SES6-CT-2003-502705

RENEW

Renewable fuels for advanced power-trains

Integrated Project

Sustainable energy systems

Deliverable D5.01.03
Residue biomass potential inventory results

Period covered	from: 01.09.2004	to:	Date of preparation	
Start date of project:	01-01-04		Duration:	48 months

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Revision 2006-12-14

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Project co-funded by the European Commission within the Sixth Framework Programme (2002-2006)

Dissemination Level		
PU	Public	X
PP	Restricted to other programme participants (including Commission Services)	
RE	Restricted to a group specified by the consortium (including Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

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1. Introduction

The deliverable D5.01.03 ‘Residue biomass potential inventory results’ is prepared within European project Renewable Fuels for Advanced Powertrains, RENEW, a project supported by the European Commission within the 6th Framework Programme.

The deliverable is a result of Workpackage WP 5.1 ‘Biomass resources and potentials’. The objective of the report is to estimate the available residue biomass potentials for BtL fuels production analyzed within the RENEW project.

This report presents the potential of residue biomass resources in Europe, namely:

- agricultural residues,
- forestry wood fractions for energy,
- wood industry by-products.

The biomass resources availability will influence the BtL fuels production rates and processing plants’ locations. Available potentials estimated in this report are coming from theoretical potential limited by technological factors, ecological restrictions and competitive use of the biomass materials. RENEW scenarios and boundary conditions are applied for the potentials calculations.

The technological factors are related to availability of harvesting technologies and their efficiency. Ecological restrictions include the fact that only part of the biomass can be removed from the production site due to environmental reasons, such as maintenance of soil sustainability, etc. Competitive uses of biomass, which are necessary to keep the assumption that food and fiber production must not be affected, were considered as not available for potentials BtL production.

The potentials of agricultural residues (straw from cereals, maize and oilseed) are analyzed on regional level NUTS-2 or NUTS-1 (Nomenclature of Units for Territorial Statistics). This is a unique approach compared to existing potential assessment studies in Europe presenting the results only for country based level, i.e. LOT5 2003, Ericsson and Nilsson 2006, Thran et al. 2004. The only exception is a study on straw potentials at regional level by Edwards et al. 2005.

The forestry and wood industry by-products potentials are presented in this report on national level, which is conditioned by the availability of input data.

For consistency in assessment, compiled data from international organs are used instead collecting data from national sources. Agricultural data are collected from EUROSTAT, while forestry data come from TB FRA 2000, TB FRA 2005 and FORESTAT.

The potentials are presented in this report in energy units PJ per year. In the ‘Country biomass profile’ the potentials are presented also in mass units as received, i.e. tons of straw and m^3 solid of wood. Then, using the appropriate heating values (presented in the ‘Country biomass profiles’) the potentials were recalculated into PJ/year.

This reports presents the methodology used for residue biomass potential calculations (**Chapter 2**). Then, the results achieved are presented and commented for each country (see **Chapter 3**). In this sections the potentials figures are presented for each RENEW scenarios, then, the straw potential is investigated on regional level, indicating the parameters, which are the most sensitive for the results. Finally, a Summary comes (**Chapter 4**).

2. Methodology

There are considered three horizontal scenarios defined for Subproject 5 (for scenarios details see the Scenario Document 2005):

Scenario SP (Starting point): is based on a current situation

Scenario S1 (Max): "Planning biofuel supply chains that maximize the biofuel production to be commissioned in 2020"

Scenario S2 (Self-sufficient): "Planning biofuel supply chains aiming at self-sufficiency to be commissioned in 2020".

2.1. Biomass from forestry

Within the study two kinds of potentials for forest biomass and wood industry by-products are estimated: theoretical potential and technical potential.

The theoretical potential is defined as all biomass of investigated fractions which exist in an analyzed area. The technical potential includes constrictions connected with ecology, technical limitations, competition with other branches of industry.

Scope of the assessment

The total potential of biomass from forestry is composed of four fractions:

- logging residues,
- thinning wood,
- root biomass,
- wood balance.

The total potential of biomass from wood industry is grouped in four fractions:

- by-products from sawmills,
- by-products from pulp and paper industry,
- by-products from board industry,
- by-products from other wood industries.

The wood industry branches producing the main share of all wood by-products are specified as separate fractions. Other wood industries which generate less significant amount of by-products are grouped in one category.

The results of all calculations are provided in 1000 m^3/year and PJ/year.

The scope of the assessment covers the results from member states of the European Union (24 countries), Switzerland and Bulgaria. Greece and Romania are excluded from the calculation of biomass potential from forestry due to the lack of data.

The national level of calculation is determined by accessibility of forestry data from databases and partners.

Input data

Four types of input data sources are used:

European forestry databases: TB FRA 2000, TB FRA 2005 and FORESTAT.

The TB FRA databases were done during The Temperate and Boreal Forest Resources Assessment coordinated by the UN/ECE Timber Committee in close cooperation with FAO. The assessment is based on the national data and covers following fields: forest area, ownership and management, wood supply and carbon sequestration, biological diversity and environmental protection, forest conditions, socio-economics function.

FORESTAT is the part of FAOSTAT databases and provides access to time-series statistical information on forest products in the UNECE region of Europe, North America and the Commonwealth of Independent States.

Partners data

Data sent by project partners based on national statistics, literature and experts opinions. Partners' data have the priority as a source.

Literature

Professional forestry and wood industry literature used for factors evaluation.

Experts opinions

Opinions given by forestry and wood industry experts are helpful for verification of factors and data harmonization.

RENEW scenarios

The forestry potentials estimates are performed for three RENEW scenarios: SP, S1 and S2. the detailed assumptions are explained below.

For Starting Point estimation the average technology level available nowadays is used. The national factors reflect specific forestry management conditions in each country. If there is no possibility to define them, the average factors for Europe are used.

In S1 a maximal forestry potential is estimated. The biomass potential in the future will depend on the volume of forest increment, environmental and forestry policies and forestry management rules.

In S2 sustainability aspects are emphasised. Stronger impacts from environmental restrictions come into prominence - the area and intensity of forest exploitation is limited.

Due to the fact that fibre production can not be affected for each scenario wood demand for wood industry is taken into consideration.

Biomass from forestry assessment

The aim of the methodology is to estimate the forest biomass potential which is not utilised and can be assign for BtL production. The calculation of total potential of biomass from forestry is based on sum of potentials of four fractions:

§ logging residues,

§ thinning wood,

§ root biomass,

§ wood balance.

The method of theoretical potential estimation is based on specific factors which allow conversion of data from partners or European databases to potentials we are interested in. The value of factors for each country is specified according to the base of partners' data, literature information or expert opinions for each country. If it is not possible to define the factors on the national level the average value for Europe is used.

In order to assess technical potential the theoretical potential is reduced by three types of factors:

Potential for industry

Potential utilised by other branches of industry and in accordance with assumption that "food and fibre production can not be affected", can not be used for BtL production.

Ecological potential

Potential necessary for proper, sustainable functioning of forest ecosystem, defined in national environmental and protection programmes.

Potential not removed from other reasons

Potential that can not be removed because of several reasons which are: imperfection of harvest systems, lack of availability of felling areas, economical reasons (small, scattered felling areas, etc.).

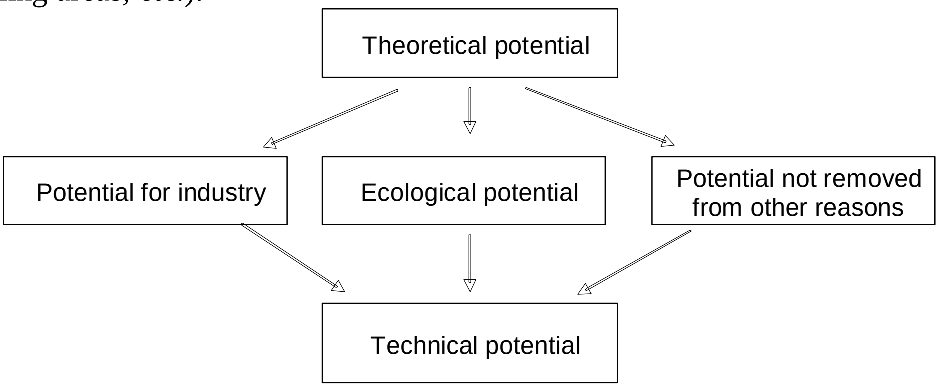


Figure 1. The method of technical potential calculation

The base for assessment of biomass from forestry potential is the amount of areas covered by forest available for wood supply (FAWS). Forest available for wood supply, is defined as a forest where any law, or specific environmental restriction do not have significant impact on the management of wood.

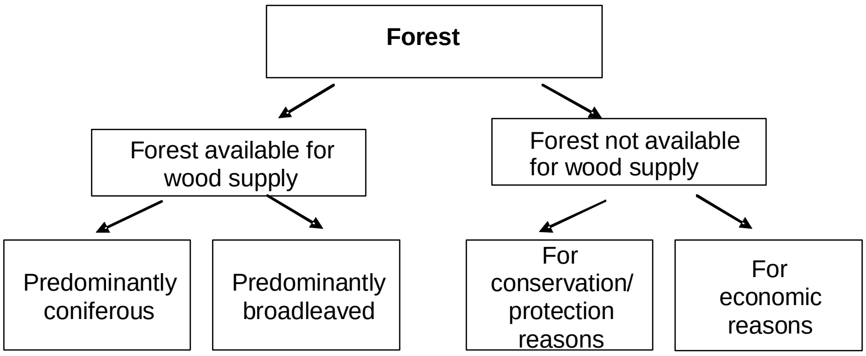


Figure 2. The scheme for forest area availability

Logging Residues Fraction (LR)

Logging residues are defined as woody biomass residues which are produced during harvest of merchantable timber (i.e. contains trees tops and branches incl. leaves and needles).

The calculations of theoretical potential of logging residues are based on the annual fellings overbark on forest available for wood supply (TB FRA, 2000; TB FRA, 2005). This value is reduced by factor of final fellings and factor of logging residues which is understood as a share of logging residues coming from all steam. The potential for coniferous and broadleaves species is calculated separately by reason of important differences in value of logging residues factor for coniferous and broadleaves trees species (Jyvaskyla, 2000; Kubiak, 1994).. Moreover, there is a different value of factor for coniferous logging residues in countries where pine is the dominant species of coniferous and different in countries where spruce dominates. This is due to differences in a structure of trees of pine and spruce - the amount and thickness of branches. According to these differences, logging residues factor can have three values:

- Factor of logging residues for broadleaves,
- Factor of logging residues for coniferous – pine,
- Factor of logging residues for coniferous – spruce.

In the future scenarios the value of factor of final fellings and logging residues factor is the same as in SP scenario. The value of fellings overbark on forests available for wood supply is corrected by factor of felling changes proper for each of future scenario. Factor of felling changes is estimated due to the base of prognosis published in European Forest Sector Outlook study and experts opinions (European Forest Sector Outlook study, Main Report, Geneva, 2005).

Technical potential is calculated by reduction of theoretical potential by three factors described previously: potential for industry, ecological potential, potential not removed from other reasons (Jyvaskyla, 2000; Hakkila 2004; Rzadkowski, 2000)..

The scheme for assessment of logging residues is presented in Figure 3:

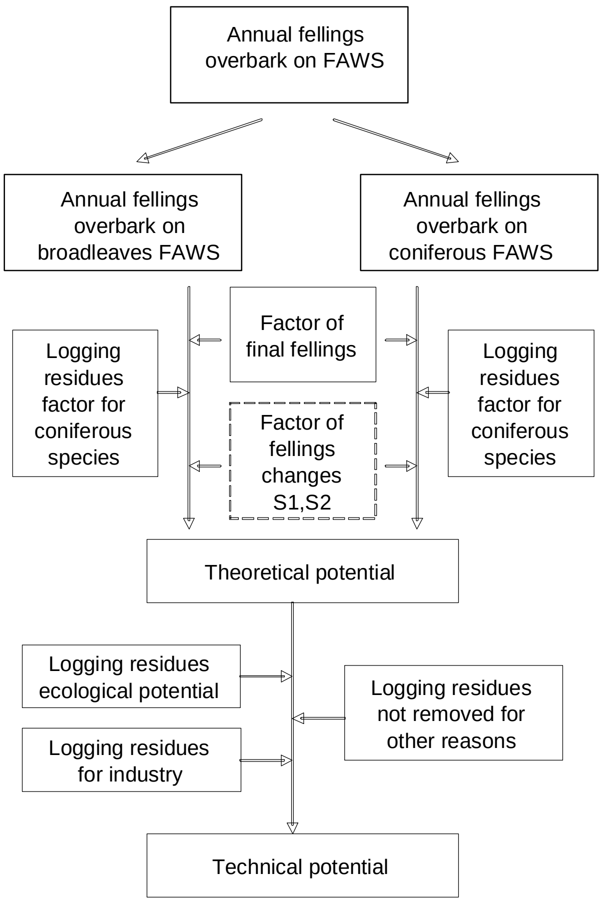


Figure 3. Scheme for logging residues potential assessment

Thinning wood fraction (TW)

The thinning cuttings include late cleaning (pre-commercial thinning), early and late thinning (commercial thinning).

The division for wood harvested during thinnings and wood removed during final fellings does not exist in databases used for calculations. According to this fact this values are estimated indirectly as the value of fellings overbark on forests available for wood supply considering thinning fellings and factor of final fellings (Różański, 2003; Wójcik, 2003). The value of fellings overbark on forests available for wood supply for S1 and S2 scenarios is estimated on the base of value of felling from SP corrected by factor of felling changes (European Forest Sector Outlook study, Main Report, Geneva, 2005)..

The theoretical potential calculated this way is reduced to technical potential by two factors: potential for industry and potential not removed from other reasons (Hakkila 2004; Laurow, 1994). Ecological potential is not taken into account because the thinning cuttings have not interfered strongly in the cycle of chemical elements in forest ecosystem (Rzadkowski, 2000; Kubiak, 1994; Różański, 2003).

Figure 4 presents the scheme for assessment of thinning wood:

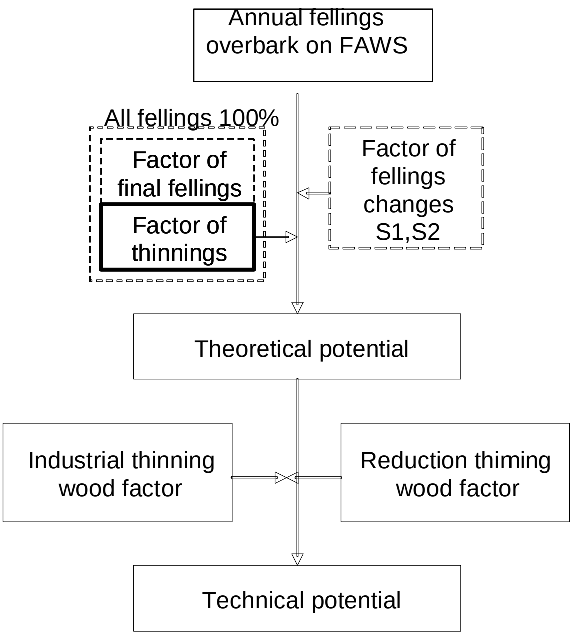


Figure 4. Scheme for thinning wood potential assessment.

Root biomass fraction (RB)

Root biomass is defined as underground mass of wood e.g. stump and roots excluding small roots.

There is an assumption made, that root biomass is extracted only after clear final felling in coniferous forest – spruce and pine. Extraction of root biomass on areas exploited by other type of cutting is excluded because of ecological reasons (Laurow, 1994; Kubiak, 1994). Among coniferous species, from which the most popular are pine and spruce, root systems are easier to be extracted therefore these species are taken into account in methodology (Hakkila 2004).

The base for the estimation of theoretical root biomass potential is the share of clear final fellings in spruce and pine forest stands. This value is calculated as the multiplication of fellings overbark on forests available for wood supply by factor of clear final felling and factor of share of spruce and pine in all species. Then the result is reduced by root biomass ratio – percent of root biomass in all steam (Hakkila 2004; Kubiak, 1994)..

The technical potential is estimated by reduction of theoretical potential by: potential for industry, ecological potential, potential not removed from other reasons (Hakkila 2004; Wójcik, 2003). For West Europe region, United Kingdom, Ireland and Poland the ecological potential is assumed to be 100 % for all scenarios, because the ecological restrictions do not allow extraction of root and stumps.

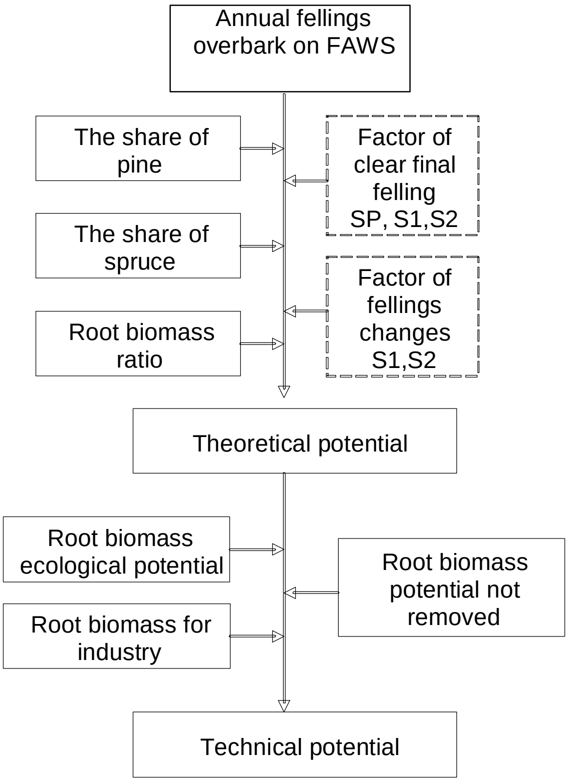


Figure 5. Scheme for root biomass assessment

Wood balance fraction (WB)

Wood balance is estimated as the difference between Net Annual Increment and fellings of growing stock. Because of the fact that Net Annual Increment is defined as average annual volume of increment in analyzed period of time excluding the increment of trees which have been felled or died, in the total amount of fellings only fellings of alive trees must be taken into consideration. That is why the fellings of growing stock are included in the calculations. The value of Net Annual Increment and fellings of growing stock for future scenarios have been corrected by two factors: changes of net annual increment and factor of felling changes (European Forest Sector Outlook study, Main Report, Geneva, 2005; TB FRA, 2000; TB FRA, 2005).

Technical potential is calculated according to the same rules as for other fractions, by reduction of theoretical potential by factors: potential for industry, ecological potential, potential not removed from other reasons (Kubiak, 1994; Hakkila 2004; TB FRA, 2000.

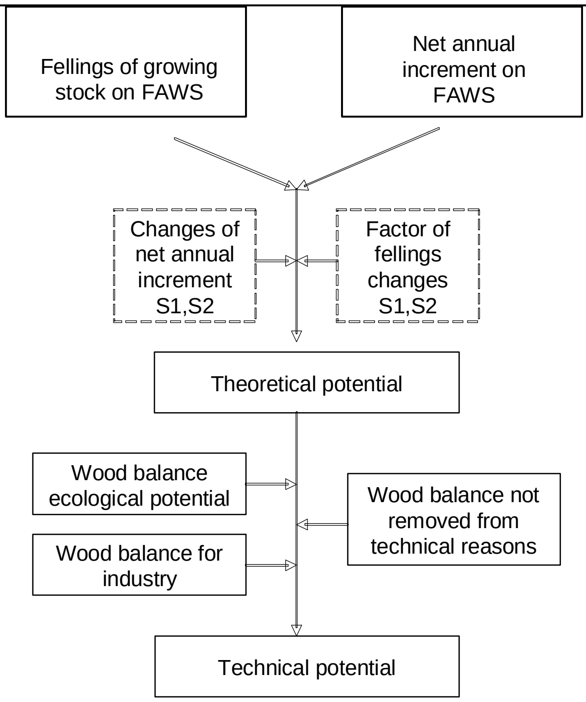


Figure 6. *Scheme for wood balance potential assessment*

The exact equations for respective assortments are presented in Annex 1.

2.2. Wood industry residues

For calculation of wood industry by-products potential four wood material groups are taken into consideration:

- sawlogs and veneer logs group includes sawlogs and veneer logs,
- pulpwood group includes pulpwood,
- other industrial wood group includes other industrial roundwood,
- wood fuel group includes fuel wood.

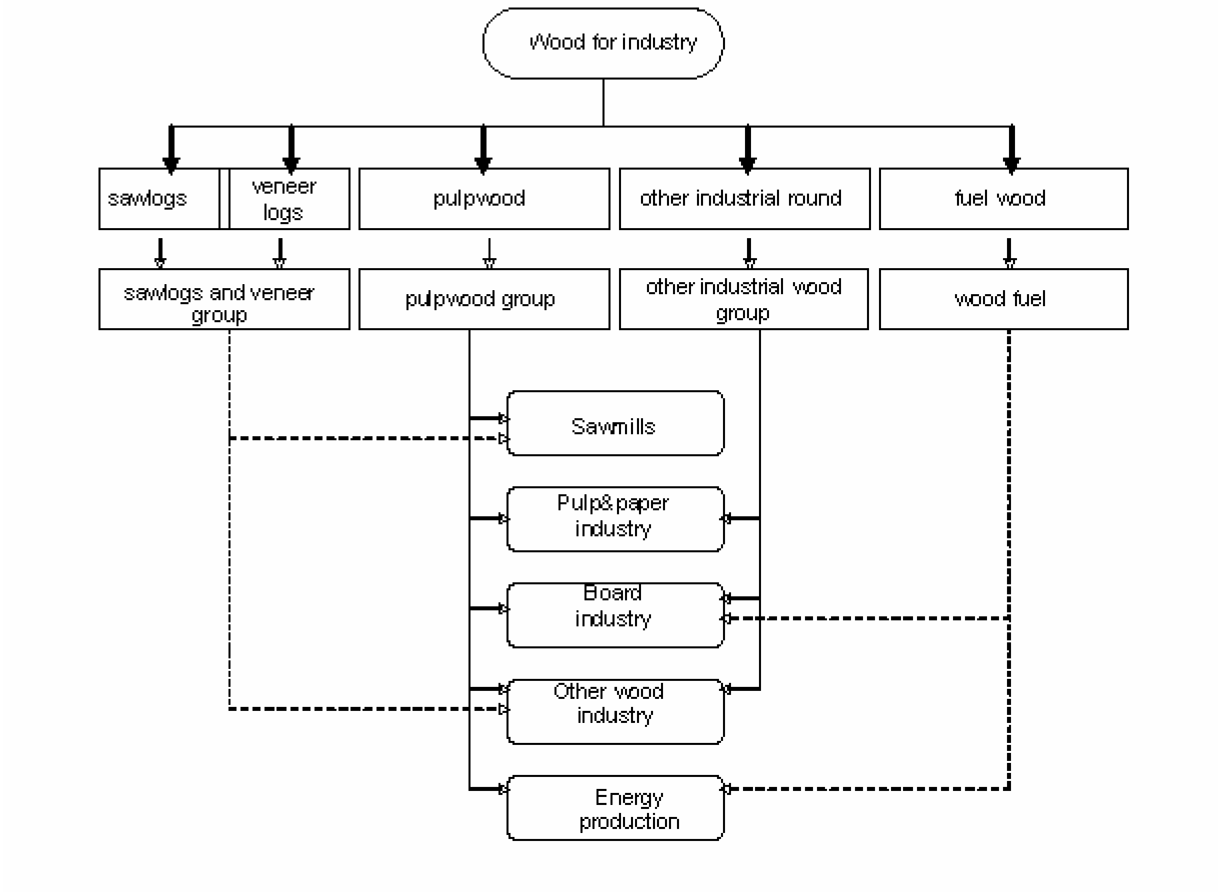


Figure 7. Scheme for wood classification and utilisation

The share of different types of wood utilization varies among wood industry branches. Due to this fact the estimation is done for each wood industry branch separately. The sort of wood used for production, factors of by-products production and utilisation are assessed on the base of information from industrial plants, literature and opinions of experts. The current utilisation of wood industry by-products for energy is taken into account in calculations. The reason is that by-products are very commonly utilised for own energy purposes of the wood industry factory and it is important factor for the factor competitivness.

Following values are received as the percentage of by-products from wood used as the raw material (100%) (Jyvaskyla, 2000; Laurow, 1994)::

- 40% for sawmills
- 30 % for pulp and paper industry
- 20 % for board industry
- 30% for other industries

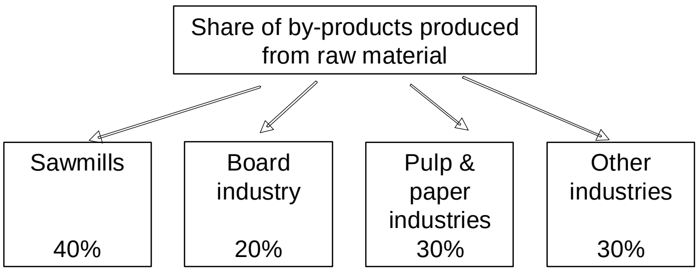


Figure 8. The share of by-products for wood industry branches

The technical potential is assessed by reduction of theoretical potential by factor of by-products utilisation.

The exact equations are in Annex 2.

By-products from sawmills

Sawmills are the wood industry plants which produce the largest amount of wood by-products from unit of raw material. It is caused by the production technology and the fact that as the raw material not process earlier wood from forest is used.

The first step of the estimation is the calculation of volume of wood used by sawmills as raw material. It is done by reduction of sawlogs and pulpwood by proper factors which indicate what percentage of material from these wood groups is used by sawmills (Wójcik, 2003; Laurow, 1994; Szostak and Ratajczak, 2002). Then the volume of by-products manufactured in sawmills is reduced by using factor of wood by-products from sawmills. While assessing the technical potential, utilisation has been taken into account (Hakkila 2004; Wójcik, 2003)

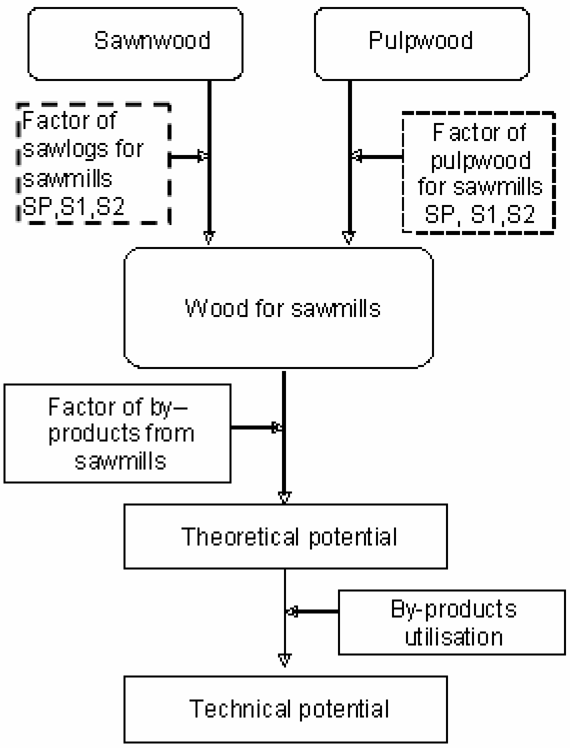


Figure 9. Scheme for by-products from sawmills assessment

By-products from pulp and paper industry

It is assumed that for pulp and paper production pulpwood and other roundwood is used as the raw material (Jyvaskyla, 2000; Szostak and Ratajczak, 2002). The volume of wood used as the raw material for pulp and paper production is calculated by using two factors:

- factor of pulpwood for pulp and paper industry,
- factor of other wood for pulp and paper industry.

Then calculated values are reduced by factor of by-products from pulp and paper industry. This factor indicates the percentage of by-products from wood used as the raw material. The technical potential is assessed by using by-products utilisation factor (Hakkila 2004; Wójcik, 2003).

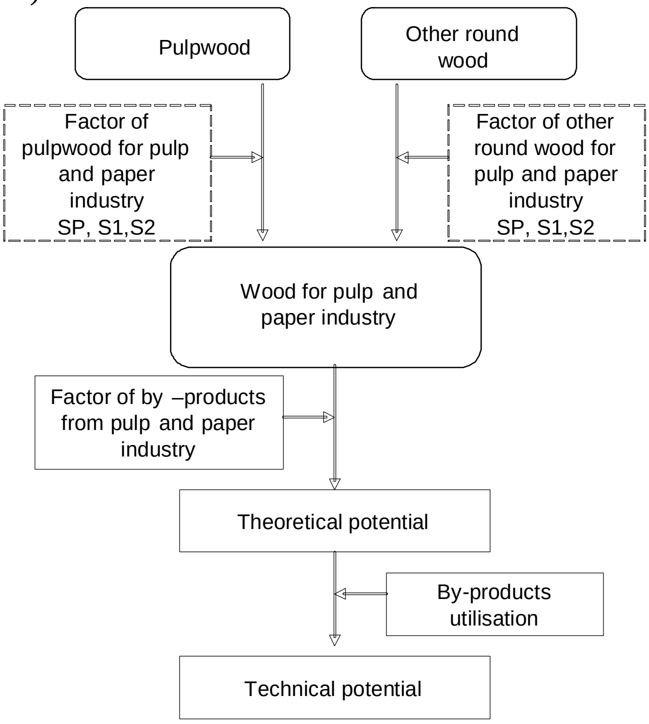


Figure 10. Scheme for by-products from pulp and paper industry assessment

By-products from board industry

The process of boards' production allows using wide range of wood.

The theoretical potential is calculated on the base of three wood groups: pulpwood, other round wood and fuel wood. Proper factors for each group are used (Szostak and Ratajczak, 2002; Wójcik, 2003; Laurow, 1994). While assessing the technical potential, utilisation has been taken into account (Hakkila 2004; Wójcik, 2003).

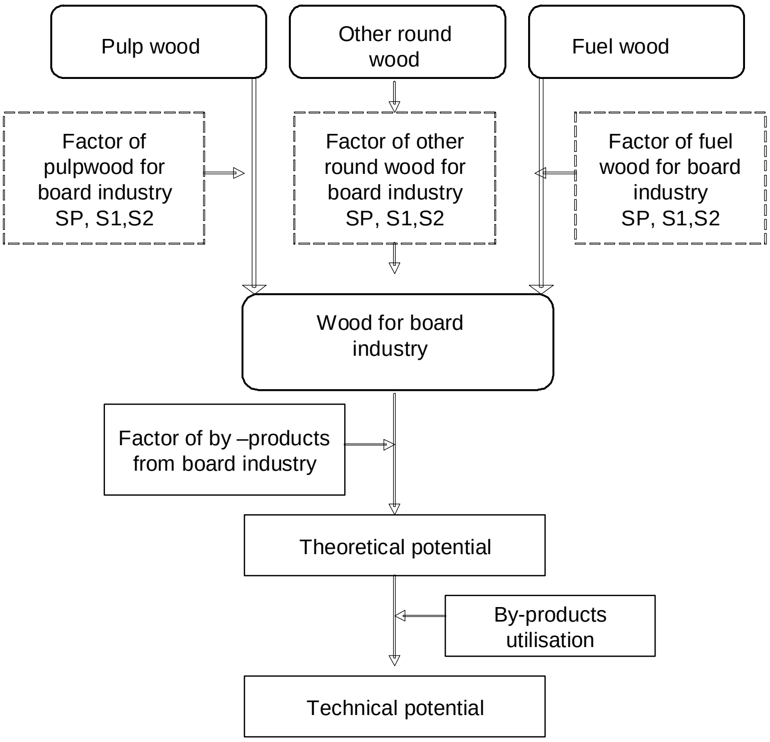


Figure 11. Scheme for by-products from board industry assessment

Other wood industries

This category includes wood industries, which generate less significant amount of by products e.g. joinery, furniture production etc. Wood from all groups (excluded fuel wood) is used as the raw material in the calculations. For the estimation of theoretical potential proper factors for each group are used (Szostak and Ratajczak, 2002; Laurow, 1994; Wójcik, 2003).. The technical potential is assessed by taking into account utilisation. While assessing the technical potential, utilization has been taken into account (Hakkila 2004; Wójcik, 2003).

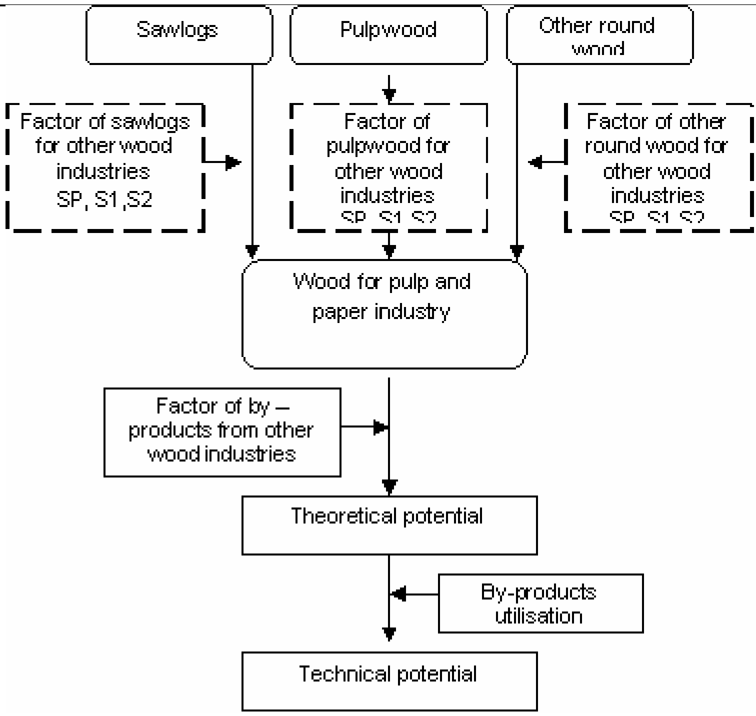


Figure 12. Scheme for by-products from other wood industry assessment

2.3. Agricultural residues

This chapter is presenting the methodological approach for agricultural residue available potential calculation. The potential of agricultural residues is estimated for:

- cereal straw (small-grain cereals: wheat, barley, rye),
- oilseeds straw (rape seed, sunflower, soya),
- maize straw (only for maize for grain).

The estimations are performed for EU-25 and Accession countries (Bulgaria and Romania) on a detail regional level. RENEW scenarios are applied. European statistics are used as common source of input data. Relevant parameters are derived from literature and WP5.3 partners.

The results of calculations are provided in 1000 tons or PJ/year. Sensitivity analysis is performed to investigate the potentials results influenced by variation of key parameters.

In this report and also geographical layout the residues of cereals, rapeseed and maize are called as “straw”. The negative potential is presented as ‘zero’, which means that no surplus straw is available in such a NUTS-2 region.

Level of data collection and potential assessment

One of the aims of RENEW is to identify biomass available potentials at national and regional level in Europe. For identification of these potentials, the level of the analysis is assumed at NUTS-2 (*Nomenclature of Units for Territorial Statistics)*. In some justified cases (e.g. statistical data availability) NUTS-0 or NUTS-1 level is applied. This is an important criterion for the appropriate geographical level of detail for the project. The same level of analysis will be used for energy crop potential assessment.

RENEW scenarios

Three RENEW scenarios are implemented for the potential analysis: SP, S1 and S2.

In the potential analysis the scenarios are introduced by the application of specific factors' values adequate for the SP, S1 and S2.

Data availability

The information source of land use, crop area and production statistics is EUROSTAT . The data for the years 2000-2004 are used. Averages for that period are calculated to avoid annual fluctuations. The data are available on adequate NUTS-2 region level.

Population change and future consumption patterns

Application of the RENEW scenarios (S1 and S2) for the year 2020 requires the introduction of population and consumption projections. These are applied to evaluate the production of crops and animas in 2020.

The population prognosis are derived from EUROSTAT database "Population and social conditions" (EUROSTAT 2006). Data on consumption change are derived from FAO study "World Agriculture: towards 2015/2030 an FAO perspectives" (FAO 2003).

Methodology for agricultural residues assessment

The aim of the methodology is to estimate the surplus of agricultural residues, which is not utilized and could be available for BtL production. There is a strong assumption that food (also fodder) and fiber requirements must be fulfilled first. Only the surplus can be used for other purposes such as BtL. It should be stressed that in the methodology the current and future straw utilization for heat and electricity production is not taken into account. It is assumed that these straw resources could be available for BtL, which is the matter of market competition.

The interdependencies between NUTS regions are not taken into account in the methodology.

Figure 13 presents the scheme of straw distribution for different purposes and available straw surplus for BtL production.

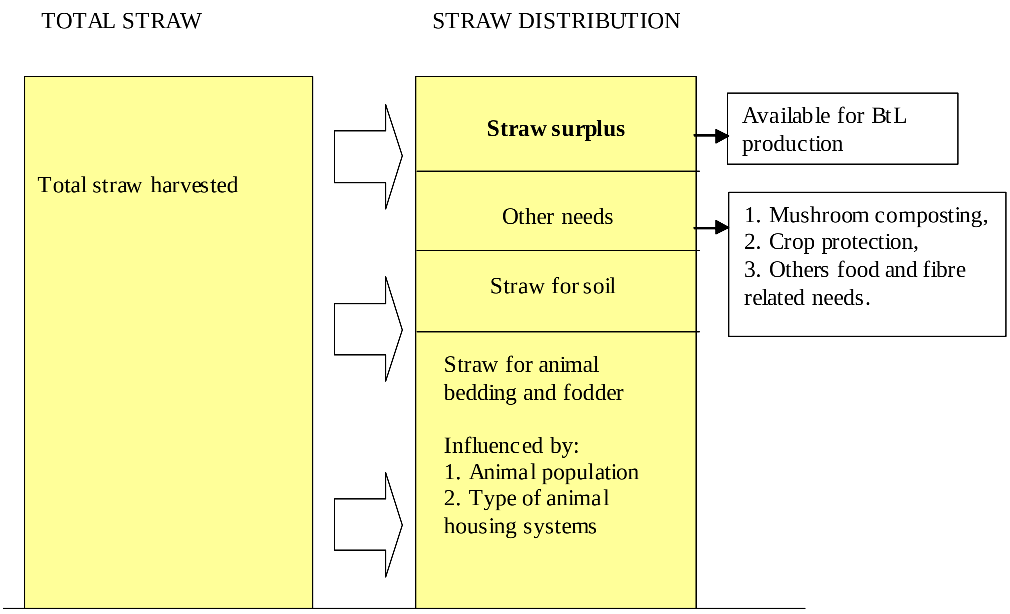


Figure 13. Straw distribution and surplus potentially available

The methodology to assess the amount of straw residues in the NUTS-2 regions consists of the several steps. For the exact equations see Annex 3.

Total straw production

Total straw production is based on total cereal production (average from 2000-2004) and a straw/grain mass ratio.

The ratio refers the amount of crop residue, which could be technically harvested. For each type of residues (cereal straw, oilseed and maize residues) the mass ratio of the most common crop of a given group is taken for the calculations, e.g. for cereal straw the straw/grain ratio of winter wheat is applied, as this is the most common crop among the small-grain cereals in Europe. For oilseed residues the ratio of rape is applied.

Straw for animals

The straw requirements for animals are estimated only for cereal straw. Oilseed and maize residues usage for animal production (bedding or fodder) is insignificant.

Cattle, pigs, sheep and equidae (horses) are animals, which traditionally need straw for breeding. Cattle and equidae need straw also as a bulky fodder.

In the methodology straw requirements (bedding and fodder) are calculated for cattle, pigs and equidae based on the number of livestock units (LU) and straw demand in tons/LU/year. Specifically, the requirements of straw for bedding depends on the type of animal housing system; systems with straw bedding and without bedding are common in Europe. For each country the share of animals kept in housing systems with straw bedding is estimated (based on Burton C. and Turner C. 2003).

For S1 and S2 scenarios the calculations are based on current livestock units (2000-2004), however the parameters of population change and meat consumption in 2020 are applied as they will influence the animal population. The factors of straw requirements for bedding and fodder as well as the share of animals kept on straw have been estimated for 2020.

Straw amounts needed for sheep and poultry bedding are far less than for cattle, pigs and equidae. Sheep most of the year are kept on grazing. For this reason there is only a rough estimation of these amounts (instead of exact calculation). For simplicity reasons these straw amounts are included in the category “Straw for other purposes” in the result sheets.

Straw for soil

Part of the straw should be left in the field as to ensure high content of organic matter in the soil and thereby long-term productivity of the soil (Börjesson and Gustavsson 1996).

In the methodology the requirement of straw for soil is calculated for all types of straw: cereal, oilseed and maize. It is assumed that 30% of the total straw produced must be ploughed back into the soil. This is based on the recommendations of good agricultural practices (Smagacz 2003).

Straw for other purposes

Straw is also used for gardening (like crop protection), mushroom compost, as a building material and other needs. Straw use for these purposes is considered only for cereal straw. It is important that current energy production from straw is excluded from the calculations.

In the results in the category “straw for other purposes” also straw requirements for sheep and poultry is included –see straw for animals.

Straw surplus - available potential

Total available straw potential (surplus), which could be used for BtL or other needs is calculated as a distinction between total straw production and the requirements for animals, soil and other purposes.

The available straw potential shows the amounts of surplus straw while food and fibre production is not be affected (for all scenarios). However, in real cases the potential available for a certain solution will be changeable due to price competitiveness of different straw uses. This is not included in the methodology.

Sensitivity analysis

The straw potential model allows analysing sensitivity of straw potential on different parameters for respective scenarios and regions.

The scope of parameter variations can be modified, however model allows definition four variables in one step. The starting variables are: – 20%; -10%; 0%; 10%; 20% and they are changeable.

The parameters which are considered:

§ demography change

§ cereal Consumption change

§ meat Consumption change

§ cereal straw/grain ratio SP-S2

§ oilseed straw/grain ratio SP-S2

§ maize gr straw/grain ratio SP-S2

§ straw for bedding

§ straw for fodder SP-S2

§ share of cattle on straw SP-S2

§ share of pigs on straw SP-S2

§ share of straw for soil

§ share of straw for other purposes.

3. Residue biomass potentials in countries

The results of simulation are presented in Biomass potential database. The database is the integrated part of the deliverable.

3.1. Austria

Total Residue Biomass Potential estimated for present time (SP) equals 69,8 PJ/a, 45 % of this amount comes from forestry potential, 3 % from wood industry and 53 % is due to gaining straw. In S1 the total biomass potential reaches 72,1 PJ/a where 52 % comes from the forestry activities, 3 % falls to wood industry potential and the rest, that is 45 % occurs to be straw potential.

The S2 scenario reveals the total amount of biomass potential of 65,3 PJ/a. Partial potential equals respectively 51 % of forestry actions, 3 % of wood industry and 46 % of straw potential.

Utilized agricultural area in this country totals up at 3352 thousands ha that is 40 % of the total area of the country and wooden area amounts 38,7 % of the country area which gives 3840 thousands ha.

The main share in wood industry potential, in all scenarios comes from wood by-products from sawmills.

It is estimated that nowadays in Austria the largest amount of straw comes from maize, almost 70 %, 23 % is cereal straw and the rest comes from rape straw. The highest straw potential in all analyzed scenarios occurs in the Niederösterreich region yet regions Salzburg, Tirol and Vorarlberg show no potential in any scenario. In both future scenarios the most important factor seems to be 'cereal consumption' but in the present scenario factor that changes the most within different deviation is 'share of straw for soil'.

3.2. Belgium

In Belgium total utilized agricultural area reaches 1393 thousands ha that is more than 45% of the total country area while the area covered by wood is estimated to be more than two times less. The total residue biomass potential in this country nowadays is 16,61 PJ/a, of which the main share (61 %) comes from the straw. Forestry potential is measured to establish 36 % of the whole measure while potential coming from the wood industry is assessed to be about 3 %.

In S1 the total biomass potential reaches 14,8 PJ/a, forest potential, with a main influence of thinning wood, as well as wood industry potential are expected to grow whereas the straw potential shall decrease.

In S2 the total potential from biomass is expected to reach 12,3 PJ/a, more than half of it is measured to come from the forestry potential. This scenario is the only one in which straw potential is assessed to be only 40 %, so less than the half of the total potential.

In Belgium the largest share (53 %) of straw comes from the maize. It is interesting to notice that almost the same amount (45 %) of straw comes from the cereal straw and rape straw supply only 2 % of the entire straw potential.

In all analyzed scenarios the highest straw potential occurs in prov. Vlaams-Brabant, where the production density is also the hightest, while in regions Bruxelles-Capitale, Antwerpen, West-Vlaanderen and Luxembourg no potential was found, nor is predicted.

Prov. West-Vlaanderen occurs to be very interesting due to the fact that it shows the highest amount of straw production however in this region usage of straw for the agricultural needs is so high that no material can be taken into consideration for any other needs.

In the starting point scenario the most important factor that has been found is 'cereal straw/grain ration' while in scenario S1 'cereal consumption' and in scenario S2 'meat consumption' seems to differ the most within changing deviation.

It is worth noticing that in both future scenarios factor 'share of cattle on straw' shows variable numerical value.

Particular regions in this country display different sensitivity to various factors.

3.3. Bulgaria

In this country, that is covering in total 11100 thousands ha almost 50 % is used for agricultural purposes and 33 % is wooded land. Total Residue biomass potential was calculated to be 91,5 PJ/a nowadays and in future scenarios it is assessed to lower to 80,3 PJ/a (S1) and 78,2 PJ/a (S2). Forestry potential equals now almost 19 % of the whole potential and it is expected to rise and to establish at the level of 26 % in S1 and level of 24 % in S2. In all the scenarios and both from the theoretical and technical point of view the wood balance fraction will form the most important share and it will vary between 68-88% of the total forestry biomass potential.

The wood industry potential is not expected to play an important role in total calculations and it will not differ much among scenarios (less than 1%).

Straw potential determine the largest part of the total biomass potential. Nowadays it is estimated to equal 74,1 PJ/a, that is 81 % of the total potential. In the scenario S1 it is expected to lower to 74 % and in scenario S2 to 76 %.

In Bulgaria the greatest amount of straw comes from the cereals (57 %) and about 21% comes from rape and maize straw each. The most influencing calculation parameters were found in 'straw for bedding' and a 'share of cattle on straw'.

In all three scenarios the highest potential occurs in Severoiztochen region as well as the lowest in Yugozapaden. The potential of straw in particular regions doesn't differ between scenarios 1 and 2.

In S1 and S2 factors 'demography', 'cereal consumption' and 'share of straw for soil' are the most sensitive. Nowadays 'share of straw for soil' and 'cereal straw/grain ratio' differ the most within changing deviation. Comparing the regions, all the factors show comparable changeability.

3.4. Switzerland

Total Residue biomass Potential was estimated at the level of 8,7 PJ/a, the main share of that amount, 89,5 %, comes from forestry and the rest is due to wood industry by-products. No straw potential was detected in this country, nor is expected to occur. The total biomass potential is suspected to change to 10,7 PJ/a in S1 and to 9,7 PJ/a in S2. Forestry potential is assessed to establish at the level of about 90 % of the whole biomass potential in both future scenarios.

No cereal straw appears in the results for this country.

Although the total straw produced in all scenarios amounts about 16 PJ/a there is no surplus straw to be used.

3.5. Czech Republic

Total area of the country is 7887 thousands ha, 49,5 % of that is an agricultural land, 33,5 % is covered by forests and 17 % is used for other purposes. The total residue biomass potential in this country was calculated to be 71,4 PJ/a. The majority is due to the straw potential that gives about 66 % of the total amount. Forestry potential was assessed to be 32

% (with the largest share of thinning wood fraction) and the potential of wood industry by-products stands for 3 % of the total potential.

In S1 the capability of biomass usage increases to 73,1 PJ/a mainly because of the growth of forestry potential (35 %) and wood industry potential (4 %). In the scenario S2 the total biomass potential is going to lower to 67,2 PJ/a and will be divided among 62 % of straw capabilities, 34 % of forestry potential and 4 % potential of wood industry by-products.

In present and future scenarios the highest potential was detected in Jihovychod region and the lowest in Praha region. In general, the main amount of products comes from the cereal straw and it is calculated that surplus straw will present about 37-39%, depending on the analyzed scenario, of the total straw gained.

Factors showing the widest variation in the present scenario are ‘cereal straw/grain ratio’ and ‘share of straw for soil’. In both future scenarios most changeable factors are ‘cereal consumption’ and ‘share of straw for soil’.

3.6. Germany

In this country, that is covering in total 35703 thousands ha 48% of the land is used for agricultural purposes and 30% is wooded land. Total Residue biomass potential was calculated to be 268,6 PJ/a nowadays and in future scenarios it is assessed to lower to 249,1 PJ/a (S1) and 230,6 PJ/a (S2). Forestry potential equals now almost 37 % of the whole potential and it is expected to rise and to establish at the level of 43 % in S1 and level of 46 % in S2.

In all the scenarios and both from the theoretical and technical point of view the wood balance fraction will form the largest share and it will vary from 48-56% of the whole forestry biomass potential.

The wood industry potential is not expected to play an important role in total calculations and it will not differ much among scenarios (2-3 %).

Straw potential determine the largest part of the total Biomass potential. Nowadays it is estimated to equal 163,6 PJ/a, that is 61 % of the whole potential. In the scenario S1 it is expected to lower to 53 % and in scenario S2 to 51 %.

When analyzing the straw structure, 70,9% of straw comes from cereal production and the rest is maize straw; rape straw does not appear. The amount of surplus straw that can be utilized was estimated to reach 31 % of the whole straw collected in the present vision. This number is expected to lower to 29 % in scenario 1 and to 25 % in the second scenario.

The highest straw capability of the whole straw potential estimated was found in region Niedersachsen. Other two regions that show not much lower ability to gaining straw are Nordrhein-Westfalen and Mecklenburg-Vorpommern. There were three regions detected, where the straw potential equals zero, Berlin, Bremen and Hamburg.

While in present estimation the ‘cereal straw/grain ratio’ and ‘share of straw for soil’ show the highest variability, in present scenarios the most changeable factors occurred to be ‘cereal consumption’ and the ‘share of straw for soil’.

3.7. Denmark

In Denmark total utilized agricultural area reaches 2727 thousands ha that is more than 63% of the total country area while the area covered by wood is estimated to be more than ten times less. The total residue biomass potential in this country nowadays equals 37,7 PJ/a, of which the main share (89 %) comes from the straw. Forestry potential is measured to establish 11 % of the whole measure while potential coming from the wood industry is assessed to be less than one percent. In S1 the total biomass potential reaches 31,7 PJ/a, forest potential, with a main influence of thinning wood, as well as wood industry potential are expected to grow whereas the straw potential shall decrease to 86 %.

In S2 the total potential from biomass is expected to reach 25,1 PJ/a, more than 82 % of it is measured to come from the straw potential, 17 % from the forestry and only less than 1 % wood industry by-products potential.

The great share of straw in this country comes from cereal straw (87,5 %) the rest is assessed to come from maize straw. Straw from rape does not appear in the calculations. While in the present estimation, and in S1, the amount of surplus straw is about 30 % of the straw collected, in S2 only 22,9 % of gained straw can be utilized for other purposes.

In the present view factor that changes the most within different deviation is the 'cereal straw/grain ratio', and in future scenarios both 'cereal consumption' and 'cereal straw/grain ratio' vary the most.

3.8. Estonia

Total Residue Biomass Potential estimated for present time (SP) equals 13 PJ/a, 77 % of this amount comes from forestry potential, 9 % from wood industry and 14 % is due to gaining straw. In the scenario S1 the total biomass potential reaches 14,7 PJ/a where 77 % comes from the forestry activities, 12 % falls to wood industry potential and the rest, that is 11 % occurs to be straw potential.

The scenario S2 reveals the total amount of biomass potential of 12,7 PJ/a. Partial potential equals respectively 78 % for forestry actions, 12 % for wood industry and 10 % for straw potential.

Utilized agricultural area in this country totals up at 809 thousands ha that is 17,9% of the total area of the country and wooden area amounts 49,9% of the country area which gives 2016 thousands ha.

It is interesting to notice that in this country the potential from wood industry by-products exceed the straw potential, in both future scenarios.

The total amount of the straw collected in present equals 8,7 PJ/a, and 20 % of that amount is straw that can be used for other purposes. In both future scenarios the amount of total straw reaches 7,5 PJ/a, however in S1 21 % and in S2 only 16 % is surplus straw. In general 54 % of the total straw amount is cereal straw and 45 % comes from maize straw. No rape straw appears in the potential analysis.

While in the present estimation the 'cereal straw/grain ratio' changes the most within different deviation, in the future scenarios also 'cereal consumption' varies considerably.

3.9. Spain

Total area of the country is 50518 thousands ha, 50,1% of that is an agricultural land, 32,8 % is covered by forests and 17% is used for other purposes. The total residue biomass potential in this country was calculated to be 169,6 PJ/a. The majority is due to the straw potential that gives 66 % of the entire amount. Forestry potential was assessed to be 33 % (with the largest share of wood balance fraction) and the potential of wood industry by-products stands for 1 % of the total biomass capability.

In S1 the capability of biomass usage lowers to 165,4 PJ/a that consist of straw capability (60 %) forestry potential (39 %) and wood industry potential (2 %). In the second future scenario the total biomass potential is expected to grow less to 157,4 PJ/a and will be divided among 60 % of straw capabilities, 38 % of forestry potential and 2 % potential of wood industry by-products. Depending on the scenario and theoretical and technical estimation the potential from wood balance fraction will differ between 72 and 91%.

Total amount of straw gained can be divided into cereal straw (41,6%), maize straw (48%) and straw from rape that supplies 10,4%. The highest straw production density was discovered in Castilla y Leon region with a present estimation of 36,7 PJ/a, and future predictions for 31,9 PJ/a (S1) and 30,9 PJ/a (S2). No straw potential in any scenario was found in seven regions: Galicia, Principade de Asturias, Cantabria, Pais Vasco, Cataluna, Comunidad Valenciana, Region de Murcia.

Two factors that differ the most in the present vision are ‘share of straw for soil’ and ‘cereal straw/grain ratio’. In both future scenarios the most changeable factor is ‘cereal consumption’. It is worth pointing out that in the regions where the potential was estimated to equal zero (or was established at the level below zero) the most sensitive factor occurred to be ‘straw for bedding’, while in the regions where the potential has been positive the factor that changes the most is the ‘share of straw soil’.

3.10. Finland

In this country, that is covering in total 33814 thousands ha more than 66% is used for forest purposes and only 6% is utilized agricultural area. Total residue biomass potential was calculated to be 101,8 PJ/a nowadays and in future scenarios it is assessed to grow to 107,6 PJ/a (S1) and to 109,3 PJ/a (S2). Forestry potential equals now almost 78 % of the whole potential and it is expected to increase and to establish at the level of 80 % in S1 and at the level of 82 % in S2. In all the scenarios and both from the theoretical and technical point of view the thinning wood fraction will form the most important share of the forestry potential and it will vary from 63-82% of the total forestry biomass potential.

The wood industry potential is not expected to play an important role in total calculations and it will not differ much among scenarios (6,8-8,3% of the entire biomass potential).

Straw potential nowadays is estimated to equal 14,9 PJ/a, that is 15 % of the whole potential. In the scenario S1 it is expected to lower to 12 % and in S2 to 11 %.

No rape straw takes part in the straw structure results. The majority of the total amount is cereal straw that gives more than 90% of total straw gained. Rest comes from the maize straw.

Among five regions of Finland in three the straw potential has been found. In Etela-Suomi and Lansi-Suomi regions together the estimated capability (SP) reaches 90% while in Lland region it is less than 1% of the total straw potential in this country. While in the present estimation the ‘cereal straw/grain ratio’ changes the most within different deviation, in the future scenarios also ‘cereal consumption’ varies considerably. In all regions the factor that changes the most within different deviation is ‘cereal straw/grain ratio’.

3.11. France

Total Residue Biomass Potential estimated for present time (SP) equals 591,2 PJ/a, 15 % of this amount comes from forestry potential, less than 1 % from wood industry and 84 % is due to gaining straw.

In S1 the total biomass potential reaches 552,8 PJ/a where 16 % comes from the forestry activities, 1 % falls to wood industry potential and the rest, that is 83 % occurs to be straw potential. The scenario S2 reveals the total amount of biomass potential of 541,4 PJ/a. Partial potential equals respectively 18 % for forestry actions, 1 % for wood industry and 81 % for straw potential.

Utilized agricultural area in this country totals up at 29212 thousands ha that is 53,2 % of the total area of the country and wooden area amounts 28,1 % of the country area.

The main share in forestry potential comes from thinning wood fraction in present estimation and from wood balance fraction in both future scenarios.

From the total amount of straw each, cereal straw and maize straw supplies about 42%, while the rest (16%) comes from the rape straw. Total straw collected in this country was estimated to be 1093,1 PJ/a however in both scenarios prepared for the year 2020 it will lower to 1021,1 PJ/a. The part of surplus straw in these amounts is estimated to be between 43-45%. The highest production density was found in Centre region. Also in both regions Poitou-Charentes and Aquitaine, the total straw potential was estimated to be close 60 PJ/a. In three regions total potential has been assessed to be below zero, these regions are Limousin, Corse and Martinique. In some parts of France the production density was so low that the numbers were established to equal zero.

For the present estimation the most sensitive factors are 'cereal straw/grain ratio' and 'share of straw for soil' however in future scenarios these factors change and the most variable occur to be 'cereal consumption', 'demography' and the 'share of straw for soil'.

In some areas the factor 'maize straw/grain ratio' becomes the most sensitive factor. It is possible to come to the conclusion that these regions are more dependent on the maize straw than on the cereal straw.

It is also important to notice that in regions where the total potential was estimated to be zero or below zero the most changeable factors are 'share of cattle for straw' and 'straw for bedding'.

3.12. Greece

In Greece total utilized agricultural area reaches 3869 thousands ha that is more than 29% of the total country area. The total residue biomass potential in this country nowadays is 63,3 PJ/a, of which the main share (over 99 %) comes from the straw. Wood industry potential is measured to establish less than 1% of the whole potential. Due to the lack of data, the forestry potential in this country in all the scenarios equals zero.

In S1 the total biomass potential is assessed to lower to 52 PJ/a, in S2 the total potential from biomass is expected to reach 51,7 PJ/a.

Almost no rape straw (less than 1%) takes part in the straw structure results. The majority of the whole amount is cereal straw that supplies more than 55,9 % of total straw gained. The rest comes from the maize straw. The amount of surplus straw equals 63,2 PJ/a for the present estimation, 51,8 PJ/a for S1 and 51,6 PJ/a for S2.

In two regions the straw potential is much higher than in the others analyzed parts of this country. In Anatoliki Makedonia, Traki it is assessed to be 16,5 PJ/a now and expected to lower to 13,6 PJ/a in the future. In Kentriki Makedonia region now the potential is at a similar level. There are two regions, Notio Aigaio and Kriti where the potential estimated for the present is very low and in the future it is predicted to equal zero or to be even below zero.

In the present estimation factors that change the most within different deviation are 'cereal straw/grain ratio', 'maize straw/grain ratio' and 'share of straw for soil'. In the future scenarios also some other factors are supposed to vary considerably, 'cereal consumption' and 'demography'. It is interesting that in the regions where the straw potential was assessed to be very low in the present scenario 'cereal consumption' is the factor that does not change at all and in scenarios for 2020 the same factor is among these, which show the largest sensitivity.

3.13. Hungary

Total area of the country is 9303 thousands ha, 63 % of that is an agricultural land, 19 % is covered by forests and 17,93% is used for other purposes. The total residue biomass potential in this country was calculated to be 133,7 PJ/a. The majority is due to the straw potential that supplies about 93 % of the total capability. Forestry potential was assessed to be 7 % (with the largest share of thinning wood fraction) and the potential of wood industry by-products stands for less than 1% of the total potential.

In S1 the capability of biomass usage lowers to 130,5 PJ/a, with a part of forestry potential 8 % and wood industry potential less than 1 %. In the second future scenario the total biomass potential reaches 127,2 PJ/a and will be divided among 92 % of straw capabilities, 7 % of forestry potential and below 1 % potential of wood industry by-products.

According to the data the total biomass potential is quite high for this country mainly due to straw potential.

When analyzing the straw structure one comes to the conclusion that the main part of product comes from the maize straw (65,5%), 21.8% comes from cereal straw and rape straw supplies 12,6 % of total straw collected. In all scenarios the percentage of surplus straw reaches 44,4%. Dél-Dunántúl region shows the highest production density in all scenarios. Quite high potential was also found in two other regions: Észak-Alföld and Dél-Alföld. In all regions in this country straw potential is assessed to be above zero.

In future scenarios three factors seem to be noticeably sensitive: 'cereal consumption', 'demography' and 'share of straw for soil' while in the present estimation 'share of straw for soil' and 'maize straw/grain ratio' change the most. Analyzed factors do not vary much among different regions.

3.14. Ireland

In Ireland, that is covering in total 7027 thousands ha, more than 62% of the country area is used for agricultural purposes and 8,4 % is wooded land. Total Residue biomass potential was calculated to be 16,5 PJ/a nowadays and in future scenarios it is assessed to rise to 46,8 PJ/a (S1) and 43,3 PJ/a (S2). Forestry potential equals now 77 % of the total potential and it is expected to rise and to establish at the level of 98 % in S1 and level of 99 % in S2. In all the scenarios and both from the theoretical and technical point of view the thinning wood fraction will form the most important share and it will vary from 68-92 % of the whole forestry biomass potential.

The wood industry potential is not expected to play an important role in total calculations and it will not differ much among scenarios (1-2,4 %).

Straw potential determine quite small part of the total Biomass potential. Nowadays it is estimated to equal 3,4 PJ/a, that is 20 % of the total biomass capabilities. In S1 it is expected to lower considerably to 1 % and in S2 the straw potential is expected to be below zero.

The main share of straw, more than 95 %, comes from the cereal straw. The rest is supplied by maize straw. No rape straw appears in the calculations. Although the amount of total straw collected is predicted to establish at the same level as assessed for the present scenario, the amount of surplus straw will change and in S2 it will reach zero, while in S1 it is expected to be not much above that number.

In the Border, Midlands and Western region, in all scenarios the straw capabilities are assessed to be zero, in this region the most variable factor is 'meat consumption'. In the other analyzed region the positive potential was found in the present estimation and in the scenario for maximized biofuel production. The factor that differ the most within changing deviation is 'cereal straw/grain ratio'.

In the present vision the most sensitive factor seems to be 'cereal straw/grain ratio', however in both future scenarios factor that changes the most is 'meat consumption'.

3.15. Italy

Total Residue Biomass Potential estimated for present time (SP) equals 226,8 PJ/a, 12 % of this amount comes from forestry potential, less than 1% from wood industry and 88 % is due to gaining straw. In S1 the total biomass potential reaches 185,5 PJ/a where 18 % comes from the forestry activities, less than 1% falls to wood industry potential and the rest, that is 82 % occurs to be straw potential.

The scenario S2 reveals the total amount of biomass potential of 175,4 PJ/a. Partial potential equals respectively 17 % for forestry actions, less than 1% for wood industry and 83 % for straw potential.

Utilized agricultural area in this country totals up at 15400 thousands ha that is 51,1 % of the total area of the country and wooden area amounts 22,7 % of the country area.

The main share of straw in this country comes from maize straw only about one-third is supplied by cereal and rape straw. Total straw collected in present estimation reaches the number of 485 PJ/a, and in scenarios for year 2020 it is much smaller and equals 396 PJ/a. The highest production density was found in region Piemonte, however regions Friuli-Venezia Giulia and Emilia-Romagna show the high potential as well. In five regions the straw potential was estimates to be zero, both in a present and future perspective.

In the present view three factors differ the most within changing values of deviation, these factors are: ‘cereal straw/grain ratio’, ‘maize straw/grain ratio’ and ‘share of straw for soil’. In the estimation for ear 2020 (in both scenarios) the ‘cereal consumption’ and ‘demography’ show the highest sensitivity.

3.16. Lithuania

In this country, that is covering in total 6530 thousands ha 44,2 % of the land is used for agricultural purposes and 30,7 % is wooded area. Total Residue biomass potential was calculated to be 18,5 PJ/a nowadays and in future scenarios it is assessed to change to 18,8 PJ/a (S1) and 16,57 PJ/a (S2). Forestry potential equals now almost 45 % of the total potential and it is expected to rise and to establish at the level of 51 % in S1 and level of 52 % S2. In all the scenarios and both from the theoretical and technical point of view the thinning wood fraction will form the most important share and it will equal 46% of the whole forestry biomass potential.

The wood industry potential is not expected to play a very important role in total calculations and it will not differ much among scenarios (4-6 %).

Straw potential determine the largest part of the total Biomass potential in the present estimation, however it is expected to change. Nowadays it is estimated to equal 9,4 PJ/a, that is 51 % of the total potential. In S1 it is expected to lower to 44 % and S2 to 42 %.

The majority of the straw potential comes from the cereal straw and is estimated to be more than 82 % of the total straw. On the second position there is maize straw with the percentage of 15,8 %. Rape straw supplies 1,3 % of total straw gained. In the present vision and in the scenario for maximized biofuel production the amount of surplus straw reaches 26 % of the total straw collected while in the second future scenario it lowers to 22 %. Among different factors ‘cereal straw/grain ratio’ occurs to be the most sensitive in the present estimation, yet in the future scenarios two factors differ within changing deviation the most: ‘cereal consumption’ and ‘cereal straw/grain ratio’.

3.17. Luxembourg

Total Residue biomass Potential was estimated at the level of 1,8 PJ/a, the main share of that amount, 79 %, comes from forestry potential, 19 % is assessed to be straw potential and 2 % is supplied by the wood industry by-products capabilities. The total biomass potential is suspected to change to 1,8 PJ/a in S1 and to 1,5 PJ/a in S2. Forestry potential is assessed to establish at the level of 91 % of the total biomass potential in S1 and 97 % in S2 scenario. Capabilities of wood industry by-products are not expected to change much.

The most interesting is straw potential which, as mentioned before, in the present estimation reached 19 % of the whole biomass potential however in S1 is predicted to lower to 7 % while in S2 even to zero.

In this country the dominant amount of straw comes from cereal and rape straw, about 44 % each.

In the present view one factor differs noticeably within different values of deviation, ‘cereal straw/grain ratio’. In the estimation for ear 2020 (in both scenarios) the ‘cereal consumption’, ‘cereal straw/grain ratio’ and ‘meat consumption’ show the highest sensitivity.

3.18. Latvia

Total area of the country is 6459 thousands ha, 30,2 % of that is an agricultural land, 44,4 % is covered by forests and 25,4 % is used for other purposes. The total residue biomass potential in this country was calculated to be 14,2 PJ/a. The majority is due to the forestry potential that gives about 73 % of the calculated amount. Straw potential was assessed to be 14.1% and the potential of wood industry by-products stands for 13 % of the total potential.

In S1 the capability of biomass usage increases to 16,1 PJ/a mainly because the growth of forestry potential (73 %) and wood industry potential (17 %). In the second future scenario the total biomass potential is going to lower to 14,1 PJ/a and will be divided among 8 % of straw capabilities, 76 % of forestry potential and 16 % potential of wood industry by-products. Very absorbing case is that in the estimation for this country for the year 2020 wood industry potential plays more important role than straw capabilities.

As mentioned before straw potential is predicted to lower from 13 % (SP) to 10 % (S1) and finally to 8 % of the total biomass potential (S2). The majority of the whole amount of straw comes from the cereal straw. Only 20 % in the straw structure is maize straw, while rape straw does not appear at all. According to the present estimation one factor differs considerably within different values of deviation, ‘cereal straw/grain ratio’. In the assumption for year 2020 (in both scenarios) the ‘cereal consumption’, ‘cereal straw/grain ratio’ and ‘meat consumption’ show the highest changeability.

3.19. Netherlands

Total Residue Biomass Potential estimated for present time (SP) equals 13 PJ/a, 18 % of this amount comes from forestry potential, less than 1% from wood industry and 81 % is due to gaining straw. In the scenario S1 the total biomass potential reaches 11,3 PJ/a where 25 % of that amount comes from the forestry activities, 1 % falls to wood industry potential and the rest, that is 74 % occurs to be straw potential.

The scenario S2 reveals the total amount of biomass potential of 8,4 PJ/a. Partial potential equals respectively 31 % for forestry actions, 1 % for wood industry and 68 % for straw potential.

Utilized agricultural area in this country totals up at 1937 thousands ha that is 48,6 % of the total area of the country and wooden area amounts 8,8 % of the country area.

The main share of straw in this country comes from cereal straw only about one-third is supplied by maize straw. Total straw collected in present estimation reaches the number of 23,9 PJ/a, and in scenarios for year 2020 it is smaller and equals 22,2 PJ/a. The highest production density was found in region Zeeland, but region Groningen shows the high potential as well.

In four regions the straw potential was estimates to be zero, both at present and in a future perspective. Region Noord-Brabant occured to be very interesting due to the potential results, which in present view and in S1 show quite high capabilities comparing to other regions, while in the second future scenario the potential was estimated to be much below zero. This situation can not be explained by different sensitivity of the factors which in both future scenarios change comparably. In the present view one factor differs the most within different values of deviation- ‘cereal straw/grain ratio’.

In the estimation for year 2020 (in both scenarios) the ‘cereal consumption’, ‘cereal straw/grain ratio’, ‘meat consumption’ and ‘straw for bedding’ show the highest sensitivity.

3.20. Poland

In this country, that is covering in total 31269 thousands ha 55,1 % of the land is used for agricultural purposes and 29 % is wooded area. Total Residue biomass potential was calculated to be 160,9 PJ/a nowadays and in future scenarios it is assessed to lower to 155,3 PJ/a (S1) and 139,5 PJ/a (S2). Forestry potential equals now almost 26 % of the total potential and it is expected to rise and to establish at the level of 31 % in both scenarios. In all the scenarios from the technical point of view the thinning wood fraction will form the most important share and it will equal 53-55 % of the whole forestry biomass potential.

The wood industry potential is not expected to play a very important role in total calculations and it will not differ much among scenarios (2-3 %).

Straw potential determine the largest part of the total biomass potential in the present estimation. Nowadays it is estimated to equal 115,8 PJ/a, that is 72 % of the total potential. In the scenarios S1 and S2 it is expected to lower to 66 % of the total potential estimated.

The majority of the total straw potential comes from the cereal straw and is estimated to be more than 62% of the total straw collected. On the second position there is maize straw with the percentage of 20,1 %. Rape straw supplies 17,4 % of total straw gained. In the present vision and in the scenario for maximized biofuel production the amount of surplus straw reaches 31 % of the total straw collected while in the second future scenario it equals 28%. The highest production density was found in region Dolnoslaskie however in region Zachodniopomorskie the straw potential was also assessed to be high. Only one area shows no potential, the Podlaskie region.

Among different factors ‘cereal straw/grain ratio’ occurs to be the most sensitive in the present estimation, yet in the future scenarios two factors differ within changing deviation the most: ‘cereal consumption’ and ‘cereal straw/grain ratio’ however their variation do not differ much from the variation of other factors.

3.21. Portugal

In Portugal total utilized agricultural area reaches 3828 thousands ha that is more than 41% of the total country area while the area covered by wood is estimated to be about 37,7 %. The total residue biomass potential in this country nowadays is 28,9 PJ/a, of which the main share (57 %) comes from the straw. Forestry potential is measured to establish 39 % of the whole measure while potential coming from the wood industry is assessed to be 4 %.

In the scenario S1 the total biomass potential reaches 27,6 PJ/a, forest potential, with a main influence of thinning wood, as well as wood industry potential are expected to grow whereas the straw potential shall decrease.

In the scenario S2 the total potential from biomass is expected to reach 27,6 PJ/a, more than half of it (54 %) is measured to come from the forestry potential.

In this country the largest share (64,6 %) of straw comes from the maize. Only 33 % of the total potential comes from cereal straw while the rape straw supplies less than 3 % of the total gained straw.

In all analyzed scenarios the highest straw potential occurs in region Alentejo , where the production density reaches 10,1 PJ/a (SP), and in region Algarve almost no potential was found, nor is predicted.

In the starting point scenario the most important factors, that have been found are the 'cereal straw/grain ratio', 'maize straw/grain ratio' and 'share of straw for soil' while in scenarios S1 and S2 the 'cereal consumption' seems to differ the most within changing deviation.

It is worth noticing that in both future scenarios factor 'Share of cattle on straw' shows variable numerical value.

Particular regions in this country show comparably different sensitivity to various factors.

3.22. Romania

Total area of the country is 23839 thousands ha, 62,2 % of that is an agricultural land, 37,8 % of the area in used for other purposes. No data about forests area have been found. The total residue biomass potential in this country was calculated to be 180,6 PJ/a. Forestry potential has not been assessed (lack of data). Potential of wood industry by-products stands for 1,8 PJ/a in present estimation and in both future scenarios it is expected to rise respectively to 2,6 PJ/a (S1) and 2,23 (S2).

In the scenario S1 the capability of biomass usage lowers to 142 PJ/a, and in the second future scenario the total biomass potential is expected to be 141,5 PJ/a.

When analyzing the straw structure one comes to the conclusion that the main part of product comes from the maize straw (57,4 %), 30,2 % comes from cereal straw and rape straw supplies 12,4 % of total straw. In all the scenarios the percentage of surplus straw reaches 44-49 %. Sud est and Sud regions show the highest production density in all scenarios. On the whole area of the country straw potential is assessed to be above zero. In future scenarios two factors seem to be noticeably sensitive: 'cereal consumption' and 'demography' while in the present estimation 'share of straw for soil', 'maize straw/grain ratio' and 'cereal straw/grain ratio' change the most. Analyzed factors do not vary much among different regions.

3.23. Sweden

Total Residue Biomass Potential estimated for present time (SP) equals 123 PJ/a, 82 % of this amount comes from forestry potential, 7 % from wood industry and 11 % is due to gaining straw.

In the scenario S1 the total biomass potential reaches 130,8 PJ/a where 83 % comes from the forestry activities, less than 9 falls to wood industry potential and the rest, that is 9 occurs to be straw potential.

The scenario S2 reveals the total amount of biomass potential of 131,8 PJ/a. Partial potential equals respectively 85 % for forestry actions, 7 % for wood industry and 8 % for straw potential.

Utilized agricultural area in this country totals up at 3.1 mln ha that is 7,3% of the total area of the country and wooden area amounts 52,9 % of the country area.

The main share in forestry potential comes from thinning wood fracture in all estimations.

From the total amount of straw, cereal straw supplies more than 80 % while the rest comes from the maize straw. No rape straw potential was found. Total straw collected in this country was estimated to be 60,7 PJ/a however in both scenarios prepared for the year 2020 it will lower to 56,2 PJ/a. The part of surplus straw of these amounts will be between 17-21 %.

The highest production density was found in Östra Mellansverige region, where it equals 5,4 PJ/a according to present estimation (4,8 PJ/a in S1 and 4,4 PJ/a in S2). Also in region Sydsverige, the total straw potential was estimated around 4 PJ/a in scenarios SP and S1 and 3,6 PJ/a in S2. In four regions total potential was estimated to be below zero.

For the present estimation the most sensitive factors are the ‘cereal straw/grain ratio’ and ‘share of straw for soil’ however in future scenarios also the factor ‘cereal consumption’ shows high variability. In the regions where the total straw potential was estimated to be low, the most sensitive factor found was the ‘share of straw for soil’ in present estimation and the ‘meat consumption’ in scenarios for year 2020.

3.24. Slovenia

Total residue biomass potential was estimated at the level of 9,2 PJ/a, the main share of that amount, 73 %, comes from forestry, 3 % is due to wood industry by-products and the rest, that is 24 % is estimated to be straw potential. The total biomass potential is suspected to change to 10,1 PJ/a in S1 and to 8,6 PJ/a in S2. Forestry potential is assessed to establish at the level of about 75-78 % of the whole biomass potential in both future scenarios, while straw potential will decrease and reach the level of 21 % (S1) and 18 % (S2). Wood industry capabilities are predicted to reach the amount of 0,4 PJ/a, that is about 4 % of the total predicted potential.

The majority of the total straw potential comes from the maize straw and is estimated to be more than 97 % of the total straw. In the present vision and in the S1 the amount of surplus straw reaches about 20 % of the total straw collected while in the second future scenario only 14 %.

Among different factors the ‘cereal straw/grain ratio’, ‘maize straw/grain ratio’, ‘share of straw for soil’ and ‘straw for bedding’ occur to be the most sensitive in the present estimation, yet in the future scenarios two factors differ within changing deviation the most: ‘cereal consumption’ and ‘meat consumption’.

3.25. Slovakia

In this country, that is covering in total 4903 thousands ha 46,6 % of the land is used for agricultural purposes and 40,8 % is wooded area. Total residue biomass potential was calculated to be 32,5 PJ/a nowadays and in future scenarios it is assessed to change to 34,3 PJ/a (S1) and 31,1 PJ/a (S2). Forestry potential equals now almost 41 % of the whole potential and it is expected to rise and to establish at the level of 43-46 % of the total potential in both future scenarios. In all the scenarios from the technical point of view the wood balance fraction will form the most important share and it will equal 44-48% of the whole forestry biomass potential.

The wood industry potential is not expected to differ much in total calculations (2-4 %).

Straw potential determine the largest part of the total Biomass potential in the present estimation. Nowadays it is estimated to equal 18,2 PJ/a, that is 56 % of the total potential. In the scenario S1 it is expected to lower to 50 % and in the scenario S2 to 53 %. It is worth noticing that that the percentage of straw capabilities is higher in the scenario S2 than in the scenario S1.

When analyzing the straw structure one comes to the conclusion that the main part of product comes from the maize straw (more than 43 %), about 28 % comes from cereal straw and rape straw each. In all the scenarios percent of surplus straw reaches about 40 %. Západné Slovensko region shows the highest production density in all scenarios. No potential was found in one region Stredné Slovensko, while in two other regions it was assessed to be relatively low. In future scenarios two factors seem to be noticeably sensitive: ‘cereal consumption’ and ‘demography’ while in the present estimation ‘share of straw for soil’ and ‘cereal straw/grain ratio’ change the most.

3.26. United Kingdom

In UK total utilized agricultural area reaches 16388 thousands ha that is more than 67,2 % of the total country area while the area covered by wood is estimated to be about 10,1 %. The total residue biomass potential in this country nowadays is 101,2 PJ/a, of which the main share (84 %) comes from the straw. Forestry potential is measured to establish 15 % of the whole measure while potential coming from the wood industry is assessed to be 1 %.

In the scenario S1 the total biomass potential reaches 84,4 PJ/a, forest potential, with a main influence of thinning wood, as well as wood industry potential are expected to grow whereas the straw potential shall decrease.

In the scenario S2 the total potential from biomass is expected to reach 76,8 PJ/a, more than 77 % comes from straw, about 21 % from the forest potential and over 1 % is supplied by the wood industry capabilities.

In this country the largest share (78,2 %) of straw comes from the cereals. About 21 % of the total potential comes from maize straw while the rape straw does not appear in the calculations.

The amount of surplus straw fluctuates between 27-34 %.

In the SP scenario the most important factor, that has been found is the ‘cereal straw/grain ratio’, while in scenarios S1 and S2 the ‘cereal consumption’ an ‘cereal straw/grain ratio’ seem to differ the most within changing deviation.

4. Summary

Total potentials

Residue biomass constitute a significant biomass potential in Europe estimated at 2 726 PJ/year for SP and 2 579 PJ/year and 2 471 PJ/year for S1 and S2, respectively. The figures are presented in Table 1.

Table 1. Residue biomass potentials in Europe in PJ/year for RENEW scenarios

Biomass assortments	SP	S1	S2
FORESTRY WOOD	682,8	787,9	769,3
Logging residues	65,4	90,8	52,1
Thinning wood	306,8	408,9	379,2
Roots and stumps	7,6	3,4	5,1
Wood balance	303	284,8	332,9
WOOD INDUSTRY BY-PRODUCTS	50,5	67,7	57
AGRICULTURAL RESIDUES	1 831	1 566,8	1 477,8
Cereal straw	855,2	703,38	631,1
Maize straw	764,1	683,63	683,6
Oilseed straw	240,5	217	217
TOTAL	2 564,3	2 422,4	2 304,2

Generally, in the scenario S1 the biomass potential is higher for woody biomass assortments* than in the scenario SP, what is due to the assumptions on more intensive production and harvesting rates. For the scenario S2, in which sustainability aspects are emphasised, the available biomass potential is lower compared to SP and S1. The relation is different for agricultural residues, where the highest straw potential is for scenario SP, the lowest for scenario S2.

The applied methodology of biomass potential calculations reviled some important factors influencing much the available potentials. Forestry potentials are most sensitive to changes of the value of parameters estimating the share of logging residues not removed from forests, the industrial thinning wood rates, share of root biomass potential not removed and finally wood balance for industry. For wood industry by-products the industrial by-products utilization is the most sensitive parameter. For straw the most important parameters are straw/grain mass ratio and share of straw left for soil organic matter restoration. However, this must be stressed that depending on the country conditions and the scenario the most sensitive parameters may be different.

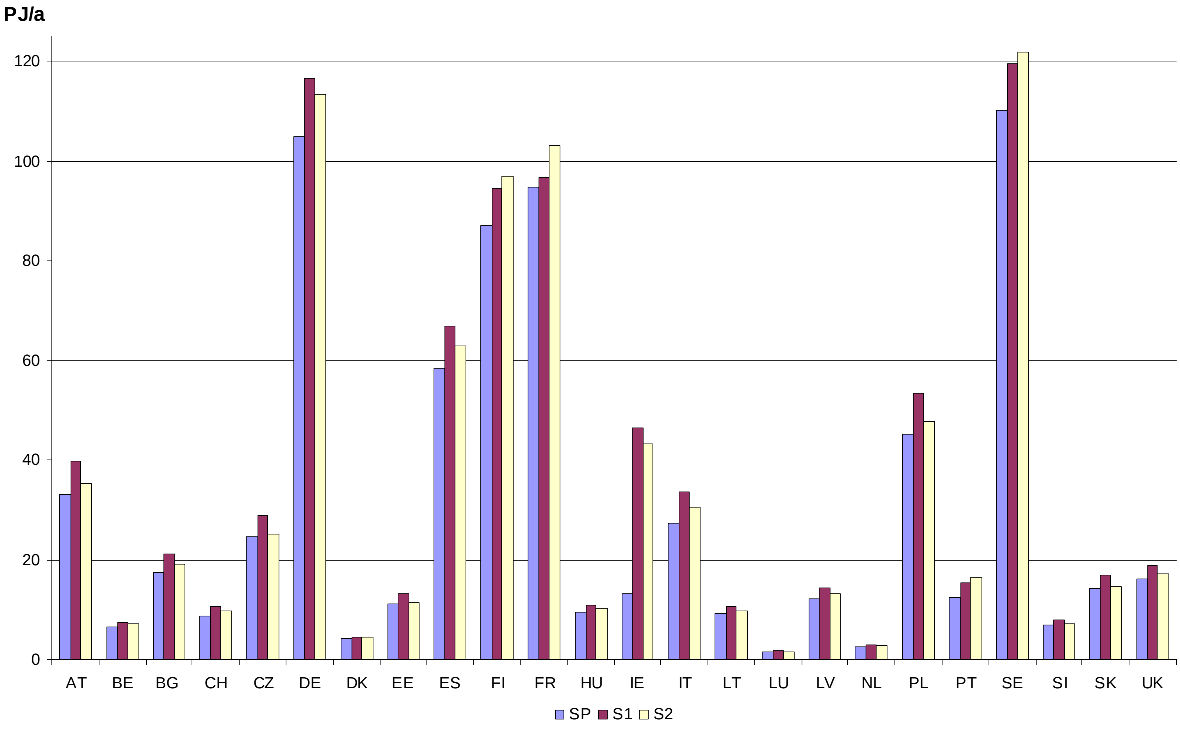
Forestry and wood industry

The highest biomass potentials from forestry and wood industry are in Germany, Spain, Finland, France, Poland and Sweden, countries of large land areas – see Graph 1 and Figure 14.

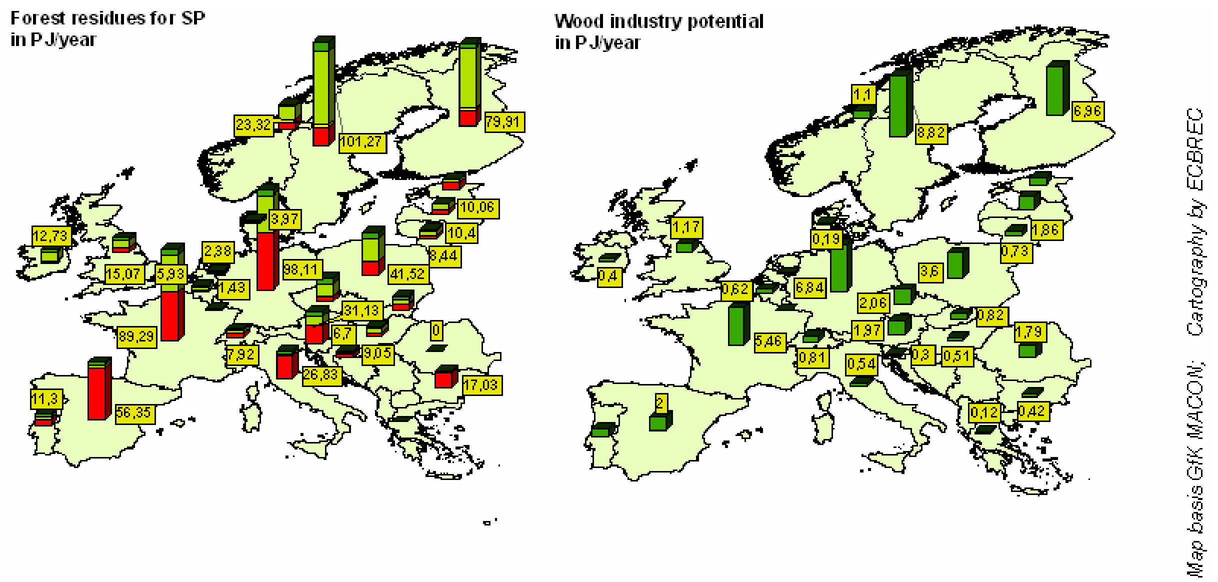
The biomass potential from forestry and wood industry for S1 is generally higher then for SP, which is connected with more intensive forest management and exploitation in S1. For a

* With the exception of wood balance. Generally, wood balance fraction in S2 is higher then in S1 and SP, which is due to higher volume of not harvested stands, while lower felling rate is assumed for S2 compared with SP and S1.

few countries potential in S2 is higher then S1, this is due to the fact that wood balance for these countries have big share in total wood potential.



Graph 1. Biomass potentials of forestry wood and wood industry by-products (cumulated) in European countries



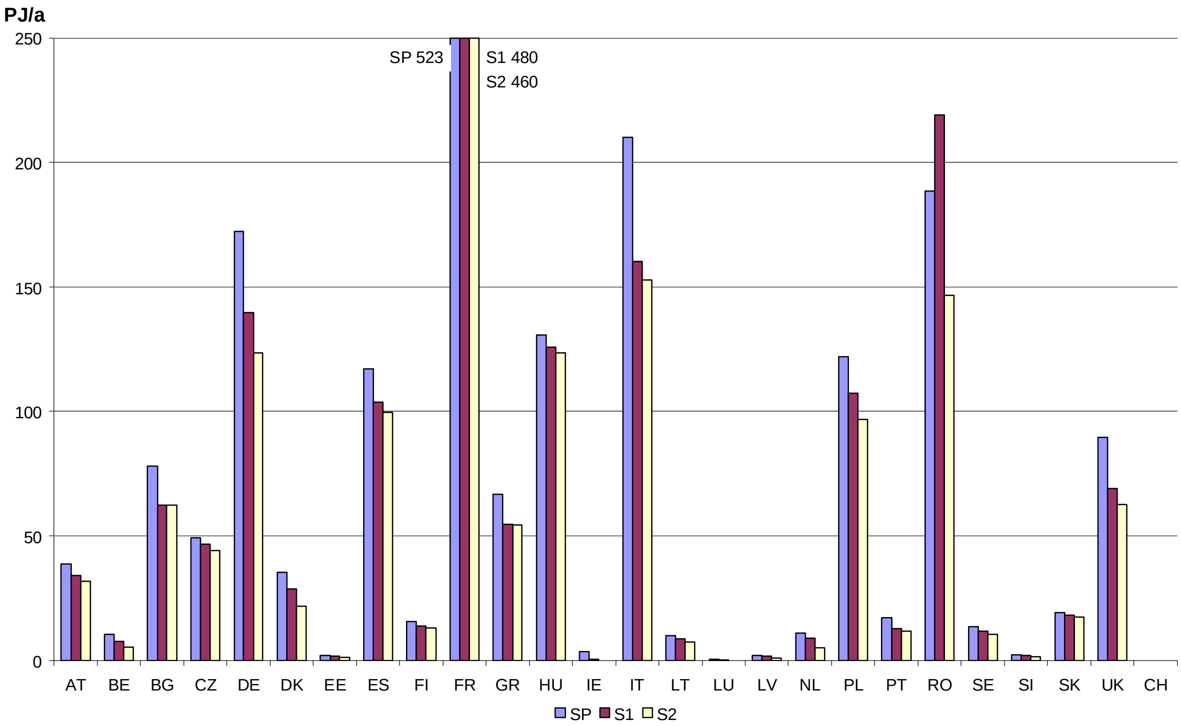
Legend:

Logging residues	Thinning wood	Root and stumps	Wood balance

Figure 14. Forestry and wood industry biomass potential in Europe

Agricultural residues

The highest straw potential is in France, a country with largest area of arable land and high grain production, then Italy, Romania, Denmark, Hungary, Poland and Spain come in the place of order – see Graph 2. In the rest of countries *the available straw potentials are lower than 100 PJ/a for each of them. In some countries straw deficits exists, e.g. Switzerland, but it was marked as zero potential on the Graph. The potentials for future scenarios are lower than for SP, on average the potential is 11% and 20% lower than SP, for S1 and S2 respectively. This is mainly caused by the introduction of cereals varieties of shorter straw in 2020. The difference between S1 and S2 comes from the fact that in S2 more straw would be used for animal bedding compared to S1.*



Graph 2. Straw potentials in European countries

Straw potentials can be also analysed at regional level, namely in NUST-1 or NUTS-2 regions. The regions of high straw availability present the best conditions concerning the raw material for a processing plant locations for BtL fuels. Looking at potentials density calculated as GJ/ha of total land, the highest values can be found in some regions of France, Italy, Hungary, Bulgaria, Denmark, Poland and Greece – see Graph 2. On the other hand, there are also regions, where no straw is available or even straw deficits exits (both cases *presented as zero potential).*

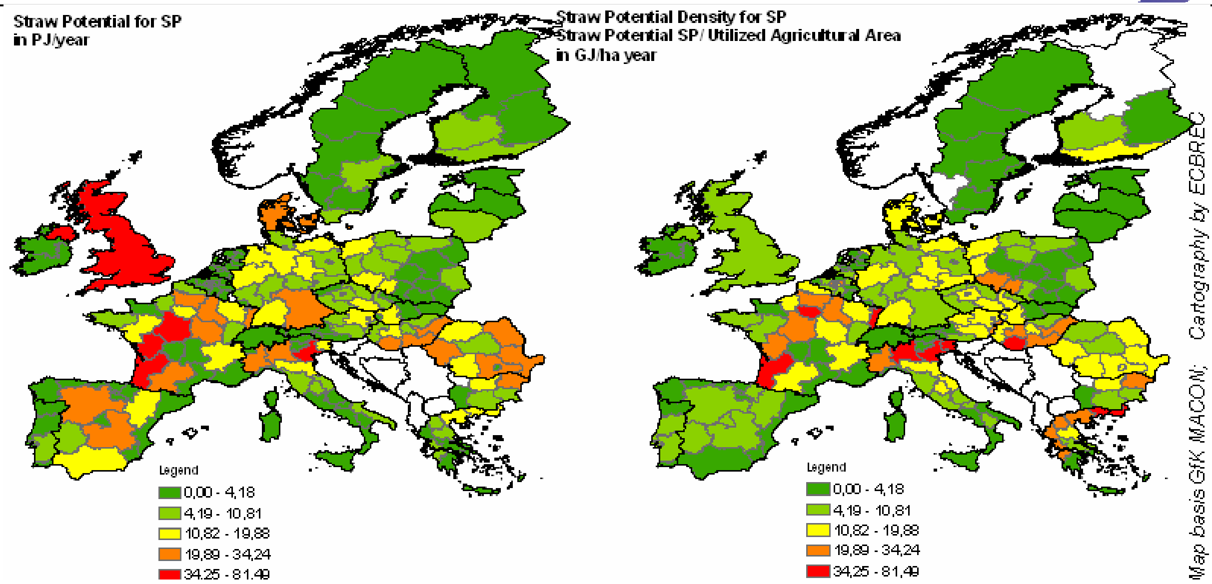


Figure 15. Straw potential and potential density in Europe

Comparison with existing studies

Biomass potentials have been calculated in some existing studies. Studies presenting the results on national level and published not earlier than 2000 have been chosen. Table 2 presents the results of biomass residue potentials from RENEW (Starting Point) and the selected studies. The results presented are potentials for EU 25.

It is evident that the potentials estimated vary greatly between the studies. The methodologies applied resulted in very different potentials, thus making the study cross comparisons difficult. Another reasons of different results are the input data. The existing studies used input data of EUROSTAT 2000 for agricultural residues and TBFRA 2000 for forestry wood and industry by-products. RENEW calculations were based on more recent data, averages of 2000-2004 for agriculture biomass and data of 2000 and 2004 for forestry and wood industry biomass (TBFRA 2000, 2005).

It must be stressed that RENEW calculations have the advantage of including regional specifications of different calculation parameters, which was possible due to the contribution of project partners from different European regions.

Looking at the potentials figures it can be noticed that the agricultural residues potential of RENEW is higher than in other studies. There is a quite significant difference in the figures. This results to the largest extent from the methodological assumptions on the share of straw surplus available. While the other studies use quite general assumptions, RENEW calculations are very specific ones, strictly connected with the animal production specifications (number of animals, share of animals using straw bedding).

Potential of forestry fractions for energy use by RENEW is in between the results of Karjalainen and Ericsson studies. Of course, detailed methodologies investigation of the studies is out of scope of this report, but some general remarks can be easily mentioned. The existing studies define the technical potential available for energy use as available amount of forest residues concerning technical and economical restrictions of harvesting. RENEW calculations take in to account additionally the fact that some part of the logging residues and thinning wood is already used for material production (fiberboards industry) and thus is not easily available for energy use or BtL fuels.

Wood industry by-products potential by RENEW is presented as two values. The higher value is theoretical potential (total amount of by-products produced), which is very close to the value by Ericsson and Nilsson. This value do not include current material nor energy *uses. The lower value by RENEW is wood industry by-products share available after regarding the current material use of by-products as well as use for energy at the production site.*

Table 2. *Biomass potentials in RENEW and other studies. Total potentials in PJ/a for EU 25*

Biomass assortments/Study	Value PJ/a	Comments
Agricultural residues		
RENEW SP*	1578	Straw of cereal, maze, oilseeds
Ericsson and Nilsson 2006	816	Straw of cereals and maize
LOT5 2003	1248	Straw of cereal, maize, oilseeds plus permanent crops residues
THRAN et al. 2004	824	Straw of cereal, maze oilseeds plus permanent crops residues
Forestry wood		
RENEW SP	665	Felling residues, thinning wood, root and stumps plus wood balance
Ericsson and Nilsson 2006	552	Felling residues
LOT5 2003	1450	Forestry residues and woodfuel (no details available)
THRAN et al. 2004	2 321	Felling residues from current fellings plus raw wood potential from unutilized growth
Karjalainen et al. 2004	773	Felling residues, root and stump wood, wood balance
Wood industry by-products*		
RENEW SP	966/ 48	Theoretical potential/ available potential (competitive material and energy** uses included)
Ericsson and Nilsson 2006	1034	Theoretical potential – no competitive uses included
LOT5 2003	508	Available potential (no details available)
THRAN et al. 2004	435	Available potential, competitive material uses included

* only dry industry by-products included, no black liquor

** wood industry by-products used for energy production at the place of origin

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TB FRA 2000: Temperate and Boreal Forest Resources Assessment of the UN/ECE-FAO 2000

Annex 1 Formulas for calculations of biomass from forestry

THO = THO LR + THO TW + THO RB + THO WB

TECH = TECH LR + TECH TW + TECH RB + TECH WB

TECH	Technical potential
THO	Theoretical potential
LR	Logging residues fraction
TW	Thinning wood fraction
RB	Root biomass fraction
WB	Wood balance fraction

Logging residues potential

TECH SP= THO x (1-LRE) x (1- LRI) x (1-LRO)

THO SP = (FCFAWS x FLRC + FBFAWS x FLRB) x FFF

TECH S1 = THO x (1-LRE S1) x (1- LRI S1) x (1-LRO S1)

THO S1 = (FCFAWS x FLRC + FBFAWS x FLRB) x FFC S1 x FFF

TECH S2 = THO x (1-LRE S2) x (1- LRI S2) x (1-LRO S2)

THO S2 = (FCFAWS x FLRC + FBFAWS x FLRB) x FFC S2 x FFF

TECH	Technical potential
THO	Theoretical potential
FCFAWS	Annual fellings overbark on coniferous forest available for wood supply
FLRC	Logging residues factor for coniferous species
FBFAWS	Annual fellings overbark on broadleaves forest available for wood supply
FLRB	Logging residues factor for broadleaves species
FFC	Factor of fellings changes
FFF	Factor of final fellings
LRE	Logging residues ecological potential
LRI	Logging residues for industry
LRO	Logging residues not removed for other reasons

Thinning wood potential

TECH SP = THO x (1- TWO) x (1-TWI)

THO SP = FFAWS x (1-FFF)

TECH S1 = TWO x (1- TWO S1) x (1-TWI)

THO S1 = FFAWS x FFC S1 x (1-FFF)

TECH S2 = THO x (1- TWO S2) x (1-TWI)

THO S2 = FFAWS x FFC S2 x (1-FFF)

TECH	Technical potential
THO	Theoretical potential
FFAWS	Annual fellings overbark on forest available for wood supply
FFC	Factor of fellings changes
FFF	Factor of final fellings
TWO	Reduction thinning wood factor
TWI	Industrial thinning wood factor

Root biomass potential

TECH SP = THO x (1-RBE) x (1-RBI) x (1-RBO)

THO SP = FFAWS x (S+P) x FCLFF x RBR

TECH S1 = THO x (1-RBE) x (1-RBI) x (1-RBO S1)

THO S1 = FFAWS x FFC S1 x (S+P) x FCLFF S1 x RBR

TECH S2 = THO x (1-RBE) x (1-RBI) x (1-RBO S2)

THO S2 = FFAWS x FFC S2 x (S+P) x FCLFF S2 x RBR

TECH	Technical potential
THO	Theoretical potential
FFAWS	Annual fellings overbark on forest available for wood supply
FFC	Factor of fellings changes
S	The share of spruce in all species
P	The share of pine in all species
FCLFF	Factor of clear final felling
RBR	Root biomass ratio
RBE	Root biomass ecological potential
RBI	Root biomass for industry
RBO	Root biomass potential not removed

Wood balance potential

TECH SP = THO x (1-WBI) x (1- WBE) x (1-WBO)

THO SP = (NAIFAWS-FGSFAWS)

TECH S1 = THO x (1-WBI) x (1- WBE S1) x (1-WBO S1)

THO S1 = (NAIFAWS x NAICH S1 - FGSFAWS x FFC S1)

TECH S2 = THO x (1-WBI) x (1- WBE S2) x (1-WBO S2)

THO S2 = (NAIFAWS x NAICH S2 - FGSFAWS x FFC S2)

TECH	Technical potential
THO	Theoretical potential
NAIFAWS	Net annual increment on forest available for wood supply
NAICH	Changes of net annual increment
FGSFAWS	Fellings of growing stock in
FFC	Factor of fellings changes
WBI	Wood balance for industry
WBE	Wood balance ecological potential
WBO	Wood balance not removed from technical reasons

Annex 2 Formulas for calculations of biomass from wood-industry

Theoretical and technical total potential of industrial by-products

IBP THO = THO S + THO P + THO B + THO O

IBP TECH = IBP THO x (1-IBU)

IBP TECH	Technical potential of total industrial by-products
IBP THO	Theoretical potential of total industrial by-products
S	Industrial by-products from sawmills
P	Industrial by-products from pulp and paper industry
B	Industrial by-products from board industry
O	Industrial by-products from other wood industry
IBU	Factor of industrial by-products utilisation

Potential of industrial by-products from sawmills

THO S SP = (SG x SSG SP + PG x SPG SP) x IBS SP

THO S1 = (SG x SSG S1 + PG x SPG S1) x CHP S1 x IBS S1

THO S2 = (SG x SSG S2 + PG x SPG S2) x CHP S2 x IBS S2

THO S	Theoretical potential of industrial by-products from sawmills
SG	sawlogs and veneer logs group
SSG	sawlogs in sawlogs and veneer logs group
PG	pulpwood group
SPG	sawlogs in pulpwood group
IBS	% of wood by-products in sawmills production
CHP	changes of production related to 2004

Potential of industrial by-products from pulp and paper industry

THO P SP = (PG x PPG SP + OG x POG SP) x IBP SP

THO P S1 = (PG x PPG S1 + OG x POG S1) x CHP S1 x IBP S1

THO P S2 = (PG x PPG S2 + OG x POG S2) x CHP S2 x IBP S2

THO P	Theoretical potential of industrial by-products from pulp and paper industry
PG	pulpwood group
PPG	pulpwood in pulpwood group
OG	other wood group
POG	pulpwood in other wood group
IBP	% of wood by-products in pulp and paper production
CHP	changes of production related to 2004

Potential of industrial by-products from board industry

THO B SP = (PG x BPG SP + OG x BOG SP + FG x BFG SP) x IBB SP

THO B S1 = (PG x BPG S1 + OG x BOG S1 + FG x BFG S1) x CHP S1 x IBB S1

THO B S2 = (PG x BPG S2 + OG x BOG S2 + FG x BFG S2) x CHP S2 x IBB S2

THO B	Theoretical potential of industrial by-products from board industry
PG	pulpwood group
BPG	boardwood in pulpwood group
OG	other wood group
BOG	boardwood in other wood group
FG	fuel wood group
BFG	boardwood in fuel wood group
IBB	% of wood by-products in board production
CHP	changes of production related to 2004

Potential of industrial by-products from other wood industry

THO O SP = (SG x OSG SP + PG x OPG SP + OG X OOG SP) x IBO SP

THO O S1 = (SG x OSG S1 + PG x OPG S1 + OG X OOG S1) x CHP S1 x IBO S1

THO O S2 = (SG x OSG S2 + PG x OPG S2 + OG X OOG S2) x CHP S2 x IBO S2

THO O	Theoretical potential of industrial by-products from other wood industry
SG	sawlogs and veneer logs group
OSG	other wood in sawlogs and veneer logs group
PG	pulp wood group
OPG	other wood in pulp wood group
OG	other wood group
OOG	other wood in other wood group
IBO	% of wood by-products in other production
CHP	changes of production related to 2004

Annex 3 Formulas for calculations of biomass from agricultural residues

Total straw production

Small-grain cereal straw

[Total cereal straw SP] = [Average cereal production (00-04)] x [Straw/grain ratio (SP)]

[Total cereal straw (S1, S2)] = [Average cereal production (00-04)] x [Population change (2020)] x [Cereal consumption change (2020)] x [Straw/grain ratio (S1/S2 respectively)]

Oilseed

[Total oilseed straw SP] = [Average oilseed production (00-04)] x [Oilseed straw/grain ratio (SP)]

[Total oilseed straw (S1,S2)] = [Average oilseed production (00-04)] x [Population change (2020)] x [Cereal consumption change (2020)] x [Straw/grain ratio (S1/S2 respectively)]

Maize grain

[Total maize green straw SP] = [Average maize green production (00-04)] x [Maize green straw/grain ratio (SP)]

[Total maize green straw (S1,S2)] = [Average maize green production (00-04)] x [Population change (2020)] x [Cereal consumption change (2020)] x [Maize green straw/grain ratio (S1/S2 respectively)]

Straw for animals

Straw for animal bedding

Calculated for cattle, pigs and equidae.

[Straw for bedding SP] = [Factor of straw for bedding per LSU] x ||[Average cattle production (00-04)] x [Share of cattle on straw SP]|+|[Average pig production (00-04)] x [Share of pig on straw SP]|+|[Average equid production (00-04)] ||

[Straw for bedding S1,S2] = [Factor of straw for bedding per LSU] x ||[Average cattle production (00-04)] x [Population change (2020)] x [Meat consumption change (2020)] x [Share of cattle on straw S1,S2]|+|[Average pig production (00-04)] x [Population change (2020)] x [Meat consumption change (2020)] x [Share of pig on straw S1,S2]|+|[Average equid production (00-04)] x [Population change (2020)] x [Meat consumption change (2020)]||

Straw for animal fodder

Calculated for cattle.

[Straw for fodder SP] = [Factor of straw for fodder per LSU SP] x |[Average cattle production (00-04)]+[Average equid production (00-04)]|

[Straw for fodder S1,S2] = [Factor of straw for fodder per LSU S1, S2] x ||[Average cattle production (00-04)] x [Population change (2020)] x [Meat consumption change (2020)]|+|[Average equid production (00-04)] x [Population change (2020)] x [Meat consumption change (2020)] ||

Total straw for animals

[Total straw for animals SP] = [Straw for bedding SP] + [Straw for fodder SP]
[Total straw for animals S1,S2] = [Straw for bedding S1,S2] + [Straw for fodder S1,S2]

Straw for soil

[Total straw for soil SP] = [Share of straw for soil] x [Total cereal straw SP]
[Total straw for soil S1, S2] = [Share of straw for soil] x [Total cereal straw S1, S2]

Straw for other purposes

[Total straw for other needs SP] = [Total cereal straw SP] x [Share of straw for other purposes]
[Total straw for other needs S1, S2] = [Total cereal straw S1, S2] x [Share of straw for other purposes]

Straw surplus - available potential

[Cereal straw potential SP] = [Total cereal straw SP] – [Total cereal straw for animals SP] -[Total straw for soil SP] - [Total straw for other needs SP]
[Cereal straw potential S1,S2] = [Total cereal straw S1,S2] – [Total straw for animals S1, S2] -[Total cereal straw for soil S1, S2] - [Total cereal straw for other needs S1,S2]

[Oilseed straw potential SP] = [Total oilseed straw SP] – [Total oilseed for soil SP]
[Oilseed straw potential S1,S2] = [Total oilseed straw S1, S2] – [Total oilseed for soil S1,S2]

[Maize straw potential SP] = [Total maize straw S1,S2] – [Total maize for soil S1,S2]
[Maize straw potential S1,S2] = [Total oilseed straw S1, S2] – [Total oilseed for soil S1,S2]

[Total straw potential SP] = [Cereal straw potential SP] + [Oilseed straw potential SP] + [Maize straw potential SP]
[Total straw potential S1,S2] = [Cereal straw potential S1,S2] + [Oilseed straw potential S1,S2] + [Maize straw potential S1,S2]