



**Integral technical, economic and ecological system assessments to select the most promising market specific integrated biorefineries**  
**Preliminary results Work Package 4**

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## Background

- Technical, economic and ecological assessment of advanced biorefinery concepts integrated into existing industrial complexes (reference cases)
- VTT, Finland is overall co-ordinator of WP4
- Leading parties (subtask leaders) for different market sectors studied:
  - Bioethanol sector (Abengoa, Spain)
  - Biodiesel sector (UGent, Belgium)
  - Pulp/paper sector (Innventia, Sweden)
  - Oil refinery sector (Repsol, Spain)
  - Power production sector (ECN, the Netherlands)
  - Food industry sector (AFSG, the Netherlands)
  - Agro sector (AFSG, the Netherlands)
- The results of WP4 is used as an input to Work Package 5 (Technology deployment)



## Objectives

- The reliable and realistic input data for the evaluations of reference cases established in Work Package 1
- Applying and developing the ECN cash flow model also to processes producing fuels and chemicals (reference cases and biorefinery cases)
- Evaluation the production costs of main products of reference cases
- Definition and modelling of integrated biorefinery schemes (basing on reference cases)
- Technical, environmental, financial-economic and socio-economic studies for integrated biorefinery concepts



## Production costs of main product of reference cases studied – input data 1

- Are based on the results (input data):
- Work Packages 1-3, especially to WP1 results
- Questionnaire to responsible subtask leaders of different market sectors (to evaluate investment costs, operating costs, by-product credits etc)
- Further discussions with subtask leaders to make data consistent



## Production costs of main product of reference cases studied – input data 2

- Input data for 11 reference cases includes:
- Mass and energy flows
- Utility flows and costs
- Waste flows and costs
- Investment costs
- Feedstock costs
- Other fixed and variable operating costs
- Byproduct values



## Production costs of main products of reference cases studied – Modified ECN cash flow model calculations

- ECN model was originally used for Renewable Energy Evaluations (for example, wind electricity production)
- Modified ECN model is applied here first time to fuels and chemicals producing processes – first to reference cases
- Modified ECN model is now used also in evaluations of the biorefinery concepts (basing on reference cases studied)



## Production costs of main products of reference cases studied – Summary of results of bioethanol, biodiesel, food and agro sectors (no subsidies included)

Reference Case	Production capacity of main product, t/a	Production Cost, €/t (based on modified ECN CF Model)	Market Value of main product, €/t	Market value estimate
Bioethanol from grain and wine	155 600	967	610 - 800	Market report D2.2
Biodiesel from rapeseed oil	100 000	889	720 - 850	Kingsman Biodiesel weekly
Food sector: Cheese from milk	28 800	2099	2275	AFSG
Agro sector, Sugar from sugarbeet	315 400	355	350 - 450	AFSG



## Production costs of main products of reference cases studied – Summary of results of pulp and paper sector (no subsidies included)

Reference Case	Production capacity of main product, t/a	Production Cost, €/t (based on modified ECN CF Model)	Market Value, €/t	Market value estimate
Bleached softwood pulp	653 300	387	500 - 550	Innventia: 500 €/t
Bleached hardwood pulp	818 000	329	450 - 500	Innventia: 450 €/t

Note:

Main product is market pulp having 10 wt-% moisture

The reference mill is a hypothetical pulp mill representing existing best available commercially proven Nordic technology in 2004.



## Production costs of main products of reference cases studied – Summary of results of conventional oil refinery sector (no subsidies included)

Reference Case	Production capacity of main product, t/a	Production Cost, €/t (based on modified ECN CF Model)	Market Value, €/t	Market value estimate
Conv. oil refinery, FCC	1 496 000	330	360	Repsol
Conv. oil refinery, HDS	1 804 000	380	382	Repsol

Notes:

Market values are based on the average prices for the last ten years; referred to a price of Brent barrel of 57 €/bbl CIF NWE. Market values does not include taxes.

Fluid Catalytic Cracking (FCC) main product: naphta, diesel, LPG and fuel oil

Hydrosulfuration (HDS) main product: hydrotreated middle distillates (diesel; hydrotreated heating oil, heavy naphta and kerosene)



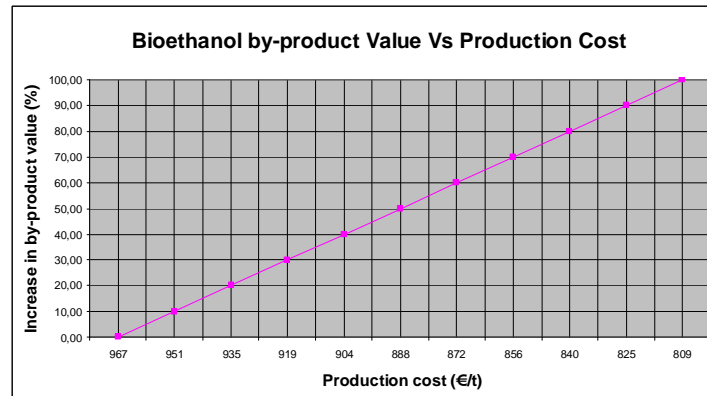
## Production costs of main products of reference cases studied – Summary of results of power production sector (no subsidies included)

Reference Case	Production capacity of electricity, GWhe/a	Production Cost, €/MWhe (based on modified ECN CF Model)	Market Value, €/MWhe	Market value estimate
Small size, power from biogas from grass	1.6	88	50	VTT
Medium size, power and heat by biomass boiler	93.5	36	50	VTT
Large size, gasification of wood (BIGCC)	1254	60	50	VTT

## Production costs of main products of reference cases studied – Sensitivity studies, feedstock cost change $\pm 20\%$

Reference Case	Production capacity of main product, t/a	Production Cost (based on modified ECN CF Model)	Market Value of main product, €/t
Bioethanol from grain and wine alcohol	155 600	901-1032 €/t	610 - 800
Biodiesel from rapeseed oil	100 000	733-1046 €/t	720 - 850
Bleached softwood pulp	653 300	356-418 €/t	500 - 550
Bleached hardwood pulp	818 000	302-356 €/t	450 - 500
Conv. oil refinery, FCC unit	1 496 000	268-392 €/t	360
Conv. oil refinery, HDS unit	1 804 000	305-454 €/t	382
Power from biogas from grass	1.6 GWhe/a	85-92 €/MWhe	50
Power from biomass CHP boiler	93.5 GWhe/a	29-43 €/MWhe	50
Power from wood gasification (BIGCC)	1254 GWhe/a	54-66 €/MWhe	50
Cheese from milk	28 800	1684-2513 €/t	2275
Sugar from sugar beet	315 400	330-381 €/t	350 - 450

## Effect of DDSG by-product value on bioethanol production costs (base value 150 €/t):



## One example of biorefinery cases – Sugar from sugar beet

Reference Case	Mass flows, t/a	Biorefinery case	Mass flows, t/a
<b>Feed</b>		<b>Feed</b>	
Sugar beet	453 000	Sugarbeet	453 000
		Preprocessed leaves and intercrops	282 000
<b>Total</b>	<b>453 000</b>	<b>Total</b>	<b>735 000</b>
<b>Products</b>		<b>Products</b>	
Sugar	315 000	Sugar	189 000
Molasses	53 000	Ethanol	64 000
Pulp	82 000	Protein rich product	113 000
<b>Total</b>	<b>450 000</b>	<b>Total</b>	<b>366 000</b>

Note:

Biorefinery case produces electricity 292 GWh/a



## Some examples of biorefinery cases – Sugar from sugar beet

Case	Production cost of sugar, €/t
Reference Case	335
Biorefinery case	202

Note:

The lower production cost of sugar in biorefinery case is due to the more valuable by-products than in reference case



# Thank you

