

▷ 30. March 2009, Brussels



# Prospects for further demonstration

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[biorefinery.nl/biopol](http://biorefinery.nl/biopol)

[biorefinery-euroview.eu](http://biorefinery-euroview.eu)



## ▷ Introduction

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### Main questions

- What will **drive** biorefinery establishment?
- What will **hinder** biorefinery establishment?
- **Where** will biorefineries be established?
  
- What are the **costs** of pilot and demo scale biorefineries?
- What could be done to increase biorefinery establishment?



## Part I:

# Establishment of biorefineries

## ▷ Method biorefinery establishment

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Start from info from:

- Technical evaluation
- Political, Industry and Consumer Survey
- Mapping

Combine results from different work packages in spider plots

Estimate 'likeliness' of different types of biorefinery in different regions

## ▷ Regions and biorefinery types

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### Four regions:

- Northern Europe
- Eastern Europe
- Southern Europe
- Western Europe

### Four biorefinery types

- Whole crop biorefinery
- Lignocellulosic biorefinery (enzymatic)
- Green biorefinery
- Syngas biorefinery (thermo-chemical)

## ➤ Scaling of survey and mapping results

### Problem:

- each survey has different units and scales
- both qualitative and quantitative scales

### Solution:

- convert to uniform 'intuitive' 1-5 scales

Score	Conditions	Opinions	Profitability
1	highly unfavourable	not a chance	very unprofitable
2	unfavourable	unlikely	unprofitable
3	neutral	likely	neutral
4	favourable	very likely	profitable
5	very favourable	for sure	very profitable

## ▷ Two main groups of results

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1. Industrial, Consumer and Political Survey
  - General information only
2. Technical issues and establishment factors
  - Region and / or biorefinery type specific information

## ▷ 1. Issues in Industrial, Consumer and Political Survey

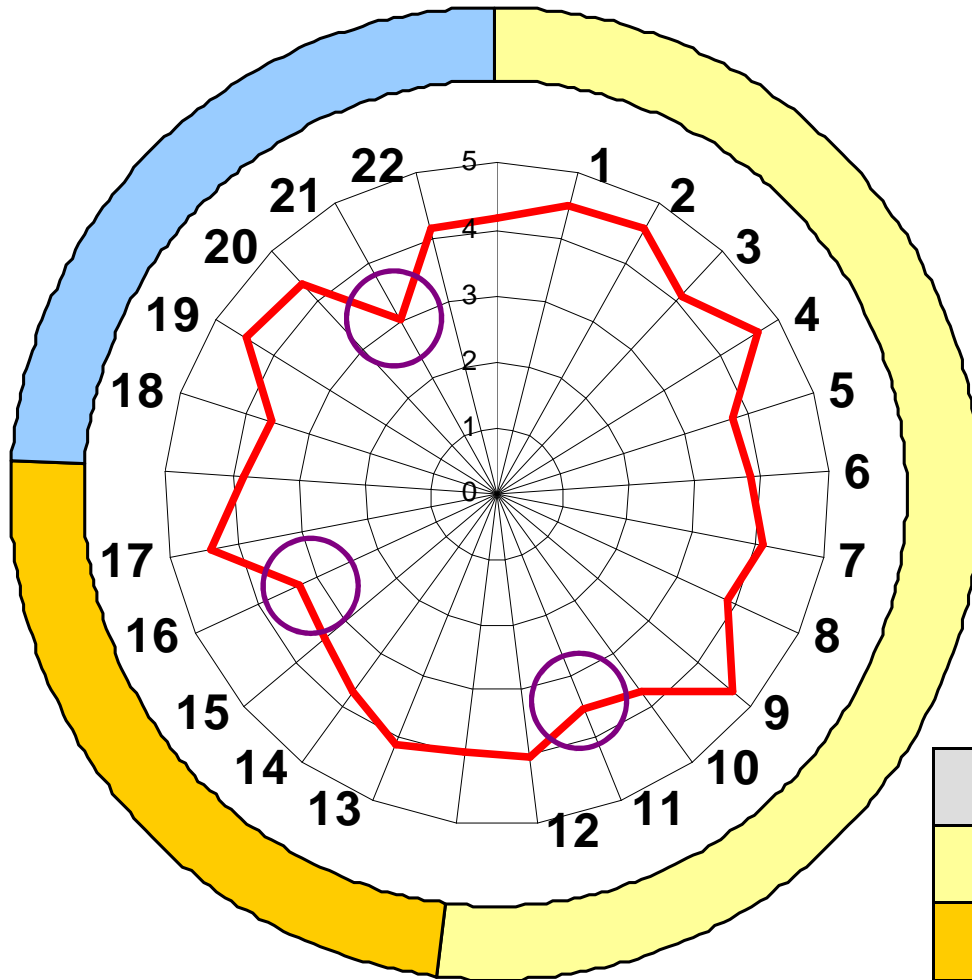
#	Issue (Industrial Survey)
1	Promising concept
2	Economical potential
3	Implementable
4	Interesting markets
5	Fits into regulations
6	Economical barriers
7	Political/legal barriers
8	Technological barriers
9	Other barriers
10	Feedstock/raw material problems
11	Plant/mill/manufacturing problems
12	Problems with market conditions

#	Issue (Consumer Survey)
13	General attitude
14	Biorefineries are eco-friendly
15	Technical materials
16	Biorefineries are odourless
17	Willingness to pay

#	Issue (Political Survey)
18	Stakeholder opinion
19	CO <sub>2</sub> reduction
20	Security of supply
21	Food and feed competition
22	(Rural) economy



# 1. Spider from Industrial, Consumer and Political Survey



- Industry Survey
- Consumer Survey
- Political Survey

= Attention issue

#	Attention Issue
11	Plant/mill/manufacturing problems
16	Biorefineries are odourless
21	Food and feed competition

## ▷ 1. Results Industrial, Consumer and Political Survey

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Generally very positive opinions on biorefineries

Attention needed (but still positive):

- Plant/mill/manufacturing problems
- Regulations (some industries only)
- Eco-friendliness (consumers' demand)
- Food/feed vs. Fuel/Products from agricultural crops

## ▷ 2. Technical issues

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Aspects	WCBR	LCBR	GreenBR	SyngasBR
Technical feasibility	3	2.5	3.5	4.5
Capital costs not a problem	3	2.5	4	2
Feedstock costs not a problem	3	3.5	4	3.5
Technological improvement pot.	3.5	4	3.5	2.5

### **Lignocellulosic biorefinery:**

- Undeveloped but high improvement potential

### **Green biorefinery:**

- Low capital costs and low feedstock costs

### **Syngas:**

- Ready for implementation, but high capital costs

## ▷ 2. Establishment factor mapping

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Likelihood of biorefinery will depend on establishment factors:

- Raw material availability
  - Agricultural production (crop and straw)
  - Forest production
  - Presence of harbors
- Possibility to sell side products (on local markets)  
Presence of:
  - Oil refineries
  - Chemical industry
  - Meat and milk industry
  - Harbors

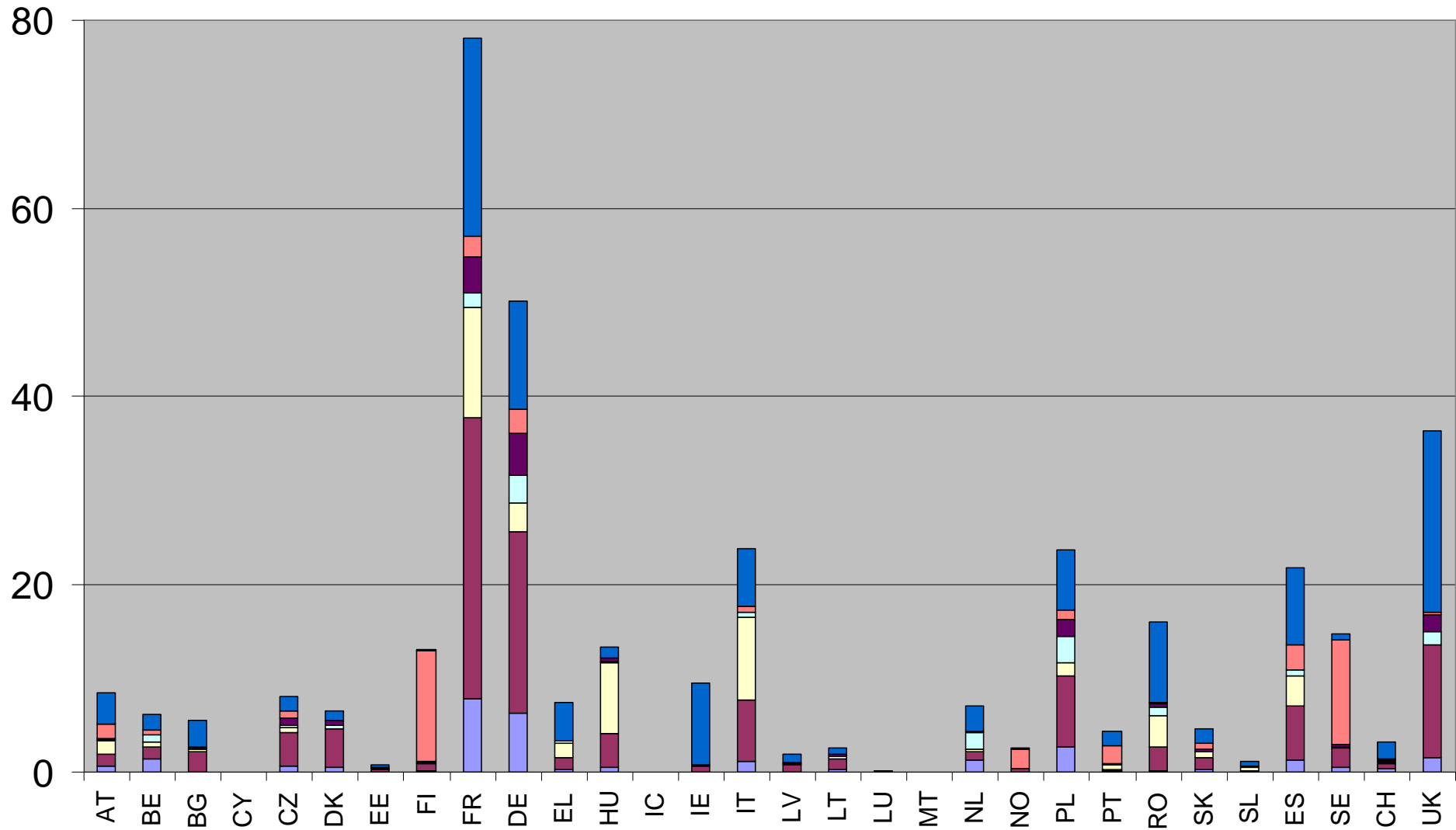
## ▷ 2. Preferred feed stocks

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Each type of biorefinery has its own preferred feed stocks:

- Whole crop biorefinery
  - Wheat, maize, rapeseed and also straw
- Lignocellulosic biorefinery
  - Wood, straw
- Green biorefinery
  - Grass, clover, etc.
- Syngas biorefinery
  - Wood, straw

# Production in Mton dry matter per year



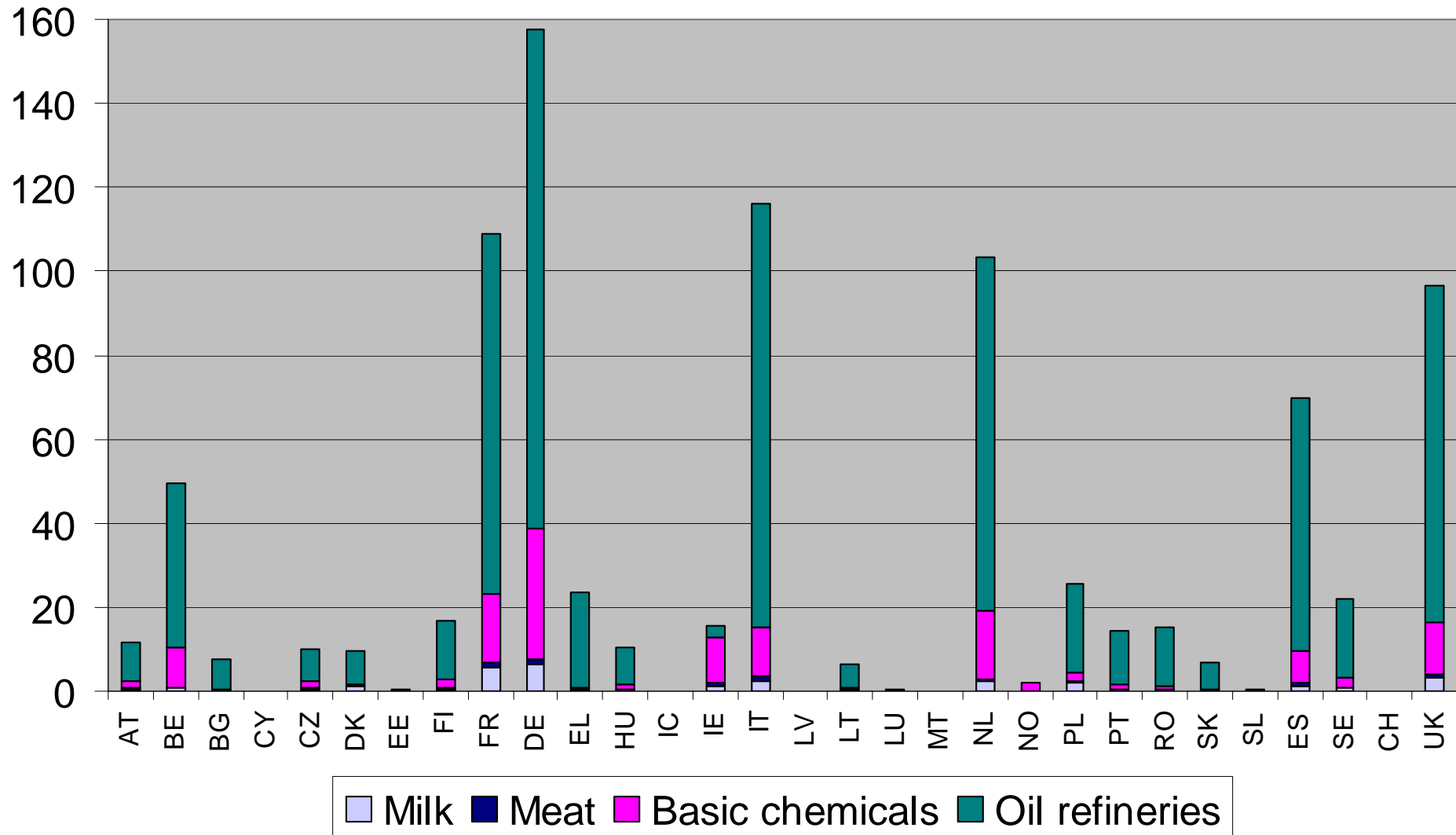
## ▷ Side products

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...and produces its own side products

- Whole crop biorefinery
  - Feed, lignin, fertilizer
- Lignocellulosic biorefinery
  - Lignin, fertilizer
- Green biorefinery
  - Feed
- Syngas biorefinery
  - Ash, tars, tail gas, heat

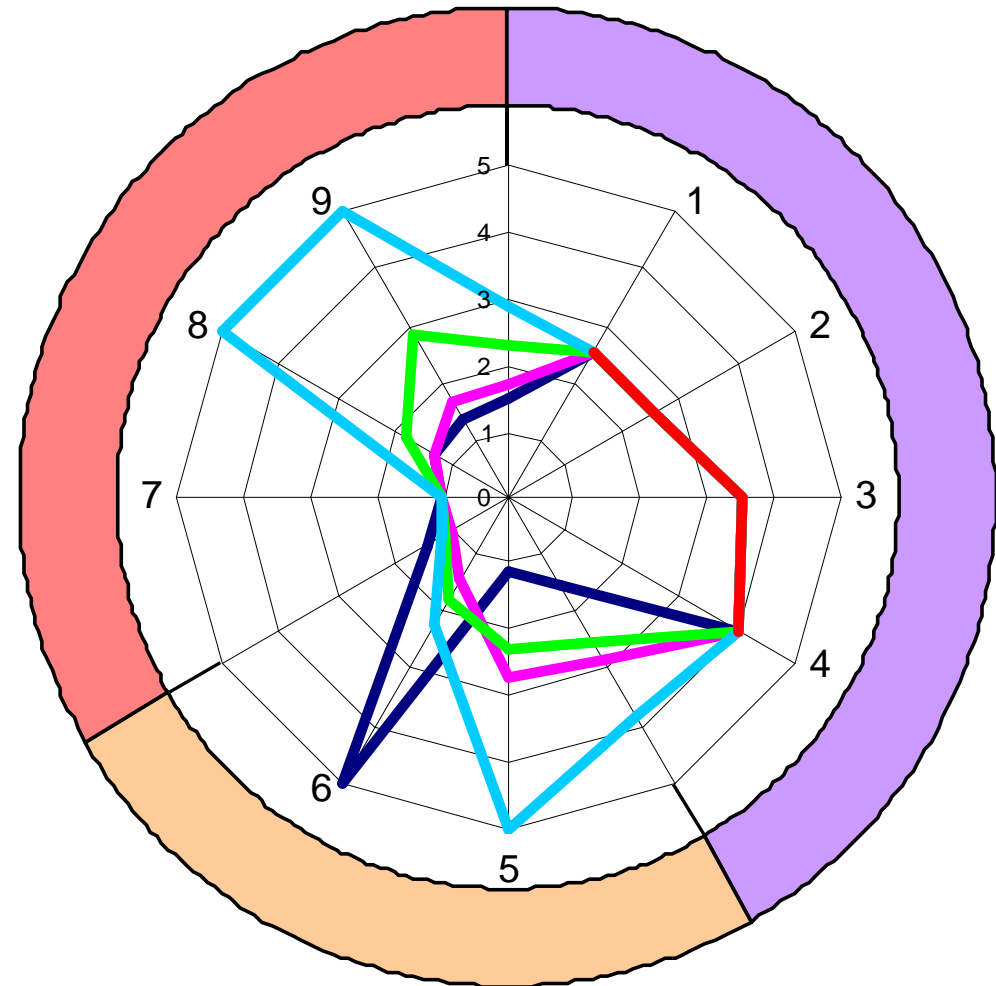
## ▷ Side product markets in Mton (dry matter) per year





## ▷ Lignocellulosic biorefinery

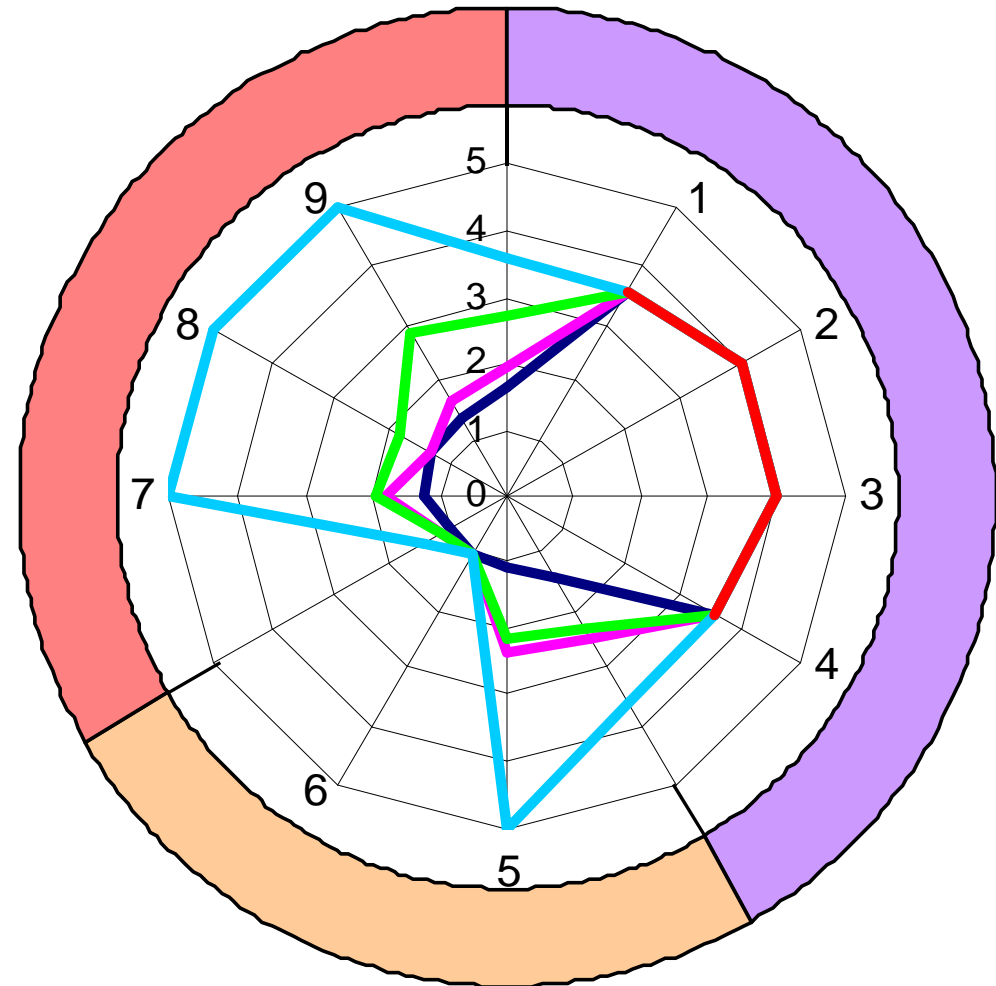
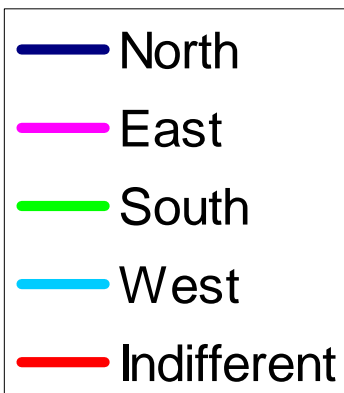
#	Issue
1	Technical feasibility
2	Capital costs not a problem
3	Feedstock costs not a problem
4	Technological improvement pot.
5	Agricultural crops
6	Pulp/wood
7	Husbandry
8	Basic chemicals
9	Oil refineries



■ Technical eval. 
 ■ Raw materials 
 ■ Side product markets

## Green biorefinery

#	Issue
1	Technical feasibility
2	Capital costs not a problem
3	Feedstock costs not a problem
4	Technological improvement pot.
5	Agricultural crops
6	Pulp/wood
7	Husbandry
8	Basic chemicals
9	Oil refineries



Technical eval.
  Raw materials
  Side product markets

## ▷ Likelihood as function of establishment factors

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Each region has its own crops

Each biorefinery type has its own preferred raw materials and side products

Establishment will depend on these factors

Method developed to estimate likelihood of establishment in one number on 1-5 scale

## ▷ Biorefinery establishment per region

	WC	LC	Green	Syn
North	3.4	3.5	3.7	4.0
East	4.5	4.6	4.4	4.4
South	4.2	4.7	4.5	4.6
West	5.0	5.0	5.0	5.0

**Western Europe** has highest potential for all biorefinery types. This holds to lesser extent for **Southern Europe**.

**Eastern Europe** has slightly lower potential, but possibility to increase agricultural yield

**Northern Europe** has potential for lignocellulosic and syngas biorefinery. Biorefineries could lead to establishment of chemical industry

## ▷ Biorefinery establishment per country

	AT	BE	BG	CY	CZ	DK	EE	FI	FR	DE	EL	HU	IC	IE	IT
WC	4.4	5.0	3.6	2.3	4.6	4.2	2.9	3.2	4.7	4.9	3.8	4.5	1.0	3.6	4.3
LC	4.7	5.0	4.1	2.0	4.7	2.8	3.1	3.4	4.7	4.8	3.5	4.5	1.0	2.6	4.6
Green	4.4	4.9	4.0	3.2	4.3	4.4	3.6	3.4	4.5	4.6	4.1	4.1	1.0	4.9	4.4
Syn	4.6	5.0	3.8	2.1	4.5	2.8	3.2	3.8	4.5	4.7	3.1	4.1	1.0	3.0	4.5

	LV	LT	LU	MT	NL	NO	PL	PT	RO	SK	SL	ES	SE	CH	UK
WC	3.1	4.1	3.8	2.4	4.8	2.2	4.5	3.5	4.0	4.4	4.1	4.0	3.3	3.4	4.1
LC	2.2	3.2	3.3	2.1	4.6	3.1	4.4	4.3	4.2	4.6	4.4	4.4	3.5	3.8	3.5
Green	3.6	4.0	2.7	2.0	5.0	2.7	4.2	4.2	4.0	4.2	4.2	4.2	3.6	2.8	4.7
Syn	2.0	2.9	3.1	1.6	4.7	3.4	4.2	4.3	3.9	4.4	4.1	4.3	3.8	3.1	3.8

## ▷ Biorefinery establishment per country

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All types of biorefineries in:

- Austria, Czech republic, Belgium, France, Germany, Netherlands

Green biorefinery in:

- Denmark, Ireland and UK

Development of wood based biorefineries in Sweden and Finland from current facilities



## Part II:

# Costs of pilot and demonstration scale biorefineries

## ▷ 3 Different approaches

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1. From chemical plant point of view
  - Situation (expansion vs. new)
  - Size (pilot, demo, full scale)
2. From research project point of view
3. From existing pilot and demonstration scale biorefineries



## ▷ 1. Costs from chemical plant point of view

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### Situation (Expansion vs. New)

Expansion is cheaper than new

- Sharing of utilities (cooling, steam)
- Sharing of facilities (weighing bridge, canteen)
- 10% cheaper





### Scale (Small vs. Large)

Small scale processes are more expensive

- Higher contingencies at small scale (up to 25% extra)
- Economy of scales (larger = cheaper)
- Generally investment is only 85% higher at double capacity

# 1. Costs from chemical plant point of view

Scale	Capacity (kton/year)	FCI (M€)
Pilot	1	0.51
Demo	10	2.8
Full	100	17
Full (very large)	1000	106

-  Increasing scale
-  Economy of scale
-  Project life time (capital amortization)
-  No revenues at pilot, little at demo

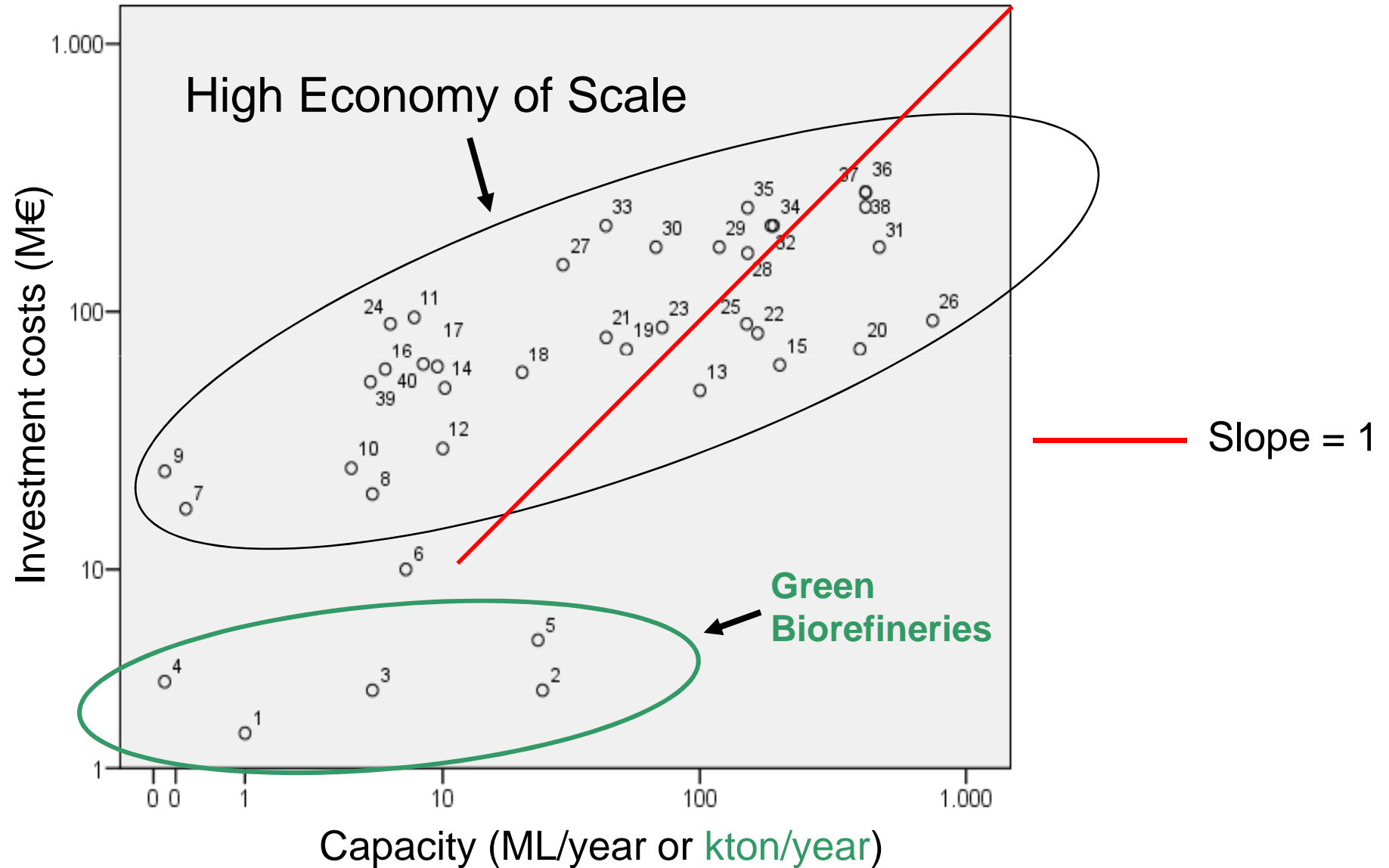
Scale	Cap depr	RMC	Other	Total costs	Revenues	Income	Years	Total
Pilot	0.51	0.1	0.29	0.90	0.0	-0.90	1	-0.9
Demo	0.93	1	1.4	3.3	1.1	-2.2	3	-6.5
Full	1.7	10	9.3	21	30	9	10	90
Full (very large)	11	100	76	187	300	113	10	1131

After presentation at BioreFuture 2009, this sheet was adapted in consideration of comments from the audience.

## ▷ 2. Costs from research project

	Calculation	M€
<b>Researcher</b>	5 FTE, 200 k€/year	1
<b>Assistant</b>	2.5 FTE @ 150 k€/year	0.4
<b>Pilot plant</b>	Investment	1
<b>Materials</b>	Material costs	0.1
<b>Total</b>		<b>2.5</b>

### 3. Costs of real world biorefineries



## ▷ Conclusions (1)

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- Generally positive opinions from industry, consumers and politicians
- Problems indicated with
  - Regulations
  - Technical issues
  - Food/feed competition
  - Environmental issues
- Technical feasibility low for lignocellulosic biorefinery, but: improvement expected
- Capital costs are high for lignocellulosic and syngas biorefineries

## ▷ Conclusions (2)

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- Biorefineries likely to develop in Western Europe
  - Raw materials and side stream markets present
- Eastern Europe could increase agricultural yield
- Northern Europe could attract chemical industry based on ligno-cellulosic by-products
  
- Costs of demo biorefineries are dependent on scale, situation and biorefinery type
- Costs vary from 2 up to 300 M€

## ▷ Recommendations

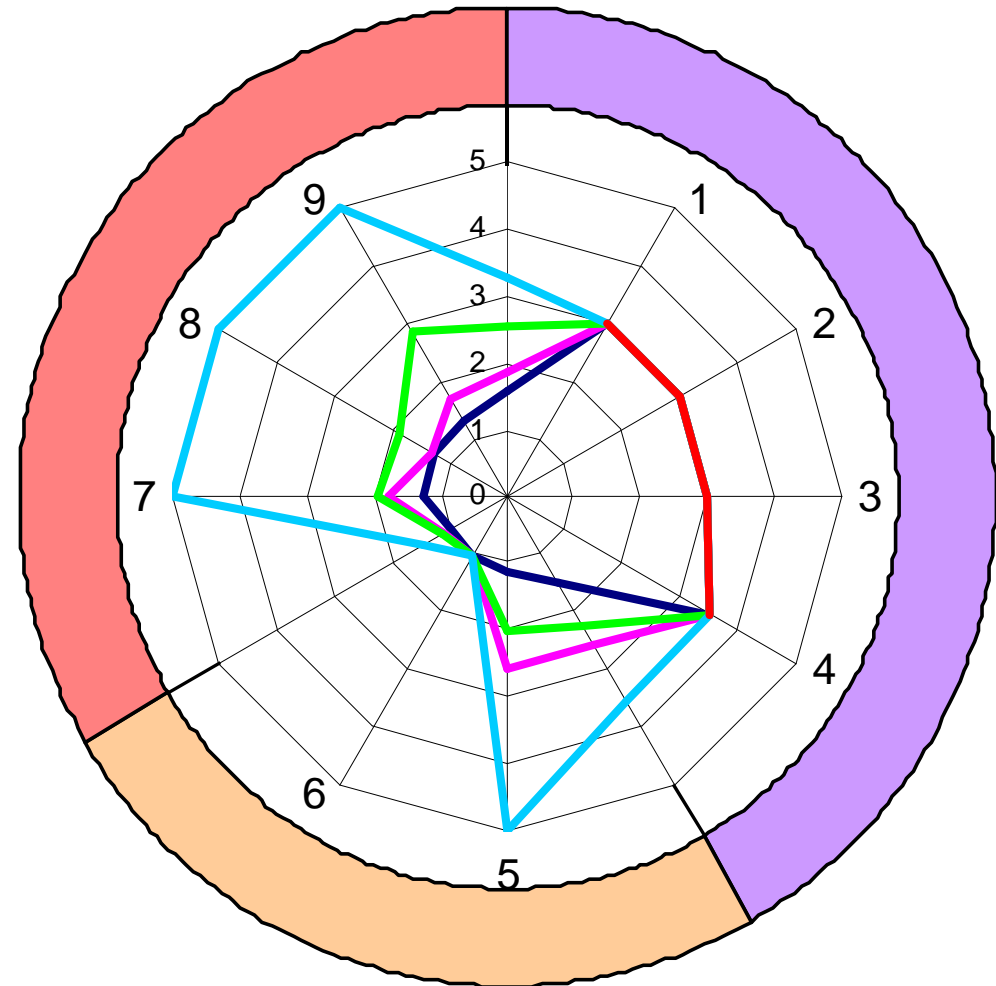
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Pay attention to:

- Improvement of regulations
- Image of biorefineries
  - Tackle food vs. feed issues
- Technological issues
  - Pilot and demo research needed
- Presence of suitable establishment factors

# Whole crop biorefinery

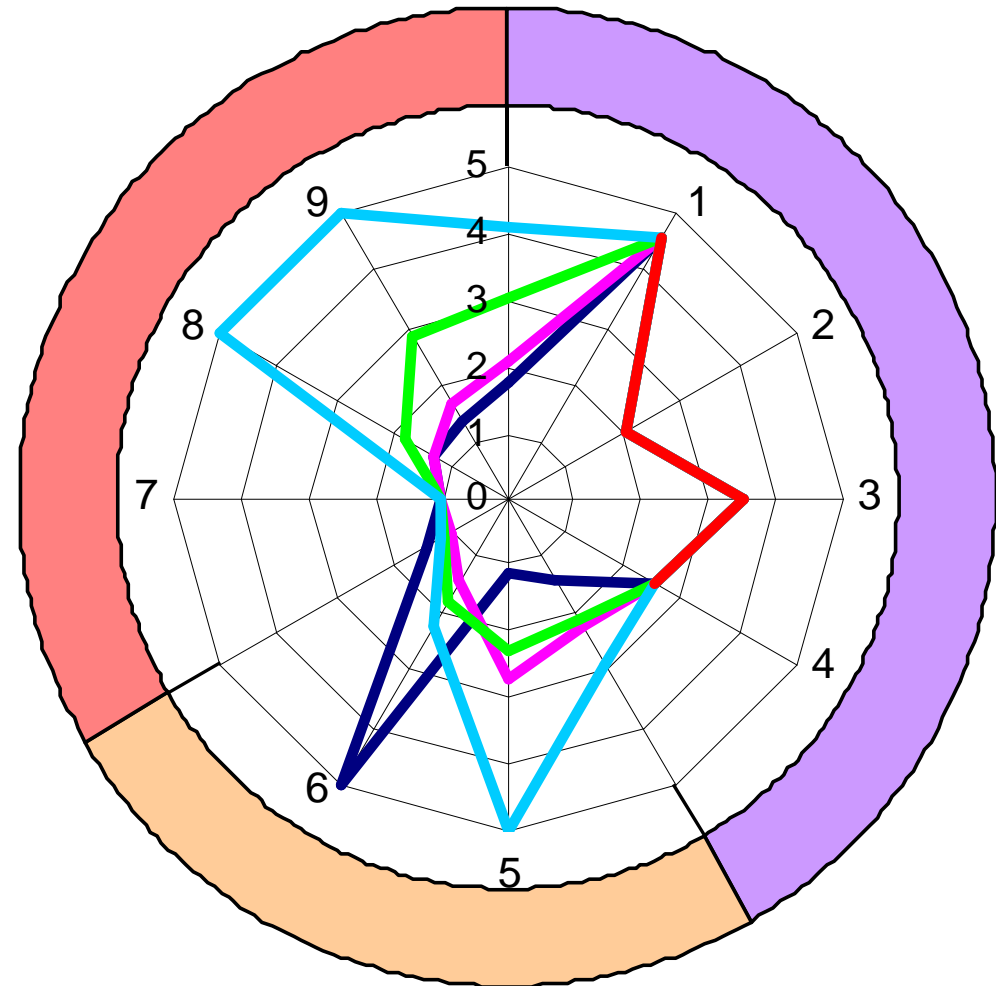
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## ▷ Syngas biorefinery

#	Issue
1	Technical feasibility
2	Capital costs not a problem
3	Feedstock costs not a problem
4	Technological improvement pot.
5	Agricultural crops
6	Pulp/wood
7	Husbandry
8	Basic chemicals
9	Oil refineries



■ Technical eval. 
 ■ Raw materials 
 ■ Side product markets