

Ethanol-based Organosolv Biorefineries: Feedstock- Flexibility & Economic Evaluation

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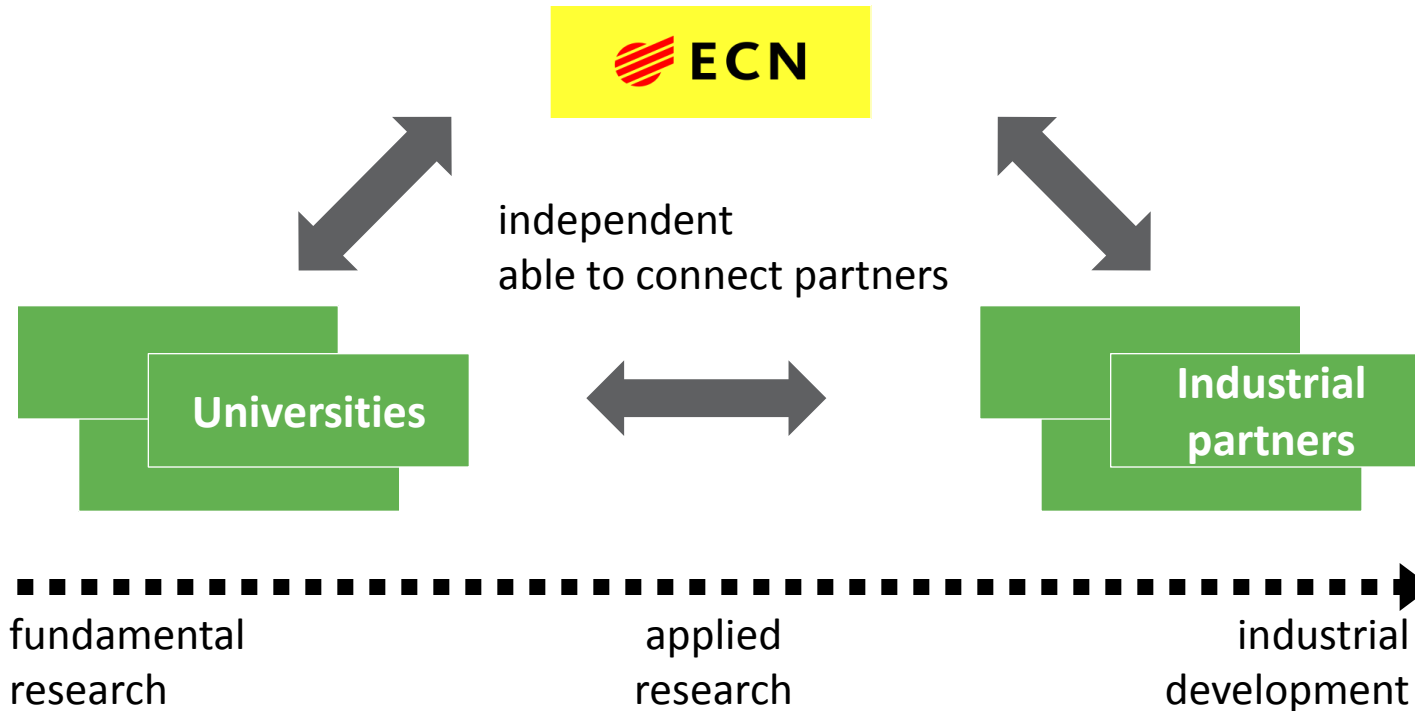
NWBC, Helsinki
25-10-2012

ECN – Geographical position

- Head office: Petten
- Other offices:
 - Amsterdam
 - Eindhoven
 - Wieringerwerf
 - Brussels
 - Beijing (not in picture)



ECN – Position among partners

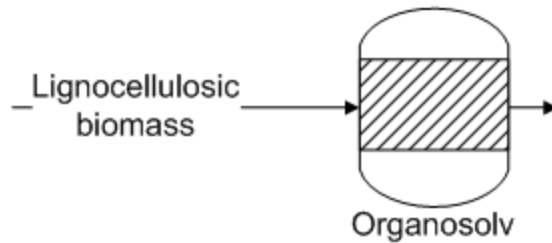
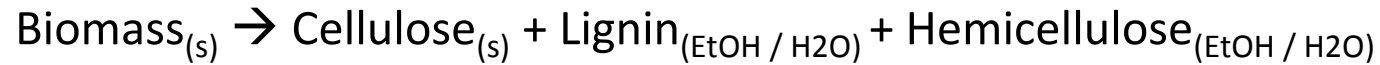


Organosolv – Why?

- Fractionation of all major constituents
- Valorization of all major constituents
 - Increased revenue from biorefinery
 - Financially more attractive
- Cellulose: High conversion enzymatic hydrolysis
- Lignin: High-quality for production of chemicals
- Hemicellulose: Choice for xylose or xylose derivatives (furfural)

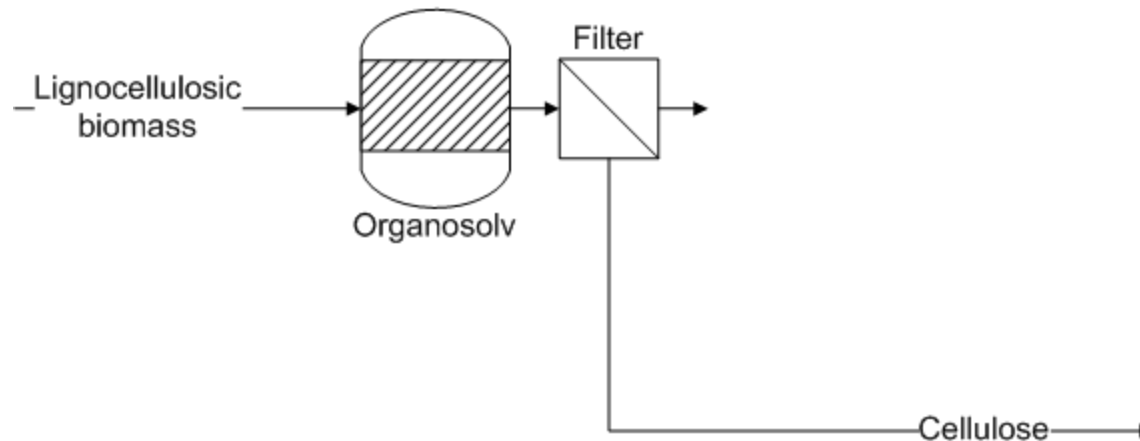
Organosolv – How?

- Specific for lignocellulosic biomass
- Organosolv reactor:



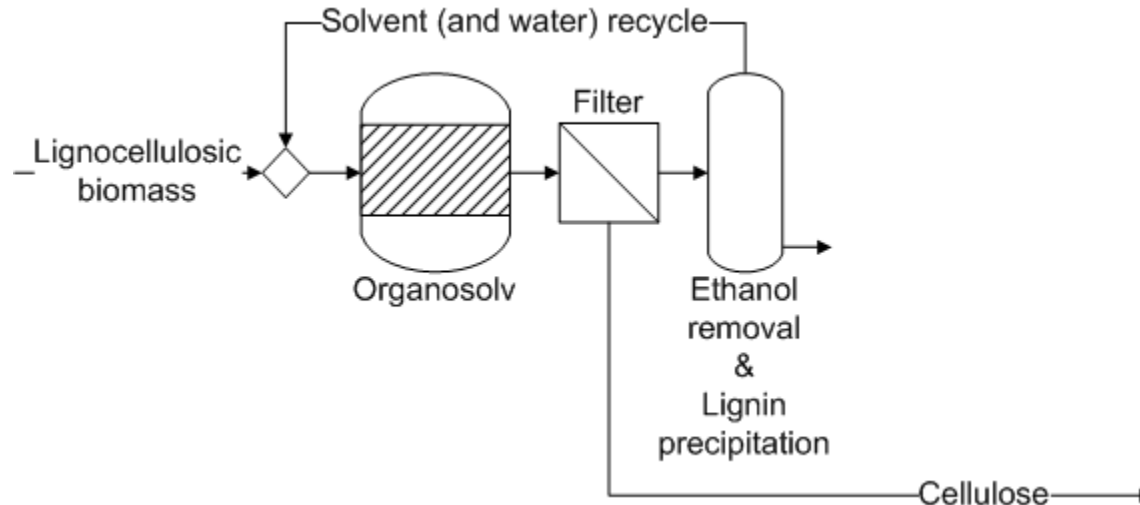
Organosolv – How?

- A filter removes cellulose from the liquid mixture



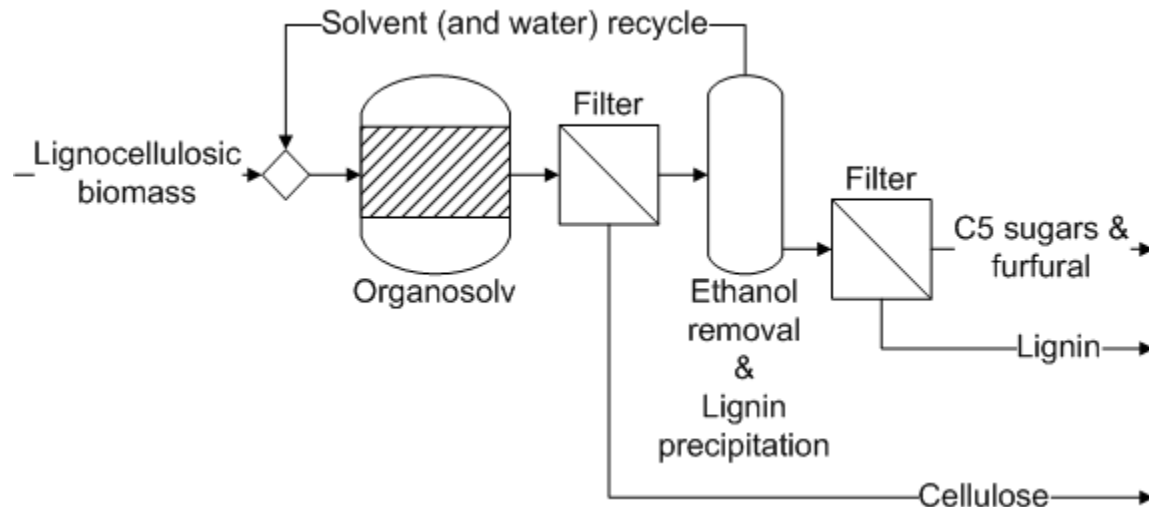
Organosolv – How?

- Lignin is precipitated by removing the ethanol (lowering lignin solubility)
- Ethanol recycling is 99.9%; Crucial for economics

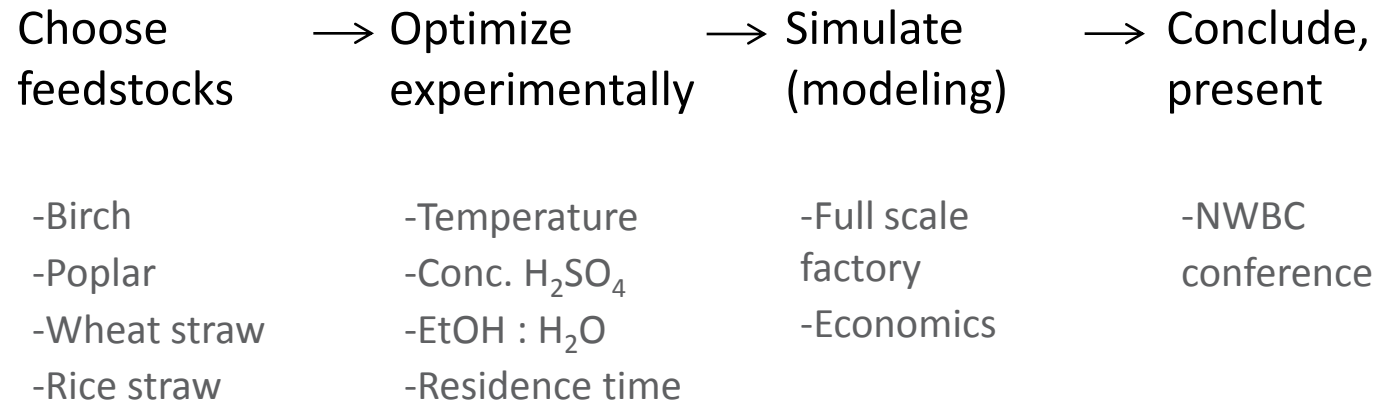


Organosolv – How?

- A filter separates the lignin from the C5 sugars
- Organosolv can fractionate all three main biomass components into separate streams



Method



Optimal process conditions

- Organosolv process conditions optimized in parametric study (experimental)

Feedstock	Birch	Wheat straw	Rice Straw	Poplar
Temperature (°C)	190	190	200	210
H ₂ SO ₄ (mM)	5	30	50	15
EtOH:H ₂ O (w/w)	50:50	60:40	60:40	60:40
Enz. glucose yield (%)	99%	98%	89%	~100%
Lignin recovery (% wt)	80%	79%	86%	95%

- Enz. glucose yield: analysis method possibly causes slight overestimation
- Lignin recovery: on biomass dry weight basis

Organosolv biorefinery (simulation)

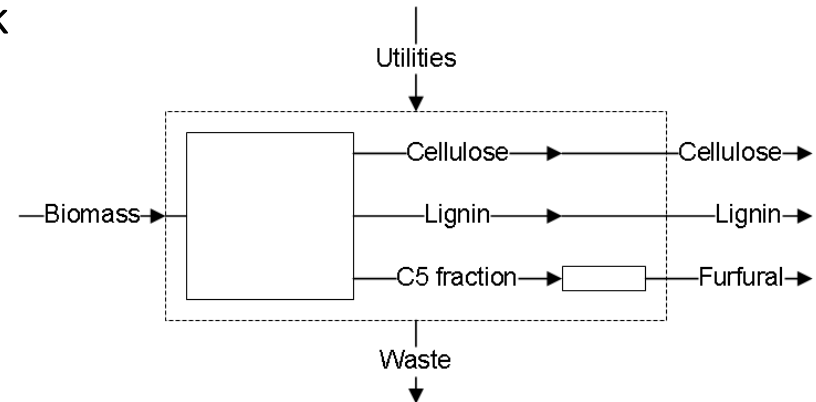
- 150 kton/yr (dw) biomass feedstock

- Biomass:

- Birch
- Poplar
- Wheat straw
- Rice straw
- Flexible feedstock

- Products (chosen)

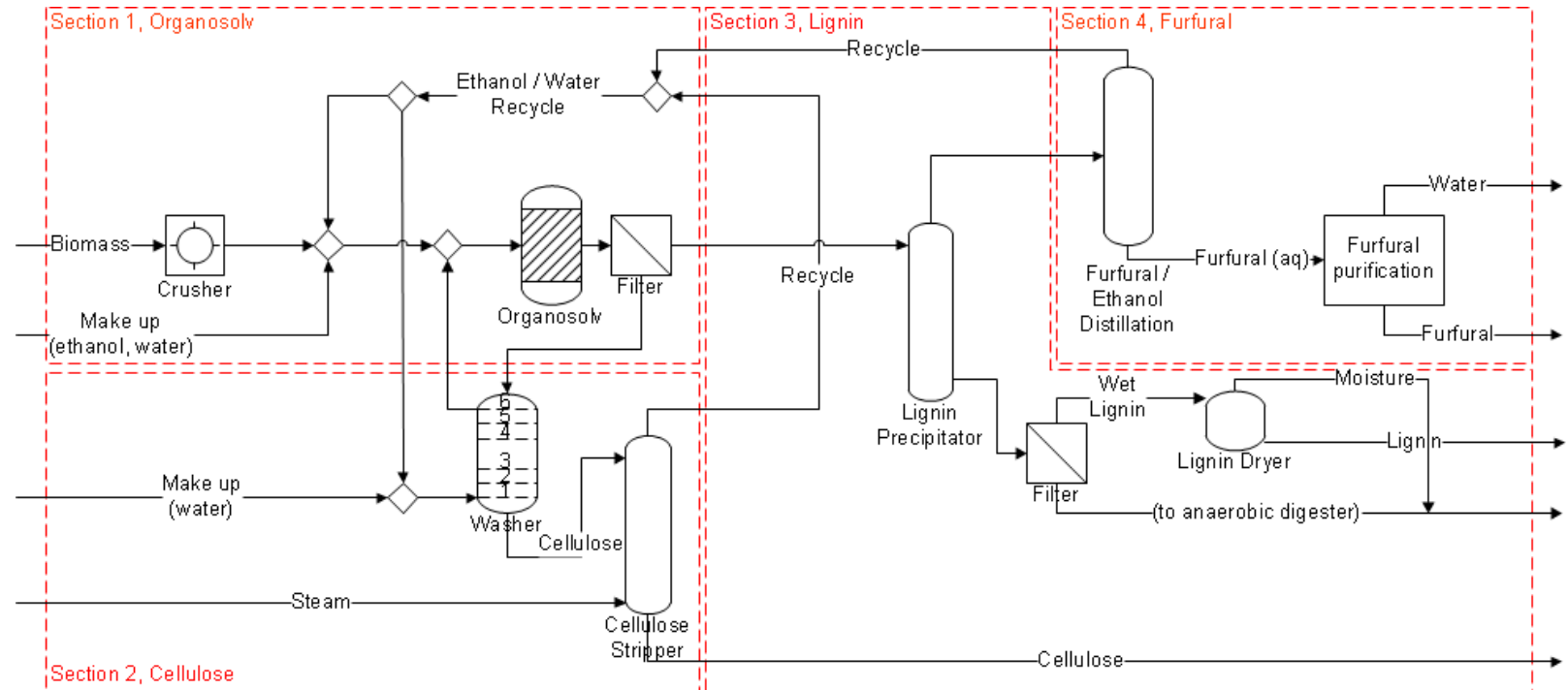
- Cellulose
- Lignin
- Furfural



- Software

- Aspen Plus
- Excel

Process flowsheet

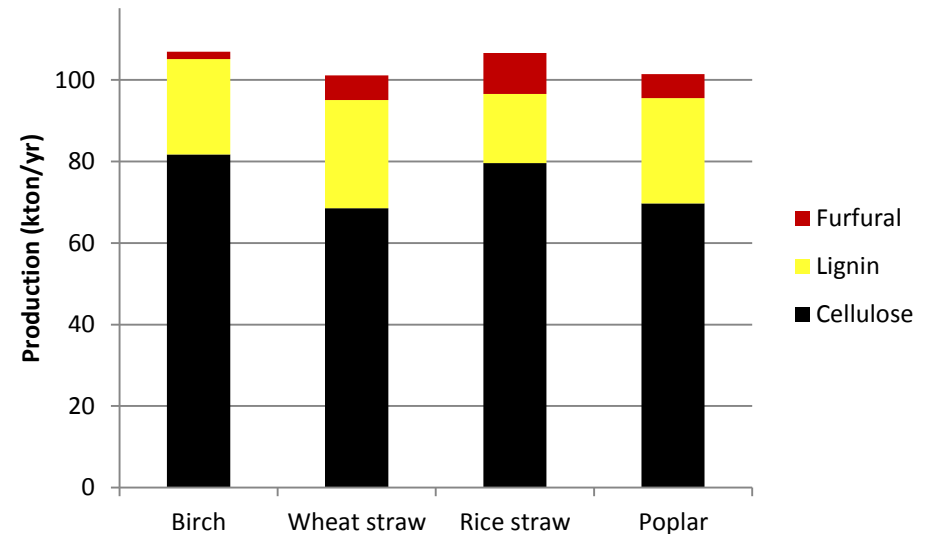


Production

- Cellulose by far largest product in weight

Products

- Pulp
 - Cellulose content varies
 - Will hydrolyze to large extent
- Lignin
 - < 1% carbohydrates
 - ~ 0% ash
- Furfural
 - 99.9%

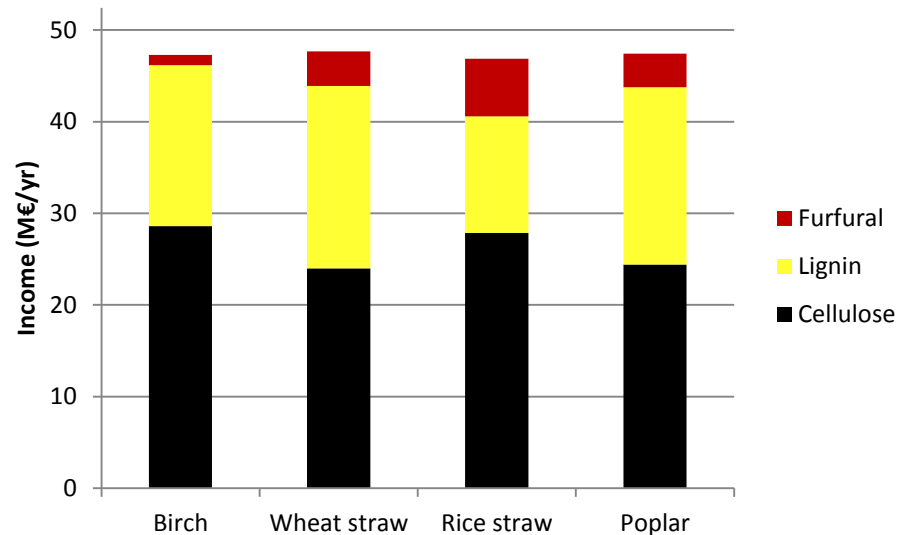


Income

- Cellulose is largest product in terms of economy
- Lignin critical to create added value from biomass

Product prices

- Cellulose: 350 €/ton
 - Lignin: 750 €/ton
 - Furfural: 625 €/ton
-
- Room for improvement:
Further utilization C5 fraction

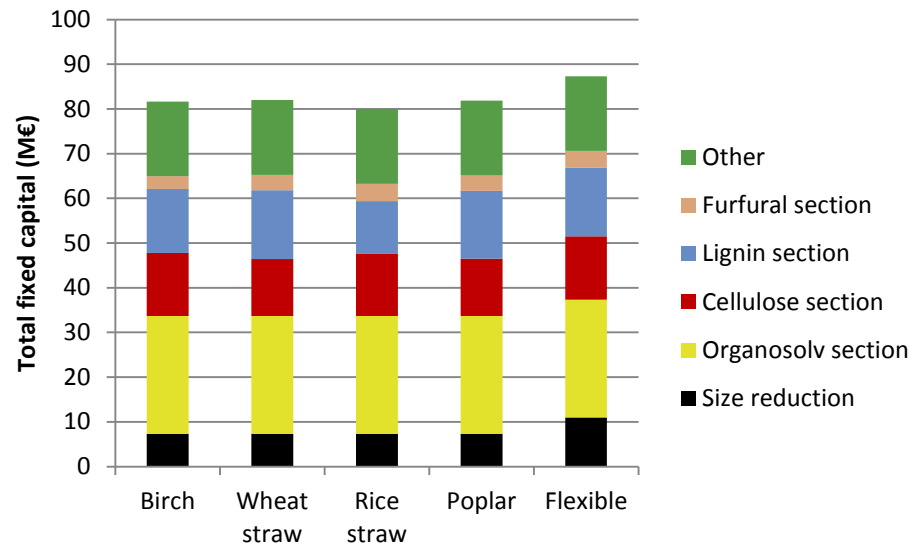


Capital cost estimate

- Based on literature methods and data from manufacturers
- Scale of cellulose / lignin / furfural sections depends on production volume
- 5th case added: flexible feedstock
- 25% Birch, 25% wheat straw, 25% rice straw, 25% poplar
 - 50% investment added to size reduction section
 - Cellulose / lignin / furfural sections scaled to maximum possible production volume

Capital cost estimate

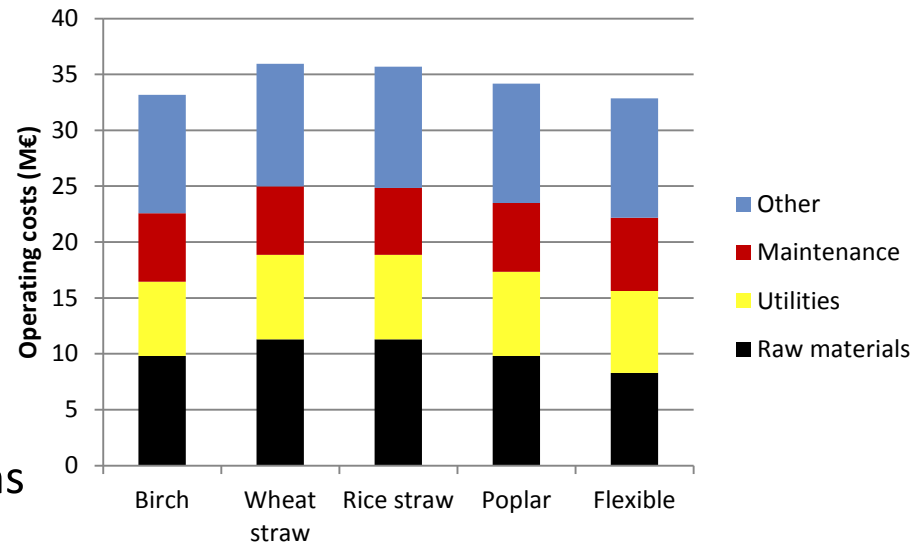
- CAPEX highest for flexible feedstock biorefinery
- Organosolv reactor section most expensive
- Extremes cancel each other out



Operating costs

- Flexible feedstock biorefinery:
 - Feedstock costs lower for flexible biorefinery
 - Maintenance higher
- Straw more expensive feedstock (assumed)

- Birch: 60 €/ton dw
- Wheat straw: 70 €/ton dw
- Rice straw: 70 €/ton dw
- Poplar: 60 €/ton dw
- Flexible: (average – 15 €)
- Benefit from market fluctuations



Conclusions Economic Analysis

- Payback times of Birch, poplar and flexible feed lowest
- Operating costs of mixed feed lowest, CAPEX highest

	Birch	Wheat straw	Rice Straw	Poplar	Flexible feed
Income (M€/yr)	47.3	47.7	46.9	47.4	47.3
OPEX (M€/yr)	33.2	35.9	35.7	34.2	32.8
CAPEX (M€/yr)	81.7	82.0	80.0	81.8	87.3
Payback time (yr)	5.8	7.0	7.2	6.2	6.0

Take home message

- Feedstock price very important
- Feedstock-flexible biorefinery economically interesting, despite higher CAPEX, due to lower feedstock prices
- Organosolv is a feedstock-flexible technology

Thank you for your attention

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