BIOFUEL PRODUCTION AND CONSUMPTION IN THE EUROPEAN UNION: CONFRONTING AMBITIONS WITH POTENTIALS

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ABSTRACT: EU objectives for bioenergy consumption are unclear with respect to type of feedstock that is to be used. This paper examines three EU bioenergy scenarios for 2020: Business As Usual ('BAU'), '1stGen' and '2ndGen' that differ in the replacement rate of fossil fuels (7, 15 and 15%, respectively), share of second generation technology (80, 67, and 33%), type of feedstock and import for bioethanol (0, 3, 0% of total consumption) and biodiesel (55, 37, 23%). The paper discusses how the required feedstock (67 to 105 million ton or Mton) can be generated from sources like yield increase, area expansion, use of Set Aside area and improvement of conversion efficiency. Together, these can generate 1.4 to 2.4 times the required feed stocks for the alternative scenarios. It is concluded that, in principle, sufficient biomass can be produced within the EU to replace up to 15% of the transportation biofuels. This does not automatically mean that this potential will be realised. Reasons of eventually not realising the potential include (i) unfavourable price ratios for farmers, (ii) unfavourable future climatic conditions and (iii) further restrictions in input use regulations.

Keywords: biomass supply, biofuels, scenarios

1 INTRODUCTION

The need for a reduction in the emission of Greenhouse Gases (GHG) has been widely accepted. Several options exist to realise this goal. Next to energy savings, wind, solar, geothermal and hydro energy, replacement of fossil fuels by biomass is an important alternative. Biomass is considered as potentially the third largest non-fossil energy source, after solar and wind energy [1].
According to a recent WWI estimate of biomass potentials for 2050, energy crops in an optimistic scenario can generate up to 850 EJ per year [2]. Most of this (700 EJ) originates from cultivation of energy crops on agricultural land. In a more modest scenario, energy crops still could generate 200 EJ or half the current total global energy use. Many countries have embraced biomass and especially bioenergy crops as an important source of renewable energy. This is also the case in the EU. It remains uncertain, however, which energy crops will play a role and how and where the required biomass can be grown.
The current paper discusses potential domestic production of biofuels in the EU by 2020. Starting from three scenarios on the use of biomass as alternative transportation fuel source, we will discuss how the required feedstocks might be generated using solely food crop products. The paper is organised as follows. First, the EU biofuel scenarios are introduced (Section 2). Next, required biomass feedstocks are calculated (Section 3), after which alternative feedstock sources are evaluated (Section 4). The paper ends with a discussion and some conclusions.

2 EU BIOFUEL SCENARIOS

2.1 BIOFUEL POLICY

The European Union has formulated an ambitious policy on GHG emission reductions. An important role in this policy has been allocated to the application of biofuels. Following the first European Climate Change Programme (2001), several policies were implemented, including the Biofuels Directive of 2003 which specifically aimed at the promotion of the use of biofuels. More recently, concrete steps towards implementation of the objectives were formulated in the so-called Biomass Action Plan and Biofuels Strategy. Early 2007, ambitions in GHG emission reduction for 2020 were formulated, again stipulating the role of biofuels.
So far, however, implementation of the policy at national level is very limited in most of the EU member states. Average fossil fuel replacement rate in 2005 was estimated at 1% for the EU25[1], thus lacking behind the moderate national policy objectives for that year which required a 1.4% replacement while a timely implementation of the 2010 objective (5.75%) would require even higher replacement rates for 2005. Many countries are lacking behind, Germany and Sweden being the exception to the rule. In a recent document [3], the EU identified the gap as well as the need for further action. For the future (2020), a 10% replacement objective is expected.

2.1 BIOFUEL SCENARIOS

In the process of preparing policy adjustments, an impact assessment study was done on the potential effects of possible changes in the biofuel directive [4]. Scenarios identified in this study include increased replacement shares, sources of biofuel feedstocks, technologies for feedstock conversion, investment requirements and cost implications. Effects of alternative scenarios were discussed in different documents. In our paper, we include three of the scenarios. Next to the Business As

[1] Figures presented in this paper refer to the number of EU member states (25) at the time the scenarios were formulated. Bulgaria and Romania, recently entering the EU, have not been included in the analysis.

Usual (BAU) scenario, our scenarios refer to increased replacement shares in 2020 based predominantly on either first generation (1stGen) or second generation (2^{nd}Gen) technology. Major characteristics of the scenarios are depicted in Figure 1.

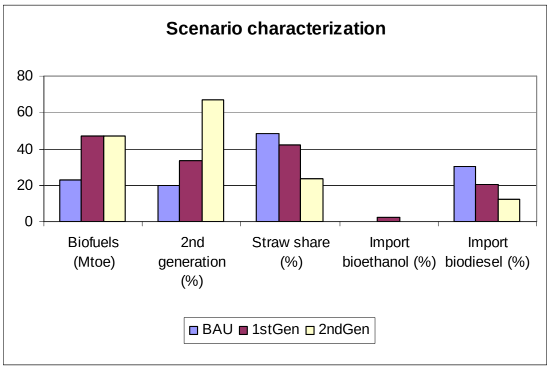


Figure 1 Major characteristics of the scenarios

Replacement share of fossil fuels is 7, 15 and 15% for the BAU, 1stGen and 2ndGen scenarios, respectively, biofuel requirements amounting to 23, 47 and 47 Mtoe. The share of second generation technology varies between 20% in BAU and 67% in 2ndGen. Straw is the major feedstock for second generation conversion in BAU (50%), the remainder being produced from a variety of lignocellulosic sources including short term coppice. The importance of straw decreases in the 1stGen and especially the 2ndGen scenarios. Import of bioethanol is negligible. Biodiesel imports are low to moderate, varying between 13 (2ndGen) and 30% (BAU).

3 FEEDSTOCK REQUIREMENTS

Scenario definition included indication as to the different crops feedstock sources to be used to produce the biofuels. Major bioethanol feedstocks are cereals, sugarbeet and straw, while biodiesel mainly is made from oilseed rape. Annual requirements of crop biomass amount to 33, 52 and 28 million ton (Mton y^{-1}) of cereals for BAU, 1stGen and 2ndGen, respectively (Table I). Demand for sugar beet varies between 7 and 10 Mton y^{-1}. Oilseed rape requirements are 8 to 23 Mton per year.

Table I: Feedstock requirements in the EU25 in 2020 (Mton y^{-1})

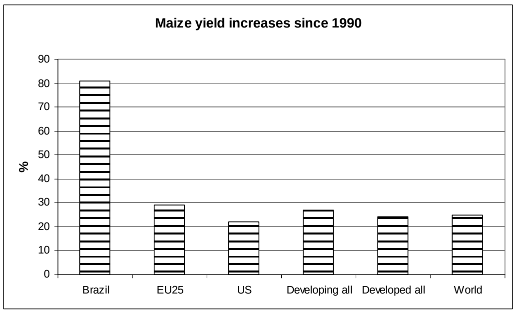
	Cereals	Sugar beet	Oilseed rape	Straw
BAU	33	7	9	10
1stGen	52	10	23	20
2ndGen	28	7	8	24

4 ALTERNATIVE FEEDSTOCK RECOURCES

The amount of feedstocks required in the scenarios were compared to the potential of possible feedstock sources. Total cultivated area required to produce the feedstocks, normally is calculated against *present* crop yields, while the feedstocks have to be produced in 2020. In order to assess future areas, we will have to consider *future* crop yields. Therefore, expected yield increase will be discussed below. Further, we discuss (i) potentials for area expansion, (ii) use of set aside area and (iii) improved feedstock conversion.

4.1 YIELD INCREASE

Crop yields have shown important improvement since the 1940s. Although relatively small changes are realised on a year-to-year basis, accumulated effects over longer periods can be considerable. Historically, high yield increases have been realised for all crops in all parts of the world. As an example, maize yield increases since 1990 are depicted in Figure 2. Over a period of less than 15 years, yield increases amounted to 22 (US) to 81% (Brazil). Results for the EU, showing a 29% rise, are above the average realised in developed countries.



Source: [4]

Figure 2 Yield increases realised in maize in 1990-2004

It is not realistic to expect the improvements shown above for longer periods (results for maize being rather exceptional, annual average EU25 wheat yield increases for this period e.g. amounting to 0.8 %.). In the calculations, therefore, an average crop yield increase of 1% per year will be assumed. Actual progress will depend on a number of factors, including (i) the type of crop, (ii) base yield levels in given a area, but also (iii) availability of inputs and (iv) research on crop improvement.

Assuming an average annual yield increase of 1% for major food crops in the EU over a period of 15 years will generate an additional annual production of 37 Mton of cereals, 20 Mton of sugar beet and 2 Mton of rape seed (Table II). Yield increases will not apply to straw, as this is a by-product and it may be expected that yield improvements of cereals will partly go at the extent of straw availability.

Table II: Increased feedstock production (Mton y^{-1}) in in the EU25 in 2020

	Cereals	Sugar beet	Oilseed rape	Straw
Yield increase	37	20	2	n.a.
Area expansion	25	13	1.6	21
Set aside	7	4	0.5	6
Conversion	3	0.5	1.2	1.0
All measures	72	38	6	28

4.2 AREA EXPANSION

Expansion of cultivated area often is considered as the first alternative for increased feedstock production. In the

EU25, currently 103 Mha is cultivated. Although there is some scope for further expansion, it is not clear how much land would be available.
In this report, a potential area expansion of 10% is assumed. Under conditions similar to those on existing agricultural areas (distribution of crops, input and yield levels), this may be expected to generate 61 Mton of feedstocks per year (Table II).

4.3 SET ASIDE AREA

Currently, close to four million ha agricultural land in the EU is excluded from cultivation. This so called set aside land could be used for the production of bioenergy feedstocks. Already, EU policy has been adjusted to allow this, rewarding farmers who use this land for bioenergy crops with a subsidy of € 45 per ha. Assuming that three million ha is cultivated and applying similar crop ratios and yields as currently found on agricultural land, annually, some 18 Mton of feedstocks may be generated (Table II).

4.4 IMPROVED FEEDSTOCK CONVERSION

Conversion rates of feedstock into biofuels may be expected to improve. Historically, considerable improvements have been realised, especially in Brazil and the US. An accumulated improvement of 5% (an annual increase of nearly 0.4%) could release considerable feedstocks. The exact amount will depend on the total amount of feedstocks that is converted into biofuels. Application of the 5% improvement rate to the highest calculated feedstock requirements (105 Mton y^{-1} in the 1stGen scenario) shows that this could release an equivalent of over 5 Mton of feedstock per year.

4.5 COMBINED SOURCES

Each of the alternative sources in theory is able to generate a significant part of the required feedstocks. It is, however, not to be expected that sources can be used separately. Any combination of individual sources can occur. The cumulative supply capacity, over 140 Mton per year, is more than sufficient to compensate for the increased demand for crop products in 2020 (it is equivalent to 2..4 times the total requirements of the BAU scenario, 1.4 times the 1stGen and 2.1 times the 2ndGen requirements, respectively). There are, however, important differences between individual crops. Demand requirements for cereals, sugar beet, and wheat are more than sufficiently covered. This is not the case for the demand for oilseed rape.

5 DISCUSSION

Future domestic demand for biofuel crop feedstock in the EU25 has been estimated using three alternative scenarios. Under the assumptions made in this study, EU feedstock demand in 2020, estimated at 67 to 105 Mton per year, can more than sufficiently be covered by potential sources that were identified. This applies to most of the individual crop feedstocks, rapeseed being the only exception. Requirements of rapeseed oil therefore can only be covered if an important area expansion is realised as compared to the data used in this study (applying to 2005). More recent data suggest that this indeed is the case.
Not all changes discussed above are equally probable. Yield increases may differ for specific crops, while a 10% area expansion of the entire agricultural area is not likely. A 10% expansion for *specific* crops (related to biofuel production) is, however, not unrealistic, especially given the fact that agricultural area in the two new EU member states (Bulgaria and Romania) equals 30% of the total area of the EU25 that is discussed here. Current policy, further, intends to subsidise biofuel crop production on a maximum of 2 Mha of set aside land, indicating that an expansion of 3 Mha might be an optimistic estimate. Assumptions on conversion improvement have been based on historic data for the US. Given the large numbers of new plants that are constructed (or planned) in the EU over the next years, it seems realistic to expect further improvement in conversion efficiency.
Although not all of the improvements discussed above may be realised in the next 15 years, their combined effect may be expected to be sufficient. It therefore seems safe to conclude that, from a technical perspective, future demand for biofuel feedstocks can be covered from available domestic sources. This is even more the case if current (5.75%) and expected future (10%) policy replacement levels are considered in stead of the 15% level that is used here. A 10% replacement level will require 39 Mton of feedstocks, an amount that can be covered almost four times by identified feedstock sources.
It is not to be expected, however, that increases in the biofuel feedstock supply will be evenly distributed. Large differences can be expected between individual countries or within countries at local or regional level. Recent estimations for Germany [5] suggest that this country may be able to generate a substantial part of the 2020 EU requirements. While currently 1.3 Mha of oilseed rape are being cultivated, an increase of bioenergy crop area up to 3 to 4 Mha is expected for 2020. Although this will include substantial areas for non-biofuel bioenergy crops (mainly silage maize for biogas production) it seems safe to expect a further increase in the oilseed rape area in Germany in the years to come.
Not all feedstock sources that were discussed here have equal perspectives, and some uncertainties must be attached to the calculations. We will mention some of them here.
First, decision making on cultivated crop areas as well as allocated input levels is basically driven by economic perspectives. Hence, net price comparisons between biofuel and alternative crops in the future will remain the major decisive factors at least for the farmers. Thus, although our analysis shows that there is sufficient perspective to meet the future demands, actual realisation of this perspective will depend on market driven decisions. Price support, tax redemptions and availability of cheap alternative biofuel imports are only a few of the factors that will play a role here. It goes without saying that any changes in either of these factors may have a large effect on the outcome of future production estimations.
Second, expected increases in yields or even a continuation of existing yield levels are subject to assumptions on future climatic conditions. Already, effects of climate change have been shown to affect growing conditions in the EU and it must be expected that these changes will continue and most probably

increase further. Although it is beyond the scope of this paper to elaborate on the impact this may have on yield levels, problems are almost certainly to rise or increase with respect to water availability in southern Europe (mostly affecting cereal production) while climate extremes may negatively affect cultivation of cereals, sugar beet and oilseed rape in the remainder of the study area.

Third, potential yield and production levels are subject to important assumptions on input use and, hence, input availability and extent of any restrictive policies that exist or may be expected. This holds especially to the required application levels of nitrogen and phosphorus, nutrients whose application increasingly is being restricted under regulations related to the EU Nitrate Directive and Water Framework Directive. Limitations are in place or can be expected especially on light (sandy) soils but basically are impacting intensively fertilised crops (potato, horticultural crops). Cereals and sugar beet will be generally less affected.

A more detailed analysis of (individual) factors affecting production potentials in the near future is called for. Such an analysis is, however, not in the scope of the current paper.

It should be noted here that crop residues, forest products and forest residues, which have been identified as considerable sources of biofuel feedstocks, have been excluded from the analysis. Clearly, these sources can contribute considerably to the bioenergy production potential. Focussing solely on the agricultural system, the current study shows this potentially can fullfil domestic biomass requirements of a 15% biofuel replacement policy.

It is emphasised that this does not necessarily mean that such a policy is desirable or justified. Elsewhere, objections have been formulated against the use of food crop products for biofuel production. These objectives mainly focus on two issues: the assumed effect of biofuel production on GHG emissions and the feed versus fuel debate. Without going into detail, some remarks will be given on these issues, which call for far more detail than can be given here,

There is no unambiguous evidence as to the expected effect production of biofuel feedstocks will have on GHG emissions. A considerable number of studies has been published, but with conflicting conclusions. Conijn *et al.* [6] show that, under Dutch conditions, there is considerable scope for biofuel feedstock production realising positive GHG effects. Actual effects will depend on the selection of suitable crop production systems as well as moderate nutrient (nitrogen) application levels.

Outcome of the calculations presented in this paper contribute to the debate on food versus fuel. Clearly, any use of food crop feedstocks for biofuel production will affect food availability. It is, however, too simple to emphasize the risks alone. Half of the malnourished live in rural areas, where increased investments in agriculture and/or higher commodity prices may improve rather than threaten their situation. Several factors, including the existence of the set aside system and declining yield increases since the 1980s do, further, indicate that there is sufficient potential for production increase that is not utilised presently.

6 CONCLUSION

EU domestic biofuel feedstock requirements at a 15% replacement rate, amounting to 67 to 105 Mton, can in potential be covered by several processes that lead to increased crop production. Yield increase, increased use of set aside area, area expansion and improved conversion efficiency can, individually or in combination with each other, provide the required feedstocks. This holds for most individual crops or crop products included in this study (cereals, sugar beet, and straw). Exception is oilseed rape, for which insufficient feedstock can be generated unless major area increases (as compared to the 2005 data used here) will occur. Indeed, such increases have been observed in 2006. The fact that, in theory, sufficient perspective exists to cover feedstock requirements in 2020 does not automatically mean that this potential will be realised. Three major causes of eventually not realising the potential have been discussed: unfavourable price ratios for farmers, unfavourable future climatic conditions and further restrictions in input use regulations.

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