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EPOBIO: Realising the economic potential of sustainable resources - bioproducts from non-food crops

EPOBIO Workshop: Products from Plants – the Biorefinery Future

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Work Package: Analysis of the economic potential of bioproducts and applications from non-food crops, including impacts from regulations/legislation

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Introduction

In the following template, we present the main principles of the cost estimation project for the production of new products based on biological feedstock. Use of biological feedstock has a low fossil fuel intensity and as the products are biodegradable, the disposal process is harmless for the environment. However, the used materials can be recycled or used for energy production. But there are disadvantages, as e.g. these products have to compete with established products and production processes are not optimised and total amount of output is fairly low, so that cost degression effects are hardly be used. Therefore some existing biodegradable products, based on renewable resources, are niched. Economics of these and future products will therefore have the aim to reduce production costs, assess the environmental costs and benefits and look for new markets without competition with petrochemical products. Regulations and legislation can influence the speeding up of the market penetration of the sustainable alternative products and will be considered.

Basics

Full cost analysis for the whole cycle of biological based products from seeding over production until waste disposal is a complex venture, as there exists a lot nonlinear contexts in the particular pocesses. Furthermore the intention to replace petrochemical products with the aim to reduce greenhouse gas emissions and external costs demands an extra calculation and valuing of the emitted gases and other waste components like particles.
Therefore the production and lifecycle process has been devided in four main levels:

- Agricultural production of the feedstock
- Transport of feedstock to production facilities
- Processing of basic products like plastic resin
- Disposal of used products like combustion

An analysis of the full cycle, taking in account that goods needed for production like fertilisers, machinery and others have been produced with fossil resources, is not our intention. The external costs of these and other goods will be – if necessary - implemented by an overhead, as they are marginal compared to other fossil fuel uses.

Agricultural production of the feedstock

In the first level of the process the used plants, climate parameters of growing area, soil quality and agricultural production technique have to be recognized. Total substitution of agricultural diesel use by plant oil would e.g. induce in Germany a demand of 1.67 million metric tons of rapeseed oil (~ 90% of today's total production or 10% of total used field area). As present agriculture without use of fossil fuels is not possible, the fossil fuel input and the external costs due to their use have to be calculated. There are huge differences between the different world wide crop and plant production areas in yield and costs, depending on climate parameters, more or less intensified use of technique, technical knowledge, fertilisers, agrochemicals and irrigation. Year to year fluctuating parameters of daily temperature, precipitation and sunshine hours influence yield, emissions and costs of crop production.

However, there is no ideal way to calculate all these parameters in the first production level. A parameterisation of the fluctuating costs may be one way to calculate production costs. In cost calculation, costs have to be devided in fixed and variable costs. But what is variable and what is fixed in agricultural production?
In deviation to standard business accountings we define the following costs positions as fixed and variable:

Operating Costs		Environmental Costs
Fixed [€/ha]	**Variable [€/t]**	
Capital	Irrigation	N_2O
Buildings	Drying	CO_2
Management	Storage	Ozone
Rent	Fertilisers	Biodiversity
Machinery	Fuel	Human Health
Hail Insurance	Pest Management	Soil Degradation
GM Insurance	Weeds Management	Particles
Seeds	Transport	Water Contamination
Wages		
		Eutrophication

Table 1: Definition of fixed, variable and environmental costs: Agricultural production

Dependent on the used feedstock, e.g. as defined in WP 6 by Wageningen University, we will calculate the operating costs of feedstock production for every flagship. Nevertheless there is a need to calculate or take account of the external or virtual costs of feedstock production and other parts of processing.

Most of environmental impacts cannot exactly be valued, as the impact of agrochemicals and fertilizers are difficult to measure. Similarly greenhouse gas emissions cannot be valued exactly. Therefore in the first step, these impacts have to be identified. The assessment can be done later in a comparison to conventional petrochemical products.

Transport of the feedstock

Transport of Feedstock depends on the collection strategy of the production facilities and the crop. Possible transport units are trucks for collection and transportation to a central storage unit, followed by transport with railway or ships to the facilities in case of centralised huge production facilities. German corn starch production is done in this way, as the corn is imported by ship from Hungary and France. The costs of these part depend on the transported feedstock, as e.g. potato transportation means a huge amount of transported water in comparison to maize or wheat as starch containing crops. Therefore potato starch facilities are located in or near the growing area. German bio-diesel (rapeseed-dimethyl-ester) production facilities are typically located in the main rapeseed growing areas. This part of the whole cycle is well known and the final costs depend on the distribution of the fields in the crop growth area and the necessary crop rotation, which is e.g. for rapeseed 4 years. Table 2 shows the principle calculation scheme.

Operating Costs		Environmental Costs
Fixed [€/a]	Variable [€/tkm]	
Management	Wages	NOx
Buildings	Repair & Service	CO_2
Insurance	Fuel	Particles
Capital	Toll	Human Health
Taxes		

Table 2: Calculation scheme of transport costs

Production of the base products

Calculation of the base products, like thermoplastic resin or native and refined oils, needs a huge amount of special inputs for each production step. It may start with milling the wheat or washing the potatoes and end with the drying of the raw material, e.g. starch, which is later used to be transformed in their base polymers, which can then be polymerised to thermoplastics. As starch and plant oil extraction, refinery and saccharification are based on standard procedures an input-output flow calculation of the needed production goods can be used, as these procedures are optimised. If the production has new and different production steps, each step has to be scanned for costs intensity and possible cost reduction. An input-output flow calculation can give precise information about real costs, but not about reduction potentials. Table 3 shows the cost positions, which have to be estimated for the input-output flow analysis. The sales of byproducts, like corn germ or corn protein cake lowers the variable costs and help to rise profit, so that a new product can reach break even earlier.

Operating Costs			Environmental Costs
Fixed [€/a]	**Variable [€/t]**		
Capital	Storage	Chemicals	NOx
Buildings	Wages	R&D	CO2
Equipment	Water	Marketing	Solid Waste
Management	Electricity	Byproducts	Waste Water
Concession	Fuel	Wastewater Treatment	Eutrophication
		Waste Disposal	

Table 3: Cost calculation scheme of the base fabrication process

End of product cycle

Costs of the end of the product cycle depend on the method of disposal. If products are biodegradable, there are in principle three ways, which have to be taken in account. The products can be recycled, composted or combusted for electricity or heat production. Combustion of biodegradable material can be done in conventional power plants, biogas plants or be gasified and burned in combined cycle gasturbines to have an optimum conversion efficiency. If the products are bonded or mixed with non biodegradable products, and a separation is not possible, the only disposal option is combustion. For the whole process costs of collection, transport, separation and cleaning have to be estimated. This shows that a number of different disposal options exist. Table 4 shows the main calculation principle.

Operating Costs			Environmental Costs
Fixed [€/a]	**Variable [€/t]**		
Capital	Collection	Storage	NOx
Management	Separation	Cleaning	CO_2
Equipment	Transport	Recycling	Particles
Buildings	Fuel	Combustion	Eutrophication
	Energy: In- or output	Composting	
		Wastewater Treatment	

Table 4: Calculation of disposal process

Outlook

As shown above, cost calculation of a full new product cycle need a lot of input positions and data. Some of these inputs are well known, others depend on the input materials and the growing constraints, made by policy makers. To do a good job, we need for non standard production procedures special knowledge of input, conversion efficiency of the goods and duration of each process step. As it is planned to do representative calculations for a number of world wide regions, where it may be useful to establish renewable technology instead of not yet existing petrochemical facilities, the calculation scheme may differ from that presented as the database may be poor.