Bioenergy production in Finland and its effects on regional growth and employment

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Abstract

Finnish national climate and energy strategy sets the share of renewables in energy use to 38%, and a significant amount of this should be covered by biomass based energy. In 2020 forestry is set to contribute 24 TWh and agriculture 4-5 TWh to energy production. In particular, bioenergy resources are considerable in the rural areas. However, the regional aspects have gone without investigation before this study.

This study is a general equilibrium analysis. We considered only the by-products and waste material from agriculture and forestry as the resources for bioenergy, and only heat and power production were considered as the potential end uses. A regional CGE-model (RegFinDynBio) was used to analyse the impact of increased use of bioenergy potential.

Increase in bioenergy use will lower the levels of GDP and employment marginally but will, nevertheless, help to achieve the emission reduction goals. However, the regional results showed the uneven distribution of the costs. The regions that beforehand seemed to be the most promising ones fared the worst. Southern Ostrobothnia was the sole exception, because of its bioenergy export income. The greatest difficulties are seen in Kainuu. Eastern Uusimaa shows significant losses as well, but they can be traced back to the region's economic structure, which is heavily dependent on fossil fuel refining industries. Some regions that use gas as energy source are seen to gain marginally because of their more diverse energy production system.

Keywords: bioenergy, agriculture and forestry, regional economy, growth, employment, CGE-modelling

1. INTRODUCTION

Finnish national climate and energy strategy sets objectives for the share of renewable energy in the final energy use. In the EU level the target is to achieve 20 % share by the year 2020. In 2005, the share was only 8.5% and total energy consumption was still increasing. Renewable share in Finland was already in 2005 at 28.5%, which was mainly caused by the country's high degree of forestry and pulp and paper industries that have been able to exploit their waste materials in production. Because of this high starting level and the potential for increase, the target for Finland was set at 38%. However, this target could be quite difficult to achieve. EKHOLM et al. (2008: 33) assessed that the increase of emission permit price to 50 €/ton would be enough to raise the share only to 31.5%. Another assessment (VTT 2008: 41) found that 60-68 €/ton price would be enough for achieving the target and even 20 €/ton emission permit price would be enough if technological development is appropriately directed. Only 25.4% share is achieved in the absence of emission trade system.

The strategy sets specific goals for bioenergy production increase in both the agriculture and forestry for the year 2020. In forestry, the amount of residues should be raised from 3.6 millions of solid cubic meters to 12 million that would mean approximately 12 TWh of energy. In agriculture, the residues are set to generate 4-5 TWh. According to the bioenergy potential data in Finland, these targets are feasible. In the forestry the target is very close to its techno-economic potential, while in the agriculture the target is only a quarter of the techno-economically feasible amount. The lower level in agriculture can be explained by the very low willingness to supply biomass to energy production among farmers. The likely reason for this is that the logistical solutions are much more underdeveloped in agriculture when compared to forestry.

In this study we aim to assess how the fulfilling of these targets will affect main economic indicators like GDP growth and employment in Finland at the regional level. We restrict our study to deal only with by-products and waste materials produced in agriculture and forestry and used in production of heat and electricity.

2. MATERIAL AND METHODS

2.1. Overall

We used a CGE-model for our analysis. CGE-model was an obvious choice due to the strong interconnections of energy sector with the rest of the economy. RegFin model by TÖRMÄ and RUTHERFORD (1998) was the basis for our study. We used the recursive dynamic version of the model (RegFinDyn) quite recently constructed by KINNUNEN (2007). For this study, we further updated the model with a more specific energy production structure that includes the most important fossil fuel industries and two separate industries for bioenergy production. Furthermore, the climate and energy policy instruments like emission trade system and carbon tax were first time implemented in the model for this study. The model version we used contains 20 regions (Finnish regions at NUTS3 level) and 38 industries. Technological change is exogenous in the model, and is built via total factor productivity of growth that varies by industry.

We constructed 20 social accounting matrices (SAMs) for all the regions to calibrate the model to the base year 2005. Statistics Finland has produced regional input/output tables for Finland twice, and we used the newest data set for the year 2003 as the starting point for our data work. We also used supplementary data such as energy production unit data from VTT Technical Research Centre Finland to determine the regional shares in the energy resource use and Finnish GTAP SAM for the energy production structure. Two collaborating institutions, MTT Economic Research and Pellervo Economic Research Institute, provided us with the data of the regional bioenergy potentials in the agriculture and forestry, respectively. The potentials have three different categories in descending order: 1) the theoretical potential that presents the biological potential of biomass production, 2) techno-economic potential that is the share of the previous category, which is economically feasible to exploit with the current technologies, and 3) willingness to supply that is the share of the previous category, which the producers are willing to supply with the current prices. The potentials for different regions are shown in Figure 1.

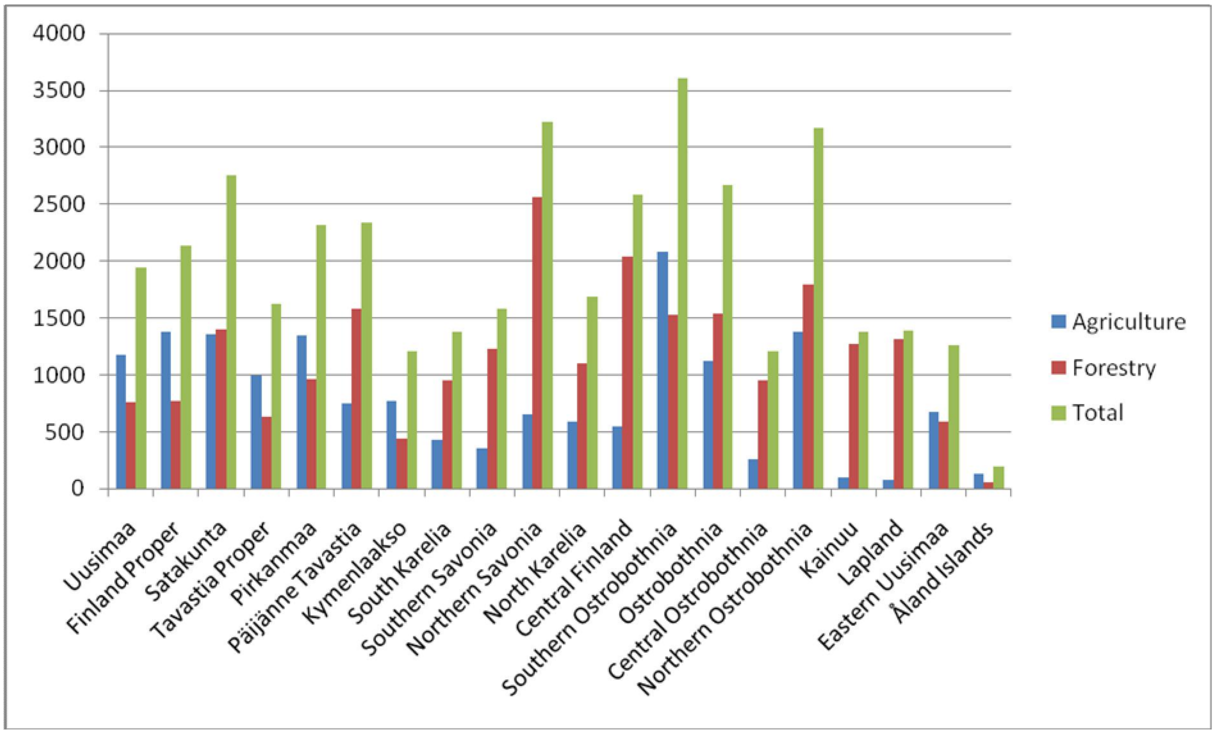

Figure 1. Techno-economic bioenergy potentials (GWh) per region.
Source: MAIDELL et al. (2010) and TUOMISTO (2010).

In our study, we considered only the by-products and waste materials generated in agriculture and forestry. Thus, we did not need to consider the possible effects in the supply of food and wood materials. Furthermore, we examined only heat and power production as the potential final uses for bioenergy as with the current technologies the use of biomass in transportation fuels is clearly more inefficient. The second generation biofuels might however alter that situation.

2.2. Modelling work

We set three different simulations to present the various levels of increase in bioenergy exploitation. The simulations are in the ascending order: 1) conservative increase in bioenergy (CONSERV), 2) the targets set in climate and energy strategy (STRATEGY) and 3) the full exploitation of techno-economic potential (TECHECON). We evaluated these increases against various scenarios portraying environmental policy circumstances. With these scenarios constructed, we can investigate e.g. 1) varying emission targets, 2) varying emission permit prices, 3) varying coverage of industries in emission trade system, and 4) the differences between the emission trade system and carbon tax as policy measures. We divided these scenarios to seven cases. Next we will give more detailed description of simulations and scenarios and then give a summary of the results for two relevant economic indicators, the GDP and employment.

2.2.1. Simulations

In addition to the base simulation, we made three alternative simulations to represent the supply shocks in the bioenergy production. All the scenarios run from 2005 to 2020. In the alternative simulations the use of the fossil fuels in heat and electricity production is gradually replaced by the bioenergy resources. In the last year, the use of bioenergy reaches its maximum, which varies by the simulation.

1. Conservative increase in bioenergy (CONSERV)

In the first alternative simulation the bioenergy use increases in the agriculture to the level set in the strategy, whereas in the forestry the target is left unachieved. In the forestry the techno-economic potential is not used completely as stumpage is not used for energy because of conservational reasons. In this simulation we present a case that can safely been seen to not have any serious detrimental effects for the soil nutrient balances. The techno-economic potential is less than fully used in both agriculture and forestry.

2. Climate and energy strategy targets (STRATEGY)

In the second alternative simulation both the agriculture and forestry produce the amount of bioenergy they are set to produce in the climate and energy strategy. In the agriculture the level is the same as in the previous simulation, but in the forestry about one quarter higher. In the forestry, the amount also coincides with the techno-economic potential.

3. Full exploitation of techno-economic potential (TECHECON)

In the third alternative simulation the whole techno-economic potential is used in energy production in both the agriculture and forestry. In the forestry, the level does not change from the previous simulation, but in the agriculture the increase is about four-fold.

2.2.2. Scenarios

We built seven cases to represent various background policy scenarios. There are four different aspects by which we built the scenarios. The amount of emissions in both emission trade sector (ETS) and non-emission trade sector (NETS) can be set to gradually increase to some target level. Additionally, an exogenous emission permit price can be set. The industry coverage of emission trade system can be varied between emission trade seasons. A carbon tax can be put on both of the sectors’ fossil fuel inputs. We classify the scenarios in three main groups, which are described in more detail below. Exogenous emission limit is included in the model to describe the total effects of the various non-specified policy measures. The international price for the emission permits is exogenous as well, and it describes the changes that happen in the emission permit markets. Carbon tax can be used as a national measure to supplement the emission trade system.

1. Target reductions at the base paths

In all of the scenarios the emission permit price is exogenously determined at the EU level. In the first group of scenarios the price at the first season (2005-2007) is 10 €/ton, at the second (2008-2012) 15 e/ton, and at the third (2013-2020) 30 €/ton. The case 1a represents the case in which the amount of emissions is not restricted at all. In the case 1b, the emissions are restricted to the level set in the Kyoto treaty. Finally, in the case 1c, ETS emissions are further reduced by 20% and NETS emissions by 16% (which is the target set for NETS in climate and energy strategy).

2. Increase in emission permit prices – no restriction for the NETS

In the second group of the scenarios the emission permit price increases to 50 €/ton. In this group no restrictions are set to NETS. In case 2a, the ETS emissions are reduced by 20 %. Additionally, in the case 2b, an extra carbon tax of 20 €/ton is set for the fossil fuel inputs in the ETS.

3. Increase in emission permit prices – restrictions for both of the sectors

Cases 3a and 3b differ from the cases 2a and 2b only in a sense that now the emissions are restricted in both the ETS and NETS. In the NETS the reduction is 16% as in the case 1c. The carbon tax that is 20 €/ton, is set for the inputs used in both ETS and NETS.

3. RESULTS

3.1. National level results

Figures 2 and 3 show the base paths for the GDP and employment in the various scenarios. Figure 2 depicts how the various climate policy options affect the economic growth in the model. Unsurprisingly, the highest growth is achieved in the case 1a, where the emissions are not restricted at all. The highest reduction of the growth can be seen in the case 3b, where the GDP in 2020 is 2.9% less than in the case 1a. If the comparison is made with the case 1b, which more accurately describes the current situation, the difference reduces to 1.7%. When we compare the cases 1b and 1c, we get an idea about what kind of an effect the climate and energy strategy goals have in the model. The change is 1.2%, which is somewhat higher than the value estimated with another national level CGE-model for Finland by HONKATUKIA and FORSSTRÖM (2008: 33), 0.8%.

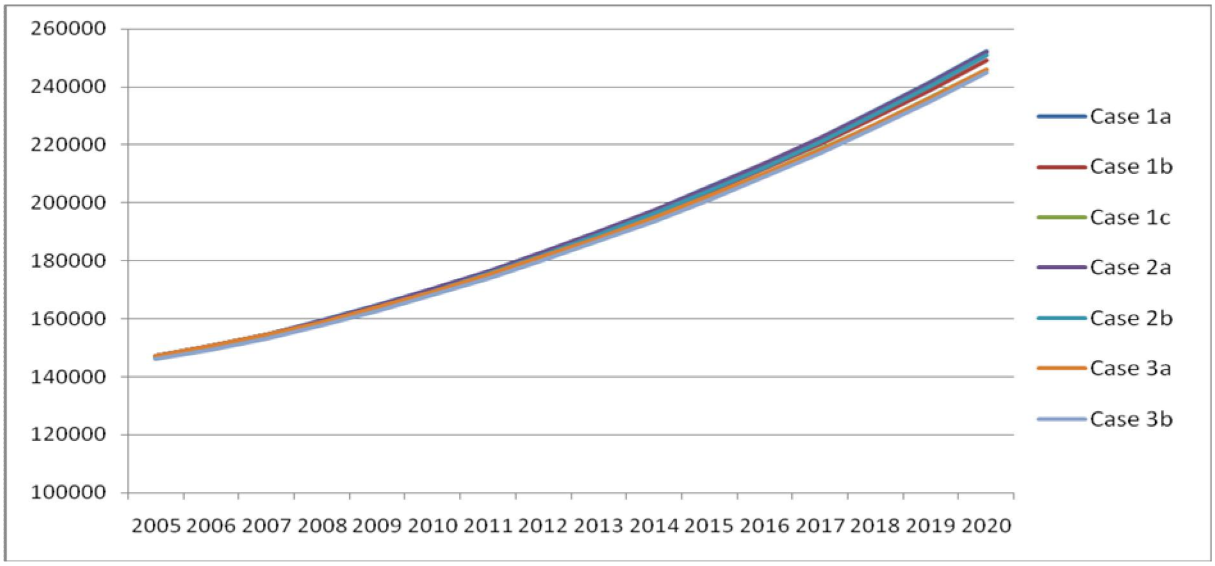

Figure 2. The base paths for the GDP in the scenarios.

Figure 3 shows that the employment evolves at a slower pace than the GDP and that the changes are smaller in magnitude as well. The extreme cases remain same: the case 3b is 0.9% less than the case 1a in the year 2020.

Increase in bioenergy is reduced from fossil energy imports. As with the current prices the fossil energy resources are less costly to use, it is easy to predict that the shift to the costlier inputs will lead to a decrease in the economic productivity. Thus, the results actually indicate how much the increase in the bioenergy use will cost to the society in the foregone growth and worsened employment situation. Tightening the environmental policies increases the comparative advantage of using bioenergy and in that way decreases the comparative losses in productivity. We can also evaluate how much the emission reductions will come to cost to the society. The results for the national level are expected, but the regional level is much more complicated due to differing bioenergy potentials and especially differing energy production structures.

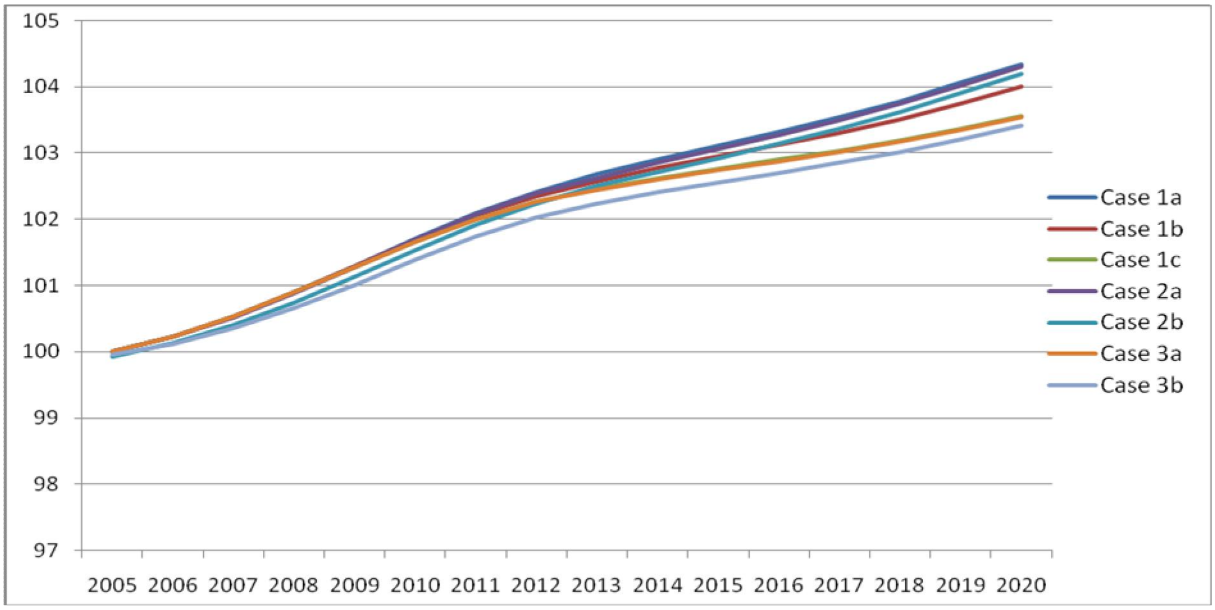

Figure 3. The base paths for the employment in the scenarios (2005 = 100).

Figures 4 and 5 depict how different levels of increase in the bioenergy use affect the GDP and employment at the national level. Figure 4 shows that in overall, the bioenergy increase has slightly negative effect for the national level of the GDP. The effect is straightforward: the higher the increase, the higher is also the loss for the society's welfare. The effect of climate policies is also visible in the cases 1a, 1b and 1c: tightening the climate policy will make bioenergy comparatively more profitable. Still, even conservative increase will not bring positive effects even with the strictest scenario. By comparing the cases 2a/b with 3a/b we can see that the more sectors is covered by climate policy, the better (or less worse) the bioenergy will fare. By comparing 2a with 2b and 3a with 3b we can see that the extra carbon tax also makes bioenergy bit more desirable.

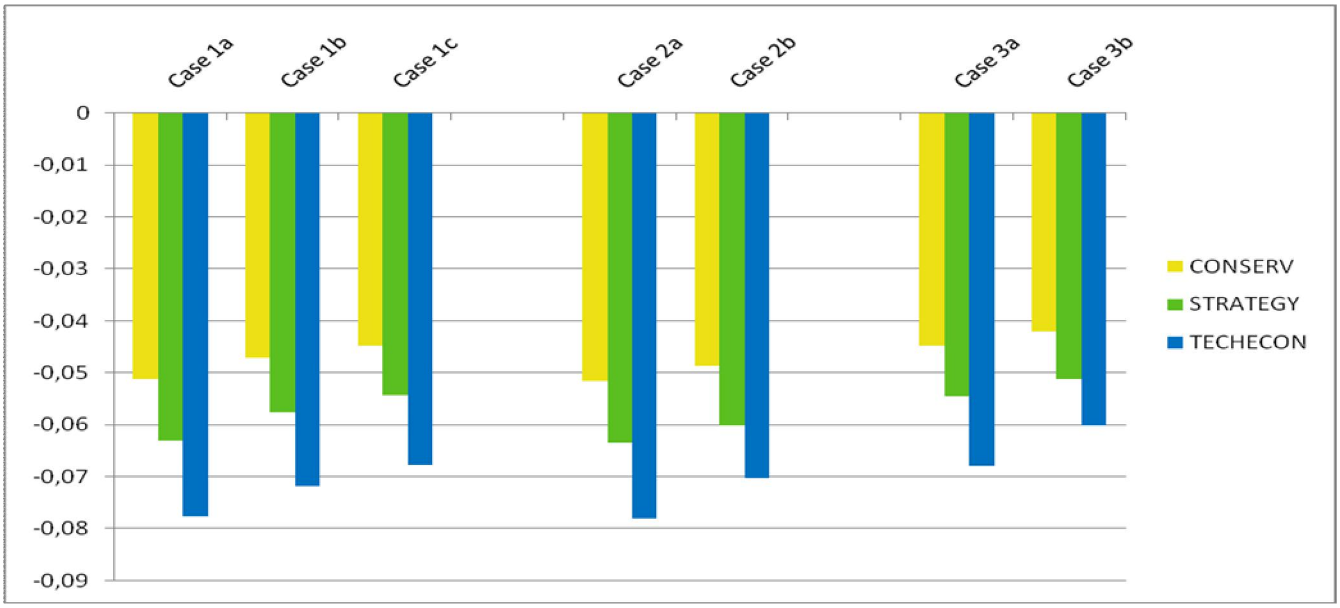

Figure 4. %-changes for the GDP compared to the base simulation at the national level in all the scenarios.

Figure 5 shows that the situation is a bit more complicated for the employment. The effects are small although slightly higher than with the GDP. It is somewhat surprising to see that increase of bioenergy does not have straightforward effect for the employment. The effect of the conservative increase is the smallest and that of the strategy is the highest. The full exploitation of techno-economic potential is somewhere in between. This anomaly might be best explained with the regional level results to which we will return to later. Tightening of the climate policy has negative effect: the more the emissions are restricted, the more negatively the increase in bioenergy use will affect the employment situation. This is probably due to the fact that tightening the climate policy will leave less room for the employment to adjust. By comparing the cases 2a/b with the cases 3a/b might give some support for this intuition: the higher coverage of the climate policies will be detrimental for the employment when more bioenergy is used. By comparing the cases 2a with 2b and 3a with 3b we can see that carbon tax proves to be quite neutral employment-wise. So it seems that the carbon tax might contribute to achieving the emission targets with lesser employment effects than emission permit trade.

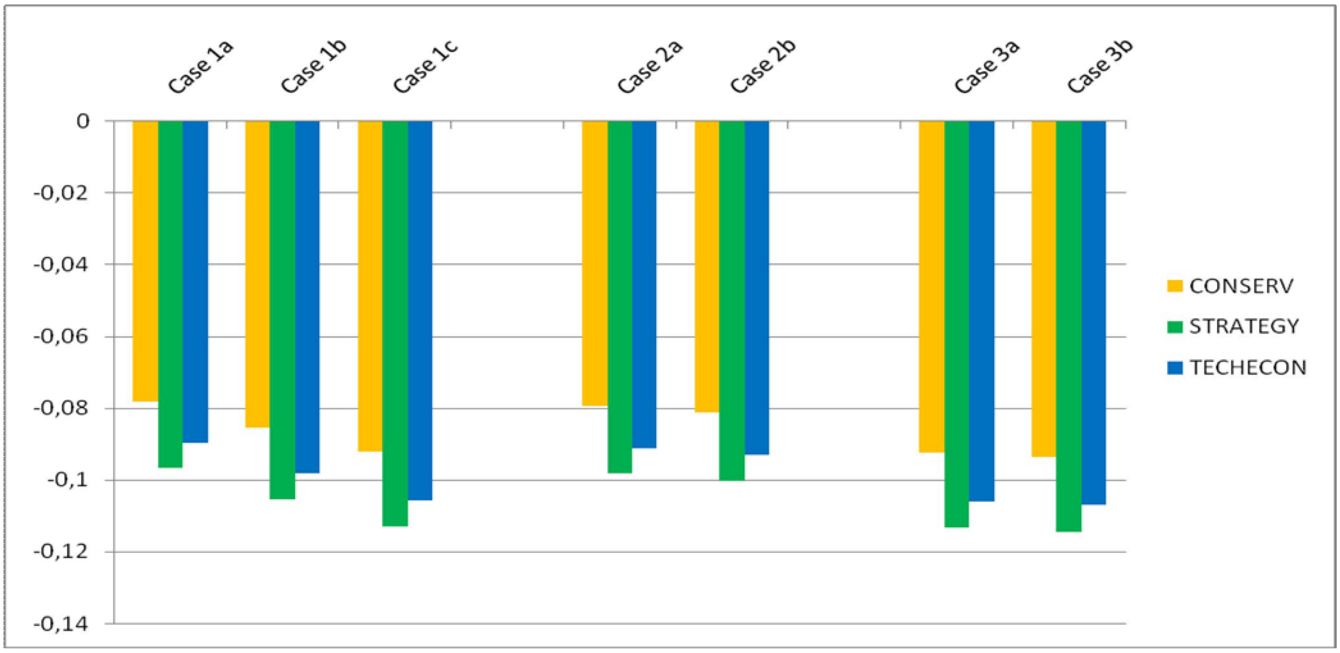

Figure 5. %-changes for the employment compared to the base simulation at the national level in all the scenarios.

3.2. Regional level results

Figures 6 and 7 depict how the national level results are distributed along the regions in the case 1b that portrays the current situation best. Figure 6 shows the results for the GDP and figure 7 for the employment. It is easy to see the differences among the regions are much higher than the national level results would indicate. The effects are negative in almost all the regions. The most notable exception is the Southern Ostrobothnia, which has a clear positive result with the full exploitation of the techno-economic potential. This is easily explained by the fact that the techno-economic potential in the Southern Ostrobothnia is larger than its own energy consumption. By fully utilizing that potential, the extra amount will be exported to the other regions. Kainuu and Eastern Uusimaa are the regions that will lose the most. The former is best explained by the broadly dire economic situation in the region, which makes adjustment to increased costs more difficult. The latter, on the other hand, with the economic structure that has a huge share of fossil fuel energy refining, was easy to expect to lose from increased use of its competing products. In overall, quite a few regions in the southern parts of the country that have higher shares of services and gas (compared to coal and oil) seem fare well, even with marginal gains.

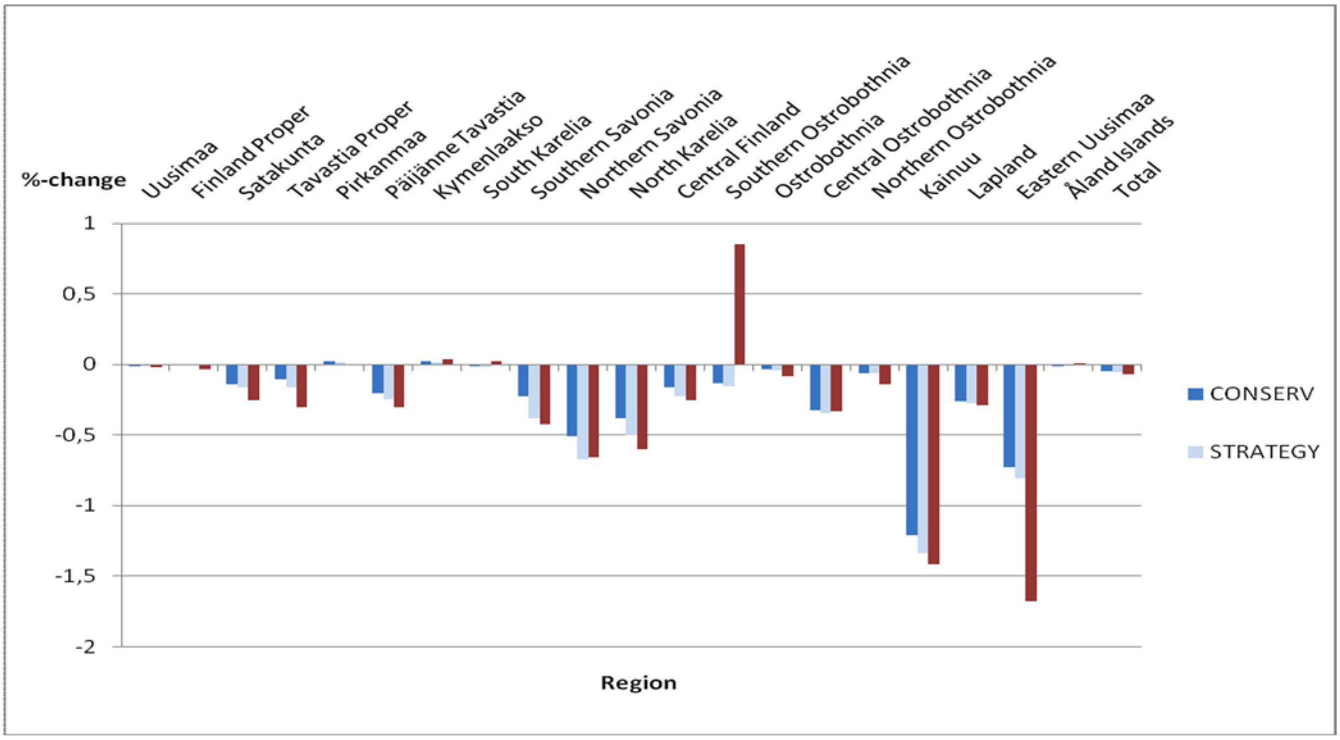

Figure 6. %-changes of GDP by the regions in the case 1b.

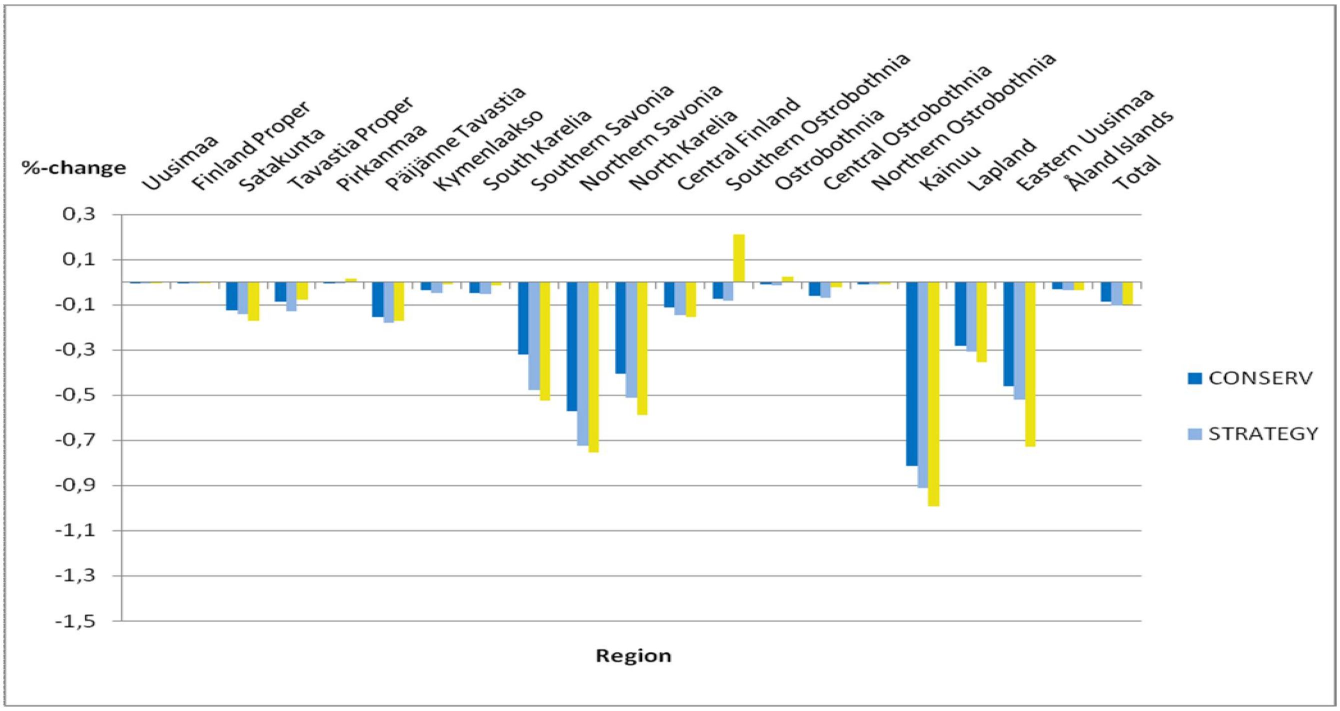

Figure 7. %-changes of employment by the regions in the case 1b.

4. DISCUSSION

Based on our results, we are able to see that with the current technologies the increase of the bioenergy production will cost the society as the growth slows down and the employment decreases. However, this change is quantitatively quite modest and it depends on the level of environmental policy. Carbon emissions can be cut down with bioenergy production but not without losses in productivity; according to our results it is not a win-win option. Therefore it is open to discussion whether this cost is acceptable.

Nonetheless, based on our results, we can safely say that a mere national level investigation is not enough to yield the required information for supporting bioenergy production. The differences between the regions can be quite significant in what comes to potentials of both production and exploitation of bioenergy. Various policy measures could be used to spur the bioenergy production. For example in Southern Ostrobothnia, where the gains are visible only when the whole techno-economic potential is taken into production, some investment subsidies might be reasonable to help to find the optimal scale of production. In general, such policy measures that aim at improving technologies are needed. In regions like Kainuu that have dire overall regional economic situation, might need more compensation if required to produce more bioenergy. Eastern Uusimaa is detrimentally affected because of its high share of fossil fuel refining and it might require some measures to help this region to cope with the structural changes in the energy production and diversify its production.

According to our results, the carbon tax seems to have some desirable features when compared to the emission permit trade. It seems that the employment effects of carbon tax are more favourable than with the emission trade. It was also proved again that overall efficiency gains are achieved when climate policies cover as much of the industries as possible.

There are few points that would need more investigation later. We did not consider the use of biomass to produce transportation fuels. It would be interesting to see how that would fare against the use of the same biomass in the heat and electricity production in a general equilibrium framework. In agriculture and forestry the land use issues have gained more and more attention recently and were not considered in this study. The full life cycle analysis with the emissions of the other greenhouse gases would be required to give any definitive answer for the future development of the emissions in our scenarios. However, the model that we put up in this study, could serve as a good starting point for such extensions.

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APPENDIX: Map of Finnish regions (NUTS3-level)