What becomes of Green Gold? Evaluating the effects of increasing bio-fuel production in Finland with VATTAGE – A MONASH-type CGE model for Finland

The European directive on renewable energy mandates increased use of bio-fuels in the transport sector and sets an overall target of 20% to renewable energy for all 27 of the Member States. Finland is one of the few countries that already exceeds the 20% target with a renewable share of 24% of all primary energy, with bio-energy accounting for some 20%. Finland does not meet the target for bio-fuels in the transport sector, however. The potential for increasing crop-based bio-fuels is limited in the northernmost country in the world, but there is plenty of potential to use Finland's Green Gold, the forests, for bio-fuel production. However, forest-based bio-fuel production will be in competition with other uses of wood, most notably as an input for forest industry and combined heat and electricity generation. Consequently, the various bio-energy targets may actually be in conflict with each other with possibly negative environmental and financial consequences. This study evaluates the effects of increasing the production of bio-fuels in Finland both in the light of imposing the mandatory targets, and in the light of potential bio-fuel production capacity. The study uses the VATTAGE model, a MONASH-type CGE model for Finland.

1. Introduction

The European Council reached an agreement on common, European energy policy goals at the beginning of March this year. The Council endorsed the proposals of the council of environmental ministers that proposed a binding emissions reduction target of 20 per cent compared to 1990 levels for the European Union as a whole, and also agreed on a target of 20 per cent of primary energy consumption for the use of renewable energy for the union as a whole. In addition, the Council has also set a separate, binding target for the use of biofuels in the transport sector.

It is clear that these ambitious targets are interconnected. If the union succeeds in raising the share of renewables from the current level of about seven per cent of primary energy to 20 per cent by 2020, emissions of greenhouse gases will in all likelihood be significantly lower by the strength of this policy alone. Yet it pays to study the implications of the energy policy targets separately as well. This is primarily because the member states have very different starting points. Some countries, notably the Nordic countries, already have renewable shares exceeding 20 per cent of primary energy, whereas others, like the UK, are below the seven per cent current average share. The potential for increasing the share of renewables, however, differs very much between the member states.

This paper studies the renewable energy target form the Finnish point of view. We describe the Finnish energy system and the role renewable energy currently has in it. Then, we survey recent estimates of the potential for increasing the use of renewables especially form the point of view of measures that have been applied to subsidise renewables. Finally, we present results from a simulation studying the effects of increasing the use of renewables.

2. The Finnish energy system

The Finnish economy is among the most energy intensive in the World (in terms of primary energy use per unit GDP) but it is also one of the most energy efficient (in terms of energy use per unit of output). The reason for this is that energy intensive industries – forestry and basic metal industries - account for around one third of total value added, which is a much higher share than in most other OECD countries. While the share of industries is especially reflected in electricity consumption, the Country is dependent on imported primary energy and to compensate for this, its energy supply is very diversified.

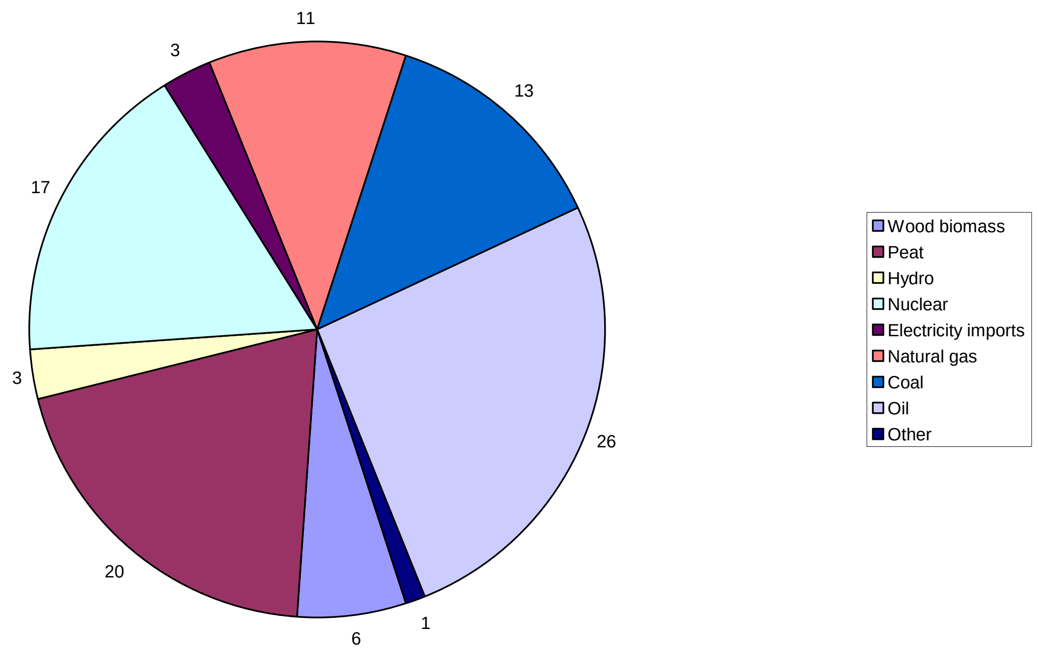
Energy consumption has been forecast in the National energy and climate strategy. There, industrial production is assumed to grow at an average annual rate of 3.5 per cent until 2010, the reference year for the impact evaluations. Emissions of greenhouse gases are expected to grow accordingly, unless additional measures are taken, although at a slower pace than the economy. By 2010, CO2 emissions are expected to be close 67 Mt. To reach the Finnish emission target (1990 levels), CO2 emissions from fossil fuels will have to be cut by 14 per cent (while the other green house gases can be cut slightly more). In the longer run, by 2025, the CO2 emissions are expected to rise well above 70 Mt. The structure of energy use is also changing, with electricity consumption growing from 85,2 TWh to 95 TWh by 2010, and to 108 TWh by 2025.

2.3. The potential for increasing renewable energy

In the past, the share of renewable energy in Finland has been around 24 to 25 per cent of primary energy use. A Commission background study has considered a 45 per cent share feasible for Finland by 2020, exceeding considerably the domestic target of around one third by 2025 that was adopted in the national climate and energy strategy.

The main reason for the very high share of renewable energy in the Finnish energy system is in the use of wood residues in forest industries. Of all renewable energy sources – including hydro power – black liquer and and wood residues stemming from the forest industries account for more than 40 per cent, and together they account for more than 80 per cent of bioenergy use.

Figure 1 Primary energy shares in Finland in 2002



Renewable energy has been subsidised in Finland for a long time. Electricity generated from renewable sources enjoyed tax cuts compared to fossil fuel–based generation, and investments in renewable generation capacity have also been granted direct investment subsidies. The domestic goal for renewable energy use was a 50 per cent increase compared to 1995.

The domestic targets have been moderated for several reasons, however. The first among these is that climate policies will inevitable affect the relative costs of different fuels. For example, the use of bioenergy and wind power will according to previous studies increase considerably, if the prices of emission permits reach 20 euro per tonne of CO_2, as they appear likely to do. The second reason for changing priorities is that the European Commission updates its own targets constantly. Thus the new European targets have also replaced domestic targets. The transport fuel target – that biofuels should account for 5.75 per cent of transport fuels by 2010 – and overall renewables target – renewables should account for more than 20 per cent of primary energy by 2020 have replaced the energy strategy targets. Finland already exceeds the latter goal, but the transport fuel directive will necessitate further measures. It is unclear at the moment, whether Finland will be required to increase her use of renewables as well. What is clear is that the new targets will necessitate further measures, such as tax breaks or direct subsidies. Feed-in tariffs and green certificates could also provide the necessary signals, although they have not been considered in Finland so far.

The most promising source for renewable energy in Finland is still bioenergy, despite its already high rate of utilisation. The national energy strategy estimates that for the Kyoto period, the share of bioenergy could be increased in communal district heating and in industry use. In a background report, the Technical Research Centre of Finland estimated that the increase would be the equivalent of emission cuts in the order of 2.8 to 3.7 million tonnes of CO_2 (out of a total reduction target for CO_2 of around 12 million tonnes). The centre also estimated that even larger increases of bioenergy use would be possible. For transport fuels, the results are not as promising, since the scope for domestic production has appeared much more limited than for heating purposes.

The estimates for bioenergy potential have recently been reviewed. The reviewed figures are given in Tables 1 and 2. It is clear from the tables that bioenergy is produced in Finland foremost as wood residues from forestry and forest industries and as other forest industry residues. The realistic potential for wood residue from stumpage is estimated to be the equivalent of 9.5 TWh a year, while with intensified measures it could be even higher than that. Within the industrial potential, the forest industry itself is in a key role. It is clear that the potential, and especially the economically feasible potential, depends on the growth of the forest industry. It is also clear that with higher prices of biofuels, the direct use of wood as energy will become more and more attractive, forcing forest industries to compete for wood with the energy sector, as is already happening in some European countires.

The use of transport biofuels in Finland is already taking place by increasing imports of ethanol from Brasil, and by refining biodiesel from imported peanut oil. Domestic potential for increased production based on domestic grains is limited and uneconomical, but it is possible that sophisticated new technologies enable the refinement of biodiesel from wood residues in the future. So far, however, domestic raw materials are not sufficient to cover the required increase in transport biofuels. It is seems clear that economic measures need to be taken to render transport biofuels economically feasible.

Table 1. Estimated potential for increasing the use of bioenergy until 2015 by sector

Sector, TWh	Current support: price of fossil fuels and emission permits, 20 EUR/tonne	Enhanced measures and/or higher energy prices
Heating	3.0	10.0
Combined heat and power generation in communities	5.0	13.0

Combined heat and power generation in industries	9.5	15.0
- of which small-CHP	0.2	2.0
Separate power generation		
- separate condensing plant	0.5	0.5
- condensing plants of CHP-units	2.0	5.0
Biocarburants in transport	2.5	5.0
Total increase	22.7	50.5
Note: Biocarburants in transport do not incluce the share of fodder, heat or other side products.		

Table 2. Estimated potential for increasing the use of bioenergy until 2015 by fuel type		
Fuel type, TWh	Current support: price of fossil fuels and emission permits, 20 EUR/tonne	Enhanced measures and/or higher energy prices
Wood residue from forestry		
- from stumpage	6.0	10.0
- from thinning	2.0	5.0
Wood used for heating of houses		
-wood pellets and chips	3.0	10.0
Recycled fuels	2.0	6.0
Biomass from fields		
-straw, crop residue, manure	0.5	1.0
-new energy crops	2.0	4.0
-crops and other biomass cultivated for producing fuel for transport	2.2	2.5
Wood residues from industry		
-increase of energy content through drying /condensing	1.0	2.0
Peat	5.0	10.0
Total increase	22.7	50.5

3. Overview of VATTAGE

The study uses VATTAGE, a CGE model for Finland, based on the ORANI and MONASH models and in its latest development, most closely resembling the MONASH model with MONASH-type dynamics in the capital and labour markets (Dixon and Rimmer, 2002). The model however includes some extensions to deal with the peculiarities of the Finnish economy, such as the Finnish income transfer and income tax systems. It also distinguishes three sources for commodities, namely, domestic firms, EU-countries, and non-EU-countries. Exports have similarly two alternative foreign destinations.

The model assumes that capital in each period is sector-specific. The sector-specific capital stock changes depending on the investments targeted to it. In dynamising the model, three inter-temporal links were added to connect the model's individual simulation periods: (1) accumulation of fixed capital, (2) accumulation of financial claims and (3) lagged adjustment mechanisms notably in the labour markets and in the balancing of the public sector budgets.

The core of the VATTAGE database consists of industry specific supply and use data. The database is designed to facilitate flexible aggregation. The database consists of 918 commodities and 175 industries. The data allows for different base years, from2000 to 2004. One of the distinguishing features of the VATTAGE database is also its disaggregated tax data, which includes indirect taxes by products and branches. Government expenditures are also modelled in a fairly detailed way.

The IO -table identifies only costs related to demand and supply of commodities. National account data is used to add transfers that are not present in IO-accounts to form a complete SAM, which represents a mapping between institutions and agents in the model. As in the input output table, each cell in the SAM also represents the value of an economic transaction between a pair of institutions in the economy. Such transactions occur in the commodity, factor and capital markets. Each economic transaction represents a linkage between institutions, each institution's purchases being another institution's sale.

The third part of the database is behavioural parameters that characterise demand and supply responses of different agents.

The Input-Output structure of VATTAGE -model is schematically described in figure 1. The column headings in the main part of the figure (an absorption matrix) identify the following demanders: 1) Industries, 2) Investments, 3) Households, 4) Exports, 5) Public sector and 6) Change in inventories.

The commodity flow part of the database is divided into three categories value flows at basic prices (V_BAS) and value flows that constitute the wedges between producers (who receive the basic prices) and users of the commodities that are distribution margins (V_MAR) and commodity taxes (V_TAX).

The entries in each column show the structure of the purchases made by the agents identified in the column heading. Each of the C commodity types identified in the model can be obtained locally or imported from overseas from alternative sources. The source-specific commodities are used by industries as inputs to current production and capital formation, are consumed by households and governments, are exported, or are added to or subtracted from inventories. Only domestically produced goods appear in the export column. M of the domestically produced goods are used as margins services (wholesale and retail trade, and transport) which are required to transfer commodities from their sources to their users. Commodity taxes are payable on the purchases. As well as intermediate inputs, current production requires inputs of three categories of primary factors: labour V1LAB (divided into O occupations), V1CAP fixed capital, and V1LND agricultural land. Besides primary factor costs product and production taxes (OCT) and product subsidies (PTX) are included in the industry costs.

Each cell in the illustrative absorption matrix in Figure 1 contains the name of the corresponding data matrix. For example, V1BAS is a 3-dimensional array showing the cost of C goods, both domestically produced and imported (S), to I industries.

Figure 1 The VATTAGE data base

		Absorption Matrix					
		1	2	3	4	5	6
		Producers	Investors	Household	Export	Government	Change in Inventories
	Size	I	I	1	D	1	1
Basic Flows	CxS	V1BAS	V2BAS	V3BAS	V4BAS	V5BAS	V6BAS
Margins	CxSxM	V1MAR	V2MAR	V3MAR	V4MAR	V5MAR	n/a
Taxes	CxS	V1TAX	V2TAX	V3TAX	V4TAX	V5TAX	n/a
Labour	O	V1LAB					
Capital	1	V1CAP					
Land	1	V1LND					
Production Subsidies	1	V1PTX					
Production and product taxes	1	V1OCT					

C =Number of Commodities
I = Number of Industries

S =Domestic Supplies + No. of Import Sources
O = Number of Occupation Types

M = Number of Commodities used as Margins

D = Number of Export Destinations

	Joint Production Matrix
Size	I
C	MAKE

	Import Duty
Size	MRC
C	V0TAR

4. VATTAGE simulations

The simulations presented here present a first attempt at evaluating the possibilities of bioenergy. It is clear that the measures for reaching the bioenergy and emission targets are interrelated. Reaching the emission target will necessitate increased use of bioenergy. On the other hand, a siginificant increase of bioenergy will cut emissions. For the moment, only the national emission targets under the Kyoto Protocol are binding and so, we concentrate on the case where emissions are cut by the amount the Kyoto protocol and study the impact of those targets on bioenergy on the one hand, and on the costs of the combined energy and climate policy, on the other.

The simulations take as given the policies required for meeting the Kyoto target and long term emission target. These consist of several parts. First, the European Emission Trading Scheme (ETS) has been operational for close more than a year now, and forms a natural starting point for the simulations, with an ETS permit price of around 5 euro per tCO2 expected for 2007. Second, the recently elected Finnish government has already announced an increase of energy taxes that we assume will take place during the current year. Third, during the Kyoto period, we assume that ETS emission permit prices will gradually rise to hit 20 euros per tCO2 by 2012. By 2020, when the target is tightened to 20 per cent below 1990 GHG levels, the Commission expects a CO2 price of 44 euros per tonne CO2.

As to the increased use of bioenergy, we concentrate on the potential at the district heating and electricity generation. Here, the figures of the study of the expert group suggest a potential for a 15 per cent increase by 2015 provided ETS permit prices remain close to 20 euro per tCO2 or more. Since this seems likely, we can form a scenario where the potential will become available. As to the other bioenergy potentials, it is currently unclear whether biofuels for transport will be domestically produced or imported. Neste Oil, a Finnish oil company, has more than the capacity to produce the biofuels mandated by the biofuel directive, but with current policies in place, they might find it more lucrative to export their biodiesel production to Central Europe. Their NeXBTL process is not based on domestic raw materials, either, which tends to make their effect on the domestic economy less significant than processes using domestic biomass. This leaves the traditional wood biomass route as the most likely to grow during the next years.

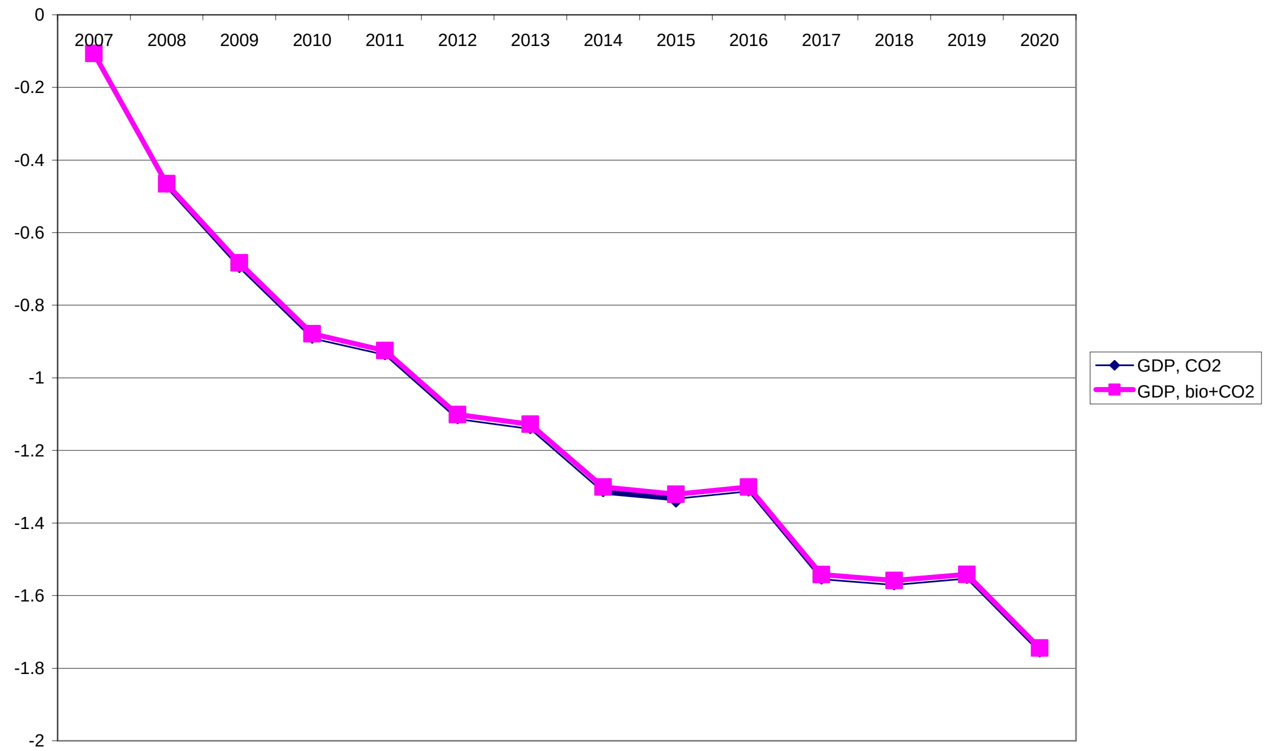
The 15 per cent increase suggested by the expert group represents a very significant increase. In practice, reaching it would necessitate giving up the use of coal in a large share of communal CHP-plants, and also in the large cities. A large part of the increase would take place in industries themselves, however, and would also entail increased use of peat and waste fuels.

Here, we concentrate on the power sector. We assume that a shift from coal to wood is technologically change is economically and technically feasible. The policy has two immediate results: the value share of wood biomass in power and heat generation rises from 0.5 to 0.9 per cent, while the use of coal decreases from about 25 per cent to 21 per cent. The activity level in the forestry sector decreases overall, however, as the activity of the forest industry decreases as a result of the climate policy.

We model the shift from coal to biomass as a (coal) input saving technological change in power generation and force a technology change that produces the assumed increase in biomass use. While this approach is not really satisfactory in that it does not need with the price signals necessary to achieve the shift, it serves to illustrate the overall effects of the bio potential. Furthermore, the policy measures that the shift most likely necessitates are still under debate.

An interesting feature in the results is that the combined bioenergy and climate policy seems to be slightly less costly to the economy than climate policies alone would be, at least until the measures are accounted for. This is illustrated in figure 3. This result has to be interpreted with some caution, though, since we have not taken into account the costs of modifying the generation plants and arranging the not inconsiderable logistics for providing wood fuel to large CHP plants, neither have we accounted for the investments and subsidies in the forestry sector and in the forest industries.

Figure 2 GDP and emissions



With respect to emissions, increasing biofuel use has clear effects, as shown in figure 2. The overall drop in domestic emissions is larger by close to a percentage point – equivalent to close to half a million tonnes of CO2. The effects on power generation are shown in figure 3, whence it is apparent that the sector copes better with climate policies when the options for switching to biofuels are taken into account.

Figure 3 CO2 Emissions

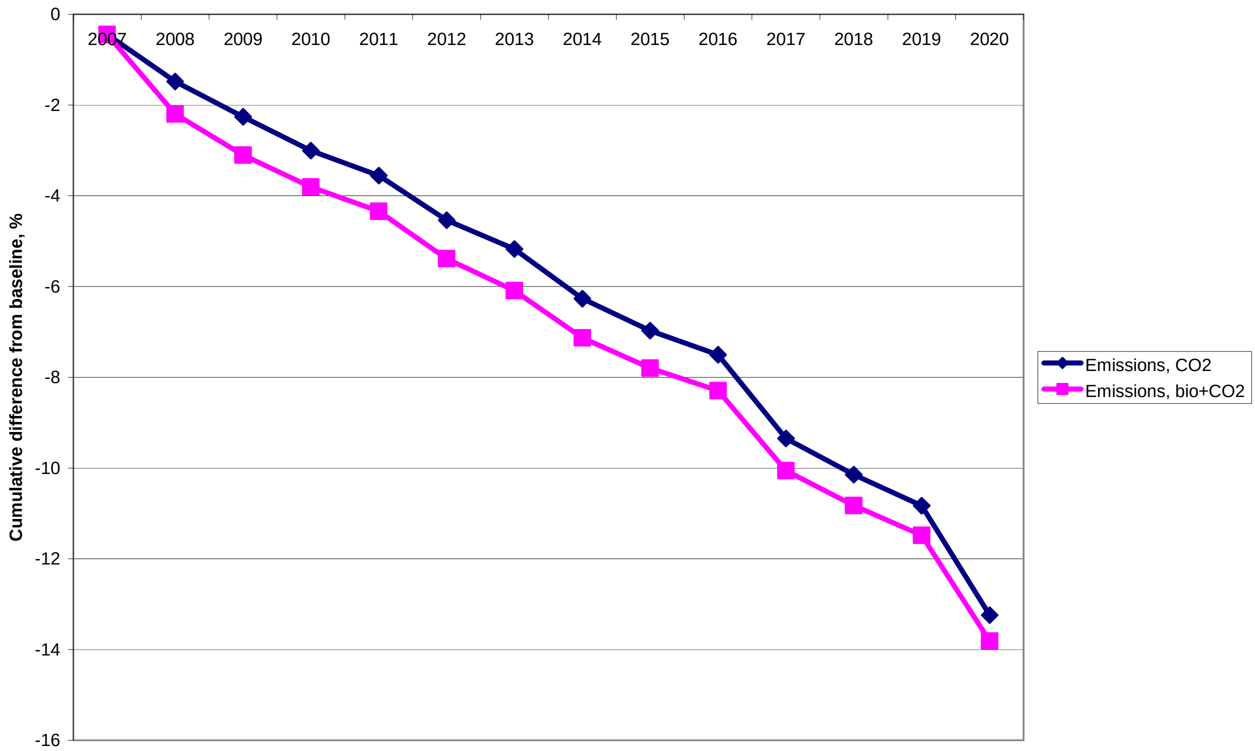
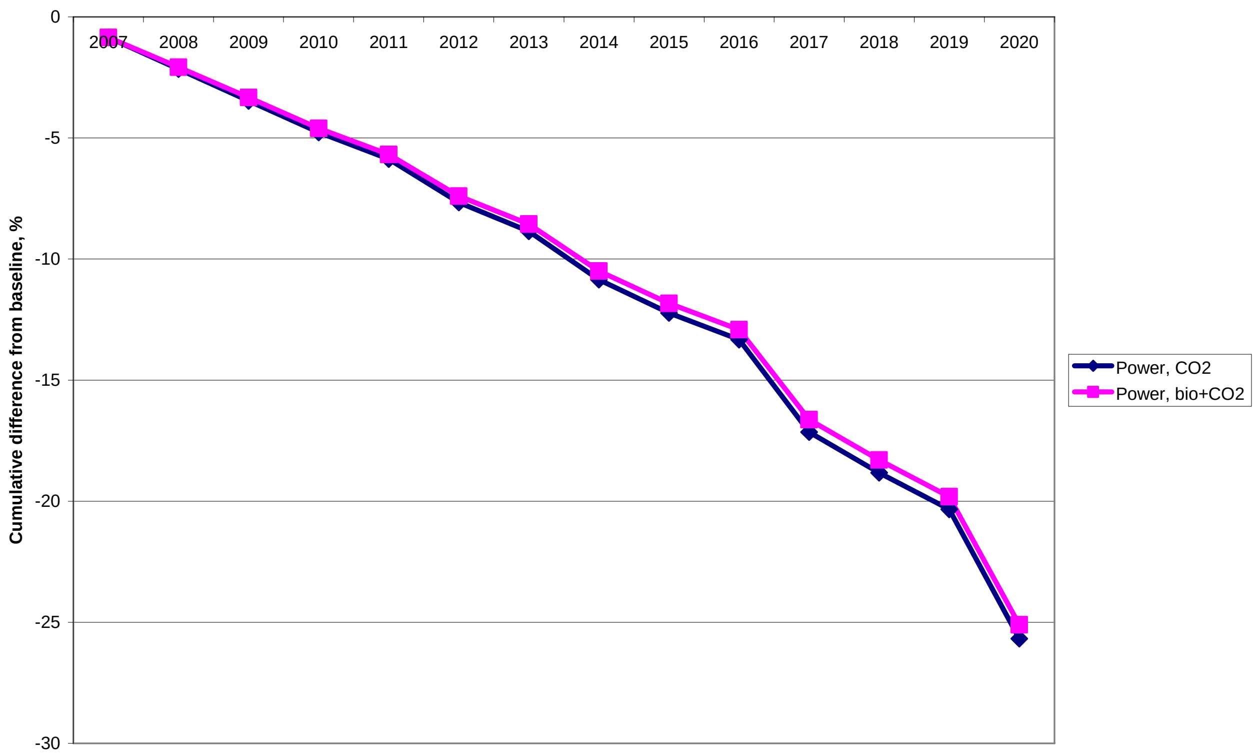


Figure 4 Power and heat generation



5. Conclusions

This paper has taken a first look into increasing the use of biofuels in Finland, as necessitated by the decision of the EU Council. We have argued that this poses quite a challenge to Finland, which already uses more bioenergy in proportion to primary energy than most other countries. Nevertheless, there is still potential for increases and this paper has utilised a recent committee estimate on the feasible potential.

We have demonstrated the effects of increased biofuel use on the economy, emissions and the power sector in general. Our simulations suggest increasing bioenergy has many positive effects. However, there are also costs and limits to the economic potential.

References

Dixon, P. – Rimmer, M. (2002): Dynamic General Equilibrium Modelling for Forecasting and Policy. North-Holland, Amsterdam.

"Long-Term Prospects for Increased Energy Use of Biomass". Expert group report, Ministy of Trade and Industry.