IEA Bioenergy
Task 42 Biorefining

2-platform (C5&C6 sugars, lignin) biorefinery to produce bioethanol, electricity & heat from corn stover

Part A: Biorefinery plant

Ethanol is produced based on corn stover. The milled corn stover is pre-treated in a dilute acid pre-treatment process. Enzymatic hydrolysis is used to convert the hemicellulose and cellulose into monomeric C5 and C6 sugars and lignin. Cellulase is produced on-site. The fermentation uses metabolically engineered strains of Saccharomyces cerevisiae microorganisms that are capable of co-fermenting xylose and glucose to ethanol, whereas a separate hydrolysis and fermentation process (SHF process) is applied.

Finally, the fermentation broth is fed into a distillation process. Distillation columns and molecular sieves are used to produce 99.5 % ethanol. The lignin is fed into a CHP plant in order to produce thermal energy and electricity which is used as process energy for the biorefinery process. The stillage by-product from the distillation process is used as an agricultural fertilizer. If the stillage is dried, it may also be used as energy carrier.

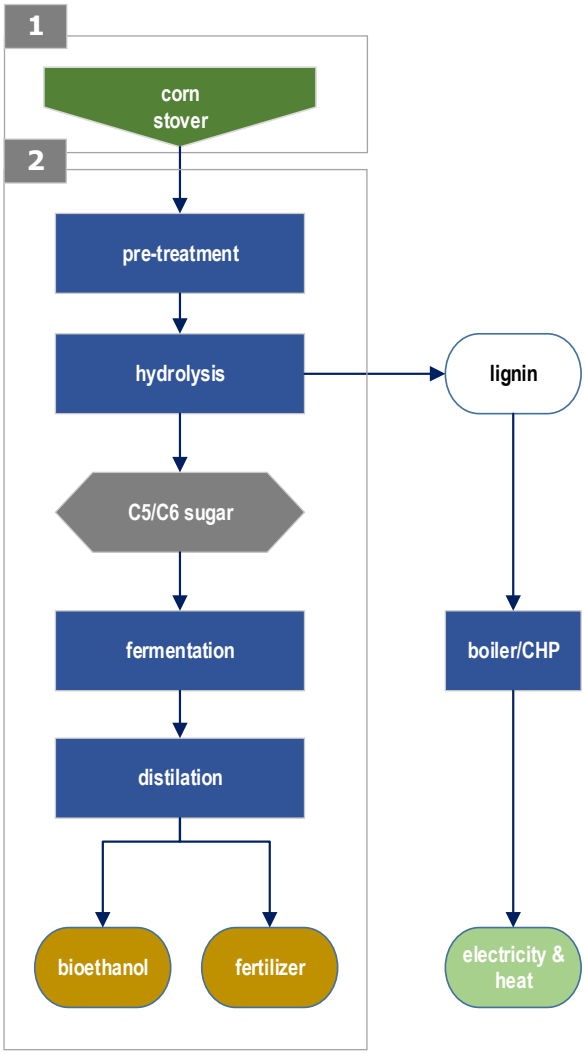

Figure 1: 2-platform using corn stover to produce ethanol, electricity and heat

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Key characteristics

2-platform (C5&C6 sugars, lignin) biorefinery to produce bioethanol, electricity & heat from corn stover							
State of technology		*Demonstration/commercial (TRL 6-9)*					
Country		*US, EU 27*					
Main data source		*Literature (technical report Humbird et al., 2011)*					
Products				*Auxiliaries*			
	Ethanol	*4,400*	*TJ/a*		*Heat*	*3,273*	*TJ*
	Electricity	*387*	*TJ/a*		*Chemical inputs*	*82,727*	*t/a*
Costs				***Feedstock***			
	Investment	*422*	*Mio. €*		*Corn stover*	*1,535*	*TJ/a*
	Feedstock	*48*	*Mio. €/a*			*764*	*kt/a*
	Operating	*26*	*Mio. €/a*	*Conversion rates (Efficiencies)*			
	Labour	*3*	*Mio. €/a*		*Corn stover to bioethanol*	*0.35*	*MJ_{EtOH}/MJ*
					By-products to CHP	*0.46*	*MJ/MJ_{EtOH}*

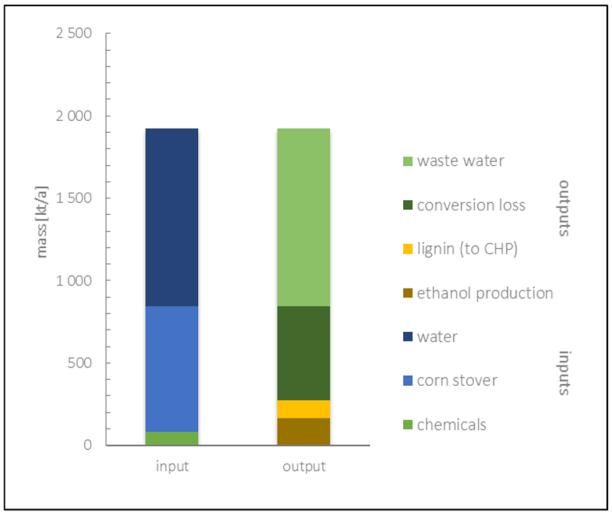

Figure 2: Mass balance of biorefinery plant

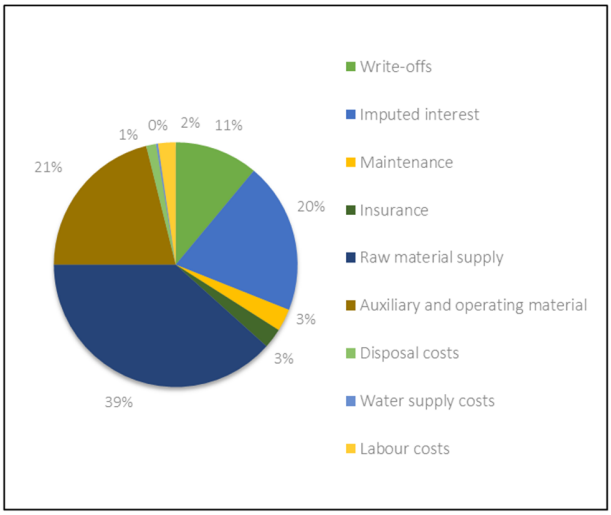

Figure 3: Share of costs

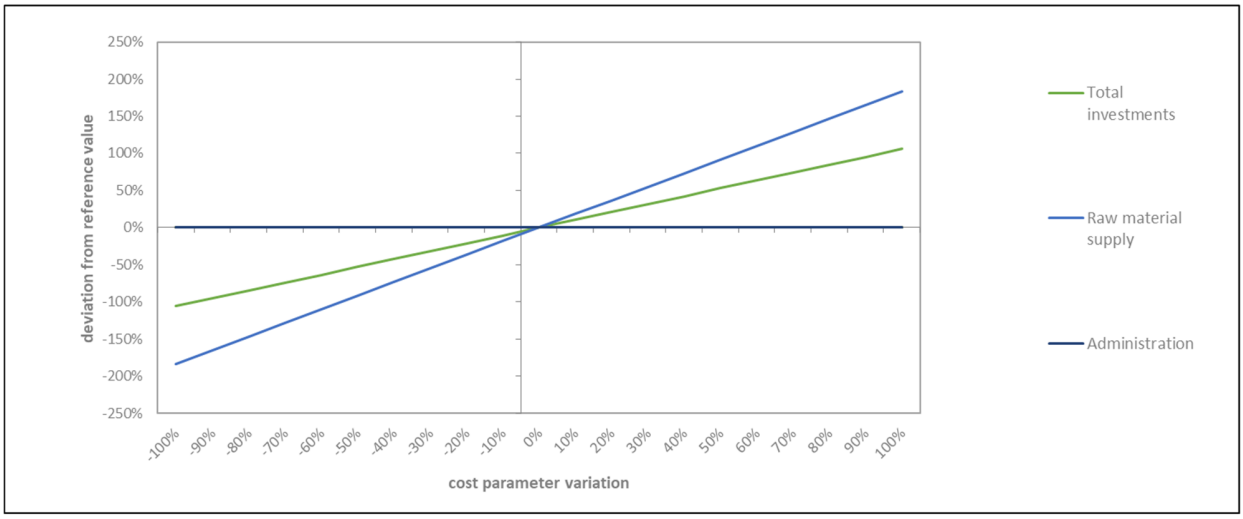

Figure 4: Sensitivity analysis cost structure

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Part B: Value Chain Sustainability Assessment

2-platform (C5&C6 sugars, lignin) biorefinery to produce bioethanol, electricity & heat from corn stover

Conventional reference system

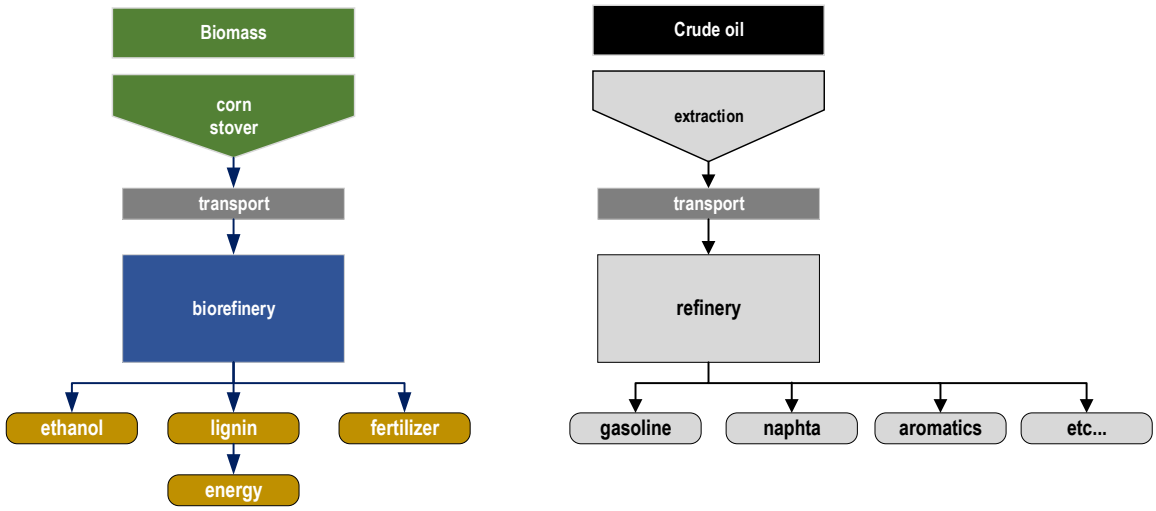

Figure 5: Biorefinery and reference system - value chain (cradle to gate)

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Key characteristics of biorefinery value chain

Greenhouse gas emissions		
Raw material sourcing (corn stover)	2,651	t CO_2eq.
Biorefinery	35,017	t CO_2eq.
Reference system	368,751	t CO_2eq.
Savings	331,083	t CO_2eq.
Cumulated energy demand		
Fossil (material transports, ...)	30	TJ
Renewable (corn stover, ...)	12,609	TJ
Reference system	5,302	TJ
Difference	7,337	TJ
Costs		
Annual costs	127	Mio. €
Specific costs	0.61	€/l_{EtOH}
Investment costs	422.5	Mio. €
Revenues		
Revenues ethanol	140.7	Mio. €
Specific revenues	~ 0.68	€/l_{EtOH}

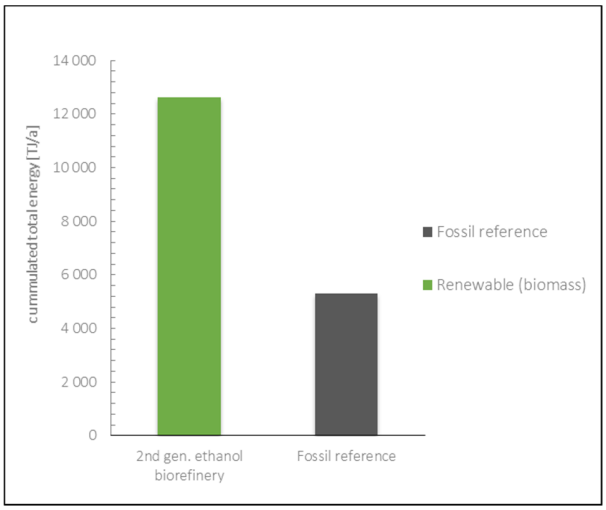

Figure 6: Cumulated energy demand of biorefinery and reference

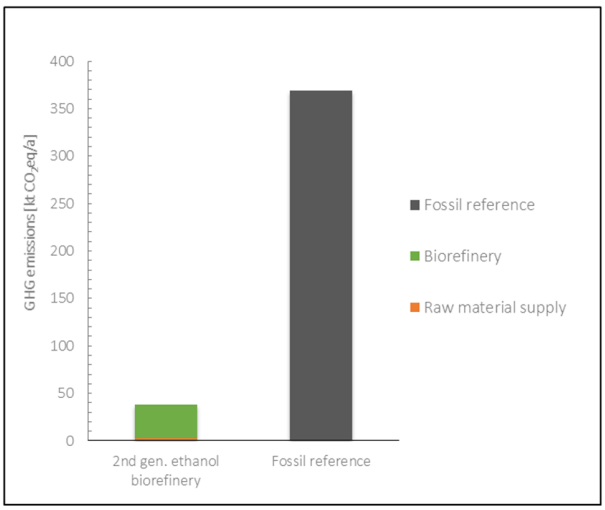

Figure 7: Greenhouse gas emissions of biorefinery and reference

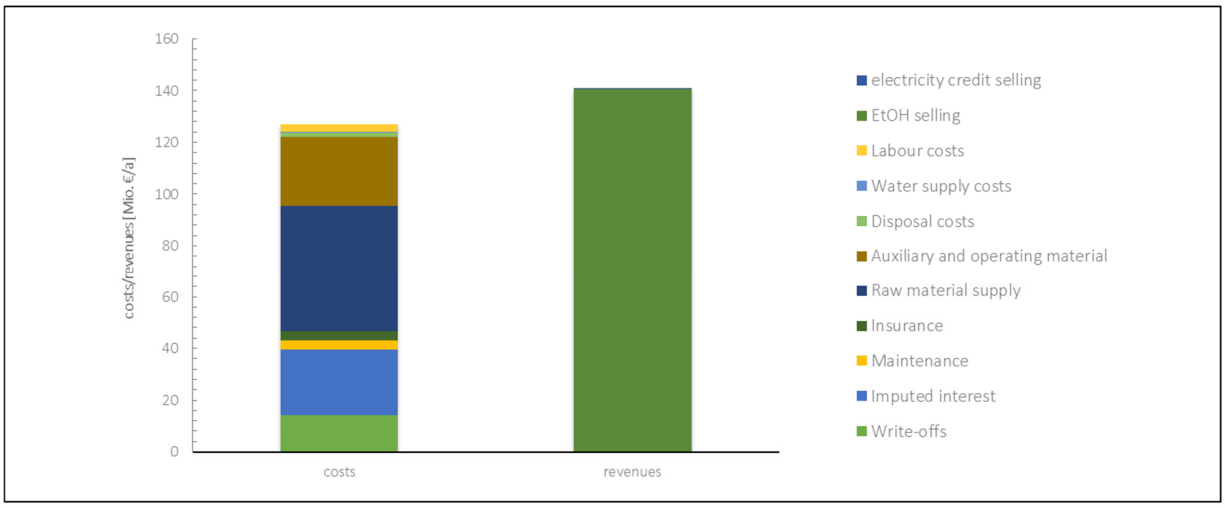

Figure 8: Estimated costs and revenues of biorefinery plant

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