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International bioenergy trade - scenario study on international biomass market in 2020

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- scenario study on international biomass market in 2020

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ABSTRACT

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The markets of biomass for energy are developing rapidly and becoming more international. A remarkable increase in the use of biomass for energy needs parallel and positive development in several areas, and there will be plenty of challenges to overcome. The main objective of the study was to clarify the alternative future scenarios for the international biomass market until the year 2020, and based on the scenario process, to identify underlying steps needed towards the vital working and sustainable biomass market for energy purposes. Two scenario processes were conducted for this study. The first was carried out with a group of Finnish experts and the second involved an international group. A heuristic, semi-structured approach, including the use of preliminary questionnaires as well as manual and computerised group support systems (GSS), was applied in the scenario processes.

The scenario processes reinforced the picture of the future of international biomass and bioenergy markets as a complex and multi-layer subject. The scenarios estimated that the biomass market will develop and grow rapidly as well as diversify in the future. The results of the scenario process also opened up new discussion and provided new information and collective views of experts for the purposes of policy makers. An overall view resulting from this scenario analysis are the enormous opportunities relating to the utilisation of biomass as a resource for global energy use in the coming decades. The scenario analysis shows the key issues in the field: global economic growth including the growing need for energy, environmental forces in the global evolution, possibilities of technological development to solve global problems, capabilities of the international community to find solutions for global issues and the complex interdependencies of all these driving forces. The results of the scenario processes provide a starting point for further research analysing the technological and commercial aspects related the scenarios and foreseeing the scales and directions of biomass streams.

FOREWORD

The use of biomass for energy production can be increased remarkably from the current level over the next decades, when fossil fuels become scarce and more expensive. The markets of biomass are developing rapidly and becoming more international. Although biomass has the potential to become a more important source of energy, the remarkable increase in biomass use for energy requires parallel and positive development in several sectors, and there will be plenty of challenges to overcome. Vital and well-functioning international biomass market will be one of the key factors combining the production potential and growing demand for biomass. The decisions made by politicians, the strategies of market actors and the direction of research activities will have a significant influence on the future development of the biomass market, and because of this several parties and stakeholders have ambitions to contribute to the development of the market. To support the positive development of the market and to make the most of the development, the market dynamics must be understood. For instance, there is a need for awareness of factors affecting the future development and for knowledge of interactions between the markets of biomass and other bio-products. The main objective of the study is to clarify the alternative future scenarios for the international biomass market until the year 2020, and based on the scenario process, to identify underlying steps needed towards a vital working and sustainable biomass market for energy purposes.

This research was carried out between December 2004 and December 2007 as a part of the group project "The EU's forest energy resources, market of energy technology and international bioenergy trade" coordinated by the Finnish Forest Research Institute (METLA). The research work was financed by the ClimBus Technology programme of the Finnish Funding Agency for Technology and Innovation (TEKES). Two scenario processes were carried out within this study in collaboration with the representatives of various interest groups of the bioenergy market, including companies, authorities, research and development organisations and academia. The authors acknowledge a great gratitude to the participants of the scenario workshops as well as IEA Bionergy Task 40, EUBIONET II and the Copernicus Institute of Utrecht University for their contribution regarding the realisation of the international scenario workshop.

Mikkeli, February 2007

Jussi Heinimö Virpi Pakarinen Ville Ojanen Tuomo Kässi

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1 INTRODUCTION

Most of the industrialised countries have committed themselves to a significant decrease in greenhouse gas emissions when ratifying the Kyoto Protocol. One of the most important means of attaining this goal is to increase the share of renewable energy sources in the total energy consumption. Efforts to decrease the dependence on fossil fuels and to increase the security of the energy supply are also important factors promoting the use of renewable energy sources. At present, biomass is the largest source of renewable energy covering approximately 11% of the world's total energy consumption (2004). Several studies have researched the production potential of biomass for energy at local, regional and global levels. Berndes et al. have reviewed 17 studies that have investigated how much biomass can globally be harvested for energy in the longer term (Berndes et al., 2003). The studies showed that the use of biomass for energy production can be increased remarkably from the current level over the next decades, when fossil fuels become scarce and more expensive. In the light of the Kyoto Protocol, the use of biomass for energy production will be increased especially in the industrialised countries which are aiming to decrease the emission of greenhouse gases. The market of biofuels is developing rapidly and becoming more international. For example, the procurement areas of biofuels, especially of large biomass users, are expanding quickly, and even more biomass than before is sourced from abroad and from other continents. It has been observed that some areas have a biomass potential that exceeds their own consumption and that in some other areas the demand for biofuels surpasses the local production potential. Consequently, some areas seem to be becoming net suppliers of bioenergy to countries that are in lack of biomass resources.

Although biomass has the potential to become a more important source of energy, the remarkable increase in biomass use for energy requires parallel and positive development in several sectors, and there will be plenty of challenges to overcome. Vital and well-functioning working international biomass market will be one of the key factors combining the production potential and growing demand for biomass. The decisions made by politicians, the strategies of market actors and the direction of research activities will have a significant influence on the future development of the biomass market, and because of this several parties and stakeholders have ambitions to contribute to the development of the market. To support the positive development of the market and to make the most of the development, a more comprehensive understanding about the market dynamics is needed. For instance, there should be an increase in the awareness of factors affecting the future development and in the knowledge of interactions between the markets of biomass and other bio-products. A collaboration project entitled Task 40

"Sustainable International Bioenergy Trade: securing supply and demand", carried out within the framework of the IEA Bioenergy agreement, has the vision that the global bioenergy market will develop over time into a real "commodity market" which will secure supply in a sustainable way. The task has, among other things, discussed driving forces and prime causes behind the current development of the biomass market and identified potential barriers to the market development [1].

There are systematic and proven methods available for foreseeing alternative future development and increasing capabilities to confront unexpected development. Scenario planning is one of the most frequently applied methods for evaluating the future development routes. Several earlier scenario studies have investigated the future development of energy and environmental issues on a global scale. For instance, the Intergovernmental Panel on Climate Change (IPCC) has created scenarios focusing on the future development of green house gas emissions (IPCC, 2000). In addition, Brown et al. (2001) have studied scenarios focusing on a clean energy future. Their study concentrated on how clean energy technologies are able to address the challenges of the energy and environment sector. Also Shell has utilised scenarios to identify opportunities and challenges in the global business environment (Shell, 2005). The methods of group assessments and group decision support systems (GDSS) provide tools for the scenario process to efficiently collect and refine knowledge from experts. Various examples of the successful application of the decision support system in scenario research can be found, e.g. Blanning et al. have carried out research on how GDSS can be used in the scenario process, as have Bergman and Georgopoulos (Bergman, 2005; Blanning et al., 2002; Georgopoulos et al., 1998) In this study, scenario processes supplemented by GDSS are applied for investigating the future development of the biomass market.

The main objective of the study is to clarify the alternative future scenarios for the international biomass market until the year 2020, and based on the scenario process, to identify underlying steps needed towards the vital working and sustainable biomass market for energy purposes. The sub-objectives that are addressed in the research and which are related to the overall objective are to define and analyse the main factors influencing the development of the biomass market. Two scenario processes were conducted for this study. The first was carried out with a group of Finnish experts and the second involved an international group.

[1] Findings of the Task are listed e.g. in (Faaij et al., 2006; Faaij et al., 2005).

This report is organised as follows: In the beginning (Chapter 2), an overview is presented of the current status of the international biomass market and its future potential. After that (Chapter 3), the research methods and processes that are utilised to meet the objectives are introduced. Subsequently (Chapter 4), the results from the scenario processes are presented according to the phases of the processes. Following that (Chapter 5), the results of the scenario processes are analysed and the research process discussed. Finally, the conclusions are drawn and recommendations based on the findings of the study are given (Chapter 6).

2 OVERVIEW OF INTERNATIONAL BIOENERGY MARKET AND FUTURE TRENDS

2.1 The role of biomass in the world's energy supply

Fossil fuels – oil, coal and natural gas – dominate the world energy economy covering nearly 80% of the world's primary energy supply of 433 EJ[2] (Fig. 1). Renewable energy sources[3] accounted for 14% (59 EJ) of the world's total primary energy demand in 2002. Biomass[4] is by far the largest source of renewable energy, having an 11% (47 EJ) share of the total energy supply. Over two thirds (32 EJ) of biomass is used for cooking and heating in developing countries. The remaining 15 EJ of the energy use of biomass takes place in industrialised countries where biomass is utilised both in industrial applications within the heat, power and road transportation sectors and in the heating purposes of the private sector. Generally, biomass has been a marginal source of energy in industry and district heating. However, in countries such as Sweden, Finland and Austria, which have a large forestry sector, forest-based biomass has a remarkable importance. E.g. in Finland, renewable energy sources cover 25% of the total primary energy consumption, and over 80% of renewable energy was derived from wood (Statistics Finland, 2005). Biomass fuels approximately 1% of global electricity production, and it is often used in combined heat and power production (CHP) (IEA, 2004). The global biomass power generation capacity is approximately 39 GW (REN21, 2005). The global consumption of biofuels in transportation was 0.33 EJ in 2002, of which Brazil accounted for 70% and the United States for 23%. The share of biofuels in total transport consumption was only 0.4% (IEA, 2004). Nevertheless, several factors, such as striving to decrease greenhouse gas emissions and securing the supply of energy, are increasing the interest shown by industrialised countries in biomass as a fuel, and the modern use of biomass is increasing rapidly in many parts of the world.

[2] EJ = Exajoule = 10^{18} J

[3] Refers to renewable non-fossil sources of energy (wind, solar, geothermal, wave, tidal, hydropower, biomass, landfill gas, sewage treatment plant gas and biogas).

[4] Refers to the biodegradable fraction of products, wastes and residues from agriculture (including vegetal and animal substances) and forestry and related industries, as well as the biodegradable fraction of industrial and municipal waste.

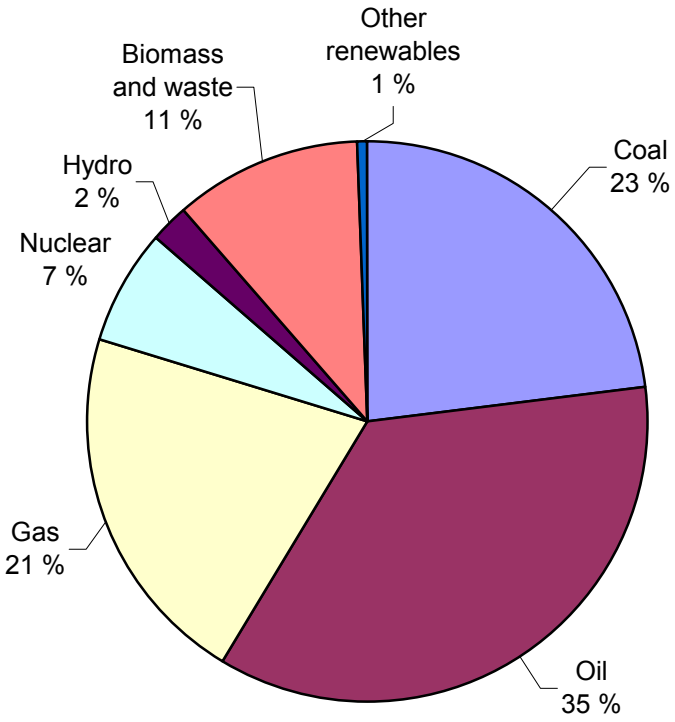

Figure 1. World energy demand in 2002, in total 433 EJ. (IEA, 2004)

International climate agreements are the ultimate factor for the ongoing positive development of bioenergy. Most industrialised countries have committed themselves to a significant decrease of greenhouse gas emissions in the Kyoto Protocol. An important means of attaining this goal is increasing the share of renewable energy sources in the total energy supply. The European Union (EU), as an example, aims to double the use of biomass from the level of 2003 by 2010 (Commission of the European Communities, 2005). This will mean a 3.4 EJ increase in the annual energy use in the union.

2.2 Long-term biomass production potential for energy purposes

Despite the current minor role of bioenergy, biomass has, in the long run, potential to become a much more remarkable source of energy in the global energy supply. Numerous studies have been carried out to estimate the potential to harvest energy from biomass. A review of the studies carried out in the year 2002 revealed that the studies gave widely differing estimates of the contribution of biomass; from below 100 EJ/yr to above 400 EJ/yr in 2050- in the global energy supply (Fig. 2) (Berndes et al., 2003). Nevertheless, it was clarified that the largest biomass production potential will be in large-scale energy plantations that are located in areas having a favourable climate for maximising the produce of biomass. The major reason for the differences

between the results of the studies is that the most crucial parameters – land availability and yield levels in energy crop production – are very uncertain, and subject to widely different opinions.

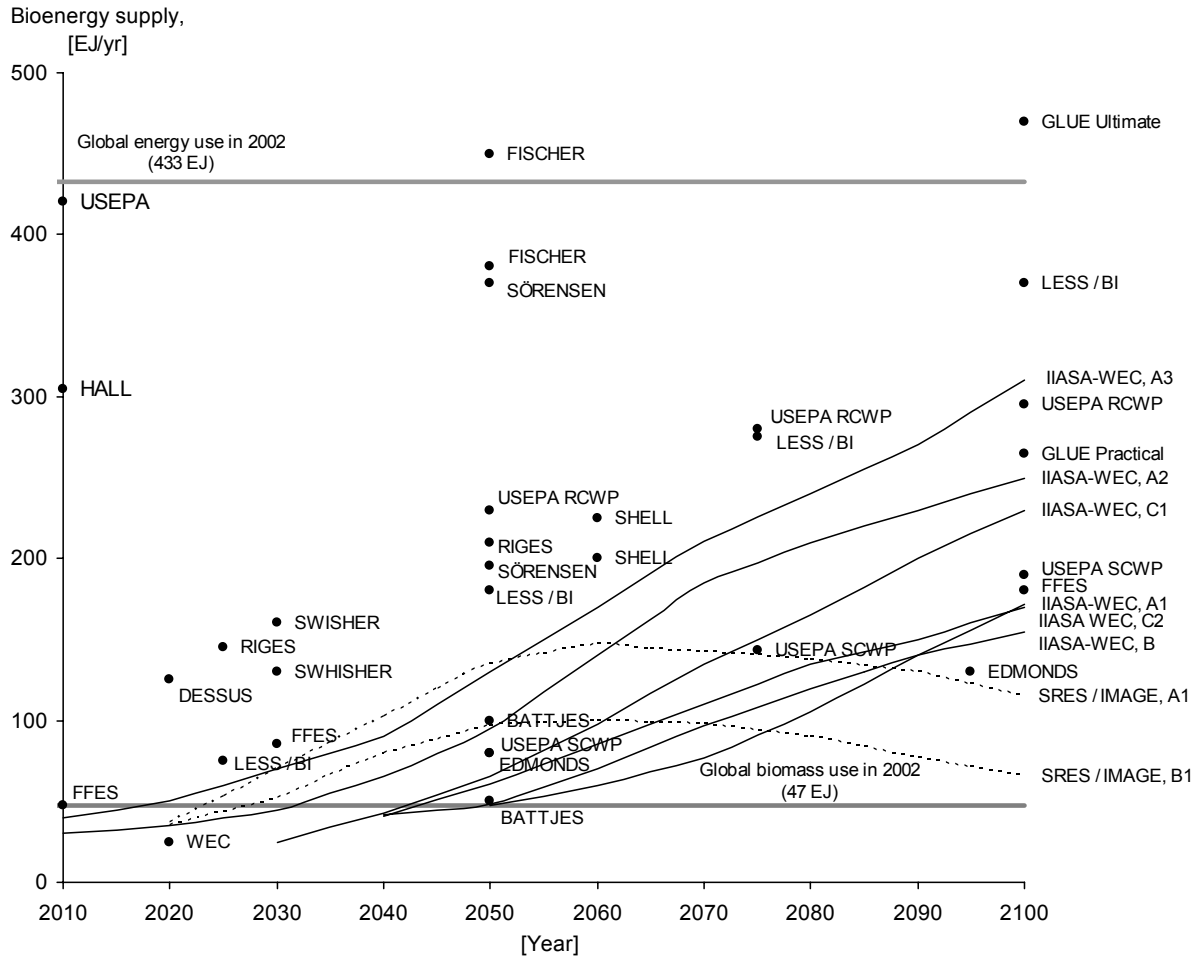

Figure 2. Results from 17 studies that have evaluated the potential to harvest energy from biomass up to 2100. Small circles and lines indicate results from various studies[5]. (Berndes et al., 2003)

Recently, several new studies have been addressed to the issue (see e.g. Hoogwijk, 2004; Hoogwijk et al., 2005; Smeets et al., 2004). In the most optimistic scenarios, bioenergy provides for more than the current global energy demand, without competing with wood production, forest production and biodiversity. Table 1 gives a summary of the biomass production potential in the light of the latest studies by biomass categories and shows the main assumptions made in the determination of the potentials. Latin America, Sub-Saharan Africa and Eastern Europe as well as Oceania and East and North-East Asia have the most promising potentiality to become important biomass producers in the long run (Faaij et al., 2006).

[5] Note that the global primary energy consumption was estimated to increase from the current level over the coming decades, but the grey line indicates the present consumption.

Table 1. Overview of the global potential bio-energy supply on the long term for a number of categories and the main pre-conditions and assumptions that determine these potentials (Faaij et al., 2006).

Biomass category	**Main assumptions and remarks**	**Potential bio-energy supply up to 2050, [EJ/yr].**
Energy farming on current agricultural land	Potential land surplus: 0-4 Gha (more average: 1-2 Gha). A large surplus requires structural adaptation of intensive agricultural production systems. When this is not feasible, the bio-energy potential could be reduced to zero as well. On average, higher yields are likely because of better soil quality: 8-12 dry tonne/ha*yr is assumed [a].	0 – 700 (more average development: 100 – 300)
Biomass production on marginal lands	On a global scale a maximum land surface of 1.7 Gha could be involved. Low productivity of 2-5 dry tonne/ha*yr [a]. The supply could be low or zero due to poor economics or competition with food production.	(0) 60 – 150
Bio-materials	Range of the land area required to meet the additional global demand for bio-materials: 0.2-0.8 Gha. (Average productivity: 5 dry tonnes/ha*yr). This demand should come from categories I and II in case the world's forests are unable to meet the additional demand. If they are, however, the claim on (agricultural) land could be zero.	**Minus** (0) 40 –150
Residues from agriculture	Estimates from various studies. Potential depends on yield/product ratios and the total agricultural land area as well as type of production system: Extensive production systems require re-use of residues for maintaining soil fertility. Intensive systems allow for higher utilisation rates of residues.	15 – 70
Forest residues	The (sustainable) energy potential of the world's forests is unclear. Part is natural forest (reserves). Range is based on literature data. Low value: figure for sustainable forest management. High value: technical potential. Figures include processing residues.	(0) 30 – 150
Dung	Use of dried dung. Low estimate based on global current use. High estimate: technical potential. Longer-term utilisation (collection) is uncertain.	(0) 5 – 55
Organic wastes	Estimate on basis of literature values. Strongly dependent on economic development, consumption and the use of bio-materials. Figures include the organic fraction of municipal solid waste (MSW) and waste wood. Higher values possible by more intensive use of bio-materials.	5 – 50 (+) [b]
Total	Most pessimistic scenario: no land available for energy farming; only utilisation of residues. Most optimistic scenario: intensive agriculture concentrated on the better quality soils. (between brackets: more average potential in a world aiming for large scale utilisation of bio-energy)	**40 – 1 100** **(250 – 500)**

[a] *Calorific value: 19 GJ/tonne dry matter.*

[b] *The energy supply of bio-materials ending up as waste can vary between 20-55 EJ or 1 100-2 900 Mt dry matter per year. This range excludes cascading and does not take into account the time delay between production of the material and 'release' as (organic) waste.*

2.3 International trade of biomass for energy purposes

Increasing the global use of biomass needs large-scale trading of biomass for energy purposes. International biofuel trade is currently reality, and the trade will certainly continue growing. In many areas, regionally and nationally, the biomass production potentials can not meet the demand, but on the other hand, there are areas where biomass production potential exceeds local demand. To fulfil the increasing demand, biomass has to be transported longer distances and even imported from other continents. However, local use of biomass is often more reasonable than exporting, and for this reason imported biomass will have only a limited proportion in the global energy use of biomass. Taking the local production and usage potentials into account, Hansson and Berndes have estimated the global biofuels trade flow potential between different world regions to be 80-150 EJ in favourable conditions in the year 2050 (Hansson et al., 2006), which can be stated as a theoretical upper limit for international biofuels trade.

Compared to the long-term potential, the development of international trade of biomass for energy purposes is in its initial stages. Ethanol, vegetable oils, fuel wood, charcoal and wood pellets are at present the most important biofuels that are traded internationally. Nevertheless, the international trade of these products is much smaller than the international trade of biomass for other end-use purposes. Table 2 depicts the volumes of global production and international trade of various biomass products. Most of the reviewed biomass products are mainly consumed locally in the countries where they were produced, but in the case of products such as sawn timber, paper and paperboard, palm oil and wood pellets, remarkable shares of the total production are exported.

Table 2. An overview of world biomass production and international trade in 2004.

Product	World Production in 2004	Volume of international trade in 2004
Industrial wood and forest products[a]		
Industrial round wood	1 646 Mm^3	121 Mm^3
Wood chips and particles	197 Mm^3	37 Mm^3
Sawn timber	416 Mm^3	130 Mm^3
Pulp for paper production	189 Mt	42 Mt
Paper and paperboard	354 Mt	111 Mt
Agricultural products[b]		
Maize	725 Mt	83 Mt
Wheat	630 Mt	118 Mt
Barley	154 Mt	22 Mt
Oats	26 Mt	2.5 Mt
Rye	18 Mt	2 Mt
Rice	608 Mt	28 Mt
Palm Oil	37 Mt	23 Mt
Rapeseed	46 Mt	8.5 Mt
Rapeseed oil	16 Mt	2.5 Mt
Solid and liquid biofuels[c]		
Ethanol	41 Mm^3	3.5 Mm^3
Biodiesel	3.5 Mt	<0.5 Mt
Fuel wood	1 772 Mm^3	3.5 Mm^3
Charcoal	44 Mt	1 Mt
Wood pellets	4Mt	1 Mt

[a] Source FAOSTAT 2006 (FAOSTAT, 2006).
[b] Source FAOSTAT 2006 (FAOSTAT, 2006), excluding production of palm and rapeseed oils, which were sourced from Indexmundi 2006 (Indexmundi, 2006).
[c] Sources: (Ethanol) (Rosillo-Calle et al., 2006), production is the total production, trade is trade of fuel ethanol, Biodiesel production (Worldwatch Institute, 2006), trade volume is an individual estimate by the authors, Fuel wood and Charcoal (FAOSTAT, 2006), Wood pellet production authors' own estimate, trade volume from Dahl et al. (2005).

Table 3 gives a preliminary and rough estimate of the current scope of the international trade of biomass for energy purposes. Currently, indirect trade[6] of biofuels through trading of industrial round wood and material byproducts composes the largest share of the trade. The trading represents approximately 5% of the total use of biofuels in industrialised countries.

[6] This was derived from the fact that nearly half of raw wood ends up in energy production during or right after the production processes of the main products in forest industry.

Table 3. An estimate on the scope of international trade of biofuels in 2004, (EJ). Tall oil, ETBE and wastes excluded.

Indirect trade	**0.54**
Industrial round wood [a]	0.41
Wood chips and particles [b]	0.13
Direct trade	**0.22**
Ethanol [c]	0.09
Biodiesel [d]	0.02
Fuel wood [e]	0.03
Charcoal [f]	0.02
Wood pellets [g]	0.02
Palm oil [h]	0.04
In total	**0.76**

[a] Round wood in FAO statistics is without bark, so we added 10% bark. Other assumptions: average density 0.8 t/m^3, 45% average conversion into biofuels, calorific value 9.4 GJ/t.
[b] Assumptions: average density 0.8 t/m^3, 45% average conversion into biofuels and 9.4 GJ/t calorific value.
[c] Assumed calorific value 27 GJ/m^3.
[d] Assumed calorific value 37 GJ/t.
[e] Assumed density and calorific value 0.7 t/m^3 and 13 GJ/t.
[f] Assumed calorific value 22 GJ/t.
[g] Assumed calorific value 17.5 GJ/t
[h] According to Indexmundi (2006) the global industrial use of palm oil was 6.8 Mt in 2004. Palm oil use for energy purposes (for power generation and biodiesel production) was estimated at 1 Mt, which approximately equals the volume of industrial use of palm oil in EU-25 indicated by Indexmundi (2006). The calorific value of palm oil was assumed at 37 GJ/t.

3 RESEARCH METHODS AND PROCESS APPROACH

3.1 Scenario planning

Scenario planning is a structured strategic planning method that is used to make flexible long-term plans. It is applied to policy planning, organisational development and, more generally, when strategies are needed to be tested against uncertain future developments. Scenario planning is a method for learning about the future by understanding the nature and impact of the most uncertain and important driving forces affecting the future. Usually, scenario planning yields 3-5 diverging scenarios, which are descriptions of a future situation. In a scenario, hypothetical situations are interspersed with expected extrapolations of trends to list a combination of events that describes how a situation might occur. The scenarios usually include plausible, but unexpectedly important situations and problems that exist in some small form in the present day. Any particular scenario is unlikely. Scenario creation expands people's thinking and simultaneously increases the knowledge and understanding on the unknown subject. Scenario planning helps policy-makers to anticipate hidden weaknesses and inflexibilities in organisations and methods. When disclosed years in advance, these weaknesses can be avoided or their impacts reduced more effectively than if a similar real-life problems were considered under duress of an emergency. Using scenario planning is especially useful when the research object is facing chances and when the uncertainty of the research question is high and there are multiple solutions to the issue. (Börjesson, 2007; Wikipedia, 2007)

Earlier literature (e.g. Schwartz, 1996; Wack, 1985) emphasises that scenarios are different from forecasts. E.g. according to the definition of Schwartz (1996), scenarios are "alternative plausible stories that may show how world might develop". Scenario planning approaches have been used in various organisations for decades; e.g. General Electric and Shell (see e.g. Schoemaker et al., 1992; Wack, 1985; Verity, 2003) are well-known examples of large firms that have been among the pioneering adopters of scenario approaches as strategic management tools. In strategic planning, scenarios are argued to be efficient especially when the uncertainties related to business and future play a significant role in the industry (e.g. Walsh, 2005). However, scenarios mean different things for different people (Schoemaker, 1993) and they can be analysed on different levels quite flexibly. The flexibility and widespread applicability and the fact that there are several "schools" of thoughts in the scenario literature may, however, also limit their everyday use in companies (Verity, 2003) or lead to misuse of scenarios (e.g. Godet et al., 1996). At their best, however, they can help in facilitating and structuring the interaction between an organisation and its environment, sharing and disseminating personal knowledge of people,

bringing forth the future possibilities and threats and building a holistic understanding on the alternative future views (Bergman, 2005; Schoemaker, 1993; Schwartz, 1996; Wack, 1985; Wilson, 2000) .

The above-mentioned "schools" of scenario planning can be basically categorised in to two main groups: 1) intuitive style, which emphasises alternative views, challenging implicit assumptions, and organisational learning, and 2) formal style, which emphasises the use of computers, models and processes grounded in analytical rigour (Verity, 2003). On the other hand, we can make the distinction to three approaches as suggested by Bergman (2005), i.e. 1) intuitive (e.g. Schwartz, 1996; Wack, 1985), 2) heuristic (e.g. van der Hejden, 2000; Schoemaker, 1991), and 3) statistical (mathematical) models (e.g. Godet, 1993).

Mathematical models for scenario development often become complex and thus might not be easily applicable for the purposes of this study, and on the other hand, approaches that rely solely on intuitive processes in scenario development might provide results that are not reliable enough. In this study, the process model can be treated as a heuristic approach aiming to obtain a holistic picture of the issue with the help of a semi-structured phased process, which also includes some elements of an intuitive approach.

The construction of scenarios can be typically seen as a process with several phases. In the earlier literature, different authors present numerous ways to implement the process and different numbers of phases in the process. E.g. Schoemaker identified a total of 10 steps to go trough the whole scenario process (Schoemaker, 1993). In his review of previous literature, Walsh (2005) has sum up the process in six main phases 1) identification of future actionable issues or drivers of change, 2) creation of framework for conceptualising data pertaining to issues or drivers, 3) development and testing of a large number of scenarios (e.g. 7-9), 4) reduction to smaller numbers of ultimate scenarios (e.g. 2-4), 5) construction of scenarios and 6) examination of scenarios and identification of issues arising from them. Basically, the process can be simplified into four main phases that are (see e.g. Bergman, 2005):

1) Structuring the scenario process
This includes the background analysis of the scenario context and the delimitation of the focus.

2) Exploring the scenario context

Includes the determination of the main stakeholders and driving forces and key environmental uncertainties that are changing the operational environment. Also the significance of the main driving forces is explored.

3) Development of scenarios

This phase provides alternative future scenarios related to the issue considered.

4) Implementation of the scenarios

Stakeholders can formulate strategies that account for environmental changes and exploit future opportunities with an acceptable risk level. Scenarios also serve as a platform for the evaluation of new business ideas and policies, assessing their market potential and possible impacts, e.g. posing "what if" questions.

3.2 Group support systems in the scenario process

Scenario processes can be implemented flexibly in many ways and by using different manual and computerized group work methods or decision support systems in processes. If scenarios are used in proper way and with the help of suitable methods, there is a possibility to prevent the impacts of important contributors of decision failure, i.e. bounded rationality, a tendency to consider only external variables, the stickiness and friction of information and knowledge, and mental models that include decision premises or policies (Chermack, 2004).

A relatively small number of earlier studies has so far focused on the use of group support systems (GSS) in the scenario process. However, the use of group support systems has shown their possible efficiency in scenario processes as well as in other areas of strategic planning. For instance, Blanning et al. (2002) have studied the possibilities of GSS in multiperiod scenario development. Additionally, there are general benefits in supporting a group to promote its co-operation and effectiveness by using group support systems, e.g. parallel communication among group members, equal and anonymous opportunities to contribute ideas and opinions, elimination of exaggerated domination of a single participant in a meeting, the possibility to find out rapidly the agreed and disagreed opinions of the group members, and management of the schedule and agenda of the meeting as well as effective automatic electronic documentation capabilities (see e.g. Jessup et al., 1992; Turban et al., 1998).

These points may be helpful also in the scenario process, as the typical features of scenario processes are complexity, uncertainty and interdependency (see e.g. Schoemaker, 1993). When the context and focus of the study is especially on an emerging market, e.g. the international biomass market as in the present study, the benefits of GSS have an even greater potential in promoting the scenario process. The existing group support system laboratories are designed to look like an ordinary meeting room with computers for each participant. GSS systems are equipped with software that aids and supports group decision making (Fig 3.). GSS laboratories usually allow 10-14 persons' participation for efficient group work and achieving the set targets (Elfvengren, 2006).

Figure 3. Use of group support systems in the scenario process: An outlook onto the Policy Lab at the University of Utrecht, the Netherlands. Foto: J. Heinimö

3.3 Process approach of the study

The approach of the study was to collect and refine tacit knowledge of experts to clarify the future visions on the international biomass market. Figure 4 depicts the process that was followed in two separate and partly parallel processes in which two different groups of experts participated. The scenario process can be seen as a heuristic process (Schoemaker, 1991) including intuitive and systematic elements, and it can also been seen as "participative" scenario process (Rotmans et al., 2000), where business decision-makers and policy-makers also play a

significant role and thus, does not involve a small group of technical experts only, who would be responsible for design and development of scenarios. The process as a whole takes several months to go through.

The preliminary work for structuring the scenario was carried out with the help of literature reviews on the issue and two preliminary questionnaires. The aim of the preliminary questionnaires was to collect a list of driving forces influencing the bioenergy market as initial data for the workshops. Both questionnaires were carried out through the Internet by means of the Webropol software tool. The questionnaire sent to international experts mainly concentrated on gathering driving forces, and it contained 11 questions. It was sent to the workshop participants and the members of the EUBIONET II project. Driving forces were gathered by asking which factors promote or hinder the development of the bioenergy market, the use of bioenergy in the transportation sector, in energy production and in the generation of heat, electricity or both. In total, 14 experts answered the questionnaire.

The scope of the Finnish questionnaire was larger and it focused both on scale questions and on gathering the driving forces influencing the international biomass market. In addition, in the Finnish questionnaire the questions, e.g. driving forces, were asked from the Finnish point of view. The questionnaire in the Finnish scenario process was sent to a total of 90 experts of whom 32 answered, making the answering rate approximately 36%. The questionnaire contained all in all 21 scale types and open questions concerning the development of the international biomass market from the Finnish point of view. The respondents represented companies, research and development organisations or teaching, public authorities and associations or interest groups.

A significant part of the work was completed in two equivalent intensive one-day workshops that included the phases from “Mapping of the driving forces” to “Formulation of preliminary value networks and business models” (Fig. 4). The results of the preliminary questionnaire, i.e. the experts’ opinions on the main driving forces of the international biomass market together with the literature reviews, were then analysed and utilised as preliminary data for the workshops. The participants of the workshops then brought forth their opinions on the additional driving forces. The first workshop was from the perspective of Finnish actors, and second from the global perspective. A total of 27 experts participated in the workshops, in which the tentative scenarios were formulated. Both groups of experts (Annex I), i.e. the Finnish and international groups applied the same process approach. The Finnish scenario session was held in the GDSS laboratory of Lappeenranta University of Technology on 10 January 2006. The international

scenario session “The future visions of biomass trade workshop” was held in the Policy Lab of Utrecht University in the Netherlands on 31 January 2006. The first half of the workshop was supported by computerised group support systems, and the same software, GroupSystems, was utilised in both cases.

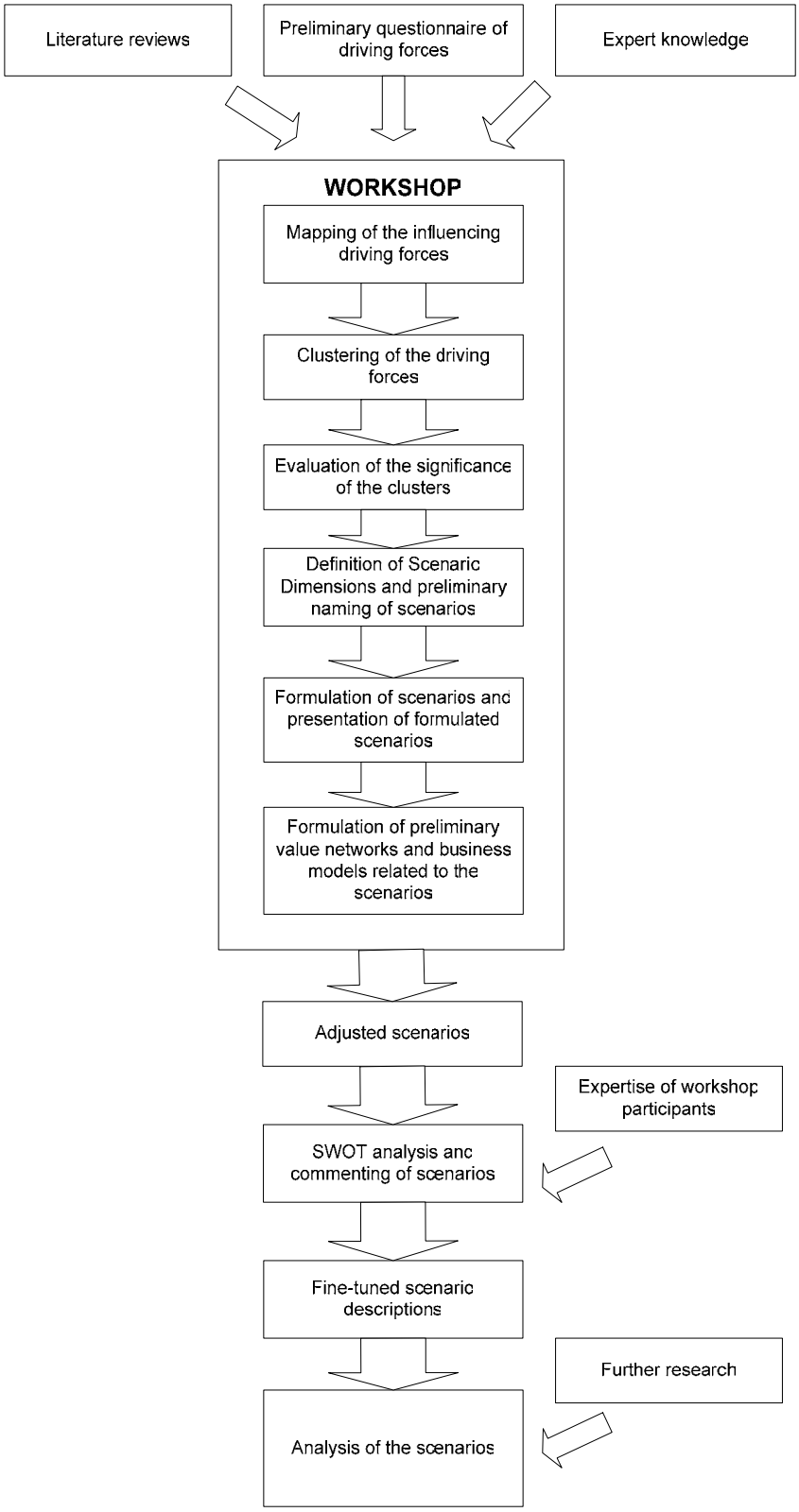

Figure 4. Phases of scenario processes applied in the study.

By means of computerised support systems the workshop participants could very efficiently and anonymously and simultaneously generate a large number of ideas for driving forces in circa 10 minutes. Then the participants also had the possibility to anonymously comment on the generated ideas and ask questions about them. These two steps took all in all about 20 minutes.

After that, so-called clusters, i.e. groups including similar types of driving forces, were created and named through a general discussion. The driving forces were then grouped into clusters. A suitable number of clusters is generally 6-10 clearly distinct groups. The significance of the clusters (regarding the development of the international biomass market) was then evaluated by the workshop participants anonymously with the help of the GSS. The scale used in the voting was 1–10. (10 = very significant driving force)

The latter part of the workshop was supported by manual group work. First, the whole group of participants formulated the scenario dimensions through a general discussion and partly on the basis of the earlier results, and evaluated the groups of driving forces. Alternative future development routes, i.e. scenarios, were then named and put into a map of dimensions, which shows the emphasised drivers and areas in each scenario. The experts then formulated 1-2 pages of tentative descriptions of the scenarios in smaller groups, including the state of the international biomass market in next fifteen years, the driving forces influencing the development, and the path which will lead to the future state. In the Finnish workshops, the participants also had time to preliminary discuss about value chains, networks and actors related to the scenario, in the same small groups. Each group presented their descriptions and the others commented on the presentation. The researchers following the sessions made notes and included them in the adjusted descriptions of the scenarios

After the workshops, adjusted scenario drafts were sent to the participants for commenting. The participants were also asked to think about the strengths, weaknesses, opportunities and threats included in the scenarios. As a result, the scenario descriptions were validated and further fine-tuned and analysed by the researchers. In addition, they perfected SWOT analyses of the each scenario.

4 RESULTS

4.1 Preliminary surveys

Despite the different perspective of the questionnaires in Finland and among international experts, the gathered driving forces concerned the same issues on a large scale, e.g. the price competitiveness of bioenergy, subsidies, taxes, R&D, imbalance between supply and demand, international agreements and sustainability. In addition, both the international and Finnish bioenergy experts agreed that the trade of liquid biofuels will develop most strongly.

At an international level, the most frequently mentioned promoting factors of international biomass trade were the high fossil fuel prices together with environmental issues and national or international agreements, action plans and legislation. In addition, research and development activities, e.g. new technology development, subsidies and sharing knowledge "how to utilise biomass resources", were considered as an enhancing factor for the utilisation of bioenergy. A remarkable observation is that the number of political promoting factor was the largest. It can be deduced that political decisions and actions probably are the most effective way to enhance the development of the bioenergy market and the utilisation of biomass. An important factor, which can hinder the development of the utilisation of biomass, is logistics. At the moment, there are difficulties all the way from the collection of biomass from the source to the utilisation and commercialisation: for instance low competitiveness because of a free energy market, high supply chain costs, lack of capital and appropriate technology and expensive investments. In addition, biomass is considered difficult to handle and use at the consumer level. The sustainable availability and production of biomass is also questioned. The most hindering factors can be related to economical, social and technological issues. Decision making of politicians does not seem to be a hindering factor at least on a large scale, although at the moment there are, according to experts, no sufficient financial incentive systems and standardisation.

Finnish experts think that the bioenergy sector will grow and diversify in Finland in the future. The entire bioenergy sector, except the production and use of peat, is expected to grow steadily or strongly. Over half of the respondents agreed that in Finland especially the production of forest chips and wood pellets will develop very strongly. Also the domestic use of wood pellets and production of liquid biofuels are estimated to grow slightly or quite strongly. There was no remarkable difference between the opinions and answers of different respondent groups. Three felicitous open comments from the Finnish questionnaire illustrate the complex nature of the bioenergy market and sum up the current market status from the Finnish perspective:

"When we are planning to increase the use of renewable energy, one must recall that renewable energy resources are also limited and their production has remarkable environmental impacts. Therefore the effectiveness of production and consumption should be developed simultaneously. Otherwise when we are solving the problem, we end up creating ten new ones."

"The stop-go nature of Finland's legislation has been a significant obstacle to the development of the utilisation of biofuels. There is a lot of reserve, but legislators still encourage the import of energy. There have not been enough investments in domestic development, nor are the employment aspects recognised."

"The development of bioenergy is mainly connected with the development of the market. With the current price levels, companies are no yet themselves able to create the market. A determined strategy based on future visions is needed, like the guidance of the government at an early stage."

4.2 Driving forces and clusters

International workshop

In the first part of the international scenario workshop, a total of 81 separate driving forces and 150 comments or questions (Table 4) were ideated in circa 20 minutes. The international experts grouped the driving forces created into ten clusters representing larger entities. A detailed list of driving forces is presented in Appendix II.

Table 4. Clusters of driving forces in the international workshop.

Cluster	Number of driving forces per cluster	Voting	
		Significance	Deviation
1. Economy	10	8.57	1.16
2. Policy	17	8.50	1.56
3. Environment	7	8.00	1.84
4. Technology	8	7.50	1.83
5. Production	7	7.29	2.13
6. Trade	8	6.86	2.14
7. Communication	7	6.79	1.53
8. Consumers/suppliers	4	6.57	2.50
9. Entrepreneurs	9	6.14	2.44
10. Social	4	5.86	2.85
Total	81		

Economical and political aspects are the first ones in order of importance when thinking about the development of the international bioenergy market. The economy cluster consists mainly of efficiency, cost-efficiency and competitiveness issues, and the policy cluster is compounded of a great variety of political instruments e.g. agreements, taxes, subsidies and obligations. They also include the largest amount of driving forces, ten in the economy and seventeen in the policy cluster, which also implies their significance in the development of the international bioenergy market. The number of different driving forces in the environment cluster is not at the level of the economy and policy clusters, but it became clear during the workshop discussion that environmental driving forces, e.g. climate change, emission targets and the use of fossil fuels, have a remarkable role in the development of the international bioenergy market.

Even if the consumer and social clusters are at the tail end in the order of importance, they contain important and maybe crucial driving forces which can change the pace of the bioenergy trade. Ultimately, customers and consumers are the key factors in the development of bioenergy trade because their positive opinions could make large-scale bioenergy trade acceptable. Also social aspects have to be taken into account to ensure sustainable development all over the world, e.g. the expansion of international trade may cause unfavourable development in poor areas if large scale export of local biomass starts. According to the international experts, a balanced approach between social, economical and environmental issues is needed.

Finnish workshop

In the Finnish scenario drafting during the first part of the workshop a total of 77 separate driving forces (Table 5) were ideated in circa 20 minutes. Finnish experts grouped the driving forces into six clusters representing larger entities. A detailed list of driving forces is presented in Appendix III.

Table 5. Clusters of driving forces in the Finnish workshop.

Cluster	Number of driving forces per cluster	Voting	
		Significance	Deviation
1. Economy	12	8.55	0.93
2. Policy	18	8.45	0.93
3. Competition	15	7.18	1.40
4. Environment	7	5.82	1.33
5. Technology	17	5.55	1.97
6. Globalisation	8	5.09	1.51
Total	77		

It can be noted that the economy and policy clusters are in the first place in order of importance in influencing the development of the international biomass market. The low deviation of the economy and policy clusters indicates the unanimity of the participants about their significance. The group of economical driving forces consists for instance of price, cost and economy development, whose changes strongly affect the consumer habits of energy and therefore are linked with the development of biomass. The policy cluster includes agreements, taxes and legislation, and in addition, the harmonisation of the biomass market. Finnish experts agreed that, together with the economy and policy clusters, competition issues have an important role in the international biomass market. Within the competition cluster, attention is paid among other things to different usage for example in the case of forest biomass, i.e. bioenergy producers and forest companies are competing for forest biomass in some cases. Finnish experts also recognised that globalisation creates special features on the bioenergy market even if it is put in the tail end in order of importance. In addition to global energy consumption issues, Finnish experts also highlighted the challenges that separate energy policies and cultures create. A global market and trade necessitate networking and international co-operation, which can be challenging for smaller companies.

4.3 Scenarios

The clusters and their significance were taken into account when defining the scenario dimensions. In both workshops, globalisation and economical and political aspects were included in the scenarios representing the state of the international biomass market in 2020 (Fig. 5 and Fig. 6). In the international workshop, four scenarios were drafted. The Finnish workshop for one crafted three preliminary scenario descriptions. The international workshop ended up using scenario dimensions similar to IPCC (2000). However, the clusters and their importance were naturally taken into account in the crafting of the scenario descriptions.

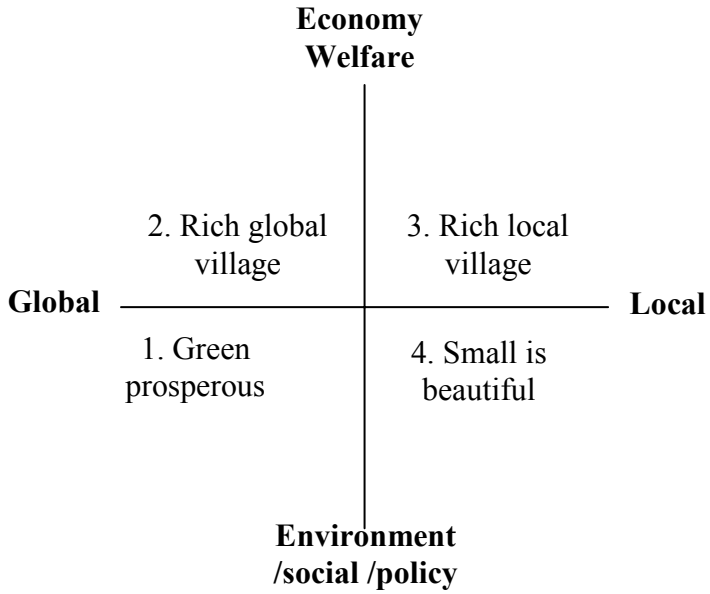

Figure 5. Scenarios created by the international group of experts.

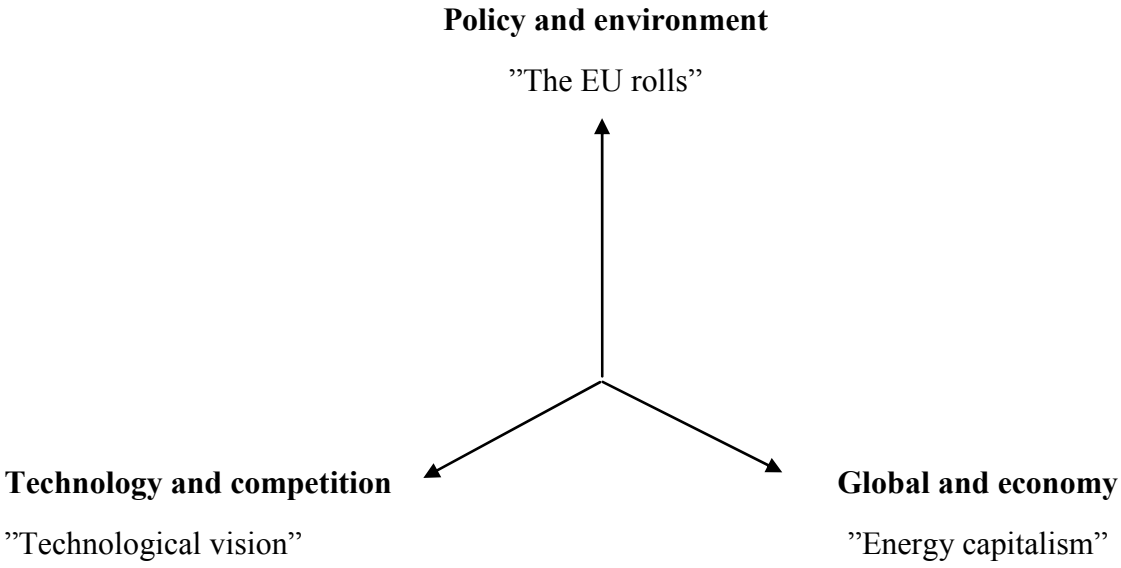

Figure 6. Scenarios created by the Finnish group of experts.

4.3.1 International workshop

In the following, the scenarios and their SWOT analyses are presented (Tables 6-9). The SWOT analyses are based on the comments received from the participants after the workshop. In addition, researchers had to supplement the analysis. Comprehensive descriptions of the scenarios are included in Appendix IV.

Green prosperous

In the "Green prosperous" world, emphasis is on the global market and important global actors as well as on environmental, policy related and social aspects and driving forces.

Table 6. SWOT analysis of "Green prosperous"

Strengths	Weaknesses	Opportunities	Threats
• No need for strong regional policy and regulatory measures on bioenergy • Global market of biomass • Extensive international agreements, to which all important countries are committed, guide the development	• Global energy crisis will inhibit the scenario	• Attracts resources from wide spectrum of actors in the society • Will create new trade streams and increase trade volumes of biomass • In addition to technological development, can contribute to global social and environmental development	• Too loose international agreements can cause economical factors to disrupt the "green" development

Rich global village

In the "Rich global village", emphasis is on the global market and important global actors, as well as on economic performance and maximisation of economic welfare. The world is seen as a paradise full of biomass ready for utilisation.

Table 7. SWOT analysis of "Rich global village"

Strengths	Weaknesses	Opportunities	Threats
• No barriers to the development of interantional trade • Biomass is competitive without national subsidies against fossil fuels	• The production of biomass is centralised to a few key producers and regions • The development of the biomass market is mainly based on economical driving forces • Not enough attention to environmental and social issues (an increasing risk of environmental and social problems)	• Rapid development opens up new opportunities (especially for large and global actors in the biomass market) • Emphasised global trading of biomass	• Increasing energy consumption sets challenges to environmental and sustainability issues • "Green thinking" will decline • People might become impervious to increasing social and environmental problems caused by increased utilisation of biomass

Rich local village

In the “Rich local village”, regional barriers limit the global trade, and emphasis is on the local market with relatively small actors, as well as on economic performance and the maximisation of economical welfare.

Table 8. SWOT analysis of "Rich local village"

Strengths	Weaknesses	Opportunities	Threats
• Security of energy supply is a central objective • The market development is mainly based on economical factors • Import restrictions of biomass exhort companies to invest in local production and refining of biomass	• Price of energy will increase • Market status of biomass is sustained artificially and rapid changes in energy policy can cause trouble for market actors	• Biomass producers enjoy very promising and “wealthy” market conditions • New possibilities for the utilisation of local waste streams and energy crops	• Increases the competition for biomass with other traditional industrial users of biomass and might lead to mill closures and relocations • Risk of unsustainable utilisation of local biomass resources of the “village”

Small is beautiful

In “Small is beautiful”, the energy consumption has decreased and the emphasis is on the local market with relatively small actors, as well as on environmental, policy-related and social aspects and driving forces.

Table 9. SWOT analysis of "Small is beautiful"

Strengths	Weaknesses	Opportunities	Threats
• High emphasis on environment and sustainable development • Will lead to improved overall energy efficiency and more efficient use of raw materials • Will broaden the base of energy supply • Not vulnerable to global energy crisis	• High price of energy will hinder the economic growth • Needs a strong regulation of the energy market	• Needs new and improved energy technologies • Possibilities to develop energy efficiency and improve energy efficiency	• Lack of economic growth • Difficulties in the utilisation of local energy resources can cause regional energy crisis • Pressure towards globalisation and more important market actors

4.3.2 Finnish workshop

The scenarios crafted in the Finnish workshop and SWOT analyses of the scenarios are presented in the following. The SWOT analyses (Tables 10-12) are based on comments received from the participants after the workshop. In addition, researchers had to supplement the analysis. Comprehensive descriptions of the scenarios are found in Appendix V.

The EU rolls

The emphasis of the "EU rolls" scenario is on environmental issues that strongly affect the politics of the energy sector. The EU has also become the forerunner of renewable energy, and energy consumption has grown.

Table 10. SWOT analysis of "The EU rolls"

Strengths	Weaknesses	Opportunities	Threats
• Regulation enables stable and predictable development	• Strong EU countries manage the development • Remarkable dependence on imported biomass	• In Finland there is a possibility for diverse selection • Peat is a slowly renewable energy source • Good peat resources for full utilisation	• In emission and certificate trade no joint extension • Everyone goes their own way in subsidy politics

Technological vision

"Technological vision" stresses the importance of know-how, technology and efficiency. Distributed energy systems are in use in both heat and electricity production.

Table 11. SWOT analysis of "Technological vision"

Strengths	Weaknesses	Opportunities	Threats
• Aim is towards technologically sustainable structure (in the long-term, greater efficiency and lower emissions • Technological development • Enlarging the raw-material base of traffic fuels by developing techonology	• Access of new technology to the market takes time • Spot-market and biofuels exchange gives the market a speculative nature	• The need to develop opens up opportunities for new innovations • Integration with other industries (advantages of co-operation etc.) • Growth of Finnish companies to global actors and development	• Different means in different counties to promote renewables • Unrealistic for technology commercialisation • Slowness of technological development and failures. Fragmentariness of the field translates into ineffectiveness • contradictions between environmental demands and efficiency

Energy capitalism

"Energy capitalism" is a scenario where commodity exchange of biofuels has become true and large quantities of bio-based products are traded.

Table 12. SWOT analysis of "Energy capitalism"

Strengths	Weaknesses	Opportunities	Threats
• Actions are mostly based on a free energy market, no large subsidies are needed to promote the use of bioenergy • Resources are being utilised effectively	• Competition for land between energy and food purposes • Strong actors are the leaders, limited room for smaller market actors and producers • Environmental aspects has a low priority	• efficiency of biomass cultivation yield levels can be improved significantly by applying existing technologies • Intensification of forest industry	• Availability of nutrients and water for the production of biomass can strongly restrict the production • Mega-level actors are strong multinational companies

5 ANALYSIS OF THE PROCESS AND RESULTS

5.1 Created clusters

In the Finnish workshop, the ideas were grouped into six clusters, economy and policy being the most important groups with the lowest divergence between the opinions. Also in the international workshop the clusters including driving forces related to economy and policy were considered as the most important groups among the ten clusters that were created. The policy cluster also contains the largest number of driving forces in both cases, and driving forces in it have an influence on each alternative scenario created. It also stresses the significance of policy making in the development of the international biomass market. Although the environment cluster was not the first in order of importance, environmental aspects have notable roles in the scenarios of both workshops. Based on the number of created clusters, one might conclude that the international expert group considers the future of the international biomass market as more complicated. Additionally, as seen in Tables 4 and 5, the significance of the environment and technology clusters was evaluated higher in the international experts' case than in the Finnish case.

A significant observation is that the international experts agreed that communicational aspects, such as motivation and promoting the image of bioenergy as well as customer awareness, are important, together with other forces, in enhancing the development of the international biomass market and trade. In addition to the communication aspect, consumer and entrepreneur perspectives were highlighted more in the international workshop than in the Finnish workshop. The international group of experts stressed stable investment and market conditions as an enhancing factor. Finnish experts, in turn, partly concentrated on more detailed aspects of the international biomass market, in the technology cluster, for instance. Besides the technology development, quality aspects were also strongly emphasised. It was recognised in the Finnish workshop that international standardisation related to the technical characteristics of biomass fuels is an important subject promoting the development of the biomass market.

As a whole, the Finnish experts were more unanimous than the international experts, as the deviation in the voting on significance in the Finnish workshop varied between 0.93-1.97, while in the international workshop the range was 1.16-2.85 (Tables 4 and 5). This also implies the overall heterogeneity that existed in the international group. The divergent opinions that are revealed by analysing the voting results and deviations could be important aspects for more detailed discussion.

5.2 Evaluation of the scenarios

Reviewing the scenarios and the intermediate results of the processes, including the preliminary questionnaire, driving forces and clusters, enables the identification of the scenarios that will lead to the most desired outcome. Respectively, the worst scenarios can be identified. The international biomass market is a wide issue, and depending on the position and viewpoint of the stakeholder, the analysis will give various outcomes as the most desired scenario. In the following, the scenarios from both processes are summarised and discussed. The main focus is on the evaluation of the scenarios from the perspective of a vital and well-functioning international bioenergy market. In addition, the scenarios crafted by Finnish experts are reviewed from the Finnish national point of view.

The key characteristics of the scenarios crafted by the international group are represented in Figure 13. When considering the volume of international biomass trade, “Rich global village” would most likely result in the most voluminous trading globally. Also a strong fear of high fossil fuel prices intensely boosts the growth of international biomass trade. However, the biomass trade is only seen as a means to gain economic prosperity and it is centred into the hands of a few leading players, who set the rules and dominate the market. The activity as a whole is effectiveness orientated and the large trade volumes and internationalisation of the biomass market are not the only generally accepted objectives concerning the international bioenergy trade. The main priority along with the large trade volumes is to develop the biomass market according to the principles of sustainable development. The overall attitude in “Rich global village” might be too self-centred to meet this objective. “Small is beautiful” for one would be a proper option in terms of sustainable development, because people are aware of environmental issues and it can be called a “recycling society”. However, if does not qualify because it is an isolated community and trade barriers are set to prevent the development of international trade. “Rich local village”, on the other hand, would be the worst case scenario, because its two main priorities are the localisation of the biomass market and economic performance, paying less attention to ecological aspects. On the grounds of the objectives, large trade volumes internationally and the use of biomass in accordance with sustainable development, “Green prosperous” seems to be the scenario with the most desired results. It rises to the challenge of extensive international trade and sustainable development of the biomass market.

Figure 7. The main features of the scenarios created by the group of international experts.

The key characteristics of each scenario from the Finnish workshop are represented in Table 14. From the global perspective of the vital and well-functioning biomass market, "The EU-rolls" would be the future state to reach for because a cohesive biomass market area has taken form, and incentive and subsidy systems have been harmonised. Also clear use-targets of biomass and bioenergy are set to strongly enhance the use of biomass and bioenergy. In addition, environmental aspects affect the development of the biomass market according to the general objective connected with the biomass market development. The other two scenarios – "Technological vision" and "Energy capitalism" – are not as wide in their outlooks.

Table 13. The main features of each scenario created by the group of Finnish experts.

The EU-rolls	Technological vision	Energy capitalism
• Harmonised subsidies in the EU • Wide import of bio-based products to the EU • Security of energy supply • Environmental issues • European-wide green electricity certificates • Clear usage targets of bioenergy	• Commercialisation of key bioenergy technologies • Decentralised and efficient production units • Biofuels commercially available (spot-market, exchanges) • Certified biomass products • Biorefineries	• Free trade and global market of biomass • Procurement of biofuels from different continents • Acquiring large land areas • Conflicts between local people and big companies • No subsidies for bioenergy and agricultural production

From the Finnish national point of view neither the “EU-rolls” nor “Energy capitalism” would be the best choice for which to strive. In “Energy capitalism”, the possibilities of a single state to influence the energy market have decreased, and the “EU-rolls” will lead a remarkable import of bio-based raw-materials and fuels. “Technological vision”, for one, would be the future state of bioenergy markets to strive for in terms of Finnish success. Finland has a vast amount of technological knowledge and long-term experience on the utilisation of wood in energy production. In addition, Finland has know-how to conduct research and development activities in the field of bioenergy, which are the main priorities in the “Technological vision” scenario. In addition to the research and development activities, attention should be paid to basic research in the field of bioenergy. Finland should also promote the production of liquid biofuels and heat and power production in decentralised production units, which would improve economical vitality in all parts of the country, pull down regional unemployment and reduce e.g. the transportation costs of raw-material from source to production unit as well as enable more efficient usage of by-products e.g. from harvesting and other local production of bio-based raw-materials. In this scenario, forest derived biomass is an important source of energy and Finland has the great potential to benefit from it. Finland should emphasise more and more the significance of the knowledge related to the whole forest energy chain. Also integrating the production of liquid biofuels into forest industry and plants opens up new opportunities. As a whole, Finland should invest in a position as a high-level bioenergy technology and knowledge society and thus improve its competitiveness at the global level.

5.3 Observations for the development of the international biomass market

There is one strong similarity in the scenarios created by both international and Finnish experts; all scenarios foresee an increase in the utilisation of biomass as an energy source. In addition, a few other common features can be found in all the scenarios that can be regarded as critical factors defining the future development of the biomass market:

- Price competitiveness of bioenergy
- Energy policy (taxation, subsidies, R&D)
- Imbalance between supply and demand of bioenergy (resources)
- International agreements
- Sustainability issues of the utilisation of biomass
- Strong development of liquid biofuels in coming years

From the viewpoint of a vital and well-functioning international biomass market, the scenarios "Green prosperous" and "The EU rolls" will give the most desirable outcome. These scenarios include several ideas about the actions that should be realised before the desired status is achieved. At a global level, the fundamental requirement for the well-functioning international biomass market is the removal of trade barriers. The global "Green" policy derived from international climate agreements has also to be prioritised. A strong policy is needed to guide the actions towards global and sustainable development of the biomass market. At a regional level, as in the EU, national subsidy schemes for bioenergy often contort the market of biomass and result in several separate market areas of biomass. The global biomass market has to be seen as an opportunity, and countries should recognise the importance of worldwide co-operation to ensure the positive development of the global biomass market. A well functioning certification system ensuring that biomass is produced in a sustainable way is seen as a needful tool to promote the market. Dissemination of information to consumers is important because a positive public opinion has a strong influence on politicians. It is impossible to develop the biomass market if the customer level regards biomass as an unsustainable energy source. "Green prosperous" stands for a strongly developing biomass market full of opportunities. Therefore, attention has to be paid to research and development activities, which should be concentrated on the development of production technologies and use potentials of new raw-material resources (e.g. crops) as well as on business opportunities. In the EU, the emphasis should be shifted from national energy policy measures towards harmonised subsidy systems of bioenergy. Furthermore, the import of biomass to the union should not be limited by political measures but seen as a cost-effective and sustainable measure to achieve the challenging climate targets. Also strong coupling of environmental aspects and biomass market development is necessary.

5.4 Discussion about scenario process

According to the direct feedback given by the participants involved in the process and the workshops, the use of group support systems was seen as a positive means for achieving the defined objectives. The main benefits of the workshops were mentioned to be efficiency and productivity, better handling of the whole complex issue, anonymity in sensitive issues, good working atmosphere and open discussion on the subject. Criticism was mainly related to the handling of the schedule and lack of time. For instance, in the international workshop the description work of the scenarios would have required more time because the discussion was very lively in the small groups, participants represented very different types of organisations and cultures, and there were also some language barriers regarding some concepts. On the other

hand, to achieve success in the scenario process in general and a multi-disciplinary viewpoint on the complex issue, it was very important to have a heterogeneous group of people representing different types of organisations, as well as different socio-economical and cultural aspects influencing the description of alternative scenarios. As a whole, the international biomass market is a complex and extensive subject and therefore there were slight difficulties in putting the pieces together.

6 CONCLUSIONS AND RECOMMENDATIONS

The development of the international biomass market is a very wide issue, the general characteristics of which are 1) complexity, 2) uncertainty and 3) interdependency. Because of these characteristics, a heuristic, semi-structured approach for the scenario process was presented, including the use of preliminary questionnaires as well as manual and computerised group support systems.

The international group of experts saw the economic development and welfare versus the environmental and social policies as the main driving forces at a global level. The contradiction between economy and environment is not visible in the scenarios as a level or speed of economic development. This may depend on the fast development of technologies in each case, even though into different directions. The other dimension in the scenarios of the international expert group was global versus local aspects in the evolution of the world energy economy as driving forces in the scenarios. Also here the outlooks are different at the general level, but the both developments look positive as a whole. A critical observer might say that the economy might not attain the benefits of the world trade in terms of economy in the local world.

The Finnish expert group had a conscious Finnish perspective on the energy future for the next decades. According to them, there were altogether three dimensions in the alternative driving forces of the energy future: the EU domination in the scenario “The EU rolls”, global market forces in the energy market in the scenario “Energy capitalism”, and the domination of technology and competition in the scenario “Technological vision”. All of these scenarios would bring different and varying elements into the energy future for a small open economy such as Finland.

An overall conclusion drawn from this scenario analysis are the enormous opportunities relating to the utilisation of biomass as a resource for global energy use in the coming decades. The current use of bioenergy is about 40 EJ/y, and the range of biomass potential as an energy source is in 2050 from 100 EJ/y to 500 EJ/y. This range is so wide that serious questions come up relating to conclusions based on these analyses. More research is needed to understand the future bio energy evolution. The scenario analysis shows, however, the key issues in the field: global economic growth including the growing need for energy, environmental forces in the global evolution, possibilities of technological development to solve the global problems, capability of the international community to find solutions for the global issues and the complex

interdependencies of all these driving forces. The study could be criticised for the fact that its key element – "the biomass trade at the global level" – became too dominating a factor for the evaluation. This might have made the results biased towards the utilisation of bioenergy.

The scenarios were seen as a useful tool to analyse the complex, uncertain and interdependent whole of energy development at the global level. The scenarios are possible routes to the future. They do not represent any kind of probabilities in the future development. The use of GDSS was seen among the participants as an effective means to achieve the objectives of the workshop.

The created scenarios give only one overview of how the use of bioenergy and biomass markets will look like in the year 2020. Despite this, the created scenarios give a good overall view of the alternative future states of the international biomass market, and therefore, suggest that there is not only one path to take, but several alternative ways. The creation of the scenarios does not mean that one and only one scenario will be the reality in fifteen years, but the scenarios may come true in parallel. This may help to identify the possible future events and development in the coming decades.

The created scenarios reinforce the picture of the future of the international biomass market as a complex and multi-layer subject. Many different and credible alternative future states show that the biomass market will develop and grow rapidly as well as diversify in the future. The results of the scenario process also open up new discussion and provide new information and collective views of experts for the purposes of policy makers. For firms, the scenarios provide knowledge that can be utilised in strategic decision making and e.g. in technology roadmapping of alternative future development routes. The tentative scenarios on the firm level need to be focused on more precise action scenarios and on ways to develop new business models and innovative product and service concepts for dealing with the challenges of the future in the international biomass market.

Further research is needed here also on the analysis of the probabilities of the technological and commercial aspects in each scenario as well as on what each scenario means in quantitative terms. For the practical use of the scenarios, it is also important to conceptualise the scale and directions of biomass trade streams and define the influences of the scenarios with the help of quantitative research from the viewpoints of different actors in the value network.

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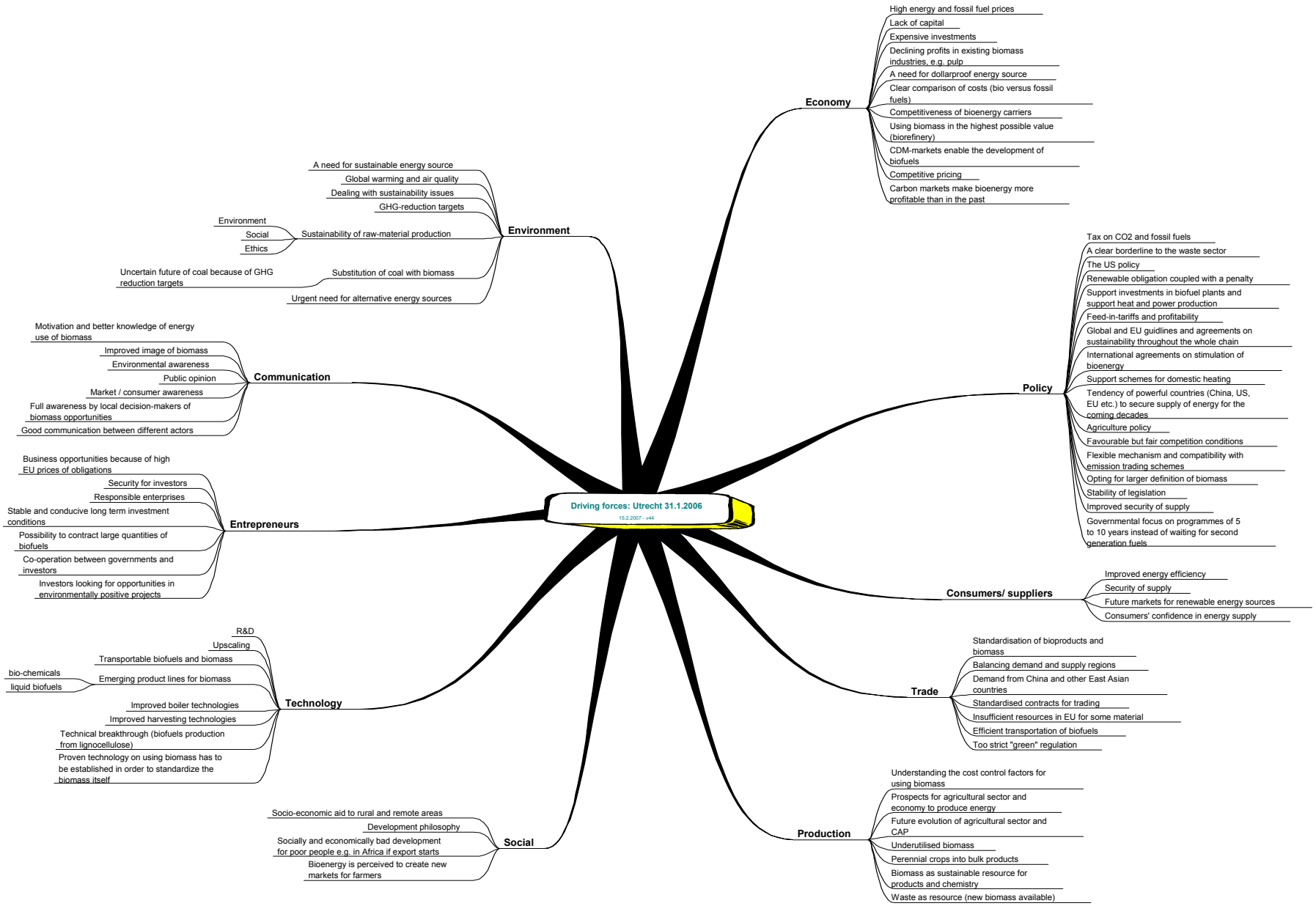
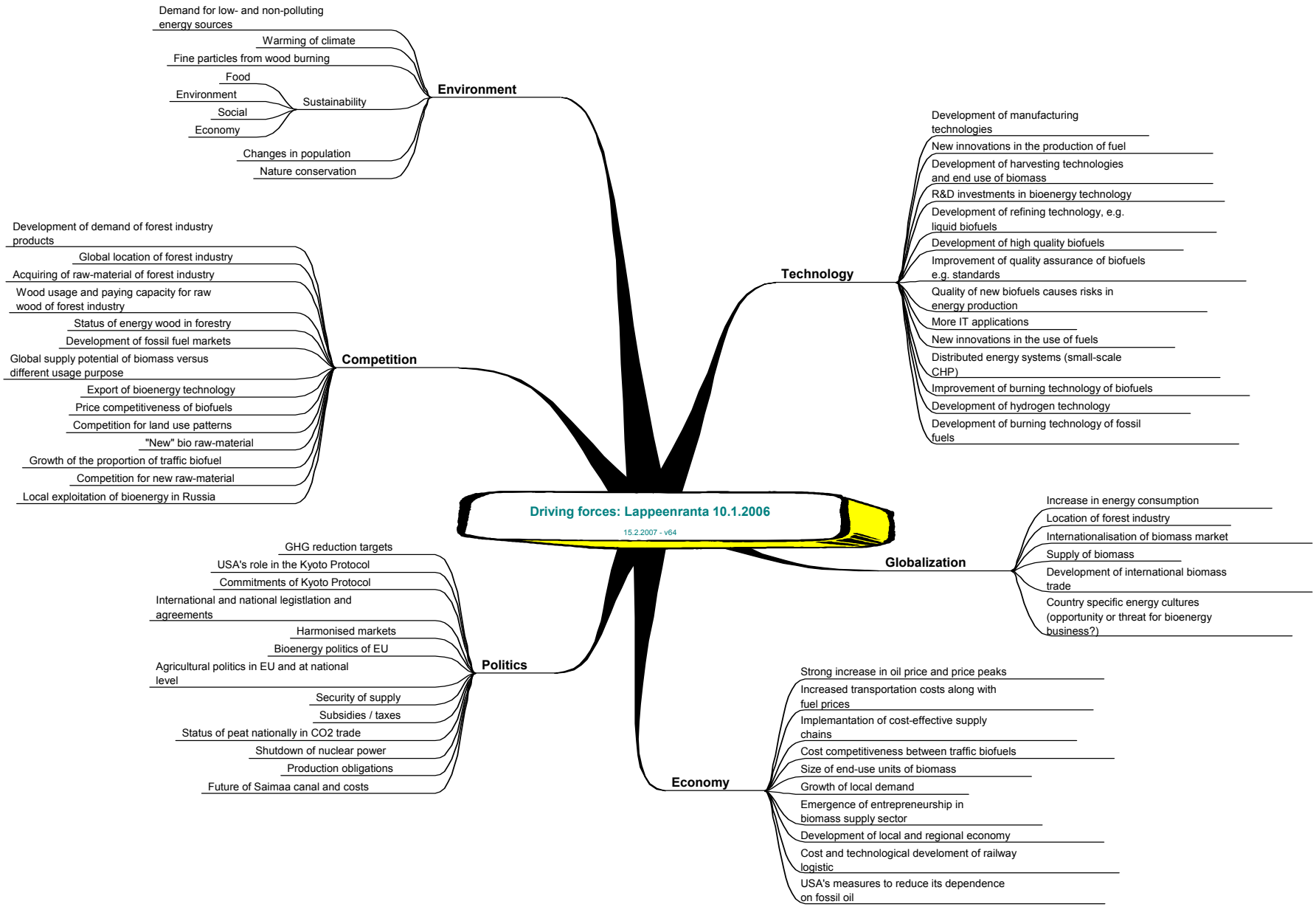

Driving forces: Utrecht 31.1.2006
15.2.2007 - v44
Economy
High energy and fossil fuel prices
Lack of capital
Expensive investments
Declining profits in existing biomass industries, e.g. pulp
A need for dollarproof energy source
Clear comparison of costs (bio versus fossil fuels)
Competitiveness of bioenergy carriers
Using biomass in the highest possible value (biorefinery)
CDM-markets enable the development of biofuels
Competitive pricing
Carbon markets make bioenergy more profitable than in the past
Environment
A need for sustainable energy source
Global warming and air quality
Dealing with sustainability issues
GHG-reduction targets
Sustainability of raw-material production
Environment
Social
Ethics
Substitution of coal with biomass
Uncertain future of coal because of GHG reduction targets
Urgent need for alternative energy sources
Policy
Tax on CO2 and fossil fuels
A clear borderline to the waste sector
The US policy
Renewable obligation coupled with a penalty
Support investments in biofuel plants and support heat and power production
Feed-in-tariffs and profitability
Global and EU guidlines and agreements on sustainability throughout the whole chain
International agreements on stimulation of bioenergy
Support schemes for domestic heating
Tendency of powerful countries (China, US, EU etc.) to secure supply of energy for the coming decades
Agriculture policy
Favourable but fair competition conditions
Flexible mechanism and compatibility with emission trading schemes
Opting for larger definition of biomass
Stability of legislation
Improved security of supply
Governmental focus on programmes of 5 to 10 years instead of waiting for second generation fuels
Communication
Motivation and better knowledge of energy use of biomass
Improved image of biomass
Environmental awareness
Public opinion
Market / consumer awareness
Full awareness by local decision-makers of biomass opportunities
Good communication between different actors
Consumers/ suppliers
Improved energy efficiency
Security of supply
Future markets for renewable energy sources
Consumers' confidence in energy supply
Entrepreneurs
Business opportunities because of high EU prices of obligations
Security for investors
Responsible enterprises
Stable and conducive long term investment conditions
Possibility to contract large quantities of biofuels
Co-operation between governments and investors
Investors looking for opportunities in environmentally positive projects
Trade
Standardisation of bioproducts and biomass
Balancing demand and supply regions
Demand from China and other East Asian countries
Standardised contracts for trading
Insufficient resources in EU for some material
Efficient transportation of biofuels
Too strict "green" regulation
Technology
R&D
Upscaling
Transportable biofuels and biomass
Emerging product lines for biomass
bio-chemicals
liquid biofuels
Improved boiler technologies
Improved harvesting technologies
Technical breakthrough (biofuels production from lignocellulose)
Proven technology on using biomass has to be established in order to standardize the biomass itself
Production
Understanding the cost control factors for using biomass
Prospects for agricultural sector and economy to produce energy
Future evolution of agricultural sector and CAP
Underutilised biomass
Perennial crops into bulk products
Biomass as sustainable resource for products and chemistry
Waste as resource (new biomass available)
Social
Socio-economic aid to rural and remote areas
Development philosophy
Socially and economically bad development for poor people e.g. in Africa if export starts
Bioenergy is perceived to create new markets for farmers



APPENDIX III

APPENDIX IV 1(4)

SCENARIOS RESULTING FROM THE INTERNATIONAL WORKSHOP

1. Green prosperous

State of biomass market in 2020:

In the year 2020 the consumption and international trading of biomass has increased remarkably compared to the situation in 2003. Strong and global green regulation has been the main reason for the past development. All the cheap traditional biomass resources are in use and new resources, e.g. dedicated crops, are being developed and utilised. Relatively free market conditions of biomass have stimulating new innovations regarding the production and utilisation of dedicated energy crops. A transparent certification system of biomass production and trade is in use and it is based on international agreements. The second generation technologies are widely in use in the production of synthetic biofuels. Because of growing utilisation of the energy crops, countries with large biomass resources such as Russia, Indonesia, Brazil etc. have now a more important role as biomass producers than in the beginning of the 21st century. It is unclear if trade between countries will happen on an important scale or will it be limited only to the surplus of biomass that can not be consumed locally. Big consumers of biomass are located in Western Europe, South-East Asia and America.

E.g. Brazil has a large surplus of crops and woody biomass and the country is probably taking part in global biomass trade as an exporter. China has invested in biomass production by planting forests. Sustainable development puts more emphasis on the education system and people now more aware of sustainability issues. An increased worry about the overexploitation and unsustainable utilisation of biomass resources has been taken into account in international agreements on free trade and mitigating the climate change.

Several markets, other than energy, have developed and benefited from the sustainable utilisation of biomass. For example, new markets for farmers and forest industry have opened up globally. Most of the forest industry's mills can be now considered as biorefineries refining biomass into traditional forest products, but also liquid biofuels and chemicals. Also the global employment situation in general has begun to look brighter and a myriad of new jobs exists especially in the production of biomass in developing countries. This has improved the economical situation in many poor countries.

Driving forces and development route of biomass market during the years 2006-2020:

During the period between 2006 and 2020, there had been a growing need for a certification system increasing the number of cases of unsustainable production of biomass, but it is not known whether the system is voluntary or obligatory. In other words, the path towards the certification system of biomass for energy remained unclear. In addition to the need of a certification system, sustainable development has been one of the key drivers of the biomass market. Also the climate change and a concern about the environment have had an influence on the development of biomass exploitation in energy production.

International agreements and long-term policies have kept the biomass production, utilisation and trade as a global issue. Additionally, incentives and obligations, technological and organisational improvements and innovations have been important driving forces for the development.

Consumers have played the most important role in the development of the biomass market. Therefore, the public opinion has been an essential factor affecting the emergence of the global market of biomass. Communication towards consumers has been in a critical role to enhance the trade of biomass and its utilisation. With a strong public and political support it is possible to plan for future success. In addition, specific education and dissemination related to bioenergy issues has also had an important role.

Year 2013 as an intermediate stopping point:

If "Green prosperous" comes true, certain things need to happen by the year 2013. There can not be any surprises and the development can be called "no-surprise strengthening of present trends". In addition, investing in new green projects has to be identified as an opportunity for economic profit. Also, biomass has to be accepted as a base-material that is readily available with a high security of supply. If things develop according to the description of the green prosperous scenario, all sectors of bioenergy of business will develop positively.

2. Rich global village

State of biomass market in 2020:

The biomass market has become global and large trade streams of biomass from dedicated production areas to the purchasing regions of biomass are a reality. Also large quantities of refined biofuels are traded worldwide. The world can be seen as a paradise full of biomass ready for utilisation and for making money. In spite of an economically orientated world, sustainability is a part of the business, but not dominating. The EU is the global leader in promoting bioenergy. The massively expanding biomass market in the EU is led by public utilities. The forest biomass in the EU has been certified as sustainable and the utilisation of forest resources has increased remarkably since the beginning of the 21st century. People are keeping themselves away from too strict green thinking because it might slow down the economic development in the short run.

The EU and North and South America are the major players in the biomass market. Brazil became certified sustainable and it attained a position as a major player in biomass trade and is the largest supplier of ethanol for the world market. This has been possible because trade barriers to the import of biomass to the United States and the EU have been removed. The biomass market would grow even faster if big players like the United States, China and India ratify the new Kyoto agreement starting in the year 2013. Energy consumption has grown because decision making of consumers is mainly based on cheap prices. Fast growth in energy consumption has led to the situation where fossil energy sources are becoming scarce, but new renewable energy sources have started to diversify the global energy supply. Palm oil is one of the major biomass products and its production in Indonesia, Malaysia, Vietnam and Brazil fulfils the prevailing loose sustainability requirements. Most of the biomass production in Africa is not certified as sustainable or secure, but on the other hand in Africa large volumes of biomass are still used locally mainly for cooking and heating. Many investments have been made in bioenergy in regions where the production potential of biomass is high, e.g. in Brazil. Biomass producers will benefit highly if "Rich global village" comes true. In addition, logistics companies will prosper because large quantities have to be transported from the production regions to the customers. Also global refiners and distributors of biofuels will profit from the market conditions.

Driving forces and development route of biomass market during the years 2006-2020:

During the period from 2006 to 2020, the market of biomass has grown as fast as possible, EU being an example. The status of the biomass market is quite similar to commodity markets, such as the oil market. The main drivers have been dwindling oil resources, the fear of even higher fossil fuel prices and socio-economical impacts of high fossil fuel prices. These factors were the main forces for enhancing large scale and global biomass production and utilisation. There was some uncertainty during the timeframe whether there was enough movement towards biomass utilisation without a high oil price or price peak because of an economically orientated world. In addition to the development of fossil fuel prices, the energy policy including instruments, such as energy taxation, carbon trade, feed-in tariffs and green certificates, can be considered as driving forces of the biomass market. However, most of the energy policy measures have been dumped, except global carbon trade that was needed to enhance the market position and local use of biomass.

Year 2013 as an intermediate stopping point:

By the year 2013, the removing of trade barriers of biomass should be well on the way and there should be perceivable signs of development towards a commodity market of biomass.

3. Rich local village

State of biomass market in 2020:

The rich local village is in other respects based on a wealthy unregulated economy, but the external trade is limited. Striving towards self sufficiency and independence from imported energy dominates the energy policy. There has been sustained economic growth, and a high level of technological development has been achieved in several sectors since the year 2006. Environmental and social sustainability have not been the priorities, however they have been taken care of in such a way that economic performance has not been impacted. High import duties of fossil fuels and other economical incentives for renewable energy have improved the competitiveness of bioenergy and boosted its consumption. A great deal of subsidies have been spent on R&D and investments in bioenergy and other renewable energy technologies for meeting the policy goals. The conditions of this scenario boost the internal production and trade of biomass, because the import of biomass has to compete with subsidised internal biomass resources and products. New local biomass sources have been introduced and they are now widely utilised in energy production. In energy production, due to availability constraints, the use of local fuels is maximised and all kinds of agricultural by-products, e.g. manure and straw, are used for energy production as well as industrial by-products and forest residues from pre-commercial thinning and final logging. The issues of biodiversity and impacts on soil conditions in the production of biomass are in the background. The price of biomass has increased close to the heavily taxed imported fossil fuels and there is a fierce competition for the limited local biomass resources. The traditional biomass-based industries, like forest industry, are coping with stronger competition for raw material than in the past. There has been a significant development in the use of liquid biofuels in the transportation sector in the EU, where biodiesel is the dominating “green” fuel.

Driving forces and development route of biomass market during the years 2006-2020:

The main driver in this scenario has been economic welfare. Therefore, the economic issues and situation have guided the development of the bioenergy sector, without significant focus on environmental performance. Efficiency has also been recognised only from an economic point of view and that is why all the resources are utilised as efficiently as possible. Protectionism of the internal market is the other dominating characteristic of this scenario. Without measures of energy policy, the competitiveness and security of the supply of local biomass would not be able to compete with import.

Year 2013 as an intermediate stopping point:

By the year 2013, if the world is going towards the “Rich local village”, the EU has given strong preference to its internal market on energy. In addition, imported energy and some biomass products such as ethanol that can be replaced by local products have been subjected to higher import duties. In the “Rich local village” biomass producers, plants and bio-refineries will mostly benefit. Also all sectors of bioenergy (heat, electricity and liquid biofuels etc.) will develop.

4. Small is beautiful

State of biomass market in 2020:

In this scenario the world consists of small, self-sufficient and isolated communities. The environmental and social aspects, especially on energy, have high priority in these communities. E.g. the EU can be regarded as a community of this type. The international trade has not grown and the general economic growth of the world has been lower than it was expected in 2006. Some regions – "the leading communities" – have been more successful in increasing their economic welfare than the rest. The relatively isolated economy and strong internal trade is specific to the communities of this world. To enhance this development, for example in the EU, more independence and power has been allocated to the member states to decide their own energy policies. This has enabled the maximised utilisation of local biomass, solar energy, wind energy and enhanced the competitiveness of local fossil energy sources, as well. There is a lot of regulation on everything, e.g. the strict regulation for international trade. Therefore, local production is important and due to the lack of international trade the prices of industrial raw material and oil have increased.

In general, the production of agricultural products and energy crops is local. Environment and the effective utilisation of raw-materials have been taken care of profoundly, e.g. more cars are using biofuels in cities and local small-scale renewable energy systems like biofuel fired CHP plants are widely applied. In addition, energy efficient neutral greenhouses are widely in use. Biomass producers and biofuel refineries are mainly local companies. The land area dedicated to biomass production has been increased. Concern about the state of the environment and climate change has led to decreasing primary energy consumption, through energy efficient technologies and measurements such as improved insulation of buildings and energy efficiency of the industrial sector. In addition, there has been a strong emphasis on promoting public transport systems.

Small-scale combined power and heat production has become a commonly utilised competitive technology on a smaller scale than previously. Recycling and reuse of materials has increased remarkably since 2006 and it is implemented on a large scale. The community of this scenario can be called a recycling society. In addition to recycling it has to be decided where to utilise different biomass or other energy sources and where to grow food products. The production of liquid biofuels is local and it is based on traditional small-scale as well as second generation technologies. The demand for biofuels has increased because of the increased price of oil. The high price of oil has made smaller cars that consume less fuel more popular. The basic idea in this scenario is that the lack of access to cheap external energy sources drives the development of energy market within the communities. The high cost of energy has been one factor that has caused a lack of overall economic growth. Particularly successful communities which have efficiently utilised their local energy resources, and developed technology in the field of energy efficiency and renewable energy have benefited from the circumstances of this scenario.

Driving forces and development route of biomass markets during the years 2006-2020:

This scenario has mainly been driven by policy and consumers. Together with policy, public opinion and general thinking have been two of the key drivers. Consumers are aware and concerned about the state of the environment which has enormously influenced the development of the bioenergy sector and the actions to enhance it. In addition, the emphasis is on localisation. When the volume of economy of a community is large enough for self-sufficiently, "Small is beautiful" can be regarded as a rather stable society in terms of the environment and with modest growth in economy and welfare. On the contrary, competition with other economic areas will be severe and without a constant adaptation of policy, after 2040 the future of the "Small is beautiful" society can go shipwrecked again within the international world.

Year 2013 as an intermediate stopping point:

If the world looks like "Small is beautiful" in 2020, by the year 2013 first generation biofuels have to be used extensively instead of waiting for the second generation, and attention must be addressed to the current social problems, which may hinder the development. If this scenario comes true, the same businesses as today will succeed, but companies will be smaller. Big companies are no longer in control of the whole energy system, but there is more diversity in energy suppliers. It is necessary to develop and to invest in new and more efficient energy technologies in order to cope with challenges of the diversifying energy supply and improved utilisation of raw-materials.

APPENDIX V 1(3)

SCENARIOS RESULTING FROM THE FINNISH WORKSHOP

1. The EU-rolls

The state of bioenergy markets in 2020:

In the negotiations of the new global climate targets, the EU took the role of a leader and the union committed itself to more ambitious targets than in the Kyoto Protocol. However, most of the industrial countries also take part in decreasing the emissions of green house gases. The EU made many efforts to rationalise its energy policy and to increase the level of the self-sufficiency of energy as cost effectively as possible. The national subsidies for the promotion of bioenergy have been harmonised. A European-wide certificate system for renewable electricity has been introduced, which has equalised the price differences of green electricity between the EU member states. The EU directive for the heat produced by renewable energy sources has been laid down, and this doubled the use of biomass in heating compared to the prevailing situation in the year 2003. The import of biomass has become a generally acceptable cost-effective way to increase the use of renewable energy and to meet the challenging climate targets of the union. Between the years 2006 and 2020, there has been a significant development in the market of bioenergy in the EU. The demand for renewable energy, especially bioenergy, has significantly increased. Furthermore, the development has been accelerated by a regional imbalance of biomass resources and demand, and the increased oil price resulting from the depleting resources. A cohesive market area of woody biomass and biofuels has been developed in Northern Europe. In 2020, the share of renewable electricity in the EU is approximately 30% and the share of liquid biofuels in the road transportation sector has risen up to 10%. The imported biomass comes from warm climate areas, such as Latin America, and it is used mainly in the road transportation sector, whereas the increase in the use of local biomass resources in the EU has taken place mainly in power and heat production. The largest share of bio-electricity in the EU is produced in condensate power plants by co-firing coal with biomass. Electricity produced from biomass is still cheaper than wind power. By the year 2020, peat has been defined as a slowly renewable energy source and it has an important role as a local energy source in areas having vast peat resources, such as in Finland.

The main idea of the scenario:

The EU takes a role as the global forerunner of renewable energy and shows the way for other regions to take over the decreasing of greenhouse gas emissions. The mitigating of climate change has become by far the major environmental driver for the energy policy in the union. This together with the aim to a strong economic development in the EU are steering the development of the bioenergy market. The measures towards free trade and removing the barriers to biomass trade are in a central position. The common benefit of the union is prioritised in the energy policy before that of separate member states. The harmonisation of the energy policy will enable the union to meet its climate target, but it will cause disadvantages for separate member states and branches of industry refining biomass into products. Other factors, such as other environmental, social and agricultural factors, have minor importance. The price of biomass in the EU will increase, but less than in the situation where the import of biomass to the union is strongly limited.

Influences on the bioenergy sector:

By the year 2020, the harvesting of woody biomass has increased close to the sustainable level. Especially the utilisation of harvesting residues, stumps and small-diameter energy wood has increased. In addition, the production of energy crops has increased, but the production in northern parts of the union is not able to compete with southern and more favourable agricultural areas. The development of the biomass market is driven by EU directives and union-wide measures instead of national energy policies. There is a strong competition for pulp chips and pulpwood between forest industry and energy producers, and this competition can not be mitigated through the measures of a national energy policy. A significant part of the pulpwood harvesting is consumed in energy production. The pulp and paper production capacity has partly moved to countries where raw wood prices are lower, but on the other hand, forest industry has been able to develop new business in the production of wood-based refined biofuels. The development of the bioenergy sector has offered new jobs e.g. in the space the heating sector, where oil and gas have been replaced by biomass.

2. Technological vision

The state of bioenergy markets in 2020:

The research and development work of bioenergy yielded significant results especially in the field of refining and end-use of biomass. First, the production of liquid biofuels was based on vegetable oils, but the price peak of oil speeded up the commercialisation of biomass to liquid technologies and biomass gasification, and their commercial breakthrough took place around 2010-2015. Since the shock of the oil market, the price of oil has gone down, but has remained at a remarkably higher level than in 2006. As a result of the increased price of oil, the production of liquid fuels from natural gas and coal became feasible. Gas and coal now partly replace oil as a raw-material of diesel fuel and gasoline. Weak price competitiveness against fossil fuels limits the investments in bioenergy, but the moderate subsidising of renewable energy has boosted the market penetration of bioenergy. The standardisation of biofuels and establishing exchanges for biomass were important factors facilitating the development of the biomass market. Biofuels have approximately a 10% proportion in the road transportation sector. The production of liquid biofuels is integrated into oil refiners and the forest industry, lingosellulosic plant material and wood biomass being the major raw-material. In addition, bio-oils, such as pyrolisis oil and biodiesel, are commonly produced in smaller decentralised production units from local raw-materials. In electricity production, pulverised-coal boilers have been replaced by multi-fuel boilers that can flexibly utilise both fossil fuels and biomass. Combined heat and power production (CHP) have become popular on even a smaller scale. Most of the heating plants that have to be renovated within heat demanding industrial processes and district heating networks have been replaced by a CHP plant. Biopellets and refined liquid biofuels are the most popular fuels in the space heating sector.

The main idea of the scenario:

This scenario relies on investment in technology. The improvement of the existing technologies and the development and commercialisation of new technologies are prioritised as the main measures to improve the competitiveness of bioenergy. Higher energy efficiency is also an important goal to decrease green house gas emissions. The strong subsidies and involvement of companies push most critical technologies in the field of bioenergy, such as the production of synthetic biofuels from lignocellulosic raw-materials and the gasification of biomass for gas turbines, towards commercialisation. However, this alone is not enough, and the production of renewable energy is moderately subsidised. In addition, a higher world market price of oil than was anticipated in 2006 is in favour of renewable energy. Governments, companies and developing organisations are collaborating internationally. Thus the research, development and demonstration of new technologies need large and high-risk investments. There are many measures to be taken in the development of pyrolisis oil, bio-based liquid heating fuels, multi-fuel boilers and small-scale CHP technologies. Also new business concepts are adopted in the energy sector, and companies offer more services instead of purely delivering equipment or technology. Comprehensive energy service becomes common where the energy company is responsible for the whole chain from fuel to energy for a customer.

Influence on the bioenergy sector:

The intensive development and demonstration of technologies have created favourable conditions for companies to develop new products and business models. Especially the companies partaking most actively in the development of new technologies and investing in them among the vanguard will gain benefit. The roles of oil and forest companies will partly commingle as their involvement in biofuels will increase and they will become equally important players in the global markets of bioenergy. Generally, large companies that are able to create new business activity based on new technologies will dominate the market as equipment suppliers and biofuels manufactures, but on the other hand, there will be much space in the market for smaller and innovative companies.

3. Energy capitalism

The state of the biomass market in 2020:

The increased price of oil has made biomass a truly competitive energy source and strongly influenced the market of biomass. The trade of biomass for energy purposes has developed towards a commodity market, and biomass and biofuels are largely traded internationally such as fossil fuels. Almost all subsidy schemes for bioenergy have been dismantled because there was no need for them. In the EU, the last subsidies for the use of biofuels and agricultural production were withdrawn in 2015. After the price of oil had started to rise, investors and energy companies began to systematically acquire land areas for the production of biomass, and in parallel biofuel companies broadened their biofuel procurement to different continents. By the year 2010, the price of agricultural land has risen strongly especially in Latin America and Eastern Europe. The forest companies have also acquired more natural forests e.g. in Russia and established vast forest plantations in the tropic. By the year 2015, the situation has led to circumstances where conflicts between the local population and large companies concerning land are commonplace. In 2020, the world market price of oil has stabilised at approximately 125 €/barrel. In the EU, the forest energy resources are in utilised almost completely and one third of the cultivated area is devoted to the production of biomass for liquid biofuels. There are diverse biofuels in use, e.g. peat that was defined as a renewable energy source in 2017 and is harvested for energy purposes in peat rich countries such as Finland, Sweden and Ireland corresponding to its sustainable annual growth.

The main idea of the scenario:

The minimised market regulation and the absence of barriers to global free trade are the focus of this scenario. After the world market price of oil has doubled from its level in 2006, biomass rapidly becomes a resource and commodity similar to oil. Strong political and economic interest towards the possession of biomass resources arises. Securing the supply of energy along with the strong and urgent need to find substitutes for fossil oil are the most important factors driving the global development of the biomass market. The possibilities of governments to rule the global energy market have dwindled. Instead, large companies owned by pension funds and other institutional investors dominate large land areas in tropical regions devoted to the intensive farming of biomass. Fresh water becomes a scarce resource in many regions of the world. Conflicts regarding to the possession of fresh water and agricultural land occur commonly. Furthermore, the more regular occurrence of extreme weather phenomena, such as draught, floods and hurricanes, resulting from climate change speeds up the development in this scenario.

Influence on the bioenergy sector:

Biomass production has become a capital-intensive business – large investments have been required in acquiring and clearing land areas for biomass cultivation as well as logistics, e.g. railways and harbour facilities. The development of the refining and end-use technologies of biomass has also needed remarkable investments. The involvement of large companies and pension funds has been the prerequisite for the realisation of these massive investments. The suppliers of the harvesting technology of biomass have established assembly plants in close proximity to the biomass production areas e.g. in Latin America and Russia. Forest companies have extended their business to the production of refined biofuels that is often integrated within the existing forest industry mills. Forest companies have become more interesting investment targets for institutional investors, and their market value has increased. Several large listed companies that operate globally in the production and refining of biomass have evolved. Overall, there are favourable conditions for large multinational actors. The small group of the largest players dominate the biomass market, and most of them manage the supply chains of bioenergy from the cultivation of biomass to the marketing of biofuels.

INTERNATIONAL BIOENERGY TRADE - scenario study on international biomass market in 2020

The use of biomass for energy production can be increased remarkably from the current level over the next decades, when fossil fuels become scarce and more expensive. The markets of biomass are developing rapidly and becoming more international. Although biomass has the potential to become a more important source of energy, the remarkable increase in biomass use for energy requires parallel and positive development in several sectors, and there will be plenty of challenges to overcome. Vital and well-functioning international biomass market will be one of the key factors combining the production potential and growing demand for biomass. The main objective of the study was to clarify the alternative future scenarios for the international biomass market for until the year 2020, and based on the scenario process, to identify underlying steps needed towards the vital working and sustainable biomass market for energy purposes.

The scenario processes reinforced the picture of the future of international biomass and bioenergy markets as a complex and multi-layer subject. The scenarios estimated that the biomass market will develop and grow rapidly as well as diversify in the future. The results of the scenario process also opened up new discussion and provided new information and collective views of experts for the purposes of policy makers. An overall view resulting from this scenario analysis are the enormous opportunities relating to the utilisation of biomass as a resource for global energy use in the coming decades. The scenario analysis shows the key issues in the field: global economic growth including the growing need for energy, environmental forces in the global evolution, possibilities of technological development to solve global problems, capabilities of the international community to find solutions for global issues and the complex interdependencies of all these driving forces.

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