



Case 6: Food sector

Evaluation of cheese whey biorefinery

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Introduction

Whey is a side product of cheese making

Reference: Whey is usually dried to be sold as whey powder

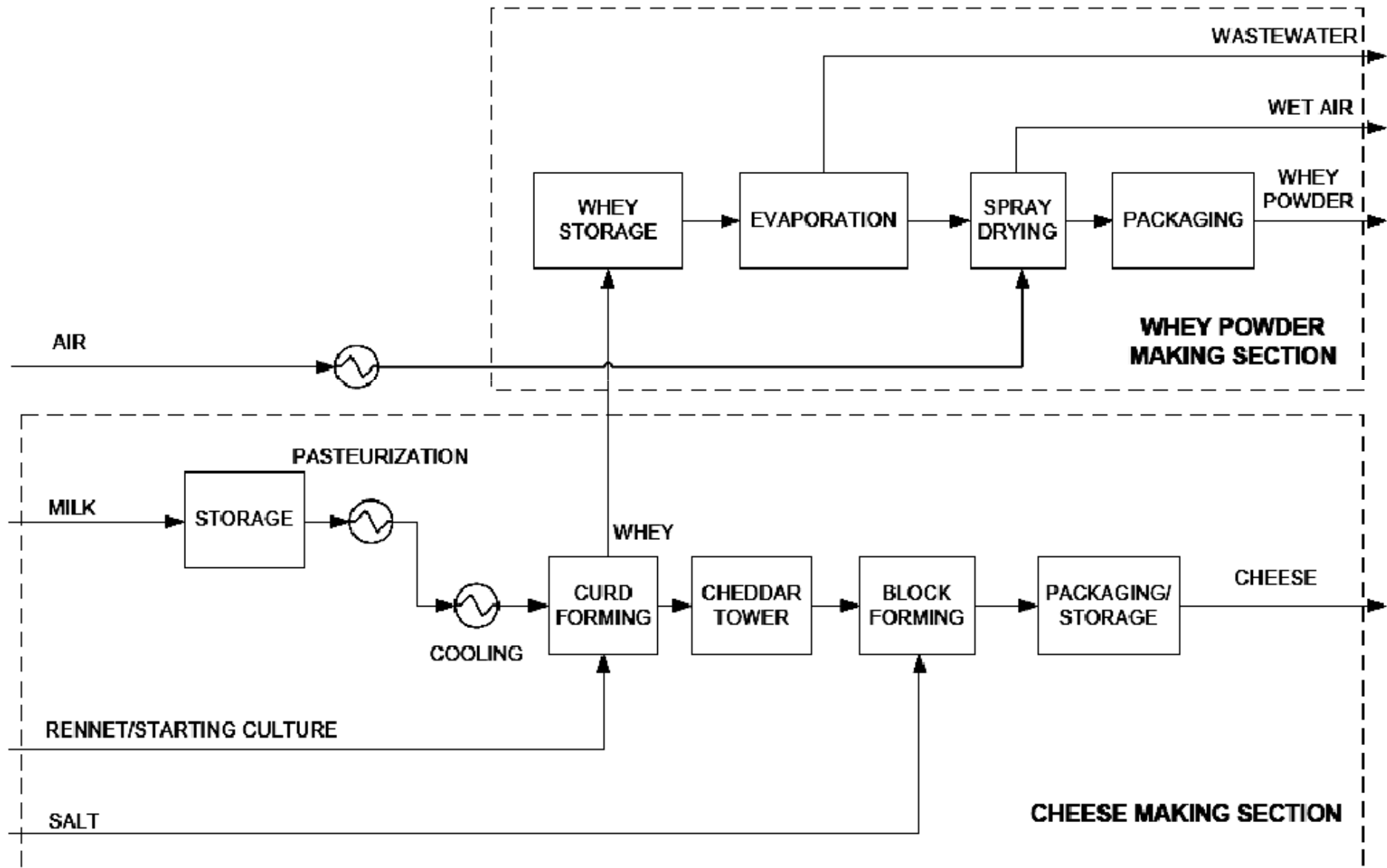
- High energy demand (= high energy costs)

Alternative: microfiltration of whey to produce

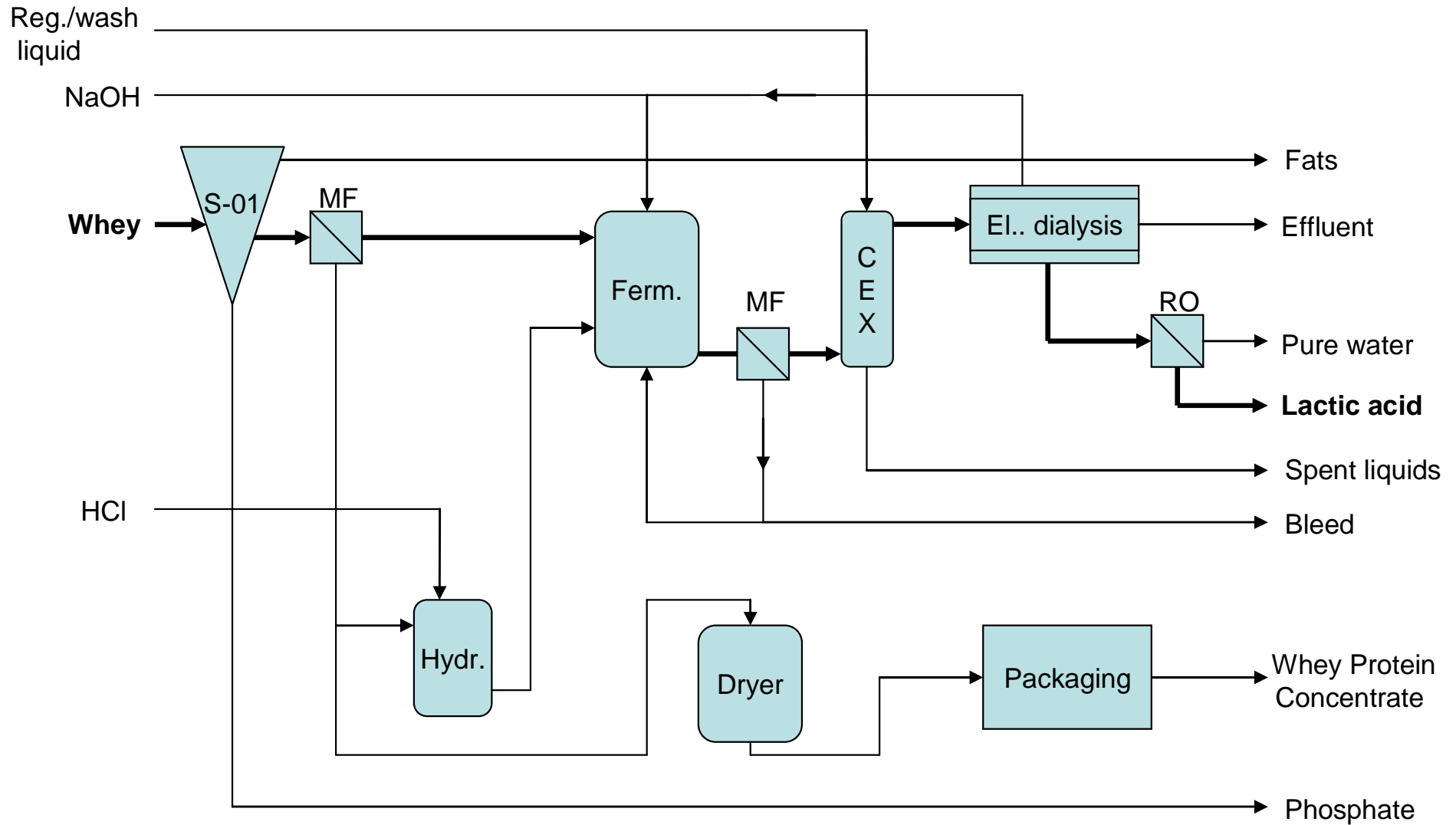
- Whey protein concentrate
- Lactose rich liquid stream
 - Fermentation to produce Lactic Acid
 - RO to remove water
- Higher added value and lower energy costs



Reference case



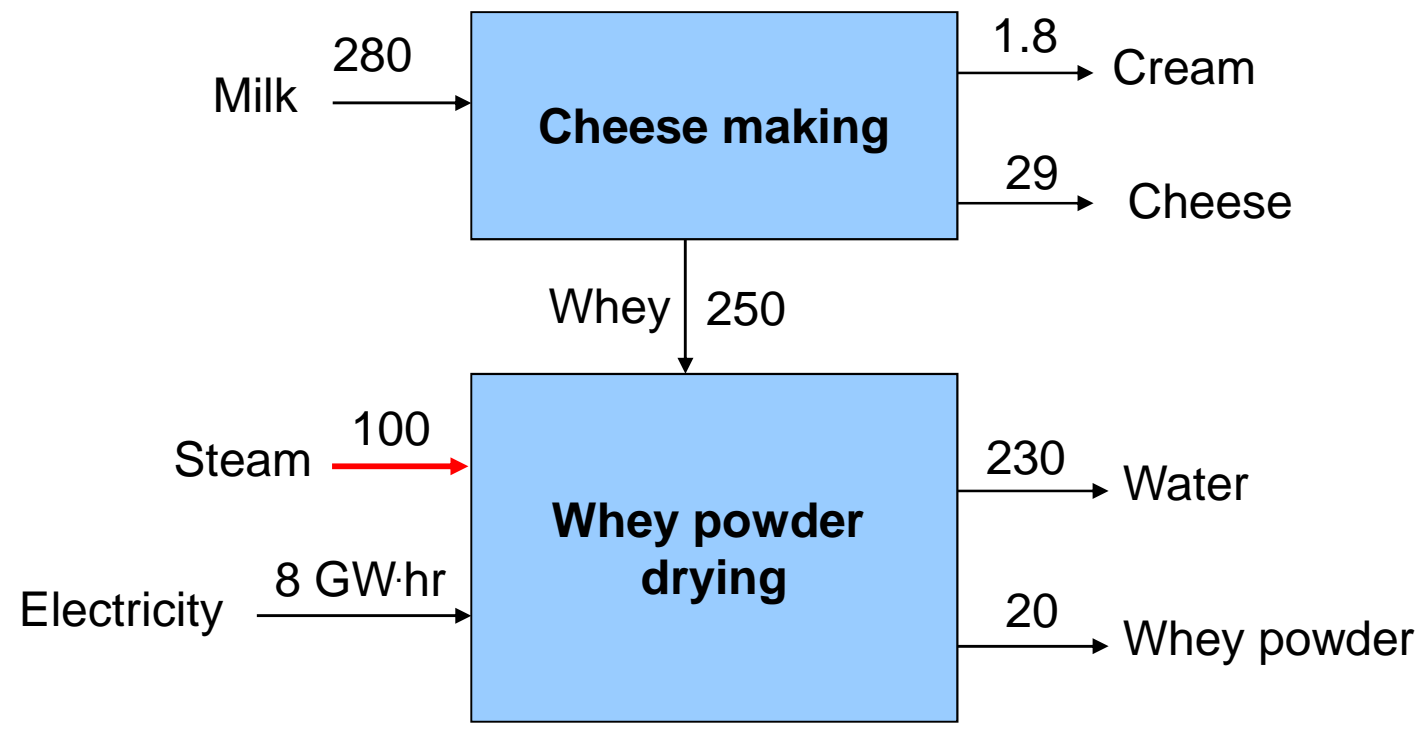
Integrated biorefinery case



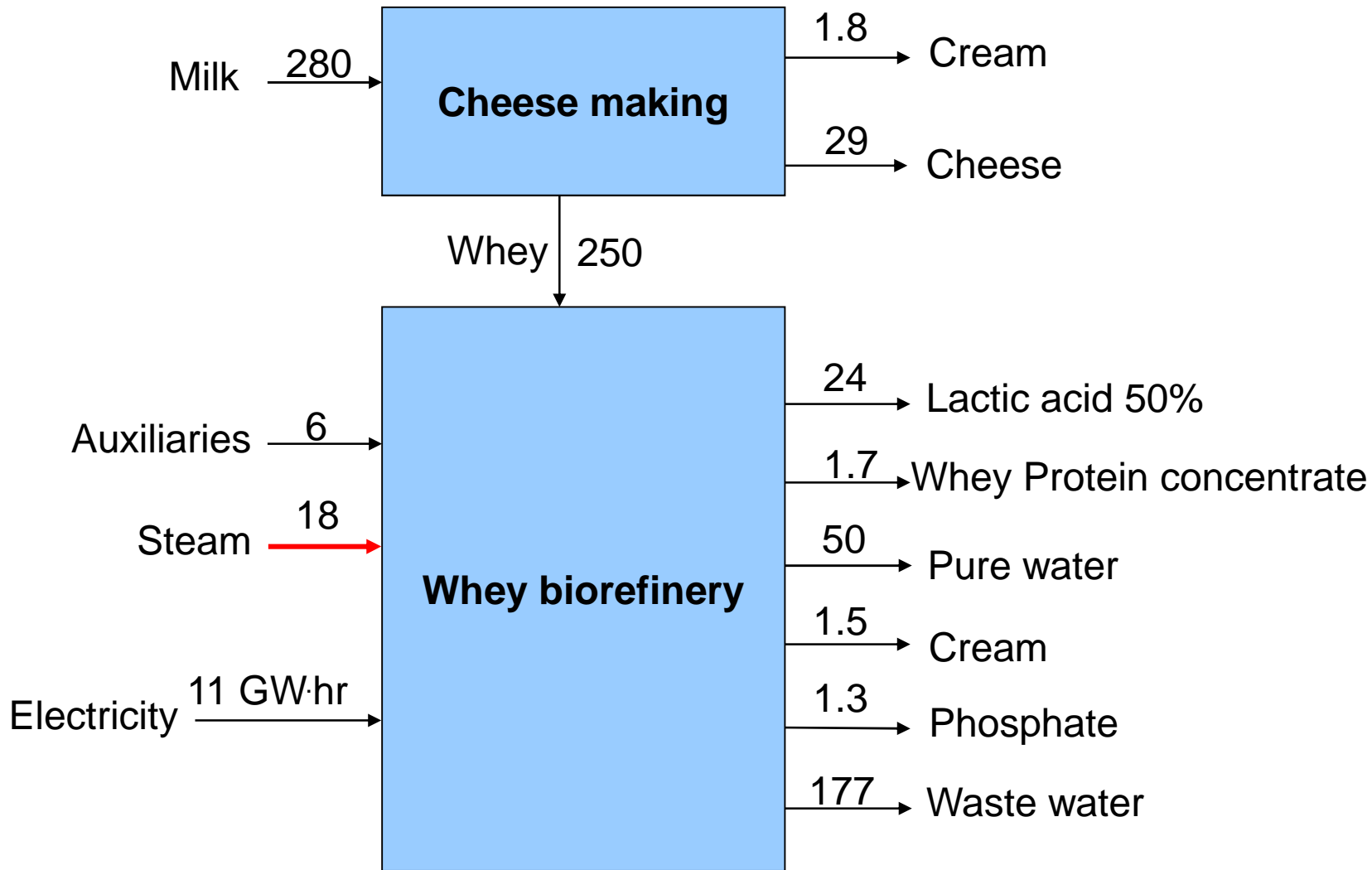
Borngardt *et al.*, 1998

Mass & Energy balances

Reference case (kton/yr)



Integrated case (kton/yr)



Environmental assessment

	Energy (GJ/yr)		CO ₂ emission (ton/yr)	
	Reference	Integrated	Reference	Integrated
Electricity	36000	46800	4176	5429
Steam	275400	51300	15300	2850
Total	311400	98100	19476	8279

- Heat demand decreases by > 80%
- Electricity demand increases by 28 %
- CO₂ exhaust reduced by > 50%



Economic assessment

Reference case

		Unit	€/unit	Unit/T cheese	€/T cheese
Raw material	Milk	T	195.00	9.74	1899.3
Auxiliaries					224.1
Steam	3 barg steam	T	12.50	3.54	44.3
Electricity		kWh	0.05	347.00	17.4
Co-products	Whey powder 10% prot.	T	960.00	0.67	-643.2
	Cream	T	600.00	0.06	-37.8
Variable costs					1504.0
Capex			50,860,307 €		
Depreciation			12 years		147.1
Other costs			15% of capex		264.8
Fixed costs					411.8
Total					1915.8
Product value	Cheese				2250.0

Integrated case

		Unit	€/unit	Unit/T cheese	€/T cheese
Raw material	Milk	T	195.00	9.74	1899.3
Auxiliaries					224.1
Steam	3 barg steam	T	12.50	0.65	8.1
Electricity		kWh	0.05	448.00	22.4
Co-products	Whey powder 80% prot.	T	3,500.00	0.14	-490.0
	Cream	T	600.00	0.06	-37.8
	Lactic acid	T	800.00	0.50	-400.0
	Pure water	T	300.00	1.75	-523.5
Variable cost					702.6
Capex			91,224,607 €		
Depreciation		12 years			263.8
Other costs		15% of capex			474.9
Fixed costs					738.7
Total					1441.3
Product value	Cheese				2250.0

Key economical parameters

	Reference	Integrated
Products	Cheese Whey powder	Cheese Lactic acid WPC
Investment	51 M€	91 M€
Pay back time	11 years	6 years
IRR	20%	26%
Cheese costs	1.9 €/kg	1.4 €/kg



Technical feasibility

Score below average (60 < 71)

Pros:

- No hazardous auxiliaries needed

Cons:

- Extensive DSP needed
- Process not well defined



Commercial feasibility

Score below average ($65 < 71$)

Pros:

- Economical benefits for user
- Benefits from integrated biorefinery

Cons:

- Sales of RO water needed for good profit
- Regular barriers to market introduction



SWOT analysis (internal)

Strengths:

- High value products
- Existing markets
- Lower non renewable energy usage

Weaknesses:

- Complex DSP → High capital costs
- Technical risks: membrane fouling



SWOT analysis (external)

Opportunities:

- Shortage of phosphates
- EU directive on renewable products

Threats:

- Lactic acid and whey market unstable
- Novel food application might be needed



Summary and conclusions

Added value from whey protein and lactic acid

- Short pay back time
- Future sales of phosphate

Complex Down Stream Processing

- High investment costs
- Technological risk (unproven technology)

Evaporation of water is replaced by ultra filtration and RO:

- Lower energy costs, lower CO₂ exhaust



Questions?

