case for Macedonia	MAGA	Kiril Popovski
Validation of illustration cases	VTT	Teuvo Paappanen, Martti Flyktman

2 Summaries of illustration cases

2.1 Pan-European illustration case

The BEE illustration case presented in this report is implemented at the European level and provides estimates of biomass potentials for bioenergy for individual EU-27 and a few additional countries. All types of biomass for bioenergy are included in the assessment: forestry biomass and forestry residues, energy crops, agricultural residues and organic waste.

The European illustration case provides not only information on European and national biomass potentials, but also demonstrates how a biomass resource assessment using harmonised approaches can be performed. The structure of chapters reflects the organisation of the work package tasks. Each chapter describes the assessment of a set of biomass types in combinations with specific methods.

Forestry - Resource-focussed statistical method

The scope of the assessment of the bioenergy potential from forestry by the resource focused statistical method covers the FAO land use categories forest and other wooded land. For the 27 EU member states the theoretical and technical biomass potential from the use of stemwood, primary forestry residues and secondary forestry residues from wood processing industries was estimated. As the base years of the various statistical data bases used varies, the estimates can be considered to assess the situation in the period 2005 – 2010. Table 3 gives an overview of the results at EU level, while detailed results per country and for EU27.

Table 3: Summary table forestry potential including fellings, primary and secondary forestry residues and trees outside forests.

Type of potential	Energy potential [PJ]	In % of the overall theoretical potential
Overall theoretical domestic potential from forests (considering also wood used for material use assuming a cascade use of wood with a final utilisation for energy purposes)	7939.4	100%
Theoretical potential from forests (stemwood and primary forest residues)	5232.3	65.9%
Technical potential from forests considering a minimum of restrictions (Demonstration option) and including secondary forest residues	3896.0	49.1%
Technical potential from forests including secondary forest residues	3268.1	41.2%

Compared to other EC studies, the technical potential estimated in this report was lower than the technical potential estimated by Thrän et.al. (2006) and higher than the environmentally compatible potential estimated by EEA (EEA 2006).

The application of the basic statistical method is a simple approach to assess the technical potential at EU27 level. The data demand is rather limited and updates with new statistics are easily implementable. It can serve as a reference to more complex approaches.

Reducing uncertainties associated with the sensitive parameter of recovery rates and other reduction factors would certainly improve the quality of the estimates of the technical potentials. Furthermore, it is recommended to increase the completeness of data on the current use of wood for energy from forests to enable a solid comparison between the potential estimates and the current use. This could be used to identify the development opportunities per country and at EU level.

Since the consideration of sustainability issues in potential assessments is difficult and will remain so in future, it is recommended to establish monitoring facilities to monitor the influence of increasing harvesting levels and the utilisation of primary forestry residues on soil fertility and biodiversity.

Energy crops and agriculture- Resource-focussed statistical method

Energy crops

The assessment of dedicated energy crops, agricultural residues (primary and secondary) and manure was also assessed using a basic statistical method provided by the BEE method handbook. The main focus was on finding the technical potential of these bioenergy sources, but also theoretical potentials are given for the year 2008.

The results of the assessment are affected by the selection of factors applied to guarantee food security. Three different diet scenarios were applied. In case of vegetable diet the total available area for energy crops in all EU member states is about 29.9 million ha. For mixed diet and meat diet these values are 6.4 and 0.2 million ha, respectively. Assuming a mixture of Reed canary grass, Miscanthus, Rape seed and Sunflower in shares that are currently observed, these differences in area affect bioenergy potentials of energy crops on cropland significantly: vegetable diet 3465 PJ, mixed diet 742 PJ and meat diet 22 PJ (Table 4).

Table 4: Potential of energy crops in EU countries (PJ).

	Vegetable diet	Mixed diet	Meat diet
EU27	3465.3	741.9	22.4

The illustration case chapter on bioenergy potential from energy crops reveals the challenges of such estimates, even if only a basic statistical method is used. Many assumptions on reduction factors are difficult to support with empirical data. The main difficulty relates to the requirement that energy crops are supposed to be cultivated only on surplus land. To define and quantify what really is surplus land is a challenge. However using the assessment method that was applied here, approximate results can be achieved quite easily keeping in mind the simplicity of the approach.

Agricultural residues and manure

Using also the basic statistical method primary and secondary agricultural residues and manure were estimated for EU member states for the year 2008. The chapter estimated the theoretical and technical potential of agricultural residue biomass, except for manure where only the theoretical potential was determined.

The total technical potential in EU-27 is 806 PJ (theoretical 2686 PJ). The largest part from the potential comes from common cereal straw (560 PJ), followed by rapeseed straw (91 PJ) and maize straw (86 PJ). The largest total potentials were found for France (164 PJ), Germany (125 PJ) and Spain (105 PJ). The technical potential of secondary agricultural residues is 51.5 PJ (theoretical 88.9 PJ).

Table 5: The potential of primary agricultural residues in 27 EU countries (PJ).

Soruce	Cereals	Rice	Maize	Rape seed	Sun flower	Olive	Wine-yards	TOTAL
Primary agricultural residues	560.3	11.1	85.5	90.9	16.2	27.7	14.2	805.9

Source	Rice husks	Sunflower husks	Sugar beet	TOTAL
Secondary agricultural residues	8.7	17.5	25.3	51.5

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Source	Pigs	Cattle	Chicken	TOTAL
Manure	265.0	380.3	119.7	765.0

The total theoretical manure potential produced in EU27 countries is 796 million tonnes. The energy content of this manure is 765 PJ. The largest share of manure comes from cattle, about 380 PJ, which is about 50% of all produced manure.

Assessment methods for both primary and secondary agricultural residues are relatively simple and straightforward. The initial values can easily be obtained from statistical databases. These methods use correction factors by which the available amount of residues is calculated using cultivation areas and yields of crops. These correction factors vary on literature, which is caused by the fact that also physical conditions in different countries and climate conditions vary. Sufficient attention has to be paid to the selection of these factors including a thorough documentation.

Waste - Resource-focussed statistical method

Organic waste, also called biomass waste, biowaste or tertiary residues, origin from the final use of biomass containing products. Important examples are biodegradable municipal waste, demolition wood, and sewage sludge. In this illustration the example of biodegradable municipal waste (BMW) was worked out.

BMW is available and potentially usable wherever the population has access to municipal waste services. However, the potential differs from one country to the other in relation to the waste production and its organic content. In addition, since most BMW and MSW is already collected from households, the locations in which the waste is currently stored or processed, could be of more interest than the locations of the households where the BMW is generated. In order to determine how the potential is distributed between countries, country data can be used. The results of country assessments are shown in the table below.

Biodegradable municipal waste consists of mainly paper and paperboard and kitchen and garden waste. For calculation of the theoretical potential, paper and paperboard is included in OC. The theoretical potential of the EU27 for the year 2008 was 1096.50 PJ/year. For calculation of the technical potential, paper and paperboard are excluded of OC, since a large fraction of the paper and paperboard can be/is being recycled and used in paper products. The technical potential of the EU27 for the year 2008 was 722.17 PJ/year.

The illustration case on BMW shows that especially good and recent estimates of the organic content of BMW are hard to find. The method itself was tested which has lead to some changes in the methods description in the methods handbook.

The method presented in the Methods handbook shows how with using present available data, the availability of biomass could be assessed. On the level of member states, under the supervision of Eurostat, a harmonised method should be developed to measure or estimate the amount of biodegradable municipal waste in Europe.

Forestry - Resource-focussed spatially explicit method

This illustration case applies a resource-focussed, basic spatially explicit method to estimate the bioenergy potential of stemwood and primary forest residues at the European level for the average year 2005 (i.e. average over different base years of the iput data). The final maps presented in that chapter give an indication of the average biomass potential from unutilized stemwood and primary forest residues, based on net annual increment, expansion factors, and under consideration of environmental criteria and basic technical constraints as well as annual fellings for industry. Countries with already high biomass extraction rates, will consequently have lower potential for additional biomass extraction. According to the types of biomass potentials defined within the BEE project, the resulting estimates can be referred to as technical biomass potential. It should be noted that the applied method assumes an even distribution of age classes for forest at the country level.

Table 6: Potential from forestry for EU27 (PJ).

Biomass type	Biomass resource	Theoretical potential	Technical potential
Forest biomass	Stem wood	968	825
Primary forest residues	Above ground	373	341
	Below ground	148	134

The illustration case shows the applicability of the spatially explicit method at large scale. The results of the assessment are not the directions for an implementation of the assessed potential, but a base for planning further assessments on more detailed (national/regional) level. Another benefit of this illustration case is that results of the assessment can serve communication among society and leads to “ignition" of new research in bioenergy potentials. The main gaps in datasets used in the illustration case are related to calculation of constraints based on proposed sustainability criteria (mainly soil data). As a main challenge of the method itself we see the dependence of results on sustainability criteria selection.

Energy crops - Resource-focussed spatially explicit method

The BEE Methods handbook lists various approaches and methods for estimating the present and future potential of various types of biomass energy crops. The approaches and methods that are evaluated by the Handbook are in principle suitable for all types of energy crops.

To estimate the theoretical biomass potential from energy, crop models simulating biophysical processes can be applied to calculate crop yield and environmental externalities associated with their cultivation. Especially, they can be used to compare land management systems and their effects on water, nitrogen, phosphorus, and green house gas emissions. Biophysical crop yield models typically integrate a large number of biophysical processes and allow assimilation of earth observation products for global calibration of environmental impact assessments. This chapter describes the application of a resource-focused spatially explicit method for an assessment of the theoretical potential for biomass production from perennial energy crops on arable lands, i.e. on the total agricultural area used for crop production. The study excludes grasslands that could potentially be used for the production of energy crops but cannot be represented by the crop model chosen. The method covers the EU 25 Member State countries, thus excluding Bulgaria and Romania. As an example results for woody crops and grasses are presented, namely Poplar, Miscanthus and Reed canary grass. Their potential yields will be described as a theoretical production potential. Advanced integrated modelling can subsequently be used to calculate actual yields corresponding to the economic level of intensification.

In total the cropland area in EU25 of about 94 Mha produces on average 12.1 tonnes biomass per ha from Miscanthus, 7.1 from poplar and 5.3 from Reed canary grass. The productivity is very variable across European countries with lowest values for Northern Europe (Finland) and parts of the South (Portugal) and highest for Southern and Central Europe (Italy, Greece, Slovenia but also Latvia), similarly for all three crops. Reed canary grass shows relatively higher productivities in Northern Europe compared to poplar and Miscanthus. Poplar finds optimal growth conditions in Central and Western Europe. EU25 could theoretically produce about 18,400 PJ bioenergy from Miscanthus, 12,700 PJ from poplar and 8,100 PJ from Reed canary grass when growing on the same area of about 94 Mha.

A spatially explicit assessment of energy crops has several advantages over more aggregated methods. The more or less detailed geography of crop yields that can be derived from such methods allows for a visual assessment of maps that display differences in yields and other parameters between different geographical regions within and across national and administrative borders. The illustration case has also shown that such an assessment is very data intensive and can become very complex (e.g. a crop yield model like EPIC has more than a hundred variables and parameters that need to be specified for a model run). However, the complexity of tools that address biomass production accurately in a spatially explicit way cannot be avoided given the complexity of plant growth in a diverse landscape. Therefore detailed geographically explicit crop yield models are usually developed by whole research groups and over a longer period of time.

Integrated assessment methods

Integrated assessment models are suitable to study land use impacts on agricultural and forestry markets and competition for land between forestry, food and non-food agriculture as well as the net environmental impacts of bioenergy production on these land use options. This chapter describes the application of an integrated assessment method to investigate the technical biomass potentials and the competitive economic portions of the technical potentials of biomass in the agriculture and forest sectors of the 27 European Member States, excluding Cyprus and Malta.

The biomass types from the agricultural sector include biomass for energy production from the traditional agricultural annual crops, i.e. wheat, sunflower, rape and sugar beet. Biomass from non-food agriculture includes dedicated perennial grasses and short rotation woody crops for energy production, i.e. willow, poplar, Miscanthus and Reed canary grass. In the forest sector, on the other hand, distinct biomass types involve forest felling and forest residues.

The biomass potential in Europe can reach up to more than 4300 PJ in 2020 and would increase to about 5000 PJ in 2030 under the free trade setting. And so, if for example, there is a 35 EUR/ton incentive for biomass plantations, the total biomass subsidy needed to achieve the total potential of 4300 PJ would amount to about 7200 million EUR in 2020.

Given an incentive of 35 EUR/ton for biomass plantations the biomass potential in Europe can reach up to more than 4300 PJ in 2020 and would increase to about 5000 PJ in 2030 under the free trade setting. Subsequently, the total biomass subsidy needed to achieve the potential of 4300 PJ would amount to about 7200 million EUR in 2020.

Generally, results suggest that in the presence of economic incentives such as subsidies, the competitive potentials of different bioenergy markets will increase despite constraint on the conversion of land to biomass plantations. Gradual improvements in biomass subsidies correspond to higher biomass production potential but may significantly affect the potentials of other land use categories due to the substantial pressure on land brought about by the amplified biomass activities. The inclusion of sustainability parameters in the assessment which aimed to avoid negative environmental impacts of indirect land use change therefore restrict the resulting potential through limiting the area of land available for bioenergy use.

Integrated modelling approaches are needed to tackle issues related to the development of bioenergy production strategies in response to the European Union's renewable energy targets and biodiversity protection initiatives as these objectives will involve significant impacts on land use and land use management. These developments have raised questions regarding their effects on agricultural and forestry products, markets and competition for land between forestry, food and non-food agriculture and nature reserves.

Efficient policy regulation therefore requires cooperation on data and modelling across national and regional borders. However, the quality of data inputs, the specified boundary conditions, assumptions and the applied biomass or bioenergy policy conditions generally affect the simulation results of economic potential values.

Synthesis of results

Given the fact that all illustration case results were produced on basis of the harmonised BEE handbooks, comparison of results of the same biomass and potential type across methods give insights into underlying uncertainties and remaining issues of harmonisation.

Figure 1 summarises the results of the European illustration case at the level of biomass types and sources and the type of potential. The data were averaged over different assessment methods if estimated by more than one. The typical cascade of potentials as theoretically expected, i.e. the stepwise shrinking potential with increasing number of constraints, is well expressed in some biomass categories, e.g. primary forestry residues or stemwood. This applies also for the energy crops.

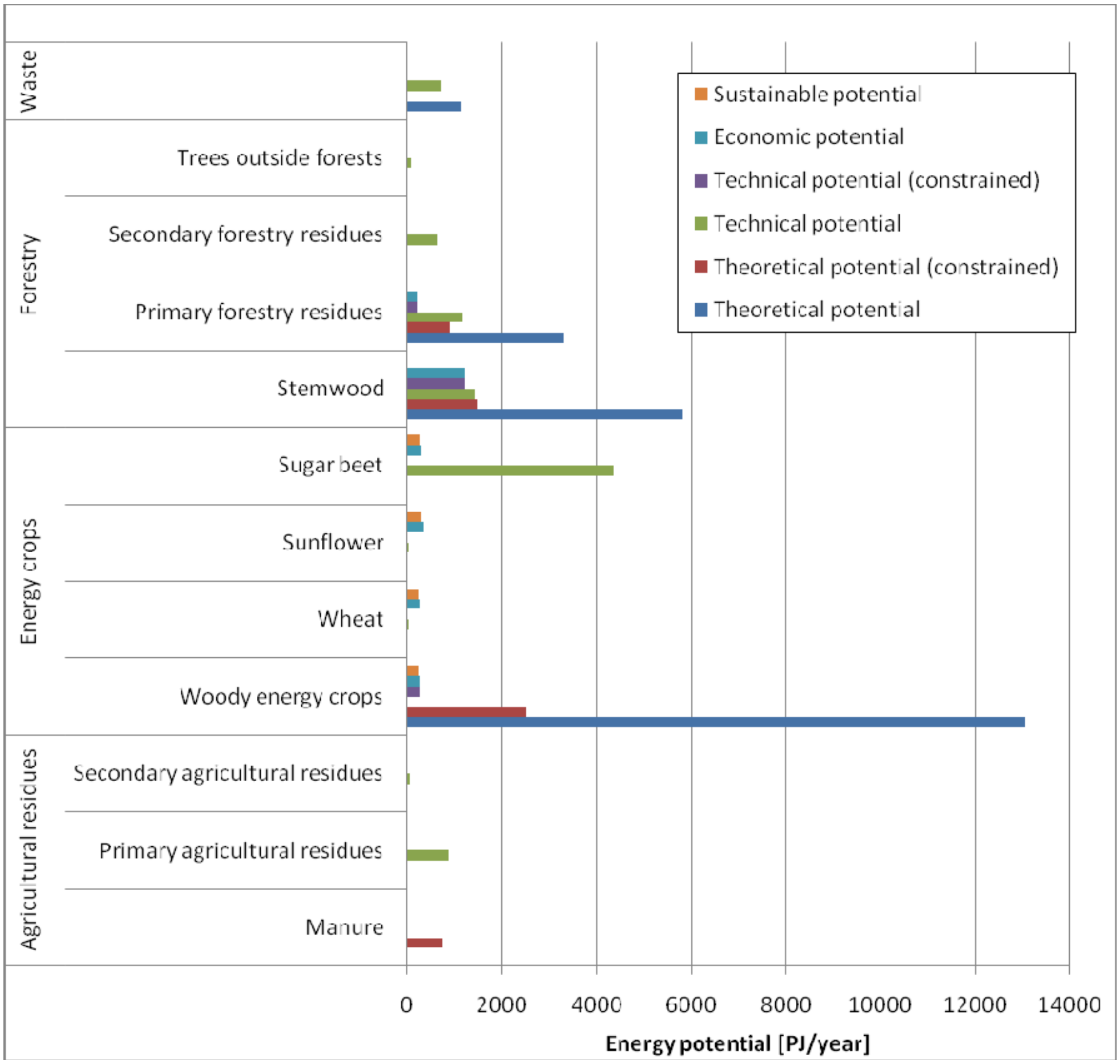

Figure 1: Summary of the EU illustration case results. Sums over all EU27 countries for the different biomass types and sources separated by potential types. Values in PJ per year. For the averages from forestry biomass sources factors for the conversion of tonnes DM wood to PJ were harmonised to a value of 15.48.

Table 7: Percentage share of the theoretical potential. Potentials were summed over EU27 countries and averaged over the different methods applied.

Biomass type	Biomass sources	Technical	Economic
Forestry	Stemwood	25%	21%
	Primary forestry residues	36%	7%
Energy crops	Woody energy crops		2%
Waste		64%	

It is striking that for different biomass types the differences between potential levels vary. When summing over all countries and averaging over all methods, some basic relationships can be observed. Table 7 displays the percentage share of the theoretical potential for the technical and economic potential for different biomass types and sources. The numbers have to be interpreted with care as the estimates for the same level of potential differ significantly between methods (see Figure 1). For energy crops, in general, a reduction of one order of magnitude can be expected when going from the theoretical to the technical potential. For forestry the reduction is less severe. Potentials are reduced to about one third or fourth on average going from theoretical to technical potential and halved again for the economic potential. However, for fellings large variability due to alternative definition of potential types were observed. Here the technical potential can be very close to the economic.

The results of the European illustration case provide information on national and EU biomass potentials for biomass from forestry, energy crops, agricultural residues and organic waste. The results can support national policies and strategies for biomass utilisation e.g. for the compilation of national biomass action plans. At an aggregated level they can also be used to inform European policy and other stakeholders about biomass potentials and availability.

Further this report will help the European research community to address remaining questions and carry out more detailed assessments at national or international level.

For full details on the European illustration case see Annex I:

BEE (2010). European illustration case. H. Böttcher, M. Dees, S. M. Fritz, K. Gunia, I. Huck, M. Lindner, T. Paappanen, C. I. Ramos, U. Schneider, J. Torén, A. Thebaud, J. v. Brusselen, M. Vis, A. Woynowski and S. Zudin. IIASA, Laxenburg.

2.2 Illustration case for Croatia

The main objective of the illustration case for Croatia was to estimate the theoretical and technical potential of short rotation coppice (SRC) energy plantations on abandoned land or on land where agricultural production is not profitable.

The methodology utilised for estimating the SRC potential within this illustration case was based on the basic spatially explicit method, which is described in detail in chapter 4.4.3 of the BEE method handbook. The main data source used for the assessment was the basic pedological map of Croatia, which formed the basis for the estimations of soil suitability for SRC plantation.

Based on the different types of soils, the current utilisation and their characteristics, the total area suitable for the production of energy crops was estimated. This area was further reduced based on the information available regarding the implementation of the EU Natura 2000 network in Croatia, to obtain the area potentially available for short rotation energy crops. From this area information the *theoretical potential* of crop production was derived.

In order to attain the *technical potential* the available area for SRC was further reduced taking into account that certain parts of the land are not suitable for the currently applied harvesting techniques, for instance alluvial river banks and deposits, areas prone to flooding and areas with a steep inclination.

The theoretical potential for short rotation energy crops production in Croatia was estimated to amount as follows:

- Forest area suitable for energy crops – a total of 51,200 ha was estimated to be suitable for SRC, producing in total 470,200 t DM/year or 8.7 PJ
- Agricultural areas with moderately suitable soils and limited soil suitability – a total of 617,000 ha was estimated to be suitable for SRC, producing a total of 7,404,000 t DM/year or 136.2 PJ

The technical potential for short rotation energy crops production in Croatia was estimated to amount as follows:
Forest area suitable for energy crops – a total of 46 850 ha was estimated to be suitable for SRC, producing in total 430,000 t DM/y or 7.9 PJ. Agricultural areas with moderately suitable soils and limited soil suitability – a total of 235,650 ha was estimated to be suitable for SRC, producing a total of 2,827,800 t DM/y or 52.1 PJ.

In spite of the considerable potential for short rotation energy crops production, currently a very small amount of the available area is utilised in Croatia. The issues and problems to be addressed in order to increase this production include a change in policy approach, especially aimed at small landowners, introduction of incentives and subsidies, lack of knowledge and experience in growing energy crops and generally a lack of cooperation between relevant stakeholders.

For full details on the Croatian illustration case see Annex II:

BEE (2010). Illustration case for Croatia. D. Kajba, J. Domac and V. Segon. FFZG, Zagreb.

2.3 Illustration case for Finland

The illustration case for Finland differs from the other illustration cases with respect to methodology. The illustration case made intensively use of information derived from National Forest Inventories (NFI) and satellite images. The study aimed to provide estimates of technical potential of forest chips for bioenergy by using a harmonised estimation method. The sources of chips considered here were logging residues and stumps from final fellings. The methods used for the Finnish illustration case combine spatially explicit biomass maps, segmentation of Earth Observation (EO) data, polygons for protected areas, and forests characteristics for each segment. The advanced spatially explicit method is describe in detail in chapter 3.4.2 of the BEE method handbook.

The result of the illustration case provides estimates of technical potential for Central Finland and two types of potentials were assessed: Business as Usual (BAU) and Maximum Sustainable Cuttings (MAX). The applied harvesting level scenarios were as follows:

- Business as Usual (BAU). The scenario is based on mean annual roundwood removals in 2000–2009.
- Maximum Sustainable Cuttings (MAX). The scenario is based on maximum harvesting level that can be maintained sustainably during 2007–2016 in Central Finland.

The total bioenergy potentials from final fellings for the region of Central Finland were estimated at 10.6 PJ/year for the BAU scenario and 12.8 PJ/year for the MAX scenario.

For full details on the Finnish illustration case see Annex III:

BEE (2010). Illustration case for Finland. A. Lehtonen, P. Anttila and P. Puolakka. Metla, Helsinki.

2.4 Illustration case for Ukraine

With its territory of 603,500 km^2 Ukraine is one of the largest countries in Europe. Diversity of natural conditions determines geographical peculiarities of distribution of agricultural and forest lands in Ukraine. In this report four biomass types are addressed: energy crops, forestry biomass, agricultural residues and waste. All biomass potentials are estimated at a regional level (oblast). For the assessment the harmonized methodologies of resource focused approach basic statistical method (for the year 2008) and integrated assessment methods (for the years 2010, 2020 and 2030) were applied as described in the BEE Handbook.

Theoretically the two major constituents of the potential are agricultural residues and energy crops. This is due to highly developed agriculture in the country and availability of large areas of unused lands which may be involved in growing energy crops. The theoretical biomass potential in Ukraine could reach up to more than 16 EJ for which around 95% comes from traditional food crops.

The theoretical potential for forest biomass amounts 651 PJ annually. About 94% account for stem wood, 3% for primary and 3% for secondary forestry residues (averaged over different methods). The economic potential could be about 5% of the theoretical stemwood potential.

In addition to the biomass types mentioned above, Ukraine also has a potential of feedstock for the production of liquid biofuels. This feedstock is corn grain for bioethanol and rapeseed for biodiesel. At the moment a big share of these kinds of feedstock is exported. The assumption is that at least part of the corn grain and rapeseed may be used inside the country for the production of bioethanol and biodiesel.

Table 8 presents a summary of the illustration case results for Ukraine for different biomass types. Values are averaged over methods if more than one method was applied. Therefore the number might differ from the original values in the chapters above. The theoretical potential was estimated to amount more than 16,000 PJ annually, a large share being energy crops. However, on average only 30% of it are technically available (the technical potential of energy crops was not estimated). Largest differences between the theoretical and technical potential are observed for stemwood potentials (if material use is not considered a constraint, e.g. through full cascade use of bioenergy along the wood product chain). Also primary agricultural residues are estimated to have a much higher theoretical potential compared to the potential under technical constraints. Both, primary agricultural residues and stemwood also form the largest single potentials (after energy crops).

The economic potential estimated by the integrated assessment method reveals that in the case of stemwood only 5% of the theoretical potential would be used under competition and less than 1% of the energy crop potential for the year 2010. There is, however, a temporal dynamic in the economic potential that is most pronounced in the stemwood potential numbers.

According to the integrated assessment method, the economic potential could be increased substantially if subsidies would be introduced.

The BEE method handbook was applied to the illustration case for Ukraine and documents how the methods collected in the handbook can be applied in conditions outside the European Union. In case of forest biomass potentials assessment main challenge with harmonization is not of lack of data but the absence of proper methodology, models and complete standard data sets.

Table 8: Summary of illustration case results for Ukraine for different biomass types. Values are averaged over methods if more than one method was applied (see *). Therefore the number might differ from the original values in the chapters above. Values in PJ per year for the year 2008 or 2010 (depending on method).

Biomass type	Biomass type detail	Theoretical potential (constrained value)	Technical potential	Economic potential	Tech/ Theo	Econ/ Theo
Forestry	Stemwood *	613 (264)	39	29	6% (15%)	5%
	Primary forestry residues *	14	11	4	79%	25%
	Secondary forestry residues	20	17	-	83%	-
	total	**647**	**67**	**-**	**10%**	**-**
Agricultural residues	Manure	90.9	68.1	-	75%	-
	Primary agricultural residues	1135.5	415.1	-	37%	-
	Secondary agricultural residues	32.9	18.3	-	56%	-
	total	**1259**	**502**	**-**	**40%**	**-**
Energy crops		14172.7	-	6.0	-	<<1%
Waste	Landfill gas	22.7	13.7	-	60%	-
	Sewage sludge and sewage gas	6.3	4.0	-	63%	-
	total	**29**	**18**	**-**	**61%**	**-**
TOTAL		**16108**	**586**		**4%**	
TOTAL without energy crops		**1935**	**586**		**30%**	

* Average over different methods

For full details on the Ukrainian illustration case see Annex IV:

BEE (2010). Illustration case for Ukraine. P. Lakyda, R. Vasylyshyn, S. Zibtsev, T. Zheliezna, C. I. Ramos, U. Schneider, I. Huck and H. Böttcher. NUBiP, Kiev.

2.5 Illustration case for FYR Macedonia

Forest biomass is an important source of energy for FYR Macedonia, and has accounted for about 10% of the total energy supply the last 20 years. Contrary to most EU countries the bulk of the forest fellings, 80%, is used for energy purposes, while the remainder is used in industry. The share of illegal fellings is also large, accounting for as much as 35% of the total volume.

The objective of the illustration case was to estimate the theoretical and technical potential of stemwood. Due to the lack of reliable forest statistics for FYR Macedonia the basic resource focused statistical method, which is described in detail in chapter 3.2.1 of the BEE method handbook, was used for the Macedonian illustration case. The basic statistical method allows estimates considering minimum constraints and using results of forest inventories only, an additional advantage of this method is that expert judgement can be used to fill gaps where statistics are not available. However, the accuracy of the assessment may be reduced.

The theoretical potential for stemwood for energy purposes is estimated at 1.2 million m^3 for the year 2000, whereas the technical potential is estimated to 0.3 million m^3. Correspondingly, the technical potential for stemwood in Macedonia in 2020 is estimated to 0.24 million m^3.

However, the illustration case of FYR Macedonia shows that even simple methods described in the BEE methods handbook can only applied when basic standardised data is available. The national forest inventories of FYR Macedonia for example, are therefore not appropriate sources for a realistic biomass assessment. The results of this illustration case demonstrate the limits of harmonisation when basic standard data are not recorded in a country.

For full details on the FYR Macedonian illustration case see Annex V:

BEE (2010). Illustration case for the Former Yugoslavian Republic of Macedonia. K. Popovski. MAGA, Skopje.

3 General conclusions

- The results of the BEE illustration cases provide information on regional, national and EU biomass potentials for biomass from forestry, energy crops, agricultural residues and organic waste. These were estimated using a wide variety of approaches and methods, following the BEE method and data handbooks.

- The results can support national policies and strategies for biomass utilisation e.g. for the compilation of national biomass action plans. At an aggregated level they can also be used to inform European policy and other stakeholders about biomass potentials and availability.

- Further the reports will help the European research community to address remaining questions and carry out more detailed assessments at national or international level.

- The biomass potentials presented in the BEE illustration case reports were estimated at different levels of integration, ranging from the theoretical and technical potential to the integration of costs and demand in the economic potential.

- The illustration cases demonstrate how a biomass resource assessment using harmonised approaches can be performed. They prove the applicability of the approaches and methods described in the BEE method and data handbooks.

- The illustration cases make suggestions for every method and biomass type about how methods and data sources can be further harmonised and improved with respect to consistency, completeness and accuracy. It also lists data that are currently not available/accessible but would be needed for advancing methods and improving estimates.

- Sustainability issues were addressed where applicable. The illustration case revealed that a sufficient level of detail in data sources and methodology is required to include sustainability criteria in a meaningful way. Basic methods often fail to provide those details.

- Uncertainties in biomass assessments at the level presented in the BEE illustration cases can be large. The application of different methods gives insight into uncertainties associated with the choice of the assessment method by looking at the same object from different angles.

- Uncertainties are, however, associated with all methods and there is no “best method” or one fits all solution. Basic methods incorporate less data but accumulate uncertainty in few factors that account for many assumptions in a rather intransparent way. More advanced methods leave the decisions on single parameters to the user. They have thus the potential for being more transparent.

- All methods presented in the illustration cases require still assumptions and choices of the user. Many factors are highly uncertain and their choice may influence results substantially. The BEE method handbook can impossibly resolve all necessary decisions. These depend on the scope of the study to be performed, the data availability etc.

- A central conclusion from the application of the BEE method and data handbooks is, that the documentation of such details is essential for comparability of results. The BEE handbooks can therefore only supply a common language and registry for the presentation of future biomass assessments. It does not free the user from a thorough documentation.

- Biomass assessments remain a complex matter that requires complex methods for an appropriate consideration of all influencing factors. The BEE illustration cases also help users to decide the level of complexity they require.

4 References

BEE (2010a). European illustration case. H. Böttcher, M. Dees, S. M. Fritz, K. Gunia, I. Huck, M. Lindner, T. Paappanen, C. I. Ramos, U. Schneider, J. Torén, A. Thebaud, J. v. Brusselen, M. Vis, A. Woynowski and S. Zudin. IIASA, Laxenburg.

BEE (2010b). Harmonization of biomass resource assessments Volume I: Best practices and methods handbook. BTG Biomass Technology Group, Enschede, The Netherlands.

BEE (2010c). Harmonization of biomass resource assessments Volume II: Data Sources Handbook. VTT, Hesinki, Finland.

BEE (2010d). Illustration case for Croatia. D. Kajba, J. Domac and V. Segon. FFZG, Zagreb.

BEE (2010e). Illustration case for Finland. A. Lehtonen, P. Anttila and P. Puolakka. Metla, Helsinki.

BEE (2010f). Illustration case for the Former Yugoslavian Republic of Macedonia. K. Popovski. MAGA, Skopje.

BEE (2010g). Illustration case for Ukraine. P. Lakyda, R. Vasylyshyn, S. Zibtsev, T. Zheliezna, C. I. Ramos, U. Schneider, I. Huck and H. Böttcher. NUBiP, Kiev.

BEE (2010h). Validation of illustration cases. T. Paappanen and M. Flyktman. VTT, Jyväskylä.

EEA (2006). How much bioenergy can Europe produce without harming the environment? European Environment Agency (EEA), Copenhagen, Denmark. 59 plus Appendixes.

Thrän, D., M. Weber, A. Scheuermann, N. Fröhlich, J. Zeddies, A. Henze, C. Thoroe, J. Schweinle, U. Fritsche, W. Jenseit and L. a. S. Rausch, K. (2006). Sustainable strategies for biomass use in the European context. Institut für Energetik und Umwelt (IE), Leipzig, Germany. 337 + Appendices.

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