LONG-TERM BIOENERGY-SCENARIOS FOR AUSTRIA: IDENTIFYING EFFICIENT PATHS AND A CORRESPONDING ACTION PLAN

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ABSTRACT: The paper provides insight into the long-term perspectives of the Austrian bioenergy sector. First the methodology is described with a focus on the dynamic simulation model Green-$X_{Bio-Austria}$ and its input parameters. Second, four simulations of scenarios of the Austrian bioenergy sector up to 2050 are presented. They give an impression of the achievable contribution of bioenergy to the Austrian energy supply in the sectors heat, electricity and mobility, the achievable GHG saving and the costs related to it. The scenarios are based on different bioenergy policies and provide a basis for conclusions on how the efficiency of the bioenergy sector can be maximized. Cost-efficiency and greenhouse gas emission reduction are considered as the main criteria. Finally, recommendations for policy measures are derived and current policies (especially in the field of liquid biofuels) reviewed critically. The model results indicate that ambitious biofuel quotas are not reasonable for Austria. A bioenergy strategy should instead focus on promoting heat and – to some extent – combined heat and power generation.

Keywords: bio-energy strategy, bio-energy policy, economic aspects, CO2 emission reduction

1 INTRODUCTION

The enhanced use of bioenergy is of major strategic importance for the future energy-supply and the establishment of a sustainable energy system. Considering the political effort throughout Europe (and partly global) to increase the utilization of bioenergy (e.g. biomass action plan, RES-E directive, biofuels directive and the proposal for a RES-directive [4]), it is essential to carry out profound systematic and strategic investigations about possible long-term developments in the bioenergy sector.

There is a huge variety of bioenergy systems, both concerning the primary energy resources (e.g. forestry and industrial residues, different energy crops, agricultural wastes, biogenous municipal solid wastes) and the technologies applied. Energy services that can be provided with biomass include electrical applications, low-temperature and industrial heat and mobility. However, biomass resources are limited and the way these limited resources are utilized determines the ecological and economic efficiency of the bioenergy sector.

The paper is organized as follows:

- **Chapter 2** gives a short description of the objective.
- In **Chapter 3** the methodology is described; this includes an introduction into the model Green-$X_{Bio-Austria}$ (Green-X-BA).
- **Chapter 4** gives a short summary of the status quo of bioenergy utilization in Austria.
- Selected model input data, including costs and emissions of bioenergy technologies, biomass resource potentials and scenarios for the energy demand in Austria, are presented in **Chapter 5**.
- In **Chapter 6** simulation results of the model Green-X-BA are presented and analyzed.
- In **Chapter 7** conclusions and recommendations concerning bioenergy policies are derived.

2 OBJECTIVE

The objective of this paper is to carry out investigations about possible long-term developments in the bioenergy sector for the case of Austria. Furthermore, conclusions concerning a strategy for maximizing the efficiency of the bioenergy sector are drawn.

Crucial questions concerning the future development of bioenergy are:

- To what extent can domestic biomass resources contribute to a sustainable energy system?
- What percentage of the energy demand (heat, power and transport fuels) can be provided with bioenergy?
- What is the greenhouse gas (GHG) emission reduction which can be achieved with the enhanced use of bioenergy?
- To what extent should bioenergy policies focus on the heat, power or transport sector?
- To what extent can the future development of the bioenergy sector be influenced with subsidies, taxes, quotas etc.?
- Apart from reducing GHG emissions, what other positive aspects of bioenergy have to be considered?

These are the questions we are assessing in the project "Bioenergy Strategy 2050". The project is carried out for the Austrian ministry of transport, innovation and technology and will be completed in August 2008.

3 METHODOLOGY

The central element of our approach is the design and application of the dynamic simulation model Green-X-BA. To provide the necessary model input data, a biomass technology review, an assessment of biomass resource potentials and a comprehensive analysis of the currently installed capacities of bioenergy plants in Austria (technologies, age structure etc.) have been carried out.

The scenarios of the future development of the bioenergy sector are generated with the dynamic simulation model Green-X-BA. Basically, the model simulates investments in bioenergy plants (biomass boilers, CHP-plants and biofuel production plants) based on economic criteria on an annual basis. The parameters which are considered in the simulation include:

- Costs of bioenergy plants (To assess future costs the concept of learning curves is applied.).
- Reference price developments (for fossil transport fuels and heat and power from conventional fossil-fuelled plants).
- Non-renewable GHG emissions of bioenergy plants and reference systems.
- Primary energy potentials of biomass.
- Promotion schemes for bioenergy (e.g. investment subsidies, quotas, taxes etc.).
- Energy demand (heat, electricity and transport fuels).

The main results of the simulation runs are time series up to 2050 of:

- The installed capacities of bioenergy plants of different sizes and technologies.
- Primary energy consumption of these plants.
- The annual energy output of these plants.
- GHG emission reduction and reduction costs.
- Additional costs of the bioenergy sector compared to the reference systems.
- The share of bioenergy in the sectors heat, electricity and transport fuels.
- Total expenditures for promoting bioenergy.

Figure 1 gives a simplified overview of the structure of the model Green-X-BA and its input and output parameters.

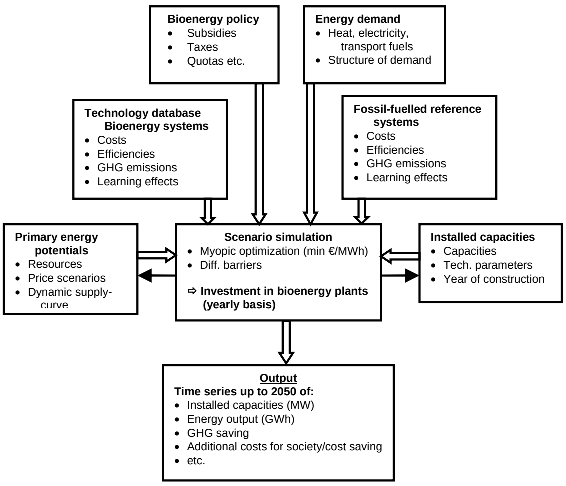

Figure 1: Simplified structure of the model Green-X-BA

Some hard facts about the model:

- The biomass resource potential is implemented as a cost-supply curve consisting of more than 50 categories.
- About 250 technology chains (combinations of biomass fuels, conversion processes and end-use technologies) are represented.
- The currently installed bioenergy capacities in Austria are represented by approximately 250 datasets.

To get an impression of the effects of different promotion strategies, simulation runs with different priorities are carried out (e.g. a focus on biofuels for transport or heat and power generation). Due to the limited length of this paper, sensitivity analyses for exogenous parameters (such as price scenarios, energy demand scenarios, technological progress etc.) which have also been carried out are not described in detail here; but the findings have been considered in the conclusions (Chapter 7).

4 STATUS QUO - CHARACTERISTICS OF THE AUSTRIAN BIOENERGY SECTOR

In order to derive scenarios for the bioenergy sector it is essential to carry out a detailed analysis of the status quo. The following paragraphs give a short overview of the current utilization of biomass in Austria and its characteristics.

Compared to most other European countries, the contribution of bioenergy to the Austrian energy supply is quite high. Since Austria is a heavily wooded country, wood has traditionally played an important part as fuel for residential heating. More than 20% of the low-temperature heat demand is covered with biomass [1]. Outdated log wood stoves still account for the largest proportion but the number of modern high-efficiency heating systems is increasing steadily. For industrial applications, biomass is mainly used in the wood-processing industries where big amounts of wood wastes (wood residues like bark, sawdust etc.) are available and in the paper and pulp industry (waste liquor boilers). Apart from large-scale heating plants, there are also several CHP plants which are operated by wood-processing companies.

Due to the promotion of renewable energy sources, the share of biomass in the electricity production and in the transport sector has increased in recent years. Still, biomass power plants currently account for no more than 2.2% (2006) of Austria’s electricity demand [2] and since 2006 progress has almost come to a halt. The main reasons are alterations in the legislation for the support of green electricity on the one hand, and shortfalls of biomass fuels (due to the rapidly rising demand in recent years) on the other. However, an amendment to the green electricity law which provides slightly more favorable framework conditions for biomass CHP has recently been implemented.

In the transport sector, the share of biofuels will reach 5.75% in 2008 due to an obligatory quota and, according to the government program there are ambitious plans for a further increase (10% until 2010 and 20% until 2020). However, these targets are not obligatory and from the current point of view are quite unlikely to be achieved.

The conditions for production of 1st generation biofuels in Austria are not suitable for producing substantial amounts of biofuels. Already now, the main part of energy plants for biofuel production has to be imported, since there is not enough arable land available in Austria to grow the amount required to fulfill the current biofuel quota of 5.75%.

Figure 2 shows the historic development and a short-term outlook (until 2010) of the primary energy consumption of biomass for the different applications.

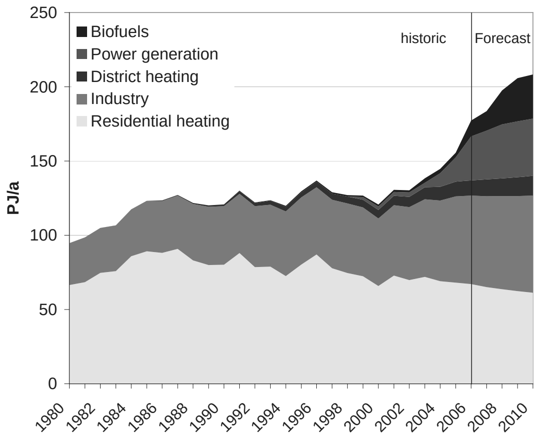

Figure 2: Historic primary energy use of biomass in Austria and forecast until 2010

5 MODEL INPUT DATA

In the following chapters some of the model input data are presented, in order to give an impression of the data the simulation runs are based upon.

5.1 Energy demand scenarios

The development of the total energy demand (heat, electricity and transport fuels) is of course a crucial parameter for any long-term energy scenario. In the past, we have experienced a steady increase in all sectors in Austria. In a baseline scenario [5], the electricity demand will continue to rise significantly until 2030, while the increases in the heat and transport fuel demand will rather stabilize after 2015 and 2020, respectively. However, serious efforts in energy efficiency could result in significant reductions in energy demand. Figure 3 und 4 illustrate the historic development of the energy demand and scenarios for the different sectors.

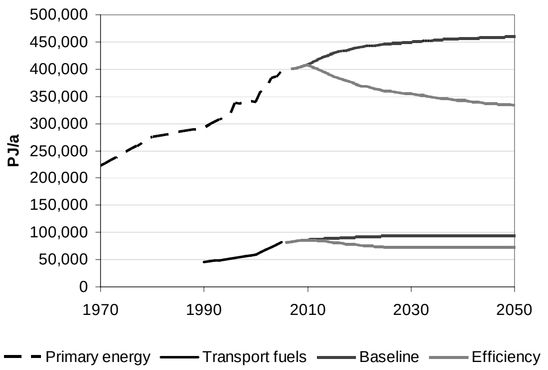

Figure 3: Total primary energy consumption and road transport fuel consumption (final energy) in Austria; historic development, baseline- and efficiency-scenario
Sources: based on [5], EEG

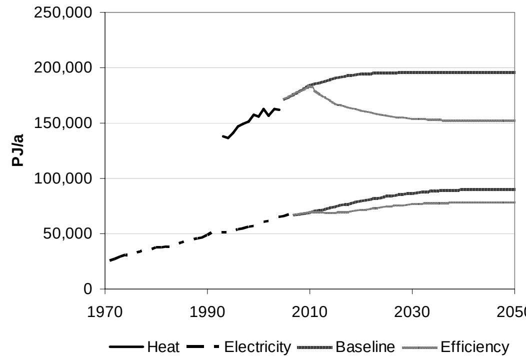

Figure 4: Heat (residential and industrial heat – end energy) and electricity consumption (final energy) in Austria; historic development, baseline- and efficiency-scenario.
Sources: based on [5], EEG

5.2 Costs of bioenergy technologies

The input data for the model Green-X-BA include technical data (efficiencies, capacities etc.) and costs (investment costs, operation cost etc.) for biomass heating systems, CHP plants and biofuel production plants. Based on these data and biomass fuel prices, heat and power generation and biofuel production costs are calculated. Since fuel prices and costs are subject to dynamic changes, the generation costs of each technology have to be calculated for each simulation year.

Figure 5 shows a comparison of typical heat generation costs of different small-scale biomass boilers for the year 2010. The total costs are subdivided into investment and operation costs, fuel costs, costs for conversion or preparation (e.g. pelletization, gasification) and a trade margin for end consumers. Typical heat generation costs of fossil-fueled heating systems (oil and gas boilers) range from 85 to 120 €/MWh (in the year 2010 in a low-price scenario). Thus, in this scenario small-scale biomass heating systems with a capacity of 30 kW or more are basically competitive to the fossil-fuelled reference.

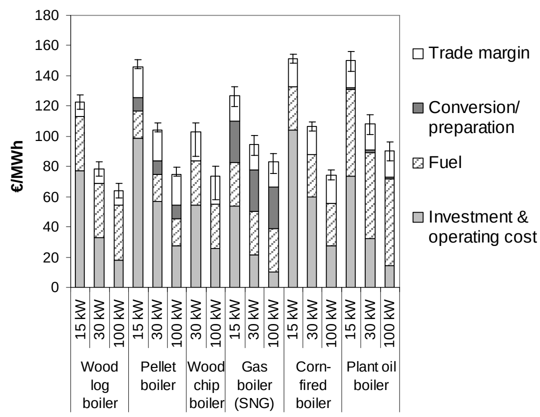

Figure 5. Heat generation costs of small-scale biomass boilers in 2010.

In Figure 6, typical power generation costs of selected biomass CHP plants (steam turbine and biogas plants) are illustrated. In this figure costs for transportation, which can be significant especially for larger plants, are not considered. In the model Green-X-BA, transportation costs are assumed to depend on the size of the plant. Further technologies which not shown in Figure 3 but are considered in the model Green-X-BA include vegetable oil CHP plants, fuel cells, (micro-) gas turbines, gas and steam plants, etc. Generally the power generation costs of biomass CHP plants are clearly higher than current electricity wholesale prices of about 60 €/MWh (average EEX Base Futures price for 2009). Hence, without any subsidies, power generation with biomass is usually not economic. Exceptions in Austria are CHP plants of the wood-processing industries, because of the big amounts of cheap fuels available (wood wastes and waste liquor of the paper and pulp industry) and the substantial heat demand throughout the whole year.

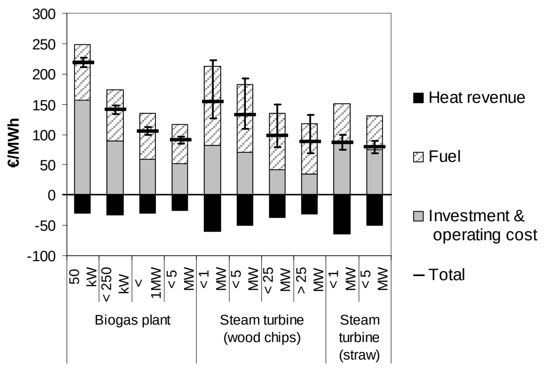

Figure 6. Power generation costs of selected biomass CHP plants in 2010.

Typical production costs for biodiesel and ethanol in Central Europe reach from about 70 to 85 €/MWh. They highly depend on raw material prices, which are unlikely to decrease significantly on the long term. Therefore, significant cost reductions in the production of 1st generation biofuels cannot be expected. Since there are currently no data from large-scale 2nd generation biofuel production plants, costs can only be estimated. In the model runs it is assumed that the large-scale production of 2nd generation biofuels will be feasible from 2015 and that the production costs will be about 75 to 90 €/MWh (depending on the raw material used).

To assess future energy production costs, raw material price scenarios are assumed and the concept of learning curves is applied. As an example, the power generation costs of a biogas plant are shown in Figure 7.

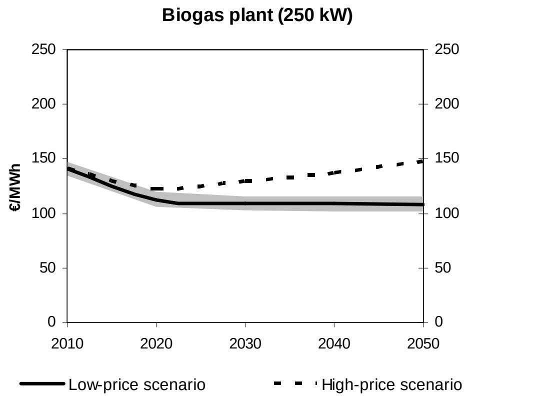

Figure 7. Example for the dynamic development of power generation costs up to 2050.

5.3 GHG impact of bioenergy technologies

The reduction of GHG-emissions is a main reason for promoting bioenergy. However, due to fuel and power demand for raw material provision and preparation, the use of pesticides and fertilizers etc., the application of bioenergy technologies is also connected with the emission of non-renewable greenhouse gases.

Especially in the case of liquid biofuels, these emissions can be significant. Figure 8 gives an overview of relative GHG emission savings with biofuels (compared to fossil fuels). The data in literature vary widely. There are two main reasons: First, different methods for life-cycle assessment are applied and second, different specifications of the production plants (e.g. energy source, utilization of by-products) can cause considerable differences. The input data for the model Green-X-BA are primarily based on the *typical greenhouse gas emission saving* stated in Annex VII of the proposal for the EU RES directive [4].

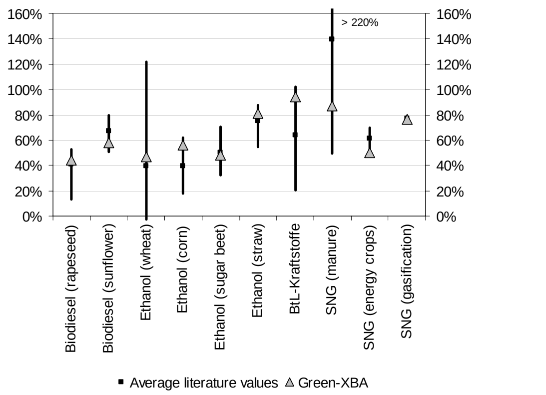

Figure 8: Relative GHG emission saving with biofuels

Figure 9 illustrates the GHG emission saving with biomass-fired heating systems, compared to a fossil-fuelled reference system (mix of oil and gas heating systems). Typical saving of wood log/chip boilers reach up to more than 90 %.

The Austrian mix of fossil fuelled power plants has been chosen as the reference system for biomass CHP. With the electricity and heat output taken into account, typical relative GHG savings of biogas plants reach from 100 to 200% (mainly depending on the substrate used), those of steam turbine CHP plants can be even higher, assuming a high heat utilization rate.

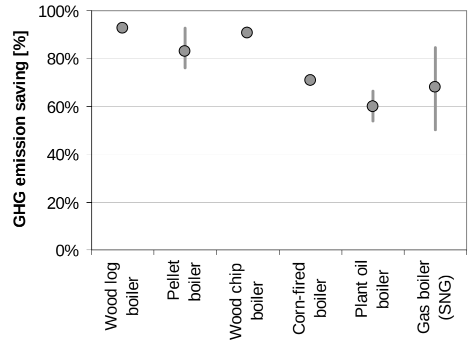

Figure 9: Relative GHG emission saving with biomass heating systems

5.4 Primary energy potentials

The current use of biomass primary energy resources in Austria (2005) and the results of the potential assessment are shown in Figure 10. They can be considered as feasible potentials with respect to ecological restrictions.

It is clear to see that forest resources and residues of the wood processing industries (wood chips, bark, saw dust etc.) are already used extensively and that the additionally available potential of these fractions are quite limited. The bulk of the currently unused potential is agricultural resources (energy crops, plant residues, grassland yields, manure etc.). Waste wood and other biogenous wastes only play a minor part.

As already stated, the focus of this paper is on the optimal use of the domestic biomass resources. However, since already today vast amounts of rapeseed are being imported to Austria for producing biodiesel, imports cannot be neglected in the simulation runs. Limited import potentials of wood chips and energy crops are therefore included as separate fractions.

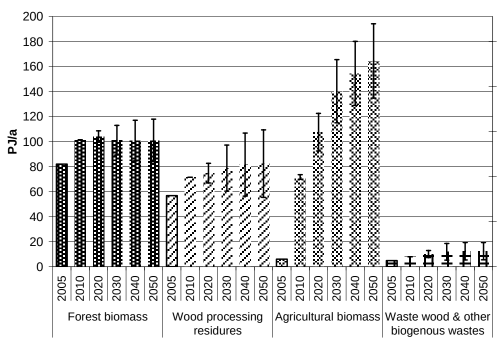

Figure 10: Current utilization of biomass resources in Austria (2005) and feasible potentials (2010 – 2050)

6 SIMULATION RESULTS - SCENARIOS

In the following chapters, simulation results of the model Green-X-BA are illustrated. The simulations are all based on a Low-price scenario, i.e. the assumed increase in real prices (fossil fuels and biomass) is assumed to be relatively low (about 25% from 2010 to 2050 for fossil fuels; based on [5]). Concerning the development of the energy demand, the Baseline scenario (see Chapter 5.1) is assumed.

Basically, the following simulations are to illustrate the effects of different bioenergy policies. The first simulation is a No-Policy scenario. In the simulation entitled “Heat-and-Power scenario”, feed-in tariffs are granted for power generation (over a period of 15 years; value depending on the fuel used) and investment subsidies for small-scale heating systems (20 % of the investment costs). In the “Balanced-Policy scenario” additionally a biofuel quota of 10% is obligatory from the year 2020 (as proposed by the European Commission [4]). In the “Biofuel scenario”, a very ambitions quota of 10 % in 2010, rising to 30 % until 2030 is simulated. (Until 2020 a share of 20% is obligatory which is consistent with the current Austrian government program.) These framework conditions are summarized in Table I. The results of the simulations concerning costs and GHG savings are discussed in Chapter 6.5.

Table I: Overview of promotion schemes in the scenarios

Sector	Small-scale heat	Power generation	Biofuels
Promotion scheme	Investment subsidy	Feed-in tariffs	Quota
6.1 No-Policy scenario	No	No	No
6.2 Heat-and-Power scenario	20%	Yes	No
6.3 Balanced-Policy scenario	20%	Yes	10% (2020-2050)
6.4 Biofuel scenario	20%	Yes	10% (2010) 30% (2030-2050)

The following chapters are to give an impression of the conveniences of the model Green-X-BA: Since various influencing factors including primary energy potentials, economic parameters, demand-side restrictions, promotion schemes etc. are considered, the results give a comprehensive insight into possible long-term developments of the Austrian bioenergy sector.

Of course the simulation results are highly sensitive to exogenous scenario parameters which can only be estimated roughly. The authors are aware of the uncertainties which are connected with any long-term scenarios and consider it as essential to keep underlying assumptions in mind (such as the development of fuel prices or the energy demand). Sensitivity analyses can help to better understand the influence of certain parameters and get an idea of the range of possible developments.

However, the whole range of simulations and sensitivity analyses we are carrying out in the project “Bioenergy strategy 2050” would go far beyond the scope of this paper. Therefore, the main objective is to give an overview of our methodical approach and the purpose of the model Green-X-BA, to show some simulation results and draw robust conclusions concerning future prospects of the Austrian bioenergy sector.

6.1 No-Policy scenario

For this simulation run, no subsidies, quotas, feed-in tariffs or other promotion schemes for bioenergy were assumed. Thus, in this scenario bioenergy plants are only installed if they are competitive to the fossil-fuelled reference systems without any financial support.

Figure 11 shows one of the simulation results: the development of the biomass primary energy use in small-scale and large-scale heating plants, CHP and biofuel production plants. It is clear to see that after 2010 (the simulation starts with the year 2011) no more biofuel production plants are installed. As soon as the already installed production plants reach the end of their life-time no more resources are used for biofuel production, since the production of biofuels is not economic without promotion schemes (at least in case of this low-price scenario). In the model it is assumed that once a plant is installed, it will stay operational until the end of its life-time, no matter if it is economic or not.

Similarly, the share of CHP plants decreases significantly around 2020, since only a very limited number of CHP plants are economic without feed-in tariffs.

Only in heat production an increase in plant capacities can be observed in the No-Policy scenario. This is due to the fact that already today heat generation with biomass is competitive to fossil fuelled plants (an exception are very small biomass boilers with a capacity of less than 15 kW).

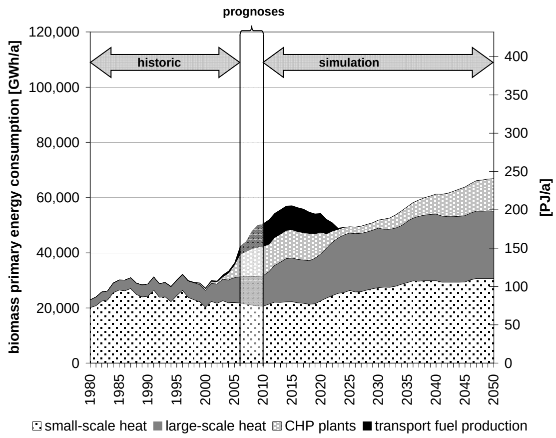

Figure 11: No-Policy scenario; biomass primary energy consumption of heat, CHP and biofuel production plants

Figure 12 illustrates the shares of the total energy demand which are satisfied with bioenergy in the No-Policy scenario. The decline in electricity and biofuels around 2020 is clear to see, as well as the steady increase in the heat supply.

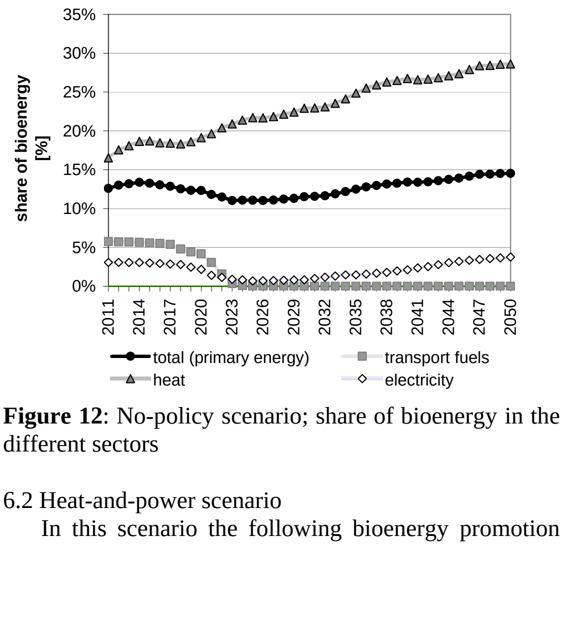

Figure 12: No-policy scenario; share of bioenergy in the different sectors

6.2 Heat-and-power scenario

In this scenario the following bioenergy promotion schemes are introduced: feed-in tariffs for electricity from biomass CHP plants and an investment subsidy for small-scale biomass heating systems (up to 100 kW) of 20%. The main difference in the resulting scenario compared to the No-Policy scenario is a higher deployment of CHP plants, partly at the expense of large-scale heating plants. With higher feed-in tariffs (the values in this scenario are relatively low), a much stronger shift towards combined heat and power generation could of course be brought about.

This simulation illustrates that by promoting biomass CHP additional resource potentials can be activated and a higher share of bioenergy can be achieved (cp. Figure 13 and 14). The effects on the GHG impact and the overall costs will be shown in Chapter 6.5.

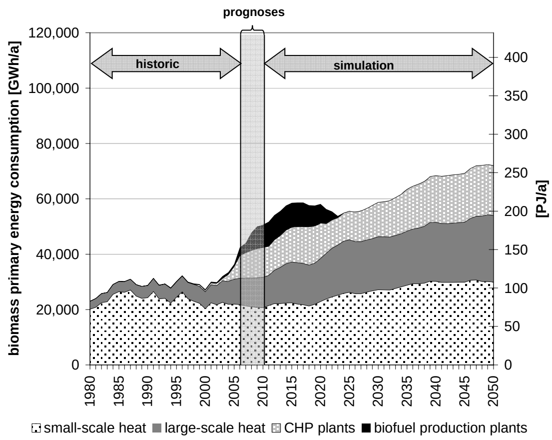

Figure 13: Heat-and-Power scenario; biomass primary energy consumption of heat, CHP and biofuel production plants

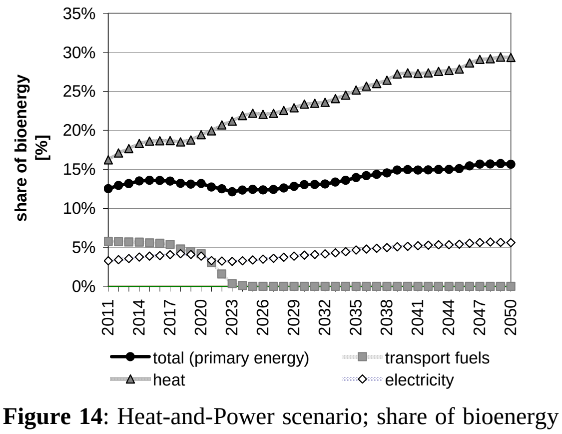

Figure 14: Heat-and-Power scenario; share of bioenergy in the different sectors

6.3 Balanced-Policy scenario

A core objective in the current bioenergy strategy of the European Union is to increase the share of biofuels in the road transport sector. For this scenario the obligatory biofuel quotas of 5.75% in 2010 and 10% in 2020 (as intended by the European Commission) are simulated.

Figure 15 illustrates that this measure has a massive influence on the whole bioenergy sector. As stated above, already today vast amounts of energy crops are imported to Austria in order to fulfill the 5.75% quota. With the introduction of 2nd generation biofuels (which are assumed to become commercially available by 2015) the demand for lingocellulose biomass increases significantly. Thus, 2nd generation biofuels are produced at the expense of heat and power generation. This has a negative impact on both the economic performance and the GHG impact of the bioenergy sector, as will be shown in Chapter 6.5.

An obvious alternative would be to import vast amounts of either raw materials or biofuels. This however would neither result in reduced import dependency, nor generate domestic income effects. Furthermore, concerns about the sustainability and all kinds of possible adverse effects of biofuel production in countries which are capable of producing vast amounts of biofuels (mostly developing countries) have to be considered.

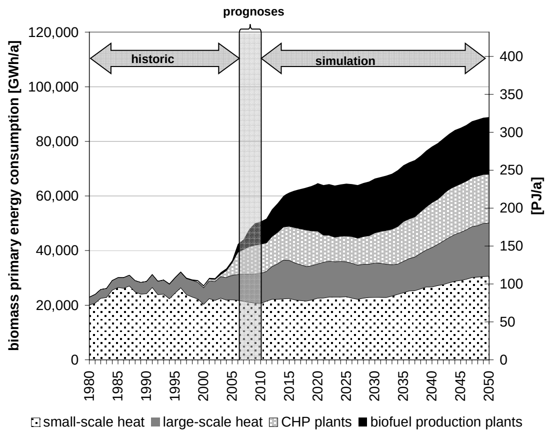

Figure 15: Balanced-Policy scenario; biomass primary energy consumption of heat, CHP and biofuel production plants

As Figure 16 shows, the fulfillment of the biofuel quota results in a clearly lower share of bioenergy in the heat sector (compared to the previous scenarios). The higher share of biomass in the total primary energy consumption is caused by higher imports.

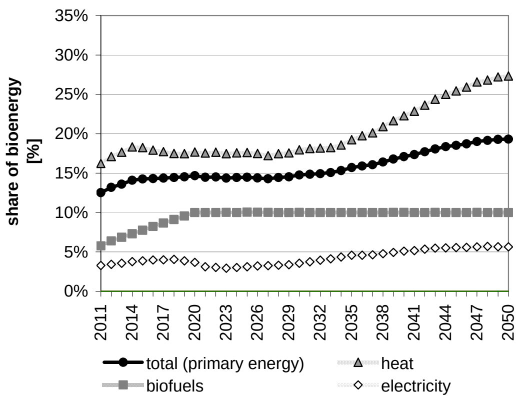

Figure 16: Balanced-Policy scenario; share of bioenergy in the different sectors

6.4 Biofuel-scenario

According to the Austrian government program a biofuel share of 10% is intended for 2010 and 20% for 2020. The quota for this scenario is based on these benchmarks and is extended to 30% by 2030.

Figure 17 shows quite impressively what amounts of biomass would be required to fulfill this quota. Already in the year 2020 the biomass consumption for biofuel production accounts for about 50 % of the total consumption. If we assume limited import potentials (as it was done in the simulation) the biofuel quota causes a dramatic shortage of biomass for heat generation.

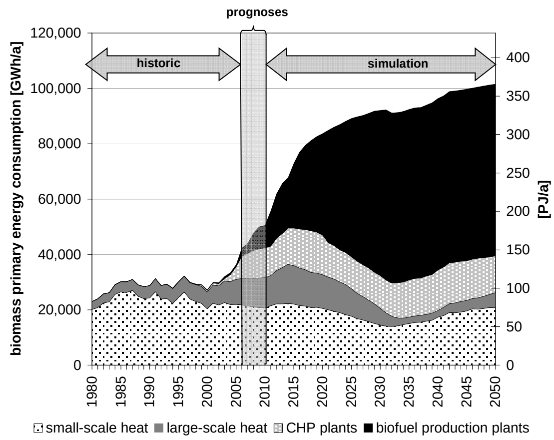

Figure 17: Biofuel scenario; biomass primary energy consumption of heat, CHP and biofuel production plants

Figure 18 illustrates the rapid increase of bioenergy in the transport sector according to the quota and the resulting decline in the heat sector. Due to the feed-in tariffs assumed in this simulation, combined heat and power generation has a higher profitability than sole heat generation and is therefore not effected as much by the shortage of biomass fuels.

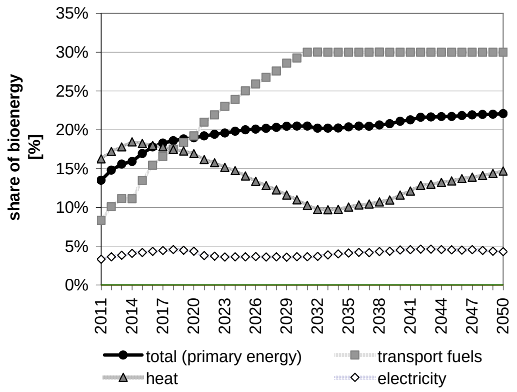

Figure 18: Biofuel scenario; share of bioenergy in the different sectors

It is essential to note that the impact of a quota strongly depends on the total demand of transport fuels. Thus, an ambitious efficiency scenario leading to a substantial decrease of transport energy demand could change these results correspondingly.

6.5 Comparison and discussion

In the following figures, the four scenarios are compared with regard to the achieved GHG saving (Figure 19) and the costs of GHG saving (Figure 20). The data illustrated in these figures are annual averages over the whole bioenergy sector.

In Figure 19 it can be seen that there are only slight differences in the total GHG saving between the four scenarios. The main reason why there is no stronger increase in GHG saving over the 40-year-period is that we assume an improvement in the specific GHG emissions of the fossil-fuelled reference systems (see e.g. [5]).

By comparing the results of the No-policy and the Heat-and-Power scenario it becomes obvious that by promoting biomass CHP, additional GHG savings can be achieved. However, the costs for promoting biomass CHP also result in higher average costs of GHG saving (see Figure 20).

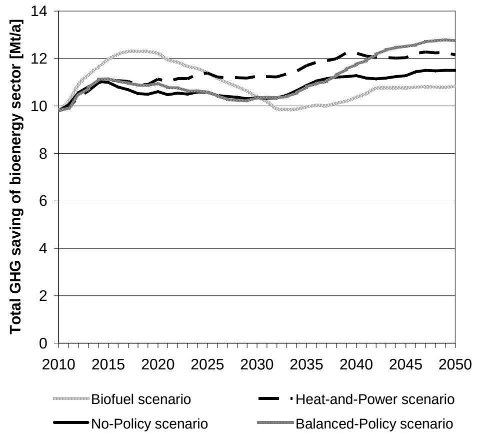

Figure 19: Comparison of the total GHG saving in the four scenarios

The results of the Balanced-Policy scenario and the Biofuel scenario illustrate that the costs of GHG saving with biofuels are very high. Moreover, the total GHG reduction in these scenarios is not higher than in the other scenarios. By introducing obligatory biofuel quotas, resources are partly shifted from heat and/or power generation towards biofuel production. This has a negative impact on both the economic performance and the GHG impact of the bioenergy sector.

Even though substantial technological progress has been assumed, the production of biofuels does not become economic in the Low-price scenario. In a High-price scenario things may look different, but sole heat and combined heat and power generation still show a clearly better economic performance. Furthermore, the efficiency of 2nd generation biofuel production cannot be expected to improve significantly.

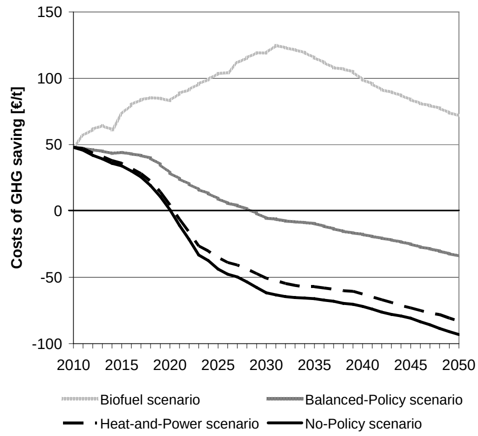

Figure 20: Comparison of the average costs of GHG saving in the four scenarios

7 CONCLUSIONS

The scenarios illustrate that policy measures can have a strong, but not necessarily positive impact on the bioenergy sector.

Biomass heating systems and large-scale heating plants are economically attractive alternatives to fossil-fuelled systems. The financial support required for a further deployment of biomass heat is relatively low. Furthermore, due to the high efficiency of biomass heating the GHG balance is very good. Even though it can be assumed that on the long-term, the heat demand for residential heating will decrease significantly, a further increase in the utilization of biomass heat is possible and should be the central objective of bioenergy policies (at least on the short-term).

Power generation with biomass is only reasonable if there is an adequate demand for the waste heat. In order to optimize the efficiency of the bioenergy sector, a high utilization rate of the waste heat should therefore be a precondition for the promotion of biomass CHP. Applications and locations with a high heat demand (at best throughout the whole year) are most suited. They should be identified and the required financial incentives for CHP established. Due to this precondition the contribution of biomass to the electricity supply should not be expected to be particularly high.

In the case of highly increasing electricity wholesale prices (due to carbon taxes and/or rising prices for fossil fuels) the economic efficiency of biomass CHP may improve significantly on the middle- to long-term.

Austria's ambitious targets concerning biofuels should be viewed critically. First, already now the Austrian agricultural sector is not capable of producing the vast amounts of energy crops required for fulfilling the 5.75% quota. Importing energy crops for the production of biofuels has neither a positive effect on domestic value added, nor does it necessarily help improve the security of supply (of security of supply depends on the country of origin). Second, the GHG impact of biofuels is poor and the total environmental impact controversial.

2nd generation biofuels are generally assumed to show a clearly better performance; both in environmental issues and in potential cost reductions. Also, significant amounts of 2nd generation biofuels could be produced with domestic resources. But as the simulations have shown, this would result in a highly increased resource demand and therefore go at the expense of biomass heat and power generation.

But what are the points in focusing bioenergy policies on the transport sector?

First of all it has to be argued that in the transport sector there are very little short-term alternatives to biofuels. For residential heating solar thermal systems and heat pumps are attractive environmentally sound alternatives to biomass, especially for well-insulated houses with a low heating load. And for power generation a wide variety of RES technologies are available.

Another point is that in the European transport sector the dependency on fossil fuel imports is clearly higher than in the electricity and heat supply. Proponents of biofuels argue that a minimum level of self-supply is also essential in the transport sector and on the short- to medium-term can only be achieved with biofuels.

Gaseous biofuels (synthetic natural gas (SNG) from fermentation or gasification) could be economically and ecologically more efficient the liquid biofuels. Of course the widespread use of SNG is only feasible if a distribution system is set up and if there is a certain demand for gaseous transport fuels.

The main advantages compared to liquid biofuels are:

- Generally higher efficiencies in the conversion process.
- Higher yields per hectare. For fermentation a wide variety of energy crops with high yields and also plant residues, biogenous wastes and manure can be utilized. Also it is possible to apply sustainable and ecologically sound cropping systems, such as multi-cropping or intercropping.
- Small-scale, decentralized production plants are feasible. A clearly higher environmental compatibility can be achieved with small-scale production plants using regionally available resources. Furthermore, regional value added can be generated in rural areas.
- Eventually lower costs (slightly higher distribution costs for SNG may make up for the savings in the conversion process).

To put it in a nutshell: A bioenergy strategy for Austria has to focus on the mobilization and efficient use of domestic resources. Economic efficiency and high GHG saving can be achieved by promoting heat and – to some extent – combined heat and power generation. Ambitious biofuel targets can only be fulfilled with imports (at least in the short term). The effects of biofuel quotas on domestic value added and GHG reduction are very limited and the additional costs are disproportionally high. Instead of an obligatory quota, the promotion of decentralized environmentally sound biofuel and SNG production plants and use in niche markets (e.g. agricultural machines) should be considered. Ambitious biofuel quotas can possibly be justified as an instrument to reduce the dependency on fossil fuel imports in the transport sector, especially due to a diversification of energy supply. But for reducing GHG emissions biofuel quotas are no suitable instrument due to their high GHG-abatement costs.

Finally, it has to be stressed that the probably most crucial aspect in order to establish a sustainable energy system are energy efficiency and reducing the energy demand. The measures which have to be taken include regulations in the field of electrical equipment, household appliances and transport, enhanced building insulation etc. By applying efficiency measures, the share of the energy demand which can be satisfied with bioenergy (and other renewable energy sources) can be increased dramatically.

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The final report (in German) will be available in early fall 2008. Further information and a summary in English can be viewed on our website:

http://www.eeg.tuwien.ac.at/biomassestrategie/