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Case 2: Biodiesel sector

Evaluation of integrated biorefinery schemes based on valorisation of glycerol

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Biodiesel production in partner-related countries (2007)

	Biodiesel ktonnes
Belgium	166
Finland	39
Netherlands	85
Spain	168
Sweden	63
United Kingdom	150
France	872
Total	1543
Total EU-27	5713

EurObservÉR, 2008

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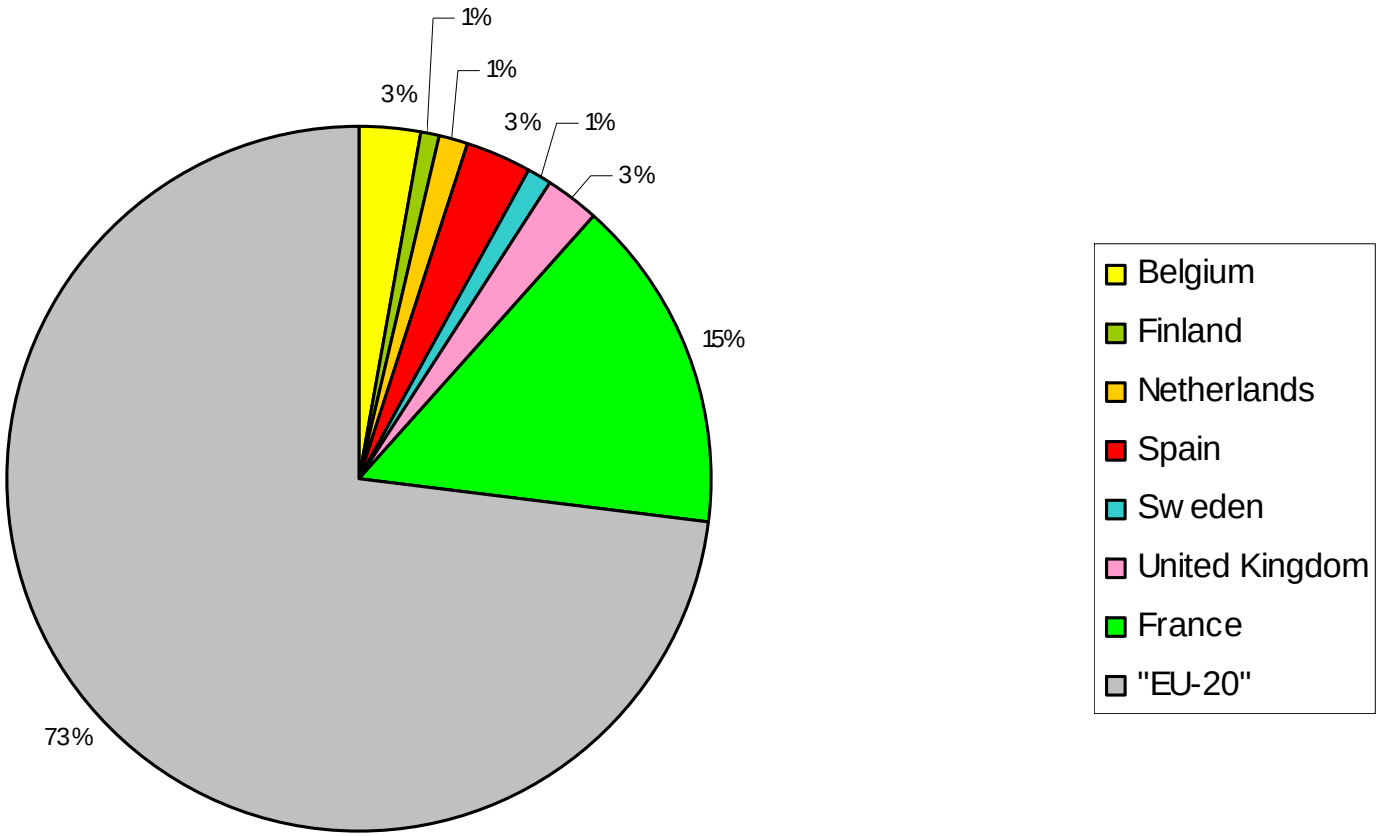
Biodiesel production in partner-related countries (2007)

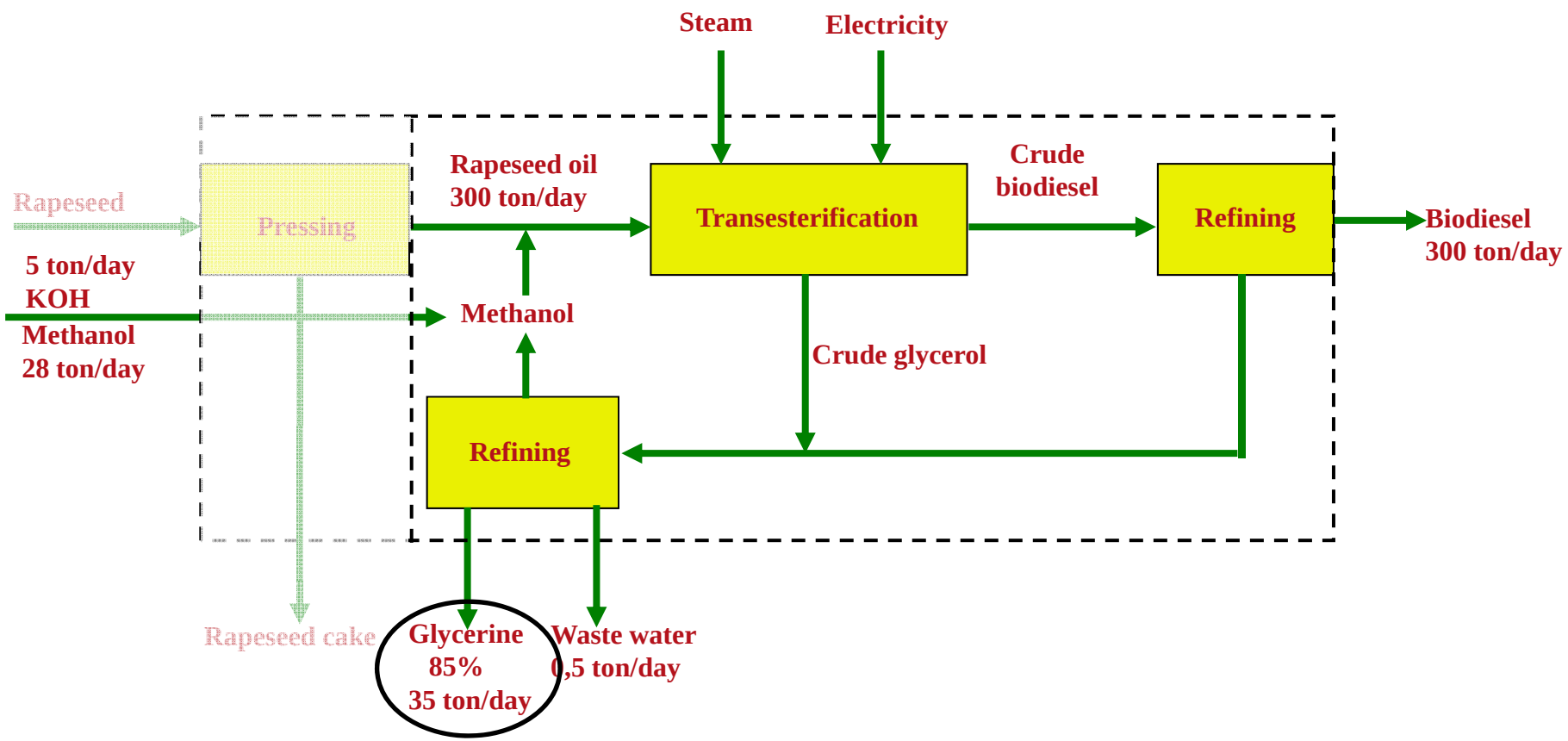


EurObservÉR, 2008

Survey biodiesel sector (1)

	Number of plants	Main feedstock
Belgium	4	Rapeseed oil Soybean oil
Finland	2	Palm oil
The Netherlands	20	Rapeseed oil Oil residue Animal fat Palm oil
Spain	30	Rapeseed oil Soybean oil Sunflower oil Used oil
Sweden	12	Rapeseed Tall oil
United Kingdom	18	Rapeseed oil Cooking oil
France	22	Rapeseed Sunflower Animal fat
Total	**108**	

Reference case



Average size rapeseed-based plants: 150-250 ktonnes biodiesel

Average size used oil / animal fat-based plants: 50-100 ktonnes biodiesel

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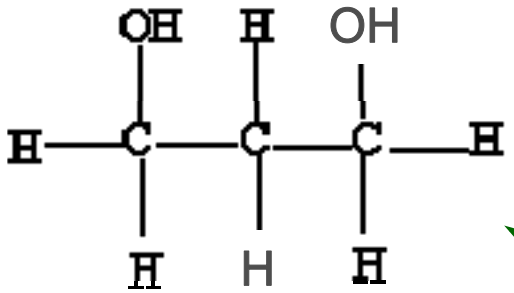
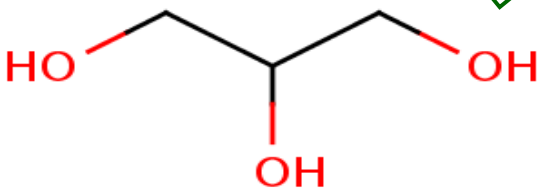
Integrated biorefinery cases

- 1,3 propanediol as a bulk chemical through fermentation of glycerol
- Epichlorohydrin as a specialty chemical through catalytic hydrochlorination of glycerol

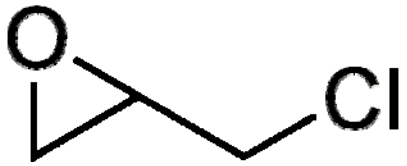
1,3-propanediol



glycerol



Epichlorohydrin



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1,3-propanediol

Properties:

- Applications in polyester, cosmetics, foods, lubricants, and medicines
- Industrially: important monomer to synthesize a new type of polyester, polytrimethylene terephthalate (PTT) – fibre and textile applications

History:

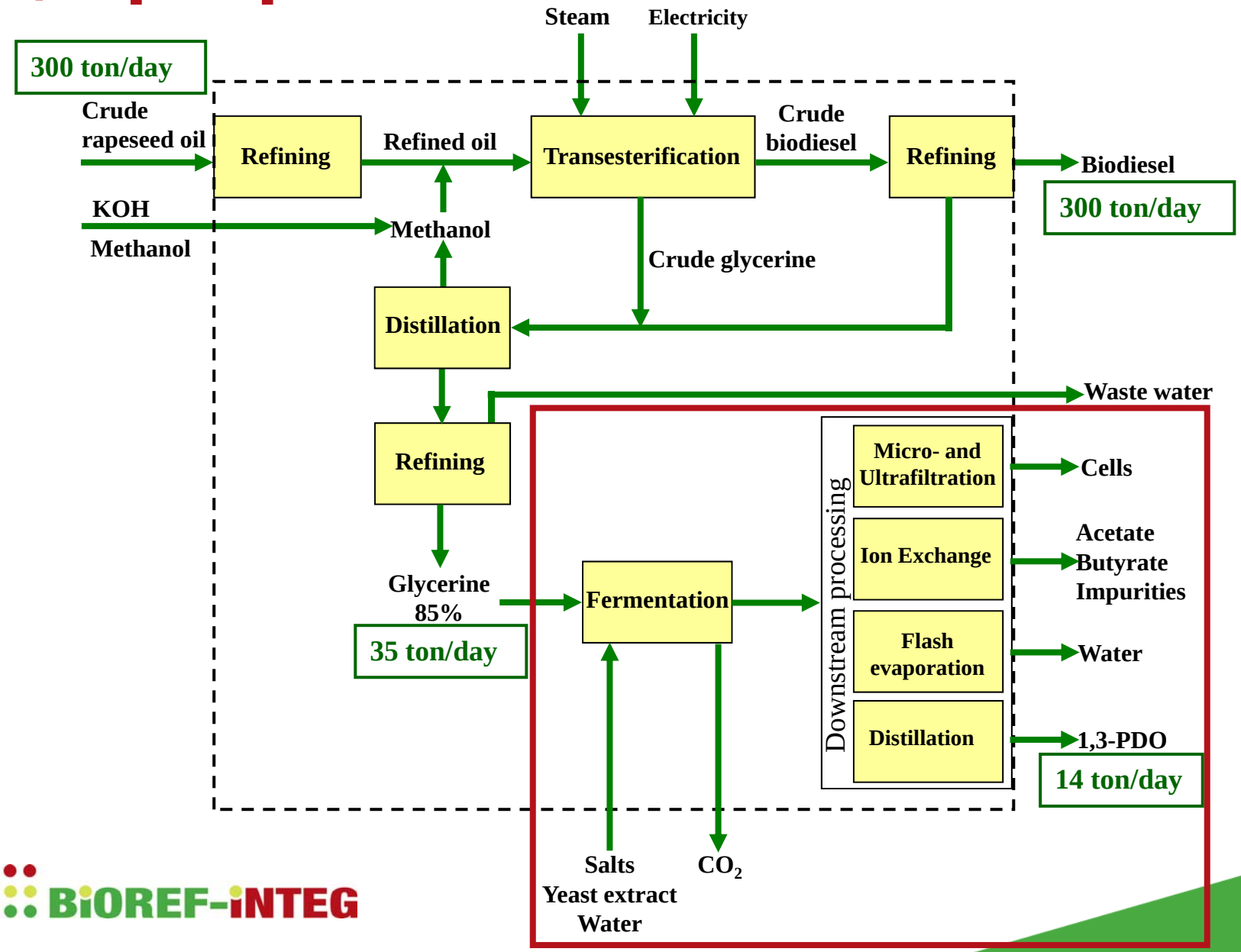
- In the past: niche applications due to high production cost
- Current: opportunities due to low glycerol price
- 1995: new chemical route by Shell for use in a new polyester, Corterra
- DuPont + Genencor: new biotechnological route

1,3-propanediol

Characteristics	Glycerol	Glucose
Organism	*Klebsiella pneumoniae* *Clostridium butyricum*	Recombinant *E. coli*, modified in more than 10 genes
PDO concentration	80-85 g/l	135 g/l
PDO production rate	3.0 g/l/h	3.5 g/l/h
Yield (w/w)	55%	51%
Type of process	Anaerobic, fed-batch	Aerobic

Patel *et al*., 2006

1,3-propanediol



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Epichlorohydrin

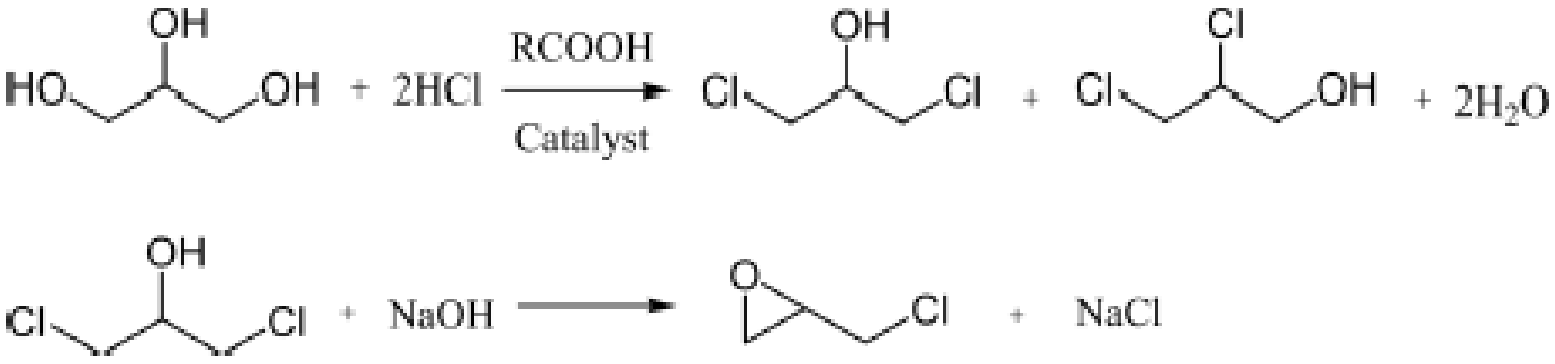
Properties:

- high volume commodity chemical
- used largely in epoxy resins
- glycerol was by-product of early epichlorohydrin production

History:

- production out of glycerine already described in 1862!
- the historically high cost of glycerine has prevented its development as a commercial process so far
- is currently being commercially developed:
  - DOW Chemical Company -> glycerine to epichlorohydrin (GTE) process
  - Solvay -> EPICEROL®

Epichlorohydrin



Two-step process for the production of epichlorohydrin that employs renewable glycerine as feedstock. Only one equivalent of waste chloride is produced.

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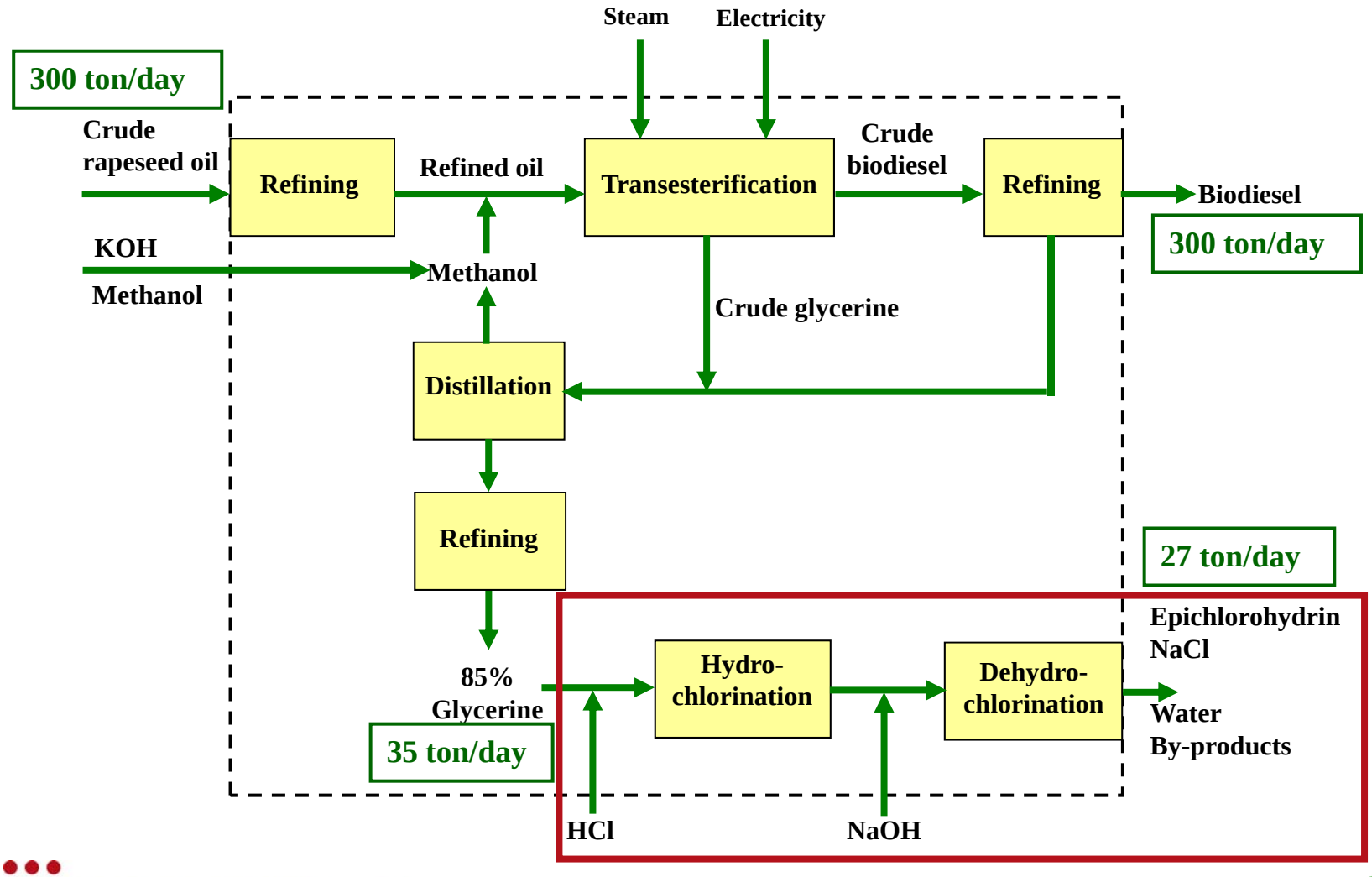
Epichlorohydrin



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Results techno-economic assessment

Reference case		Unit	€/unit	Unit/T Biodiesel	€/T Biodiesel
Raw material	Rapeseed oil	T	640.00	1.00	640.00
Auxiliaries		T		0.11	34.0
Energy	Steam + electr				4.6
Co-products	Glycerol	T	50.00	0.12	-5.8
Variable cost					**672.8**
Capex	20,000,000	€			
Depreciation	12 years				16.7
Labour	28	#	100 000		28.0
Other costs	9	% of capex			18.0
Fixed costs					**62.7**
Total product cost					**735.5**
Product value	**Biodiesel**				**700.0**

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Results techno-economic assessment

		Unit	€/unit	Unit/T Biodiesel	€/T Biodiesel
Reference case					
Co-products	Glycerol	T	50.00	0.12	-5.8
Capex	20,000,000	€			
Total product cost					**735.5**
Integrated case: PDO					
Co-products	PDO	T	1300.00	0.05	-60.7
Capex	37,000,000	€			
Total product cost					**728.7**
Integrated case: EPI					
Co-products	Epichlorohydrin	T	1250.00	0.09	-112.3
Capex	35,000,000	€			
Total product cost					**677.0**
Product value	**Biodiesel**				**700.0**

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Technical feasibility

Statement	Biodiesel		
	PDO	Epi	Project average
Technical feasibility	**73,6**	**83,2**	70.7

Glycerine to 1,3-PDO
- merely an average case
- technology is considered as rather mature and benign
- main penalty comes from the significant downstream processing.

Glycerine to Epichlorohydrin (ECH)
- well above average
- high scores for the process feasibility
- worries mainly about safety issues (epichlorohydrin is toxic) and waste treatment.

Commercial feasibility

Statement	Biodiesel		
	PDO	Epi	Project average
Technical feasibility	**78,6**	**75,4**	71,0

Glycerine to 1,3-PDO

- Commercially attractive project, especially regarding integration benefits and functional attributes (functionality of PDO-based polyesters)
- Some concerns related to water needs

Glycerine to Epichlorohydrin

- slightly above average
- driven by integration benefits and slightly better score on other statements.

SWOT-analysis 1,3-PDO

Strength:

• **High added value product** out of glycerine leading to more competitive biodiesel operation

Weaknesses:

• Technical issues: Fermentation based on glycerol **not proven at industrial scale yet**

• Economical issues: **Market for 1,3-PDO is limited** and depends on textile fibre development

• Strategic issues: Currently only 1 significant customer

Opportunities:

• **Future product diversification possible** (e.g. fatty acid esters of 1,3-PDO → lubricants)

Threats:

• Dependence on DuPont patent restrictions

• **Competition with PDO from sugars**

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SWOT-analysis Epichlorohydrin

Strength:

• **Stable outlet** (price-wise) for glycerine towards ‘bulk’ chemical

Weaknesses:

• Epichlorohydrin is a **toxic** product

• Investment cost: **large scale needed** ideally

Opportunities:

• Chemical modification of glycerol platform: **further conversion potential** to other products (glycidol, propylene oxide, 1,2-PG)

Threats:

•Technology controlled by Solvay and Dow and operated at much larger scale

Summary and conclusions

- Both integrated cases have good technical and commercial feasibility
- Both profitable, with slight advantage for EPI
- Larger scale needed to become more profitable
- > 80% of product cost comes from feedstock cost -> look for alternatives!

THANK YOU !

Contact

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