BIOTRADE[1]: INTERNATIONAL TRADE IN RENEWABLE ENERGY FROM BIOMASS

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ABSTRACT: This paper discusses international trade in renewable energy from biomass. Main objective is to compare options for international trade in energy from biomass and to compare these options with non-trade options like domestic use of biomass and afforestation. Aspects that are taken into account are costs, macro-economic effects (i.e. changes in GDP and national employment), energy balance and environmental effects. Several cases are analysed: in all cases the importing country is the Netherlands. Exporting countries are Sweden, Estonia and Ecuador. In each country several biomass sources available for export are considered like forestry residues and energy crops. In addition several transport routes are studied like shipment of unprepared biomass, upgraded biomass or biofuels and international transport of the biomass as electricity. Research so far concerns the import of Swedish energy from biomass by the Netherlands. Five chains that all result in the delivery of electricity to the Netherlands have been analysed. General conclusions are that the total costs are lowest when the biomass is imported as electricity and that for all chains the macro-economic effects are larger in Sweden than in the Netherlands. Compared to the current costs of electricity in the Netherlands, the electricity from biomass imported from Sweden is expensive.

1. BACKGROUND

International trade in renewable energy from biomass might have several advantages. It might increase the utilisation of renewable energy from biomass, for example when biomass is exported from countries with a low energy demand but large biomass potential to countries where renewable energy is demanded but not available. In addition biomass might be a valuable export product for the exporting country and might increase the diversification of the energy supply in the importing country. International trade might also have a stabilising effect on global biomass prices. On the other hand international trade in energy from biomass might have disadvantages. Biomass meant for export might not be cultivated or harvested sustainably. In addition export might not be the best application for the biomass, for example if domestic use of the biomass could replace use of fossil fuels. Furthermore import of energy from biomass might not be the best way to reduce CO_2 emissions for the importing country, for example if other measures like afforestation are cheaper.

2. OBJECTIVE

This paper discusses international trade in renewable energy from biomass. The main objective is to compare options for international trade in energy from biomass and to compare these options with non-trade options like domestic use of biomass and afforestation. In the comparisons the following aspects are taken into account:

- Costs
- Macro-economic effects (i.e. changes in the Gross Domestic Product (GDP) and the national employment)
- Energy balance
- Environmental effects

The timeframe for this study is 2010. At that time international trade in renewable energy from biomass might take place on a large scale. In this study several cases are analysed that are described in the following section:

3. CASES

3.1 Import by the Netherlands

In all cases the importing country is the Netherlands. The Dutch national government has recently formulated its energy policy for the coming years. One of the objectives is to reach a share of 10 percent of renewable energy sources in the total energy supply in 2020 [1]. Import of renewable energy from biomass is expected to be necessary to meet this objective. About 30 PJ of renewable energy from biomass should be imported in 2020 [2].

3.2 Export by Sweden, Estonia and Ecuador

The biomass imported by the Netherlands can originate from several countries. In this study the countries selected as biomass supplying countries are Sweden, Estonia and Ecuador. In Sweden possible biomass sources are residues from timber- and pulpwood forestry (like logging residues from final fellings and small trees from thinnings) and energy crops (like willow). In Estonia a possible biomass source is residues from timber- and pulpwood forestry (mainly logs). Finally in Ecuador two options are considered: export of energy crops (like eucalyptus) and afforestation[2].

3.3 Transport routes

The biomass from Sweden, Estonia and Ecuador can be transported to the Netherlands via various routes. Routes considered in this study are shipment of unprepared biomass (as bales, bundles, logs or chips), upgraded biomass (as pellets), shipment of biofuels made from biomass (like methanol or H_2) and export of electricity generated with biomass.

3.4 Summary

The above mentioned variables result in several cases that are summarized in table I:

Table I: Summary of the cases analysed in Biotrade

Biomass exporting country	Biomass sources	Transport to the Netherlands
Sweden	Forestry residues/ Energy crops	Shipment of unprepared biomass Shipment of upgraded biomass Shipment of biofuels Export of electricity
Estonia	Forestry residues	Shipment of unprepared biomass Shipment of biofuels Export of electricity
Ecuador	Energy crops/ Afforesta-tion	Shipment of unprepared biomass Shipment of biofuels No international transport in the case of afforestation

All cases result in the delivery of electricity in the Netherlands, except for the cases in which biofuels are exported and the case in which afforestation takes place. An important aspect of all cases is that conversion to electricity and production of biofuels take place in stand-alone units. The costs are estimated for the electricity (in ECUct/kWh) or the biofuel (in ECU/GJ) delivered in the Netherlands and per tonne avoided CO_2 emission (in ECU/tonne). The change in GDP and national employment caused by the trade is estimated for the exporting and importing country only. The energy balance and environmental effects are analysed in particular for Sweden.

4. RESULTS: SWEDEN - THE NETHERLANDS

The preliminary results of this paper concern the costs and changes in GDP and national employment for the import of Swedish biomass by the Netherlands [4].

4. 1 Chains

The chains that have yet been analysed for the case Sweden - the Netherlands are specified in table II:

Table II: Chains Sweden - the Netherlands

	Biomass source	Handling Sweden	International transport	Handling the Netherlands
1	Logging residues	Compressed to bales	Shipment	Converted to electricity
2	Trees from thinnings	Bundled	"	"
3	Willow	Harvested as chips	"	"
4	Logging residues	Pelletised	"	"
5	Logging residues	Converted to electricity	International grid	-

The shipment takes place between Karlstad in Sweden and Rotterdam in the Netherlands, a distance of approximately 1000 km. The international electricity transport in the fifth chain takes place via the existing international grid. All chains result in the delivery of electricity to the Netherlands. In all chains conversion to electricity takes place via gasification in a stand-alone biomass-integrated gasification/combined cycle unit (BIG/CC unit) with a capacity of 30 MWe.

4.2 Costs

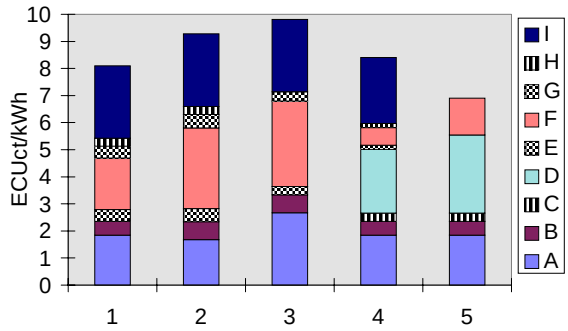
For each chain the costs for the delivery of electricity to the Netherlands have been estimated for today and for 2010. They have been found through literature study, interviews and comparison with other studies. The costs for today are presented in table III and figure 1:

Table III: Total costs today for the delivery of 1 kWh of electricity from Swedish biomass to the main grid in the Netherlands

Chains	Total costs today (ECUct/kWh)
Bales from logging residues	8,10
Bundles of trees from thinnings	9,27
Willow chips	9,81
Pellets from logging residues	8,40
Electricity from logging residues	6,90

The interest rate and lifetime vary from operation to operation according to the data source used.
Shipment takes place along a distance of about 1000 km.
The conversion takes place in a 30 MWe BIG/CC unit with a conversion efficiency of 40,3 %.

Figure 1: Total costs today for the delivery of 1 kWh of electricity to the main grid in the Netherlands for each chain divided over the various operations (ECUct/kWh)



The numbers at the horizontal axis refer to the numbers of the chains in table II. Legend:

A. Production in Sweden
B. Road transport in Sweden
C. Crushing in Sweden
D. Pelletising/conversion in Sweden
E. Loading in Sweden
F. Shipment from Sweden to the Netherlands
G. Unloading in the Netherlands
H. Crushing in the Netherlands
I. Conversion in the Netherlands

The general conclusions for the costs today are:

- Biomass sources: Logging residues and trees from thinnings are the cheapest sources of biomass from the three sources of biomass considered in this study. Willow is considerably more expensive. An

explanation for this result is that willow has to be specially cultivated while logging residues and trees are a by-product from forestry.

- Pelletising: Pelletising reduces the international transport costs considerably, but because it is such an expensive additional operation, it does not decrease the total costs.
- International transport: If international transport takes place by ship than the costs for international transport mainly depend on the energy bulk density of the biomass transported. Of the unprepared biomass types bales, bundles and chips, bundles have the lowest, chips the second lowest and bales the highest energy bulk density. Consequently shipment is cheapest for bales, more expensive for chips and most expensive for bundles. However, international electricity transport is the cheapest way for international transport of energy from biomass from Sweden to the Netherlands. It is cheaper than the shipment of any unprepared biomass type while no additional operations are necessary.

For the estimation of the costs in 2010 the following additional assumptions have been made:

- an improvement of the productivity of the recovery of logging residues and trees from thinnings
- a higher yield per hectare for willow
- a decrease in the shipment costs based on an alternative shipment route
- an increase of the electrical conversion efficiency of the BIG/CC unit

These assumptions are based on expert guesses. The costs for 2010 are presented in table IV:

Table IV: Total costs in 2010 for the delivery of 1 kWh of electricity from Swedish biomass to the main grid in the Netherlands

Chains	Total costs 2010 (ECUct/kWh)
Bales from logging residues	6,11
Bundles of trees from thinnings	6,60
Willow chips	6,41
Pellets from logging residues	6,86
Electricity from logging residues	6,16

The general conclusions for the costs in 2010 are:

- The total costs for all chains might reduce considerably.
- The differences in the total costs between the chains might be considerably smaller.

4.3 GDP and national employment

For each chain described in table II the increases in GDP and national employment in Sweden and the Netherlands are estimated. Both direct and indirect effects have been taken into account. Direct effects are GDP and employment that are created within the chain itself, for example at the recovery of the biomass. Indirect effects are GDP and employment that arise when supplying sectors of the chain produce products demanded by the chain, like forestry machinery. The direct effects are found through literature study, interviews and comparison with other studies. The indirect effects are based on these data as well, but in addition statistical data about the economies of Sweden and the Netherlands are used[3]. The change in GDP and national employment is estimated for the export of 10 PJ of biomass per year. The results are presented in table V and VI:

Table V: Increase in GDP in Sweden and the Netherlands caused by the trade of 10 PJ of energy from biomass per year

Chains	Increase in GDP (MECU/10 PJ.year)		
	Se	Nl	Total
Bales from logging residues	40	30	71
Bundles of trees from thinnings	50	31	81
Willow chips	59	26	85
Pellets from logging residues	50	23	73
Electricity from logging residues	55	0	55

Table VI: Increase in employment in Sweden and the Netherlands caused by the trade of 10 PJ of energy from biomass per year

Chains	Increase in employment (job equivalents/ 10 PJ.year)		
	Se	Nl	Total
Bales from logging residues	832	534	1366
Bundles of trees from thinnings	1255	552	1807
Willow chips	1404	416	1820
Pellets from logging residues	1085	356	1440
Electricity from logging residues	1164	0	1164

The general conclusions for the GDP and national employment are:

- The most expensive chain generates the highest increase in GDP and national employment
- For all chains the increase in GDP and national employment is higher in Sweden than in the Netherlands
- The allocation between Sweden and the Netherlands is not the same for each chain. Upgrading the biomass before transport to the Netherlands increases the macro-economic effects in Sweden at the expense of the macro-economic effects in the Netherlands

When costs, GDP and national employment are all taken into account in the comparison of the chains there is no chain that is optimal from both a Swedish and a Dutch perspective. However, it is possible to change the allocation of GDP and employment between Sweden and the Netherlands, for example by negotiations about the nationalities of the companies and supplyers involved. In addition the differences in the total costs between the chains might be smaller on the longer term, which will make the choice for a chain with a more equal allocation of GDP and national employment easier.

5. CONCLUSION AND DISCUSSION

The most important conclusion of this paper so far is that the cheapest route for import of biomass from Sweden by the Netherlands is as electricity via the international electricity grid. However, further study is recommended. The actual transport costs will depend on the developments

in the European market for electricity. In addition practical limitations like energy losses and capacity of the grid should be studied closer.

Compared to the current costs of electricity in the Netherlands (4,5 ECUct/kWh, [3]) the electricity from biomass from Sweden is expensive, even in 2010. The increase in GDP and national employment takes mainly place in Sweden and is therefore no additional argument for governmental support of the import. Therefore, import of energy from other countries than Sweden is necessary to identify options that are more economically feasible for the Netherlands.

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FOOTNOTES

[1] Biotrade is an international research project financed by the European Union, the NUTEK (The Swedish National Board for Industrial and Technical Development) and the NOVEM (Ducth Association for Energy and Environment). Participants are, besides the authors, SIMS (Department of Forest Industry Market Studies, Swedish University of Agricultural Sciences, Uppsala, Sweden) and SEP (Dutch Electricity Generating Board, Arnhem, the Netherlands).

[2] Equador is a so called FACE (Forests Absorbing Carbondioxied Emission) country. The SEP (Dutch electricity generating board) has started afforestation projects in several countries all over the world as a means to compensate for the CO_2 emissions of fossil fuel fired electricity plants in the Netherlands.

[3] The indirect macro-economic effects are calculated by using the input-output method. This method calculates the total productivity that is needed throughout the economy for the delivery of a demand for products from a certain sector. In this calculation intermediairy deliveries between sectors are taken into account.