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Case 7: Agro sector

7a. Evaluation of integrated biorefinery technologies in the Sugar Industry

7b. Evaluation of Small Scale Power production vs. Grass Biorefinery

Koen Meesters (WUR-FBR, the Netherlands)

Final BIOREF-INTEG Seminar

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Introduction: Biorefinery in Sugar industry

Sugar price has been high due to EU minimum price guarantee

- Sugar factories are optimized for maximum sugar production

Sugar price will drop due to EU sugar reform

- Optimum product mix will shift:
  - bioethanol
  - feed protein
  - biogas

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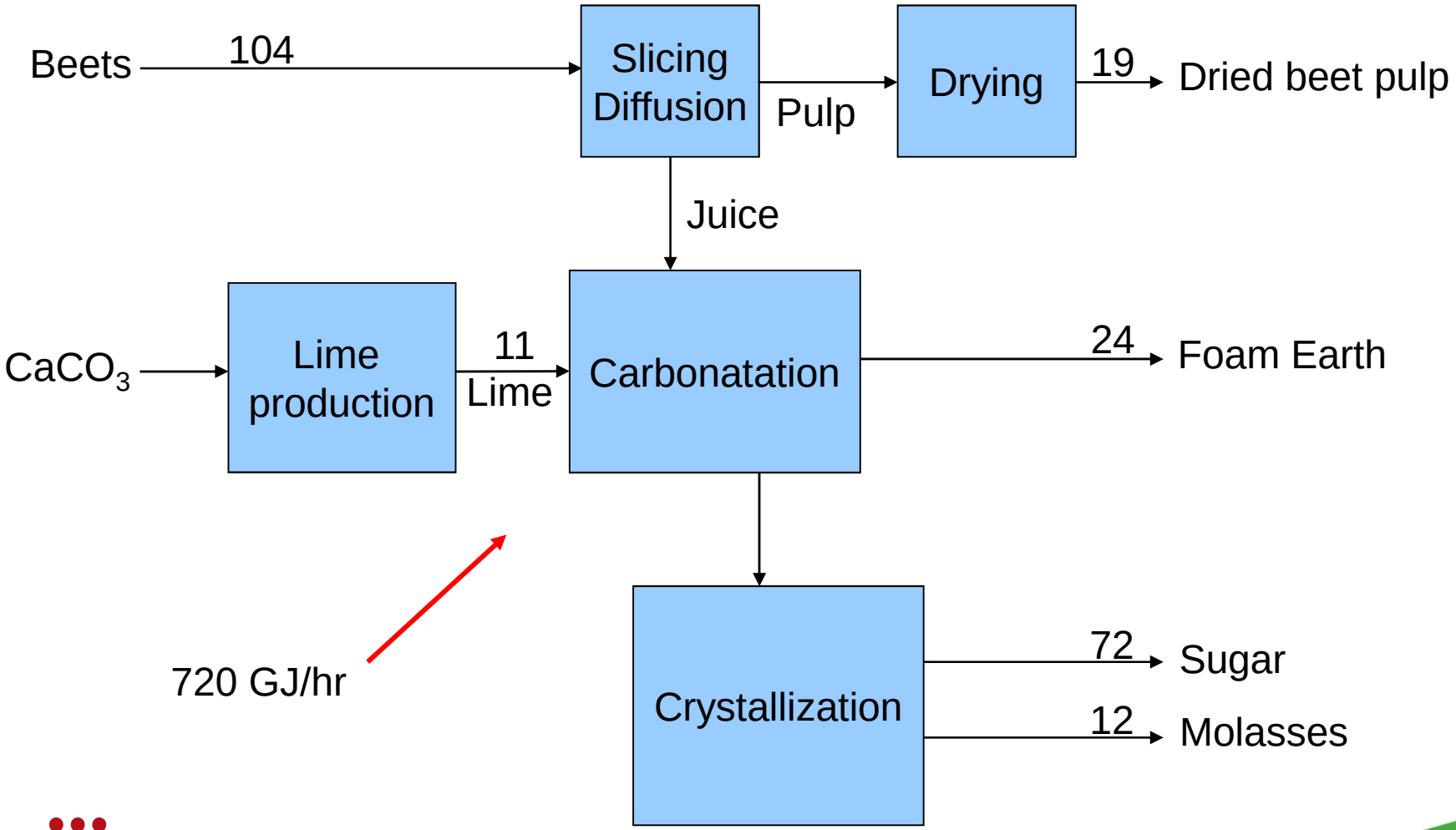
Mass balance

Reference case (ton dry / hour)



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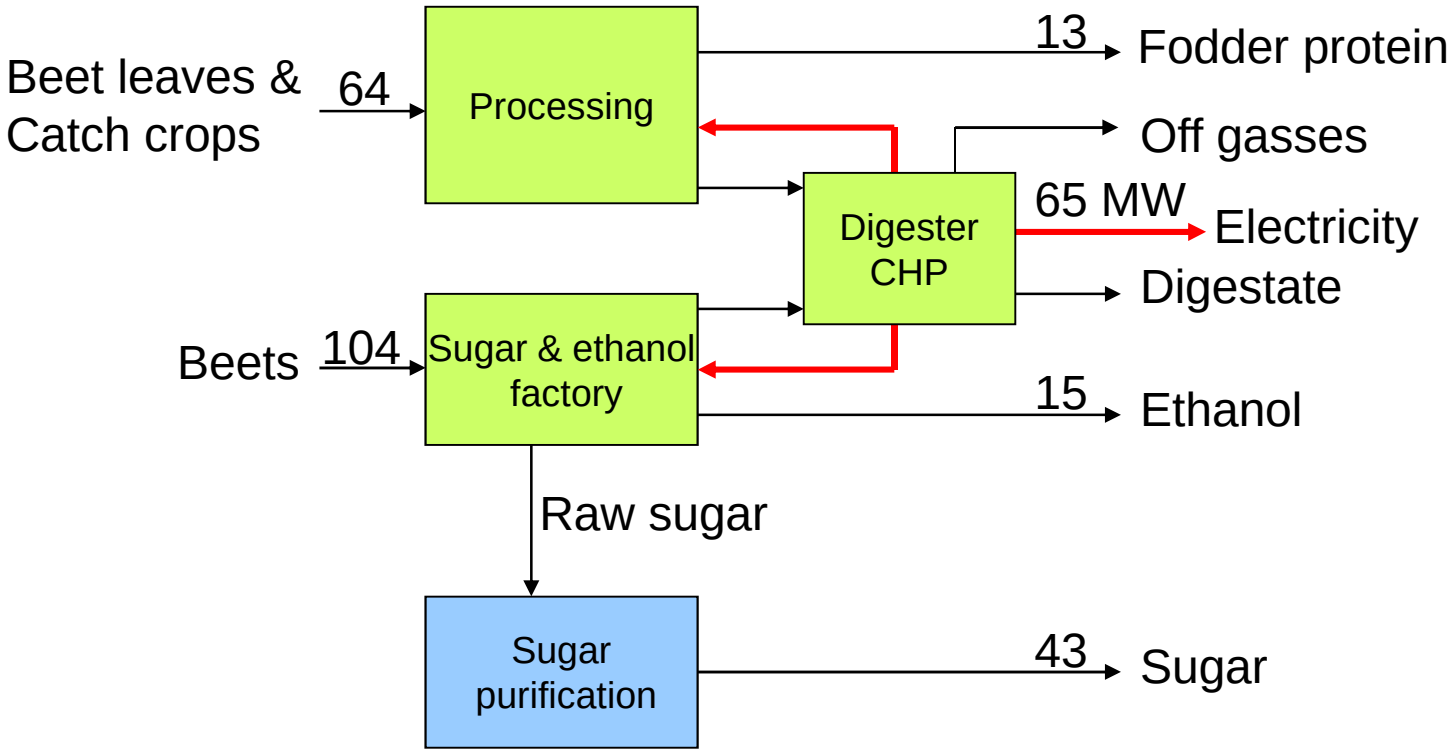
Mass balance

Integrated biorefinery case (ton dry / hour)



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Environmental assessment

	Energy (TJ/yr)		CO_2 (kton/yr)	
	Reference	**Integrated**	**Reference**	**Integrated**
Heat	2691		164	
Ethanol		1009		68
Biogas		2077		154*
	2691	**3086**	**164**	**222**

* Electricity only (heat is used in process)

- Integrated case: no external heat demand due to simplified process and heat from CHP
- High reduction of CO_2 emission, lower sugar production

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Economical assessment

Reference case

		Unit	€/unit	Unit/T sugar	€/T sugar
Raw material	Beets (dry weight)	T	112.52	1.44	161.8
Auxiliaries					9.0
Energy		GJ	3.00	10.00	30.0
Co-products	Molasses	T	90.00	0.17	-15.3
	Dried beet pulp	T	30.00	0.26	-7.8
	Foam Earth	T		0.34	0.0
Variable cost					**177.7**
Capex	168,000,000	€			
Depreciation	12 years				44.4
Other costs	20%	of capex			106.5
Fixed costs					**150.9**
Total					**328.7**
Product value	**Sugar**				**400.0**

Integrated case

		Unit	€/unit	Unit/T BSP	€/T BSP
Raw material	Beets (dry weight)	T	93.02	2.40	223.2
Chemicals	Processed leaves	T	110.00	1.49	163.9
	Ethanol factory (excl. raw materials)	T	177.00	0.34	60.2
	An. Dig. & CHP (excl. raw materials)	kWh	0.08	1,545	129.0
Co-products	Ethanol	T	800.00	0.34	-269.6
	Protein rich feed	T	300.00	0.60	-179.1
	Renewable electricity	kWh	0.05	1,545	-77.3
Variable cost					**50.4**
Capex	134,400,000	€			
Depreciation	12 years				59.2
Other costs	20%	of capex			142.1
Fixed costs					**201.3**
Total					**251.6**
Product value	**Sugar**				**400.0**

Key economical parameters

	Reference case	Integrated case
Products	Sugar	Sugar Ethanol Feed Protein Electricity
Investment	168 M€	134 M€*
Pay back time	7 years	5 years
IRR	7%	22%
Sugar costs	329 €/ton	252 €/ton

*Capital costs of catch crop processing, ethanol production and CHP are included as ‘lump sum’ variable costs

Sugar can be produced at expected low future price

Technical feasibility

Score better than average (75 > 71)

Pros:

- Selected application already existing

Cons:

- None

Commercial feasibility

Score better than average (79 > 71)

Pros:

- Economical benefit for user
- Benefit of integrated concept

Cons:

- No functional benefit for user

SWOT analysis

Strengths:

- Value maximization

Weaknesses:

- Abandoning current capital

Opportunities:

- Other products possible (proteins)

Threats:

- Independence of farmers

Introduction: Small scale power production

Reference: Manure and grass are digested to produce electricity

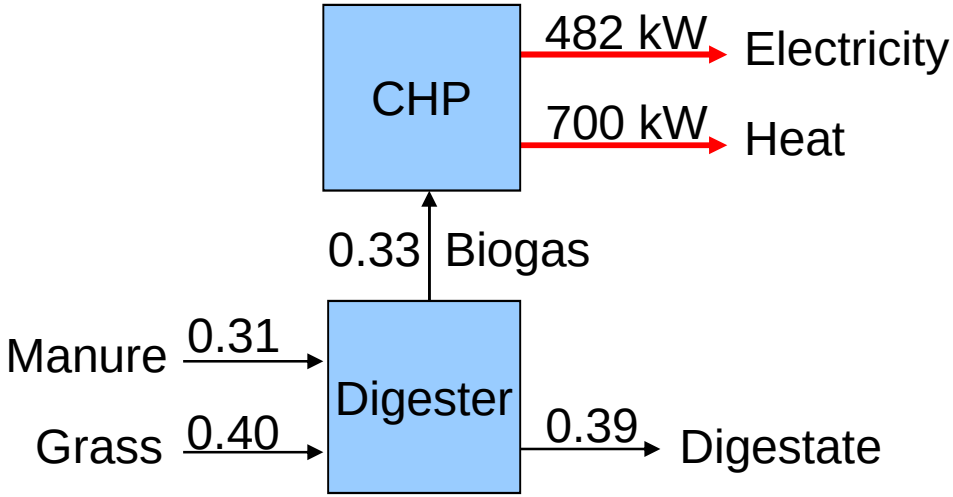
- No application for heat
- Very high capital costs
- Electricity sold at a loss

Alternative: Grass biorefinery

- Production of fibres and proteins
- Higher value, less electricity (= lower loss)

Mass and energy balance

Reference case (ton dry / hour)



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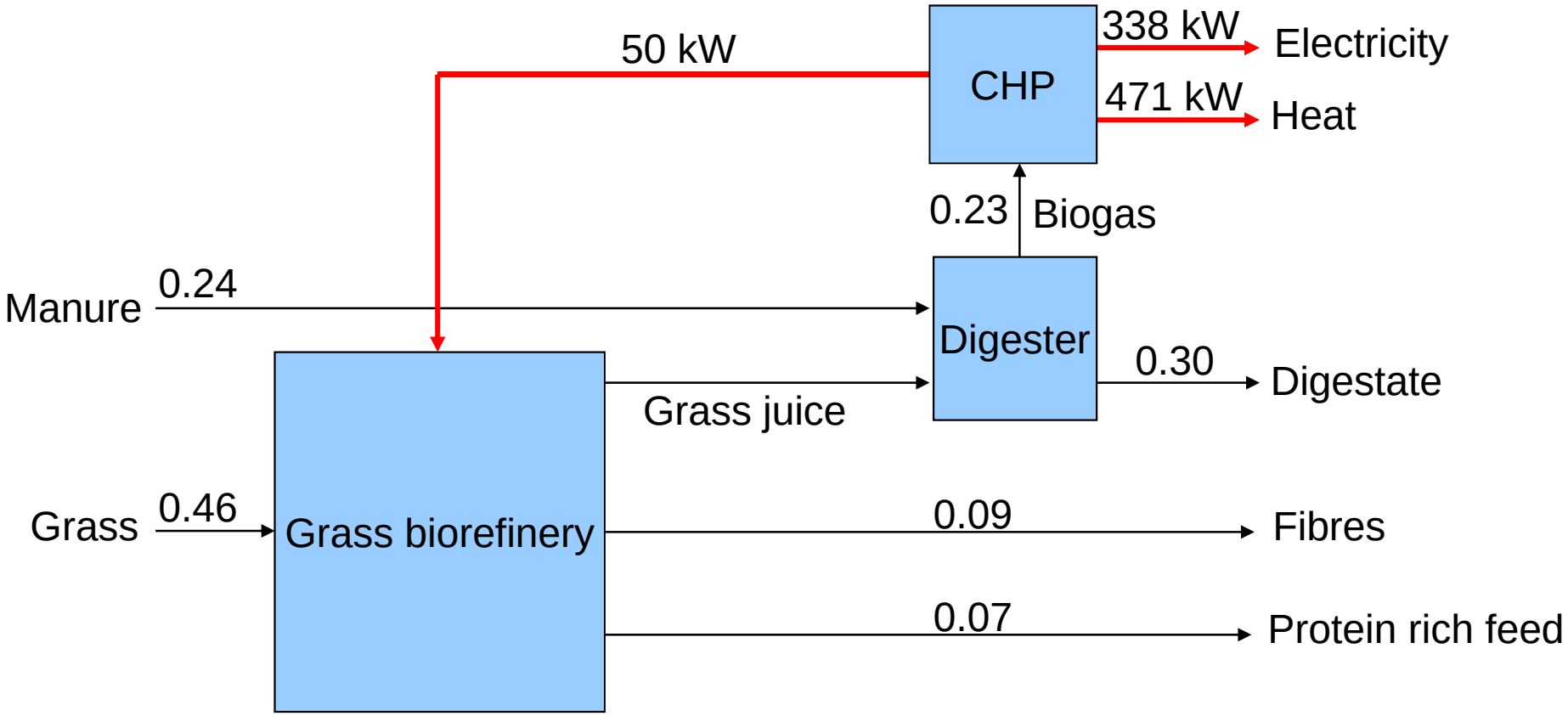
Integrated biorefinery case (ton dry / hour)



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Environmental assessment

	Energy (GJ/yr)		CO_2 (ton/yr)	
	Reference	**Integrated**	**Reference**	**Integrated**
Electricity	14040	9720	1629	1128
Heat	20160	13680	1129	766
	34200	**23400**	**2758**	**1894**

- Electricity and heat production reduced
- Less CO_2 reduction
- Feed and fibres produced
  - Less land needed, which can be used to grow food, feed or fibres

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Economic assessment

Reference case

		Unit	€/unit	Unit/MWh	€/MWh
Raw material	Grass silage	T	10.00	2.08	20.8
	Manure (transport)	T	3.00	7.40	22.2
Co-products	Digestate (transport)	T	-3.00	8.52	25.6
Variable cost					**68.5**
Capex	2,150,000	€			
Depreciation	12 years				46.5
Labour	730	hr	35.00		6.6
Other costs	10%	of capex			55.8
Fixed costs					**108.9**
Total					**177.4**
Product value	**Electricity**				**50.0**

Integrated case

		Unit	€/unit	Unit/MWh	€/MWh
Raw material	Fresh grass	T	3.00	5.70	17.1
	Manure (transport)	T	3.00	8.33	25.0
	Grass silage	T	10.00	1.23	12.3
Co-products	Digestate (transport)	T	-3.00	12.68	38.0
	Coagulated protein	T	36.00	1.09	-39.1
	Fibres	T	80.00	0.68	-54.0
Variable cost					**-0.7**
Capex	2,266,250	€			
Depreciation	12 years				69.8
Labour	1363	hr	35.00		17.6
Other costs	10%	of capex			83.8
Fixed costs					**171.2**
Total					**170.6**
Product value	**Electricity**				**50.0**

Key economical parameters

	Reference case	Integrated case
Products	Electricity	Electricity Protein feed Fibres
Investment	2.15 M€	2.27 M€
Electricity costs	0.177 €/(kW·hr)	0.170 (kW·hr)

- Costs of electricity production are reduced

Technical feasibility

Lower score than average (55 < 71)

Pros:

- None

Cons:

- Required technologies not developed
- Process not proven on industrial scale
- Products not referenced in target applications

Commercial feasibility

Score slightly lower than average (69 < 71)

Pros:

- Economical benefit for user
- Benefit from integration

Cons:

- No supporting regulations

SWOT analysis

Strengths:

- Cheap feedstock

Weaknesses:

- Extraction plant idle 75% of time
- No established markets or approvals

Opportunities:

- Purification of minerals (reducing mineral load on land)

Threats:

- Cut down of subsidies
- Dependent on weather conditions

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Summary and conclusions

Biorefinery in sugar industry

- Highly profitable
- Sugar factories will feel threatened by outsourcing of ‘their’ activities at the farm

Small scale power production (grass biorefinery)

- Refinery of grass might be profitable
- Cannot make up for the losses of anaerobic digestion plus CHP
- Uncertainty on technology and product market
  - Immature technology, research needed