IHS Economics Series
Working Paper 227
October 2008

The Enhanced Use of Wood-biomass: Macroeconomic, Sectoral and Environmental Impacts

Todor Balabanov
Wolfgang Schwarzbauer

Institut für Höhere Studien
Institute for Advanced Studies
Vienna

Impressum

Author(s):
Todor Balabanov, Wolfgang Schwarzbauer

Title:
The Enhanced Use of Wood-biomass: Macroeconomic, Sectoral and Environmental Impacts

ISSN: Unspecified

2008 Institut für Höhere Studien - Institute for Advanced Studies (IHS)
Josefstädter Straße 39, A-1080 Wien
E-Mail: office@ihs.ac.at
Web: www.ihs.ac.at

227

Reihe Ökonomie

Economics Series

The Enhanced Use of Wood-biomass

Macroeconomic, Sectoral and Environmental Impacts

Todor Balabanov, Wolfgang Schwarzbauer

227

Reihe Ökonomie

Economics Series

The Enhanced Use of Wood-biomass

Macroeconomic, Sectoral and Environmental Impacts

Todor Balabanov, Wolfgang Schwarzbauer

October 2008

Institut für Höhere Studien (IHS), Wien
Institute for Advanced Studies, Vienna

Contact:

Todor Balabanov
Department of Economics and Finance
Institute for Advanced Studies
Stumpergasse 56
1060 Vienna, Austria
☎: +43/1/599 91-243
email: todor.balabanov@ihs.ac.at

Wolfgang Schwarzbauer
Department of Economics and Finance
Institute for Advanced Studies
Stumpergasse 56
1060 Vienna, Austria
☎: +43/1/599 91-112
email: wolfgang.schwarzbauer@ihs.ac.at

Abstract

The main objective of this paper is to identify fuel substitution potential by estimating potential price induced energy substitution and by considering available technological options. We consider the impacts of CO_2 taxation on reduction of emissions until 2020, assuming CO_2 neutrality of burning fuel wood. We finally address the macroeconomic, environmental and sectoral impacts of enhanced usages of fuel wood for energy. The main assumptions are a 1.5 times increase of fuel wood use by 2020 and achieving a share of renewables of 29.83 %. The main outcome for this scenario is that the Austrian economy could benefit from the double dividend of sustained economic growth and fulfilment of EU targets on renewables and CO_2 reduction. The prospects for the energy intensive industries deteriorate – most of them would have to reconsider their technological options and face adverse conditions for their production sites.

Keywords

Sustainable development, aggregate supply and demand analysis, demand and supply of renewable resources and conservation

JEL Classification

Q01, Q11, Q21

Comments

This research was supported by the Jubilaeumsfonds of the Austrian National Bank Grant no. 12497.

Contents

1. Introduction

From the experience of the last decades it became clear that national energy systems, including the Austrian, are highly interdependent, in that a variety of energy forms can be employed to satisfy many end uses. Secondly, alternative production modes compete for many of the same resources. Thirdly physical and technological limitations can restrict the supply or potential uses of energy. Fourthly environment effects or other externalities can alter the permissible production and use patterns, and that eventually new technologies can rapidly transform the options available.

The development of a national energy policy must therefore include a description and assessment of these and other complexities. The evaluation of alternatives must be done within the framework of a flexible system, able to include the diverse approaches that are necessary to describe and quantify the many components of the energy system.

To perform this comprehensive analysis, we combine two models, a quantitative forest-sector specific model (FOHOW) and a computable general equilibrium macroeconomic model (ATCEM-E3). Therefore we address the complex system interaction between macroeconomics, the main economic sectors, including the forest sector, and the environment (for more details see Balabanov, Revesz, 2007 and Balabanov et al., 2008).

The aim of this study is a quantification of demand, supply, trade and prices of wood products (including wood for energy[1] - further denoted as fuel wood) and their macroeconomic and sectoral impacts.

The price system is the primary mechanism for developing an efficient allocation of any economic good, including energy. Changes in prices affect the demand and supply for energy and the resulting structure of the energy use. As of mid September 2008, there was almost four times difference between the prices of fuel oil and of the wood briquettes, and the electricity tariffs are rending electrical heating 2.5 times more expensive than that using fuel oil.

Resource limitations can inhibit the increase in the potential fuelwood-for-energy supply. Storage and transportation capacities, shortages due to the not commercially active owners of the forest plots, or other limitations are a few candidates from the lengthy list of potential bottlenecks that must be addressed. To that end Forest Sector Simulation Model (FOHOW), as described in Balabanov et al. (2008), has taken care of detailed modelling of the prospects of the forest sector.

Environmental impacts are a prime example of side effects of energy production and consumption, and in our analysis we consider two particular externalities. Firstly burning fuel wood is a CO_2-neutral energy option, which might, however, adversely influence wood-processing industries. Secondly CO_2 taxation and its elevation is a prime topic in environmental policies all across the world.

The conversion technologies exhibit great variation within the energy systems - conversion efficiencies, fuel requirements, product qualities and costs are useful parameters for describing current or proposed technologies. Latest developments in fuel wood based combined heat and electricity production facilities,

[1] Wood-for-energy, or fuelwood, is a connotation for natural and processed wood burnables, e.g., wood briquettes, wood pellets, cut wood, chopped wood, chopped wood, etc.

in reduced pellets prices and improved pellets burners, slumping prices for the conventional fuel-wood/brown coal burning furnaces, etc., are factors that we have duly recognized and are included in the evaluations of the technological potential.

Inter-fuel substitution and the competition between fuels are closely related to the issue of price sensitivity. In evaluating the fuel substitution potential we consider the potential price induced by energy substitution options.

Basically, the 1,200,000 Austrian households, which are using either fuel oil or electricity for heating, can determine the fuel switching potential that is estimated at 100 PJ/year.

The energy balance for 2020 is based on analysis of the trends in energy use, judgments on energy efficiency improvements and the potential for inter-fuel substitution.

A primary externality of the energy system is the interaction with the rest of the economy. The ATCEM-E3 model (see Balabanov, Revesz, 2007) provides a basis for evaluating economic impacts of the chosen fuel-wood-for-energy policies, both at macroeconomic and at the sectoral level – indicating the effects of the economic environment on energy decisions.

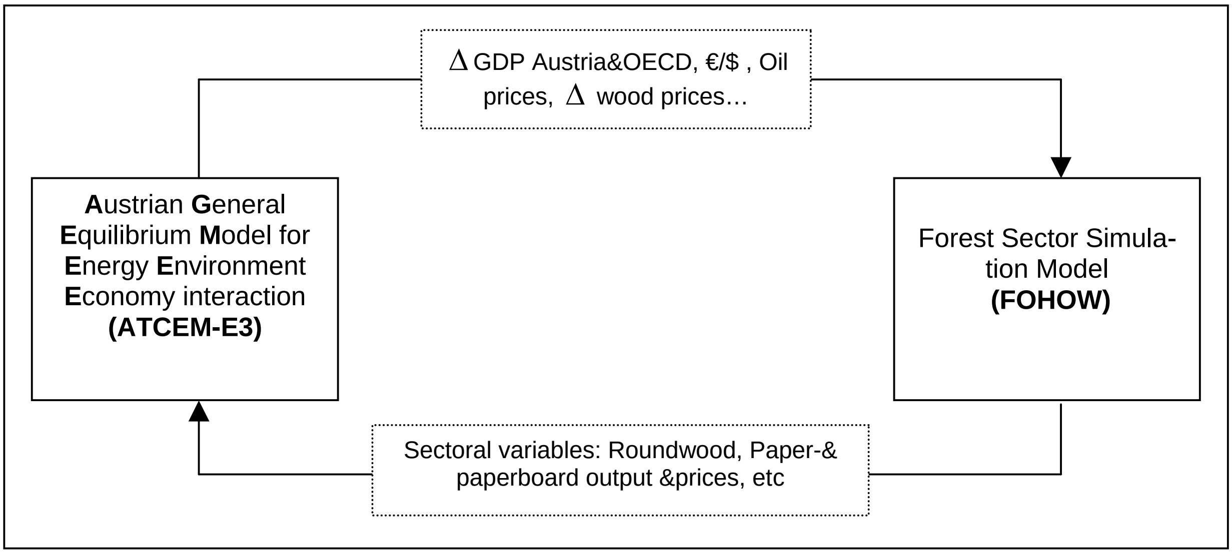
Our primary research objective is to evaluate the economic impact of fuel-wood-for-energy and CO_2 taxation policies at the macroeconomic and the sectoral level. We address the system interaction between macroeconomics, the main economic sectors, and the environment by quantifying the demand, supply, trade and prices of wood products and their macroeconomic and sectoral impacts. We secondly identify fuel substitution potential by estimating potential price induced energy substitution options and by considering the technological potential of combined heat and electricity production, improved pellets burners, but also the slumping prices for the conventional fuel wood/brown coal burning furnaces and pellets, etc. We consider the effects of a possible elevation of CO_2 taxation in the light of the EU-target to reduce CO_2 emissions by 20 % until 2020.

This paper is organised as follows: Section 2 briefly discusses the combination of the two models. The following section develops the three scenarios. Section 4 discusses the simulation results and section 5 summarizes and concludes.

2. Macroeconomic and forest sector-specific quantitative models

Our modelling framework combines two different models, a quantitative forest-sector specific and a quantitative macroeconomic model. Therefore we address the complex system interaction between macroeconomics, the forest sector and the environment. The main aim of the combination is the quantification of demand, supply, trade and prices of wood products (including wood for energy) and their macroeconomic impacts. The interaction of the models is shown in figure 1:

Figure 1: Interaction of models



Source: IHS.

As can be seen from the figure, the output generated by FOHOW is used to determine forest sector specific variables. In a second step these variables are fed into ATCEM-E3, which generates macroeconomic and sectoral effects. These effects could then be used as an input for the FOHOW and so on.

We use these two models to analyse long-term socio-economic and environmental development resulting from the 3 scenarios considered to allow the relative competitiveness of the forest sector to be analysed in the local context as well as to account for the effects of globalisation.

Within ATCEM-E3 forestry is associated with a set of energy policy variables and both relate to the economy that is represented by the social accounting matrix (for details see Balabanov, Revesz, 2007).

3. Scenario building

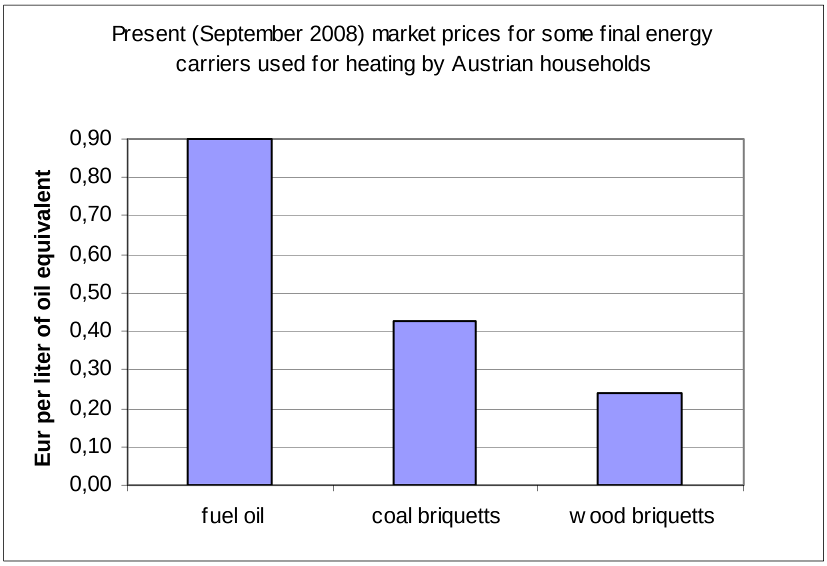
3.1. Price sensitivity and resource limitations

The price system is the primary mechanism for developing an efficient allocation of any economic good, including energy. Changes in prices affect the demand and supply for energy and the resulting structure of the energy use.

Figure 2 shows that the differential between the prices of fuel oil and of the wood briquettes is almost four times and the electricity tariffs are rending electrical heating up to 2.5 times more expensive than fuel oil. This significant price differential should be broadly advertised, so that the households react by fuel switching from oil/electricity to fuel wood in heating their residences.

According to Statistik Austria (2007) more than 955,000 Austrian flats/residences are being heated by natural gas, around 876,300 are being heated by oil, 590,000 households use Biomass and around 254,500 use electricity. Thus 1,150,000 Households are heated by oil and electricity, so that the potential of switching to fuel wood can be estimated to be around 100 PJ.

Figure 2: Market prices for selected final energy carriers.



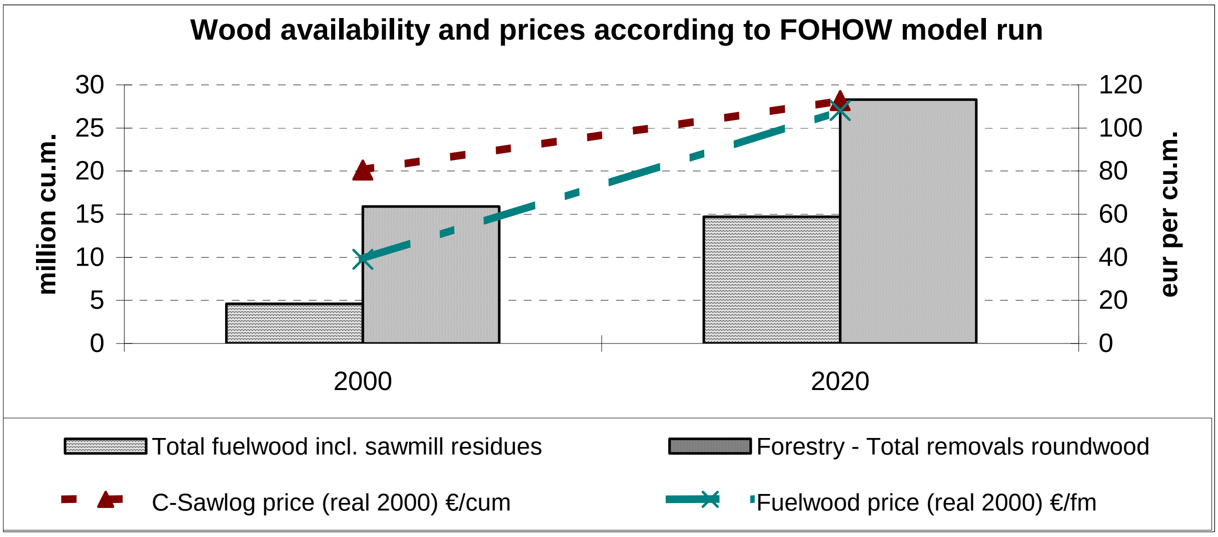
Source: own calculations.

Resource limitations can inhibit the increase in potential supply of fuel-wood-for-energy. Shortages due to the not commercially active owners of the forest plots, or other limitations, are examples from the lengthy list of potential bottlenecks, that must be addressed.

The output of the forest sector simulation model (FOHOW) is indicating substantial changes in the output, demand and prices for Forestry raw materials and sectoral products between 2000 and 2020. For example while the total removal of fuel wood is increasing by factor of 3 the real prices of it are increasing by only 176.5 %, indicating that relative fuel wood prices are actually declining. Another interesting result is that the paper- and paperboard production will decline relatively, i.e., increasing by 31.8 % - below the growth rate of the GDP (48.7 %). (compare Table 2 in the appendix)

Figure shows that by 2020 there will be up to 25 million m^3 (193 PJ) indigenous roundwood available at the market with relative modest prices increases. The figures for fuelwood for 2020 are 15 million m^3 or 116 PJ.

Figure 3: Wood availability and prices according to the FOHOW model run



Source: FOHOW simulation.

3.2. Technology

Conversion technologies within the energy systems vary to great extent and conversion efficiencies; fuel requirements, product qualities and costs are useful parameters for describing current or proposed technologies.

Latest developments in fuel wood based combined heat and electricity production facilities for town heating, improved pellets burners, broad choice of conventional fuelwood/brown coal furnaces, etc., are factors that we have duly recognized are included in the evaluations of the technological potential.

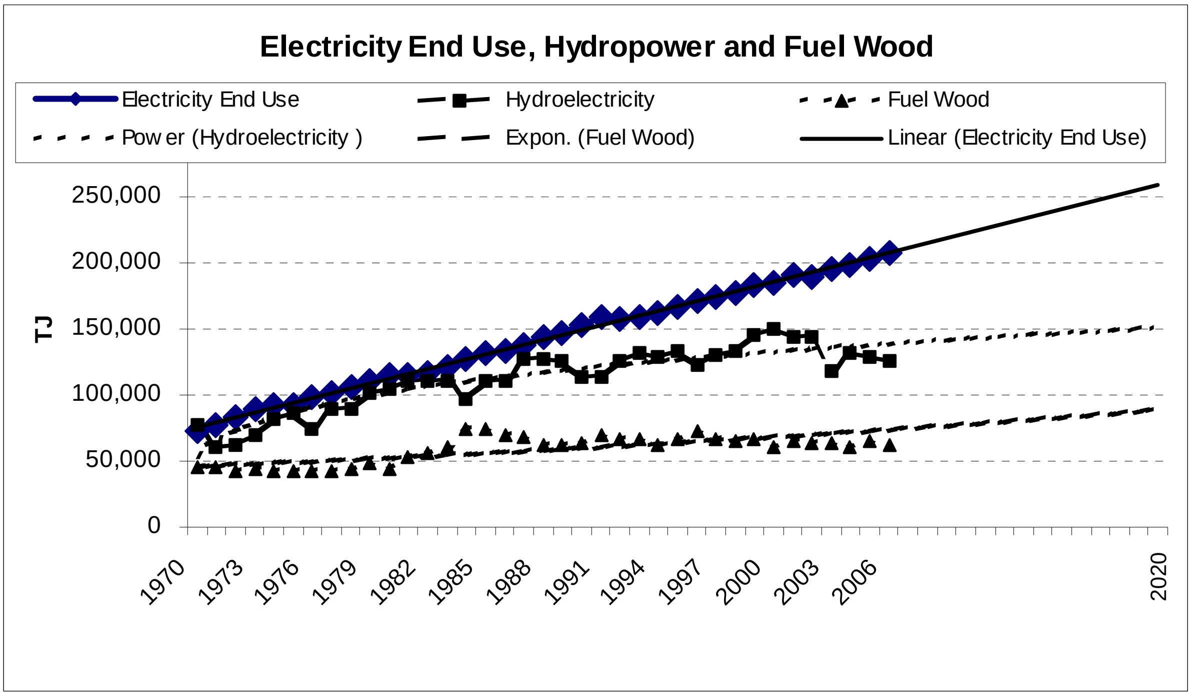
3.3. From the energy use trends to the energy balance for 2020

The data for the benchmark year 2000 were taken directly from Energiebilanzen Österreich (2007). The energy balance for 2020 is based on analysis of the trends in energy use, judgments on energy efficiency improvements and the potential for inter-fuel substitution.

To earn some understanding for the future in figure 4 some energy trend lines are shown, indicating that if the linear growth in end use electricity continues, the electricity consumption would be reaching 260.000 PJ in 2020. Provided a stable water flow and assuming an upgrade of the old hydro turbines and an increase of their performance by 2020 (Ref. 2), the production of hydroelectricity stabilises at 150.000 PJ.

If only traditional technologies would be used, the fuel wood consumption for 2020 would stabilise at around 90.000 PJ/year. In case of subsidised introduction of innovative technologies, e.g., combined heat and power production, pellet ovens, combination of fuel wood and thermal isolation, etc., the energy production from fuel wood may reach 135.000 PJ by 2020.

Figure 4: Electricity End Use, Hydropower Production and Fuel Wood use in Austria



Source: Statistik Austria (2007a).

As seen from table 1, we assume a (strong) reduction of almost 40 PJ for the uses of coal and around 50 PJ for fuel oil and motive fuels until 2020. This reduction of 90 PJ of coal- and oil-based energy production is replaced to a 100 % by fuel wood as a source of energy. All together in 2020 the domestic energy production will be around 230.867 PJ whereas energy demand will be above that figure, so that the remaining 30.000 PJ will have to be imported. In this study we do not explicitly model the generation of foreign energy.

For the general case of the fuel-wood-for-energy scenario, we assume a crude oil price of US$ 150/bbl by the year 2020 - high enough to create comparative advantage to the domestically produced fuel wood, so that an increase from the historical trend of 90 TJ (Fig. 3) to the assumed 135 PJ would be economically attractive. To that end the fuelwood-for-energy scenario can also be called *P*rice-*I*nduced substitution of oil for *F*uel*w*ood *S*cenario – (PIFWS) as it is expected to take place without significant regulatory pushes but rather than through increased fuel oil prices helped by subsidised wood using technologies, e.g., pellet stoves.

In this scenario the share of renewables in the total final energy consumption, e.g., fuelwood, solar, wind, etc. by 2020 is expected to reach 15.1 % thus remaining slightly below that of the EU regulations. If we add the 14.73 % of domestic hydropower, the share of renewables will be 29.8 %.

Table 1: Final energy Use (in TJ) for the Fuelwood-for-energy scenario (PIFWS)

	2000	2020 in TJ or percent		2020 Share of Renewables
Coal	64.787	23.500	2.3 %	
Oil, Motive fuels& Feedstock	369.687	320.205	31.5 %	
Natural Gas	174.148	228.700	22.5 %	
Electricity	181.875	230.867	22.7 %	Hydro share of the electricity - 65 %
Fuel Wood	105.015	135.000	13.3 %	*13.3 %*
District Heating	42.075	60.171	5.9 %	
Wind & Heat Pumps	6.819	19.613	1.9 %	*1.9 %*
Total	944.406	1.018.089	100 %	*Renewables 15.1 % +Hydro 14.73 %*

Source: Statistik Austria (2007a); Own assumptions

3.4. Externalities

We are assuming that in 2020 CO_2 certificates will be traded within the spread of their marginal abatement costs (MAC) estimated by the EU´s “Impact Assessment of the EU's objectives on climate change and renewable energy for 2020” (EC, 2008). This study estimates the MAC for Austria to lie between € 40 and € 90/t CO_2 .

To explore the full effects of the CO_2 trade for our scenarios we have chosen thee taxation levels - namely, PIFWS0 or no taxation (€ 0/t CO_2), € 60/t CO_2 (PIFWS60) and € 80/t CO_2 (PIFWS80).

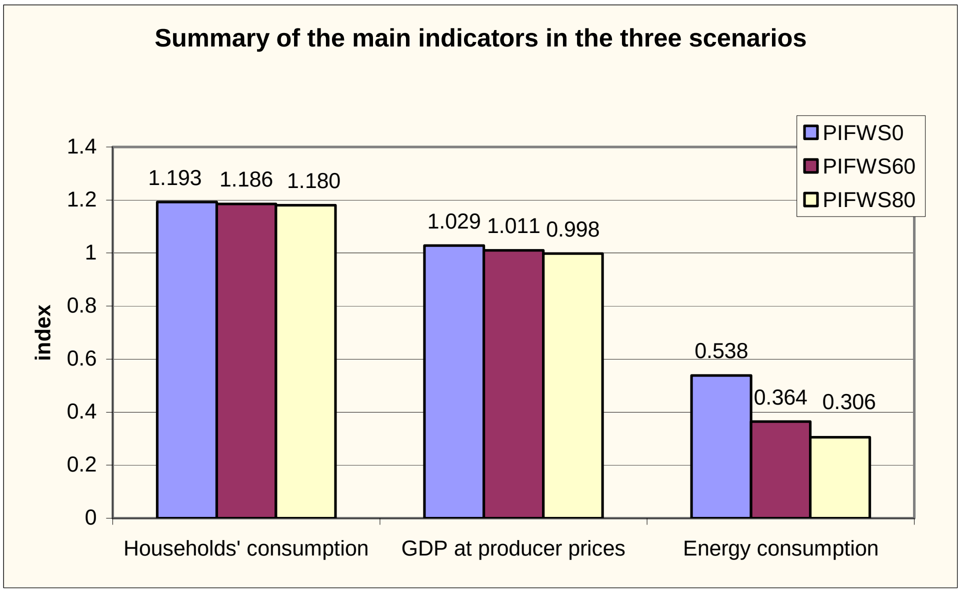
4. Macroeconomic, sectoral and environmental impacts of the fuelwood-for-energy scenario

All graphs below are compared to the GDP growth rate of in every scenario. This growth rate assumes an index value of 1 in each scenario. The only exception refers to the figures for GDP, which is compared with a GDP growth rate of 2 percent p.a., corresponding to an overall increase of 48.59 %. The three scenarios are the Fuel-wood-for-energy scenario without taxation, the Fuel-wood-for-energy scenario with medium taxation (60€/t CO_2) and the Fuel-wood-for-energy scenario with high taxation (80€/t CO_2).

4.1. Macroeconomic performance

Figure 5 shows that enhancing the use of fuel wood, as well as taxing CO_2 emissions at a higher rate will not alter the level of GDP and household consumption tremendously. Private consumption expenditures will grow at a faster rate than GDP (+18 and +19.3 percentage points) in the respective scenarios. If the usage of biomass is enhanced without taxation, Austrian GDP would grow 2.9 percentage points faster than in the benchmark case, in the medium taxation case, GDP growth would still be 1.1 percentage points higher (over the twenty years). In the high taxation case, Austrian GDP will be slightly but only marginally smaller.

Figure 5. Changes in households´ consumption, GDP at producers' prices and of the energy consumption



Source: ATCEM-E3 simulation results.

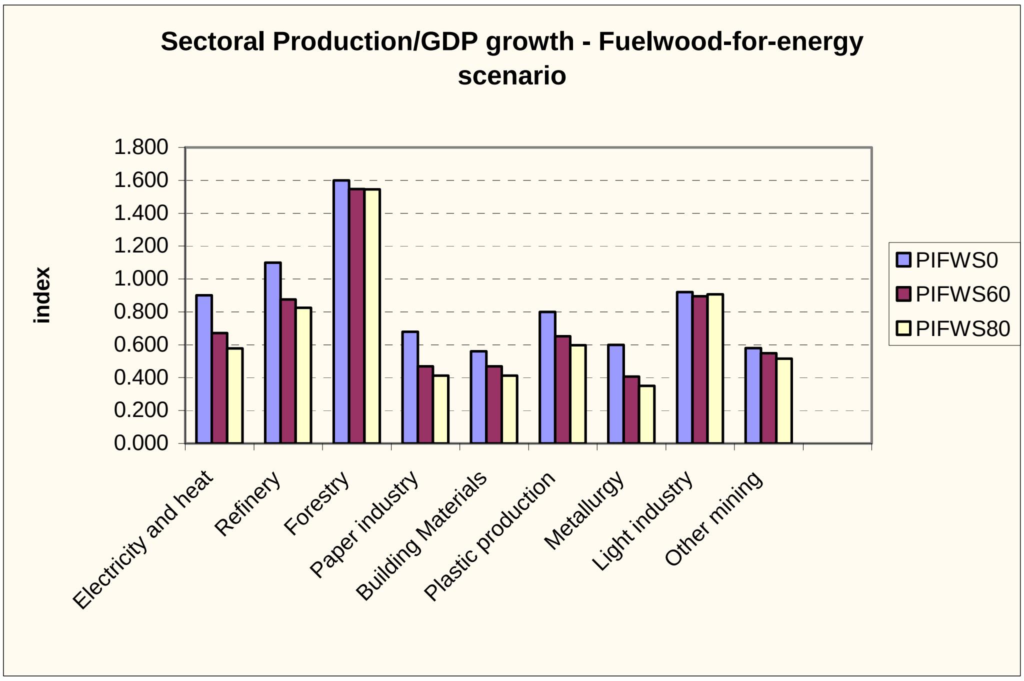
Energy consumption of the Austrian economy will grow at half the rate of GDP, indicating a deceleration in energy consumption. Energy consumption is, however, strongly sensitive to the level of taxation. In the high taxation scenario, the energy consumption growth rate of the Austrian economy is less than a third of the corresponding overall economic growth rate. This can be interpreted as a tax-enforced increases in energy efficiency per unit of GDP.

4.2. Sectoral growth

Figure 6 compares the growth rates of selected industries with that of GDP in the three scenarios. The clear winner in all scenarios would be the forestry sector with a growth rate of 50 percentage points above the growth of GDP. On the other hand we observe energy intensive sectors suffer, especially when CO_2 taxation is additionally considered. We observe that an enhancement of fuel wood use, to generate energy, will adversely affect contesting uses such as in the paper industry, where wood is a production input. A less adverse effect could be observed for the so-called light industries, which would not be severely affected, not even when accounting for increased taxation.

As wood is used more intensively for energy generation, this will have a positive impact on refinery, as the price for its input might be lowered due to less demand for its raw materials. This small bonus vanishes, however, as soon as CO_2 emissions are taxed.

Figure 6: Changes in the main production indicators

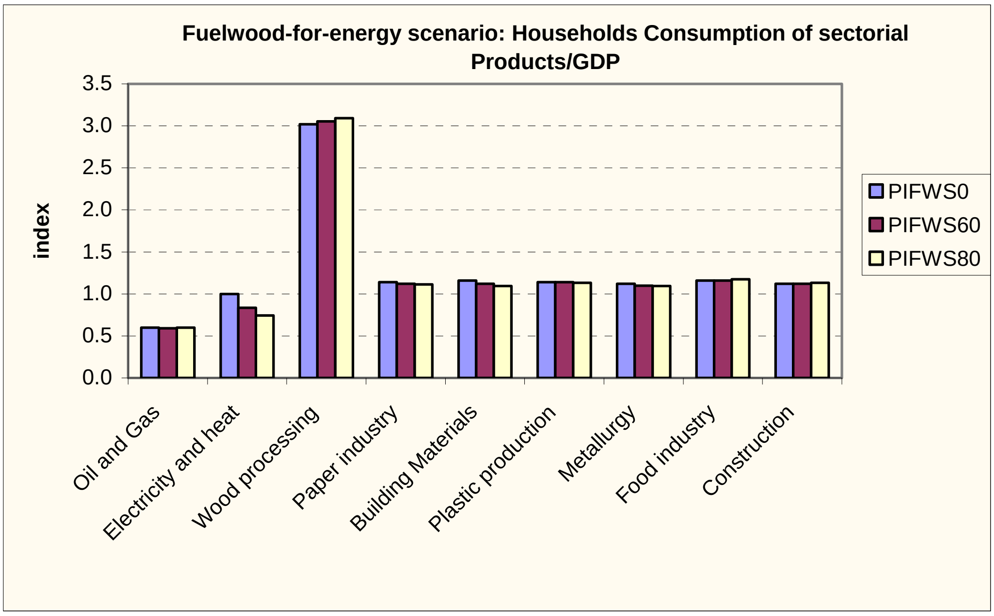


Source: ATCEM-E3 simulation results.

4.3. Household's expenses

The growth in the household expenditure (Fig 7), with exceptions for oil & gas and electricity & heat, is generally above GDP growth. Due to the enforced use of fuelwood, the corresponding expenses are three to 4.5 times higher than the GDP growth rate.

Figure 7: Changes in the Households´ consumption



Source: ATCEM-E3 simulation results.

Households will reorient their expenses to wood products and reduce their spending for oil, gas products but also for electricity and conventional heat. The other expenses correlate to a high extent with GDP growth.

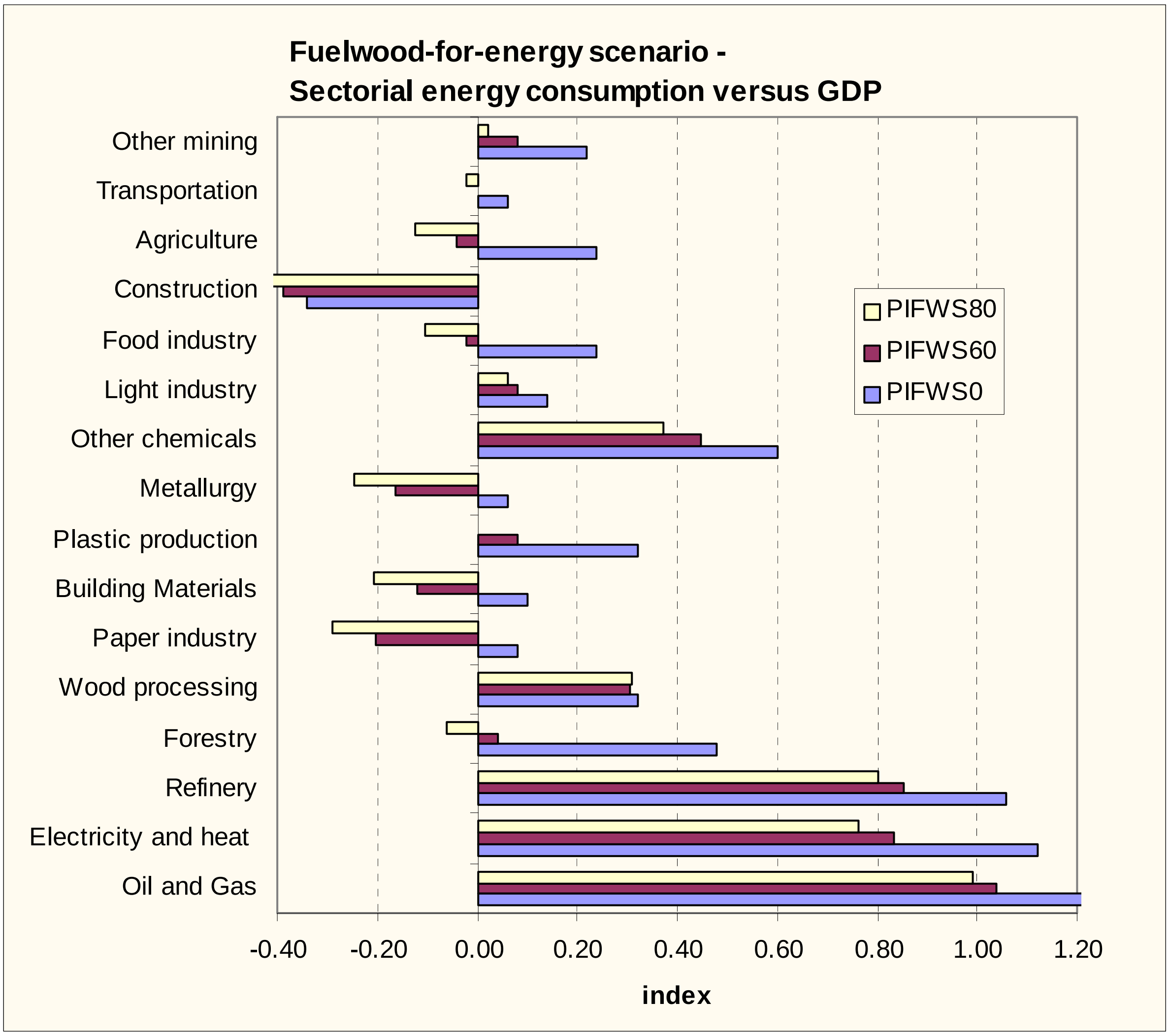
4.4. Energy

Energy demand for all sectors are highly sensitive to the level of CO_2 taxation, but this is especially relevant to the energy intensive industries, i.e., Oil & Gas, Electricity & Heat, Refinery, Forestry, Pulp & Paper Industry, Engineering, Building Materials, Plastics production and Metallurgy, Other Mining and Construction.

There are three aspects to sectoral energy demand. Firstly, the enforced economy-wide use of fuel-wood for energy generation reduces the availability and therefore increases the price of important inputs for certain industries, which can be seen in the case of paper industries, building materials and construction. This should induce at first an increase in energy efficiency. Secondly, the taxation of CO_2 emissions tremendously increases the pressure for further improvement in the energy efficiency of all industries, especially in the case of energy intensive industries. Eventually, in analysing the effect of the three scenarios on energy demand figure 6 should be kept in mind, that certain industries, among them the energy intensive branches, will relocate their production facilities outside Austria, which further decreases the demand for energy.

Figure 8 displays the extremely high sensitivity of the energy consumption of all sectors from CO_2 taxation levels where a reduction of 10 to 15 % in the PFIWS80 scenario relative to the PFIWS0 scenario for almost all industries can be observed.

Figure 8: Changes in the Sectorial Energy consumption



Source: ATCEM-E3 simulation results.

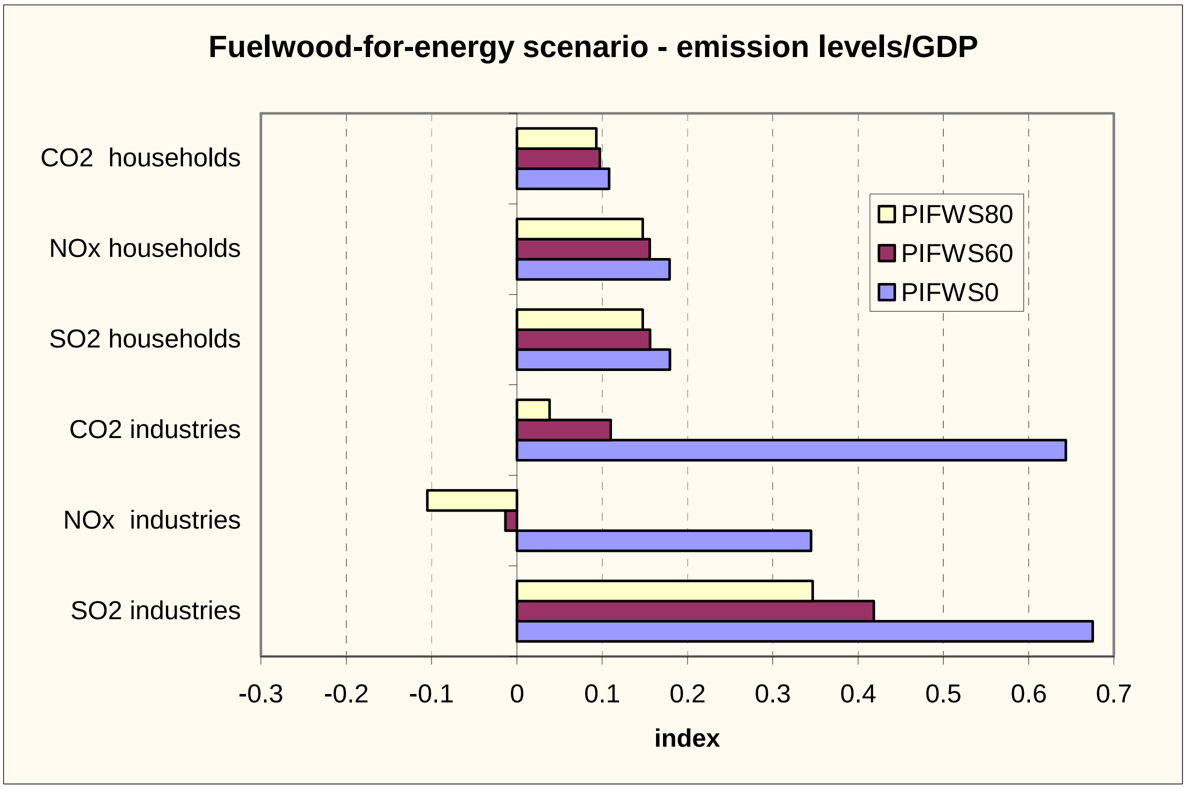
4.5. Environment

As a result of the reduced energy consumption growth, emissions increase much less than GDP, but with considerable variation across pollutants and between the household and production sphere (see Figure 9 for details). The higher CO_2 tax rate causes significant decreases in CO_2 emission in industries.

As most households can switch relatively easy to fuel wood products[2] as their main source of energy, the emission levels of this sector will decline significantly even without taxation. As a result we observe only marginal decreases in emission levels across the three scenarios. Compared to the household sector, industries are much more sensitive to the level of CO_2 taxation. For the case of zero taxation (PFIWS0) we observe a reduction of emission of 50 percent, but when a tax is introduced, the emission levels drop below that of the household sector. Again part of this has to be attributed to the relocation of production facilities outside Austria.

[2] Extensively used wood pellets have very low particulates emission and their CO_2 emissions are to be compensated by growing trees.

Figure 9: Changes of the Emission levels



Source: ATCEM-E3 simulation results.

5. Summary and conclusion

Our analysis takes the price sensitivity of consumption, the available fuel wood resources, externalities arising from a more intensive use of fuel wood as a generator for energy and rising CO_2 taxation, available technological options and the inter-fuel substitution for the energy balance into account. We evaluated the economic impact of an enhanced use of wood-biomass at both, the macroeconomic and at the sectoral level.

The analysis shows that under the presumptions of the PIFW scenarios, the Austrian economy can afford the enhanced use of renewables and a sustained economic growth; and can benefit from the double dividend - sustained economic growth and fulfilment of EU targets on renewables and CO_2 reduction. The results show that GDP growth is slightly higher than in the case without enforcement of fuel wood but this gain is diminishing with increased CO_2 taxation. Households' consumption is above that of GDP growth and aggregated energy consumption is far below the growth of GDP. These favourable developments of the main aggregates therefore seem to support the double dividend view, namely, that by enhancing the use of renewables for the generation of energy, Austria benefits from a slightly higher economic growth that is also sustainable.

At the sectoral level, however, prospects for energy-intensive industries deteriorate, as the simulation results indicate lower production levels for those compared to the overall economy. Whereas the forest sector will benefit, prospects for sectors such as pulp & paper, building material, plastics, metallurgy, construction and mining will worsen, due to the fact that their energy intensity is high and thus their sensitivity with respect to CO_2 taxation is significantly high.

Similar to their production level decreases, in several sectors impressive reductions in energy consumption (e.g., mining, transportation, agriculture, food industry metallurgy) can be observed, which is partially explained by increased energy efficiency and partially by relocations to sites outside of Austria. The energy demand for all sectors is highly sensitive to the level of CO_2 taxation, especially of the energy intensive industries. Due the cost burden on production the increased CO_2 taxation is turning the growth of energy consumption from positive to negative.

The restructuring to more energy efficient technologies, and/or production processes/practices is one of the prices to be paid for increased use of renewables. As a result of the lower growth of the energy consumption, emissions increase much less than GDP, but with considerable variation across pollutants and between the household and production sphere. The higher CO_2 tax rate will cause a higher decrease in CO_2 emissions.

References

Balabanov, T. and Revesz, T.R. (2007), A Guide to ATCEM-E3: AusTrian Computable Equilibrium Model for Energy-Economy-Environment interactions, Vienna.

Balabanov, T., Schwarzbauer, P., Schwarzbauer, W. and Stern, T. (2008), Contesting uses of wood: energy vs. material purposes – economic impacts of alternative scenarios, OeNB Jubiläumsfonds project report, Vienna.

EC (2008) "Impact Assessment of the Package of Implementation measures for the EU's objectives on climate change and renewable energy for 2020", Brussels, 27.2.2008, http://ec.europa.eu/environment/climat/climate_action.htm

Kratena, K. (2005), Energieszenarien für Österreich bis 2020, Vienna.

STATISTIK AUSTRIA (2007a), Energiebilanzen Österreich 1970 – 2006, Vienna.

STATISTIK AUSTRIA (2007b), Statistische Übersichen, Wien, http://www.statistik.at/statistische_uebersichten/deutsch

Appendix

Table 2: Main outputs of the "wood-for-energy" FOHOW scenario

	2000	Change 2020/2000
Forestry - Total removals roundwood	**15,9**	**+78.0 %**
thereof logs	*9,4*	*+17.0 %*
thereof pulpwood	*3,3*	*+75.8 %*
thereof fuelwood (forest)	*3,1*	*+267.7 %*
Roundwood prices (€/cum)		
C-Sawlog price (real 2000) €/cum	80,5	+40.0 %
C-Pulpwood price (real 2000) €/fm	36,8	+100.0 %
Fuelwood price (real 2000) €/fm[1])	39,1	+176.5 %
Total fuelwood use incl. sawmill residues (mio. m^3 (solid))	**4,6**	**+220 %**
thereof fuelw. fr. forest	*3,1*	*+280 %*
thereof sawmill residues for energy (mio. M^3solid)	*1,4*	*+107.1 %*
Panel production (mio. M3)	**3,1**	**+16.1 %**
Panel price (real 2000) €/ M^3	*200,1*	*+14.9 %*
Paper- and paperboard production (mio. t)	**4,4**	**+31.8 %**
Paper price (real 2000) €/t	740,6	+50.9 %
Pulp price (real 2000) €/t	225,4	+151.0 %
Total pulpwood use incl. sawmill residues and rw. equivalent of net-import pulp (mio. cum (solid))[total of paper & panel industry)	11,5	-12.8 %
thereof pulpwood from dom. forests (mio. m^3)	*3,3*	*-42.9 %*
Sawnwood - million m³	**10,4**	**-4.8 %**
Sawmill residues - million m³	6,7	+13.6 %
Use of sawlogs - million m³	17,8	-0,6 %
thereof domestic - million m³	*12,3*	*+4.1 %*

Source: FOHOW simulation.

Authors: Todor Balabanov, Wolfgang Schwarzbauer

Title: The Enhanced Use of Wood-biomass. – Macroeconomic, Sectoral and Environmental Impacts

Reihe Ökonomie / Economics Series 227

Editor: Robert M. Kunst (Econometrics)
Associate Editors: Walter Fisher (Macroeconomics), Klaus Ritzberger (Microeconomics)

ISSN: 1605-7996

Stumpergasse 56, A-1060 Vienna • ☎ +43 1 59991-0 • Fax +43 1 59991-555 • http://www.ihs.ac.at

ISSN: 1605-7996