EFORWOOD
Tools for Sustainability Impact Assessment

Collection Processes, Volume Flows and Values of Sustainability Indicators of the Chain of Technical Timber Production to Support the Tool for Sustainability Impact Assessment

Bernhard Bürzle and Vinzenz Fundel

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Preface

This report is a deliverable from the EU FP6 Integrated Project EFORWOOD – Tools for Sustainability Impact Assessment of the Forestry-Wood Chain. The main objective of EFORWOOD was to develop a tool for Sustainability Impact Assessment (SIA) of Forestry-Wood Chains (FWC) at various scales of geographic area and time perspective. A FWC is determined by economic, ecological, technical, political and social factors, and consists of a number of interconnected processes, from forest regeneration to the end-of-life scenarios of wood-based products. EFORWOOD produced, as an output, a tool, which allows for analysis of sustainability impacts of existing and future FWCs.

The European Forest Institute (EFI) kindly offered the EFORWOOD project consortium to publish relevant deliverables from the project in EFI Technical Reports. The reports published here are project deliverables/results produced over time during the fifty-two months (2005–2010) project period. The reports have not always been subject to a thorough review process and many of them are in the process of, or will be reworked into journal articles, etc. for publication elsewhere. Some of them are just published as a "front-page", the reason being that they might contain restricted information. In case you are interested in one of these reports you may contact the corresponding organisation highlighted on the cover page.

Uppsala in November 2010

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EFORWOOD

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(Materials and Methods Using the Example of Poland; Results for Poland, Lithuania, Czech Republic and Hungary)

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Processes, Volume Flows and Values of Sustainability Indicators of the Chain of Technical Timber Production to Support the Tool for Sustainability Impact Assessment (Materials and Methods Using the Example of Poland; Results for Poland, Lithuania, Czech Republic, and Hungary)

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Abstract:

The study supports the research project EFORWOOD, which is a four-years integrated project, funded under the EU “Global change and ecosystems“ research activity of the Sixth Framework Programme. The overall purpose of EFORWOOD is to develop a quantitative decision support Tool for Sustainability Impact Assessment (ToSIA) for the European forestry-wood chain, covering forestry, industrial manufacturing, consumption and recycling.
Target of this study is to develop a manual that supports researchers in the collection of all data, on the country specific technical timber production chain (TTPC), i.e. all felling and hauling processes that are required to develop ToSIA. These data comprise information on the TTPC structure (processes, products, process intercorrelation, and split ratios), on the quantity of material flows and values of an approved set of sustainability indicators (SI).
Detailed calculation modes have been developed to calculate the required data, based on the example of Poland, which plays a major role in EFORWOOD as representative ‘key country’ for all other East European countries. These calculation modes have been developed based on statistical data, expert guesses and own assumptions.
The result part of the study contains – in addition to the data on the Polish TTPC – the respective values of Lithuania, the Czech Republic and Hungary, which have been calculated using the same approach as for Poland.
There are several major implications of the study: The developed modes of calculation are assumed to be applicable on all other EU25+2 countries. Furthermore, the calculated SI values are all given in relation to universal reference units (m^3), which allows the direct comparison of different concepts of the technical timber production, e.g. motor manual versus fully mechanised harvesting processes, and of different country specific TTPCs – concerning their impact on sustainability.

Key words:
Sustainability Impact Assessment (SIA), ToSIA, sustainability indicators, EFORWOOD, technical timber production chain, forestry-wood sector, Poland, harvest operations, hauling operations, process oriented

Executive Summary:

The forestry-wood sector is more and more subject to new policies, especially with regard to environmental issues. The anticipation exists that future "[…] policy instruments, rules, regulations and so on designed to reach the goals set by politicians […] could include the regulation of forestry practice in a significant part of the forest area in the Atlantic region […] [; these new measures] may have positive, negligible or quite negative effects for the [...] [forestry-wood chain][...]" (EFORWOOD, 2007b, ¶ 1).
To meet these challenges decision makers "[…] dealing with forest-based sector issues, be it in government or industry, need comprehensive, reliable, timely and policy-relevant information to respond to changes and changing demands" (EFORWOOD, no date).
Against this background, the EFORWOOD project was launched in 2005 in order to develop a "[…] Decision Support Tool [called] ToSIA (Tool for Sustainability Impact Assessment) […]. […] [ToSIA] represents a dynamic sustainability impact assessment model that is analysing environmental, economic, and social impacts of changes in forestry-wood production chains, using a consistent and harmonised framework from the forest to the end-of-life of final products" (EFORWOOD, 2007d).

The analysis of the technical timber production chains (TTPC), which consist of the felling and hauling processes, contributes to the development of ToSIA. In the the course of this analysis three data sets have to be collected:

- The structure of the country specific TTPC
- The country specific values of volume flows
- The country and process specific values of an approved set of EFORWOOD forestry-wood chain sustainability indicators (EFORWOOD FWC SI)

Therefore, this study is targeted on the development of transparent modes which allow the identification and the calculation of all required information for all EU25+2 countries. This is conducted on the basis of the exemplified assessment of the TTPC of Poland, which plays a key-role within EFORWOOD as it is assumed to be representative for East Europe.

The structure information of the country specific TTPC comprises relevant processes and their intercorrelations. This information is identified by analysing national forestry statistics and by performing an expert survey based on a standardised table of possibly relevant processes, which have been defined within EFORWOOD. For Poland the relevant processes

are thinning with chainsaw, selective logging with chainsaw, clearcut with chainsaw, clearcut with harvester, the relevant hauling processes are hauling with skidder, hauling with forwarder and hauling with horse.

The country specific values of volume flows contain the following data:

- The share of each single process in the country specific total volume of timber felled and hauled respectively, and the share of each single process in the volume of timber felled and hauled respectively per tree species (**process share**).
- The share of each product in the total volume of the output of a certain process (**product share**).
- The ratio according to which a certain output product is split to be further processed in different subsequent processes (**split ratio**). In the context of this study the split ratio describes the ratio by which different hauling processes continue to process a certain output product of a certain felling process.

However, to a far extend it is not possible to directly detect the structure, the process shares, the product shares and the split ratios of the country specific TTPC from national statistics. This is mainly because the sources either do not provide this type of data at all or they do not supply the data on the needed level of detail. Therefore, again, experts on forest utilisation from the respective countries have been consulted through a survey based on one-to-one telephone conversations and on a questionnaire.

The received data have been further processed using complex calculation modes, which have been developed in the course of this study, in order to obtain all required values on the level of single processes. The calculation modes have been developed according to the same tripartite approach structure for each target value; the structure follows the three questions *'What data are needed?'*, *'What data are already available?'* and *'Which calculation mode is necessary to get the needed data by using the data that are already available?'*

All process shares, product shares and split ratios are related to data provided through an EFISCEN-calculation. EFISCEN (European Forest Information Scenario Model) is an area-based matrix model for simulating amongst others the volume of thinning and final felling over time in age-class forests on the level of European countries (ZELL, 2008: 13).

The country and process specific values of sustainability indicators (SI) have been calculated for an approved set of 21 indicators. The set of SI meets three demanded criteria: Firstly, it covers all three pillars of sustainability. Secondly, the expenditure of time for the collection of the SI values is regarded to be reasonable. Thirdly, the set of SI covers all relevant project scales.

To ensure the political acceptance among the relevant stakeholders the set of EFORWOOD forestry-wood chain SI has been developed on the base of already existing indicator sets such as SDI-Eurostat, CSD, MCPFE and PAIS. For a detailed description of these indicator sets, see EFORWOOD (2006a: 13 – 14).

For each indicator value a complex calculation mode has been developed in this study, which allows the calculation of the SI values on the level of single processes based on data from national and international statistical data bases. The approach of the calculation mode development follows the same structure as for the volume flow calculations.

The results of the study are presented in a separate results section – except the calculation modes. This is due to the fact that, firstly, these calculation modes are not only results but also important methods to calculate the required values, and secondly, the large number of calculation tables would restrict the readability of the section.

After slight modifications, the calculation modes, which have been developed with regard to the Polish TTPC, have also been applied to Lithuania, the Czech Republic and; this application has been conducted in order to verify the developed calculation modes and to calculate the data that are required to develop ToSIA regarding the Lithuanian, Czech and Hungarian TTPC.

Therefore, in contrast to the calculation modes, the country specific TTPC structure, the country specific values on the volume flows and the country and process specific SI values are given not only for Poland but also for Lithuania, the Czech Republic and Hungary.

The country specific TTPC structure is schematically displayed in figures following the structure of event-driven process chains. The country specific values on the volume flows (process shares, product shares and split ratios) are listed in separate tables for each country. To allow the direct comparison of the country and process specific SI values, these data on all four countries are compiled in conjoint result tables.

The discussion in this study concentrates on materials and methods, on practical implications and limitations of this study and on suggestions on future research.

As for the calculation of many of the values on volume flows and SI the availability of statistical input data has not been sufficient, extensive expert guesses and assumptions have been taken into consideration. In some cases, e.g. the assumptions on the volume ratio of short logs versus long logs in Poland and the assumptions with regard to several parameters related to the number of employed persons (Polish TTPC) cross-checks have been successfully conducted using corresponding statistical data.

There are three main aspects which may have a practical implication for forestry researchers. Firstly, the study allows for the direct support of ToSIA by providing calculated data that are needed to perform a SIA of the EU-forestry-wood chain; secondly, the flexible calculation modes, which have been developed to calculate volume flows and SI values, can be applied to similar contexts beyond this study; thirdly, the study represents a comprehensive collection of data on the TTPC in Poland, Lithuania, the Czech Republic and Hungary, and can therefore be used as a source of data or references.
However, as cross-checking of the expert guesses and assumptions has only been possible in those few cases where adequate statistical data have been available; the reader should always be aware of possible discrepancies between the calculated values and the actual situation in the Polish, Lithuanian, Czech or Hungarian forestry. This is why the reader of the study is recommended to cross-check the input parameters of the calculation modes whenever new statistical data are available that were not available during the compilation this study.

Further research is suggested to cover the distinct lack of data that has especially been detected with regard to technical data and economic details on felling and hauling processes. Furthermore, many of the data that are provided by international organisations reflect the country specific situation in the years around 1995 and were published in consideration of the political change in East European countries. The structure of the forestry sector of East European countries, however, is still subject to major changes – therefore, it is recommended to continue research and data collection with regard to the East European forestry sector in order to develop more actual data bases.

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ABBREVIATIONS

CC	Process of clearcut with chainsaw
CEU	Central Europe (country group)
CH	Process of clearcut with medium-sized harvester
CO_2	Carbon dioxide
CO_2e	Carbon dioxide equivalent
CZ	Czech Republic
EEU	Eastern Europe (country group)
e.g.	for example
EIA	Environmental Impact Assessment
EFORWOOD FWC SI	EFORWOOD FWC Sustainability Indicators
ERA	Environmental Risk Analysis
EU	European Union
EU25+2	Group of countries, that became EU-member states until the year 2005, plus Norway and Switzerland
EU-FWC	Forestry-Wood Chain of the EU25+2
excl.	excluding
FOR	Process of hauling with medium-sized forwarder
FTEE	Full-time Equivalent Employee(s)
FW-FTEE	Full-time Equivalent Employee(s), who is(are) forestry worker(s) (loggers and horse handlers)
FWC	Forestry-Wood Chain
FWCs	Forestry-Wood Chains
GHG	Greenhouse gas(es)
GVA	Gross value added
HOR	Process of hauling with horse
HR	Harvest residues
HU	Hungary
i.e./I.e.	this means/This means
IN_CALC	indicator value calculation
incl.	including
LCA	Life Cycle Analysis
LCC	Life Cycle Costing

LT	Lithuania
MO-FTEE	Full-time Equivalent Employee(s), who is(are) forestry machine operator(s) (drivers of harvesters, skidders and forwarders)
NEU	Northern Europe (country group)
NHW	Non-hazardous waste
p.	page
pp.	pages
PL	Poland
PLN	New Polish Zloty (= Polish currency)
PUH	Productive Unit Hour(s)
SC	Process of selective logging with chainsaw
SDS	EU Sustainable Development Strategy
SEU	Southern Europe (country group)
SH	Process of selective logging with medium-sized harvester
SI	Sustainability Indicator(s)
SIA	Sustainability Impact Assessment(s)
SKI	Process of hauling with medium-sized skidder
TC	Process of thinning with chainsaw
TH	Process of thinning with medium-sized harvester
ToSIA	Tool for Sustainability Impact Assessment
TTPC	Technical Timber Production Chain
TTPCs	Technical Timber Production Chains
UH	Unit Hour(s) (working time incl. idle time, shifting time etc.)
UN	United Nations
UNCED	UN Conference on Environment and Development
VF_CALC	volume flow calculation

SYMBOLS AND UNITS

¶	paragraph
+	plus
-	negative; minus
*	multiplied by
/	divided by
≤	is less than or equal to
≥	is greater than or equal to
<	is less than
>	is greater than
=	is equal to
#	number, no unit
%	per cent
a	1 year
cm	centimetre(s)
€	Euro
kg	kilogram(s)
kWh	kilowatt hour(s)
l	litre(s)
m^3_{ob}	1 cubic metre over bark (= 112% * m^3_{ub})
m^3_{ub}	1 cubic metre under bark (= 89.29% * m^3_{ob})
MJ	mega joule
DE	digestible energy
mln	million
PLN	New Polish Zloty

1 BACKGROUND

In March 2000 the European Heads of State or Government passed an action and development plan for the European Union (EU), called ‘Lisbon Strategy’. The objective of implementing this strategy is to enable the EU “to become the most competitive and dynamic knowledge-based economy in the world [by 2010], capable of sustainable economic growth with more and better jobs and greater social cohesion” (EUROPEAN COUNCIL, 2000, ¶ 5). The Lisbon Strategy is based on the three pillars of sustainable development, namely the economic, social and environmental pillar, as defined at the United Nations Conference on Environment and Development (UNCED) (COMMISSION OF THE EUROPEAN COMMUNITIES, 2008a).

Aiming to implement the Lisbon Strategy the Commission of the European Communities launched the EU Sustainable Development Strategy (SDS) in 2001. This strategy constitutes the political framework for sustainable development and therefore conduces to the Lisbon Strategy. The SDS is supposed to effect behaviour modification of the society towards a sustainable way of living in terms of the UNCED-definition of sustainable development (COMMISSION OF THE EUROPEAN COMMUNITIES, 2008b, ¶ 2).

2 PROBLEM OUTLINE

The EU expects the forestry-wood sector like all other sectors to contribute to the aims set in the Lisbon Strategy and in the SDS.
However, this sector faces intense challenges and adaptation constraints with regard to globalisation, changing trade relations and shiftings in demography, live-style and consumers' behaviour. Additionally, the forestry-wood sector is land-based and at the same time embodies a high-tech industry. Due to these characteristics this sector "requires a careful balancing act between economic, social and environmental sustainability" (EFORWOOD, 2007a, ¶ 3) to ensure its long-term stability and growth.
Furthermore, current debates on various issues such as climate change, boosting renewable energy-sources, saving and developing biodiversity, economic competitiveness of the European economy and the welfare of the people, have brought the European forestry sector and the European wood-working industry more and more into the focus of policy-makers: It is supposed that the forestry sector and the wood-working industry can play an important role in improving the situation in the fields named above (EFORWOOD, 2007a, ¶ 2).
This is why the forestry-wood sector is more and more subject to new policies, especially in terms of policies regarding environmental issues. The anticipation exists that future "[…] policy instruments, rules, regulations and so on designed to reach the goals set by politicians […] could include the regulation of forestry practice in a significant part of the forest area in the Atlantic region […] [; these new measures] may have positive, negligible or quite negative effects for the [...] [forestry-wood chain] – economically for the sector but also with respect to the wider sustainability impact" (EFORWOOD, 2007b, ¶ 1).

To meet these challenges decision makers "[…] dealing with forest-based sector issues, be it in government or industry, need comprehensive, reliable, timely and policy-relevant information to respond to changes and changing demands" (EFORWOOD, no date).

However, the information meeting these requirements with regard to the forestry-wood sector is not available in all scopes to date; this is due to the fact that those approaches which are ready for use are insufficient:
Available tools cover usually either the assessment of the ecological (e.g. Environmental Impact Assessment, EIA), the economic (e.g. Life Cycle Costing, LCC) or the social impact (e.g. Social Impact Assessment), i.e. they do not holistically record all effects and

consequences of assessed strategies and policies at the same time. They are normally further restricted to single products (e.g. Life Cycle Assessment, LCA) or projects (e.g. Environmental Risk Analysis, ERA), i.e. they do not cover complete value-added chains and sectors. Usually suchlike tools are also limited in terms of spatial scale and time range as they capture only a snapshot of the situation and do not allow the prediction of future effects and consequences of strategies and policies (FINLAND'S MINISTRY OF ENVIRONMENT, 2007: 12).

Therefore, tools that would integrate the advantages and at the same time resolve the disadvantages of existing approaches are to be developed, namely tools that would make holistic sustainability impact assessments (SIA) in the forestry-wood sector possible.

Against this background, the EFORWOOD project was launched in 2005 in order to develop tools for SIA that are adapted to the special conditions and requirements of the forestry-wood sector.

The main outcome of EFORWOOD is a "[…] Decision Support Tool [called] ToSIA (Tool for Sustainability Impact Assessment) […]. […] [ToSIA] represents a dynamic sustainability impact assessment model that is analysing environmental, economic, and social impacts of changes in forestry-wood production chains, using a consistent and harmonised framework from the forest to the end-of-life of final products" (EFORWOOD, 2007d).

The overall target that is to be achieved by developing ToSIA, is "[…] to provide methods and tools that will, for the first time, integrate Sustainability Impact Assessment of the whole European Forestry-Wood Chain (FWC), by quantifying [the] performance of [the] FWC, using indicators for all three pillars of sustainability" (EFORWOOD, 2007c). In order to meet this target, the set of EFORWOOD Forestry-Wood Chain Sustainability Indicators (EFORWOOD FWC SI) is compiled in a way that the economic, social and environmental dimensions of sustainable development are covered. Furthermore, the chosen indicator set allows of the quantitative analysis of the FWCs' sustainability impact on the local, regional, national and European level (for all EU25+2 countries).

In order to collect all data that are required to develop ToSIA, studies on different spatial levels have been performed, namely on the level of single production chains, on the level of regional FWCs and on the level of the European FWC (EU-FWC) (CARNUS ET AL., 2008: 12). Firstly, the required data include information on the respective chain structure, which is determined by the involved production processes, by the interconnection of the involved production processes and by the shares of production processes of a certain value-added step of the production chain in the total output volume of this value-added step. Secondly, the required data comprise information on volume flows within the FWCs, namely the volume per output product per involved production process and the product flows between the involved production processes. Thirdly, the required data include the quantitative sustainability impact, which is expressed through the process specific indicator values of the assessed single production chains, regional FWCs and EU-FWC respectively.

Especially with regard to the data collection to assess the EU-FWC it is recommendable to use similar approaches for each of the EU25+2 countries to identify required information and to calculate required data; standardised data collection modes would help to minimise time expenditure in terms of data collection and at the same time to increase transparency.

3 Purpose and Objectives of the Study

The purpose of this study is to give a guideline on the collection of country and process specific data with regard to the technical timber production chain (TTPC); the TTPC comprises the processes of timber felling and of timber extraction from the forest stands (WESTPHAL, 2005: ¶ 1).

It is aimed to develop transparent modes which allow the identification and the calculation of all country specific information and data that are required to conduct SIAs on European level. The study's target therefore represents standardised modes for which input data should be available in most EU-countries; this means that the modes can either be directly used to generate the required data with regard to a certain country out of statistical data or they can easily be modified and adapted them to the country specific situation in terms of data availability.

The standardised data collection modes are developed in the course of the examplified assessment of the TTPC of Poland. In order to perform this assessment, there are three main objectives addressed through the study:

- The first objective is to identify and display the structure of the country specific TTPC of Poland.
- The study's second objective is to calculate the country specific values of volume flows.
- The third objective is to calculate the country and process specific values of the selected set of EFORWOOD forestry-wood chain sustainability indicators (EFORWOOD FWC SI).

However, the main results of the study are the detailed calculation modes, the calculated country and process specific values of the volume flows and of the EFORWOOD FWC SI. These values are presented with regard to the TTPC of Poland, but also with regard to the TTPCs of Lithuania, the Czech Republic and Hungary to which the developed standardised calculation modes have been applied; the values directly contribute to performing the SIA of the EU-FWC as they are input data for the Tool of Sustainability Impact Assessment (ToSIA).

While the calculated values reflect a momentary situation in the regarded countries, the calculation modes allow a relatively quick future adjustment of the volume flow and the SI values to situations changing in time.

4 MATERIALS AND METHODS

This chapter is subdivided into three main sections: In chapter 4.1 the basic prerequisites for the subsequent calculations and other methods of chapter 4.2 and chapter 4.3 are collected. Then, in chapter 4.2 the methods to identify the structure of the specific Polish technical timber production chain (TTPC) are described. Furthermore, the values of the volume flows, namely the process shares on country level and on the level of tree species, the process specific product shares and the required split ratios of certain output products, are calculated in chapter 4.2 (for definitions of process shares, product shares and split ratios see chapter 4.2, paragraph 1). All values calculated in chapter 4.2 are based on data provided through an EFISCEN-calculation. EFISCEN (European Forest Information Scenario Model) is an area-based matrix model for simulating amongst others the volume of thinning and final felling over time in age-class forests (ZELL, 2008: 13); the input data that are required for EFISCEN comprise data on area, growing stock volumes and increment per age-class, which are usually derived from national forest inventories (EFI, no date); output data of EFISCEN are amongst others data on developments of growing stock, increment, felling levels and age-class distribution over time (EFI, no date).

The country specific EFISCEN data on the felling volume per tree species are assumed to cover 60 – 80% of the timber volume flows (EFORWOOD, 2009: 12). Therefore, they are further assumed to be representative for the country specific timber volume flows. According to this it is assumed that the process shares, product shares and split ratios calculated in chapter 4.2 can be applied to data on the total country specific volume of felled and hauled timber as given in country specific forestry statistics.
Applying process shares, which are based on EFISCEN data, to data from national forestry statistics is necessary for preparing basic prerequisites of the calculations of the indicator values in chapter 4.3.
The chapter 4.3 is focussed on the calculation of the country and process specific values of a defined set of sustainability indicators (SI); the calculations are primarily based on data from country specific (in the case of the study: Polish) statistics and scientific publications. In many cases, statistics and scientific publications do not provide the required input data at all or not on the needed level of detail; in such cases either experts have been asked for guesses, or own assumptions have been made.

In chapter 4.2 and in chapter 4.3 the process of developing the calculation modes, which are finally used to calculate the required data on process shares, product shares, split ratios and sustainability indicators, is displayed according to the same tripartite structure for each target value specific type of calculation; the structure is based on the three questions *'What data is needed?'*, *'What data is already available?'* and *'Which calculation mode is necessary to get the needed data by using the data that is already available?'*:

According to these questions, the target values of the respective subsequent calculations are shortly defined in section A) *'Data to be collected'.* Then, in section B) *'Underlying information and assumptions'* all data, which are already available – either from national statistics, scientific publications, expert guesses or own assumptions –, are compiled and shortly described. Finally, in section C) *'Combining the information'* calculation modes are developed based on the information given in the respective section B) in order to allow the calculation of the target values according to section A).

According to this, section C) is usually started by giving the calculation identification code (VF_CALC <NUMBER> for **v**olume **f**low **calc**ulations, and IN_CALC <NUMBER> for sustainability **in**dicator value **calc**ulations) and a short headline as description of the adjacent calculation. It is then continued by giving a generalised scheme of the final detailed calculation mode; this final calculation mode is displayed in calculation tables; the generalised input parameters of the generalised scheme are marked by different colours to allow the recognition of the respective parts of the detailed calculation modes, which are marked by the same colours, in the calculation tables. Besides the detailed calculation mode, the calculation tables contain descriptions of all respective output parameters and of all required input parameters; the corresponding values as collected in section B) are added to these input parameter descriptions, together with further information on sources if the values are e.g. provided through other calculations of the study.

In some cases, however, the target values are captured directly from sources that are given in the corresponding section B); in these cases no calculation table is created.

It is emphasised, that the detailed calculation modes as displayed in the calculation tables are main part of the methodology to collect all data that have to be collected according to the objectives of the study given in chapter 3. It is further stressed that these calculation modes are at the same time amongst others the most important results of the study, although they are not displayed in the result chapter (chapter 5), where only the final calculation results in terms of process shares, product shares, split ratios and sustainability indicator (SI) values are presented in special **re**sult tables (RE_Tables). Those values, however, which are the results of calculations that are only performed as intermediate calculations providing input data for those calculations which provide final results in terms of process shares, product shares, split ratios and SI values are displayed in the respective subchapters of chapter 4 subsequent to the corresponding calculation modes; this applies to VF_CALC 6.1, VF_CALC 6.2, VF_CALC 6.3, VF_CALC 6.4, VF_CALC 11.1, VF_CALC 11.2, VF_CALC 11.3, VF_CALC 11.4, IN_CALC 1, IN_CALC 2, IN_CALC 7.1, IN_CALC 7.2, IN_CALC 12.1 and IN_CALC 12.2.

The names of the expert, who have been consulted in the course of this study, are encoded according to the scheme ‘E_<No.>’, e.g. E_5 or E_13; this encoding is performed to ensure the privacy of the experts. However, the Institute of Forest Utilisation and Work Science, Freiburg, is in receipt of a list to decode the expert codes, together with a brief protocol of the communication.

4.1 Basic Prerequisites and Information (EU25+2 Level)

4.1.1 Definition of Reference Year

The year 2005 is the reference year for displaying and analysing the current state of the European forestry-wood chain (EU-FWC). This means that all data which are required for this part of the EFORWOOD project are to be researched and calculated for the year 2005. The reference year is chosen to allow of the comparableness of country specific FWCs by generating a standard for all EFORWOOD partner organisations; additionally, the fact that all country specific FWC structure information and country and process specific indicator values refer to the year 2005 allows linking the country specific FWCs in order to display and analyse the complete EU-FWC.

4.1.2 Definition of Country Groups

When forming the framework for the analysis of the EU-FWC in the state of 2005 during the EFORWOOD-week in Bordeaux in 2008 (EFORWOOD, 2008a: 1 – 2) it was assumed that for some countries not all data that are necessary for the project's success would be available or accessible. For other countries, however, it was expected that all of the data would be available.

Therefore, to ensure that it would nonetheless be possible to calculate all required data on volume flows and all required indicator values for all regarded EU25+2 countries, the countries have been assorted to five country groups with regard to the technical timber production chain (TTPC) (see table 4.1-1 and figure 4.1).

***Table 4.1-1**: Definition of country groups (EFORWOOD, 2008a: 1 – 2)*

Country-group	Assorted countries	Key-country
Central Europe (CEU)	Austria, Belgium, Denmark, France, Germany, Italy, Luxemburg, Netherlands, Switzerland	Germany
Northern Europe (NEU)	Estonia, Finland, Ireland, Great Britain, Norway, Sweden	Sweden
Southern Europe (SEU)	Cyprus, Greece, Malta	Greece
Eastern Europe (EEU)	Czech Republic, Hungary, Latvia, Lithuania, Poland, Slovakia, Slovenia	Poland
IBERIA	Portugal, Spain	Spain

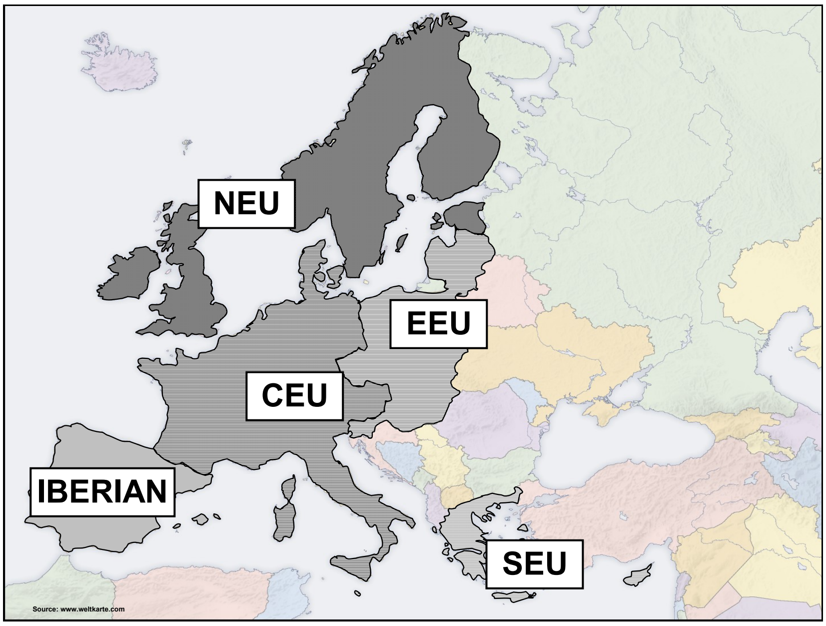

***Figure 4.1**: Map of country groups (source of background map: WELTKARTE.COM, 2009)*

The pooling of the countries has been conducted with regard to different aspects. These facets are the affiliation to a certain biogeographical province, the comparableness in the tree species composition, the comparableness in the structure of the TTPC and the comparableness in the level of mechanisation of the processes of timber felling and timber hauling.

Furthermore, one ‘key-country’ was selected for each of these country groups by project partners during the EFORWOOD-week in Bordeaux in 2008, assuming that all required data would be available for this one country (EFORWOOD, 2008a: 1 – 2). As a rule of the data collection for the EU-FWC it has been decided, that in case certain information cannot be found for a certain country, the needed values are to be collected from the key-country of the respective country group.
Poland, Lithuania, the Czech Republic and Hungary belong to the country group ‘Eastern Europe (EEU)’, where Poland is defined as key-country (see table 4.1-1).

The key-country rule has been amended with regard to this study in order to secure the complete collection of all required data on volume flows and of all required indicator values: In case that even the key-country does not provide the needed data, the data are taken from another country of the EEU. If even no other EEU country does provide the required data, the data are taken from a country of the group ‘Central Europe (CEU)’.

4.1.3 Selection of a Representative Set of Tree Species per Country

In Bordeaux during the EFORWOOD-week in 2008, EFORWOOD partners who are responsible for forest management and silviculture within the project (project module 2) presented for standardisation purpose a list of tree species that are considered to be representative for the EU-FWC, as these species are supposed to cover 60 – 80% of the volume flow of felled timber within the EU25+2. The species are beech, birch, eucalypt, oak, pine and spruce (EFORWOOD, 2008a: 2 – 3).

The partners further allocated certain species out of this list to each country of the EU25+2, with the objective to compile a specific set of tree species in each case, that, again, is supposed to be representative for the volume flow of felled timber in the respective country. For Poland the selected set of tree species consists of spruce, pine, oak, beech and birch, while it is spruce, pine, oak and beech for the Czech Republic, spruce, pine and oak for Lithuania and oak for Hungary, as compiled in table 4.1-2 (EFORWOOD, 2008a: 2 – 3).

Table 4.1-2: *Selected tree species per country (EFORWOOD, 2008a: 2 – 3)*

Country	Selected tree species
Poland	spruce, pine, oak, beech, birch
Lithuania	spruce, pine, oak
Czech Republic	spruce, pine, oak, beech
Hungary	oak

4.1.4 Volume of Timber Felled per Species in 2005

For each selected tree species, Alterra (2008.xls) provides the volume of timber felled per country in the year 2005. The values were generated by means of an EFISCEN-simulation (Eforwood, 2008a: 3) in November 2008.

Alterra (2008.xls) supplies the EFISCEN-values in $1000m^3_{ob}$ per 5 years, as the values of the years 2001 to 2005 are accumulated. By dividing these data by 5 the 2005-values that will be used in further calculations in the course of this study are obtained. The data for Poland, are compiled in table 4.1-3:

Table 4.1-3: *Volume of timber excl. harvest residues (HR), felled in Poland in the year 2005 as provided by* Alterra (2008.xls*) on the basis of EFISCEN*

Country	Species	Volume of timber excl. HR, felled in 2005 (EFISCEN) [$1000m^3_{ob}$/5a]	Volume of timber excl. HR, felled in 2005 [$1000m^3_{ob}$/a]	Volume of timber excl. HR felled in 2005 in % of total [%]
Poland	Spruce	18335.2320	3667.0464	11.43
	Pine	113949.2560	22789.8512	71.03
	Oak	9026.2869	1805.2574	5.63
	Beech	10928.1918	2185.6384	6.81
	Birch	8185.8325	1637.1665	5.10
		TOTAL	**32084.9599**	**100.00**

4.1.5 Selection of Possibly Relevant Processes

Based on discussions during the EFORWOOD-workshop on displaying the EU-FWC in Prague (24 – 26 Sept 2008) 12 standardised processes as possibly relevant elements to display the structure of the technical timber production chain (TTPC) are determined (see table 4.1-4). The selected processes in table 4.1-4 are allocated to three stages of production, namely ‘felling’, ‘hauling’, and ‘other’. Furthermore, each process is given an identification code.

Table 4.1-4: *Standardised processes that are possibly relevant to the country specific TTPCs*

Stage of production	Name of process	Identification code of process
Felling	**Thinning** with chainsaw	**TC**
	Thinning with medium-sized harvester	**TH**
	Selective logging with chainsaw	**SC**
	Selective logging with medium-sized harvester	**SH**
	Clearcut with chainsaw	**CC**
	Clearcut with medium-sized harvester	**CH**
Hauling	**Hauling** with medium-sized skidder	**SKI**
	Hauling with medium-sized forwarder	**FOR**
	Hauling with horse	**HOR**
	Hauling with cable crane	**CRA**
Other	**Bundling**	**BUN**
	Chipping	**CHI**

The processes TC, TH, SC, SH, CC, CH, SKI and FOR are standardised in terms of the type of machines that are in use in the respective process according to EFORWOOD (2008b: 4 – 5):
In the processes TH, SH and CH, the operating harvesters are represented by a fictitious medium-sized harvester, which averages an *HSM 405 H1*-, a *Valmet 911*-, a *JD 1070*- and a *Rottne H 14*-harvester in terms of the technical specifications.
The forwarder or the forwarding trailer in combination with an agricultural tractor in the process FOR is – for standardisation purpose – represented by a medium-sized forwarder, which averages an *HSM 208 F 12to*-, a *Valmet 840*-, a *JD 1110*-, a *Ponsse Wisent*- and a *Ponsse Gazelle*-forwarder.
In the process SKI the typically used skidders and agricultural tractors are represented by an imaginary medium-sized skidder averaging the skidders *HSM 805*, *JD 548 G-III*, *Welte W 150* and *CAT 515*.

On consultation with E_2 (6 Feb 2009) for Poland hauling with forwarder and hauling with tractor in combination with a forwarding trailer are subsumed in the process FOR. Likewise, hauling with skidder and hauling with agricultural tractor in combination with a winch are assorted in the process SKI. This approach is due to the fact that Polish forestry statistics usually distinguish only between forwarding, where the timber is not touching the ground when being hauled, and skidding, where the timber is dragged on the ground (E_2, 6 Feb 2009).

A fictitious chainsaw that averages a *Stihl 036 W*- and a *Husqvarna 371 XPG*-chainsaw is taken for the processes TC, SC and CC as proposed in FVA (2008.xls).

4.1.6 SELECTION OF POSSIBLY RELEVANT PRODUCTS

Based on discussions during the EFORWOOD-workshop on displaying the EU-FWC in Prague (24 – 26 Sept 2008) and during the EFORWOOD-meeting on the EU-FWC in Helsinki (12 – 13 Jan 2009) standardised output products and their nomenclature are defined. The output products of the felling and hauling processes are assigned to three categories:

- Short logs, which are 6 m or shorter as defined in accordance with E_3 (13 Jan 2009)
- Long logs, which are longer than 6 m as defined in accordance with E_3 (13 Jan 2009)
- Harvest Residues (HR), which are the entirety of all accruing timber wastes from felling process, including branches, tree tips, brushwood and unutilised pieces of wood over 7cm in diameter at smaller end. Not included is underground biomass like root stocks. Considering the data given by the DIW (1999), the arithmetic mean proportion of HR in the total volume of timber incl. HR is 32% in coniferous species and 36.4% in broadleaved species.

The output product category of the process BUN is ‘bundles’ and of the process CHI is ‘chips’.

Each single output product is further specified by the name of the tree species and by the name of the process where the product originates from. This means that the designation of each product is constituted as

<TREE SPECIES> _ <CATEGORY of PRODUCT> after <PROCESS IDENTIFICATION CODE>

According to this pattern, the output products e.g. of the process CC in Poland would be:

- Oak_Short roundwood after CC
- Oak_Long roundwood after CC
- Oak_Harvest residues after CC
- Pine_Short roundwood after CC
- Pine_Long roundwood after CC
- Pine_Harvest residues after CC
- Spruce_Short roundwood after CC
- Spruce_Long roundwood after CC
- etc.

4.1.7 DEFINITION OF THE SET OF EFORWOOD FWC SUSTAINABILITY INDICATORS

With ToSIA the impact of the entire forestry-wood chain (FWC) on sustainability is to be assessed in a holistic approach. Hence, the applied set of sustainability indicators (SI) needs to reflect all characteristics which are revelant for capturing the sustainability impact of all processes of the FWC (EFORWOOD, 2006a: 5).
According to EFORWOOD (2006a: 17) the applied set of SI has to meet three criteria: Firstly, they have to cover all three pillars of sustainability. Secondly, the expenditure of time for the collection of the SI values has to be reasonable. Thirdly, the set of SI needs to cover all relevant project scales, from European to national and regional scale within the FWC. Finally, the expenses in terms of money for collecting the SI values should be equitable.

To ensure the political acceptance the set of EFORWOOD FWC SI has been developed on the base of already existing indicator sets such as SDI-Eurostat, CSD, MCPFE and PAIS. For a detailed description of these indicator sets, see EFORWOOD (2006a: 13 – 14).

As a result of several discussions during EFORWOOD meetings, a joint list of relevant SI has been developed (EFORWOOD, 2006b). This list has then been further specified to a set of SI which are proposed to be applied to the EU-FWC.
This set of SI indicators, which has then also been chosen to be applied to the technical timber production chains (TTPCs) of Poland, is displayed in table 4.1-5. Within table 4.1-5 the indicator names are displayed together with the corresponding indicator identification codes and the indicator specific measurement units as given in EFORWOOD (2008d); in the sixth column of the table, the pages within EFORWOOD (2008d), where the corresponding indicator is defined, are given; furthermore, the mode of the indicator value collection and the corresponding calculation identification number are given in the table columns 4 and 5 for each indicator:

Table 4.1-5: *Set of EFORWOOD FWC SI, as applied to the TTPC*

1	2	3	4	5	6
EFORWOOD Indicator ID:	**Full Name of Indicator (including subclasses):**	**Measurement Unit:**	**Mode of Collection:**	**IN_CALC-No.:**	**Def. (EFORW., 2008d):**
1	**Gross value added (GVA) at factor cost and contribution to gross domestic production**				
1.1	Gross value added (at factor cost) by processes	€/m^3_{ub}	Calculation	4	pp.10-20
2	**Average production cost and share of cost of wood-based materials**				
2.1.1	Raw material from FWC	€/m^3_{ub}	Calculation	5	pp.21-23
2.1.2	Raw material from outside FWC	€/m^3_{ub}	Calculation	---	pp.21-23
2.1.3	Labour	€/m^3_{ub}	Calculation	6	pp.21-23
2.1.4	Energy	€/m^3_{ub}	Calculation	7	pp.21-23
2.1.5	Other productive costs	€/m^3_{ub}	Calculation	8	pp.21-23
2.1.6	Non-productive costs	€/m^3_{ub}	Calculation	9	pp.21-23
10	**Number of persons employed in total and gender**				
10.1	Number of persons employed in total	#/m^3_{ub}	Calculation	10	pp.38-39
11	**Wages and salaries (gross earnings)**				
11.1	Average wages and salaries: Average (male & female)	€/m^3_{ub}	Calculation	11	pp.40-43
11.2.1	Average wages and salaries per employee: Relative to country average	%	Calculation	12	pp.40-43
11.2.2	Average wages and salaries per employee: Weighted by purchasing power parity	%	Calculation	13	pp.40-43
18	**On-site energy generation (from renewables) and energy use classified by origin including the share of self-sufficiency**				
18.2.2.1	Direct fuel use: Renewable fuel	kWh/m^3_{ub}	Calculation	14	pp.58-61
18.2.2.2	Direct fuel use: Fossil fuel	kWh/m^3_{ub}	Calculation	15	pp.58-61
19	**Greenhouse gas emissions and carbon stock**				
19.1	Greenhouse gas emissions in total	kg CO_2e/m^3_{ub}	Calculation	---	pp.62-67
19.1.1	Greenhouse gas emissions from machinery	kg COe/m^3_{ub}	Calculation	16	pp.62-67
19.1.2	Greenhouse gas emissions from wood combustion	kg CO_2e/m^3_{ub}	Calculation	---	pp.62-67
27	**Generation of waste: total, hazardous, and categorised by type of waste management**				
27.1.1	Generation of waste: Not classified as hazardous waste	kg/m^3_{ub}	Calculation	17	pp.90-93
27.1.2	Generation of waste: Classified as hazardous waste	kg/m^3_{ub}	Calculation	18	pp.90-93
27.2.1	Waste management: Waste to reuse or material recycling	kg/m^3_{ub}	Calculation	19	pp.90-93
27.2.2	Waste management: Waste to incineration	kg/m^3_{ub}	Calculation	20	pp.90-93
27.2.3	Waste management: Waste to landfill	kg/m^3_{ub}	Calculation	21	pp.90-93

4.2 IDENTIFICATION OF THE STRUCTURE AND CALCULATION OF THE VOLUME FLOWS OF THE TECHNICAL TIMBER PRODUCTION CHAIN (TTPC)

The first step to implement this study is the identification and the displaying of the country specific structure of the TTPC. Besides the information on which processes are actually part of the country specific TTPC it is needed to know three main characteristics to describe the TTPC on a high level of detail (EFORWOOD, 2008e: 2 – 7):

- The share of each single process in the country specific total volume of timber felled and hauled respectively, and the share of each single process in the volume of timber felled and hauled respectively per tree species (**process share**).
- The share of each product in the total volume of the output of a certain process (**product share**).
- The ratio according to which a certain output product is split to be further processed in different subsequent processes (**split ratio**). In the context of this study the split ratio describes the ratio by which different hauling processes continue to process a certain output product of a certain felling process.

However, to a far extend it is not possible to directly detect the structure, the process shares, the product shares and the split ratios of the country specific TTPC from national statistics. This is because the sources either do not provide this type of data at all or they do not supply the data on the needed level of detail. A further reason is that the data are often not for free.

Due to these facts, experts on forest utilisation from the respective countries have been consulted. Aiming to collect all needed data in a compact way and at the same time to minimise the expenditure for the supportive experts, questionnaires and templates have been devolved and sent to the experts.

When choosing capable experts as possible facilitators the first intention was to minimise the risk of getting no response (and hereby of loosing time) by picking out a relatively high number of experts who are engaged at different universities or other research institutions. The process of choosing experts on forest utilisation or forest management in the respective country was conducted in several succeeding steps:
Firstly, it was explored whether there are appropriate experts obliged to EFORWOOD as project partners. This applies only to E_4.

Secondly, further persons have been identified as possibly appropriate experts by searching the web pages of forestry research institutes, of forestry departments of universities, and of ministerial forestry departments, and by using the network of the Faculty of Forest and Environmental Sciences in Freiburg.

Questionnaire to Collect Information on Structure, Process Shares, Product Shares and Split Ratios of the TTPC

A questionnaire which contains closed questions that would not allow different interpretations was developed as displayed in the figures 4.2-1 (part 1) and 4.2-2 (part 2) using the example of Poland. The questions were couched in a way that would allow the simultaneous collection of information which was needed to identify of the structure and for the calculation of the process shares, the product shares and the split ratios.

What are the shares [guess in %] of relevant harvest-/hauling-processes in the total amount of harvested timber of a certain tree species?

EXAMPLES: How much of the total volume of spruce-timber is felled in thinning with chainsaw/in thinning with harvester/in selective logging with chainsaw/etc.? How much of the total volume of harvested beech-timber is hauled with skidder/with forwarder/with horse?

Process \ Species		*Spruce*	*Pine*	*Beech*	*Birch*	*Oak*
FELLING	***Thinning*** *with chainsaw*					
	Thinning *with harvester*					
	Selective *logging with chainsaw*					
	Clearcut *with chainsaw*					
	Clearcut *with harvester*					
	SUM	*100%*	*100%*	*100%*	*100%*	*100%*
HAULING	***Hauling*** *with skidder/ skidding with tractor*					
	Hauling *with forwarder/ tractor with forwarding-trailer*					
	Hauling *with horse*					
	SUM	*100%*	*100%*	*100%*	*100%*	*100%*

Figure 4.2-1: *Questionnaire (part 1) to collect expert statements on process shares per tree species in the Polish TTPC*

What are the shares [guess in %] of short roundwood [≤ 6m] and long roundwood [> 6m] of a certain tree species in the processes of thinning, selective logging and clearcut with chainsaw?

EXAMPLES: How much of the spruce-timber harvested in thinning is sorted as short roundwood/as long roundwood? How much of the beech-timber harvested in selective logging is sorted as short roundwood/as long roundwood?

Species / Process	Spruce		Pine		Beech		Birch		Oak	
	Short	*Long*	*Short*	*Long*	*Short*	*Long*	*Short*	*Long*	*Short*	*Long*
Thinning										
	100%		***100%***		***100%***		***100%***		***100%***	
Selective logging										
	100%		***100%***		***100%***		***100%***		***100%***	
Clearcut										
	100%		***100%***		***100%***		***100%***		***100%***	

Figure 4.2-2: *Questionnaire (part 2) to collect expert statements on product shares per tree species in the Polish TTPC*

Before sending the questionnaire to the experts, telephone calls were conducted to create a personal link to the experts. In one-to-one telephone conversations the addressed experts were informed about the background of the request. Then, they were asked if they were willing to support the study, usually with the remark that it would be possible compensate for arising costs. The questionnaire was then only sent to those experts, who were willing to provide the requested information.

The telephone conversations were additionally used to adapt the questionnaire as exactly as possible to the actual structure of the country specific TTPCs. Those processes that the experts regarded as irrelevant for displaying the specific TTPC, were not included in the questionnaire. The aim of this procedure was to create the request as stringent as possible and to minimise the later expenditure of time for the experts. The questionnaire was further adapted to the country specific set of representative tree species.

With regard to Poland experts (E_2 and E_5) stated in the one-to-one telephone conversations that CHI does not significantly contribute to the total volume flow of timber in the respective country. This is why Polish statistics do not provide sufficient data on the process of chipping. Thus, the process of chipping is not further regarded in this study in terms of the calculation of indicator values. However, the volume of harvest residues (HR) which is extracted from the forest stands in order to be chipped is considered in the calculation of split ratios, and in the calculation of the process shares and product shares of the hauling processes.

Additionally, no HR were bundled in Poland in 2005. Furthermore, the process of CRA is irrelevant for the year 2005 according to the experts. Therefore, the processes BUN and CRA are not further regarded in the course of this study.

The Polish experts, who actually received the questionnaire via e-mail, are E_2, E_4, E_5 and E_8.

While comprehensive information on the Lithuanian, Czech and Hungarian TTPC has been available before 15 March 2009, the data availability with regard to the Polish TTPC has been insufficient until this date. 15 March 2009 had been decided to be the deadline for the collection of data on the TTPC structure.
Therefore, the calculations with regard to the Polish TTPC are based on own assumptions and on rare data from different Polish statistics.

4.2.1 IDENTIFICATION AND DISPLAY OF THE TTPC STRUCTURE BASED ON EXPERT SURVEYS AND ON FURTHER INFORMATION

In the case of Poland it was impossible to base the identification of the structure of the technical timber production chain (TTPC) on a single source. Instead, it became rather necessary to take several different sources into consideration:

A) Data to be collected:

All processes that were relevant in Poland in 2005 are to be identified, using information provided by the Polish State Forests National Forest Holding and by several Polish experts on the country's forestry. Afterwards, the structure of the Polish TTPC is to be displayed as an 'Event-driven Process Chain' through the ARIS-Business Architect.

B) Underlying information and assumptions:

(1) THE POLISH STATE FORESTS NATIONAL FOREST HOLDING (2006: 49) names six types of felling that were relevant in the Polish state forests in the year 2005:

- sanitation cutting (cleaning, thinning)
- clear-felling
- complex felling
- incidental intermediate cutting
- incidental cuttings in final felling
- other cutting

On consultation with E_2 (06 Feb 2009) these felling types are assorted to the standardised categories of felling processes as given in table 4.1-4: 'sanitation cutting (cleaning, thinning)' will be regarded as **thinning** in the further course of this study, 'clear-felling' will be regarded as **clearcut**, and 'complex felling', 'incidental intermediate cutting', 'incidental cuttings in final felling' and 'other cutting' will be subsumed under **selective logging**.

(2) According to JODLOWSKI et al. (2004: 7) hauling was conducted by using skidders or agricultural tractors, by means of forwarders or forwarding trailers in combination with tractors, and by using horses in 2004. Assumedly, the situation did not differ significantly in 2005, as there had probably been no considerable change in the level of mechanisation according to PASCHALIS-JAKUBOWICZ, 2004: 7.

(3) On consultation with E_2 (06 Feb 2009) it is assumed that harvesters are neither used in thinning nor in selective logging.

C) Combining the information:

Based on B(1), B(2) and B(3) seven felling and hauling processes are identified to be relevant in Poland (PL) in the year 2005: Regarding B(1) the assumption B(3) reveals TC, SC, CC and CH as considerable processes of timber felling. B(2) enables to identify SKI, FOR and HOR as relevant hauling processes. All relevant felling and hauling processes are compiled in table 4.2-1 (to decode the process identification codes see table 4.1-4):

Table 4.2-1: *Relevant processes of the TTPC in Poland*

Stage of Production	Process Identification Code
Felling	TC
	SC
	CC
	CH
Hauling	SKI
	FOR
	HOR

The structure of the Polish TTPC has then been displayed by creating an 'Event-driven Process Chain' using the ARIS-Business Architect. For the results see chapter 5.1.1.

4.2.2 Calculation of Process Shares Based on Expert Surveys and on Further Information

A) <u>Data to be collected</u>:

In section C of this chapter, firstly the share of each felling and hauling process in the total volume of timber felled and hauled respectively in Poland in 2005 is calculated or captured directly from statistics. Secondly, the share of each felling and hauling process in the volume of timber felled and hauled per each selected tree species is calculated or captured directly from statistics based on the information and assumptions given in section B.

The process shares enable to describe the technical timber production chain (TTPC) on a high level of detail. Primarily, however, they are essential to calculate the product shares, the split ratios and the indicator values.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> The Polish State Forests National Forest Holding (2006) provides statistical data on the proportion of different types of felling processes in the total volume of timber felled in the Polish state forests in 2005 (see figure 4.2-3).

According to figure 4.2.-3 and to the assumptions made in chapter 4.2.1, section B(1), it is supposed that 43.2% of the timber harvested in 2005 originates from TC, 36.9% from SC and 19.9% from CC and CH.

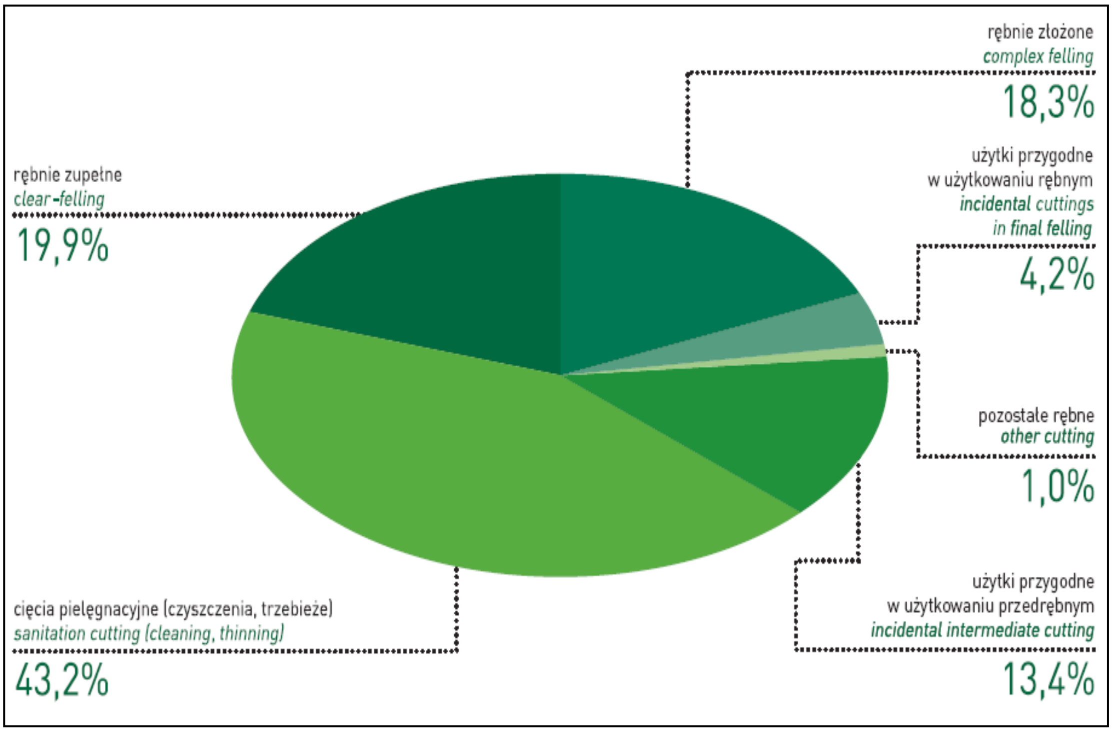

Figure 4.2-3: *"Volume of harvest of merchantable timber in the State Forest by category of utilisation" (*THE STATE FORESTS NATIONAL FOREST HOLDING 2006: 49)

(2) JODLOWSKI et al. (2004: 7) state for the year 2004 that 99% of timber was felled by using chainsaws, and that 1% of felling was conducted by using harvesters. This ratio is verified by PASCHALIS-JAKUBOWICZ (2004: 7).

(3) Assumedly, the 2005-level of mechanisation does not differ significantly from the level in 2004; therefore, the share of a certain process is regarded to be the same in 2005 as in 2004. This assessment is based on JODLOWSKI et al. (2004: 8) who states that more "[…] advanced technology is entering [the] Polish forest [sic] very slowly".

PASCHALIS-JAKUBOWICZ (2004: 7) provides several reasons for this situation: private forest enterprises, which conduct 95% of the felling and hauling of timber, are usually very small (≤ 5 employees) and their economic potential is low. They have only little own funds, "limited access to a capital market, shortage of information and difficulties with processing information" (PASCHALIS-JAKUBOWICZ (2004: 8). Due to these aspects, the enterprises have only "limited ability to invest in high-technology" (PASCHALIS-JAKUBOWICZ (2004: 8).

(4) It is assumed that not all of the processes that are relevant to the Polish TTPC in general (as displayed in Table 4.2-4) are relevant with regard to each tree species: As no respective data from Polish statistics are available, this assumption is made with regard to the data on the Lithuanian TTPC, assuming that the situation in Lithuania is similar to the situation in Poland.
According to this, it is assumed that the processes SC and CH are not conducted in broadleaved stands. Therefore, broadleaved timber originates only from TC and CC, while the felling processes for coniferous species are TC, SC, CC and CH.

(5) For beech, oak and birch no data on the specific process shares of felling processes are available. Therefore, several assumptions and expert guesses are taken into account:
According to E_2 (06 Feb 2009) birch timber is usually felled as a by-product of the felling of other species, mainly pine. Therefore, 75% of birch is supposedly felled in an immature state (i.e. felling in TC), while only 25% of birch timber originates from final felling operations (namely CC).
It is further assumed that there is no significant difference in the felling regimes for beech and oak, i.e. the process shares of TC and CC respectively are regarded to be identical for both species. Again, as no respective data from Polish statistics are available, this assumption is made with regard to the data on the Lithuanian TTPC, assuming that the situation in Lithuania is similar to the situation in Poland.
Due to a lack of data from Poland, the process shares for TC and CC in beech and oak are derived from the respective process shares of Lithuania, Hungary and the Czech Republic as arithmetic mean, with regard to the assumption that there is no significant difference between the felling regimes for beech and oak. The process shares for TC and CC in beech and oak of Lithuania, which are 3% and 97% respectively, are provided by E_1 (29 Jan 2009). E_9 (20 Feb 2009) provides the respective process shares for Hungary (TC 35% and CC 65%) and for the Czech Republic (TC 25% and CC 75%) as an expert guess.

(6) Due to a lack of data it is assumed that there is no significant difference in the felling regimes for spruce and pine. I.e. the process shares for all felling processes are regarded to be the same for spruce and pine.

(7) Furthermore, JODLOWSKI (2007) estimates for the year 2005 that 80% of the felled timber was hauled by the use of skidders and agricultural tractors, 5% by using forwarders and forwarding trailers in combination with tractors and 15% by means of horses. As no more detailed information is available this ratio is assumed to be valid for all tree species.

(8) The total volume of timber harvested in 2005 per species of the representative set of tree species is provided by ALTERRA (2008.xls) (see table 4.1-3).

C) Combining the information:

The calculation of the process shares of the Polish TTPC is subdivided into four parts, namely VF_CALC 1, VF_CALC 2, VF_CALC 3 and VF_CALC 4. Furthermore, VF_CALC 1 and VF_CALC 2 are further subdivided.

The process shares of TC, SC, CC and CH in the total volume of timber incl. harvest residues (HR) that was felled in Poland in 2005 are either captured directly from section B or calculated as shown in VF_CALC 1; the process shares of TC, SC, CC and CH in the volume of timber incl. HR that was felled per tree species are also either captured directly from section B or calculated as shown in VF_CALC 2. The process shares of SKI, FOR and HOR in the total volume of timber incl. HR that was hauled in Poland in 2005 are captured directly from section B as shown in VF_CALC 3; the process shares of the SKI, FOR and HOR in the volume of timber incl. HR that was hauled per tree species are also directly captured from section B as shown in VF_CALC 4.

The results of VF_CALC 1, VF_CALC 2, VF_CALC 3 and VF_CALC 4, which are final results of the calculations, are displayed in chapter 5.2.1.1; while the process shares in the total volume of timber felled or hauled respectively in Poland in 2005 are displayed in RE_table 1, the process shares in the volume of timber felled or hauled respectively per tree species are displayed in RE_table 2.

VF_CALC 1:

<u>Calculation or direct capture of the process share of each felling process in the total volume of timber felled in Poland (PL) in 2005</u>:

• **Process share of <u>TC and SC in the total volume of timber felled in 2005</u>** (VF_CALC 1a)**:**

The process shares of TC and SC in the total volume of timber felled in 2005 are captured directly from B(1); therefore no calculation table is required. The process shares are 43.2% of TC and 36.9% of SC.

The process shares of TC and SC in the total volume of timber felled in 2005 are displayed in RE_Table 1 in chapter 5.2.1.1.

• **Process share of <u>CC in the total volume of timber felled in 2005</u>** (VF_CALC 1b)**:**

The process share of CC is calculated in consideration of B(1) and B(2) according to the calculation scheme

(proportion of clearcut processes in the total volume of timber felled in 2005) – (proportion of felling processes with harvesters in the total volume of timber felled in 2005).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(CC)	process share of CC in the total volume of timber felled in 2005	RE_Table 1	%	
Given parameters				
a	proportion of clearcut processes in the total volume of timber felled in 2005	19.9	%	B(1)
b	proportion of felling processes with harvesters in the total volume of timber felled in 2005	1	%	B(2)
Calculation mode				
→ x(CC) = a – b				

The process share of CC in the total volume of timber felled in 2005 is displayed in RE_Table 1 in chapter 5.2.1.1.

• **Process share of <u>CH in the total volume of timber felled in 2005</u>**
(VF_CALC 1c**):**
The process share of CH in the total volume of timber felled in 2005 is captured directly; therefore no calculation table is required: As the only felling process where harvesters are used is CH, and as 1% of the timber was felled with harvesters (B(2)) in 2004, the process share of CH is 1% in 2005 in consideration of B(3).
The process share of CH in the total volume of timber felled in 2005 is displayed in RE_Table 1 in chapter 5.2.1.1.

VF_CALC 2:
<u>Calculation or direct capture of the process share of each felling process in the volume of timber felled per species in Poland (PL) in 2005</u>:

• **Process share of <u>TC and CC for birch</u>**
(VF_CALC 2a**):**
With regard to B(4) the processes affecting birch are TC and CC. The process shares of these two processes in the volume of felled birch timber are captured directly from B(5); therefore no calculation table is required. The process shares are 75% of TC and 25% of SC.
The process shares of TC and SC in the volume of felled birch timber are displayed in RE_Table 5 in chapter 5.2.1.1.

• **Process share of <u>TC and CC for beech and oak</u>**
(VF_CALC 2b**):**
The process shares of TC and CC regarding felled beech and oak timber are calculated in consideration of B(5) according to the generalised calculation scheme
[(process share of process x for oak/beech in LT) + (process share of process x for oak/beech in HU) + (process share of process x for oak/beech in CZ)] / 3.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	process share of TC for beech and oak	RE_Table 5	%	
x(CC)	process share of CC for beech and oak	RE_Table 5	%	

Given parameters				
a	process share of TC for oak in LT	3	%	B(5)
b	process share of TC for oak in HU	35	%	B(5)
c	process share of TC for oak in the CZ	25	%	B(5)
d	process share of CC for oak in LT	97	%	B(5)
e	process share of CC for oak in HU	65	%	B(5)
f	process share of CC for oak in the CZ	75	%	B(5)
Calculation mode				
→ x(TC) = (a + b + c) / 3 → x(CC) = (d + e + f) / 3				

The process shares of TC and CC in the volume of felled beech and oak timber are displayed in RE_Table 5 in chapter 5.2.1.1.

• **Process share of <u>TC, SC, CC and CH for spruce and pine</u>** (VF_CALC 2c)**:**

According to B(6) the process shares of felling processes are the same with regard to spruce and pine; the relevant felling processes are TC, SC, CC and CH as stated in B(4). The process shares of TC, SC, CC and CH are calculated according to the generalised scheme

*[(volume of spruce timber excl. HR, felled in process x regarding EFISCEN) / (total volume of spruce timber excl. HR, felled in 2005 regarding EFISCEN)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	process share of TC for spruce and pine	RE_Table 5	%	
x(SC)	process share of SC for spruce and pine	RE_Table 5	%	
x(CC)	process share of CC for spruce and pine	RE_Table 5	%	
x(CH)	process share of CH for spruce and pine	RE_Table 5	%	
Given parameters				
a	process share of TC in the total volume of timber felled in 2005	43.20	%	VF_CALC 1a
b	process share of SC in the total volume of timber felled in 2005	36.90	%	VF_CALC 1a
c	process share of CC in the total volume of timber felled in 2005	18.90	%	VF_CALC 1b
d	process share of CH in the total volume of timber felled in 2005	1.00	%	VF_CALC 1c
e	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	B(8), Table 4.1-3

f	process share of TC for beech	21	%	VF_CALC 2b
g	process share of TC for oak	21	%	VF_CALC 2b
h	process share of TC for birch	75	%	VF_CALC 2a
i	process share of CC for beech	79	%	VF_CALC 2b
j	process share of CC for oak	79	%	VF_CALC 2b
k	process share of CC for birch	25	%	VF_CALC 2a
l	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3_{ob}$	B(8), Table 4.1-3
m	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	B(8), Table 4.1-3
n	volume of beech timber excl. HR, felled in 2005 (EFISCEN)	2185.6384	$1000m^3_{ob}$	B(8), Table 4.1-3
o	volume of oak timber excl. HR, felled in 2005 (EFISCEN)	1805.2574	$1000m^3_{ob}$	B(8), Table 4.1-3
p	volume of birch timber excl. HR, felled in 2005 (EFISCEN)	1637.1665	$1000m^3_{ob}$	B(8), Table 4.1-3
Calculation mode				
→ x(TC) = {{(a*e – f*n – g*o – h*p) * [l / (l + m)]} / l} * 100 → x(SC) = {{b*e * [(l / (l + m)]} / l} * 100 → x(CC) = {{(c*e – i*n – j*o – k*p) * [l / (l + m)]} / l} * 100 → x(CH) = {{d*e * [(l / (l + m)]} / l} * 100				

The process shares of TC, SC, CC and CH in the volume of felled spruce and pine timber are displayed in RE_Table 5 in chapter 5.2.1.1.

VF_CALC 3:

<u>Direct capture of the process share of each hauling process in the total volume of timber hauled in Poland in 2005</u>:

The process shares of SKI, FOR and HOR in the total volume of timber hauled in 2005 are captured directly from B(7); therefore no calculation table is required. The process shares are 80% for SKI, 5% for FOR and 15% for HOR.

The process shares of SKI, FOR and HOR in the volume of timber hauled in Poland in 2005 are displayed in RE_Table 1 in chapter 5.2.1.1.

VF_CALC 4:

Direct capture of the process share of each hauling process in the volume of timber hauled per species in Poland in 2005:

The process shares for SKI, FOR and HOR are identical for all tree species considering B(7). The process shares are captured directly from B(7); therefore, no calculation table is required. The process shares are 80% for SKI, 5% for FOR and 15% for HOR.

The process shares of SKI, FOR and HOR in the volume of timber hauled per tree species in Poland in 2005 are displayed in RE_Table 5 in chapter 5.2.1.1.

4.2.3 Calculation of Product Shares Based on Expert Surveys and on Further Information

A) Data to be collected:

A further characteristic that allows for a very detailed description of the technical timber production chain are the process shares of the output products per regarded process.
In the course of this chapter it is aimed to calculate the product share of each output product in the total output volume of each felling and hauling process: as described in chapter 4.1.6 the products are assorted to the categories of short logs, long logs and harvest residues (HR); to obtain the product shares the proportion of each species specific product category is calculated for each felling and hauling process for which the product is relevant.

B) Underlying information and assumptions:

(1) In Poland the "long wood method is still prevailing" (Jodlowski et al., 2004: 8). According to Jodlowski (2007: 6), 30% of the timber excl. HR, which was felled in Poland in 2005, was sorted as short logs, while 70% of the timber was sorted as long logs.

(2) The ratio of long logs versus short logs in the volume of timber excl. HR per species and per felling process is essential to calculate the product shares. However, these data could not be collected from statistics, although high time expenditure was put into research. This is why extensive assumptions are made:

- The ratio of the volume of long logs versus the volume of short logs in total volume of timber felled is mainly dependent on the felling method and on the stage of development of the forest stand.
- Due to the fact that the "long wood method is […] prevailing" (Jodlowski et al., 2004: 8) it is assumed that the felled timber is is not cut to length, but sorted as long logs whenever the dimension of the tree allows it.
- In thinning with chainsaw (TC) a high proportion of timber of small dimensions accrues; most of the merchantable timber felled in TC is therefore sorted as short logs. The ratio is assumedly 55% versus 45% of short logs and long logs respectively.
- In selective logging (SC) mature trees with relatively large dimensions are selected and felled. The proportion of long logs in the volume of felled timber excl. HR is therefore high and assumedly equates 95%, whereas short logs account for 5%.

- It is assumed that clearcutting is conducted in mature stands only. However, immature trees and further trees with relatively small dimensions usually contribute to the stumpage as by-products of silviculture. This means that the proportion of short logs in the volume of timber felled in clearcutting is higher than in timber felled in SC, even though felled timber is preferably sorted as long logs.
  While in CC the proportion of long logs in the volume of felled timber excl. HR is therefore assumedly 85% and the proportion of short logs is assumedly 15%, in the process CH the felled timber is sorted exclusively as short logs. Precisely, the felled stems are usually cut into logs of 2.5 to 6 m (FOBAWI, 2002: 12), which are easy to handle within the forest stand; the underlying reason is to optimise the productivity of the expensive (in terms of investment) felling system in CH.

Due to their large extent and their far-reaching effects, these assumptions are evaluated in chapter 6.1.

(3) The assumptions made in B(2) are assumed to be valid for all relevant processes regardless of the species.

(4) JODLOWSKI (2007: 6) estimates that 80% of the total volume of the felled timber was hauled by the use of skidders and agricultural tractors, 5% by using forwarders and forwarding trailers in combination with tractors and 15% by means of horses. As no more detailed information is available, this ratio is assumed to be identical for all tree species.

(5) The short logs and the long logs are assumed to be extracted from the forest stands by 100%, i.e. none of the logs is left in the stand after felling.
In contrast to this, HR usually remain unutilised in the forests; it is assumed that only those HR that form the raw material for wood chips are extracted from the forest stands.

(6) The product category "long logs" is assumed to be hauled only with skidders (process SKI) and horses (process HOR). Forwarders are not used for hauling long logs, as they are purpose-built for hauling short logs of 2 to 6 m (FOBAWI, 2002: 17).

(7) The process shares of hauling processes in regard of HR are assumed to be the same as those of hauling short logs, as it is assumed that the same set of hauling equipment is used in both cases.

(8) According to DIW (1999) HR contribute with 32% to the total volume of felled spruce and pine timber. For broadleaved timber the respective value is 36.4%.

(9) The volume of timber excl. HR, felled in the Polish state forests in 2005 is 26.7mln m^3_{ub} according to Polish forestry statistics (THE STATE FORESTS NATIONAL FOREST HOLDING 2006: 51). This is 96% of the total volume of timber excl. HR, which was felled in Poland in 2005, as stated by STRYKOWSKI (2005, ¶ 4).

(10) The process shares in the total volume of timber felled or hauled in Poland in 2005, that are calculated in VF_CALC 1 and VF_CALC 3 are based on the values of volume of felling provided by ALTERRA (2008.xls); as these values are provided for a set of tree species, which is representative for Poland, it is assumed that the process shares can also be applied on the value of total volume of timber, which is given by Polish forestry statistics.

(11) 227000 m^3 of chips were sold from Polish forests in 2005 (THE STATE FORESTS NATIONAL FOREST HOLDING 2006: 53). According to FNR (2005: 89) 2.43 m^3 of chips correspond to 1 m^3 of solid timber over bark.

(12) In Lithuania the chips originate completely from spruce and pine HR as stated by E_1 (26 Jan 2009). Due to a lack of data the situation in Poland is assumed to be identical in terms of raw materials for wood chips, i.e. chips originate completely from spruce and pine HR. Furthermore, the raw material is considered to originate from spruce and pine respectively according to the ratio of spruce and pine timber in the total volume of timber felled in 2005 as given by ALTERRA (2008.xls) (see Table 4.1-3).

(13) The conversion factor for 1 m^3_{ob} to 1 m^3_{ub} is 0.8929 according to (EFORWOOD, 2009: 15).

(14) The following calculations are further based on data that is provided through calculations or in tables above. Precisely, results of VF_CALC 1 (process share of each felling process in the total volume of timber felled in Poland in 2005), of VF_CALC 2 (process share of each felling process in the volume of timber felled per species in Poland in 2005) and of VF_CALC 3 (process share of each hauling process in the total volume of timber hauled in Poland in 2005); additionally, data given in Table 4.1-3 (Volume of timber excl. HR, felled in Poland in the year 2005 as provided by ALTERRA (2008.xls)) are required.

C) <u>Combining the information</u>:

In VF_CALC 5 the product share of each product of a certain felling process in the total volume of timber felled in this certain process is calculated for each process.

The product shares in the output volume of the hauling processes are calculated in VF_CALC 6. To sustain clarity VF_CALC 6 is partitioned to five sub-calculations: VF_CALC 6.1 provides the total volume of timber incl. HR, that was felled in Poland in 2005 according to the values of felling volume given by ALTERRA (2008.xls) as well as according to values of felling volume given in Polish forestry statistics. VF_CALC 6.2 provides the volume of timber incl. HR, that was hauled in Poland in 2005 according to the values of felling volume given by ALTERRA (2008.xls) as well as according to values of felling volume given in Polish forestry statistics. The values obtained from these two calculations are needed to carry out VF_CALC 6.3 and VF_CALC 6.4; in VF_CALC 6.3 the volume hauled per product category (short logs, long logs and HR) is calculated per species, in VF_CALC 6.4 the proportions of relevant hauling processes in the volume of timber hauled per species specific product category are calculated.

VF_CALC 6.3 and VF_CALC 6.4 provide necessary input data to VF_CALC 6.5, where then the actual target values of VF_CALC 6, namely the product share of each product of each hauling process, are calculated. The results of VF_CALC 6.3 and VF_CALC 6.4 are further necessary to calculate the split ratios in chapter 4.2.4.1.

Furthermore, the results of VF_CALC 6.1 and VF_CALC 6.2 are needed for the calculation of several indicator values (see chapter 4.3).

The calculations VF_CALC 5, VF_CALC 6.3 and VF_CALC 6.5 are further subdivided.

As the results of the calculations from VF_CALC 6.1 to VF_CALC 6.4 are only intermediate results and not part of the final calculation results in consideration of chapter 3, the results of these calculations are displayed in conjoined tables directly subsequent to VF_CALC 6.1, to VF_CALC 6.2, to the last subcalculation of VF_CALC 6.3 and to the VF_CALC 6.4 respectively.

However, the results of VF_CALC 5 and VF_CALC 6.5, which are final calculation results according to chapter 3, are displayed in chapter 5.2.2; while the product shares in the felling processes are displayed in the result tables from RE_Table 9 to RE_Table 12, the product shares in the hauling processes are displayed in the results tables from RE_Table 13 to RE_Table 15.

VF_CALC 5:

Calculation of the product share of each product in the total volume of timber felled per felling process in Poland (PL) in 2005:

Starting with calculating the product share of the short logs volume per species in the output volume of the processes TC, SC, CC and CH for coniferous and of the processes TC and CC for broadleaved species, VF_CALC 5 is continued with calculating the product shares of long logs volume per species and harvest residues (HR) volume per species in the process specific total output volume.

To calculate the required product shares one calculation table is created for each product category (short logs, long logs and HR) per species; each calculation table shows then the mode of calculation with regard to all felling processes, which are relevant in terms of a certain product category of a certain species.

• **Product share of spruce short logs in the total felling volume of TC, SC, CC and CH respectively**

(VF_CALC 5a):

The calculation of the product shares of spruce short logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of spruce short logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data))] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of spruce short logs in the output volume of TC	RE_Table 9	%	
x(SC)	product share of spruce short logs in the output volume of SC	RE_Table 10	%	
x(CC)	product share of spruce short logs in the output volume of CC	RE_Table 11	%	
x(CH)	product share of spruce short logs in the output	RE_Table 12	%	

	volume of CH			
Given parameters				
a	process share of TC for spruce	44.58	%	B(14), VF_CALC 2c
b	process share of SC for spruce	44.75	%	B(14), VF_CALC 2c
c	process share of CC for spruce	9.46	%	B(14), VF_CALC 2c
d	process share of CH for spruce	1.21	%	B(14), VF_CALC 2c
e	proportion of HR in timber incl. HR felled from coniferous	32	%	B(8)
f	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3{}_{ob}$	B(14), Table 4.1-3
g	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
h	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
i	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
j	process share of CH in the total volume of timber felled in 2005	1.00	%	B(14) VF_CALC 1c
k	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3{}_{ob}$	B(14), table 4.2-10
l	proportion of short logs in the volume of timber excl. HR, felled in TC	55	%	B(2); B(3)
m	proportion of short logs in the volume of timber excl. HR, felled in SC	5	%	B(2); B(3)
n	proportion of short logs in the volume of timber excl. HR, felled in CC	15	%	B(2); B(3)
o	proportion of short logs in the volume of timber excl. HR, felled in CH	100	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*f*l) / (g*k)] * 100 → x(SC) = [(b*f*m) / (h*k)] * 100 → x(CC) = [(c*f*n) / (i*l)] * 100 → x(CH) = [(d*f*o) / (j*m)] * 100				

The product shares of spruce short logs are displayed in the process specific results tables RE_Table 9 to RE_Table 12 in chapter 5.2.2.

• **Product share of <u>pine short logs in</u> the total felling volume of <u>TC, SC, CC and CH respectively</u>**

(VF_CALC 5b):

The calculation of the product shares of pine short logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of pine short logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of pine short logs in the output volume of TC	RE_Table 9	%	
x(SC)	product share of pine short logs in the output volume of SC	RE_Table 10	%	
x(CC)	product share of pine short logs in the output volume of CC	RE_Table 11	%	
x(CH)	product share of pine short logs in the output volume of CH	RE_Table 12	%	
Given parameters				
a	process share of TC for pine	44.58	%	B(14), VF_CALC 2c
b	process share of SC for pine	44.75	%	B(14), VF_CALC 2c
c	process share of CC for pine	9.46	%	B(14), VF_CALC 2c
d	process share of CH for pine	1.21	%	B(14), VF_CALC 2c
e	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(8)
f	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	B(14), Table 4.1-3
g	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
h	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
i	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
j	process share of CH in the total volume of timber felled in 2005	1.00	%	B(14) VF_CALC 1c
k	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
l	proportion of short logs in the volume of timber excl. HR, felled in TC	55	%	B(2); B(3)
m	proportion of short logs in the volume of timber excl. HR, felled in SC	5	%	B(2); B(3)
n	proportion of short logs in the volume of timber excl. HR, felled in CC	15	%	B(2); B(3)
o	proportion of short logs in the volume of timber excl. HR, felled in CH	100	%	B(2); B(3)

Calculation mode
→ x(TC) = [(a*f*l) / (g*k)] * 100
→ x(SC) = [(b*f*m) / (h*k)] * 100
→ x(CC) = [(c*f*n) / (i*l)] * 100
→ x(CH) = [(d*f*o) / (j*m)] * 100

The product shares of pine short logs are displayed in the process specific results tables RE_Table 9 to RE_Table 12 in chapter 5.2.2.

• **Product share of <u>oak short logs in</u> the total felling volume of <u>TC and CC respectively</u>**

(VF_CALC 5c):

The calculation of the product shares of oak short logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of oak short logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of oak short logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of oak short logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for oak	21	%	B(14), VF_CALC 2b
b	process share of CC for oak	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of oak timber excl. HR, felled in 2005 (EFISCEN)	1805.2574	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of short logs in the volume of timber excl. HR, felled in TC	55	%	B(2); B(3)
i	proportion of short logs in the volume of timber excl. HR, felled in CC	15	%	B(2); B(3)
Calculation mode				

→ x(TC) = [(a*d*h) / (e*g)] * 100

→ x(CC) = [(b*d*i) / (f*g)] * 100

The product shares of oak short logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of beech short logs in the total felling volume of TC and CC respectively**

(VF_CALC 5d):

The calculation of the product shares of beech short logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of beech short logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of beech short logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of beech short logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for beech	21	%	B(14), VF_CALC 2b
b	process share of CC for beech	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of beech timber excl. HR, felled in 2005 (EFISCEN)	2185.6384	$1000m^3_{ob}$	B(14), Table 4.1-3
e	share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of short logs in the volume of timber excl. HR, felled in TC	55	%	B(2); B(3)
i	proportion of short logs in the volume of timber excl. HR, felled in CC	15	%	B(2); B(3)
Calculation mode				

→ x(TC) = [(a*d*h) / (e*g)] * 100

→ x(CC) = [(b*d*i) / (f*g)] * 100

The product shares of beech short logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of birch short logs in the total felling volume of TC and CC respectively**
(VF_CALC 5e):

The calculation of the product shares of birch short logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of birch short logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of birch short logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of birch short logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for birch	75	%	B(14), VF_CALC 2a
b	process share of CC for birch	25	%	B(14), VF_CALC 2a
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of birch timber excl. HR, felled in 2005 (EFISCEN)	1637.1665	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of short logs in the volume of timber excl. HR, felled in TC	55	%	B(2); B(3)
i	proportion of short logs in the volume of timber excl. HR, felled in CC	15	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*d*h) / (e*g)] * 100 → x(CC) = [(b*d*i) / (f*g)] * 100				

The product shares of birch short logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of <u>spruce long logs in</u> the total felling volume of <u>TC, SC and CC</u> <u>respectively</u>**

(VF_CALC 5f):

The calculation of the product shares of spruce long logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of spruce long logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of spruce long logs in the output volume of TC	RE_Table 9	%	
x(SC)	product share of spruce long logs in the output volume of SC	RE_Table 10	%	
x(CC)	product share of spruce long logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for spruce	44.58	%	B(14), VF_CALC 2c
b	process share of SC for spruce	44.75	%	B(14), VF_CALC 2c
c	process share of CC for spruce	9.46	%	B(14), VF_CALC 2c
d	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(8)
e	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3_{ob}$	B(14), Table 4.1-3
f	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
g	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
h	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
i	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
j	proportion of long logs in the volume of timber excl. HR felled in TC	45	%	B(2); B(3)
k	proportion of long logs in the volume of timber excl. HR felled in SC	95	%	B(2); B(3)
l	proportion of long logs in the volume of timber excl. HR felled in CC	85	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*e*j) / (f*i)] * 100 → x(SC) = [(b*e*k) / (g*i)] * 100 → x(CC) = [(c*e*l) / (h*i)] * 100				

The product shares of spruce long logs are displayed in the process specific results tables RE_Table 9 to RE_Table 11 in chapter 5.2.2.

• **Product share of <u>pine long logs in</u> the total felling volume of <u>TC, SC and CC respectively</u>**
(VF_CALC 5g)**:**

The calculation of the product shares of pine long logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of pine long logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of pine long logs in the output volume of TC	RE_Table 9	%	
x(SC)	product share of pine long logs in the output volume of SC	RE_Table 10	%	
x(CC)	product share of pine long logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for pine	44.58	%	B(14), VF_CALC 2c
b	process share of SC for pine	44.75	%	B(14), VF_CALC 2c
c	process share of CC for pine	9.46	%	B(14), VF_CALC 2c
d	proportion of HR in timber incl. HR, felled from broadleaved	32	%	B(8)
e	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	B(14), Table 4.1-3
f	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
g	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
h	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
i	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
j	proportion of long logs in the volume of timber excl. HR felled in TC	45	%	B(2); B(3)
k	proportion of long logs in the volume of timber excl. HR felled in SC	95	%	B(2); B(3)
l	proportion of long logs in the volume of timber excl. HR felled in CC	85	%	B(2); B(3)
Calculation mode				

→ x(TC) = [(a*e*j) / (f*i)] * 100 → x(SC) = [(b*e*k) / (g*i)] * 100 → x(CC) = [(c*e*l) / (h*i)] * 100

The product shares of pine long logs are displayed in the process specific results tables RE_Table 9 to RE_Table 11 in chapter 5.2.2.

• **Product share of <u>oak long logs in</u> the total felling volume of <u>TC and CC respectively</u> (VF_CALC 5h):**

The calculation of the product shares of oak long logs in the process specific felling volume is performed according to the generalised scheme *[(volume of oak long logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of oak long logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of oak long logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for oak	21	%	B(14), VF_CALC 2b
b	process share of CC for oak	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of oak timber excl. HR, felled in 2005 (EFISCEN)	1805.2574	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of long logs in the volume of timber excl. HR, felled in TC	45	%	B(2); B(3)
i	proportion of long logs in the volume of timber excl. HR, felled in CC	85	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*d*h) / (e*g)] * 100 → x(CC) = [(b*d*i) / (f*g)] * 100				

The product shares of oak long logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

- **Product share of beech long logs in the total felling volume of TC and CC respectively**

(VF_CALC 5i):

The calculation of the product shares of beech long logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of beech long logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of beech long logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of beech long logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for beech	21	%	B(14), VF_CALC 2b
b	process share of CC for beech	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of beech timber excl. HR, felled in 2005 (EFISCEN)	2185.6384	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of long logs in the volume of timber excl. HR, felled in TC	45	%	B(2); B(3)
i	proportion of long logs in the volume of timber excl. HR, felled in CC	85	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*d*h) / (e*g)] * 100 → x(CC) = [(b*d*i) / (f*g)] * 100				

The product shares of beech long logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

- **Product share of birch long logs in the total felling volume of TC and CC respectively**

(VF_CALC 5j):

The calculation of the product shares of birch long logs in the process specific felling volume is performed according to the generalised scheme

*[(volume of birch long logs felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of birch long logs in the output volume of TC	RE_Table 9	%	
x(CC)	product share of birch long logs in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for birch	75	%	B(14), VF_CALC 2a
b	process share of CC for birch	25	%	B(14), VF_CALC 2a
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of birch timber excl. HR, felled in 2005 (EFISCEN)	1637.1665	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
h	proportion of long logs in the volume of timber excl. HR, felled in TC	45	%	B(2); B(3)
i	proportion of long logs in the volume of timber excl. HR, felled in CC	85	%	B(2); B(3)
Calculation mode				
→ x(TC) = [(a*d*h) / (e*g)] * 100 → x(CC) = [(b*d*i) / (f*g)] * 100				

The product shares of birch long logs are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of <u>spruce HR in</u> the total felling volume of <u>TC, SC, CC and CH respectively</u>**

(VF_CALC 5k):

The calculation of the product shares of spruce HR in the process specific felling volume is performed according to the generalised scheme

*[(volume of spruce HR felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of spruce HR in the output volume of TC	RE_Table 9	%	
x(SC)	product share of spruce HR in the output volume of SC	RE_Table 10	%	
x(CC)	product share of spruce HR in the output volume of CC	RE_Table 11	%	
x(CH)	product share of spruce HR in the output volume of CH	RE_Table 12	%	
Given parameters				
a	process share of TC for spruce	44.58	%	B(14), VF_CALC 2c
b	process share of SC for spruce	44.75	%	B(14), VF_CALC 2c
c	process share of CC for spruce	9.46	%	B(14), VF_CALC 2c
d	process share of CH for spruce	1.21	%	B(14), VF_CALC 2c
e	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(8)
f	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3_{ob}$	B(14), Table 4.1-3
g	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
h	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
i	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
j	process share of CH in the total volume of timber felled in 2005	1.00	%	B(14) VF_CALC 1c
k	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
Calculation mode				
→ x(TC) = {{a*[(f*e)/(1-e)]} / (g*k)} * 100 → x(SC) = {{b*[(f*e)/(1-e)]} / (h*k)} * 100 → x(CC) = {{c*[(f*e)/(1-e)]} / (i*k)} * 100 → x(CH) = {{d*[(f*e)/(1-e)]} / (j*k)} * 100				

The product shares of spruce HR are displayed in the process specific results tables RE_Table 9 to RE_Table 12 in chapter 5.2.2.

• **Product share of pine HR in the total felling volume of TC, SC, CC and CH respectively**

(VF_CALC 51):

The calculation of the product shares of pine HR in the process specific felling volume is performed according to the generalised scheme

*[(volume of pine HR felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of pine HR in the output volume of TC	RE_Table 9	%	
x(SC)	product share of pine HR in the output volume of SC	RE_Table 10	%	
x(CC)	product share of pine HR in the output volume of CC	RE_Table 11	%	
x(CH)	product share of pine HR in the output volume of CH	RE_Table 12	%	
Given parameters				
a	process share of TC for pine	44.58	%	B(14), VF_CALC 2c
b	process share of SC for pine	44.75	%	B(14), VF_CALC 2c
c	process share of CC for pine	9.46	%	B(14), VF_CALC 2c
d	process share of CH for pine	1.21	%	B(14), VF_CALC 2c
e	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(8)
f	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	B(14), Table 4.1-3
g	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
h	process share of SC in the total volume of timber felled in 2005	36.90	%	B(14) VF_CALC 1a
i	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
j	process share of CH in the total volume of timber felled in 2005	1.00	%	B(14) VF_CALC 1c
k	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
Calculation mode				

→ x(TC) = {{a*[(f*e)/(1-e)]} / (g*k)} * 100 → x(SC) = {{b*[(f*e)/(1-e)]} / (h*k)} * 100 → x(CC) = {{c*[(f*e)/(1-e)]} / (i*k)} * 100 → x(CH) = {{d*[(f*e)/(1-e)]} / (j*k)} * 100

The product shares of pine HR are displayed in the process specific results tables RE_Table 9 to RE_Table 12 in chapter 5.2.2.

• **Product share of oak HR in the total felling volume of TC and CC respectively (VF_CALC 5m):**

The calculation of the product shares of oak HR in the process specific felling volume is performed according to the generalised scheme

*[(volume of oak HR felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of oak HR in the output volume of TC	RE_Table 9	%	
x(CC)	product share of oak HR in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for oak	21	%	B(14), VF_CALC 2b
b	process share of CC for oak	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of oak timber excl. HR, felled in 2005 (EFISCEN)	1805.2574	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
Calculation mode				
→ x(TC) = {{a*[(d*c)/(1-c)]} / (e*g)} * 100 → x(CC) = {{b*[(d*c)/(1-c)]} / (f*g)} * 100				

The product shares of oak HR are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of <u>beech HR in</u> the total felling volume of <u>TC and CC respectively</u>** (VF_CALC 5n):

The calculation of the product shares of beech HR in the process specific felling volume is performed according to the generalised scheme

*[(volume of beech HR felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of beech HR in the output volume of TC	RE_Table 9	%	
x(CC)	product share of beech HR in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for beech	21	%	B(14), VF_CALC 2b
b	process share of CC for beech	79	%	B(14), VF_CALC 2b
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of beech timber excl. HR, felled in 2005 (EFISCEN)	2185.6384	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
Calculation mode				
→ x(TC) = {{a*[(d*c)/(1-c)]} / (e*g)} * 100 → x(CC) = {{b*[(d*c)/(1-c)]} / (f*g)} * 100				

The product shares of beech HR are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

• **Product share of <u>birch HR in</u> the total felling volume of <u>TC and CC respectively</u>** (VF_CALC 5o):

The calculation of the product shares of birch HR in the process specific felling volume is performed according to the generalised scheme

*[(volume of birch HR felled in process x (based on EFISCEN data)) / (total volume of timber incl. HR felled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	product share of birch HR in the output volume of TC	RE_Table 9	%	
x(CC)	product share of birch HR in the output volume of CC	RE_Table 11	%	
Given parameters				
a	process share of TC for birch	75	%	B(14), VF_CALC 2a
b	process share of CC for birch	25	%	B(14), VF_CALC 2a
c	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
d	volume of birch timber excl. HR, felled in 2005 (EFISCEN)	1637.1665	$1000m^3_{ob}$	B(14), Table 4.1-3
e	process share of TC in the total volume of timber felled in 2005	43.20	%	B(14) VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.90	%	B(14) VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	B(14), table 4.2-10
Calculation mode				
→ x(TC) = {{a*[(d*c)/(1-c)]} / (e*g)} * 100 → x(CC) = {{b*[(d*c)/(1-c)]} / (f*g)} * 100				

The product shares of birch HR are displayed in the process specific results tables RE_Table 9 and RE_Table 11 in chapter 5.2.2.

VF_CALC 6:

Calculation of the product share of each product in the total volume of timber hauled per hauling process in Poland in 2005:

Due to its extent VF_CALC 6 is split into several parts:

The calculation of the product shares in the output volume of each hauling process, which is finally carried out in VF_CALC 6.5, is based on parameters provided through VF_CALC 6.1 (total volume of timber incl. harvest residues (HR), felled in Poland in 2005 according to Polish forestry statistics), VF_CALC 6.2 (total volume of timber incl. HR, hauled in Poland in 2005), VF_CALC 6.3 (volume of hauled timber per product category per species) and VF_CALC 6.4 (proportion of each relevant hauling process in hauling the volume of a certain product category per species).

The parameter values resulting from VF_CALC 6.1, VF_CALC 6.2, VF_CALC 6.3 and VF_CALC 6.4 are no final results of this study according to chapter 3, but only intermediate results; therefore, they are not displayed in RE_tables in chapter five, but in conjoined tables directly subsequent to VF_CALC 6.1, to VF_CALC 6.2, to the last subcalculation of VF_CALC 6.3 and to the VF_CALC 6.4 respectively.

VF_CALC 6.1:

Calculation of the total volume of timber incl. HR, felled in Poland (PL) in 2005:

This calculation is mainly based on assumption B(10), where it is noted that the set of tree species and their respective proportions as given by ALTERRA (2008.xls) are representative for the Polish forestry in the state of 2005. As all data on indicator values from Polish statistics are related to the total volume (100%) of the timber harvested in Poland it is necessary to extrapolate the volume given by ALTERRA (2008.xls), which is representative but does not cover the total volume of harvested timber and does not include harvest residues (HR), to 100%.

The total volume of timber incl. HR, felled in 2005, based on Polish forestry statistics is calculated according to the generalised calculation scheme

(total volume of timber excl. HR, felled in PL in 2005 based on Polish forestry statistics) + *(volume of accruing coniferous HR)* + *(volume of accruing broadleaved HR)*.

The corresponding value based on EFISCEN data is then calculated by using a rule of three calculation.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(PL)	total volume of timber incl. HR, felled in 2005 (based on Polish forestry statistics)	Table 4.2-2	$1000m^3_{ub}$	
x(EFI)	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	Table 4.2-2	$1000m^3_{ob}$	
Given parameters				
a	volume of timber excl. HR, felled in Polish state forests in 2005	26700	$1000m^3_{ub}$	B(9)
b	proportion of timber originating from Polish state forests in the total volume of timber felled PL	96	%	B(9)
c	proportion of spruce timber excl. HR in the total volume of timber felled in 2005 (EFISCEN)	11.43	%	B(14), Table 4.1-3
d	proportion of pine timber excl. HR in the total	71.03	%	B(14),

	volume of timber felled in 2005 (EFISCEN)			Table 4.1-3
e	proportion of oak timber excl. HR in the total volume of timber felled in 2005 (EFISCEN)	5.63	%	B(14), Table 4.1-3
f	proportion of beech timber excl. HR in the total volume of timber felled in 2005 (EFISCEN)	6.81	%	B(14), Table 4.1-3
g	proportion of birch timber excl. HR in the total volume of timber felled in 2005 (EFISCEN)	5.1	%	B(14), Table 4.1-3
h	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(8)
i	proportion of HR in timber incl. HR, felled from broadleaved	36.4	%	B(8)
j	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	B(14), Table 4.1-3
Calculation mode				
→ x(PL) = a/b + {[(a/b)*(c+d)]*h} / (1–h) + {[(a/b)*(e+f+g)]*i} / (1–i) → x(EFI) = ($x_{(PL)}$*j) / (a/b)				

As the values of the volume of timber incl. HR that was felled in Poland in 2005, based on Polish forestry statistics and on EFISCEN data respectively, are no final calculation results of this study but intermediate results only, they are displayed in the following Table 4.2-2:

Table 4.2-2: *Volume of timber incl. HR, felled in Poland (PL) in the year 2005 on the basis of data from Polish forestry statistics and on basis of EFISCEN data*

Basic input data of the calculation	Total volume of timber incl. HR, felled in PL in 2005
data from Polish forestry statistics	41397.05 [$1000m^3_{ub}$]
data from EFISCEN	47756.32 [$1000m^3_{ob}$]

VF_CALC 6.2:

Calculation of the total volume of timber incl. HR, hauled in Poland (PL) in 2005:

For this calculation B(5) and B(10) are taken as basis. Furthermore, the calculation is based on B(12), where the harvest residues (HR) as raw material for wood chips are stated to originate only from coniferous species.

The volume of hauled timber regarding data from Polish forestry statistics is calculated according to the generalised calculation scheme *(total volume of timber excl. HR, felled in PL in 2005 based on Polish forestry statistics)* + *(volume of timber sold as wood chips from Polish forests).*

The corresponding value based on EFISCEN data is then calculated by using a rule of three calculation.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(PL)	total volume of timber incl. HR, hauled in 2005 (based on Polish forestry statistics)	Table 4.2-3	$1000m^3_{ub}$	
x(EFI)	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	Table 4.2-3	$1000m^3_{ob}$	
Given parameters				
a	volume of timber excl. HR, felled in Polish state forests in 2005	26700	$1000m^3_{ub}$	B(9)
b	proportion of timber originating from Polish state forests in the total volume of timber felled in PL	96	%	B(9)
c	volume of wood chips sold from Polish forests in 2005	227	$1000m^3$	B(11)
d	conversion factor of 1 m^3_{ob} of solid wood to chips	2.43	#	B(11)
e	conversion factor of 1 m^3_{ob} to 1 m^3_{ub}	0.8929	#	B(13)
f	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	B(14), Table 4.1-3
Calculation mode				
→ x(PL) = a/b + (c/d)*e → x(EFI) = ($x_{(PL)}$*f) / (a/b)				

As the values of the volume of timber incl. HR that was hauled in Poland in 2005, based on Polish forestry statistics and on EFISCEN data respectively are no final calculation results of this study but intermediate results only, they are displayed in the following Table 4.2-3:

Table 4.2-3: *Volume of timber incl. HR, hauled in Poland (PL) in the year 2005 on the basis of data from Polish forestry statistics and on basis of EFISCEN data*

Basic input data of the calculation	**Total volume of timber incl. HR, hauled in PL in 2005**
data from Polish forestry statistics	27895.91 [$1000m^3_{ub}$]
data from EFISCEN	32181.18 [$1000m^3_{ob}$]

VF_CALC 6.3:

<u>Calculation of the volume of each product category that is hauled per tree species</u>:

Per each tree species the volume of short logs, long logs and harvest residues (HR) respectively that was hauled in Poland in the year 2005 is calculated. The calculation is performed on the basis of EFISCEN data (provided by ALTERRA (2008.xls)).

- **Volume of hauled <u>spruce short logs, spruce long logs and spruce HR</u> (VF_CALC 6.3a):**

Regarding short logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of spruce short logs felled in TC) + *(volume of spruce short logs felled in SC)* + *(volume of spruce short logs felled in CC)* + *(volume of spruce short logs felled in CH)*.

Regarding long logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of spruce long logs in TC) + *(volume of spruce long logs felled in SC)* + *(volume of spruce long logs felled in CC).*

Regarding HR the calculation is carried out in consideration of B(5) and B(12) according to the generalised calculation scheme

[(total volume of timber incl. HR, hauled in PL in 2005 (based on EFISCEN data)) – *(total volume of timber excl. HR, felled in PL in 2005 (based EFISCEN data))]* * *(proportion of spruce in the sum of the proportion of spruce and pine in the total volume of timber incl. HR, felled in PL in 2005 (based on EFISCEN data)).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SL)	volume of hauled spruce short logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(LL)	volume of hauled spruce long logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(HR)	volume of hauled spruce HR (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
Given parameters				
a	product share of spruce short logs in the output volume of TC	4.4	%	VF_CALC 5a
b	product share of spruce short logs in the output volume of SC	0.5	%	VF_CALC 5a

c	product share of spruce short logs in the output volume of CC	0.6	%	VF_CALC 5a
d	product share of spruce short logs in the output volume of CH	9.3	%	VF_CALC 5a
e	product share of spruce long logs in the output volume of TC	3.6	%	VF_CALC 5f
f	product share of spruce long logs in the output volume of SC	8.8	%	VF_CALC 5f
g	product share of spruce long logs in the output volume of CC	3.3	%	VF_CALC 5f
h	process share of TC in the total volume of timber felled in 2005	43.2	%	B(14), VF_CALC 1a
i	process share of SC in the total volume of timber felled in 2005	36.9	%	B(14), VF_CALC 1a
j	process share of CC in the total volume of timber felled in 2005	18.9	%	B(14), VF_CALC 1b
k	process share of CH in the total volume of timber felled in 2005	1.0	%	B(14), VF_CALC 1c
l	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	Table 4.2-2
m	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
n	proportion of spruce timber in the total volume of timber excl. HR, felled in 2005 (EFISCEN)	11.43	%	B(14), Table 4.1-3
o	proportion of pine timber in the total volume of timber excl. HR, felled in 2005 (EFISCEN)	71.03	%	B(14), Table 4.1-3
p	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	B(14), Table 4.1-3
Calculation mode				
→ x(SL) = a*h*l + b*i*l + c*j*l + d*k*l → x(LL) = e*h*l + f*i*l + g*j*l → x(HR) = (m – p) * [n/(n+o)]				

As the values of the volume of hauled spruce short logs, long logs and HR (based on EFISCEN data), are no final calculation results of this study but intermediate results only, they are displayed in Table 4.2-4 directly subsequent to VF_CALC 6.3e:

• **Volume of hauled <u>pine short logs, pine long logs and pine HR</u> (VF_CALC 6.3b):**

Regarding short logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of pine short logs felled in TC) + *(volume of pine short logs felled in SC)* + *(volume of pine short logs felled in CC)* + *(volume of pine short logs felled in CH)*.

Regarding long logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of pine long logs in TC) + *(volume of pine long logs felled in SC)* + *(volume of pine long logs felled in CC).*

Regarding HR the calculation is carried out in consideration of B(5) and B(12) according to the generalised calculation scheme

[(total volume of timber incl. HR, hauled in PL in 2005 (based on EFISCEN data)) – *(total volume of timber excl. HR, felled in PL in 2005 (based EFISCEN data))]* * *(proportion of pine in the sum of the proportion of spruce and pine in the total volume of timber incl. HR, felled in PL in 2005 (based on EFISCEN data)).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SL)	volume of hauled pine short logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(LL)	volume of hauled pine long logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(HR)	volume of hauled pine HR (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
Given parameters				
a	product share of pine short logs in the output volume of TC	27.1	%	VF_CALC 5b
b	product share of pine short logs in the output volume of SC	2.9	%	VF_CALC 5b
c	product share of pine short logs in the output volume of CC	3.2	%	VF_CALC 5b
d	product share of pine short logs in the output volume of CH	55.8	%	VF_CALC 5b
e	product share of pine long logs in the output volume of TC	22.2	%	VF_CALC 5g
f	product share of pine long logs in the output volume of SC	55.8	%	VF_CALC 5g
g	product share of pine long logs in the output volume of CC	20.3	%	VF_CALC 5g
h	process share of TC in the total volume of timber felled in 2005	43.2	%	B(14), VF_CALC 1a
i	process share of SC in the total volume of timber felled in 2005	36.9	%	B(14), VF_CALC 1a
j	process share of CC in the total volume of timber felled in 2005	18.9	%	B(14), VF_CALC 1b
k	process share of CH in the total volume of timber felled in 2005	1.0	%	B(14), VF_CALC 1c
l	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	Table 4.2-2
m	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3

n	proportion of spruce timber in the total volume of timber excl. HR, felled in 2005 (EFISCEN)	11.43	%	B(14), Table 4.1-3
o	proportion of pine timber in the total volume of timber excl. HR, felled in 2005 (EFISCEN)	71.03	%	B(14), Table 4.1-3
p	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	B(14), Table 4.1-3
Calculation mode				
→ x(SL) = a*h*l + b*i*l + c*j*l + d*k*l → x(LL) = e*h*l + f*i*l + g*j*l → x(HR) = (m – p) * [o/(n+o)]				

As the values of the volume of hauled pine short logs, long logs and HR (based on EFISCEN data), are no final calculation results of this study but intermediate results only, they are displayed in Table 4.2-4 directly subsequent to VF_CALC 6.3e.

• Volume of hauled <u>oak short logs and oak long logs</u> (VF_CALC 6.3c):

Regarding short logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of oak short logs felled in TC) + *(volume of oak short logs felled in CC)*.

Regarding long logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of oak long logs felled in TC) + *(volume of oak long logs felled in CC)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SL)	volume of hauled oak short logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(LL)	volume of hauled oak long logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
Given parameters				
a	product share of oak short logs in the output volume of TC	1.0	%	VF_CALC 5c
b	product share of oak short logs in the output volume of CC	2.4	%	VF_CALC 5c
c	product share of oak long logs in the output volume of TC	0.8	%	VF_CALC 5h
d	product share of oak long logs in the output volume of CC	13.4	%	VF_CALC 5h
e	process share of TC in the total volume of timber	43.2	%	B(14), VF_CALC 1a

	felled in 2005			
f	process share of CC in the total volume of timber felled in 2005	18.9	%	B(14), VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	Table 4.2-2
Calculation mode				
→ x(SL) = a*e*g + b*f*g → x(LL) = c*e*g + d*f*g				

As the values of the volume of hauled oak short logs and long logs and HR (based on EFISCEN data), are no final calculation results of this study but intermediate results only, they are displayed in Table 4.2-4 directly subsequent to VF_CALC 6.3e.

• **Volume of hauled <u>beech short logs and beech long logs</u> (VF_CALC 6.3d):**

Regarding short logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of beech short logs felled in TC) + *(volume of beech short logs felled in CC)*.

Regarding long logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of beech long logs felled in TC) + *(volume of beech long logs felled in CC)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SL)	volume of hauled beech short logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(LL)	volume of hauled beech long logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
Given parameters				
a	product share of beech short logs in the output volume of TC	1.2	%	VF_CALC 5d
b	product share of beech short logs in the output volume of CC	2.9	%	VF_CALC 5d
c	product share of beech long logs in the output volume of TC	1.0	%	VF_CALC 5i
d	product share of beech long logs in the output volume of CC	16.3	%	VF_CALC 5i
e	process share of TC in the total volume of timber felled in 2005	43.2	%	B(14), VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.9	%	B(14), VF_CALC 1b

g	total volume of timber incl. HR, felled in 2005 (based on EFISCEN data)	47756.32	$1000m^3_{ob}$	Table 4.2-2
Calculation mode				
→ x(SL) = a*e*g + b*f*g → x(LL) = c*e*g + d*f*g				

As the values of the volume of hauled beech short logs and long logs and HR (based on EFISCEN data), are no final calculation results of this study but intermediate results only, they are displayed in Table 4.2-4 directly subsequent to VF_CALC 6.3e.

• **Volume of hauled birch short logs and birch long logs (VF_CALC 6.3e):**

Regarding short logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of birch short logs felled in TC) + *(volume of birch short logs felled in CC)*.

Regarding long logs the calculation is carried out in consideration of B(5) according to the generalised calculation scheme

(volume of birch long logs felled in TC) + *(volume of birch long logs felled in CC)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SL)	volume of hauled birch short logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
x(LL)	volume of hauled birch long logs (based on EFISCEN data)	Table 4.2-4	$1000m^3_{ob}$	
Given parameters				
a	product share of birch short logs in the output volume of TC	3.3	%	VF_CALC 5e
b	product share of birch short logs in the output volume of CC	0.7	%	VF_CALC 5e
c	product share of birch long logs in the output volume of TC	2.7	%	VF_CALC 5j
d	product share of birch long logs in the output volume of CC	3.7	%	VF_CALC 5j
e	process share of TC in the total volume of timber felled in 2005	43.2	%	B(14), VF_CALC 1a
f	process share of CC in the total volume of timber felled in 2005	18.9	%	B(14), VF_CALC 1b
g	total volume of timber incl. HR, felled in 2005	47756.32	$1000m^3_{ob}$	Table 4.2-2

	(based on EFISCEN data)			
Calculation mode				
→ x(SL) = a*e*g + b*f*g → x(LL) = c*e*g + d*f*g				

As the values of the volume of hauled birch short logs and long logs and HR (based on EFISCEN data) are no final calculation results of this study but intermediate results only, they are displayed together with the other results of VF_CALC 6.3 in the following table 4.2-4.

Table 4.2-4: *Volume of timber per product category, hauled in Poland in the year 2005 on the basis of EFISCEN data*

Tree Species	Volume of hauled timber per species and per product category as calculated on the basis of EFISCEN data [1000m^3_{ob}]		
	Short logs	**Long logs**	**HR**
Spruce	1094.43	2591.31	13.34
Pine	6657.28	16245.41	82.88
Oak	422.93	1374.52	0
Beech	509.32	1677.54	0
Birch	744.00	890.99	0

VF_CALC 6.4:

Calculation of the proportion of each relevant hauling process in the volume of timber hauled per species specific product category (short logs, long logs and harvest residues (HR)):

In accordance to B(4) there is no difference between the process shares of the hauling processes for hauling the timber of different tree species. Consequently, the proportions of the hauling processes in the volume of the product categories are also the same for all species. Therefore, one calculation, which is representative for all tree species, is performed using the example of spruce.

As stated in B(6) forwarders are not used to haul long logs; therefore, the overall process shares in the volume of timber hauled per species in Poland in 2005 need to be adapted with regard to the process shares per product category.

According to B(7), the proportion of the processes that are to be calculated in this calculation are identical for short logs and HR; this is why there are no separate calculations for short logs and HR.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(LS)	proportion of SKI in the volume of hauled long logs	Table 4.2-5	%	
x(LH)	proportion of HOR in the volume of hauled long logs	Table 4.2-5	%	
x(SS)	proportion of SKI in the volume of hauled short logs and HR	Table 4.2-5	%	
x(SH)	proportion of HOR in the volume of hauled short logs and HR	Table 4.2-5	%	
x(SF)	proportion of FOR in the volume of hauled short logs and HR	Table 4.2-5	%	
Given parameters				
a	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
b	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
c	volume of hauled spruce short logs (based on EFISCEN data)	1094.43	$1000m^3_{ob}$	Table 4.2-4
d	volume of hauled spruce long logs (based on EFISCEN data)	2591.31	$1000m^3_{ob}$	Table 4.2-4
e	volume of hauled spruce HR (based on EFISCEN data)	13.34	$1000m^3_{ob}$	Table 4.2-4
Calculation mode				
→ x(LS) = [a / (a + b)] * 100 → x(LH) = [b / (a + b)] * 100 → x(SS) = {a – {[c/(c + e)] * ($x_{(LS)}$ – a) * d} / c} * 100 → x(SH) = {b – {[c/(c + e)] * ($x_{(LH)}$ – b) * d} / c} * 100 → x(SF) = (1 – $x_{(SS)}$ – $x_{(SH)}$) * 100				

As the resulting values are no final calculation results of this study but intermediate results only, they are displayed in the following Table 4.2-5:

Table 4.2-5: *Proportions of the hauling processes in the volume of timber hauled per product category in Poland*

Process	Proportions of the hauling processes in the volume of timber hauled per product category [%]		
	short logs	**long logs**	**harvest residues**
SKI	70.15	84.21	70.15
FOR	16.70	0	16.70
HOR	13.15	15.79	13.15
SUM	**100.00**	**100.00**	**100.00**

VF_CALC 6.5:

<u>Calculation of the product share of each product in the total volume of timber hauled per hauling process in Poland in 2005</u>:

In VF_CALC 6.5 the product share of each product category per each tree species in the total volume of timber hauled in SKI, FOR and HOR respectively is calculated, starting with short logs and continuing with long logs and harvest residues (HR).

To calculate the required product shares one calculation table is created for each product category (short logs, long logs and HR) per species; each calculation table shows then the mode of calculation with regard to all hauling processes, which are relevant in terms of a certain product category of a certain species.

• **Product share of <u>spruce short logs in</u> the total hauling volume of <u>SKI, FOR and HOR respectively</u>**

(VF_CALC 6.5a):

The calculation of the product shares of spruce short logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled spruce short logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share spruce short logs in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share spruce short logs in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share spruce short logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled spruce short logs (based on	1094.43	$1000m^3_{ob}$	Table 4.2-4

	EFISCEN data)			
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*g) / (d*h)] * 100 → x(FOR) = [(b*g) / (e*h)] * 100 → x(HOR) = [(c*g) / (f*h)] * 100				

The product shares of spruce short logs are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of <u>pine short logs in</u> the total hauling volume of <u>SKI, FOR and HOR</u> <u>respectively</u>**

(VF_CALC 6.5b):

The calculation of the product shares of pine short logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled pine short logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share pine short logs in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share pine short logs in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share pine short logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled pine short logs (based on EFISCEN data)	6657.28	$1000m^3_{ob}$	Table 4.2-4

h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*g) / (d*h)] * 100 → x(FOR) = [(b*g) / (e*h)] * 100 → x(HOR) = [(c*g) / (f*h)] * 100				

The product shares of pine short logs are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of <u>oak short logs in</u> the total hauling volume of <u>SKI, FOR and HOR</u> <u>respectively</u>**

(VF_CALC 6.5c):

The calculation of the product shares of oak short logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled oak short logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share oak short logs in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share oak short logs in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share oak short logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled oak short logs (based on EFISCEN data)	422.93	$1000m^3_{ob}$	Table 4.2-4
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3

Calculation mode
→ x(SKI) = [(a*g) / (d*h)] * 100 → x(FOR) = [(b*g) / (e*h)] * 100 → x(HOR) = [(c*g) / (f*h)] * 100

The product shares of oak short logs are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of beech short logs in the total hauling volume of SKI, FOR and HOR respectively**

(VF_CALC 6.5d):

The calculation of the product shares of beech short logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled beech short logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share beech short logs in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share beech short logs in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share beech short logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled beech short logs (based on EFISCEN data)	509.32	$1000m^3_{ob}$	Table 4.2-4
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				

→ x(SKI) = [(a*g) / (d*h)] * 100
→ x(FOR) = [(b*g) / (e*h)] * 100
→ x(HOR) = [(c*g) / (f*h)] * 100

The product shares of beech short logs are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of birch short logs in the total hauling volume of SKI, FOR and HOR respectively**

(VF_CALC 6.5e)**:**

The calculation of the product shares of birch short logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled birch short logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share birch short logs in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share birch short logs in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share birch short logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled birch short logs (based on EFISCEN data)	744.00	$1000m^3_{ob}$	Table 4.2-4
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*g) / (d*h)] * 100				

→ x(FOR) = [(b*g) / (e*h)] * 100

→ x(HOR) = [(c*g) / (f*h)] * 100

The product shares of birch short logs are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of <u>spruce long logs in</u> the total hauling volume of <u>SKI and HOR</u> <u>respectively</u>**

(VF_CALC 6.5f)**:**

The calculation of the product shares of spruce long logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled spruce long logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share spruce long logs in the output volume of SKI	RE_Table 13	%	
x(HOR)	product share spruce long logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled long logs	84.21	%	Table 4.2-5
b	proportion of HOR in the volume of hauled long logs	15.79	%	Table 4.2-5
c	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
d	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
e	volume of hauled spruce long logs (based on EFISCEN data)	2591.31	$1000m^3_{ob}$	Table 4.2-4
f	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*e) / (c*f)] * 100 → x(HOR) = [(b*e) / (d*f)] * 100				

The product shares of spruce long logs are displayed in the process specific results tables RE_Table 13 and RE_Table 15 in chapter 5.2.2.

• **Product share of <u>pine long logs in</u> the total hauling volume of <u>SKI and HOR respectively</u>**

(VF_CALC 6.5g):

The calculation of the product shares of pine long logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled pine long logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share pine long logs in the output volume of SKI	RE_Table 13	%	
x(HOR)	product share pine long logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled long logs	84.21	%	Table 4.2-5
b	proportion of HOR in the volume of hauled long logs	15.79	%	Table 4.2-5
c	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
d	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
e	volume of hauled pine long logs (based on EFISCEN data)	16245.41	$1000m^3_{ob}$	Table 4.2-4
f	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*e) / (c*f)] * 100 → x(HOR) = [(b*e) / (d*f)] * 100				

The product shares of pine long logs are displayed in the process specific results tables RE_Table 13 and RE_Table 15 in chapter 5.2.2.

• **Product share of <u>oak long logs in</u> the total hauling volume of <u>SKI and HOR respectively</u>**

(VF_CALC 6.5h):

The calculation of the product shares of oak long logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled oak long logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share oak long logs in the output volume of SKI	RE_Table 13	%	
x(HOR)	product share oak long logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled long logs	84.21	%	Table 4.2-5
b	proportion of HOR in the volume of hauled long logs	15.79	%	Table 4.2-5
c	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
d	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
e	volume of hauled oak long logs (based on EFISCEN data)	1374.52	$1000m^3_{ob}$	Table 4.2-4
f	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*e) / (c*f)] * 100 → x(HOR) = [(b*e) / (d*f)] * 100				

The product shares of oak long logs are displayed in the process specific results tables RE_Table 13 and RE_Table 15 in chapter 5.2.2.

• **Product share of <u>beech long logs in</u> the total hauling volume of <u>SKI and HOR</u> <u>respectively</u>**

(VF_CALC 6.5i):

The calculation of the product shares of beech long logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled beech long logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share beech long logs in the output volume of SKI	RE_Table 13	%	
x(HOR)	product share beech long logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled long logs	84.21	%	Table 4.2-5
b	proportion of HOR in the volume of hauled long logs	15.79	%	Table 4.2-5

c	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
d	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
e	volume of hauled beech long logs (based on EFISCEN data)	1677.54	$1000m^3_{ob}$	Table 4.2-4
f	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*e) / (c*f)] * 100 → x(HOR) = [(b*e) / (d*f)] * 100				

The product shares of beech long logs are displayed in the process specific results tables RE_Table 13 and RE_Table 15 in chapter 5.2.2.

• **Product share of <u>birch long logs in</u> the total hauling volume of <u>SKI and HOR respectively</u>**

(VF_CALC 6.5j)**:**

The calculation of the product shares of birch long logs in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled birch long logs (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share birch long logs in the output volume of SKI	RE_Table 13	%	
x(HOR)	product share birch long logs in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled long logs	84.21	%	Table 4.2-5
b	proportion of HOR in the volume of hauled long logs	15.79	%	Table 4.2-5
c	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
d	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
e	volume of hauled birch long logs (based on EFISCEN data)	890.99	$1000m^3_{ob}$	Table 4.2-4
f	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*e) / (c*f)] * 100				

→ x(HOR) = [(b*e) / (d*f)] * 100

The product shares of birch long logs are displayed in the process specific results tables RE_Table 13 and RE_Table 15 in chapter 5.2.2.

• **Product share of spruce HR in the total hauling volume of SKI, FOR and HOR respectively**
(VF_CALC 6.5k):

The calculation of the product shares of spruce HR in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled spruce HR (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share spruce HR in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share spruce HR in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share spruce HR in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.42	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.38	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.20	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled spruce HR (based on EFISCEN data)	13.34	$1000m^3_{ob}$	Table 4.2-4
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*g) / (d*h)] * 100 → x(FOR) = [(b*g) / (e*h)] * 100 → x(HOR) = [(c*g) / (f*h)] * 100				

The product shares of spruce HR are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

• **Product share of pine HR in the total hauling volume of SKI, FOR and HOR respectively**

(VF_CALC 6.5l):

The calculation of the product shares of pine HR in the process specific hauling volume is performed according to the generalised scheme

*[(volume of hauled pine HR (based on EFISCEN data) / (total volume of timber incl. HR, hauled in process x (based on EFISCEN data)] * 100.*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	product share pine HR in the output volume of SKI	RE_Table 13	%	
x(FOR)	product share pine HR in the output volume of FOR	RE_Table 14	%	
x(HOR)	product share pine HR in the output volume of HOR	RE_Table 15	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.42	%	Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.38	%	Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.20	%	Table 4.2-5
d	process share of SKI in the total volume of hauled timber	80	%	B(14), VF_CALC 3
e	process share of FOR in the total volume of hauled timber	5	%	B(14), VF_CALC 3
f	process share of HOR in the total volume of hauled timber	15	%	B(14), VF_CALC 3
g	volume of hauled pine HR (based on EFISCEN data)	82.88	$1000m^3_{ob}$	Table 4.2-4
h	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				
→ x(SKI) = [(a*g) / (d*h)] * 100 → x(FOR) = [(b*g) / (e*h)] * 100 → x(HOR) = [(c*g) / (f*h)] * 100				

The product shares of pine HR are displayed in the process specific results tables RE_Table 13 to RE_Table 15 in chapter 5.2.2.

4.2.4 CALCULATION OF THE SPLIT RATIOS

In the context of this study split ratios are proportions according to which a certain output-product of a certain felling process is split to be further processed in different subsequent hauling processes. In the context of calculating the split ratios, ‘processing’ means either hauling with skidder (SKI), forwarder (FOR) or horse (HOR), or leaving the harvest residues (HR) in the forest stands.

For Poland the split ratios for short logs and long logs after felling are identical to the ratio of the proportions of relevant hauling processes in the volume of timber hauled per species specific short logs and long logs. This is due to the assumption that 100% of the produced short logs and long logs are extracted from the forest stands. Furthermore, the long log products and short log products respectively of a certain species are split in the same ratio, although they originate from different felling processes.

The proportions of relevant hauling processes in the volume of timber hauled per species specific short logs and long logs for Poland are calculated in VF_CALC 6.4. The required split ratios are captured directly from the results of VF_CALC 6.4; this approach is possible, as short logs and long logs are assumedly hauled by 100%, i.e. none of the logs is left unutilised in the forest stand.

In contrast, the split ratios of the HR are calculated separately as not the total volume of the accruing HR is hauled, but, to a far extent, left unutilised in the forest stands, and as therefore, the split ratios for HR cannot directly be captured from the result of VF_CALC 6.4.

This is why there are calculation tables prepared only with regard to the split ratios of HR, but not with regard to the split ratios of short logs and long logs.

A) <u>Data to be collected</u>:

With regard to short logs and long logs the split ratios are captured directly from the results of VF_CALC 6.4, while with regard to HR, the split ratios are calculated in VF_CALC 7b and VF_CALC 7c for spruce and pine respectively; in VF_CALC 7d the split ratios of oak, beech and birch HR are directly captured.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> According to DIW (1999) HR contribute with 32% to the total volume of felled spruce and pine timber. For oak timber the respective value is 36.4%.

(2) It is assumed that the split ratios for short logs, long logs and HR are the same, regardless of the felling process, from where they originate.

(3) The short logs and the long logs are assumed to be hauled by 100%, i.e. no logs are left in the stand after felling.
In contrast to this, HR usually remain unutilised in the forests; it is assumed that only those HR that form the raw material for wood chips are extracted from the forest stands. Broadleaved HR are completely left unutilised in the forest stands.

(4) In accordance to VF_CALC 6.4 the proportions of relevant hauling processes in the volume of timber hauled per species specific short logs and long logs are identical for all species as no more detailed data are available.

(5) The following calculations are further based on data that is provided through calculations above or in tables above. Precisely, results of VF_CALC 6.3 as given in Table 4.2-4 (volume of timber per product category, hauled in Poland in the year 2005 on the basis of EFISCEN data) and of VF_CALC 6.4 as given in Table 4.2-5 (proportions of the hauling processes in the volume of timber hauled per product category); additionally, data given in Table 4.1-3 (Volume of timber excl. HR, felled in Poland in the year 2005 as provided by ALTERRA (2008.xls) are required.

C) Combining the information:

VF_CALC 7:

Direct capture or calculation of the split ratios, according to which a certain output product of a certain felling process is split to be further processed in different subsequent hauling processes in Poland (PL):

• **Split ratio of short logs and long logs for all species**
(VF_CALC 7a)**:**
Direct capture of the split ratios from the results of VF_CALC 6.4 as given in Table 4.2-5; with regard to B(4) the split ratios are the same for all tree species:
The ratio of splitting short logs into 'hauled in SKI', 'hauled in FOR' and 'hauled in HOR' is 70.15% to 16.70% to 13.15%. The ratio of splitting long logs into 'hauled in

SKI' and 'hauled in HOR' is 84.21% to 15.79%. In consideration of B(3), the proportion of spruce short logs and of spruce long logs, which is left unutilised in the forest stand is 0%.

As the split ratios of short logs and long logs are captured directly, no calculation table is required.

The split ratios are displayed together with the split ratios of the other felling products in RE_Table 37 in chapter 5.2.3.

• **Split ratio of spruce HR**

(VF_CALC 7b):

The proportions of those HR, which are hauled either in SKI, FOR or HOR, are calculated according to the generalised calculation scheme

*[(volume of spruce HR hauled in process x) / (total volume of spruce HR produced in the felling processes)] * 100.*

The corresponding proportion of HR which are left unutilised in the forest stands is calculated according to the generalised calculation scheme

100% – (proportion of spruce HR hauled in SKI) – (proportion of spruce HR hauled in FOR) – (proportion of spruce HR hauled in HOR).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	proportion of spruce HR hauled in SKI	RE_Table 37	%	
x(FOR)	proportion of spruce HR hauled in FOR	RE_Table 37	%	
x(HOR)	proportion of spruce HR hauled in HOR	RE_Table 37	%	
x(left)	proportion of spruce HR left in forest stand	RE_Table 37	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	B(5), Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	B(5), Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	B(5), Table 4.2-5
d	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(1)
e	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3_{ob}$	B(5), Table 4.1-3
f	volume of hauled spruce HR (based on EFISCEN data)	13.34	$1000m^3_{ob}$	B(5), Table 4.2-4
Calculation mode				

→ x(SKI) = {(a*f) / [(d*e)/(1-e)]} * 100
→ x(FOR) = {(b*f) / [(d*e)/(1-e)]} * 100
→ x(HOR) = {(c*f) / [(d*e)/(1-e)]} * 100
→ x(left) = (1 – $x_{(SKI)}$ – $x_{(FOR)}$ – $x_{(HOR)}$) * 100

The split ratios of felling products in the Polish TTPC are displayed in the results table RE_Table 37 in chapter 5.2.3.

• **Split ratio of <u>pine HR</u>**

(VF_CALC 7c):

The proportions of those HR which are hauled either in SKI, FOR or HOR are calculated according to the generalised calculation scheme

*[(volume of pine HR hauled in process x) / (total volume of pine HR produced in the felling processes)] * 100.*

The corresponding proportion of HR which are left unutilised in the forest stands is calculated according to the generalised calculation scheme

100% – (proportion of pine HR hauled in SKI) – (proportion of pine HR hauled in FOR) – (proportion of pine HR hauled in HOR).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(SKI)	proportion of pine HR hauled in SKI	RE_Table 37	%	
x(FOR)	proportion of pine HR hauled in FOR	RE_Table 37	%	
x(HOR)	proportion of pine HR hauled in HOR	RE_Table 37	%	
x(left)	proportion of pine HR left in forest stand	RE_Table 37	%	
Given parameters				
a	proportion of SKI in the volume of hauled short logs and HR	70.15	%	B(5), Table 4.2-5
b	proportion of FOR in the volume of hauled short logs and HR	16.70	%	B(5), Table 4.2-5
c	proportion of HOR in the volume of hauled short logs and HR	13.15	%	B(5), Table 4.2-5
d	proportion of HR in timber incl. HR, felled from coniferous	32	%	B(1)
e	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	B(5), Table 4.1-3
f	volume of hauled pine HR (based on EFISCEN data)	82.88	$1000m^3_{ob}$	B(5), Table 4.2-4
Calculation mode				
→ x(SKI) = {(a*f) / [(d*e)/(1-e)]} * 100				

→ x(FOR) = {(b*f) / [(d*e)/(1-e)]} * 100

→ x(HOR) = {(c*f) / [(d*e)/(1-e)]} * 100

→ x(left) = (1 – $x_{(SKI)}$ – $x_{(FOR)}$ – $x_{(HOR)}$) * 100

The split ratios of felling products in the Polish TTPC are displayed in the results table RE_Table 37 in chapter 5.2.3.

• **Split ratio of <u>oak, beech and birch HR</u>**
(VF_CALC 7d)**:**
According to B(3), the ratio of splitting HR originating from oak, beech and birch into “HR left in forest stand”, “HR hauled with skidder”, “HR hauled with forwarder” and “HR hauled with horse” is 100% to 0% to 0% to 0%.
As the split ratios of broadleaved HR are captured directly, no calculation table is required.
The split ratios of broadleaved HR are displayed together with the split ratios of the other felling products in RE_Table 37 in chapter 5.2.3.

4.3 Calculation of the Process Spedific Values of the Selected EFORWOOD FWC Sustainability Indicators

In the course of chapter 4.3 the values of all sustainability indicators (SI) that are compiled in table 4.1-5 are calculated. The calculations are performed per country and for each process of the country specific technical timber production chains (TTPCs). The resulting country and process specific SI values are then compiled and displayed in the result tables from RE_Table 41 to RE_Table 58 in chapter 5.3. The SI values in the RE_Tables can directly be used as input data for ToSIA.

The approach of the calculation of the SI values has been developed and amended throughout the procedure of researching and calculating the SI values:
When searching through national statistics in order to collect SI values, it turned out that data on the level of single processes are not available. In many cases the required data are even not available on the level of the country specific TTPC, but only on the level of the national forestry in general or even just on the level of the combined sector of ‘agriculture, hunting and forestry’, because the statistics usually provide the data in accordance to the International Standard Classification of all Economic Activities (ISIC). This fact is confirmed by E_10 (4 Dec 2008) and E_11 (15 Dec 2008) as they experienced similar problems in other projects dealing with East European topics, e.g. in COMFOR.

Therefore, in order to calculate the required process specific SI values, modes of calculation which are particular for each SI have been developed, based on the available data from statistics and on educated guesses from experts on the country specific TTPC. In fact, not a single SI value has been captured directly from statistics, but all SI values have been calculated.

In order to collect input data for the SI value calculations, internet sources have been systematically searched through, especially the international data bases of EUROSTAT, the OECD, the UN and the FAO. Furthermore, national websites (e.g. of statistical offices, of agricultural, forestry, and environmental ministries, of universities, of national research institutions, of libraries, of electronic journals, of NGOs and other institutions) have been searched through, which has caused high expenditure in time as most of these websites are not available in English versions. In many cases crucial data have been detected by using

translating software. Additionally, yearbooks and other country reports have been looked through; however, there exists a big lack of data on forestry related topics, at least in the English versions.
In order to obtain expert guesses, which were crucial to allow the calculation of many of the SI values (especially, as data from statistics and other sources has not been sufficient, as stated above), country specific experts have been identified. First, all project partners of EFORWOOD have been scanned to identify East European experts, who are obliged to EFORWOOD. This applies only to E_4.
Then, the network of the institutes of the Faculty of Forest and Environmental Sciences of the University of Freiburg has been checked for potential contacts to East European experts.
Next, employees of ministries, universities and other research institutions were contacted, although it was often very difficult to get through to the wanted experts via telephone or e-mail, due to language barriers, due to incorrect contact details on the corresponding web sites and due to high workloads of the experts.

Basic Prerequisites and Information:

Three data sets are necessary for calculating most of the required sustainability indicator values:
DATA SET 1 contains the output volume per felling process incl. and excl. harvest residues (HR) and the output volume per hauling process incl. HR; these output volumes are based on data from national forestry statistics and on calculations performed in chapter 4.2.
DATA SET 2 contains the country specific 'Weighted Mean Productivity' of TC, TH, SC, CC, CH, SKI, FOR and HOR per **p**roductive **u**nit **h**our (PUH). In this context 'units' are operating felling and hauling machines (harvesters, skidders, forwarders, horses and forestry workers as loggers and horse handlers); horses are regarded as machines in this context. PUH are defined as working hours excluding idle and shifting times.
The country and process specific 'Weighted Mean Productivity' is the product of the process and species specific 'Mean Productivity' regarding lowland and highland forests respectively weighted by the country specific area-related ratio of lowland and highland forests, and further weighted by the proportions of the tree species in the output volume per process as given in DATA SET 1. With regard to the output volume of felling processes HR are excluded, and with regard to the output volume of hauling processes HR are included.

The process and species specific 'Mean Productivity' regarding lowland and highland forests respectively are obtained through averaging very detailed process and species specific productivity values that are given in the Polish 'Catalogue of Norm Times' (THE POLISH STATE FORESTS NATIONAL FOREST HOLDING, 2008) for lowland and highland forests of spruce, pine and broadleaved species.

However, the 'Weighted Mean Productivity' of HOR is captured directly from FOBAWI (2002: 21) as the 'Catalogue of Norm Times' does not include data with regard to this hauling process. Due to a lack of differentiated data it is assumed that the value given in FOBAWI (2002: 21) is already weighted by an average area-related ratio of lowland and highland forests. Furthermore, the value is assumed to be already weighted by an average ratio of the tree species in the output volume of HOR.

DATA SET 3 contains the country specific 'Weighted Mean Productivity' of each process of the technical timber production chain (TTPC) per **u**nit **h**our (UH). UH is defined as working hours including idle and shifting times. With regard to forestry working staff (loggers, horse handlers and machine operators) no differentiation between 'Weighted Mean Productivity' per PUH and 'Weighted Mean Productivity' per UH is made.

DATA SET 1:

All indicator values regarding the TTPC processes correspond to the volume of timber which is actually further utilised in subsequent processes of the forestry-wood chain (FWC); this volume equals the total volume of timber incl. HR, which is hauled in the hauling processes. The respective output volume per felling and hauling process, which is further utilised in subsequent FWC processes, is then needed for putting absolute SI values in relation to the reporting unit m^3_{ub}, which is required for most of the sustainability indicator values (see table 4.1-5).

According to this, the calculation of the output volume per felling and hauling process excluding those HR which are left unutilised in the forest stand after felling is performed according to the following schemes:

Output volume per felling process excluding those HR which are left unutilised in the forest stand after felling:

(process share of felling process x in the total volume of timber felled in 2005 (based on EFISCEN data)), which is calculated in VF_CALC 1 for Poland multiplied to *(total volume of timber incl. HR, hauled in 2005 (based on national forestry statistics)),* which is calculated in VF_CALC 6.2 for Poland.

Output volume per hauling process excluding those HR which are left unutilised in the forest stand after felling:
(process share of hauling process x in the total volume of timber felled in 2005 (based on EFISCEN data)), which is calculated in VF_CALC 3 for Poland, multiplied to *(total volume of timber incl. HR, hauled in 2005 (based on forestry statistics)),* which is calculated in VF_CALC 6.2 for Poland.

This approach is based on the assumption that the country specific process shares calculated on the basis of EFISCEN data are representative for the conditions in the respective country; therefore, the process shares based on EFISCEN data can also be applied on the total felling and hauling volumes given in national forestry statistics.
The output volumes of all regarded felling and hauling processes resulting from the calculations above are displayed in table 4.3-1.

Table 4.3-1: *Volume of timber, which is further processed in the FWC, felled per felling and hauled per hauling process respectively.*

Process		**Output volume of timber, which is further processed in the FWC, per process [m^3_{ub}]**
Process category	**Process ID**	**Poland**
Felling	**TC**	12051465.12
	SC	10293959.79
	CC	5272515.99
	CH	278969.1
	SUM	**27896910.00**
Hauling	**SKI**	22317528.00
	FOR	1394845.50
	HOR	4184536.50
	SUM	**27896910.00**

<u>DATA SET 2</u>:

In order to obtain the country and process specific 'Weighted Mean Productivity' per productive unit hour (PUH), three steps of calculation have to be performed: First, the calculation of the process and species specific 'Mean Productivity' regarding lowland forests and of the process and species specific 'Mean Productivity' regarding highland forests is performed. Second, these process and species specific lowland and highland 'Mean Productivities' are weighted by the country specific area-related ratio of lowland and highland forests and then added to obtain the country and species specific 'Mean Productivity' per process.

<u>First step</u>**:** It is assumed that the productivity values given in the Polish 'Catalogue of Norm Times' (THE POLISH STATE FORESTS NATIONAL FOREST HOLDING, 2008) are representative for East European countries.

The productivity values that are given in the Polish 'Catalogue of Norm Times' are displayed as '[number of PUH needed to produce one m^3_{ub} of timber in the felling processes]' with regard to the felling processes, and as '[number of PUH needed to haul 1 m^3_{ub} of timber in the hauling processes]' with regard to the hauling processes. This units do not follow from the 'Catalogue of Norm Times' itself, but are stated by E_12 (20 Feb 2009). For the calculations within this study, this unit is transferred to [m^3_{ub}/PUH].

The averaging of the detailed process and species specific productivity values which are given in the Polish 'Catalogue of Norm Times' (THE POLISH STATE FORESTS NATIONAL FOREST HOLDING, 2008) for lowland and highland forests is performed according to the following:

The process specific productivity values within the 'Catalogue of Norm Times' are given for spruce, pine and broadleaved lowland forests and highland forests; they are further characterised by two dimensions each:

In terms of **chainsaw felling processes** (TC, SC, CC) the first dimension is the size (in terms of diameter) of the processed timber, namely small (M2), medium (S1) and large (W); the second dimension is the level of difficulty (regarding type of felling, stand structure and slope angle), which the respective process undergoes.

In terms of **felling with harvester** (TH, CH) the first dimension is the type of felling, namely thinning and clear cutting; the second dimension is the level of difficulty (regarding altitude and relief).

In terms of **hauling with skidder** (SKI) and **hauling with forwarder** (FOR) the first dimension is the hauling distance; the second dimension is the level of difficulty (regarding stand structure and slope angle).

Despite intensive research no information about average hauling distances in SKI and FOR has been found for Poland; therefore, based on Hungarian data (FAO, 1998, ¶ 2) it is assumed that the average hauling distance in SKI and FOR in East European countries is 450 m in upland and mountainous areas (highlands) and 250 m in lowlands.

The sets of process and species specific productivity values within the Polish 'Catalogue of Norm Times', which are relevant for calculating the process and species specific 'Mean Productivity' regarding lowland forests and the process and species specific 'Mean Productivity' regarding highland forests, are schematically displayed in table 4.3-2.

Table 4.3-2: *Description per species and process of the sections within the Polish 'Catalogue of Norm Times', where the raw data that are averaged for the purpose of this study can be found.*

Species	Process	Type of landscape	Page of the 'Catalogue of Norm Times'	First dimension: Dimension of timber	Second dimension: Level of difficulty in terms of operation
Spruce	**TC**	Lowlands	33	M2; S1	03; 04
		Highlands	39	M2; S1	03; 04
	SC	Lowlands	33	S1; W	02; 03
		Highlands	39	S1; W	02; 03; 04
	CC	Lowlands	33	S1; W	01; 02
		Highlands	39	S1; W	01; 02; 03
	CH	Lowlands	45	293 – 296	01
		Highlands	45	293 – 296	02
	SKI	Lowlands	51	200 – 300	01
		Highlands	51	400 – 500	02; 03; 04
	FOR	Lowlands	53; 54; 55; 56	200 – 300	01
		Highlands	53; 54; 55; 56	400 – 500	02; 03; 04
Pine	**TC**	Lowlands	32	M2; S1	03; 04
		Highlands	38	M2; S1	03; 04

	SC	Lowlands	32	S1; W	02; 03
		Highlands	38	S1; W	02; 03; 04
	CC	Lowlands	32	S1; W	01; 02
		Highlands	38	S1; W	01; 02; 03
	CH	Lowlands	45	293 – 296	01
		Highlands	45	293 – 296	02
	SKI	Lowlands	51	200 – 300	01
		Highlands	51	400 – 500	02; 03; 04
	FOR	Lowlands	53; 54; 55; 56	200 – 300	01
		Highlands	53; 54; 55; 56	400 – 500	02; 03; 04
Broadleaved	**TC**	Lowlands	34	M2; S1	03; 04
		Highlands	40	M2; S1	03; 04
	CC	Lowlands	34	S1; W	01; 02
		Highlands	40	S1; W	01; 02; 03
	SKI	Lowlands	52	200 – 300	01
		Highlands	52	400 – 500	02; 03; 04
	FOR	Lowlands	53; 54; 55; 56	200 – 300	01
		Highlands	53; 54; 55; 56	400 – 500	02; 03; 04

As already stated, the ‘Catalogue of Norm Times’ does not include data with regard to the process HOR. Therefore, the needed value is directly taken from FOBAWI (2002: 21). In FOBAWI (2002: 21) 40 m is given as the longest distance for hauling with horse; the given corresponding productivity value (i.e. 3.1 m^3_{ub} per PUH) is assumed to be the average HOR specific ‘Mean Productivity’, which is the same for all tree species in the case of HOR. The productivity value of 3.1 m^3_{ub} per PUH and the maximum hauling distance of 40 m in HOR is stated to be reasonable for East European conditions by E_3 (4 May 2009).

Second step: The process and species specific lowland and highland ‘Mean Productivities’ are weighted by the country specific area-related ratio of lowland and highland forests and then added to obtain the country and species specific ‘Mean Productivity’ per process.

In Poland 11.2% of the forests are situated in highlands and 88.8% are situated in lowlands (JODLOWSKI et al., 2004: 1).

In accordance to this the country and species specific 'Mean Productivity' values per process are calculated as sum of *(mean productivity of process x in lowland forests) * 88.8%* and *(mean productivity of process x in highland forests) * 11.2%.*

The country and species specific 'Mean Productivity' values per process for Poland are compiled in table 4.3-3.

Table 4.3-3: *Country and species specific 'Mean Productivity' [m^3_{ub}/PUH] of each regarded felling and hauling process in Poland*

Process	'Mean Productivity' of process per tree species [m^3_{ub}/PUH]				
	Spruce	Pine	Oak	Beech	Birch
TC	0.40	0.49	0.39	0.39	0.39
SC	0.77	0.96	---	---	---
CC	0.96	1.16	0.87	0.87	0.87
CH	12.65	12.65	---	---	---
SKI	6.24	6.24	5.58	5.58	5.58
FOR	4.50	4.50	3.92	3.92	3.92
HOR	3.1	3.1	3.1	3.1	3.1

Third step: Several calculations of sustainability inidicator values in the further course of this study are based on country and process specific 'Weighted Mean Productivity' values per PUH. This country and process specific 'Weighted Mean Productivity' values per PUH for Poland are calculated in IN_CALC 1.

IN_CALC 1:

Calculation of the country and process specific 'Weighted Mean Productivity' per PUH for Poland:

The values of the country and process specific 'Weighted Mean Productivity' per PUH are calculated by weighting the country and species specific 'Mean Productivity' per PUH as given in table 4.3-3 according to the ratio of the proportions of spruce, pine, oak, beech and birch in the total output volume of timber of the respective process.

With regard to the felling processes and SKI and FOR the calculation is performed according to the generalised calculation scheme

$\sum_{(for\ tree\ species\ that\ are\ relevant\ in\ process\ x)}$ *[(proportion of species specific volume of timber, that is processed in process x, in the total volume of timber, which is processed in process x) * (species specific mean productivity per PUH of process x)].*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	mean productivity per PUH in TC weighted according to the proportion of the tree species in the output volume of TC (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(SC)	mean productivity per PUH in SC weighted according to the proportion of the tree species in the output volume of SC (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(CC)	mean productivity per PUH in CC weighted according to the proportion of the tree species in the output volume of CC (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(CH)	mean productivity per PUH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(SKI)	mean productivity per PUH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(FOR)	mean productivity per PUH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	Table 4.3-5	m^3_{ub}/PUH	
x(HOR)	mean productivity per PUH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	Table 4.3-5	m^3_{ub}/PUH	
Given parameters				
a	process share of TC for spruce/pine in PL	44.58	%	VF_CALC 2c
b	process share of SC for spruce/pine in PL	44.75	%	VF_CALC 2c
c	process share of CC for spruce/pine in PL	9.46	%	VF_CALC 2c
d	process share of CH for spruce/pine in PL	1.21	%	VF_CALC 2c
e	process share of TC for oak/beech in PL	21	%	VF_CALC 2b
f	process share of CC for oak/beech in PL	79	%	VF_CALC 2b
g	process share of TC for birch in PL	75	%	VF_CALC 2a
h	process share of CC for birch in PL	25	%	VF_CALC 2a
i	process share of SKI for all species in PL	80	%	VF_CALC 4
j	process share of FOR for all species in PL	5	%	VF_CALC 4
k	process share of HOR for all species in PL	15	%	VF_CALC 4
l	volume of spruce timber excl. HR, felled in 2005 (EFISCEN)	3667.0464	$1000m^3_{ob}$	Table 4.1-3
m	volume of pine timber excl. HR, felled in 2005 (EFISCEN)	22789.8512	$1000m^3_{ob}$	Table 4.1-3
n	volume of oak timber excl. HR, felled in 2005 (EFISCEN)	1805.2574	$1000m^3_{ob}$	Table 4.1-3
o	volume of beech timber excl. HR, felled in 2005 (EFISCEN)	2185.6384	$1000m^3_{ob}$	Table 4.1-3
p	volume of birch timber excl. HR, felled in 2005 (EFISCEN)	1637.1665	$1000m^3_{ob}$	Table 4.1-3

q	volume of hauled spruce short logs (based on EFISCEN data)	1094.43	$1000m^3_{ob}$	Table 4.2-4
r	volume of hauled spruce long logs (based on EFISCEN data)	2591.31	$1000m^3_{ob}$	Table 4.2-4
s	volume of hauled spruce HR (based on EFISCEN data)	13.34	$1000m^3_{ob}$	Table 4.2-4
t	volume of hauled pine short logs (based on EFISCEN data)	6657.28	$1000m^3_{ob}$	Table 4.2-4
u	volume of hauled pine long logs (based on EFISCEN data)	16245.41	$1000m^3_{ob}$	Table 4.2-4
v	volume of hauled pine HR (based on EFISCEN data)	82.88	$1000m^3_{ob}$	Table 4.2-4
w	volume of hauled oak short logs (based on EFISCEN data)	422.93	$1000m^3_{ob}$	Table 4.2-4
y	volume of hauled oak long logs (based on EFISCEN data)	1374.52	$1000m^3_{ob}$	Table 4.2-4
z	volume of hauled beech short logs (based on EFISCEN data)	509.32	$1000m^3_{ob}$	Table 4.2-4
aa	volume of hauled beech long logs (based on EFISCEN data)	1677.54	$1000m^3_{ob}$	Table 4.2-4
ab	volume of hauled birch short logs (based on EFISCEN data)	744.00	$1000m^3_{ob}$	Table 4.2-4
ac	volume of hauled birch long logs (based on EFISCEN data)	890.99	$1000m^3_{ob}$	Table 4.2-4
ad	'Mean Productivity' of TC for spruce	0.4	m^3_{ub}/PUH	Table 4.3-3
ae	'Mean Productivity' of TC for pine	0.49	m^3_{ub}/PUH	Table 4.3-3
af	'Mean Productivity' of TC for oak/beech/birch	0.39	m^3_{ub}/PUH	Table 4.3-3
ag	'Mean Productivity' of SC for spruce	0.77	m^3_{ub}/PUH	Table 4.3-3
ah	'Mean Productivity' of SC for pine	0.96	m^3_{ub}/PUH	Table 4.3-3
ai	'Mean Productivity' of CC for spruce	0.96	m^3_{ub}/PUH	Table 4.3-3
aj	'Mean Productivity' of CC for pine	1.16	m^3_{ub}/PUH	Table 4.3-3
ak	'Mean Productivity' of CC for oak/beech/birch	0.87	m^3_{ub}/PUH	Table 4.3-3
al	'Mean Productivity' of CH for spruce/pine	12.65	m^3_{ub}/PUH	Table 4.3-3
am	'Mean Productivity' of SKI for spruce/pine	6.24	m^3_{ub}/PUH	Table 4.3-3
an	'Mean Productivity' of SKI for oak/beech/birch	5.58	m^3_{ub}/PUH	Table 4.3-3
ao	'Mean Productivity' of FOR for spruce/pine	4.5	m^3_{ub}/PUH	Table 4.3-3
ap	'Mean Productivity' of FOR for oak/beech/birch	3.92	m^3_{ub}/PUH	Table 4.3-3
aq	'Mean Productivity' of HOR for all species	3.1	m^3_{ub}/PUH	Table 4.3-3
ar	process share of TC in the total volume of timber felled in 2005	43.20	%	VF_CALC 1a
as	process share of SC in the total volume of timber felled in 2005	36.90	%	VF_CALC 1a
at	process share of CC in the total volume of timber felled in 2005	18.90	%	VF_CALC 1b
au	process share of CH in the total volume of timber felled in 2005	1.00	%	VF_CALC 1c
av	process share of SKI in the total volume of timber hauled in 2005	80	%	VF_CALC 3
aw	process share of FOR in the total volume of timber hauled in 2005	5	%	VF_CALC 3

ay	process share of HOR in the total volume of timber hauled in 2005	15	%	VF_CALC 3
az	total volume of timber excl. HR, felled in 2005 (EFISCEN)	32084.9599	$1000m^3_{ob}$	Table 4.1-3
ba	total volume of timber incl. HR, hauled in 2005 (based on EFISCEN data)	32181.18	$1000m^3_{ob}$	Table 4.2-3
Calculation mode				

→ x(TC) = [(a*l)/(ar*az)]*ad + [(a*m)/(ar*az)]*ae + [(e*n)/(ar*az)]*af + [(e*o)/(ar*az)]*af + [(g*p)/ar*az)]*af

→ x(SC) = [(b*l)/(as*az)]*ag + [(b*m)/(as*az)]*ah

→ x(CC) = [(c*l)/(at*az)]*ai + [(c*m)/(at*az)]*aj + [(f*n)/(at*az)]*ak + [(f*o)/(at*az)]*ak + [(h*p)/at*az)]*ak

→ x(CH) = [(d*l)/(au*az)]*al + [(d*m)/(au*az)]*al

→ x(SKI) = {[i*(q+r+s+t+u+v)]/(av*ba)}*am + {[i*(w+y+z+aa+ab+ac)]/(av*ba)}*an

→ x(FOR) = {[j*(q+r+s+t+u+v)]/(aw*ba)}*ao + {[j*(w+y+z+aa+ab+ac)]/(aw*ba)}*ap

→ x(HOR) = aq

With regard to HOR the 'Weighted Mean Productivity' per PUH is identical to the 'Mean Productivity' per PUH as no differentiated data in terms of different species are available.

As the values of the 'Weighted Mean Productivity' per PUH are no final results of this study but intermediate results only, they are displayed in a conjoined table together with the values of the 'Weighted Mean Productivity' per UH, directly subsequent to data set 3; the table's identification code is 'table 4.3-5'; the table is displayed on page 97.

<u>DATA SET 3</u>:

Besides the country and process specific 'Weighted Mean Productivity' per productive unit hour (PUH) the corresponding country and process specific 'Weighted Mean Productivity' per unit hour (UH) is needed as basic input data in several calculations of sustainable indicators.

The ratio of 'Weighted Mean Productivity' per PUH and 'Weighted Mean Productivity' per UH is inversely dependent on the ratio of the number of annual PUH per operating unit and the number of annual UH per operating unit. In FVA (2008.xls) the number of annual PUH and the number of annual UH is given per operating unit in the processes TH, CH, SKI and FOR. The corresponding values of HOR are calculated as follows: It is assumed that horses used in hauling operations are in full activity on 230 days per year in Poland (see derivation in chapter 4.3.5.1, section B(4)), assuming that there are as many working days per year for a horse in the process HOR as for a forestry worker. According to NEWSLINE WESTDEUTSCHE ZEITUNG (2009) a horse is able to haul timber during 6 hours per working day, which means that the number of annual PUH per horse is 1380 in Poland.

Furthermore, each horse needs 1 hour of breaks per working day, 1 hour of shifting time per working day and 1 hour of tending per each of the 365 days of the year (E_14, 17 Feb 2009); during these hours the forestry worker, who is the horse handler, has to be available. Therefore, the number of annual UH per horse accumulates to 2205 in Poland.

As stated before no differentiation between 'Weighted Mean Productivity' per PUH and 'Weighted Mean Productivity' per UH is made with regard to forestry working staff.

The number of annual PUH and UH per operating unit in CH, SKI, FOR and HOR is displayed in table 4.3-4:

Table 4.3-4: *Number of annual PUH and UH per operating unit in CH, SKI and FOR as given in FVA (2008.xls), and in HOR as shown above (for Poland)*

Process	# of annual PUH per operating unit	# of annual UH per operating unit
CH	1920	2400
SKI	1440	1600
FOR	2160	2400
HOR	1380	2205

IN_CALC 2:

Calculation of the country and process specific 'Weighted Mean Productivity' per UH:

Using a rule of three calculation according to the scheme *[(number of annual PUH per operating unit in process x) / (number of annual UH per operating unit in process x)] * (country specific 'Weighted Mean Productivity' per PUH in process x)*, the country and process specific 'Weighted Mean Productivity' values per UH is calculated on the basis of *IN_CALC 1* and of the values shown in table 4.3-4.

As there is no differentiation between 'Weighted Mean Productivity' per PUH and 'Weighted Mean Productivity' per UH with regard to forestry working staff, the values for 'Weighted

Mean Productivity' per PUH and 'Weighted Mean Productivity' per UH in TC, SC and CC respectively are identical.

Due to the fact that the country and process specific 'Weighted Mean Productivity' values per UH are basic prerequisites and no final calculation results of this study, they are displayed in the conjoined table 4.3-5 together with the values of the 'Weighted Mean Productivity' per PUH:

Table 4.3-5: *'Weighted Mean Productivity' of each regarded process per PUH and per UH, calculated for Poland*

Process	'Weighted Mean Productivity' [m^3_{ub}/PUH] (results of IN_CALC 1)	'Weighted Mean Productivity' [m^3_{ub}/UH]
TC	0.46	0.46
SC	0.93	0.93
CC	0.98	0.98
CH	12.65	10.12
SKI	6.15	5.54
FOR	4.33	3.90
HOR	3.10	1.94

4.3.1 GROSS VALUE ADDED (GVA) AT FACTOR COST (INDICATOR 1.1)

A) **<u>Data to be collected</u>:**

In chapter 4.3.1.1 the GVA of each felling and hauling process of the Polish technical timber production chain (TTPC) is calculated; the calculation is performed on the basis of data and information given in section B.

B) **<u>Underlying information and assumptions</u>:**

<u>(1)</u> The volume of timber excl. HR, felled in the Polish state forests in 2005 is 26.7mln m^3_{ub} according to Polish forestry statistics (THE STATE FORESTS NATIONAL FOREST HOLDING 2006: 51). This is 96% of the total volume of timber excl. HR, which was felled in Poland in 2005, as stated by STRYKOWSKI (2006, ¶ 4).

<u>(2)</u> The Polish State Forests National Forest Holding received 3950mln New Polish Zloty (PLN) as revenues from selling roundwood (THE POLISH STATE FORESTS NATIONAL FOREST HOLDING (2006: 69). E_17 (23 Feb 2009) states that timber is usually sold at road side.

<u>(3)</u> It is assumed that the average price of timber sold by The Polish State Forests National Forest Holding is also representative for timber sold by private forest owners.

<u>(4)</u> As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

<u>(5)</u> There are assumedly no direct subsidies for TTPC processes in Poland as no evidence of their existence could be found in public sources, despite intensive research. Indirect subsidies, precisely the exemption from vehicle taxes are concomitantly considered in the calculation by not factoring in vehicle taxes into the GVA calculation.

<u>(6)</u> The calculation of the process specific GVA at factor cost (IN_CALC 3) is further based on results IN_CALC 4 (costs of raw material from the FWC in the hauling and felling processes in Poland), IN_CALC 6 (process specific fuel costs excluding taxes per m^3_{ub} in Poland), IN_CALC 7 (‘other productive costs’ in the felling and hauling processes in Poland) and IN_CALC 8 ('non-productive costs' per felling and per hauling process in Poland).

C) <u>Combining the information</u>:

In EFORWOOD (2008c) it is described how to calculate the gross value added (GVA) at factor cost of the processes which are regarded in the technical timber production chain (TTPC). The general structure of the calculation is:

income at basic prices

– *costs of raw material from the FWC*

– *energy costs*

– *other productive costs*

– *non-productive costs*

= GVA at factor cost

IN_CALC 3:

<u>Calculation of the GVA at factor cost for the felling and hauling processes in Poland (PL)</u>:

According to this general structure the GVA per m^3_{ub} of felling process x is calculated according to the scheme

0 – (average costs of raw material from the FWC per m^3_{ub}) – (energy costs per m^3_{ub} in felling process x) – (other productive costs per m^3_{ub} in felling process x) – (non-productive costs per m^3_{ub} in felling process x).

In this calculation the income at basic prices is zero as the harvested timber is not sold at the interface between felling and hauling processes.

In contrast the GVA per m^3_{ub} of hauling process x is calculated according to the scheme

(average basic price of timber at road side per m^3_{ub}) – 0 – (energy costs per m^3_{ub} in hauling process x) – (other productive costs per m^3_{ub} in hauling process x) – (non-productive costs per m^3_{ub} in hauling process x).

As the harvested timber is usually sold at road side right after the hauling processes, the income at basic prices of the hauling processes is assumed to equal the basic price of timber at road side. The average costs of raw material from the FWC per m^3_{ub} with regard to hauling processes, however, are zero as there do not arise suchlike costs at the interface between felling and hauling processes.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	GVA at factor cost of TC	RE_Table 41	€/m^3_{ub}	
x(SC)	GVA at factor cost of SC	RE_Table 41	€/m^3_{ub}	
x(CC)	GVA at factor cost of CC	RE_Table 41	€/m^3_{ub}	
x(CH)	GVA at factor cost of CH	RE_Table 41	€/m^3_{ub}	
x(SKI)	GVA at factor cost of SKI	RE_Table 41	€/m^3_{ub}	
x(FOR)	GVA at factor cost of FOR	RE_Table 41	€/m^3_{ub}	
x(HOR)	GVA at factor cost of HOR	RE_Table 41	€/m^3_{ub}	
Given parameters				
a	volume of timber excl. HR, felled in Polish state forests in 2005	26700000	m^3_{ub}	B(1)
b	revenues from timber sold by The Polish State Forests National Forest Holding in 2005	3950000000	PLN	B(2)
c	exchange rate of 1 € to PLN	4.0230	#	B(4)
d	energy costs in TC	0.621	€/m^3_{ub}	B(6), IN_CALC 6
e	other productive costs (excl. labour costs) in TC	0.573	€/m^3_{ub}	B(6), IN_CALC 7
f	non-productive costs in TC	0.438	€/m^3_{ub}	B(6), IN_CALC 8
g	energy costs in SC	0.311	€/m^3_{ub}	B(6), IN_CALC 6
h	other productive costs (excl. labour costs) in SC	0.286	€/m^3_{ub}	B(6), IN_CALC 7
i	non-productive costs in SC	0.218	€/m^3_{ub}	B(6), IN_CALC 8
j	energy costs in CC	0.297	€/m^3_{ub}	B(6), IN_CALC 6
k	other productive costs (excl. labour costs) in CC	0.273	€/m^3_{ub}	B(6), IN_CALC 7
l	non-productive costs in CC	0.208	€/m^3_{ub}	B(6), IN_CALC 8
m	energy costs in CH	0.832	€/m^3_{ub}	B(6), IN_CALC 6
n	other productive costs (excl. labour costs) in CH	0.143	€/m^3_{ub}	B(6), IN_CALC 7
o	non-productive costs in CH	0.650	€/m^3_{ub}	B(6), IN_CALC 8
p	energy costs in SKI	1.060	€/m^3_{ub}	B(6), IN_CALC 6
q	other productive costs (excl. labour costs) in SKI	0.214	€/m^3_{ub}	B(6), IN_CALC 7
r	non-productive costs in SKI	1.209	€/m^3_{ub}	B(6), IN_CALC 8
s	energy costs in FOR	1.833	€/m^3_{ub}	B(6), IN_CALC 6

t	other productive costs (excl. labour costs) in FOR	0.213	€/m^3_{ub}	B(6), IN_CALC 7
u	non-productive costs in FOR	1.498	€/m^3_{ub}	B(6), IN_CALC 8
v	energy costs in HOR	0.106	€/m^3_{ub}	B(6), IN_CALC 6
w	other productive costs (excl. labour costs) in HOR	not feasible	€/m^3_{ub}	B(6), IN_CALC 7
y	non-productive costs in HOR	0.023	€/m^3_{ub}	B(6), IN_CALC 8
z	costs of raw material from FWC in felling processes	28.983	€/m^3_{ub}	B(6), IN_CALC 4
Calculation mode				
→ x(TC) = 0 – z – d – e – f → x(SC) = 0 – z – g – h – i → x(CC) = 0 – z – j – k – l → x(CH) = 0 – z – m – n – o → x(SKI) = (b/a)/c – 0 – p – q – r → x(FOR) = (b/a)/c – 0 – s – t – u → x(HOR) = (b/a)/c – 0 – v – y				

The process specific values of the GVA at factor cost are displayed in RE_Table 41 in chapter 5.3.1.

4.3.2 Production Costs: Raw Material from the FWC (Indicator 2.1.1)

In terms of felling processes, the costs of raw material originating from previous stages of the forestry-wood chain (FWC) is synonymous with the price of the stumpage which is felled in the respective felling processes. This means the scheme for calculating the 'Costs of raw material from FWC' in the felling processes is *(average basic price of timber at road side per* m^3_{ub}*) – (average felling costs incl. labour costs per* m^3_{ub}*, weighted according to the proportions of the felling processes in the total volume of felled timber) – (average hauling costs incl. labour costs per* m^3_{ub}*, weighted according to the proportions of the hauling processes in the total volume of hauled timber)*. Indicator 2.1.1 has the same value for all felling processes; this is why only one representative calculation is performed.
The 'Costs of raw material from the FWC' for the regarded hauling processes are zero as the harvested timber is not sold from the harvesting to the hauling processes.

A) <u>Data to be collected</u>:

The value of the 'Costs of raw material from the FWC', which is processed in each felling and hauling process is calculated.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> The volume of timber excl. HR, felled in the Polish state forests in 2005 is 26.7mln m^3_{ub} according to Polish forestry statistics (The State Forests National Forest Holding 2006: 51). This is 96% of the total volume of timber excl. HR, which was felled in PL in 2005, as stated by Strykowski (2006, ¶ 4).

<u>(2)</u> The Polish State Forests National Forest Holding received 3950mln New Polish Zloty (PLN) as revenues from selling roundwood (The Polish State Forests National Forest Holding (2006: 69). E_17 (23 Feb 2009) states that timber is usually sold at road side.

<u>(3)</u> It is assumed that the average price of timber sold by The Polish State Forests National Forest Holding is also representative for timber sold by private forest owners.

<u>(4)</u> As given by Eurostat (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

<u>(5)</u> The following calculation IN_CALC 4 is further based on results of VF_CALC 1 (process share of each felling process in the total volume of timber felled in Poland in 2005), VF_CALC 3 (process share of each hauling process in the total volume of timber hauled in Poland in 2005), IN_CALC 5 (labour costs in each felling and hauling process of the Polish TTPC), IN_CALC 6 (process specific fuel costs excluding taxes per m^3_{ub} in Poland), IN_CALC 7 ('other productive costs' in the felling and hauling processes in Poland) and IN_CALC 8 ('non-productive costs' per felling and per hauling process in Poland).

C) Combining the information:

IN_CALC 4:

Calculation of the costs of raw material from the FWC in the hauling and felling processes in Poland:

The value of 'Costs of raw material from the FWC', which is calculated in the following calculation, is valid for each single felling (TC, SC, CC and CH) and hauling (SKI, FOR, HOR) process respectively.

With regard to the felling processes the value of indicator 2.1.1 is calculated according to the generalised calculation scheme

(average basic price of timber at road side per m^3_{ub}) – *(average felling costs incl. labour costs per m^3_{ub}, weighted according to the proportions of the felling processes in the total volume of felled timber)* – *(average hauling costs incl. labour costs per m^3_{ub}, weighted according to the proportions of the hauling processes in the total volume of hauled timber).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(F)	costs of raw material from FWC in felling processes	RE_Table 42	€/m^3_{ub}	
Given parameters				
a	volume of timber excl. HR, felled in Polish state forests in 2005	26700000	m^3_{ub}	B(1)
b	revenues from timber sold by The Polish State Forests National Forest Holding in 2005	3950000000	PLN	B(2)
c	exchange rate of 1 € to PLN	4.0230	#	B(4)
d	process share of TC in the total volume of timber felled in 2005	43.2	%	B(5), VF_CALC 1a
e	labour costs in TC	5.333	€/m^3_{ub}	B(5),

				IN_CALC 5
f	energy costs in TC	0.621	€/m^3_{ub}	B(5), IN_CALC 6
g	other productive costs (excl. labour costs) in TC	0.573	€/m^3_{ub}	B(5), IN_CALC 7
h	non-productive costs in TC	0.438	€/m^3_{ub}	B(5), IN_CALC 8
i	process share of SC in the total volume of timber felled in 2005	36.9	%	B(5), VF_CALC 1a
j	labour costs in SC	2.650	€/m^3_{ub}	B(5), IN_CALC 5
k	energy costs in SC	0.311	€/m^3_{ub}	B(5), IN_CALC 6
l	other productive costs (excl. labour costs) in SC	0.286	€/m^3_{ub}	B(5), IN_CALC 7
m	non-productive costs in SC	0.218	€/m^3_{ub}	B(5), IN_CALC 8
n	process share of CC in the total volume of timber felled in 2005	18.9	%	B(5), VF_CALC 1b
o	labour costs in CC	2.530	€/m^3_{ub}	B(5), IN_CALC 5
p	energy costs in CC	0.297	€/m^3_{ub}	B(5), IN_CALC 6
q	other productive costs (excl. labour costs) in CC	0.273	€/m^3_{ub}	B(5), IN_CALC 7
r	non-productive costs in CC	0.208	€/m^3_{ub}	B(5), IN_CALC 8
s	process share of CH in the total volume of timber felled in 2005	1.0	%	B(5), VF_CALC 1c
t	labour costs in CH	0.303	€/m^3_{ub}	B(5), IN_CALC 5
u	energy costs in CH	0.832	€/m^3_{ub}	B(5), IN_CALC 6
v	other productive costs (excl. labour costs) in CH	0.143	€/m^3_{ub}	B(5), IN_CALC 7
w	non-productive costs in CH	0.650	€/m^3_{ub}	B(5), IN_CALC 8
y	process share of SKI in the total volume of timber hauled in 2005	80	%	B(5), VF_CALC 3
z	labour costs in SKI	0.557	€/m^3_{ub}	B(5), IN_CALC 5
aa	energy costs in SKI	1.060	€/m^3_{ub}	B(5), IN_CALC 6
ab	other productive costs (excl. labour costs) in SKI	0.214	€/m^3_{ub}	B(5), IN_CALC 7
ac	non-productive costs in SKI	1.209	€/m^3_{ub}	B(5), IN_CALC 8
ad	process share of FOR in the total volume of timber hauled in 2005	5	%	B(5), VF_CALC 3
ae	labour costs in FOR	0.770	€/m^3_{ub}	B(5), IN_CALC 5
af	energy costs in FOR	1.833	€/m^3_{ub}	B(5), IN_CALC 6
ag	other productive costs (excl. labour costs) in FOR	0.213	€/m^3_{ub}	B(5), IN_CALC 7

ah	non-productive costs in FOR	1.498	€/m^3_{ub}	B(5), IN_CALC 8
ai	process share of HOR in the total volume of timber hauled in 2005	15	%	B(5), VF_CALC 3
aj	labour costs in HOR	1.275	€/m^3_{ub}	B(5), IN_CALC 5
ak	energy costs in HOR	0.106	€/m^3_{ub}	B(5), IN_CALC 6
al	other productive costs (excl. labour costs) in HOR	not feasible	€/m^3_{ub}	B(5), IN_CALC 7
am	non-productive costs in HOR	0.023	€/m^3_{ub}	B(5), IN_CALC 8
Calculation mode				
→ x(F) = (b/a)/c – [d*(e+f+g+h) + i*(j+k+l+m) + n*(o+p+q+r) + s*(t+u+v+w)] – [y*(z+aa+ab+ac) + ad*(ae+af+ag+ah) + ai*(aj+ak+al+am)]				

The process specific values of the costs of raw material from the FWC are displayed in RE_Table 42 in chapter 5.3.2.1.

4.3.3 PRODUCTION COSTS: RAW MATERIAL FROM OUTSIDE OF THE FWC (INDICATOR 2.1.2)

As no raw materials from outside the forestry-wood chain (FWC) could be identified as being utilised in the technical timber production chain (TTPC) in Poland, it is assumed that the indicator 2.1.2 is not applicable in the context of this study.

4.3.4 Production Costs: Labour (Indicator 2.1.3)

A) Data to be collected:

For each regarded process the labour costs per m^3_{ub} are calculated on the basis of the data and information given in section B.

B) Underlying information and assumptions:

(1) According to the Central Statistical Office (2005: 181) personal wages and salaries contributed 74.5% to the labour costs in 2004. Although intensive research was performed no corresponding data of the year 2005 has been found. This is why the share of wages and salaries in the total amount of labour costs of the year 2004 is used for the calculation.

(2) The calculation is further based on results of IN_CALC 10 (average wage per full-time equivalent employee (FTEE) and m^3_{ub} of each felling and hauling process in Poland). One FTEE is a fictitious employee working full-time; within this study the number of employees is generally captured and calculated as FTEEs.

C) Combining the information:

IN_CALC 5:

Calculation of the labour costs in each felling and hauling process of the Polish TTPC:

The calculation is performed according to the generalised calculation scheme

(average wage per m^3_{ub} of process x) / *(proportion of wage in the total amount of labour costs)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	labour costs in TC	RE_Table 43	€/m^3_{ub}	
x(SC)	labour costs in SC	RE_Table 43	€/m^3_{ub}	
x(CC)	labour costs in CC	RE_Table 43	€/m^3_{ub}	
x(CH)	labour costs in CH	RE_Table 43	€/m^3_{ub}	
x(SKI)	labour costs in SKI	RE_Table 43	€/m^3_{ub}	
x(FOR)	labour costs in FOR	RE_Table 43	€/m^3_{ub}	
x(HOR)	labour costs in HOR	RE_Table 43	€/m^3_{ub}	

Given parameters				
a	average wage per m^3 $_{ub}$ in TC	3.973	€/m^3_{ub}	B(2), IN_CALC 10
b	average wage per m^3 $_{ub}$ in SC	1.974	€/m^3_{ub}	B(2), IN_CALC 10
c	average wage per m^3 $_{ub}$ in CC	1.885	€/m^3_{ub}	B(2), IN_CALC 10
d	average wage per m^3 $_{ub}$ in CH	0.226	€/m^3_{ub}	B(2), IN_CALC 10
e	average wage per m^3 $_{ub}$ in SKI	0.415	€/m^3_{ub}	B(2), IN_CALC 10
f	average wage per m^3 $_{ub}$ in FOR	0.574	€/m^3_{ub}	B(2), IN_CALC 10
g	average wage per m^3 $_{ub}$ in HOR	0.950	€/m^3_{ub}	B(2), IN_CALC 10
h	proportion of wage in the total amount of labour costs	74.5	%	B(1)
Calculation mode				

→ x(TC) = a/h

→ x(SC) = b/h

→ x(CC) = c/h

→ x(CH) = d/h

→ x(SKI) = e/h

→ x(FOR) = f/h

→ x(HOR) = g/h

The process specific values of labour costs are displayed in RE_Table 43 in chapter 5.3.2.3.

4.3.5 PRODUCTION COSTS: ENERGY (INDICATOR 2.1.4)

In this study costs of energy tally with the expenditure on fuel that is needed to run machines utilised in felling or hauling operations, namely chainsaws, harvesters, skidders and forwarders. It is assumed that harvesters, skidders and forwarders run on conventional diesel, while chainsaws are fuelled with conventional petrol. By contrast, horses used in the process HOR need renewable 'fuel' like oats, hay and additional animal feeding stuffs.
The energy costs, as calculated in this chapter, correspond to the price excluding taxes that is to be paid for the amount of fuel consumed to process one m^3_{ub} of timber. Tax expenditures are considered in the indicator 'non-productive costs'.

A) <u>Data to be collected</u>:

The calculation of energy costs per m^3_{ub} is based on the values of fuel consumption per m^3_{ub}. Prices for one litre of diesel and petrol respectively are taken from the FCBA-transport tool as displayed in EFORWOOD (2009.xls). For 'fuel' costs regarding HOR prices are collected from the CENTRAL STATISTICAL OFFICE (2008).

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> In 2005 one litre of diesel and one litre of petrol cost 0.65 € and 0.69 € respectively without taxes as noted in EFORWOOD (2009.xls). The prices are given as prices at tank, assuming that the machines are fuelled up from a tank situated on the estate of the forestry enterprise.

<u>(2)</u> The average fuel consumption corresponding to certain mean productivities per unit hour (UH) under German conditions per type of machine is given in FVA (2008.xls). It is assumed that the values given in FVA (2008.xls) are mean values corresponding to the volume of timber incl. harvest residues (HR), which is further utilised in subsequent processes of the forestry-wood chain (FWC).
These fuel consumption values of FVA (2008.xls) are adapted to the 'Weighted Mean Productivity' per UH as calculated for Poland (see table 4.3-5) through performing a rule of three calculation (see table 4.3-6). This approach is based on the assumption that productivity and fuel consumption are subject to inversely linear interdependence.

Table 4.3-6: *Average fuel consumption per process under Polish conditions [l/m³ub]*

Process	Productivity [m³ub/UH] (FVA 2008.xls)	Fuel consumption [l/m³ub] (FVA 2008.xls)	Weighted mean productivity [m³ub/UH] (table 4.3-5)	Average fuel consumption under Polish conditions [l/m³ub]
TC	2	0.208	0.46	0.90
SC	2	0.208	0.93	0.45
CC	2	0.208	0.98	0.43
CH	7.5	1.733	10.12	1.28
SKI	11.5	0.783	5.54	1.63
FOR	12	0.917	3.90	2.82

(3) According to NEWSLINE WESTDEUTSCHE ZEITUNG (2009) a horse needs 3.5 kg of oats, 3.5 kg of compound feeding stuffs and 5 kg of hay on a day with full work load. This amount of food corresponds to 124 MJ of digestible energy (DE) as stated in LANDWIRTSCHAFTSKAMMER NORDRHEIN-WESTFALEN (2004). In comparison, on a day of low strain a horse needs 84 MJ DE (LANDWIRTSCHAFTSKAMMER NORDRHEIN-WESTFALEN, 2004), which is 67.742% of the energy needed on a full strain day.

(4) According to THE WORLD BANK (2008: 67) each FTEE had 26 days of paid vacation in 2005. Assuming that the FTEE work only from Monday till Friday, the number of free days due to weekends is 104 as there are 52 weeks per year. Furthermore, there were 5 additional official holidays in Poland in 2005 that did not coincide with weekends (WWW.FEIERTAGE-WELTWEIT.COM, 2008). When subtracting 26, 104 and 5 from the total number of days in 2005, namely 365, the resulting number of working days in the year 2005 is 230.

(5) It is assumed that the number of working days per year, which are considered to be days of full work load, is the same for a horse as for a forestry worker.

(6) The 2005 purchaser's price of oats and hay is 0.3702 PLN and 0.2969 PLN respectively per kg in accordance to CENTRAL STATISTICAL OFFICE (2008: 324). The price of feeding stuffs for cattle, which assumedly equals the price of feeding stuffs for horses, is only available relative to 'kg of pigs for slaughter' for the year 2005: 1 kg of feeding stuffs for cattle is 0.212 'kg of pigs for slaughter'; the purchaser's price of 1 'kg of pigs for slaughter' is 3.91 PLN (CENTRAL STATISTICAL OFFICE, 2008: 325).

(7) As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

(8) The calculation is further based on values given in table 4.3-1 (volume of timber, which is further processed in the FWC, felled per felling and hauled per hauling process respectively), table 4.3-4 (number of annual PUH and UH per operating unit in TH, CH, SKI and FOR as given in FVA (2008.xls), and in HOR) and table 4.3-5 ('Weighted Mean Productivity' of each regarded process per PUH and per UH, calculated for Poland).

C) Combining the information:

IN_CALC 6:

Calculation of the process specific energy costs excluding taxes per m^3_{ub} in Poland (PL):

With regard to the felling processes and to SKI and FOR the energy costs are calculated according to the generalised calculation scheme

(fuel consumption in process x) * (fuel price excl. taxes).

With regard to HOR the energy costs are calculated according to the generalised calculation scheme

[(total absolute costs in PLN of oats, hay and compound feeding stuffs for HOR within one year) / (volume of timber hauled in HOR in 2005)] / (exchange rate of 1€ to PLN).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	energy costs in TC	RE_Table 44	€/m^3_{ub}	
x(SC)	energy costs in SC	RE_Table 44	€/m^3_{ub}	
x(CC)	energy costs in CC	RE_Table 44	€/m^3_{ub}	
x(CH)	energy costs in CH	RE_Table 44	€/m^3_{ub}	
x(SKI)	energy costs in SKI	RE_Table 44	€/m^3_{ub}	
x(FOR)	energy costs in FOR	RE_Table 44	€/m^3_{ub}	
x(HOR)	energy costs in HOR	RE_Table 44	€/m^3_{ub}	
Given parameters				
a	fuel consumption in TC	0.90	l/m^3_{ub}	B(2), table 4.3-6
b	fuel consumption in SC	0.45	l/m^3_{ub}	B(2), table 4.3-6
c	fuel consumption in CC	0.43	l/m^3_{ub}	B(2), table 4.3-6

d	fuel consumption in CH	1.28	l/m^3_{ub}	B(2), table 4.3-6
e	fuel consumption in SKI	1.63	l/m^3_{ub}	B(2), table 4.3-6
f	fuel consumption in FOR	2.82	l/m^3_{ub}	B(2), table 4.3-6
g	price excl. taxes of diesel	0.65	€/l	B(1)
h	price excl. taxes of petrol	0.69	€/l	B(1)
i	oat consumption in HOR per day of full work load	3.5	kg	B(3)
j	hay consumption in HOR per day of full work load	5	kg	B(3)
k	compound feeding stuffs consumption in HOR per day of full work load	3.5	kg	B(3)
l	proportion of DE needed on a low strain day in the amount of DE needed on a day with full work load	67.742	%	B(3)
m	number of working days in 2005	230	#	B(4), B(5)
n	total number of days in 2005	365	#	B(4)
o	purchaser's price of oats	0.3702	PLN/kg	B(6)
p	purchaser's price of hay	0.2969	PLN/kg	B(6)
q	purchaser's price of compound feeding stuffs	0.212	kg pigs for slaughter/ kg	B(6)
r	purchaser's price of pigs for slaughter	3.91	PLN/kg	B(6)
s	mean productivity per PUH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	3.1	m^3_{ub}/PUH	B(8), table 4.3-5
t	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	m^3_{ub}	B(8), table 4.3-1
u	number of PUH per unit in HOR in 2005	1380	#	B(8), table 4.3-4
v	exchange rate of 1 € to PLN	4.0230	#	B(7)
Calculation mode				

→ x(TC) = a*h

→ x(SC) = b*h

→ x(CC) = c*h

→ x(CH) = d*g

→ x(SKI) = e*g

→ x(FOR) = f*g

→ x(HOR) = {{[(t/s)/u]*m*(i*o + j*p + k*q*r) + [(t/s)/u]*l*(n – m)*(i*o + j*p + k*q*r)} / t} / v

The process specific values of energy costs excl. taxes are displayed in RE_Table 44 in chapter 5.3.2.4.

4.3.6 PRODUCTION COSTS: OTHER PRODUCTIVE COSTS (INDICATOR 2.1.5)

Within the borders of the technical timber production chain (TTPC) the indicator ‘Other productive costs’ comprises costs which arise for engine oil, lubricants, hydraulic oil and material needed for maintenance and repair, e.g. spare parts. In CH, SKI and FOR special engine oil and hydraulic oil are utilised for the operating harvesters, skidders and forwarders, while in TC, SC and CC chain lubricants and 2-stroke engine oil is needed to run the chainsaws. Regarding horses no information on costs of materials for ‘maintenance’, e.g. medicals or horseshoes, could be identified; therefore, the indicator is regarded to be 0 for HOR.

A) Data to be collected:

The calculation of the costs of engine oil, lubricants and hydraulic oil is based on consumption data provided in FVA (2008.xls) and on prices given on web pages of oil and lubricant traders. As only values of 2009 are available the prices are adapted to the 2005 price level according to the change rate in the consumer prices between 2005 and 2009.

Due to the large number of input data and assumptions that are necessary to perform the calculation of the values of indicator 2.1.5, calculation IN_CALC 7 is divided into three sub-calculations: in IN_CALC 7.1 the costs of consumed fuel excl. taxes is calculated, IN_CALC 7.2 provides the values of costs excl. taxes of material used for maintenance and repair, and IN_CALC 7.3 is performed to calculate the final values of indicator 2.1.5 by summarising the results of IN_CALC 7.1 and IN_CALC 7.2. As the results of IN_CALC 7.1 and IN_CALC 7.2 are just intermediate results, they are displayed directly subsequent to the respective generalised calculation scheme. In contrast the results of IN_CALC 7.3 are given in RE_Table 45 (chapter 5.3.2.5).

B) Underlying information and assumptions:

(1) H.H.U. PIOTR ZUCHOWSKI (2009) presents the prices of engine oil, hydraulic oil and 2-stroke engine lubricant valid for early 2009:

- engine oil used in CH, SKI and FOR: Super Universal Tractor Oil Premium 10W-30, 208 l, 2250.56 PLN excl. taxes; this is 10.82 PLN excl. taxes per l
- hydraulic oil used in CH, SKI and FOR: Hydraulic Oil AW 46, 208 l, 1390.50 PLN excl. taxes; this is 6.69 PLN excl. taxes per l
- 2-stroke engine lubricant used in TC, SC and CC: Motex 2T, 20 l, 241.80 PLN excl.

taxes; this is 12.09 PLN excl. taxes per l

The price of chain lubricant used in TC, SC and CC in February 2009 was 27.05 PLN excl. taxes for 5 l of VEXOL Special as given in BAZAREK.PL (2009); this is 5.41 PLN excl. taxes per l.

(2) According to EUROSTAT (2009b) the prices for liquid fuels and lubricants given for February 2009 tally with 97.5% of the average prices in the year 2005.

(3) In FVA (2008.xls) it is stated that the amount of consumed engine oil and hydraulic oil of harvesters in CH corresponds to 0.3% and 0.5% respectively of fuel consumption. The amount of engine oil and hydraulic oil needed by skidders and forwarders in SKI and FOR tallies with 0.25% and 0.4% respectively of consumed fuel. The amount of 2-stroke engine oil and chain lubricants consumed in TC, SC and CC equals 2% and 30% of the petrol consumption.

(4) In CH costs excl. taxes of 2950 € annually arise for material used for repair and maintenance, according to FVA (2008.xls). The corresponding costs in SKI and FOR are 1696 € and 1624 € respectively. In terms of TC, SC and CC the costs of maintenance and repair including labour costs for maintenance and repair annually equal 30% of the chainsaw-investment as stated in GALK (2005: 3); i.e. the costs of maintenance are 285.5 € assuming that the average investment in a chainsaw appropriate for forestry purposes is 951.66 € excl. taxes as given in FVA (2008.xls). In GALK (2005: 3) it is further noted that 50% of the overall costs of material consumed for maintenance and repair regarding chainsaw operations are due to needed material such as spare parts, i.e the annual material costs excl. taxes are 142.75 €. All values displayed in this section are valid for German conditions.

(5) According to E_16 (24 Feb 2009) the values on costs for material given in B(4) can be assumed to be the same in East European countries.

(6) As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

(7) It is assumed that there are as many chainsaws in use in TC, SC and CC as there are FTEE working per process.

(8) The calculation is further based on values displayed in table 4.3-1 (volume of timber, which is further processed in the FWC, felled per felling and hauled per hauling process respectively), table 4.3-4 (number of annual PUH and UH per operating unit in CH, SKI and FOR as given in FVA (2008.xls), and in HOR), table 4.3-5 (‘Weighted Mean Productivity’ of each regarded process per PUH and per UH) and table 4.3-6 (Average fuel consumption per process under Polish conditions [l/m^3_{ub}]). Additionally, the values given in table 4.3-9 (total absolute number of FTEE per regarded felling and hauling process of the Polish TTPC) are required.

C) Combining the information:

IN_CALC 7:

Calculation of ‘Other productive costs’ in the felling and hauling processes in Poland:

The calculation of the required indicator values is finally conducted in IN_CALC 7.3, based on the results of IN_CALC 7.1 and IN_CALC 7.2.

IN_CALC 7.1:

Calculation of the costs excl. taxes of oil and lubricants per felling and hauling process (excl. HOR):

The calculation is performed according to the generalised calculation scheme [(costs excl. taxes in PLN of oil and lubricants on the level of early 2009) / (conversion factor of the 2009 prices to the 2005 prices)] / (exchange rate of 1€ to PLN).

Symbol	Parameter	Value	Unit	Source
	Parameters to be calculated			
x(TC)	costs excl. taxes of oil and lubricants in TC	Table 4.3-7	€/m^3_{ub}	
x(SC)	costs excl. taxes of oil and lubricants in SC	Table 4.3-7	€/m^3_{ub}	
x(CC)	costs excl. taxes of oil and lubricants in CC	Table 4.3-7	€/m^3_{ub}	
x(CH)	costs excl. taxes of oil and lubricants in CH	Table 4.3-7	€/m^3_{ub}	
x(SKI)	costs excl. taxes of oil and lubricants in SKI	Table 4.3-7	€/m^3_{ub}	
x(FOR)	costs excl. taxes of oil and lubricants in FOR	Table 4.3-7	€/m^3_{ub}	
	Given parameters			

a	fuel consumption in TC	0.90	l/m^3_{ub}	B(8), table 4.3-6
b	fuel consumption in SC	0.45	l/m^3_{ub}	B(8), table 4.3-6
c	fuel consumption in CC	0.43	l/m^3_{ub}	B(8), table 4.3-6
d	fuel consumption in CH	1.28	l/m^3_{ub}	B(8), table 4.3-6
e	fuel consumption in SKI	1.63	l/m^3_{ub}	B(8), table 4.3-6
f	fuel consumption in FOR	2.82	l/m^3_{ub}	B(8), table 4.3-6
g	consumption of 2-stroke engine oil in TC, SC and CC in % of fuel consumption in TC, SC and CC	2	%	B(3)
h	consumption of chain lubricants in TC, SC and CC in % of fuel consumption in TC, SC and CC	30	%	B(3)
i	consumption of engine oil in CH in % of fuel consumption in CH	0.3	%	B(3)
j	consumption of engine oil in SKI and FOR in % of fuel consumption in SKI and FOR	0.25	%	B(3)
k	consumption of hydraulic oil in CH in % of fuel consumption in CH	0.5	%	B(3)
l	consumption of hydraulic oil in SKI and FOR in % of fuel consumption in SKI and FOR	0.4	%	B(3)
m	price excl. taxes of 2-stroke engine oil (TC, SC, CC) per l valid for 2009	12.09	PLN	B(1)
n	price excl. taxes of chain lubricants (TC, SC, CC) per l valid for 2009	5.41	PLN	B(1)
o	price excl. taxes of engine oil (CH, SKI, FOR) per l valid for 2009	10.82	PLN	B(1)
p	price excl. taxes of hydraulic oil (CH, SKI, FOR) per l valid for 2009	6.69	PLN	B(1)
q	conversion factor of 2009 prices to 2005 prices	97.5	%	B(2)
r	exchange rate of 1 € to PLN	4.0230	#	B(4)
Calculation mode				
→ x(TC) = [(a*g*m + a*h*n) / q] / r → x(SC) = [(b*g*m + b*h*n) / q] / r → x(CC) = [(c*g*m + c*h*n) / q] / r → x(CH) = [(d*i*o + d*k*p) / q] / r → x(SKI) = [(e*j*o + e*l*p) / q] / r → x(FOR) = [(f*j*o + f*l*p) / q] / r				

As the results of IN_CALC 7.1 are no final calculation results of this study but intermediate results only, they are displayed in the following table 4.3-7:

Table 4.3-7: *Costs excl. taxes of oil and lubricants per process (Poland)*

Process Identification Code	Costs excl. taxes of oil and lubricants per process [€/m^3_{ub}]
TC	0.428
SC	0.214
CC	0.204
CH	0.022
SKI	0.022
FOR	0.039
HOR	not applicable

IN_CALC 7.2:

Calculation of the costs excl. taxes of material for maintenance and repair per felling and hauling process (excl. HOR):

The calculation is performed according to the generalised calculation scheme

(total absolute costs excl. taxes of material for maintencance and repair in process x in 2005) / (output volume, which is further processed in the FWC, of process x).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	costs excl. taxes of material for maintenance and repair in TC	Table 4.3-8	€/m^3_{ub}	
x(SC)	costs excl. taxes of material for maintenance and repair in SC	Table 4.3-8	€/m^3_{ub}	
x(CC)	costs excl. taxes of material for maintenance and repair in CC	Table 4.3-8	€/m^3_{ub}	
x(CH)	costs excl. taxes of material for maintenance and repair in CH	Table 4.3-8	€/m^3_{ub}	
x(SKI)	costs excl. taxes of material for maintenance and repair in SKI	Table 4.3-8	€/m^3_{ub}	
x(FOR)	costs excl. taxes of material for maintenance and repair in FOR	Table 4.3-8	€/m^3_{ub}	
Given parameters				
a	volume of timber, which is further processed in the FWC, felled in TC in 2005	12051465.12	m^3_{ub}	B(8), table 4.3-1
b	volume of timber, which is further processed in the FWC, felled in SC in 2005	10293959.79	m^3_{ub}	B(8), table 4.3-1
c	volume of timber, which is further processed in the FWC, felled in CC in 2005	5272515.99	m^3_{ub}	B(8), table 4.3-1

d	volume of timber, which is further processed in the FWC, felled in CH in 2005	278969.1	m^3_{ub}	B(8), table 4.3-1
e	volume of timber, which is further processed in the FWC, hauled in SKI in 2005	22317528.00	m^3_{ub}	B(8), table 4.3-1
f	volume of timber, which is further processed in the FWC, hauled in FOR in 2005	1394845.50	m^3_{ub}	B(8), table 4.3-1
g	costs excl. taxes of material for maintenance and repair per unit in TC, SC and CC	142.75	€	B(4), B(5)
h	costs excl. taxes of material for maintenance and repair per unit in CH	2950	€	B(4), B(5)
i	costs excl. taxes of material for maintenance and repair per unit in SKI	1696	€	B(4), B(5)
j	costs excl. taxes of material for maintenance and repair per unit in FOR	1624	€	B(4), B(5)
k	mean productivity per PUH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	12.65	m^3_{ub}/PUH	B(8), table 4.3-5
l	mean productivity per PUH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	6.15	m^3_{ub}/PUH	B(8), table 4.3-5
m	mean productivity per PUH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	4.33	m^3_{ub}/PUH	B(8), table 4.3-5
n	number of PUH per unit in CH in 2005	1920	#	B(8), table 4.3-4
o	number of PUH per unit in SKI in 2005	1440	#	B(8), table 4.3-4
p	number of PUH per unit in FOR in 2005	2160	#	B(8), table 4.3-4
q	total absolute number of FTEE in TC	12274.57	#	B(8), table 4.3-9
r	total absolute number of FTEE in SC	5208.59	#	B(8), table 4.3-9
s	total absolute number of FTEE in CC	2547.79	#	B(8), table 4.3-9
Calculation mode				
→ x(TC) = (g*q) / a → x(SC) = (g*r) / b → x(CC) = (g*s) / c → x(CH) = {h * [(d/k)/n]} / d → x(SKI) = {i * [(e/l)/o]} / e → x(FOR) = {j * [(f/m)/p]} / f				

As the results of IN_CALC 7.2 are no final calculation results of this study but intermediate results only, they are displayed in the following table 4.3-8:

Table 4.3-8: *Costs excl. taxes of material for maintenance and repair per process (Poland)*

Process Identification Code	Costs excl. taxes of material for maintenance and repair per process [€/$m^3{}_{ub}$]
TC	0.145
SC	0.072
CC	0.069
CH	0.121
SKI	0.192
FOR	0.174
HOR	not applicable

IN_CALC 7.3:

Calculation of 'Other productive costs excl. taxes' in each felling process and in SKI and FOR:

As stated above, indicator 2.1.5 is zero for the process HOR. The calculation with regard to TC, SC, CC, CH, SKI and FOR is performed according to the generalised calculation scheme

(costs excl. taxes of oil and lubricants in process x) + (costs excl. taxes of material for maintenance and repair in process x).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	other productive costs excl. taxes in TC	RE_Table 45	€/$m^3{}_{ub}$	
x(SC)	other productive costs excl. taxes in SC	RE_Table 45	€/$m^3{}_{ub}$	
x(CC)	other productive costs excl. taxes in CC	RE_Table 45	€/$m^3{}_{ub}$	
x(CH)	other productive costs excl. taxes in CH	RE_Table 45	€/$m^3{}_{ub}$	
x(SKI)	other productive costs excl. taxes in SKI	RE_Table 45	€/$m^3{}_{ub}$	
x(FOR)	other productive costs excl. taxes in FOR	RE_Table 45	€/$m^3{}_{ub}$	
Given parameters				
a	costs excl. taxes of oil and lubricants in TC	0.428	€/$m^3{}_{ub}$	IN_CALC 7.1
b	costs excl. taxes of oil and lubricants in SC	0.214	€/$m^3{}_{ub}$	IN_CALC 7.1
c	costs excl. taxes of oil and lubricants in CC	0.204	€/$m^3{}_{ub}$	IN_CALC 7.1
d	costs excl. taxes of oil and lubricants in CH	0.022	€/$m^3{}_{ub}$	IN_CALC 7.1
e	costs excl. taxes of oil and lubricants in SKI	0.022	€/$m^3{}_{ub}$	IN_CALC 7.1
f	costs excl. taxes of oil and lubricants in FOR	0.039	€/$m^3{}_{ub}$	IN_CALC 7.1

g	costs excl. taxes of material for maintenance and repair in TC	0.145	€/m^3_{ub}	IN_CALC 7.2
h	costs excl. taxes of material for maintenance and repair in SC	0.072	€/m^3_{ub}	IN_CALC 7.2
i	costs excl. taxes of material for maintenance and repair in CC	0.069	€/m^3_{ub}	IN_CALC 7.2
j	costs excl. taxes of material for maintenance and repair in CH	0.121	€/m^3_{ub}	IN_CALC 7.2
k	costs excl. taxes of material for maintenance and repair in SKI	0.192	€/m^3_{ub}	IN_CALC 7.2
l	costs excl. taxes of material for maintenance and repair in FOR	0.174	€/m^3_{ub}	IN_CALC 7.2
Calculation mode				
→ x(TC) = a + g → x(SC) = b + h → x(CC) = c + i → x(CH) = d + j → x(SKI) = e + k → x(FOR) = f + l				

The process specific values of ‘other productive costs’ excl. taxes are displayed in RE_Table 45 in chapter 5.3.2.5.

4.3.7 PRODUCTION COSTS: NON-PRODUCTIVE COSTS (INDICATOR 2.1.6)

In accordance to EFORWOOD (2008d: 21-23) the 'non-productive costs' consist of expenditures due to taxes and insurances in the context of this study. Within the borders of the technical timber production chain (TTPC) assumedly relevant taxes are, firstly, the value added tax (VAT) on lubricants, hydraulic oils, material used for maintenance/repair and on food for horses; secondly, taxes on fuel, and thirdly expenditures of insurances on forestry vehicles are relevant.

Due to a lack of data corporate tax and the depreciation of machinery is not considered in this study; however, the resulting impreciseness is reduced as depreciation and corporate tax cancel each other to the amount of the depreciation.

Furthermore, costs of insurance premiums in regard of the workers safety and health, e.g. accidents insurances cannot be considered in calculating indicator 2.1.6 as no appropriate data is available.

A) <u>Data to be collected</u>:

Regarding CH, SKI and FOR the VAT on lubricants, hydraulic oils and material for maintenance, the taxes on fuel and the expenditures of insurance are summed up to calculate the value of indicator 2.1.6. In terms of chainsaw felling processes (TC, SC and CC) taxes on chain lubricants, on material for maintenance and on petrol are relevant. In HOR taxes on food are the only 'non-productive costs' which are taken into consideration.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> In Poland the VAT rate is 22 % according to E_12 (20 Feb 2009).

<u>(2)</u> Taxes on fuel amounted to 1.40 PLN per 1 litre (l) of unleaded petrol and to 1.138 PLN per l of diesel. These values are given by the in OECD (2007) for 01 January 2006; as for 2005 no rates are provided the figures shown for 01 January 2006 are used for calculating indicator 2.1.6.

<u>(3)</u> According to E_17 (20 Feb 2009) no taxes had to be paid on forestry vehicles in 2005.

(4) In FVA (2008.xls) it is stated that the costs for insurances on vehicles in Germany are averagely 6200 € per operating unit in CH, SKI and FOR in 2005. E_16 (25 March 2009) assumes that these costs are the same in East European countries.

(5) As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

(6) The following calculation IN_CALC 8 is further based on results of IN_CALC 6 (process specific energy costs excluding taxes per m^3_{ub} in Poland), IN_CALC 7.1 (costs excl. taxes of oil and lubricants per felling and hauling process) as displayed in table 4.3-7 and IN_CALC 7.2 (costs excl. taxes of material for maintenance and repair per felling and hauling process) as displayed in table 4.3-8; additionally data given in table 4.3-1 (volume of timber, which is further processed in the FWC, felled per felling and hauled per hauling process respectively), table 4.3-4 (number of annual PUH and UH per operating unit in TH, CH, SKI and FOR as given in FVA (2008.xls), and in HOR), table 4.3-5 ('Weighted Mean Productivity' of each regarded process per PUH and per UH) and table 4.3-6 (average fuel consumption per process under Polish conditions [l/m^3_{ub}]).

C) Combining the information:

IN_CALC 8:

Calculation of the 'non-productive costs' per felling and per hauling process in Poland:

With regard to TC, SC and CC the calculation is performed according to the generalised calculation scheme

(taxes on fuel per m^3_{ub}) + *(VAT on oil, lubricants and on material for maintenance or repair per m^3_{ub})*.

With regard to CH, SKI and FOR insurance costs are additionally taken into account; the generalised calculation scheme is therefore

(taxes on fuel per m^3_{ub}) + *(VAT on oil, lubricants and on material for maintenance or repair per m^3_{ub})* + *(insurance costs per m^3_{ub})*.

With regard to HOR only the VAT on horse food is considered.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	non-productive costs in TC	RE_Table 46	€/m^3_{ub}	
x(SC)	non-productive costs in SC	RE_Table 46	€/m^3_{ub}	
x(CC)	non-productive costs in CC	RE_Table 46	€/m^3_{ub}	
x(CH)	non-productive costs in CH	RE_Table 46	€/m^3_{ub}	
x(SKI)	non-productive costs in SKI	RE_Table 46	€/m^3_{ub}	
x(FOR)	non-productive costs in FOR	RE_Table 46	€/m^3_{ub}	
x(HOR)	non-productive costs in HOR	RE_Table 46	€/m^3_{ub}	
Given parameters				
a	fuel consumption in TC	0.90	l/m^3_{ub}	B(6), table 4.3-6
b	fuel consumption in SC	0.45	l/m^3_{ub}	B(6), table 4.3-6
c	fuel consumption in CC	0.43	l/m^3_{ub}	B(6), table 4.3-6
d	fuel consumption in CH	1.28	l/m^3_{ub}	B(6), table 4.3-6
e	fuel consumption in SKI	1.63	l/m^3_{ub}	B(6), table 4.3-6
f	fuel consumption in FOR	2.82	l/m^3_{ub}	B(6), table 4.3-6
g	tax on unleaded petrol	1.40	PLN/l	B(2)
h	tax on diesel	1.138	PLN/l	B(2)
i	exchange rate of 1 € to PLN	4.0230	#	B(5)
j	energy costs in HOR	0.106	€/m^3_{ub}	B(6), IN_CALC 6
k	costs excl. taxes of oil and lubricants in TC	0.428	€/m^3_{ub}	B(6), table 4.3-7
l	costs excl. taxes of oil and lubricants in SC	0.214	€/m^3_{ub}	B(6), table 4.3-7
m	costs excl. taxes of oil and lubricants in CC	0.204	€/m^3_{ub}	B(6), table 4.3-7
n	costs excl. taxes of oil and lubricants in CH	0.022	€/m^3_{ub}	B(6), table 4.3-7
o	costs excl. taxes of oil and lubricants in SKI	0.022	€/m^3_{ub}	B(6), table 4.3-7
p	costs excl. taxes of oil and lubricants in FOR	0.039	€/m^3_{ub}	B(6), table 4.3-7
q	costs excl. taxes of material for maintenance and repair in TC	0.145	€/m^3_{ub}	B(6), table 4.3-8
r	costs excl. taxes of material for maintenance and repair in SC	0.072	€/m^3_{ub}	B(6), table 4.3-8
s	costs excl. taxes of material for maintenance and repair in CC	0.069	€/m^3_{ub}	B(6), table 4.3-8
t	costs excl. taxes of material for maintenance and repair in CH	0.121	€/m^3_{ub}	B(6), table 4.3-8
u	costs excl. taxes of material for maintenance and repair in SKI	0.192	€/m^3_{ub}	B(6), table 4.3-8
v	costs excl. taxes of material for maintenance and	0.174	€/m^3_{ub}	B(6),

	repair in FOR			table 4.3-8
w	VAT rate	22	%	B(1)
y	insurance costs in CH, SKI and FOR	6200	€	B(4)
z	volume of timber, which is further processed in the FWC, felled in CH in 2005	278969.1	m^3_{ub}	B(6), table 4.3-1
aa	volume of timber, which is further processed in the FWC, hauled in SKI in 2005	22317528.00	m^3_{ub}	B(6), table 4.3-1
ab	volume of timber, which is further processed in the FWC, hauled in FOR in 2005	1394845.50	m^3_{ub}	B(6), table 4.3-1
ac	mean productivity per PUH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	12.65	m^3_{ub}/PUH	B(6), table 4.3-5
ad	mean productivity per PUH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	6.15	m^3_{ub}/PUH	B(6), table 4.3-5
ae	mean productivity per PUH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	4.33	m^3_{ub}/PUH	B(6), table 4.3-5
af	number of PUH per unit in CH in 2005	1920	#	B(6), table 4.3-4
ag	number of PUH per unit in SKI in 2005	1440	#	B(6), table 4.3-4
ah	number of PUH per unit in FOR in 2005	2160	#	B(6), table 4.3-4
Calculation mode				

→ x(TC) = (a*g)/i + (k+q)*w

→ x(SC) = (b*g)/i + (l+r)*w

→ x(CC) = (c*g)/i + (m+s)*w

→ x(CH) = (d*h)/i + (n+t)*w + {[(z/ac)/af]*y}/z

→ x(SKI) = (e*h)/i + (o+u)*w + {[(aa/ad)/ag]*y}/aa

→ x(FOR) = (f*h)/i + (p+v)*w + {[(ab/ae)/ah]*y}/ab

→ x(HOR) = j*w

The process specific values of ‘non-productive costs’ excl. taxes are displayed in RE_Table 46 in chapter 5.3.2.6.

4.3.8 NUMBER OF PERSONS EMPLOYED (INDICATOR 10.1)

The ‘Number of persons employed’ is calculated as number of **f**ull-**t**ime **e**quivalent **e**mployee (FTEE) per m^3_{ub} of timber that is felled per felling and hauled per hauling process. One FTEE is a fictitious employee working full-time; within this study the number of employees is generally captured and calculated as FTEE.
However, to calculate the values of several other indicators the total absolute number of FTEE per process is required. Therefore, the total absolute number of FTEE per process is given in table 4.3-9, subsequent to IN_CALC 9.

A) Data to be collected:

In this chapter the number of FTEE per m^3_{ub} per felling and hauling process of the Polish TTPC is calculated.

B) Underlying information and assumptions

(1) JODLOWSKI (2006: 41) indicates that an FTEE averagely worked 46 hours per week in 2005. This figure is affirmed by E_2 (06 Feb 2009) as typical weekly working time in the Polish forestry sector.

(2) According to THE WORLD BANK (2008: 67) each FTEE had 26 days of paid vacation in 2005. Assuming that the employees work only from Monday till Friday, the number of free days due to weekends is 104 as there are 52 weeks per year. Furthermore, there were 5 additional official holidays in Poland in 2005 that did not coincide with weekends (WWW.FEIERTAGE-WELTWEIT.COM, 2008). When subtracting 26, 104 and 5 from the total number of days in 2005, namely 365, the resulting number of working days in the year 2005 is 230.

(3) The following calculation IN_CALC 9 is further based on values displayed in table 4.3-5 (‘Weighted Mean Productivity’ per UH) and in table 4.3-1 (total volume of timber, which is further processed in the FWC, felled per felling process and hauled per hauling process).

C) <u>Combining the information</u>:

IN_CALC 9:

<u>Calculation of the number of FTEE per regarded felling and hauling process of the Polish TTPC</u>:

The calculation is performed according to the generalised calculation scheme *{[(output volume, which is further processed in the FWC, per process x) / ('weighted mean productivity' per UH)] / (number of annually worked hours per FTEE)} / (output volume, which is further processed in the FWC, per process x)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	number of FTEE in TC	RE_Table 47	#/m^3_{ub}	
x(SC)	number of FTEE in SC	RE_Table 47	#/m^3_{ub}	
x(CC)	number of FTEE in CC	RE_Table 47	#/m^3_{ub}	
x(CH)	number of FTEE in CH	RE_Table 47	#/m^3_{ub}	
x(SKI)	number of FTEE in SKI	RE_Table 47	#/m^3_{ub}	
x(FOR)	number of FTEE in FOR	RE_Table 47	#/m^3_{ub}	
x(HOR)	number of FTEE in HOR	RE_Table 47	#/m^3_{ub}	
Given parameters				
a	volume of timber, which is further processed in the FWC, felled in TC in 2005	12051465.12	m^3_{ub}	B(3), table 4.3-1
b	volume of timber, which is further processed in the FWC, felled in SC in 2005	10293959.79	m^3_{ub}	B(3), table 4.3-1
c	volume of timber, which is further processed in the FWC, felled in CC in 2005	5272515.99	m^3_{ub}	B(3), table 4.3-1
d	volume of timber, which is further processed in the FWC, felled in CH in 2005	278969.1	m^3_{ub}	B(3), table 4.3-1
e	volume of timber, which is further processed in the FWC, hauled in SKI in 2005	22317528.00	m^3_{ub}	B(3), table 4.3-1
f	volume of timber, which is further processed in the FWC, hauled in FOR in 2005	1394845.50	m^3_{ub}	B(3), table 4.3-1
g	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	m^3_{ub}	B(3), table 4.3-1
h	mean productivity per UH in TC weighted according to the proportion of the tree species in the output volume of TC (PL)	0.464	m^3_{ub}/UH	B(3), table 4.3-5
i	mean productivity per UH in SC weighted according to the proportion of the tree species in the output volume of SC (PL)	0.934	m^3_{ub}/UH	B(3), table 4.3-5
j	mean productivity per UH in CC weighted according to the proportion of the tree species in the output volume of CC (PL)	0.978	m^3_{ub}/UH	B(3), table 4.3-5
k	mean productivity per UH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	10.12	m^3_{ub}/UH	B(3), table 4.3-5

l	mean productivity per UH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	5.515	m^3_{ub}/UH	B(3), table 4.3-5
m	mean productivity per UH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	3.983	m^3_{ub}/UH	B(3), table 4.3-5
n	mean productivity per UH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	1.940	m^3_{ub}/UH	B(3), table 4.3-5
o	number of hours worked per week	46	#	B(1)
p	number of working days per year	230	#	B(2)
Calculation mode				
→ x(TC) = {(a / h) / [(o/5)*p]} / a → x(SC) = {(b / i) / [(o/5)*p]} / b → x(CC) = {(c / j) / [(o/5)*p]} / c → x(CH) = {(d / k) / [(o/5)*p]} / d → x(SKI) = {(e / l) / [(o/5)*p]} / e → x(FOR) = {(f / m) / [(o/5)*p]} / f → x(HOR) = {(g / n) / [(o/5)*p]} / g				

The process specific values of the number of persons employed are displayed in RE_Table 47 in chapter 5.3.3.

Table 4.3-9: *Total absolute number of FTEE per process (Poland)*

Process Identification Code	Total absolute number of FTEE per process
TC	12381.30
SC	5230.99
CC	2542.59
CH	13.03
SKI	1903.80
FOR	169.02
HOR	1019.29

4.3.9 AVERAGE WAGES AND SALARIES (INDICATOR 11.1)

A) Data to be collected

The average wages per full-time equivalent employee (FTEE) of the regarded felling or hauling processes of the technical timber production chain (TTPC) in Poland per m^3_{ub} of process specific are calculated.

B) Underlying information and assumptions:

(1) According to the CENTRAL STATISTICAL OFFICE (2005: 240) the average monthly gross wage was 1163.46 PLN in the Polish private forestry sector in 2004 and 3415.17 PLN in the Polish public forestry sector in 2004. As stated in EUROSTAT (2009c) wages increased by 18.33% in PL from 2004 to 2005. Therefore, it is assumed that the average monthly gross wage was 1376.81 PLN in the Polish private forestry sector in 2005 and 4041.41 PLN in the Polish public forestry sector in 2004.

PASCHALIS-JAKUBOWIZC (2004: 7) states that 95% of the harvesting and hauling activities in Poland are conducted by private companies. Taking this fact into consideration the weighted average wage in the Polish forestry is 1510.04 PLN.

(2) As given in CENTRAL STATISTICAL OFFICE (2008: 175) a skilled worker in the agricultural sector earns 80.6% of the wage that a machine operator earns. It is assumed that the same ratio is also valid for **f**orestry **w**orkers (namely loggers in TC, SC and CC and horse handlers in HOR) (= FW-FTEE) and for forestry **m**achine **o**perators (namely machine drivers in the processes CH, SKI and FOR) (= MO-FTEE). The grouping of loggers and horse handlers as well as of machine operators is based on the assumption that all FW-FTEE and all MO-FTEE respectively have the same level of qualification and are therefore paid the same wage. This assumption was made on consultation with E_20 (20 Feb 2009).

(3) As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

(4) The number of hours worked per week per FTEE is 46 (JODLOWSKI, 2006: 41).

(5) The number of weeks per year is 52. The number of months per year is 12.

(6) The following calculation IN_CALC 10 is further based on the values given in table 4.3-9 (total absolute number of FTEE per process) and on values displayed in table 4.3-5 ('Weighted mean productivity' per UH per process).

C) Combining the information:

IN_CALC 10:

The calculation of the average wage per FTEE and m^3_{ub} of each felling and hauling process in Poland in 2005:

With regard to TC, SC, CC and HOR the calculation is performed according to the generalised calculation scheme

[(average monthly wage per FW-FTEE) / (number of working hours per month)] / ('Weighted mean productivity' per UH of process x).

With regard to CH, SKI and FOR the calculation is performed according to the generalised calculation scheme

[(average monthly wage per MO-FTEE) / (number of working hours per month)] / ('Weighted mean productivity' per UH of process x).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	average wage of FW-FTEE in TC	RE_Table 48	€/m^3_{ub}	
x(SC)	average wage of FW-FTEE in SC	RE_Table 48	€/m^3_{ub}	
x(CC)	average wage of FW-FTEE in CC	RE_Table 48	€/m^3_{ub}	
x(CH)	average wage of MO-FTEE in CH	RE_Table 48	€/m^3_{ub}	
x(SKI)	average wage of MO-FTEE in SKI	RE_Table 48	€/m^3_{ub}	
x(FOR)	average wage of MO-FTEE in FOR	RE_Table 48	€/m^3_{ub}	
x(HOR)	average wage of MW-FTEE in HOR	RE_Table 48	€/m^3_{ub}	
Given parameters				
a	total absolute number of FTEE in TC	12381.30	#	B(6), table 4.3-9
b	total absolute number of FTEE in SC	5230.99	#	B(6), table 4.3-9
c	total absolute number of FTEE in CC	2542.59	#	B(6), table 4.3-9
d	total absolute number of FTEE in CH	13.03	#	B(6), table 4.3-9
e	total absolute number of FTEE in SKI	1903.80	#	B(6), table 4.3-9
f	total absolute number of FTEE in FOR	169.02	#	B(6), table 4.3-9

g	total absolute number of FTEE in HOR	1019.29	#	B(6), table 4.3-9
h	ratio of FW-FTEE wage to MO-FTEE wage	80.6	%	B(2)
i	average monthly wage per FTEE in the Polish forestry	1510.04	PLN	B(1)
j	mean productivity per UH in TC weighted according to the proportion of the tree species in the output volume of TC (PL)	0.464	m^3_{ub}/UH	B(6), table 4.3-5
k	mean productivity per UH in SC weighted according to the proportion of the tree species in the output volume of SC (PL)	0.934	m^3_{ub}/UH	B(6), table 4.3-5
l	mean productivity per UH in CC weighted according to the proportion of the tree species in the output volume of CC (PL)	0.978	m^3_{ub}/UH	B(6), table 4.3-5
m	mean productivity per UH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	10.12	m^3_{ub}/UH	B(6), table 4.3-5
n	mean productivity per UH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	5.515	m^3_{ub}/UH	B(6), table 4.3-5
o	mean productivity per UH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	3.983	m^3_{ub}/UH	B(6), table 4.3-5
p	mean productivity per UH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	1.940	m^3_{ub}/UH	B(6), table 4.3-5
q	exchange rate of 1€ to PLN	4.0230	#	B(3)
r	number of hours worked per week per FTEE	46	#	B(4)
s	number of weeks per year	52	#	B(5)
t	number of months per year	12	#	B(5)
Calculation mode				
→ x(TC) = {{{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / q} / [(r*s)/t]} / j → x(SC) = {{{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / q} / [(r*s)/t]} / k → x(CC) = {{{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / q} / [(r*s)/t]} / l → x(CH) = {{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / q} / [(r*s)/t]} / m → x(SKI) = {{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / q} / [(r*s)/t]} / n → x(FOR) = {{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / q} / [(r*s)/t]} / o → x(HOR) = {{{{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / q} / [(r*s)/t]} / l				

The process specific values of wages and salaries are displayed in RE_Table 48 in chapter 5.3.4.1.

4.3.10 Average Wages and Salaries per Employee Relative to the Average Country Wage (Indicator 11.2.1)

A) Data to be collected:

In the following calculation IN_CALC 11 the average gross monthly earnings per forestry worker full-time equivalent employee (FW-FTEE) and per machine operator full-time equivalent employee (MO-FTEE) of the Polish forestry sector are put in relation to the average gross wages and salaries of the whole Polish national economy.

B) Underlying information and assumptions:

(1) According to the Central Statistical Office (2005: 240) the average monthly gross wage was 1163.46 PLN in the Polish private forestry sector in 2004 and 3415.17 PLN in the Polish public forestry sector in 2004. As stated in Eurostat (2009c) wages increased by 18.33% in Poland from 2004 to 2005. Therefore, it is assumed that the average monthly gross wage was 1376.81 PLN in the Polish private forestry sector in 2005 and 4041.41 PLN in the Polish public forestry sector in 2004.

(Paschalis-Jakubowizc (2004: 7) states that 95% of the harvesting and hauling activities in PL are conducted by private companies. Taking this fact into consideration the weighted average wage in the Polish forestry is 1510.04 PLN.

(2) As given in Central Statistical Office (2008: 175) a skilled worker in the agricultural sector earns 80.6% of the wage a machine operator earns. It is assumed that the same ratio is also valid for forestry workers (namely loggers in TC, SC and CC and horse handlers in HOR) (= FW-FTEE) and for forestry machine operators (namely machine drivers in the processes CH, SKI and FOR) (= MO-FTEE). The grouping of loggers and horse handlers as well as of machine operators is based on the assumption that all FW-FTEE and all MO-FTEE respectively have the same level of qualification and are therefore paid the same wage. This assumption was made on consultation with E_20 (20 Feb 2009).

(3) According to the Central Statistical Office (2005: 240) the average monthly gross wage was 2396.7 PLN in the Polish national economy in 2004. As stated in Eurostat (2009c) wages increased by 18.33% in Poland from 2004 to 2005. Therefore, it is assumed that the average monthly gross wage was 2836.02 PLN in the Polish national economy in 2005.

(4) The following calculation IN_CALC 11 is further based on the values given in table 4.3-9 (total absolute number of FTEE per process).

C) Combining the information:

IN_CALC 11:

Calculation of the ratio between the average monthly wage per FTEE of the Polish TTPC and the average monthly gross wage per FTEE in the whole Polish national economy:

The calculation is performed according to the scheme generalised calculation scheme *(average monthly gross wage per FTEE in process x) / (average monthly gross wage per FTEE in the Polish national economy)*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	average wage of FW-FTEE in TC relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(SC)	average wage of FW-FTEE in SC relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(CC)	average wage of FW-FTEE in CC relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(CH)	average wage of MO-FTEE in CH relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(SKI)	average wage of MO-FTEE in SKI relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(FOR)	average wage of MO-FTEE in FOR relative to average wage of FTEE in the national economy	RE_Table 49	%	
x(HOR)	average wage of FW-FTEE in HOR relative to average wage of FTEE in the national economy	RE_Table 49	%	
Given parameters				
a	total absolute number of FTEE in TC	12381.30	#	B(4), table 4.3-9
b	total absolute number of FTEE in SC	5230.99	#	B(4), table 4.3-9
c	total absolute number of FTEE in CC	2542.59	#	B(4), table 4.3-9
d	total absolute number of FTEE in CH	13.03	#	B(4), table 4.3-9
e	total absolute number of FTEE in SKI	1903.80	#	B(4),

				table 4.3-9
f	total absolute number of FTEE in FOR	169.02	#	B(4), table 4.3-9
g	total absolute number of FTEE in HOR	1019.29	#	B(4), table 4.3-9
h	ratio of FW-FTEE wage to MO-FTEE wage	80.6	%	B(2)
i	average monthly wage per FTEE in the Polish forestry	1510.04	PLN	B(1)
j	average monthly wage per FTEE in the Polish national economy	2836.02	PLN	B(3)
Calculation mode				

→ x(TC) = {{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / j

→ x(SC) = {{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / j

→ x(CC) = {{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / j

→ x(CH) = {i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / j

→ x(SKI) = {i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / j

→ x(FOR) = {i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} / j

→ x(HOR) = {{i*(a+b+c+d+e+f+g)] / [(a+b+c+g)*h+d+e+f]} * h} / j

The process specific values of the ratio between the average monthly wage per employee in the TTPC and the country average are displayed in RE_Table 49 in chapter 5.3.4.2.

4.3.11 Average Wages and Salaries per Employee Weighted by Purchasing Power Parity (Indicator 11.2.2)

A) **Data to be collected**:

In the following calculation IN_CALC 12 the average process specific wages per m^3_{ub} weighted by the Polish purchasing power parity (PPP) on the basis of the average PPP of the EU27.

B) **Underlying information and assumptions**:

(1) The PPP for Poland equals 2.21414 PLN to 1 €. This ratio is given in EFORWOOD (2008d: 106) according to Eurostat.

(2) As given by EUROSTAT (2009a) 1 € was averagely equal to 4.0230 PLN in the year 2005.

(3) The following calculation IN_CALC 12 is further based on results of IN_CALC 10 (the average process specific wages).

C) **Combining the information**:

IN_CALC 12:

Calculation of the average process specific wages per m^3_{ub} in the Polish TTPC in 2005 weighted by the PPP:

The calculation is performed according to the generalised calculation scheme

*[(average wage per m³ub in process x in €) * (exchange rate of 1 € to PLN)] / (Polish PPP).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	average wage of FW-FTEE in TC, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
x(SC)	average wage of FW-FTEE in SC, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
x(CC)	average wage of FW-FTEE in CC, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
x(CH)	average wage of MO-FTEE in CH, weighted by the PPP	RE_Table 50	€/m^3_{ub}	

x(SKI)	average wage of MO-FTEE in SKI, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
x(FOR)	average wage of MO-FTEE in FOR, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
x(HOR)	average wage of FW-FTEE in HOR, weighted by the PPP	RE_Table 50	€/m^3_{ub}	
Given parameters				
a	average wage of FW-FTEE in TC	3.973	€/m^3_{ub}	B(3), IN_CALC 10
b	average wage of FW-FTEE in SC	1.974	€/m^3_{ub}	B(3), IN_CALC 10
c	average wage of FW-FTEE in CC	1.885	€/m^3_{ub}	B(3), IN_CALC 10
d	average wage of FW-FTEE in CH	0.226	€/m^3_{ub}	B(3), IN_CALC 10
e	average wage of FW-FTEE in SKI	0.415	€/m^3_{ub}	B(3), IN_CALC 10
f	average wage of FW-FTEE in FOR	0.574	€/m^3_{ub}	B(3), IN_CALC 10
g	average wage of FW-FTEE in HOR	0.950	€/m^3_{ub}	B(3), IN_CALC 10
h	exchange rate of 1 € to PLN	4.0230	#	B(2)
i	PPP for PL in PLN per 1 €	2.21414	#	B(1)
Calculation mode				
→ x(TC) = (a * h) / i → x(SC) = (b * h) / i → x(CC) = (c * h) / i → x(CH) = (d * h) / i → x(SKI) = (e * h) / i → x(FOR) = (f * h) / i → x(HOR) = (g * h) / i				

The process specific values of the average wages weighted by the PPP are displayed in RE_Table 50 in chapter 5.3.4.3.

4.3.12 ENERGY USE: RENEWABLE FUEL (INDICATOR 18.2.2.1)

According to E_2 (06 Feb 2009), it is uncommon to use renewable fuels like biodiesel, bioethanol or synfuels to run machines (chainsaws, harvester, skidders or forwarders) in the Polish forestry. However, horse food is regarded as renewable fuel for horses in HOR in the context of this study, as horses used in HOR are considered as forestry machines.
Therefore, HOR is the only process in the Polish where the use of renewable fuels is regarded to be relevant. This means that the value of indicator 18.2.2.1 is zero considering TC, SC, CC, CH, SKI and FOR when analysing the 2005 situation; however, the consumption of renewable energy [kWh/m^3_{ub}] contained in hay, oats and compound feeding stuffs is calculated with regard to HOR in IN_CALC 13 for Poland.

A) <u>Data to be collected</u>:

In the following IN_CALC 13 the use of renewable fuel by horses in HOR in Poland is calculated. In terms of this calculation it has to be considered that the 'forestry machine' horse, in contrast to chainsaws, harvesters, skidders and forwarders, consumes energy even when it is not in utilisation.
The unit of the resulting consumption value is 'kWh per m^3_{ub}'.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> According to NEWSLINE WESTDEUTSCHE ZEITUNG (2009) a horse needs 3.5 kg of oats, 3.5 kg of compound feeding stuffs and 5 kg of hay on a day with full work load. This amount of food corresponds to 124 MJ of digestible energy (DE) as stated in LANDWIRTSCHAFTSKAMMER NORDRHEIN-WESTFALEN (2004). In comparison, on a day of low strain a horse needs 84 MJ DE (LANDWIRTSCHAFTSKAMMER NORDRHEIN-WESTFALEN, 2004), which is 67.742% of the energy needed on a full strain day.

<u>(2)</u> According to THE WORLD BANK (2008a: 67) each FTEE, had 26 days of paid vacation in 2005. Assuming that the FTEE work only from Monday till Friday, the number of free days due to weekends is 104 as there are 52 weeks per year. Furthermore, there were 5 additional official holidays in Poland in 2005 that did not coincide with weekends (WWW.FEIERTAGE-WELTWEIT.COM, 2008). When subtracting 26, 104 and 5 from the total number of days in 2005, namely 365, the resulting number of working days in the year 2005 is 230.

(3) It is assumed that the number of working days per year, which are considered to be days of full work load, is the same for a horse as for a forestry worker.

(4) 1 kWh equals 3.6 MJ (HAMMER et HAMMER, 1994: 75).

(5) The following calculation IN_CALC 13 is further based on values given in table 4.3-1 (volume of timber, which is further processed in the FWC, felled per felling and hauled per hauling process respectively), table 4.3-4 (number of annual PUH and UH per operating unit in CH, SKI and FOR as given in FVA (2008.xls), and in HOR) and table 4.3-5 ('Weighted Mean Productivity' of each regarded process per PUH and per UH).

C) Combining the information:

IN_CALC 13:

Calculation of the use of renewable fuel per regarded process in Poland:

As stated above no renewable fuel is used in the felling processes and in SKI and FOR; i.e. the indicator value on the use of renewable energy of these processes is zero. Therefore, IN_CALC 13 is only performed with regard to HOR.

The calculation is performed according to the generalised calculation scheme

[(total amount of renewable energy, that is annually used per horse) * (number of horses used in HOR in Poland in 2005)] / (volume of timber, which is further processed in the FWC, hauled in HOR in 2005).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x	consumption of renewable energy in HOR	RE_Table 51	kWh/m^3_{ub}	
Given parameters				
a	amount of DE needed on a day with full work load	124	MJ	B(1)
b	proportion of DE needed on a low strain day in the amount of DE needed on a day with full work load	67.742	%	B(1)
c	number of working days in 2005	230	#	B(2), B(3)
d	total number of days in 2005	365	#	B(2)
e	mean productivity per PUH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	3.1	m^3_{ub}/PUH	B(5), table 4.3-5
f	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	m^3_{ub}	B(5), table 4.3-1
g	number of PUH per unit in HOR in 2005	1380	#	B(5),

				table 4.3-4
h	conversion factor of 1 kWh to MJ	3.6	#	B(4)
Calculation mode				
→ x = {{[a*c + a*b*(d – c)] / h} * [(f/e)/g]}} / f				

The process specific values of the use of renewable fuel are displayed in RE_Table 51 in chapter 5.3.5.1.

4.3.13 Energy Use: Fossil Fuel (Indicator 18.2.2.2)

In the felling processes as well as in FOR and SKI exclusively fossils fuels are used to run the forestry machines. Based on information provided in FVA (2008.xls) and other calculations of this study the process specific use of fossil fuel in kWh per m^3_{ub} is calculated in this chapter.

A) <u>Data to be collected</u>:

In the following IN_CALC 14 the amount of fossil fuel in kWh per m^3_{ub} of the process specific output volume is calculated for the processes TC, SC, CC, SKI and FOR. As the horses used in HOR run on renewable fuel only, the indicator 18.2.2.2 is regarded as not applicable in terms of HOR.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> In FVA (2008.xls) the energy use per m^3_{ub} of chainsaws, harvesters, skidders and forwarders in dependence on certain mean productivities are provided. The data are given for German conditions. It is assumed that data are also valid for the Polish forestry.

The values of energy use as given in FVA (2008.xls) are displayed in table 4.3-10 per regarded process together with the corresponding productivities; it is assumed that productivity and fuel use are subject to inversely linear interdependence.

<u>Table 4.3-10</u>: *Energy use in dependence on the productivity per UH, displayed per process that is relevant in the Polish TTPC*

Process	Productivity [m^3_{ub}/UH] (FVA 2008.xls)	Fuel Use [kWh/m^3_{ub}] (FVA 2008.xls)
TC	2	1.82
SC	2	1.82
CC	2	1.82
CH	7.5	17.09
SKI	11.5	7.72
FOR	12	9.04

(2) The following calculation IN_CALC 14 is further based on values given in table 4.3-5 ('weighted mean productivities' per UH).

C) Combining the information:

IN_CALC 14:

Calculation of the process specific amount of fossil fuel used in the felling and hauling processes of the Polish TTPC:

Through performing a rule of three calculation taking the values of table 4.3-10 and the process specific 'weighted mean productivity' per UH (table 4.3-5) into consideration the energy use values shown in table 4.3-10 are adapted to the Polish conditions.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	use of fossil fuel in TC	RE_Table 52	kWh/m^3_{ub}	
x(SC)	use of fossil fuel in SC	RE_Table 52	kWh/m^3_{ub}	
x(CC)	use of fossil fuel in CC	RE_Table 52	kWh/m^3_{ub}	
x(CH)	use of fossil fuel in CH	RE_Table 52	kWh/m^3_{ub}	
x(SKI)	use of fossil fuel in SKI	RE_Table 52	kWh/m^3_{ub}	
x(FOR)	use of fossil fuel in FOR	RE_Table 52	kWh/m^3_{ub}	
Given parameters				
a	productivity in TC, SC and CC (FVA)	2	m^3_{ub}/UH	B(1), table 4.3-10
b	productivity in CH (FVA)	7.5	m^3_{ub}/UH	B(1), table 4.3-10
c	productivity in SKI (FVA)	11.5	m^3_{ub}/UH	B(1), table 4.3-10
d	productivity in FOR (FVA)	12	m^3_{ub}/UH	B(1), table 4.3-10
e	fuel use in TC, SC and CC (FVA)	1.82	kWh/m^3_{ub}	B(1), table 4.3-10
f	fuel use in CH (FVA)	17.09	kWh/m^3_{ub}	B(1), table 4.3-10
g	fuel use in SKI (FVA)	7.72	kWh/m^3_{ub}	B(1), table 4.3-10
h	fuel use in FOR (FVA)	9.04	kWh/m^3_{ub}	B(1), table 4.3-10
i	mean productivity per UH in TC weighted according to the proportion of the tree species in the output volume of TC (PL)	0.46	m^3_{ub}/UH	table 4.3-5
j	mean productivity per UH in SC weighted according to the proportion of the tree species in the output volume of SC (PL)	0.93	m^3_{ub}/UH	table 4.3-5
k	mean productivity per UH in CC weighted according to the proportion of the tree species in the output volume of CC (PL)	0.98	m^3_{ub}/UH	table 4.3-5
l	mean productivity per UH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	10.12	m^3_{ub}/UH	table 4.3-5

m	mean productivity per UH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	5.54	m^3_{ub}/UH	table 4.3-5
n	mean productivity per UH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	3.90	m^3_{ub}/UH	table 4.3-5
Calculation mode				
→ x(TC) = (a*e) / i → x(SC) = (a*e) / j → x(CC) = (a*e) / k → x(CH) = (b*f) / l → x(SKI) = (c*g) / m → x(FOR) = (d*h) / n				

The process specific values of the use of fossil fuel are displayed in RE_Table 52 in chapter 5.3.5.2.

4.3.14 GREENHOUSE GAS EMISSIONS: TOTAL (INDICATOR 19.1)

In EFORWOOD (2008d: 62-65) Indicator 19.1 is defined as the sum of indicator 19.1.1 ("Greenhouse gas (GHG) emissions from machinery") and indicator 19.1.2 ("GHG emissions from wood combustion").

While for indicator 19.1.1 all required data are directly available from statistics or calculable, indicator 19.1.2 ("GHG emissions from wood combustion") is regarded to be irrelevant in felling and hauling processes: Although it is known from experience that forestry workers often enlighten a campfire, especially in winter, as a heat source during breaks from work, and although these fires cause GHG emissions from wood combustion, their extent is assumed to be insignificant.

Therefore, indicator 19.1.2 is regarded to be 'not applicable' in terms of this study. This is why the process specific values of indicator 19.1 are identical to the process specific values of indicator 19.1.1. For the calculations of the process specific values of GHG emissions from machinery see IN_CALC 15 for Poland.

4.3.15 Greenhouse Gas Emissions: From Machinery (Indicator 19.1.1)

A) Data to be collected:

In this chapter the amount of GHG that are emitted from machinery used in the regarded felling and hauling processes in Poland are calculated. The unit of the resulting values is kg CO_2-equivalent (kg CO_2e) per m^3_{ub}. In the context of this study horses are considered as machines.

B) Underlying information and assumptions:

(1) Berg and Fischbach (2009.xls) give the mass of carbon dioxide, methane and nitrous oxide that are emitted for producing and using fossil fuels, namely diesel and petrol, in g/MJ. It is assumed that 3.6 MJ equal 1 kWh (Hammer et Hammer, 1994: 75); it is further assumed that 1 unit of methane equals 23 units of CO_2 and that 1 unit of nitrous oxide equal 296 units of CO_2 (Berg and Fischbach, 2009.xls).

Consequently, the total quantity of GHG emissions is 279.2592 g CO_2e per kWh for diesel and 307.4652 g CO_2e per kWh for petrol as shown in table 4.3-11.

Table 4.3-11: *GHG emissions with regard to different types of fuel in g CO_2-equivalent (CO_2e) per kWh*

Type of Fuel	GHG compound	GHG emissions of fuel production and use per compound [g/kWh]	Factor to transform GHG compound into CO_2-equivalents	GHG emissions of fuel production and use in CO_2-equivalents [g/kWh]
Diesel	carbon dioxide (CO_2)	275.4	1	275.4
	methane (CH_4)	0.0288	23	0.6624
	nitrous oxide (N_2O)	0.0108	296	3.1968
			SUM	279.2592
Petrol	carbon dioxide (CO_2)	285.4080	1	285.4080
	methane (CH_4)	0.0324	23	0.7452
	nitrous oxide (N_2O)	0.0720	296	21.312
			SUM	307.4652

(2) According to Hollins University (2008) a horse annually emits 527.094 kg of CO_2 and 23.66 kg of methane, which is 1023.316 kg of CO_2e in total.

(3) With regard to the felling processes, SKI and FOR the following calculation IN_CALC 15 is further based on the process specific use of fossil fuel in kWh per m^3_{ub} as calculated in IN_CALC 14. In terms of hauling with horse (HOR) the 'weighted mean productivity' per UH (given in table 4.3-5), the volume of timber, which is further processed in the FWC, hauled in HOR in 2005 (given in table 4.3-1) and the number of PUH per unit in HOR in 2005 (given in table 4.3-4) are required.

C) <u>Combining the information</u>:

IN_CALC 15:

<u>Calculation of the process specific GHG emissions from machinery used in the felling and hauling processes of the Polish TTPC</u>:

With regard to the felling processes and SKI and FOR, the values of GHG emissions are calculated according to the generalised scheme

(use of fossil fuel in process x in kWh per m^3_{ub}) * (GHG emissions in process x in g CO_2e per kWh) * 0.001.

The GHG emissions in HOR are calculated according to the generalised calculation scheme

[(number of horses used in HOR in Poland in 2005) * (annual GHG emission per horse)] / (volume of timber, which is further processed in the FWC, hauled in HOR in 2005).

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	GHG emissions in TC	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(SC)	GHG emissions in SC	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(CC)	GHG emissions in CC	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(CH)	GHG emissions in CH	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(SKI)	GHG emissions in SKI	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(FOR)	GHG emissions in FOR	RE_Table 53	kg CO_2e/ m^3_{ub}	
x(HOR)	GHG emissions in HOR	RE_Table 53	kg CO_2e/ m^3_{ub}	
Given parameters				
a	use of fossil fuel in TC	7.913	kWh/m^3_{ub}	B(3), IN_CALC 14
b	use of fossil fuel in SC	3.914	kWh/m^3_{ub}	B(3),

				IN_CALC 14
c	use of fossil fuel in CC	3.714	kWh/m^3_{ub}	B(3), IN_CALC 14
d	use of fossil fuel in CH	12.666	kWh/m^3_{ub}	B(3), IN_CALC 14
e	use of fossil fuel in SKI	16.025	kWh/m^3_{ub}	B(3), IN_CALC 14
f	use of fossil fuel in FOR	27.815	kWh/m^3_{ub}	B(3), IN_CALC 14
g	GHG emissions [CO_2e] in TC, SC and CC	307.4652	g CO_2e/ kWh	B(1), table 4.3-11
h	GHG emissions [CO_2e] in CH, SKI and FOR	279.2592	g CO_2e/ kWh	B(1), table 4.3-11
i	mean productivity per UH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	3.1	m^3_{ub}/PUH	B(3), table 4.3-5
j	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	m^3_{ub}	B(3), table 4.3-1
k	number of PUH per unit in HOR in 2005	1380	#	B(3), table 4.3-4
l	GHG emissions in HOR per horse and per year	1023.316	kg CO_2e	B(2)
Calculation mode				

→ x(TC) = a * g * 0.001

→ x(SC) = b * g * 0.001

→ x(CC) = c * g * 0.001

→ x(CH) = d * h * 0.001

→ x(SKI) = e * h * 0.001

→ x(FOR) = f * h * 0.001

→ x(HOR) = {[(j/i)/k] * l} / j

The process specific values of GHG emissions from machinery are displayed in RE_Table 53 in chapter 5.3.6.2.

4.3.16 Greenhouse Gas Emissions: From Wood Combustion (Indicator 19.1.2)

As stated in chapter 4.3.17 the indicator 19.1.2 is not applicable within the borders of the technical timber production chain. It is therefore not further regarded within this study.

4.3.17 Generation of Waste: Classified as Non-Hazardous Waste (Indicator 27.1.1)

A) Data to be collected:

Within this chapter the amount of non-hazardous waste (NHW), which is generated per m^3_{ub} of the output volume per felling and hauling process of the Polish technical timber production chain (TTPC), is calculated.

B) Underlying information and assumptions:

(1) AFOCEL (2005: 4) provides information on the average mass of waste generated per year and per type of machine or process respectively; the data given in AFOCEL (2005: 4) are assumed to be generally valid for the regarded type of operating machines or processes, regardless of the country where the respective machine is in use or the processes are performed:

According to AFOCEL (2005: 4) the mass of waste generated per year and per each harvester is 1050 kg; thereof, 17% are regarded as NHW. Secondly, 750 kg of waste are generated per skidder and year; thereof, 53% are regarded as NHW. Furthermore, AFOCEL (2005: 4) states that per forwarder and year 800 kg of waste are generated, 30% thereof are regarded as NHW. Finally, per logger and year 22kg of waste are produced; thereof, 89% are regarded as NHW.

The values of the absolute mass of NHW that is generated per process, based on the data given above, are compiled in table 4.3-12. Besides this, the mass of NHW generated per horse and year are added to the table: as stated by E_14 (17 Feb 2009) 22 kg of NHW from packaging of feeding stuffs, medical care and hauling equiqment accrue per horse and year.

Table 4.3-12: *Mass of NHW that is averagely generated per process per year*

Type of machine/ Processes	Harvester: CH	Forwarder: FOR	Skidder: SKI	Logger: TC, SC, CC	Horse: HOR
Mass of NHW (kg/year)	178,5	240	397,5	19,58	22

(2) The following calculation IN_CALC 16 is further based on the process specific output volume of timber, which is further processed in the FWC, (as displayed in table 4.3-1), on the process specific 'weighted mean productivity' per PUH (as displayed in table 4.3-5), on the process specific number of annual PUH per operating unit (as displayed in table 4.3-4), and on the total absolute number of FTEE in TC, SC and CC as given in table 4.3-9.

C) Combining the information:

IN_CALC 16:

Calculation of the mass of NHW generated per m^3_{ub} in each process of the Polish TTPC:

The calculation is performed according to the generalised calculation scheme

*[(number of operating units in process x) * (mass of NHW generated per operating unit and per year)] / (output volume of timber, which is further processed in the FWC, of process x).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	NHW generated in TC	RE_Table 54	kg/m^3_{ub}	
x(SC)	NHW generated in SC	RE_Table 54	kg/m^3_{ub}	
x(CC)	NHW generated in CC	RE_Table 54	kg/m^3_{ub}	
x(CH)	NHW generated in CH	RE_Table 54	kg/m^3_{ub}	
x(SKI)	NHW generated in SKI	RE_Table 54	kg/m^3_{ub}	
x(FOR)	NHW generated in FOR	RE_Table 54	kg/m^3_{ub}	
x(HOR)	NHW generated in HOR	RE_Table 54	kg/m^3_{ub}	
Given parameters				
a	mass of generated NHW per operating unit per year in TC	19.58	kg	B(1)
b	mass of generated NHW per operating unit per year in SC	19.58	kg	B(1)
c	mass of generated NHW per operating unit per year in CC	19.58	kg	B(1)
d	mass of generated NHW per operating unit per year in CH	178.5	kg	B(1)
e	mass of generated NHW per operating unit per year in SKI	397.5	kg	B(1)
f	mass of generated NHW per operating unit per year in FOR	240	kg	B(1)
g	mass of generated NHW per operating unit per year	22	kg	B(1)

	in HOR			
h	volume of timber, which is further processed in the FWC, felled in TC in 2005	12051465.12	$m^3{}_{ub}$	B(2), table 4.3-1
i	volume of timber, which is further processed in the FWC, felled in SC in 2005	10293959.79	$m^3{}_{ub}$	B(2), table 4.3-1
j	volume of timber, which is further processed in the FWC, felled in CC in 2005	5272515.99	$m^3{}_{ub}$	B(2), table 4.3-1
k	volume of timber, which is further processed in the FWC, felled in CH in 2005	278969.1	$m^3{}_{ub}$	B(2), table 4.3-1
l	volume of timber, which is further processed in the FWC, hauled in SKI in 2005	22317528.00	$m^3{}_{ub}$	B(2), table 4.3-1
m	volume of timber, which is further processed in the FWC, hauled in FOR in 2005	1394845.50	$m^3{}_{ub}$	B(2), table 4.3-1
n	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	$m^3{}_{ub}$	B(2), table 4.3-1
o	mean productivity per PUH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	12.65	$m^3{}_{ub}$/PUH	B(2), table 4.3-5
p	mean productivity per PUH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	6.15	$m^3{}_{ub}$/PUH	B(2), table 4.3-5
q	mean productivity per PUH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	4.33	$m^3{}_{ub}$/PUH	B(2), table 4.3-5
r	mean productivity per PUH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	3.10	$m^3{}_{ub}$/PUH	B(2), table 4.3-5
s	number of PUH per unit per year in CH	1920	#	B(2), table 4.3-4
t	number of PUH per unit per year in SKI	1440	#	B(2), table 4.3-4
u	number of PUH per unit per year in FOR	2160	#	B(2), table 4.3-4
v	number of PUH per unit per year in HOR	1380	#	B(2), table 4.3-4
w	total absolute number of FTEE in TC	12381.30	#	B(2), table 4.3-9
y	total absolute number of FTEE in SC	5230.99	#	B(2), table 4.3-9
z	total absolute number of FTEE in CC	2542.59	#	B(2), table 4.3-9

Calculation mode

→ x(TC) = (w * a) / h

→ x(SC) = (y * b) / i

→ x(CC) = (z * c) / j

→ x(CH) = {[(k/o) / s] * d} / k

→ x(SKI) = {[(l/p) / t] * e} / l

→ x(FOR) = {[(m/q) / u] * f} / m

→ x(HOR) = {[(n/r) / v] * g} / n

The process specific values of the generation of NHW are displayed in RE_Table 54 in chapter 5.3.7.1.

4.3.18 Generation of Waste: Classified as Hazardous Waste (Indicator 27.1.2)

A) <u>Data to be collected</u>:

Within this chapter the amount of hazardous waste (HW), which is generated per m^3_{ub} of the output volume per felling and hauling process of the Polish TTPC, is calculated.

B) <u>Underlying information and assumptions</u>:

<u>(1)</u> AFOCEL (2005: 4) provides information on the average mass of waste generated per year by per type of machine or process respectively:

According to AFOCEL (2005: 4) the mass of waste generated per year and per each harvester is 1050 kg; thereof, 83% are regarded as HW. Secondly, 750 kg of waste are generated per skidder and year; thereof, 47% are regarded as HW. Furthermore, AFOCEL (2005: 4) states that per forwarder and year 800 kg of waste are generated, 70% thereof are regarded as HW. Finally, per logger and year 22kg of waste are produced; thereof, 11% are regarded as HW.

The values of the absolute mass of HW that is generated per process, based on the data given above, are compiled in table 4.3-13. Besides this, the mass of HW generated per horse and year is added to the table: as stated by E_14 (17 Feb 2009) no significant amount of HW accrues for horses.

<u>Table 4.3-13</u>: *Mass of HW that is averagely generated per process per year*

Type of machine/ Processes	Harvester: CH	Forwarder: FOR	Skidder: SKI	Logger: TC, SC, CC	Horse: HOR
Mass of HW (kg/year)	871.5	560	352.5	2.42	0

<u>(2)</u> The following calculation IN_CALC 17 is further based on the process specific output volume of timber, which is further processed in the FWC, (as displayed in table 4.3-1), on the process specific ‘weighted mean productivity’ per PUH (as displayed in table 4.3-5), on the process specific number of annual PUH per operating unit (as displayed in table 4.3-4), and on the total absolute number of FTEE in TC, SC and CC as given in table 4.3-9.

C) Combining the information:

IN_CALC 17:

Calculation of the mass of HW generated per m^3_{ub} in each process of the Polish TTPC:

The calculation is performed according to the generalised calculation scheme *[(number of operating units in process x) * (mass of HW generated per operating unit and per year)] / (output volume of timber, which is further processed in the FWC, of process x).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	HW generated in TC	RE_Table 55	kg/m^3_{ub}	
x(SC)	HW generation in SC	RE_Table 55	kg/m^3_{ub}	
x(CC)	HW generated in CC	RE_Table 55	kg/m^3_{ub}	
x(CH)	HW generated in CH	RE_Table 55	kg/m^3_{ub}	
x(SKI)	HW generated in SKI	RE_Table 55	kg/m^3_{ub}	
x(FOR)	HW generated in FOR	RE_Table 55	kg/m^3_{ub}	
x(HOR)	HW generated in HOR	RE_Table 55	kg/m^3_{ub}	
Given parameters				
a	mass of generated HW per operating unit per year in TC	2.42	kg	B(1)
b	mass of generated HW per operating unit per year in SC	2.42	kg	B(1)
c	mass of generated HW per operating unit per year in CC	2.42	kg	B(1)
d	mass of generated HW per operating unit per year in CH	871.5	kg	B(1)
e	mass of generated HW per operating unit per year in SKI	352.5	kg	B(1)
f	mass of generated HW per operating unit per year in FOR	560	kg	B(1)
g	mass of generated HW per operating unit per year in HOR	0	kg	B(1)
h	volume of timber, which is further processed in the FWC, felled in TC in 2005	12051465.12	m^3_{ub}	B(2), table 4.3-1
i	volume of timber, which is further processed in the FWC, felled in SC in 2005	10293959.79	m^3_{ub}	B(2), table 4.3-1
j	volume of timber, which is further processed in the FWC, felled in CC in 2005	5272515.99	m^3_{ub}	B(2), table 4.3-1
k	volume of timber, which is further processed in the FWC, felled in CH in 2005	278969.1	m^3_{ub}	B(2), table 4.3-1
l	volume of timber, which is further processed in the FWC, hauled in SKI in 2005	22317528.00	m^3_{ub}	B(2), table 4.3-1
m	volume of timber, which is further processed in the	1394845.50	m^3_{ub}	B(2),

	FWC, hauled in FOR in 2005			table 4.3-1
n	volume of timber, which is further processed in the FWC, hauled in HOR in 2005	4184536.50	m^3_{ub}	B(2), table 4.3-1
o	mean productivity per PUH in CH weighted according to the proportion of the tree species in the output volume of CH (PL)	12.65	m^3_{ub}/PUH	B(2), table 4.3-5
p	mean productivity per PUH in SKI weighted according to the proportion of the tree species in the output volume of SKI (PL)	6.15	m^3_{ub}/PUH	B(2), table 4.3-5
q	mean productivity per PUH in FOR weighted according to the proportion of the tree species in the output volume of FOR (PL)	4.33	m^3_{ub}/PUH	B(2), table 4.3-5
r	mean productivity per PUH in HOR weighted according to the proportion of the tree species in the output volume of HOR (PL)	3.10	m^3_{ub}/PUH	B(2), table 4.3-5
s	number of PUH per unit per year in CH	1920	#	B(2), table 4.3-4
t	number of PUH per unit per year in SKI	1440	#	B(2), table 4.3-4
u	number of PUH per unit per year in FOR	2160	#	B(2), table 4.3-4
v	number of PUH per unit per year in HOR	1380	#	B(2), table 4.3-4
w	total absolute number of FTEE in TC	12381.30	#	B(2), table 4.3-9
y	total absolute number of FTEE in SC	5230.99	#	B(2), table 4.3-9
z	total absolute number of FTEE in CC	2542.59	#	B(2), table 4.3-9
Calculation mode				

→ x(TC) = (w * a) / h

→ x(SC) = (y * b) / i

→ x(CC) = (z * c) / j

→ x(CH) = {[(k/o) / s] * d} / k

→ x(SKI) = {[(l/p) / t] * e} / l

→ x(FOR) = {[(m/q) / u] * f} / m

→ x(HOR) = {[(n/r) / v] * g} / n

The process specific values of the generation of HW are displayed in RE_Table 55 in chapter 5.3.7.2.

4.3.19 WASTE MANAGEMENT: WASTE TO REUSE OR RECYCLED MATERIAL (INDICATOR 27.2.1)

A) Data to be collected:

Within this chapter the mass of waste, which is reused or recycled, generated per regarded felling and hauling process of the Polish TTPC is calculated.

B) Underlying information and assumptions:

(1) Despite intensive research no sufficient country specific information on the respective management of the different types of waste that accrue in felling and hauling processes according to AFOCEL (2005: 4) could be found for Poland. Therefore, own assumptions have been made based on EFORWOOD (2008c: 92) where recycling is defined "[…] as any reprocessing of material in a production process that diverts it from the waste stream, except reuse as fuel".

Own assumptions have additionally been made on wether a certain type of waste generally accrues in the regarded processes.

The assumptions about the type of waste management (recycling or landfill/incineration) and on wether a certain type of waste accrues in the different processes are compiled in table 4.3-14:

Table 4.3-14: *Main categories of waste which are relevant for the specific processes*

Type of waste (Source: AFOCEL)		Management	Assumption on wether a certain type of waste accrues in the different processes						
			TC	SC	CC	CH	SKI	FOR	HOR
HW	electronic equipment	recycling	no	no	no	yes	yes	yes	no
	soiled containers	landfill/ incineration	yes	yes	yes	yes	yes	yes	no
	aerosols	landfill/ incineration	no	no	no	no	no	no	no
	used oils	landfill/ incineration	no	no	no	yes	yes	yes	no
	other fluids	landfill/ incineration	no	no	no	yes	yes	yes	no
	soiled equipments	landfill/ incineration	yes	yes	yes	yes	yes	yes	no
	batteries, accumulator	recycling	no	no	no	yes	yes	yes	no
	other HW	landfill/ incineration	yes	yes	yes	yes	yes	yes	no
NHW	unsoiled packaging	recycling	no	no	no	no	no	no	yes
	scrap metal	recycling	yes	yes	yes	yes	yes	yes	yes
	used tyres	landfill/ incineration	no	no	no	yes	yes	yes	no
	other (clothing etc.)	landfill/ incineration	yes	yes	yes	yes	yes	yes	yes

<u>(2)</u> In AFOCEL (2005: 4) the mass of generated waste is given in tons per year for each waste category.

Therefore, the proportion of each relevant waste category in the total amount of generated waste is calculated by performing a rule of three calculation. The absolute values provided by AFOCEL (2005: 4) and the respective proportions in % are displayed in table 4.3-15.

***Table 4.3-15**: Proportion of each waste category in the total mass of waste generated in felling and hauling processes*

Type of waste (Source: AFOCEL)	**Management**	**Mass (tons/year)** (Source: AFOCEL)	**% of total**
electronic equipment	Recycling	1,5	**0.0516**
soiled containers	Landfill/ Incineration	157	**5.3989**
aerosols	Landfill/ Incineration	4,3	**0.1479**
used oils	Landfill/ Incineration	1080	**37.1389**
other fluids	Recycling	69	**2.3728**
soiled equipments	Landfill/ Incineration	369	**12.6891**
batteries, accummulators	Recycling	60	**2.0633**
other HW	Landfill/ Incineration	0,3	**0.0103**
unsoiled packaging	Landfill/ Incineration	26	**0.8941**
scrap metal	Recycling	499	**17.1596**
used tyres	Landfill/ Incineration	581	**19.9794**
other (clothing…)	Landfill/ Incineration	60	**2.0633**
undefined waste	unknown	0,9	**0.0309**
	SUM	**2908**	**100.0000**

(3) The following calculation IN_CALC 18 is further based on the results of IN_CALC 16 (NHW generated per process) and on the results of IN_CALC 17 (HW generated per process).

(C) Combining the information:

IN_CALC 18:

Calculation of the mass of waste, generated per process of the Polish TTPC, that is recycled or reused:

The calculation is performed according to the generalised calculation scheme:

*[(process specific mass of NHW generated per m^3_{ub}) + (process specific mass of HW generated per m^3_{ub})] * [(sum of the proportions of waste, which is recycled or reused and relevant in process x, in the total mass of waste in felling and hauling processes) / (sum of the proportions of waste, which is relevant in process x, in the total mass of waste generated in felling and hauling processes)].*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	waste, generated in TC, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
x(SC)	waste, generated in SC, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
x(CC)	waste, generated in CC, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	

x(CH)	waste, generated in CH, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
x(SKI)	waste, generated in SKI, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
x(FOR)	waste, generated in FOR, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
x(HOR)	waste, generated in HOR, that is recycled or reused	RE_Table 56	kg/m^3_{ub}	
Given parameters				
a	NHW generated in TC	0.0201	kg/m^3_{ub}	B(3), IN_CALC 16
b	NHW generated in SC	0.0099	kg/m^3_{ub}	B(3), IN_CALC 16
c	NHW generated in CC	0.0094	kg/m^3_{ub}	B(3), IN_CALC 16
d	NHW generated in CH	0.0073	kg/m^3_{ub}	B(3), IN_CALC 16
e	NHW generated in SKI	0.0449	kg/m^3_{ub}	B(3), IN_CALC 16
f	NHW generated in FOR	0.0257	kg/m^3_{ub}	B(3), IN_CALC 16
g	NHW generated in HOR	0.0051	kg/m^3_{ub}	B(3), IN_CALC 16
h	HW generated in TC	0.0025	kg/m^3_{ub}	B(3), IN_CALC 17
i	HW generation in SC	0.0012	kg/m^3_{ub}	B(3), IN_CALC 17
j	HW generated in CC	0.0012	kg/m^3_{ub}	B(3), IN_CALC 17
k	HW generated in CH	0.0359	kg/m^3_{ub}	B(3), IN_CALC 17
l	HW generated in SKI	0.0398	kg/m^3_{ub}	B(3), IN_CALC 17
m	HW generated in FOR	0.0599	kg/m^3_{ub}	B(3), IN_CALC 17
n	HW generated in HOR	0	kg/m^3_{ub}	B(3), IN_CALC 17
o	proportion of electrical and electronic equipment in the total mass of generated waste (recycled)	0.0516	%	B(2), table 4.3-15
p	proportion of soiled containers in the total mass of generated waste (landfill/incineration)	5.3989	%	B(2), table 4.3-15
q	proportion of used oils (hydraulic and engine oils) in the total mass of generated waste (landfill/incineration)	0.0516	%	B(2), table 4.3-15
r	proportion of other fluids (brakes, cooling,…) in the total mass of generated waste (landfill/incineration)	5.3989	%	B(2), table 4.3-15
s	proportion of soiled equipments in the total mass of generated waste (landfill/incineration)	0.0516	%	B(2), table 4.3-15
t	proportion of batteries and accumulators in the total mass of generated waste (recycled)	5.3989	%	B(2), table 4.3-15
u	proportion of other HW in the total mass of generated waste (landfill/incineration)	0.0516	%	B(2), table 4.3-15
v	proportion of unsoiled packaging in the total mass of generated waste (recycled)	5.3989	%	B(2), table 4.3-15
w	proportion of scrap metal (guides,chains,...) in the total mass of generated waste (recycled)	0.0516	%	B(2), table 4.3-15
y	proportion of used tyres in the total mass of generated waste (landfill/incineration)	5.3989	%	B(2),

				table 4.3-15
z	proportion of other (clothing…) in the total mass of generated waste (landfill/incineration)	0.0516	%	B(2), table 4.3-15
Calculation mode				

→ x(TC) = (a + h) * [w / (p+s+u+w+z)]

→ x(SC) = (b + i) * [w / (p+s+u+w+z)]

→ x(CC) = (c + j) * [w / (p+s+u+w+z)]

→ x(CH) = (d + k) * [(o+u+w) / (o+p+q+r+s+t+u+w+y+z)]

→ x(SKI) = (e + l) * [(o+u+w) / (o+p+q+r+s+t+u+w+y+z)]

→ x(FOR) = (f + m) * [(o+u+w) / (o+p+q+r+s+t+u+w+y+z)]

→ x(HOR) = (g + n) * [(v+w) / (v+w+z)]

The process specific values of recycled or reused waste are displayed in RE_Table 56 in chapter 5.3.7.3.

4.3.20 Management of Waste: Incineration of Waste (Indicator 27.2.2)

A) <u>Data to be collected</u>

Within this chapter the mass of waste, which is incinerated, generated per regarded felling and hauling process of the Polish TTPC is calculated.

EFORWOOD (2008c: 92) defines incineration as "[…] controlled burning of solid, liquid or gaseous waste materials at high temperatures."

B) <u>Underlying information and assumptions:</u>

<u>(1)</u> According to CHEFDEBIEN (2008: 24) there was one incineration plant in use in Poland in 2005; in this plant 0.045mln tonnes of waste were incinerated in 2005. This mass equals 0.205% of the total quantity of waste generated in PL in 2005 and not been recycled or reused, which was 21.9296mln tonnes (CENTRAL STATISTICAL OFFICE, 2008: 54).

It is assumed that the proportion of incinerated waste in the total quantity of waste generated in felling and hauling processes in the forestry and disposed to landfill/incineration is also 0.205%.

<u>(2)</u> The following calculation IN_CALC 19 is further based on the results of IN_CALC 16 (NHW generated per process), of IN_CALC 17 (HW generated per process) and of IN_CALC 18 (waste, generated per process, that is recycled or reused).

(C) <u>Combining the information</u>:

IN_CALC 19:

<u>Calculation of the mass of waste, generated per process of the Polish TTPC, that is incinerated</u>:

The calculation is performed according to the generalised calculation scheme:

*{[(process specific mass of NHW generated per m^3_{ub}) + (process specific mass of HW generated per m^3_{ub})] – (process specific mass of waste that is recycled or reused per m^3_{ub})} * (proportion of incinerated waste in the total quantity of waste disposed to landfill/incineration).*

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	waste, generated in TC, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(SC)	waste, generated in SC, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(CC)	waste, generated in CC, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(CH)	waste, generated in CH, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(SKI)	waste, generated in SKI, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(FOR)	waste, generated in FOR, that is incinerated	RE_Table 57	kg/m^3_{ub}	
x(HOR)	waste, generated in HOR, that is incinerated	RE_Table 57	kg/m^3_{ub}	
Given parameters				
a	NHW generated in TC	0.0201	kg/m^3_{ub}	B(2), IN_CALC 16
b	NHW generated in SC	0.0099	kg/m^3_{ub}	B(2), IN_CALC 16
c	NHW generated in CC	0.0094	kg/m^3_{ub}	B(2), IN_CALC 16
d	NHW generated in CH	0.0073	kg/m^3_{ub}	B(2), IN_CALC 16
e	NHW generated in SKI	0.0449	kg/m^3_{ub}	B(2), IN_CALC 16
f	NHW generated in FOR	0.0257	kg/m^3_{ub}	B(2), IN_CALC 16
g	NHW generated in HOR	0.0051	kg/m^3_{ub}	B(2), IN_CALC 16
h	HW generated in TC	0.0025	kg/m^3_{ub}	B(2), IN_CALC 17
i	HW generation in SC	0.0012	kg/m^3_{ub}	B(2), IN_CALC 17
j	HW generated in CC	0.0012	kg/m^3_{ub}	B(2), IN_CALC 17
k	HW generated in CH	0.0359	kg/m^3_{ub}	B(2), IN_CALC 17
l	HW generated in SKI	0.0398	kg/m^3_{ub}	B(2), IN_CALC 17
m	HW generated in FOR	0.0599	kg/m^3_{ub}	B(2), IN_CALC 17
n	HW generated in HOR	0	kg/m^3_{ub}	B(2), IN_CALC 17
o	waste, generated in TC, that is recycled or reused	0.0157	kg/m^3_{ub}	B(2), IN_CALC 18
p	waste, generated in SC, that is recycled or reused	0.0077	kg/m^3_{ub}	B(2), IN_CALC 18
q	waste, generated in CC, that is recycled or reused	0.0074	kg/m^3_{ub}	B(2), IN_CALC 18
r	waste, generated in CH, that is recycled or reused	0.0171	kg/m^3_{ub}	B(2), IN_CALC 18
s	waste, generated in SKI, that is recycled or reused	0.0336	kg/m^3_{ub}	B(2), IN_CALC 18
t	waste, generated in FOR, that is recycled or reused	0.0682	kg/m^3_{ub}	B(2), IN_CALC 18
u	waste, generated in HOR, that is recycled or reused	0.0044	kg/m^3_{ub}	B(2), IN_CALC 18
v	proportion of incinerated waste in the total quantity	0.205	%	B(1)

	of waste disposed to landfill/incineration			
Calculation mode				
→ x(TC) = [(a + h) – o] * v → x(SC) = [(b + i) – p] * v → x(CC) = [(c + j) – q] * v → x(CH) = [(d + k) – r] * v → x(SKI) = [(e + l) – s] * v → x(FOR) = [(f + m) – t] * v → x(HOR) = [(g + n) – u] * v				

The process specific values of incinerated waste are displayed in RE_Table 57 in chapter 5.3.7.4.

4.3.21 Management of Waste: Waste to Landfill (Indicator 27.2.3)

A) Data to be collected:

Within this chapter the mass of incinerated waste, which is generated per regarded felling and hauling process of the Polish technical timber production chain, is calculated. EFORWOOD (2008c: 92) defines incineration as "[…] controlled burning of solid, liquid or gaseous waste materials at high temperatures."

B) Underlying information and assumptions:

The following calculation IN_CALC 20 is based on the results of IN_CALC 16 (NHW generated per process) and on the results of IN_CALC 17 (HW generated per process), on the results of IN_CALC 18 (waste, generated per process, that is recycled or reused) and on the results of IN_CALC 19 (waste, generated per process, that is incinerated)

C) Combining the information:

IN_CALC 20:

Calculation of the mass of waste, generated per process of the Polish TTPC, that is disposed to landfill:

The calculation is performed according to the generalised calculation scheme:

(process specific mass of NHW generated per m^3_{ub}) + *(process specific mass of HW generated per m^3_{ub})* – *(process specific mass of waste that is recycled or reused per m^3_{ub})* – *(process specific mass of waste that is incinerated per m^3_{ub})*.

Symbol	Parameter	Value	Unit	Source
Parameters to be calculated				
x(TC)	waste, generated in TC, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(SC)	waste, generated in SC, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(CC)	waste, generated in CC, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(CH)	waste, generated in CH, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(SKI)	waste, generated in SKI, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(FOR)	waste, generated in FOR, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
x(HOR)	waste, generated in HOR, that is disposed to landfill	RE_Table 58	kg/m^3_{ub}	
Given parameters				
a	NHW generated in TC	0.0201	kg/m^3_{ub}	B, IN_CALC 16
b	NHW generated in SC	0.0099	kg/m^3_{ub}	B, IN_CALC 16

c	NHW generated in CC	0.0094	kg/m^3_{ub}	B, IN_CALC 16
d	NHW generated in CH	0.0073	kg/m^3_{ub}	B, IN_CALC 16
e	NHW generated in SKI	0.0449	kg/m^3_{ub}	B, IN_CALC 16
f	NHW generated in FOR	0.0257	kg/m^3_{ub}	B, IN_CALC 16
g	NHW generated in HOR	0.0051	kg/m^3_{ub}	B, IN_CALC 16
h	HW generated in TC	0.0025	kg/m^3_{ub}	B, IN_CALC 17
i	HW generation in SC	0.0012	kg/m^3_{ub}	B, IN_CALC 17
j	HW generated in CC	0.0012	kg/m^3_{ub}	B, IN_CALC 17
k	HW generated in CH	0.0359	kg/m^3_{ub}	B, IN_CALC 17
l	HW generated in SKI	0.0398	kg/m^3_{ub}	B, IN_CALC 17
m	HW generated in FOR	0.0599	kg/m^3_{ub}	B, IN_CALC 17
n	HW generated in HOR	0	kg/m^3_{ub}	B, IN_CALC 17
o	waste, generated in TC, that is recycled or reused	0.0157	kg/m^3_{ub}	B, IN_CALC 18
p	waste, generated in SC, that is recycled or reused	0.0077	kg/m^3_{ub}	B, IN_CALC 18
q	waste, generated in CC, that is recycled or reused	0.0074	kg/m^3_{ub}	B, IN_CALC 18
r	waste, generated in CH, that is recycled or reused	0.0171	kg/m^3_{ub}	B, IN_CALC 18
s	waste, generated in SKI, that is recycled or reused	0.0336	kg/m^3_{ub}	B, IN_CALC 18
t	waste, generated in FOR, that is recycled or reused	0.0682	kg/m^3_{ub}	B, IN_CALC 18
u	waste, generated in HOR, that is recycled or reused	0.0044	kg/m^3_{ub}	B, IN_CALC 18
v	waste, generated in TC, that is incinerated	$1.41*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
w	waste, generated in SC, that is incinerated	$0.69*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
y	waste, generated in CC, that is incinerated	$0.66*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
z	waste, generated in CH, that is incinerated	$5.34*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
aa	waste, generated in SKI, that is incinerated	$10.47*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
ab	waste, generated in FOR, that is incinerated	$10.59*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19
ac	waste, generated in HOR, that is incinerated	$0.15*10^{-5}$	kg/m^3_{ub}	B, IN_CALC 19

Calculation mode

→ x(TC) = a + h – o – v

→ x(SC) = b + i – p – w

→ x(CC) = c + j – q – y

→ x(CH) = d + k – r – z

→ x(SKI) = e + l – s – aa

→ x(FOR) = f + m – t – ab

→ x(HOR) = g + n – u – ac

The process specific values of waste that is disposed to landfill are displayed in RE_Table 58 in chapter 5.3.7.5.

5 RESULTS

Within this chapter, firstly, the results of the identification of the structure of the Polish, Lithuanian, Czech and Hungarian technical timber production chain (TTPC) are displayed.
Secondly, the results of the volume flow calculations that would allow for a detailed quantitative description of the TTPC structure are given in plain result tables; the values, as provided in these tables RE_Table 1 to RE_Table 40, can directly be transferred into the EFORWOOD database client in order to support the development of ToSIA.
Further to that, the results of the process specific calculations of the values of the sustainability indicators (SI) are displayed in the RE_Tables 41 to 58. Again, displaying the values in these plain tables allows for the direct transfer of all data, which are required to perform the assessment of the sustainability impact of the EU-FWC, into the EFORWOOD database client.

The detailed calculation modes, which have been developed in the course of this study to calculate the values of the volume flows and of the SI and which are therefore also results of the study, are not part of chapter 5. This is due to the fact that these calculation modes are not only results but also important methods to calculate the required values.
However, it is stressed, that the detailed calculation modes are actually important results of this study; this is due to several reasons:

- The detailed calculation modes have been developed based on the actual data availability with regard to the Polish, Lithuanian, Czech and Hungarian TTPC; this means that – by using the developed detailed calculation modes – the result parameter values can relatively quickly be adapted to input parameter values that are different from those used in this study, e.g. when the volume flows or the indicator values are to be calculated for a year other than 2005.
- It can be assumed that the data availability for other EU-countries is similar or even better than for Poland, Lithuania, the Czech Republic and Hungary; therefore, the developed detailed calculation modes can probably also be used to calculate the volume flows and the SI values for other EU-countries than the ones named above.

5.1 DISPLAY OF THE TTPC STRUCTURE

Based on the approaches described in chapter 4.2.1, the country specific sets of felling and hauling processes, of which the Polish, Lithuanian, Czech and Hungarian TTPC consisted in the year 2005, have been identified. By using the software of the ARIS-Business Architect, the general structures of the TTPCs are displayed as Event-driven Process Chains in chapter 5.1.1 for Poland, in chapter 5.1.2 for Lithuania, in chapter 5.1.3 for the Czech Republic and in chapter 5.1.4 for Hungary.

5.1.1 STRUCTURE OF THE POLISH TTPC

Seven processes play a significant role in terms of output volume in the Polish TTPC:

- **Four felling processes**:
  - Thinning with chainsaw (TC)
  - Selective logging with chainsaw (SC)
  - Clearcut with chainsaw (CC)
  - Clearcut with medium-sized harvester (CH)

- **Three hauling processes:**
  - Hauling with skidder (SKI)
  - Hauling with forwarder (FOR)
  - Hauling with horse (HOR)

As these seven processes represent the Polish TTPC, all calculations of the timber volume flows within the Polish TTPC have been performed with regard to them. Furthermore, the values of the selected set of EFORWOOD FWC sustainability indicators (SI) have been calculated precisely for these seven processes.

The output products of these processes are assigned to three categories, namely short logs, long logs and harvest residues.

To allow a quick overview on the general structure of the Polish TTPC, it is displayed as an Event-driven Process Chain in figure 5.1-1; the figure has been created by using the software of the ARIS-Business Architect.

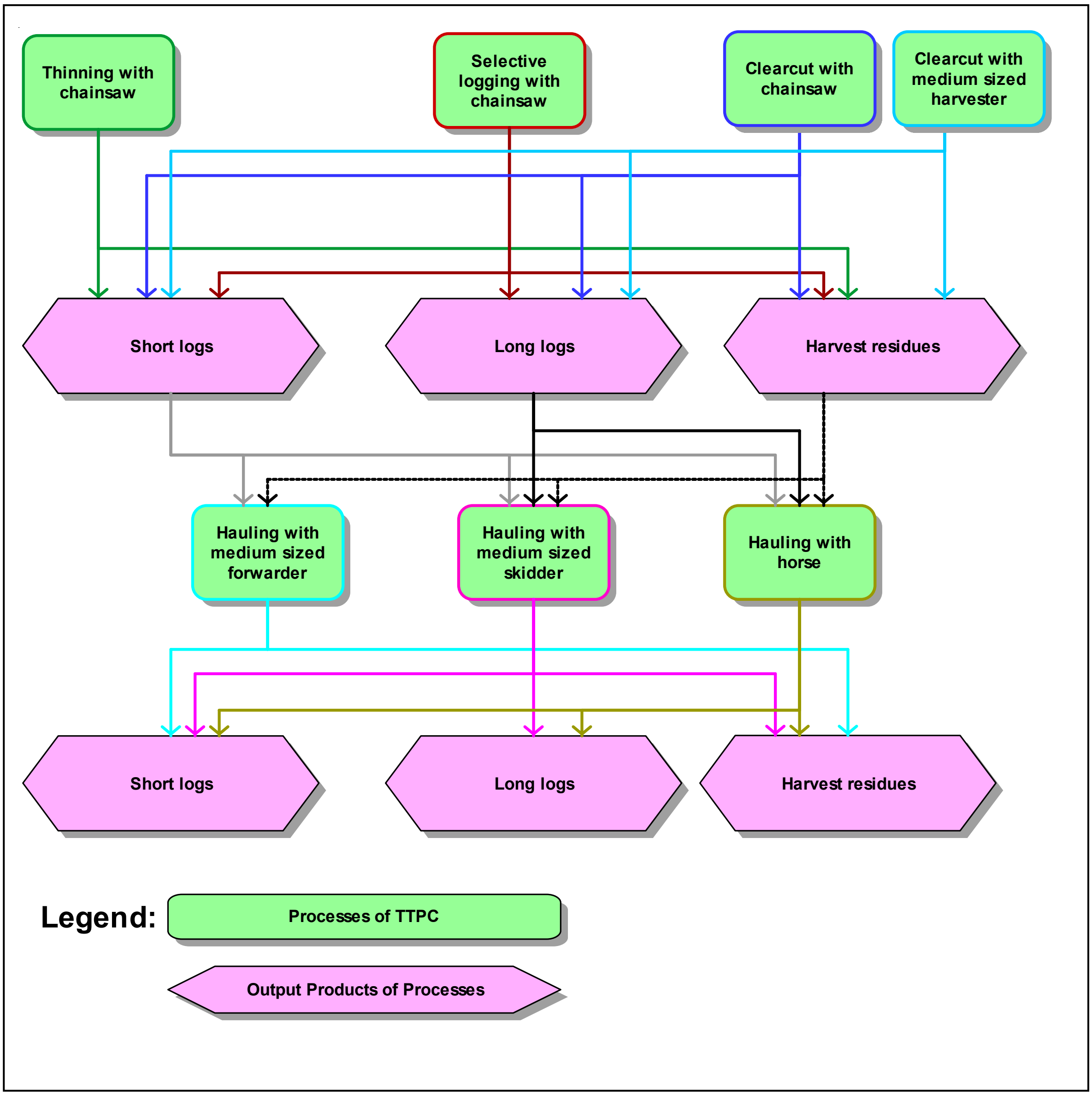

Figure 5.1-1: *Structure of the TTPC in Poland*

5.1.2 STRUCTURE OF THE LITHUANIAN TTPC

In comparison to the Polish TTPC one additional felling process has been identified to be relevant for the Lithuanian TTPC, namely thinning with medium-sized harvester (TH).

Therefore, all calculations of the timber volume flows and of the SI values have been performed with regard to eight processes:

- **Five felling processes**:
  - Thinning with chainsaw (TC)
  - Thinning with medium-sized harvester (TH)
  - Selective logging with chainsaw (SC)
  - Clearcut with chainsaw (CC)
  - Clearcut with medium-sized harvester (CH)

- **Three hauling processes:**
  - Hauling with skidder (SKI)
  - Hauling with forwarder (FOR)
  - Hauling with horse (HOR)

Again, to allow a quick overview on the general structure of the Lithuanian TTPC, it is displayed as an Event-driven Process Chain in figure 5.1-2; the figure has been created by using the software of the ARIS-Business Architect.

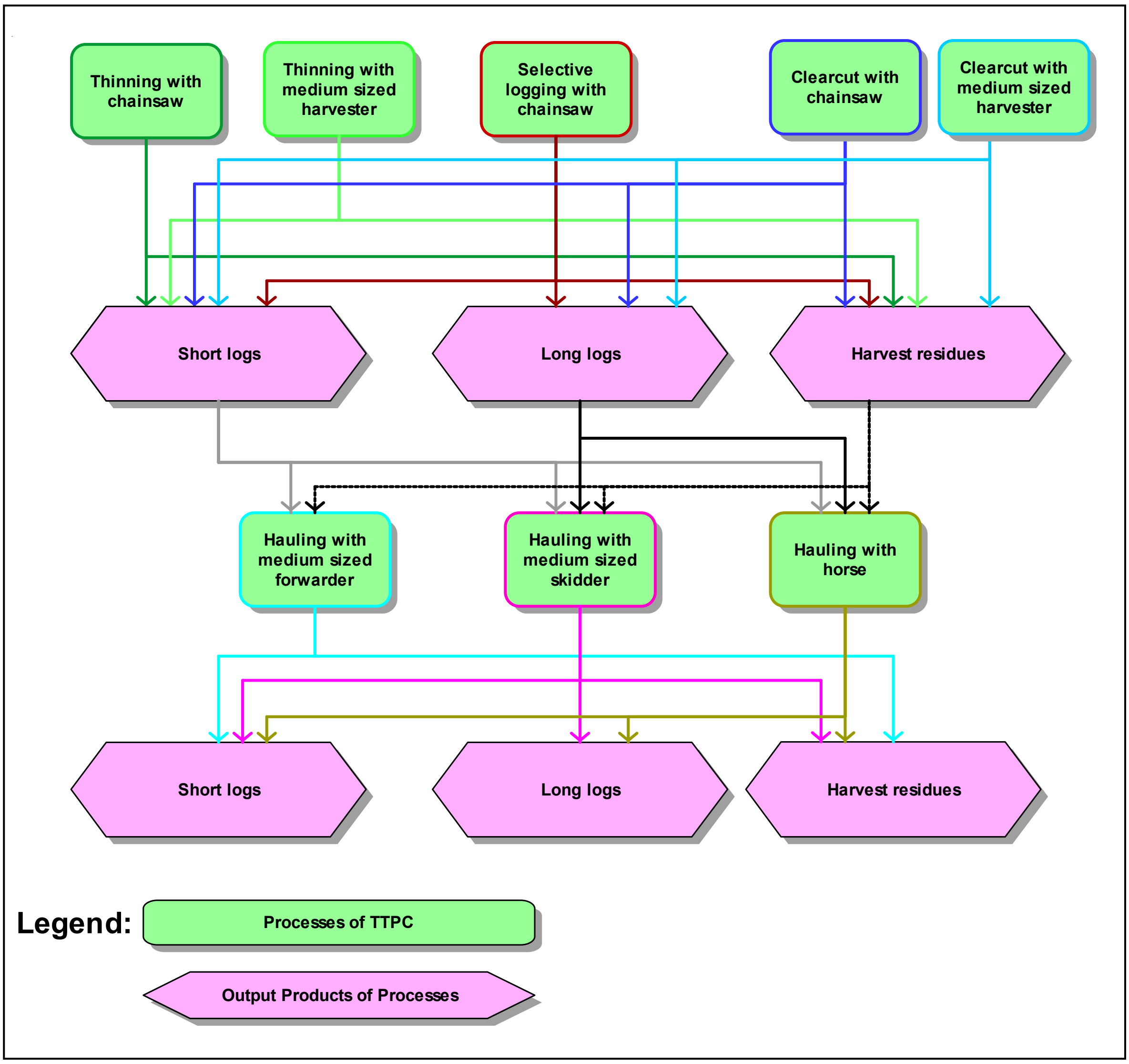

Figure 5.1-2: *Structure of the TTPC in Lithuania*

5.1.3 STRUCTURE OF THE CZECH TTPC

Eight processes and three product categories play a significant role in terms of output volume in the Czech TTPC in 2005:

- **Five felling processes**:
  - Thinning with chainsaw (TC)
  - Thinning with medium-sized harvester (TH)
  - Selective logging with chainsaw (SC)
  - Clearcut with chainsaw (CC)
  - Clearcut with medium-sized harvester (CH)

- **Three hauling processes:**
  - Hauling with skidder (SKI)
  - Hauling with forwarder (FOR)
  - Hauling with horse (HOR)

As these eight processes represent the Czech TTPC, all calculations of the timber volume flows within the Czech TTPC have been performed with regard to them. Furthermore, the values of the selected set of EFORWOOD FWC sustainability indicators (SI) as shown in table 4.1-5 have been calculated precisely for these eight processes in the Czech Republic.
To allow a quick overview on the general structure of the Czech TTPC, with the integration of the processes and the products, it is displayed as an 'Event-driven Process Chain' in figure 5.1-3; the figure has been created by using the software of the 'ARIS-Business Architect'.

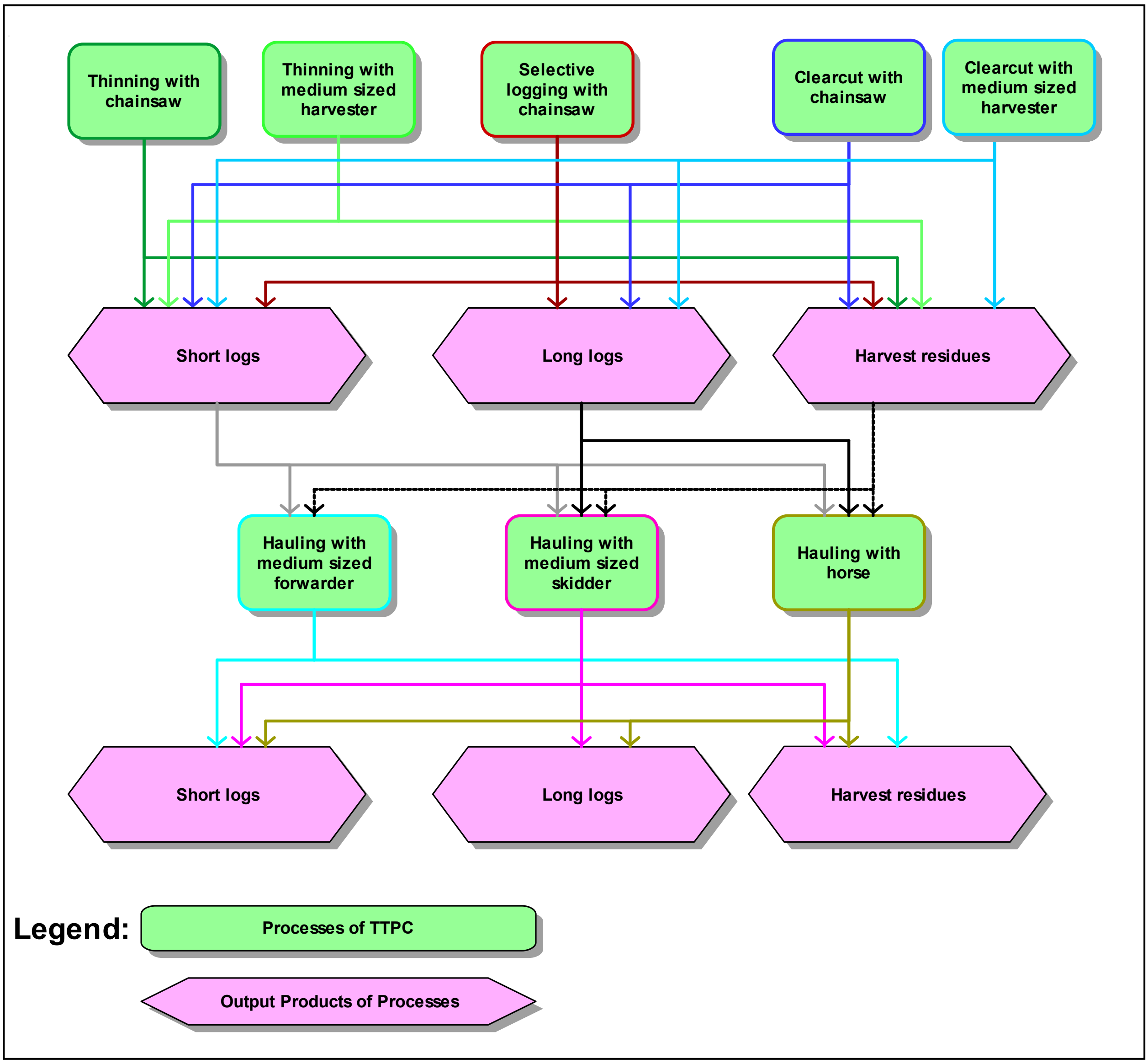

Figure 5.1-3: *Structure of the TTPC in the Czech Republic*

5.1.4 STRUCTURE OF THE HUNGARIAN TTPC IN 2005

Five processes and one product category play a significant role in terms of output volume in the Hungarian TTPC in 2005:

- **Two felling processes**:
  - Thinning with chainsaw (TC)
  - Clearcut with chainsaw (CC)

- **Three hauling processes:**
  - Hauling with skidder (SKI)
  - Hauling with forwarder (FOR)
  - Hauling with horse (HOR)

As these five processes represent the Hungarian TTPC for the species of oak, all calculations of the timber volume flows within the Hungarian TTPC have been performed with regard to them. Furthermore, the values of the selected set of EFORWOOD FWC sustainability indicators (SI) as shown in table 4.1-5 have been calculated precisely for these five processes in HU.

To allow a quick overview on the general structure of the Hungarian TTPC, with the integration of the processes and the products, it is displayed as an 'Event-driven Process Chain' in figure 5.1-4; the figure has been created by using the software of the 'ARIS-Business Architect'.

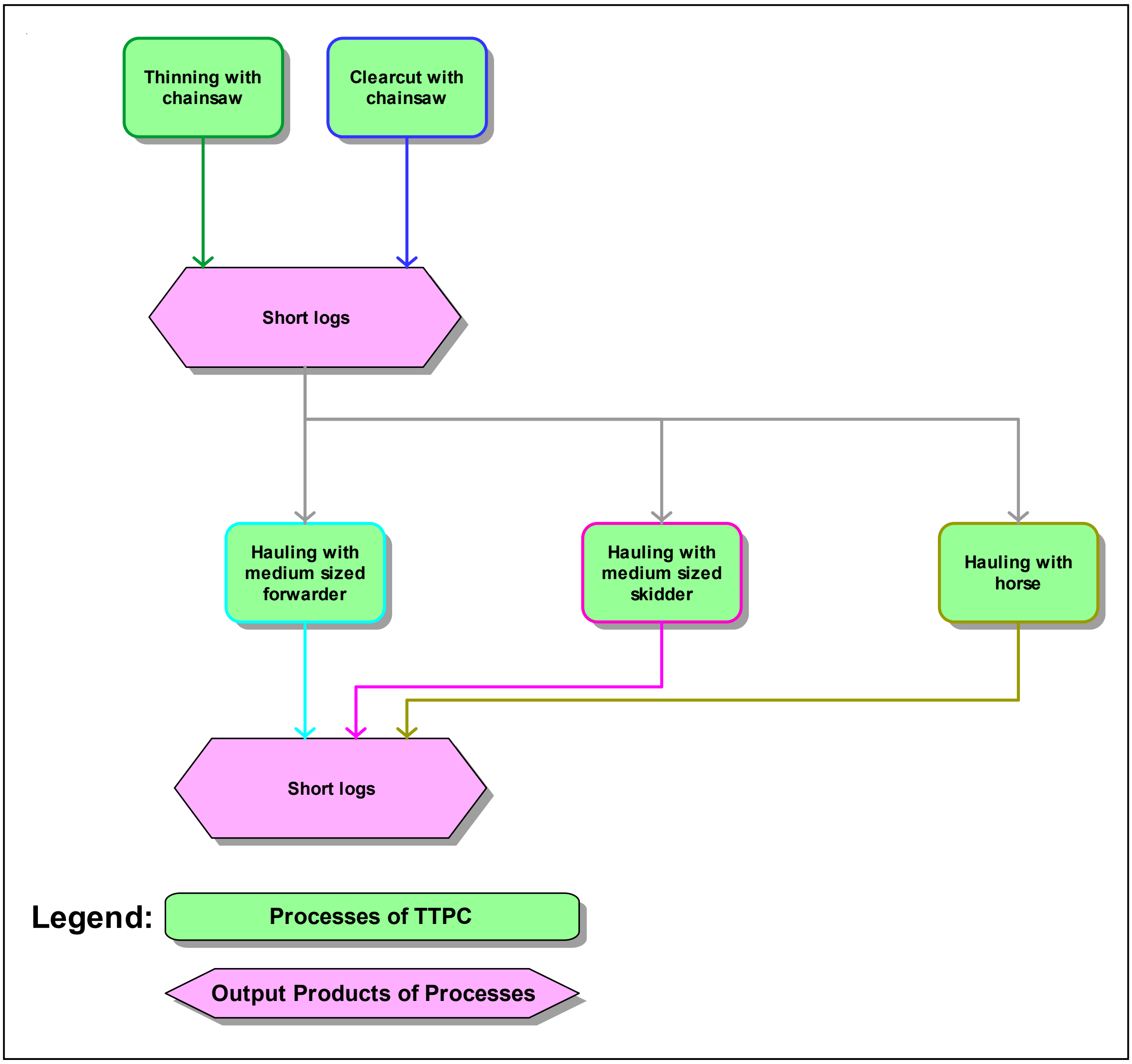

Figure 5.1-4: *Structure of the TTPC in Hungary*

5.2 RESULTS OF THE VOLUME FLOW CALCULATION

In chapter 5.2 the volume flows within the Polish, Lithuanian, Czech and Hungarian TTPC are displayed in plain tables. The chapter is started with the process shares and continued with the product shares and the split ratios for all four country specific TTPCs. All parameter categories allow the detailed quantitative description of the TTPCs. The results displayed in the RE_Tables 1 to 40 are prepared in a way that allows the direct transferring of the values into the EFORWOOD database client.

5.2.1 Process Shares

'Process share' is defined as the share of each single process in the country specific total volume of timber felled and hauled respectively, and the share of each single process in the volume of timber felled and hauled respectively per tree species

The process shares of all regarded felling and hauling processes in the total volume of timber felled and hauled respectively in Poland, Lithuania, the Czech Republic and Hungary are compiled in the following chapter 5.2.1.1, while the process shares in the volume felled and hauled respectively per tree species are compiled in chapter 5.2.1.2.

5.2.1.1 Process Share per Process in the Total Volume of Processed Timber

***RE_Table 1*:**

***Process share** of each felling and hauling process **in the total volume** of timber felled or hauled respectively in **Poland** in 2005*

Process		Process share in the total volume of timber felled and hauled in 2005 [%]	Underlying calculation
Category	**Identification Code**		
Felling	**TC**	43.20	VF_CALC 1a
	TH	-----	-----
	SC	36.90	VF_CALC 1a
	CC	18.90	VF_CALC 1b
	CH	1.00	VF_CALC 1c
	SUM	**100.00**	**-----**
Hauling	**SKI**	80.00	VF_CALC 3
	FOR	5.00	VF_CALC 3
	HOR	15.00	VF_CALC 3
	SUM	**100.00**	**-----**

***RE_Table 2*:**

***Process share** of each felling and hauling process **in the total volume** of timber felled or hauled respectively in **Lithuania** in 2005*

Process		Process share in the total volume of timber felled and hauled in 2005 [%]
Category	Identification Code	
Felling	TC	14.71
	TH	5.60
	SC	23.12
	CC	43.07
	CH	13.50
	SUM	**100.00**
Hauling	SKI	11.49
	FOR	87.54
	HOR	0.97
	SUM	**100.00**

***RE_Table 3*:**

***Process share** of each felling and hauling process **in the total volume** of timber felled or hauled respectively in the **Czech Republic** in 2005*

Process		Process share in the total volume of timber felled and hauled in 2005 [%]
Category	Identification Code	
Felling	TC	24.60
	TH	4.70
	SC	13.40
	CC	53.70
	CH	3.60
	SUM	**100.00**
Hauling	SKI	75.40
	FOR	19.60
	HOR	5
	SUM	**100.00**

***RE_Table 4*:**

***Process share** of each felling and hauling process **in the total volume** of timber felled or hauled respectively in **Hungary** in 2005*

Process		Process share in the total volume of timber felled and hauled in 2005 [%]
Category	Identification Code	
Felling	TC	35
	CC	65
	SUM	**100.00**
Hauling	SKI	81.42
	FOR	13.58
	HOR	5
	SUM	**100.00**

5.2.1.2 Process Share per Process per Tree Species

***RE_Table 5*:**

***Process share** of each felling and hauling process in the volume of timber felled or hauled respectively **per tree species** in **Poland** in 2005*

Tree Species	Process		Process shares in the volume of timber felled and hauled per tree species in 2005 [%]	Underlying calculation
	Category	Identification Code		
Spruce	Felling	TC	44.58	VF_CALC 2c
		SC	44.75	VF_CALC 2c
		CC	9.46	VF_CALC 2c
		CH	1.21	VF_CALC 2c
		SUM	**100.00**	-----
	Hauling	SKI	80.00	VF_CALC 4
		FOR	5.00	VF_CALC 4
		HOR	15.00	VF_CALC 4
		SUM	**100.00**	-----
Pine	Felling	TC	44.58	VF_CALC 2c
		SC	44.75	VF_CALC 2c
		CC	9.46	VF_CALC 2c
		CH	1.21	VF_CALC 2c
		SUM	**100.00**	-----
	Hauling	SKI	80.00	VF_CALC 4

		FOR	5.00	VF_CALC 4
		HOR	15.00	VF_CALC 4
		SUM	**100.00**	-----
Oak	**Felling**	**TC**	21.00	VF_CALC 2b
		CC	79.00	VF_CALC 2b
		SUM	**100.00**	-----
	Hauling	**SKI**	80.00	VF_CALC 4
		FOR	5.00	VF_CALC 4
		HOR	15.00	VF_CALC 4
		SUM	**100.00**	-----
Beech	**Felling**	**TC**	21.00	VF_CALC 2b
		CC	79.00	VF_CALC 2b
		SUM	**100.00**	-----
	Hauling	**SKI**	80.00	VF_CALC 4
		FOR	5.00	VF_CALC 4
		HOR	15.00	VF_CALC 4
		SUM	**100.00**	-----
Birch	**Felling**	**TC**	75.00	VF_CALC 2a
		CC	25.00	VF_CALC 2a
		SUM	**100.00**	-----
	Hauling	**SKI**	80.00	VF_CALC 4
		FOR	5.00	VF_CALC 4
		HOR	15.00	VF_CALC 4
		SUM	**100.00**	

***RE_Table 6*:**

***Process share** of each felling and hauling process in the volume of timber felled or hauled respectively **per tree species** in **Lithuania** in 2005*

Tree Species	Process		Process shares in the volume of timber felled and hauled per tree species in 2005 [%]
	Category	Identification Code	
Spruce	Felling	TC	13.00
		TH	3.00
		SC	19.00
		CC	49.00
		CH	16.00
		SUM	**100.00**
	Hauling	SKI	10.00
		FOR	89.00
		HOR	1.00
		SUM	**100.00**
Pine	Felling	TC	16.00
		TH	7.00
		SC	26.00
		CC	38.00
		CH	13.00
		SUM	**100.00**
	Hauling	SKI	12.00
		FOR	87.00
		HOR	1.00
		SUM	**100.00**
Oak	Felling	TC	3.00
		CC	97.00
		SUM	**100.00**
	Hauling	SKI	15.00
		FOR	85.00
		SUM	**100.00**

***RE_Table 7*:**

***Process share** of each felling and hauling process in the volume of timber felled or hauled respectively **per tree species** in the **Czech Republic** in 2005*

Species	Process		Process shares in the volume of timber felled and hauled per tree species in 2005 [%]
Tree Species	Category	Identification Code	
Spruce	Felling	TC	26
		TH	6
		SC	15
		CC	50
		CH	5
		SUM	100.00
	Hauling	SKI	73
		FOR	22
		HOR	5
		SUM	100.00
Pine	Felling	TC	30
		TH	2
		SC	15
		CC	53
		SUM	100.00
	Hauling	SKI	73
		FOR	22
		HOR	5
		SUM	100.00
Beech	Felling	TC	20
		CC	80
		SUM	100.00
	Hauling	SKI	95
		HOR	5
		SUM	100.00
Oak	Felling	TC	20
		CC	80
		SUM	100.00
	Hauling	SKI	95
		HOR	5
		SUM	100.00

***RE_Table 8*:**

***Process share** of each felling and hauling process in the volume of timber felled or hauled respectively **per tree species** in **Hungary** in 2005*

Species	Process		Process shares in the volume of timber felled and hauled per tree species in 2005 [%]
Tree Species	Category	Identification Code	
Oak	**Felling**	**TC**	35
		CC	65
		SUM	**100.00**
	Hauling	**SKI**	81,42
		FOR	13,58
		HOR	5
		SUM	**100.00**

5.2.2 Product Shares

'Product share' is defined as the share of each process specific product in the total volume of the output of a certain process. In chapter 5.2.2 the product shares are given in separate tables for each relevant process.

The product shares with regard to the felling and hauling processes are compiled in the RE_Tables 9-36: For Poland they are displayed in chapter 5.2.2.1 in the RE_Tables 9 to 15, for Lithuania in chapter 5.2.2.2 in the RE_Tables 16-23, for the Czech Republic in chapter 5.2.2.3 in the RE_Tables 24-31 and for Hungary in chapter 5.2.2.4 the RE_Tables 31-36.

5.2.2.1 Product Shares per Process in Poland

***RE_Table 9*:**

***Product shares** in the volume of timber felled in process **TC in Poland** in 2005*

Species	Product category	Share per product in the output volume of TC [%]	Underlying calculation
Spruce	short logs	4.4	VF_CALC 5a
	long logs	3.6	VF_CALC 5f
	harvest residues	3.7	VF_CALC 5k
Pine	short logs	27.1	VF_CALC 5b
	long logs	22.2	VF_CALC 5g
	harvest residues	23.2	VF_CALC 5l
Oak	short logs	1.0	VF_CALC 5c
	long logs	0.8	VF_CALC 5h
	harvest residues	1.1	VF_CALC 5m
Beech	short logs	1.2	VF_CALC 5d
	long logs	1.0	VF_CALC 5i
	harvest residues	1.3	VF_CALC 5n
Birch	short logs	3.3	VF_CALC 5e
	long logs	2.7	VF_CALC 5j
	harvest residues	3.4	VF_CALC 5o
	SUM	**100.0**	

***RE_Table 10*:**

***Product shares** in the volume of timber felled in process **SC in Poland** in 2005*

Species	Product category	Share per product in the output volume of SC [%]	Underlying calculation
Spruce	short logs	0.5	VF_CALC 5a
	long logs	8.8	VF_CALC 5f
	harvest residues	4.4	VF_CALC 5k
Pine	short logs	2.9	VF_CALC 5b
	long logs	55.8	VF_CALC 5g
	harvest residues	27.3	VF_CALC 5l
	SUM	**99.7**	

***RE_Table 11*:**

***Product shares** in the volume of timber felled in process **CC in Poland** in 2005*

Species	Product category	Share per product in the output volume of CC [%]	Underlying calculation
Spruce	short logs	0.6	VF_CALC 5a
	long logs	3.3	VF_CALC 5f
	harvest residues	1.8	VF_CALC 5k
Pine	short logs	3.2	VF_CALC 5b
	long logs	20.3	VF_CALC 5g
	harvest residues	10.2	VF_CALC 5l
Oak	short logs	2.4	VF_CALC 5c
	long logs	13.4	VF_CALC 5h
	harvest residues	9.0	VF_CALC 5m
Beech	short logs	2.9	VF_CALC 5d
	long logs	16.3	VF_CALC 5i
	harvest residues	9.9	VF_CALC 5n
Birch	short logs	0.7	VF_CALC 5e
	long logs	3.7	VF_CALC 5j
	harvest residues	2.3	VF_CALC 5o
	SUM	**100.0**	

***RE_Table 12*:**

***Product shares** in the volume of timber felled in process **CH in Poland** in 2005*

Species	Product category	Share per product in the output volume of CH [%]	Underlying calculation
Spruce	short logs	9.3	VF_CALC 5a
	harvest residues	4.4	VF_CALC 5k
Pine	short logs	58.7	VF_CALC 5b
	harvest residues	27.5	VF_CALC 5l
	SUM	**99.9**	

***RE_Table 13*:**

***Product shares** in the volume of timber hauled in process **SKI in Poland** in 2005*

Species	Product category	Share per product in the output volume of SKI [%]	Underlying calculation
Spruce	short logs	2.98	VF_CALC 6.5a
	long logs	8.48	VF_CALC 6.5f
	harvest residues	0.04	VF_CALC 6.5k
Pine	short logs	18.14	VF_CALC 6.5b
	long logs	53.14	VF_CALC 6.5g
	harvest residues	0.23	VF_CALC 6.5l
Oak	short logs	1.15	VF_CALC 6.5c
	long logs	4.50	VF_CALC 6.5h
Beech	short logs	1.39	VF_CALC 6.5d
	long logs	5.49	VF_CALC 6.5i
Birch	short logs	2.03	VF_CALC 6.5e
	long logs	2.91	VF_CALC 6.5j
	SUM	**100.48**	

***RE_Table 14*:**

***Product shares** in the volume of timber hauled in process **FOR in Poland** in 2005*

Species	Product category	Share per product in the output volume of FOR [%]	Underlying calculation
Spruce	short logs	11.36	VF_CALC 6.5a
	harvest residues	0.14	VF_CALC 6.5k
Pine	short logs	69.09	VF_CALC 6.5b
	harvest residues	0.84	VF_CALC 6.5l
Oak	short logs	4.39	VF_CALC 6.5c
Beech	short logs	5.29	VF_CALC 6.5d
Birch	short logs	7.72	VF_CALC 6.5e
	SUM	**98.83**	

***RE_Table 15*:**

***Product shares** in the volume of timber hauled in process **HOR in Poland** in 2005*

Species	Product category	Share per product in the output volume of HOR [%]	Underlying calculation
Spruce	short logs	2.98	VF_CALC 6.5a
	long logs	8.48	VF_CALC 6.5f
	harvest residues	0.04	VF_CALC 6.5k
Pine	short logs	18.14	VF_CALC 6.5b
	long logs	53.14	VF_CALC 6.5g
	harvest residues	0.23	VF_CALC 6.5l
Oak	short logs	1.15	VF_CALC 6.5c
	long logs	4.50	VF_CALC 6.5h
Beech	short logs	1.39	VF_CALC 6.5d
	long logs	5.49	VF_CALC 6.5i
Birch	short logs	2.03	VF_CALC 6.5e
	long logs	2.91	VF_CALC 6.5j
	SUM	**100.48**	

5.2.2.2 Product Shares per Process in Lithuania

***RE_Table 16*:**

***Product shares** in the volume of timber felled in process **TC in Lithuania** in 2005*

Species	Product category	Share per product in the output volume of TC [%]
Spruce	short logs	17.5
	long logs	0.4
	harvest residues	8.4
Pine	short logs	49.1
	long logs	0.5
	harvest residues	23.3
Oak	short logs	0.4
	harvest residues	0.2
	SUM	**99.8**

***RE_Table 17*:**

***Product shares** in the volume of timber felled in process **TH in Lithuania** in 2005*

Species	Product category	Share per product in the output volume of TH [%]
Spruce	short logs	10.8
	harvest residues	5.1
Pine	short logs	57.0
	harvest residues	26.8
	SUM	**99.7**

***RE_Table 18*:**

***Product shares** in the volume of timber felled in process **SC in Lithuania** in 2005*

Species	Product category	Share per product in the output volume of SC [%]
Spruce	short logs	16.6
	harvest residues	7.8
Pine	short logs	51.3
	harvest residues	24.1
	SUM	**99.8**

***RE_Table 19*:**

***Product shares** in the volume of timber felled in process **CC in Lithuania** in 2005*

Species	Product category	Share per product in the output volume of CC [%]
Spruce	short logs	22.6
	long logs	0.5
	harvest residues	10.8
Pine	short logs	39.4
	long logs	0.8
	harvest residues	18.9
Oak	short logs	4.7
	harvest residues	2.7
	SUM	**100.4**

***RE_Table 20*:**

Product shares** in the volume of timber felled in process **CH in Lithuania

in 2005

Species	Product category	Share per product in the output volume of CH [%]
Spruce	short logs	24.0
	harvest residues	11.3
Pine	short logs	43.9
	harvest residues	20.7
	SUM	**99.9**

***RE_Table 21*:**

Product shares** in the volume of timber hauled in process **SKI in Lithuania

in 2005

Species	Product category	Share per product in the output volume of SKI [%]
Spruce	short logs	22.6
	long logs	3.2
	harvest residues	0.3
Pine	short logs	64.7
	long logs	4.9
	harvest residues	0.6
Oak	short logs	3.9
	SUM	**100.2**

***RE_Table 22*:**

***Product shares** in the volume of timber hauled in process **<u>FOR in Lithuania</u>** in 2005*

Species	Product category	Share per product in the output volume of FOR [%]
Spruce	short logs	30.1
	harvest residues	0.3
Pine	short logs	66.2
	harvest residues	0.6
Oak	short logs	2.9
	SUM	**100.1**

***RE_Table 23*:**

***Product shares** in the volume of timber hauled in process **<u>HOR in Lithuania</u>** in 2005*

Species	Product category	Share per product in the output volume of HOR [%]
Spruce	short logs	26.8
	long logs	3.8
	harvest residues	0.3
Pine	short logs	63.9
	long logs	4.8
	harvest residues	0.6
	SUM	**100.2**

5.2.2.3 Product Shares per Process in the Czech Republic

***RE_Table 24*:**

***Product shares** in the volume of timber felled in process **TC in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of TC [%]
Spruce	short logs	23.72
	long logs	23.72
	harvest residues	22.32
Pine	short logs	7.02
	long logs	7.02
	harvest residues	6.61
Beech	short logs	0.53
	long logs	3.02
	harvest residues	2.03
Oak	short logs	0.30
	long logs	1.74
	harvest residues	1.17
	SUM	**99.2**

***RE_Table 25*:**

***Product shares** in the volume of timber felled in process **TH in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of TH [%]
Spruce	short logs	62.60
	harvest residues	29.44
Pine	short logs	4.94
	harvest residues	2.32
	SUM	**99.3**

***RE_Table 26*:**

***Product shares** in the volume of timber felled in process **SC in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of SC [%]
Spruce	short logs	16.25
	long logs	38.19
	harvest residues	25.68
Pine	short logs	3.89
	long logs	9.05
	harvest residues	6.08
	SUM	**99.14**

***RE_Table 27*:**

***Product shares** in the volume of timber felled in process **CC in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of CC [%]
Spruce	short logs	2.26
	long logs	42.92
	harvest residues	21.26
Pine	short logs	0.57
	long logs	10.78
	harvest residues	5.34
Beech	short logs	2.60
	long logs	3.90
	harvest residues	3.72
Oak	short logs	1.50
	long logs	2.25
	harvest residues	2.15
	SUM	**99.25**

***RE_Table 28*:**

***Product shares** in the volume of timber felled in process **CH in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of CH [%]
Spruce	short logs	67.49
	harvest residues	31.76
	SUM	**99.25**

***RE_Table 29*:**

***Product shares** in the volume of timber felled in process **SKI in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of SKI [%]
Spruce	short logs	7.36
	long logs	62.24
	harvest residues	0.15
Pine	short logs	0.54
	long logs	15.98
	harvest residues	0.06
Beech	short logs	2.84
	long logs	5.27
Oak	short logs	1.64
	long logs	3.05
	SUM	**99.13**

***RE_Table 30*:**

***Product shares** in the volume of timber felled in process **FOR in the Czech Republic** in 2005*

Species	Product category	Share per product in the output volume of FOR [%]
Spruce	short logs	79.20
	harvest residues	1.62
Pine	short logs	18.68
	harvest residues	2.37
Beech	short logs	0
Oak	short logs	0
	SUM	**101.87**

***RE_Table 31*:**

***Product shares** in the volume of timber felled in process **HOR in the Czech Republic** in 2005*

Species	Product Category	Share per product in the output volume of HOR [%]
Spruce	short logs	7.60
	long logs	64.28
	harvest residues	0.15
Pine	short logs	0.56
	long logs	16.50
	harvest residues	0.07
Beech	short logs	2.25
	long logs	4.19
Oak	short logs	1.30
	long logs	2.42
	SUM	**99.32**

5.2.2.4 PRODUCT SHARES PER PROCESS IN HUNGARY

RE_Table 32:

***Product shares** in the volume of timber felled in process **TC in Hungary** in 2005*

Species	Product category	Share per product in the output volume of TC [%]
Oak	short logs	100
	long logs	0
	harvest residues	0
	SUM	**100**

RE_Table 33:

***Product shares** in the volume of timber felled in process **CC in Hungary** in 2005*

Species	Product category	Share per product in the output volume of CC [%]
Oak	short logs	100
	long logs	0
	harvest residues	0
	SUM	**100**

RE_Table 34:

***Product shares** in the volume of timber felled in process **SKI in Hungary** in 2005*

Species	Product category	Share per product in the output volume of SKI [%]
Oak	short logs	100
	SUM	**100**

***RE_Table 35*:**

***Product shares** in the volume of timber felled in process **FOR in Hungary** in 2005*

Species	Product category	Share per product in the output volume of FOR [%]
Oak	short logs	100
	SUM	**100**

***RE_Table 36*:**

***Product shares** in the volume of timber felled in process **HOR in Hungary** in 2005*

Species	Product category	Share per product in the output volume of HOR [%]
Oak	short logs	100
	SUM	**100**

5.2.3 Split Ratios

'Split ratio' is defined as the ratio according to which a certain output product of the felling processes is hauled in different hauling processes or left unutilised in the forest stands.

5.2.3.1 The Split Ratios of the Polish TTPC

All split ratios, which are relevant for the Polish TTPC are compiled in the following RE_Table 37:

***RE_Table 37*:**
Split ratios of felling output products into hauling by the different hauling processes

Species	Product category	Proportion of hauling in SKI [%]	Proportion of hauling in FOR [%]	Proportion of hauling in HOR [%]	Proportion of being left in forest stand [%]	SUM	Underlying calculation
Spruce	short logs	70.15	16.7	13.15	0	100	VF_CALC 7a
	long logs	84.21	0	15.79	0	100	VF_CALC 7a
	harvest residues	0.54	0.13	0.1	99.23	100	VF_CALC 7b
Pine	short logs	70.15	16.7	13.15	0	100	VF_CALC 7a
	long logs	84.21	0	15.79	0	100	VF_CALC 7a
	harvest residues	0.54	0.13	0.1	99.23	100	VF_CALC 7c
Oak	short logs	70.15	16.7	13.15	0	100	VF_CALC 7a
	harvest residues	0	0	0	100	100	VF_CALC 7d
Beech	short logs	70.15	16.7	13.15	0	100	VF_CALC 7a
	harvest residues	0	0	0	100	100	VF_CALC 7d
Birch	short logs	70.15	16.7	13.15	0	100	VF_CALC 7a
	harvest residues	0	0	0	100	100	VF_CALC 7d

5.2.3.2 The Split Ratios of the Lithuanian TTPC

All split ratios, which are relevant for the Lithuanian TTPC are compiled in the following RE_Table 38:

***RE_Table 38*:**

Split ratios of felling output products into hauling by the different hauling processes in the Lithuanian TTPC

Species	Product category	Proportion of hauling in SKI [%]	Proportion of hauling in FOR [%]	Proportion of hauling in HOR [%]	Proportion of being left in forest stand [%]	SUM
Spruce	short logs	8.9	90.21	0.89	0	100
	long logs	90.91	0	9.09	0	100
	harvest residues	0.2	2.1	0.02	97.67	100
Pine	short logs	11.26	87.8	0.94	0	100
	long logs	92.31	0	7.69	0	100
	harvest residues	0.2	1.6	0.02	98.18	100
Oak	short logs	15	85	0	0	100
	harvest residues	0	0	0	100	100

5.2.3.3 The Split Ratios of the Czech TTPC

All split ratios, which are relevant for the Czech TTPC are compiled in the following RE_Table 39:

RE_Table 39:
Split ratios of felling output products into hauling by the different hauling processes in the Czech TTPC

Species	Product category	Proportion of hauling in SKI [%]	Proportion of hauling in FOR [%]	Proportion of hauling in HOR [%]	Proportion of being left in forest stand [%]	SUM
Spruce	short logs	25.87	72.36	1.77	0	100
	long logs	93.59	0	6.41	0	100
	harvest residues	0.34	0.94	0.02	98.70	100
Pine	short logs	9.93	89.40	0.67	0	100
	long logs	93.59	0	6.41	0	100
	harvest residues	0.13	1.16	0.01	98.70	100
Beech	short logs	95	0	5	0	100
	harvest residues	0	0	0	100	100
Oak	short logs	95	0	5	0	100
	harvest residues	0	0	0	100	100

5.2.3.4 THE SPLIT RATIOS OF THE HUNGARIAN TTPC

All split ratios, which are relevant for the Hungarian TTPC are compiled in the following RE_Table 40:

***RE_Table 40*:**
Split ratios of felling output products into hauling by the different hauling processes in the Hungarian TTPC

Species	Product category	Proportion of hauling in SKI [%]	Proportion of hauling in FOR [%]	Proportion of hauling in HOR [%]	Proportion of being left in forest stand [%]	SUM
Oak	short logs	81.42	13.58	5	0	100
	harvest residues	0	0	0	100	100

5.3 Results of the Indicator Value Calculation

In this chapter all values of the selected SI as calculated in chapter 4.3 are compiled in indicator specific plain tables. By contrast to the volume flow values of Poland, Lithuania, the Czech Republic and Hungary, the indicator values of the Polish TTPC processes are displayed next to the corresponding indicator values of the Lithuanian, Czech and Hungarian TTPC processes; this allows for the direct comparison of the processes between these countries. Furthermore, the mode of displaying the resulting indicator values in tables and not e.g. in charts allows the direct transfer of the values into the data bases of EFORWOOD.

Besides the values of indicator 11.2.1 ('average wages and salaries relative to country average') all indicator values are given in relative terms, i.e. per m^3_{ub} of the output volume of the processes, according to the determination in EFORWOOD (2008d).

5.3.1 Country and Process Specific GVA at Factor Cost (Indicator 1.1)

***RE_Table 41*:**

Country and process specific values of indicator 1.1:

GVA at factor cost

Process (Identification Code)	**GVA at factor cost (Indicator 1.1)**				
	PL		**LT**	**CZ**	**HU**
	Indicator value in €/m³ub	**Underlying calculation**	**Indicator value in €/m³ub**	**Indicator value in €/m³ub**	**Indicator value in €/m³ub**
TC	-30.615	IN_CALC 3	-25.035	-50.560	-34.380
TH	-----	-----	-26.280	-52.422	-----
SC	-29.761	IN_CALC 3	-24.223	-49.798	-----
CC	-29.761	IN_CALC 3	-24.131	-49.544	-33.353
CH	-30.608	IN_CALC 3	-24.741	-50.272	-----
SKI	34.291	IN_CALC 3	29.471	59.735	45.124
FOR	33.230	IN_CALC 3	27.156	58.876	43.912
HOR	36.645	IN_CALC 3	30.016	62.633	48.429

5.3.2 Country and Process Specific Production Costs

5.3.2.1 Country and Process Specific Costs of Raw Material from the FWC (Indicator 2.1.1)

***RE_Table 42*:**

Country and process specific values of indicator 2.1.1:

Production costs: raw material from the FWC

Process (Identification Code)	Production Costs: Raw Material from the FWC (Indicator 2.1.1)				
	PL		LT	CZ	HU
	Indicator value in €/m^3_{ub}	Underlying calculation	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}
TC	28.983	IN_CALC 4	23.482	48.627	32.365
TH	-----	-----	23.482	48.627	-----
SC	28.983	IN_CALC 4	23.482	48.627	-----
CC	28.983	IN_CALC 4	23.482	48.627	32.365
CH	28.983	IN_CALC 4	23.482	48.627	-----
SKI	not applicable	IN_CALC 4	not applicable	not applicable	not applicable
FOR	not applicable	IN_CALC 4	not applicable	not applicable	not applicable
HOR	not applicable	IN_CALC 4	not applicable	not applicable	not applicable

5.3.2.2 Country and Process Specific Costs of Raw Material from Outside of the FWC (Indicator 2.1.2)

As described in chapter 4.3.3 indicator 2.1.2 is not applicable with regard to felling and hauling processes; therefore, no values are provided for this indicator.

5.3.2.3 Country and Process Specific Labour Costs (Indicator 2.1.3)

***RE_Table 43*:**

Country and process specific values of indicator 2.1.3:

Production costs: labour

Process (Identification Code)	Production Costs: Labour (Indicator 2.1.3)				
	PL		LT	CZ	HU
	Indicator value in €/m³ub	Underlying calculation	Indicator value in €/m³ub	Indicator value in €/m³ub	Indicator value in €/m³ub
TC	5.333	IN_CALC 5	4.693	11.370	12.425
TH	-----	-----	0.552	1.339	-----
SC	2.650	IN_CALC 5	2.322	6.756	-----
CC	2.530	IN_CALC 5	1.988	5.297	5.988
CH	0.303	IN_CALC 5	0.248	0.580	-----
SKI	0.557	IN_CALC 5	0.469	1.311	1.431
FOR	0.770	IN_CALC 5	0.663	1.651	1.882
HOR	1.275	IN_CALC 5	1.138	2.429	2.569

5.3.2.4 Country and Process Specific Energy Costs (Indicator 2.1.4)

***RE_Table 44*:**

Country and process specific values of indicator 2.1.4:

Production costs: energy

Process (Identification Code)	Production Costs: Energy (Indicator 2.1.4)				
	PL		LT	CZ	HU
	Indicator value in €/m³$_{ub}$	Underlying calculation	Indicator value in €/m³$_{ub}$	Indicator value in €/m³$_{ub}$	Indicator value in €/m³$_{ub}$
TC	0.621	IN_CALC 6	0.502	0.656	0.759
TH	-----	-----	1.520	1.881	-----
SC	0.311	IN_CALC 6	0.251	0.390	-----
CC	0.297	IN_CALC 6	0.211	0.305	0.365
CH	0.832	IN_CALC 6	0.684	0.818	-----
SKI	1.060	IN_CALC 6	0.899	1.260	1.497
FOR	1.833	IN_CALC 6	1.549	1.940	2.412
HOR	0.106	IN_CALC 6	0.088	0.106	0.109

5.3.2.5 Country and Process Specific Other Productive Costs (Indicator 2.1.5)

***RE_Table 45*:**

Country and process specific values of indicator 2.1.5:

Production costs: other

Process (Identification Code)	**Production Costs: Other (Indicator 2.1.5)**				
	PL		**LT**	**CZ**	**HU**
	Indicator value in €/m^3_{ub}	**Underlying calculation**	**Indicator value in €/m^3_{ub}**	**Indicator value in €/m^3_{ub}**	**Indicator value in €/m^3_{ub}**
TC	0.573	IN_CALC 7	0.679	0.734	0.684
TH	-----	-----	0.162	0.323	-----
SC	0.286	IN_CALC 7	0.334	0.436	-----
CC	0.273	IN_CALC 7	0.282	0.341	0.329
CH	0.143	IN_CALC 7	0.073	0.140	-----
SKI	0.214	IN_CALC 7	0.192	0.254	0.273
FOR	0.213	IN_CALC 7	0.180	0.226	0.251
HOR	0	IN_CALC 7	0	0	0

5.3.2.6 Country and Process Specific Other Productive Costs (Indicator 2.1.6)

RE_Table 46:

Country and process specific values of indicator 2.1.6:

Production costs: non-productive

Process (Identification Code)	Production Costs: Non-Productive (Indicator 2.1.6)				
	PL		LT	CZ	HU
	Indicator value in €/m^3_{ub}	Underlying calculation	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}
TC	0.438	IN_CALC 8	0.372	0.541	0.570
TH	-----	-----	1.116	1.590	-----
SC	0.218	IN_CALC 8	0.156	0.343	-----
CC	0.208	IN_CALC 8	0.156	0.269	0.293
CH	0.650	IN_CALC 8	0.502	0.686	-----
SKI	1.209	IN_CALC 8	1.034	1.509	1.664
FOR	1.498	IN_CALC 8	1.235	1.716	1.984
HOR	0.023	IN_CALC 8	0.016	0.020	0.021

5.3.3 Country and Process Specific Number of Persons Employed (Indicator 10.1)

RE_Table 47:

Country and process specific values of indicator 10.1:

Number of persons employed

Process (Identification Code)	Number of Persons Employed (Indicator 10.1)				
	PL		LT	CZ	HU
	Indicator value in #/m^3_{ub}	Underlying calculation	Indicator value in #/m^3_{ub}	Indicator value in #/m^3_{ub}	Indicator value in #/m^3_{ub}
TC	$6{,}9233*10^{-4}$	IN_CALC 9	$7{,}20395*10^{-4}$	$6{,}98081*10^{-4}$	$8{,}8579*10^{-4}$
TH	-----	-----	$6{,}82677*10^{-5}$	$6{,}27661*10^{-5}$	-----
SC	$3{,}4244*10^{-4}$	IN_CALC 9	$3{,}56409*10^{-4}$	$4{,}14802*10^{-4}$	-----
CC	$3{,}2497*10^{-4}$	IN_CALC 9	$3{,}05032*10^{-4}$	$3{,}25243*10^{-4}$	$4{,}2689*10^{-4}$
CH	$3{,}1476*10^{-5}$	IN_CALC 9	$3{,}06696*10^{-5}$	$2{,}72066*10^{-5}$	-----
SKI	$5{,}7486*10^{-5}$	IN_CALC 9	$5{,}80766*10^{-5}$	$6{,}06553*10^{-5}$	$8{,}2018*10^{-5}$
FOR	$8{,}1658*10^{-5}$	IN_CALC 9	$8{,}19817*10^{-5}$	$7{,}70694*10^{-5}$	
HOR	$1{,}6415*10^{-4}$	IN_CALC 9	$1{,}74551*10^{-4}$	$1{,}47533*10^{-4}$	$1{,}8264*10^{-4}$

5.3.4 Country and Process Specific Wages and Salaries (Gross Earnings)

5.3.4.1 Country and Process Specific Average Wages and Salaries (Indicator 11.1)

***RE_Table 48*:**

Country and process specific values of indicator 11.1:

Average wages and salaries

Process (Identification Code)	Average Wages and Salaries (Indicator 11.1)				
	PL		LT	CZ	HU
	Indicator value in €/m^3_{ub}	Underlying calculation	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}
TC	3.973	IN_CALC 10	3.412	7.029	8.598
TH	-----	-----	0.401	0.828	-----
SC	1.974	IN_CALC 10	1.688	4.176	-----
CC	1.885	IN_CALC 10	1.445	3.274	4.143
CH	0.226	IN_CALC 10	0.180	0.359	-----
SKI	0.415	IN_CALC 10	0.341	0.810	0.990
FOR	0.574	IN_CALC 10	0.482	1.021	1.302
HOR	0.950	IN_CALC 10	0.827	1.501	1.777

5.3.4.2 Country and Process Specific Average Wages and Salaries Relative to the Average Country Wage (Indicator 11.2.1)

***RE_Table 49*:**

Country and process specific values of indicator 11.2.1:

Average wages and salaries relative to country average

Process (Identification Code)	Average Wages and Salaries Relative to Country Average (Indicator 11.2.1)				
	PL		LT	CZ	HU
	%	Underlying calculation	%	%	%
TC	52.12	IN_CALC 11	86.50	80.9	97.1
TH	-----	-----	107.32	106.1	-----
SC	52.12	IN_CALC 11	86.50	80.9	-----
CC	52.12	IN_CALC 11	86.50	80.9	97.1
CH	64.67	IN_CALC 11	107.32	106.1	-----
SKI	64.67	IN_CALC 11	107.32	106.1	120.5
FOR	64.67	IN_CALC 11	107.32	106.1	120.5
HOR	52.12	IN_CALC 11	86.50	80.9	97.1

5.3.4.3 Country and Process Specific Average Wages and Salaries Weighted by the Purchasing Power Parity (Indicator 11.2.2)

RE_Table 50:

Country and process specific values of indicator 11.2.2:

Average wages and salaries weighted by the purchasing power parity

Process (Identification Code)	Average Wages and Salaries Weighted by the Purchasing Power Parity (Indicator 11.2.2)				
	PL		LT	CZ	HU
	Indicator value in €/m^3_{ub}	Underlying calculation	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}	Indicator value in €/m^3_{ub}
TC	7.219	IN_CALC 12	7.078	12.246	13.892
TH	-----	-----	0.832	1.443	-----
SC	3.587	IN_CALC 12	3.502	7.276	-----
CC	3.425	IN_CALC 12	2.998	5.705	6.694
CH	0.411	IN_CALC 12	0.373	0.625	-----
SKI	0.754	IN_CALC 12	0.707	1.412	1.600
FOR	1.043	IN_CALC 12	1.000	1.778	2.104
HOR	1.726	IN_CALC 12	1.716	2.616	2.872

5.3.5 Country and Process Specific Fuel Use

5.3.5.1 Country and Process Specific Use of Renewable Fuel (Indicator 18.2.2.1)

***RE_Table 51*:**

Country and process specific values of indicator 18.2.2.1:

Use of renewable fuel

Process (Identification Code)	Use of Renewable Fuel (Indicator 18.2.2.1)				
	PL		LT	CZ	HU
	Indicator value in kWh/m^3_{ub}	Underlying calculation	Indicator value in kWh/m^3_{ub}	Indicator value in kWh/m^3_{ub}	Indicator value in kWh/m^3_{ub}
TC	0	IN_CALC 13	0	0	0
TH	-----	-----	0	0	-----
SC	0	IN_CALC 13	0	0	-----
CC	0	IN_CALC 13	0	0	0
CH	0	IN_CALC 13	0	0	-----
SKI	0	IN_CALC 13	0	0	0
FOR	0	IN_CALC 13	0	0	0
HOR	2.588	IN_CALC 13	2.606	2.596	2.659

5.3.5.2 Country and Process Specific Use of Fossil Fuel (Indicator 18.2.2.2)

***RE_Table 52*:**

Country and process specific values of indicator 18.2.2.2:

Use of fossil fuel

Process (Identification Code)	Use of Fossil Fuel (Indicator 18.2.2.2)				
	PL		LT	CZ	HU
	Indicator value in kWh/m³ub	Underlying calculation	Indicator value in kWh/m³ub	Indicator value in kWh/m³ub	Indicator value in kWh/m³ub
TC	7.913	IN_CALC 14	7.745	8.878	9.1
TH	-----	-----	25.842	28.108	-----
SC	3.914	IN_CALC 14	3.832	5.275	-----
CC	3.714	IN_CALC 14	3.279	4.136	4.385
CH	12.666	IN_CALC 14	11.610	12.183	-----
SKI	16.025	IN_CALC 14	15.228	18.849	20.550
FOR	27.815	IN_CALC 14	26.267	29.005	33.022
HOR	not applicable	IN_CALC 14	not applicable	not applicable	not applicable

5.3.6 Country and Process Specific Greenhouse Gas Emissions

5.3.6.1 Country and Process Specific Total Greenhouse Gas Emissions (Indicator 19.1)

As indicator 19.1.2 (‘Greenhouse gas emissions (GHG) from wood combustion’) has been decided not to be applicable within the TTPC (see chapter 4.3.14), indicator 19.1, which is the sum of indicator 19.1.1 (‘GHG emissions from machinery’) and indicator 19.1.2, is in its values identical to the values of indicator 19.1.1. Therefore, no separate result table is presented here. For the process specific values of indicator 19.1 see RE_Table 53 in chapter 5.3.6.2.

5.3.6.2 Country and Process Specific Greenhouse Gas Emissions from Machinery (Indicator 19.1.1)

***RE_Table 53*:**

Country and process specific values of indicator 19.1.1, which are identical to the country and process specific values of indicator 19.1:

GHG emissions from machinery = Total GHG emissions

Process (Identification Code)	GHG Emissions from Machinery = Total GHG Emissions (Indicator 19.1.1 = Indicator 19.1)				
	PL		LT	CZ	HU
	Indicator value kg CO_2e/m^3_{ub}	Underlying calculation	Indicator value kg CO_2e/m^3_{ub}	Indicator value kg CO_2e/m^3_{ub}	Indicator value kg CO_2e/m^3_{ub}
TC	2.433	IN_CALC 15	2.381	2.730	2.799
TH	-----	-----	7.946	7.850	-----
SC	1.203	IN_CALC 15	1.178	1.622	-----
CC	1.142	IN_CALC 15	1.008	1.155	1.349
CH	3.537	IN_CALC 15	3.570	3.402	-----
SKI	4.475	IN_CALC 15	4.682	5.264	5.739
FOR	7.768	IN_CALC 15	8.076	8.100	9.222
HOR	0.239	IN_CALC 15	0.241	0.240	0.247

5.3.6.3 Country and Process Specific Greenhouse Gas Emissions from Wood Combustion (Indicator 19.1.2)

As explained in chapter 4.3.14 indicator 19.1.2 is assumed not to be applicable within the TTPC.

5.3.7 Country and Process Specific Generation and Management of Waste

5.3.7.1 Country and Process Specific Generation of Non-Hazardous Waste (Indicator 27.1.1)

***RE_Table 54*:**

Country and process specific values of indicator 27.1.1:

Generation of non-hazardous waste

Process (Identification Code)	Generation of Non-Hazardous Waste (Indicator 27.1.1)				
	PL		LT	CZ	HU
	Indicator value kg/m^3_{ub}	Underlying calculation	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}
TC	0.0201	IN_CALC 16	0.0206	0.0271	0.0272
TH	-----	-----	0.0150	0.0163	-----
SC	0.0099	IN_CALC 16	0.0102	0.0161	-----
CC	0.0094	IN_CALC 16	0.0087	0.0126	0.0131
CH	0.0073	IN_CALC 16	0.0080	0.0070	-----
SKI	0.0449	IN_CALC 16	0.0426	0.0527	0.0575
FOR	0.0257	IN_CALC 16	0.0242	0.0267	0.0304
HOR	0.0051	IN_CALC 16	0.0052	0.0051	0.0053

5.3.7.2 Country and Process Specific Generation of Hazardous Waste (Indicator 27.1.2)

RE_Table 55:

Country and process specific values of indicator 27.1.2:

Generation of hazardous waste

Process (Identification Code)	Generation of Hazardous Waste (Indicator 27.1.2)				
	PL		LT	CZ	HU
	Indicator value kg/m^3_{ub}	Underlying calculation	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}
TC	0.0025	IN_CALC 17	0.0025	0.0033	0.0033
TH	-----	-----	0.0732	0.0796	-----
SC	0.0012	IN_CALC 17	0.0013	0.0019	-----
CC	0.0012	IN_CALC 17	0.0011	0.0015	0.0016
CH	0.0359	IN_CALC 17	0.0390	0.0345	-----
SKI	0.0398	IN_CALC 17	0.0378	0.0468	0.0509
FOR	0.0599	IN_CALC 17	0.0565	0.0624	0.0710
HOR	0	IN_CALC 17	0	0	0

5.3.7.3 Country and Process Specific Quantity of Reused or Recycled Waste (Indicator 27.2.1)

RE_Table 56:

Country and process specific values of indicator 27.2.1:

Waste management: recycling or reuse

Process (Identification Code)	Waste Management: Recycling or Reuse (Indicator 27.2.1)				
	PL		LT	CZ	HU
	Indicator value kg/m³ub	Underlying calculation	Indicator value kg/m³ub	Indicator value kg/m³ub	Indicator value kg/m³ub
TC	0.0157	IN_CALC 18	0.0161	0.0002	0.0002
TH	-----	-----	0.0350	0.0240	-----
SC	0.0077	IN_CALC 18	0.0080	0.0001	-----
CC	0.0074	IN_CALC 18	0.0068	0.0001	0.0001
CH	0.0171	IN_CALC 18	0.0186	0.0104	-----
SKI	0.0336	IN_CALC 18	0.0319	0.0250	0.0250
FOR	0.0682	IN_CALC 18	0.0320	0.0224	0.0224
HOR	0.0044	IN_CALC 18	0.0044	0.0051	0.0051

5.3.7.4 COUNTRY AND PROCESS SPECIFIC QUANTITY OF INCINERATED WASTE (INDICATOR 27.2.2)

RE_Table 57:

Country and process specific values of indicator 27.2.2:

Waste management: incineration

Process (Identification Code)	Waste Management: Incineration (Indicator 27.2.2)				
	PL		LT	CZ	HU
	Indicator value kg/m^3_{ub}	Underlying calculation	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}
TC	$1.41*10^{-5}$	IN_CALC 19	0	0.0033	0.0029
TH	-----	-----	0	0.0080	-----
SC	$0.69*10^{-5}$	IN_CALC 19	0	0.0020	-----
CC	$0.66*10^{-5}$	IN_CALC 19	0	0.0015	0.0014
CH	$5.34*10^{-5}$	IN_CALC 19	0	0.0034	-----
SKI	$10.47*10^{-5}$	IN_CALC 19	0	0.0083	0.0081
FOR	$10.59*10^{-5}$	IN_CALC 19	0	0.0074	0.0076
HOR	$0.15*10^{-5}$	IN_CALC 19	0	$5.42*10^{-6}$	$2.05*10^{-5}$

5.3.7.5 Country and Process Specific Quantity of Waste Disposed to Landfill (Indicator 27.2.3)

RE_Table 58:

Country and process specific values of indicator 27.2.3:

Waste management: waste to landfill

Process (Identification Code)	Waste Management: Waste to Landfill (Indicator 27.2.3)				
	PL		LT	CZ	HU
	Indicator value kg/m^3_{ub}	Underlying calculation	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}	Indicator value kg/m^3_{ub}
TC	0.0069	IN_CALC 20	0.0070	0.0302	0.0303
TH	-----	-----	0.0532	0.0718	-----
SC	0.0034	IN_CALC 20	0.0035	0.1796	-----
CC	0.0032	IN_CALC 20	0.0030	0.0140	0.0146
CH	0.0260	IN_CALC 20	0.0284	0.0311	-----
SKI	0.0511	IN_CALC 20	0.0485	0.0745	0.0834
FOR	0.0174	IN_CALC 20	0.0487	0.0668	0.0790
HOR	0.0007	IN_CALC 20	0.0008	0.00004	0.0002

6 DISCUSSION

The discussion of this study is presented in five sections: In chapter 6.1 certain issues concerning methods and materials are discussed, amongst others through evaluating assumptions and basic input data. Chapter 6.2 outlines practical implications of the study. In the subsequent chapter 6.3 limitations of the study are discussed. Finally, in chapter 6.4 suggestions on further research are made on the basis of experiences that have been made when conducting this study.

6.1 Methods and Material

A) General remarks on data availability and on the corresponding quality of results

Two different types of data sets have been collected for the TTPC for Poland. The first data set has been required for the calculation of the representative timber volume flows which include the process shares, the product shares and the spit ratios of the respective countries.
All values which have been calculated for the volume flows are based on input data given through an EFISCEN simulation on the felling volume per tree species. All other required input data for the calculation of the process shares, product shares and the split ratios of the timber volume flows had to be exclusively collected through expert guesses and assumptions, due to a distinct lack of data in the respective countries.
The second data set has been required for the calculation of the values of a selected set of sustainability indicators (SI) (see chapter 4.1.7) of the respective country. These SI value calculations are based on input data provided through national forestry statistics, international statistics, expert guesses and assumptions.
All expert guesses are clearly defined in their origin and all assumptions are made traceable within this study. However, there has been no possibility within the study to quantify all of the expert guesses and assumptions. This is due to missing data for comparison. If no data has been available at all, assumptions had to be made for a further proceeding of the study. The study has been conducted in this way to overcome the lack of data in the respective countries and therefore to avoid a failure of the study.

Except for the assumptions on the ratio of short logs volume and long logs volume (see section B) and for the assumptions with regard to parameters that are related to the number FTEE (see section C), it has not been possible to perform a cross-check as no corresponding data have been available.

B) Evaluation of the extensive assumptions on the volume ratio of short logs versus long logs in Poland

In chapter 4.2.3.1, section B(2), assumptions are made on the proportion of short logs and of long logs in the volume of timber excl. HR, felled in Poland per felling process in 2005.

These proportions represent input data for the calculation of the process specific product shares of short logs and long logs in VF_CALC 5 and VF_CALC 6. The assumptions are necessary as no corresponding data are available from forestry statistics.
However, JODLOWSKI (2007: 6) states that 30% of the timber excl. HR, which was felled in Poland in 2005, was sorted as short logs. This value makes it possible to evaluate the extensive assumptions.

To perform this evaluation, the volumes of short logs, which accrued per tree species according to EFISCEN data as given in Table 4.2-4, are summed up first. Secondly, the proportion of this total volume of short logs in the total volume of timber felled in Poland in 2005 according to EFISCEN data is calculated. Then, this proportion is compared to the value of 30% as given by JODLOWSKI (2007: 6).
If this calculated proportion does not differ significantly from 30%, it can be regarded as given that the assumptions made in chapter 4.2.3.1, section B(2), do correspond to the conditions in the Polish forestry – at least in terms of the entirety of all assumed process specific ratios of short logs and long logs.

When actually performing this evaluation, it turns out that the calculated proportion of short logs in the total volume of felled timber is 29.83%, which does not differ significantly from 30% as given by JODLOWSKI (2007: 6).

Therefore, it is regarded as given, that the assumptions made in chapter 4.2-5, section B(2), are quite reasonable – at least in terms of the entirety of all assumed process specific ratios of short logs and long logs.

C) Combined evaluation of assumptions with regard to several parameters related to the number of employed persons (Polish TTPC)

According to PASCHALIS-JAKUBOWICZ (2004: 7), 95% of all felling and hauling processes in Poland are conducted by private companies, which employed 22635 full-time equivalent employees (FTEE) in 2005 (CENTRAL STATISTICAL OFFICE, 2006: 20).

According to calculations within this study, the total number of FTEE (of the public and of the private sector), as calculated by summarising the process specific absolute total number of FTEE in Poland (displayed in table 4.3-9), is 23260.02.

These values can be used for evaluating several calculation results and assumptions within this study:

The calculated process specific total absolute numbers of FTEE (as given table 4.3-9) are assumed to meet the real conditions in the Polish TTPC, if the proportion of 22635 FTEE (as given by the CENTRAL STATISTICAL OFFICE (2006: 20)) in the calculated total number of FTEE (23260.02) does not differ significantly from 95%. In this case it is further regarded as given that all underlying assumptions on the process specific productivity, on the annual number of working hours and on the process and species specific felling and hauling volumes are reasonable.

When performing this evaluation, it turns out that the proportion of 22635 FTEE in the calculated total number of FTEE (23260.02) is 97.3%; the discrepancy of this value to 95% is regarded as insignificant. Therefore, it is regarded as given that the results and therefore also the modes of the calculations of the process specific numbers of FTEE are realistic. Furthermore, it is regarded as given that all underlying assumptions on the process specific productivity, on the annual number of working hours and on the process and species specific felling and hauling volumes are realistic.

D) <u>Remarks on productivity values</u>

As displayed in table 4.3-5 the calculated values of the ‘Weighted Mean Productivity’ of forwarding (FOR) are only 70% of the corresponding values of skidding (SKI). This is contradictory to the data provided by FOBAWI (2002: 17 – 19) for Germany; according to FOBAWI (2002: 17 – 19), the productivity of forwarding is at least as high as the one of skidding.

The reason for the relatively low values of forwarding is a definition of forwarding and skidding in East European countries, which is differs from the definition that is used in Germany:

According to E_2, ‘forwarding’ in East European countries comprises not only the use of special, purpose built forwarders, but all hauling methods, in which the hauled timber does not touch the ground during the process of hauling; this applies to forwarders but also to forwarding trailers in combination with agricultural tractors with relatively low productivity. Furthermore, it is indicated in the Polish 'Catalogue of Norm Times' (THE POLISH STATE FORESTS NATIONAL FOREST HOLDING, 2008) that 'forwarding' comprises processes in which the timber that is to be hauled is manually loaded on a trailer and that therefore have a low productivity. As this value is included in the calculation of the mean productivity values, the productivity of FOR is relatively low.

6.2 Practical Implications of the Study

There are three main aspects which may have a practical implication for forestry researchers. Firstly, the study allows for the direct support of ToSIA by providing calculated data that are needed to perform a SIA of the EU-FWC; secondly, the flexible calculation modes, which have been developed to calculate volume flows and SI values, can be applied to similar contexts beyond this study; thirdly, the study represents a comprehensive collection of data on the TTPC in Poland, Lithuania, the Czech Republic and Hungary, and can therefore be used as a source of data or references:

On the one hand, the aim of this study has been to provide data on the Polish, Lithuanian, Czech and Hungarian TTPC of the year 2005 in order to support the development of a tool (ToSIA) for the SIA of the entire FWC of the EU25+2. These data comprise country specific values of the timber volume flows, namely the process shares, the product shares and the split ratios, and further to that country and process specific values of a selected set of sustainability indicators (SI). The calculated values are displayed in corresponding tables in chapter 5; they are prepared in a way that allows their direct transfer into the EFORWOOD data bases.

On the other hand, calculation modes with regard to all of these target values have been developed. The calculation modes are flexible models, which can be applied to contexts beyond the borders of this study and of EFORWOOD, with regard to the following aspects:

- The calculation modes are adapted to the data availability with regard to the Polish TTPC in the year 2005; as the data availability with regard to the Polish TTPC is expected to have rather improved since 2005, it is supposed that the calculation modes are also applicable to the years after 2005.
- The data availability in terms of the Polish TTPC has appeared to be rather poor. As the calculation modes are adapted to the data availability with regard to the Polish TTPC, it is supposed that the calculation modes can also be applied to all other countries where the data availability is at least as high as in Poland; this is probably the case in the North, West and Central European countries and possibly also in some South and further East European countries.
- The calculation modes can easily be improved, if new statistical raw data become available and if these new data are then used as updated input data for the calculation modes.

Thirdly, in the course of this study, many data on the Polish forestry have been collected from many different sources and then compiled; this is why the study represents a comprehensive collection of data on the TTPC in Poland. It is therefore supposed that the study can serve as a considerable source of data and references for future research projects on the Polish and East European forestry in general.

6.3 LIMITATIONS OF THE STUDY

Besides practical implications, the study also has certain limitations and restrictions:
Firstly, there is a distinct lack of statistical data that would have been required as input parameters for the calculation of most of the volume flow values and of most of the SI values. Due to this fact, extensive expert guesses and assumptions had to be considered in some parts of the study to allow a further proceeding and thereby to avoid a failure of the study. As described in chapter 6.1, cross-checking of the expert guesses and assumptions has only been possible in those few cases where adequate statistical data have been available.
These facts require a cautious use of the calculated values. The reader should always be aware of possible discrepancies between the calculated values and the actual situation in the Polish, Lithuanian, Czech or Hungarian forestry. This is why the reader of the study is recommended to cross-check the input parameters of the calculation modes whenever new statistical data are available that were not available during the compilation this study.

The reader should further be aware of the fact that not all SI values have the same susceptibility towards changing or inaccurate input parameters in terms of the relative extent of change that the resulting SI values are subject to. If, for example, the number of employees changes in a certain process, the linked value of the indicators 12.1, 12.1.1 and 12.1.2 (number of accidents) changes for this process significantly more than the value of the indicators 27.1.1 and 27.1.2 (generation of waste), which is also linked.

6.4 Suggestions on Future Research

An intensive proceeding has been made towards a quantitative description of the structure of the Polish, Lithuanian, Czech and Hungarian TTPC by providing values of the volume flows, and towards the capture of country and process characteristics by providing SI values.

However, to obtain an overall understanding of the TTPCs in the regarded countries, a considerable amount of further research remains to be done:
A distinct lack of data has especially been detected with regard to technical data and economic details on felling and hauling processes. Therefore, data from Germany had to be considered in several cases.
Furthermore, many of the data that are provided by international organisations (e.g. FAO) reflect the country specific situation in the years around 1995 and were published in consideration of the political change in East European countries. The structure of the forestry sector of East European countries, however, is still subject to major changes, e.g. as the privatisation is an ongoing and continuous process.

Therefore, further research, data collection and data preparation is suggested. With regard to future SIAs it is especially proposed to develop country specific and centralised data bases, in which all data on the country specific forestry are collected on a high level of detail, if possible on the level of single processes.

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