TECHNOLOGY FACTSHEET

PRODUCTION OF ETHANOL VIA THE FERMENTATION OF LIGNOCELLULOSIC BIOMASS (LC-ethanol)

Date of factsheet	28.04.2021
Author	Ayla Uslu
Sector	Transport
ETS / Non-ETS	Non-ETS
Type of Technology	Biomass
Description	Advanced or second-generation ethanol is produced from lignocellulosic materials including straw, bagasse, stover, agro and forestry-residues, shells, etc. Production steps are: pre-treatment, enzymatic hydrolysis, fermentation and recovery of ethanol as a final product. The pre-treatment process is aimed at optimising the hydrolysis and the following processes. The pretreatment method depends on the characteristics of the raw material. During the pre-treatment cellulose and hemicellulose are separated from lignin. Lignin is usually separated and dried to serve as fuel for the processes. Cellulose is broken down into glucose during the enzymatic hydrolysis (also called saccharification). Hemicellulose is also converted into fermentable sugar. In the fermentation process, all sugars are converted into bioethanol by various microorganisms. The product from fermentation has low concentration of bioethanol, hence an upgrade to the desired high concentration through evaporation and ratification is the final step so the resulting ethanol can be used as biofuel. In this factsheet, we assume that the process' energy demand is supplied via combustion of lignin. Thus, no external energy supply is required and net electricity may be generated depending on the operating mode.
TRL level 2020	TRL 8
	In Europe there is only one commercial plant (TRL9) in Norway. This plant uses brown liquor from the pulping operations. Other operating plants are at demonstration scale (TRL 6-7). However, most of the plants under construction or are planned have the TRL 8. the most recent information about the status of the plants can be found in ETIP (2020).

TECHNICAL DIMENSIONS

	Functional Unit		Value and Range								
Capacity	Mwout		77.00								
			66.00			-			77.00		
Potential			Current			2030			2050		
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Market share		%	-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*

Capacity utlization factor	1.00
Full-load running hours per year	8,000.00
Unit of Activity	
Technical lifetime (years)	20.00
Progress ratio	
Hourly profile	
Explanation	The functional unit refers to MWth ethanol output. Currently, there are no commercial plants at large scale that are operational and producing LC ethanol in Europe. The Beta Renewables plant in Italy was a first-of-a-kind commercial plant with 100-150 MWth input capacity. This plant was terminated in 2017 due to financial issues in one of the parent companies . The plant was bought by Versalis in 2018 and it has announced that the biorefinery will start its operations. Norwegian plant Borregaard is operational using brown liquor as feedstock.

COSTS

Year of Euro	2015									
Investment costs	Euro per Functional Unit	Current			2030			2050		
	mln. € / MW	3.80			2.85			1.90		
		2.75	–	3.65	2.06	–	2.74	1.38	–	1.90
Other costs per year	mln. € / MW							-		
		-	–	-	-	–	-	*Min*	–	*Max*
Fixed operational costs per year (excl. fuel costs)	mln. € / MW	0.19			0.19			0.19		
		0.11	–	0.15	0.10	–	0.13	0.09	–	0.12
Variable costs per year	mln. € / kWh	0.01			0.01			0.01		
		0.01	–	0.01	0.01	–	0.01		–	
Costs explanation	In above figures, MWth refers to ethanol output. Investment cost refers to the costs regarding pre-treatment, fermentation, distillation and ethanol recovery. Costs related to the wastewater treatment and land are not included within SDE++, the main reference for this factsheet. The fixed O&M costs consist of all the costs for operation and maintenance, contracts and insurances. Labour costs are also included in this category. Variable O&M costs relate to chemicals, yeast and enzymes and also the credit received from the surplus electricity. The fixed O&M costsfrom IEA (2020) is defined as 4% of CAPEX and the varibale O&M costs as 2%. The CAPEX reductions for 2030 and 2050 are assumed as 25% and 50%, respectively. According to IEA (2020), developers expect measures such as scaling up plant size, improvements and integration of process steps and integration with other processing facilities, to enable these reductions in the specific capital costs for a plant. Plant developers expect to achieve also significant reductions in O&M costs. They indicate a reduction of 10% to 20% of current O&M costs. These values are applied for 2030 and 2050.									

ENERGY IN- AND OUTPUTS

	Energy carrier	Unit	Current			2030			2050		
Energy carriers (per unit of main output)	*Main output:* Bioethanol	PJ	-2.20			-2.42			-2.64		
			-2.20	–	-2.20	-2.42	–	-2.42	-2.64	–	-2.64
	Biomass (wood)	PJ	5.90			5.90			5.90		
			5.90	–	5.90	5.90	–	5.90	5.90	–	5.90
	Electricity	PJ	-0.39			-0.39			-0.39		
			-0.39	–	-0.39	-0.39	–	-0.39	-0.39	–	-0.39
	Biogas	PJ	-0.02			-0.02			-0.02		
			-0.02	–	-0.02	-0.02	–	-0.02	-0.02	–	-0.02
Energy in- and Outputs explanation	The ethanol yield is assumed to be increased by 10% in 2030 and 20% in 2050 compared to 2020. Produced lignin is considered to be burned to meet the steam and electricity demand of the plant. The surplus electricity is assumed to be sold to the grid. Produced waste water is considered to be terated via a wastewater treatment plant. Biogas derived from the WWT is included above. However, the CAPEX and OPEX related costs of biogas generation from WWT is kept outside of the battery limits.									

MATERIAL FLOWS (OPTIONAL)

	Material	Unit	Current			2030			2050		
Material flows			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
			-			-			-		
			Min	–	*Max*	*Min*	–	*Max*	*Min*	–	*Max*
Material flows explanation											

EMISSIONS (Non-fuel/energy-related emissions or emissions reductions (e.g. CCS)												
	Substance	Unit	Current			2030			2050			
Emissions			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
Emissions explanation												
OTHER												
Parameter	Unit		Current			2030			2050			
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
			-			-			-			
			Min	–	Max	Min	–	Max	Min	–	Max	
Explanation												

REFERENCES AND SOURCES	
1	SDE++2021 Eindadvies basisbedragen. https://www.pbl.nl/sites/default/files/downloads/pbl-2021-eindadvies-basisbedragen-sde-plus-plus-2021_4032.pdf
2	IEA, 2020. Advanced Biofuels-Potential for cost reduction. See https://www.ieabioenergy.com/wp-content/uploads/2020/02/T41_CostReductionBiofuels-11_02_19-final.pdf
3	ETIP, 2020. Bioenergy-Current status of advanced biofuel demonstrations in Europe. See https://www.etipbioenergy.eu/databases/reports/443-current-status-of-advanced-biofuels-demonstrations-in-europe