

# Bioresources for biobased polyester production

Workshop by PL6.1 BBC Scoping Study Bioresources

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# Objective scoping study Bioresources PL6.1

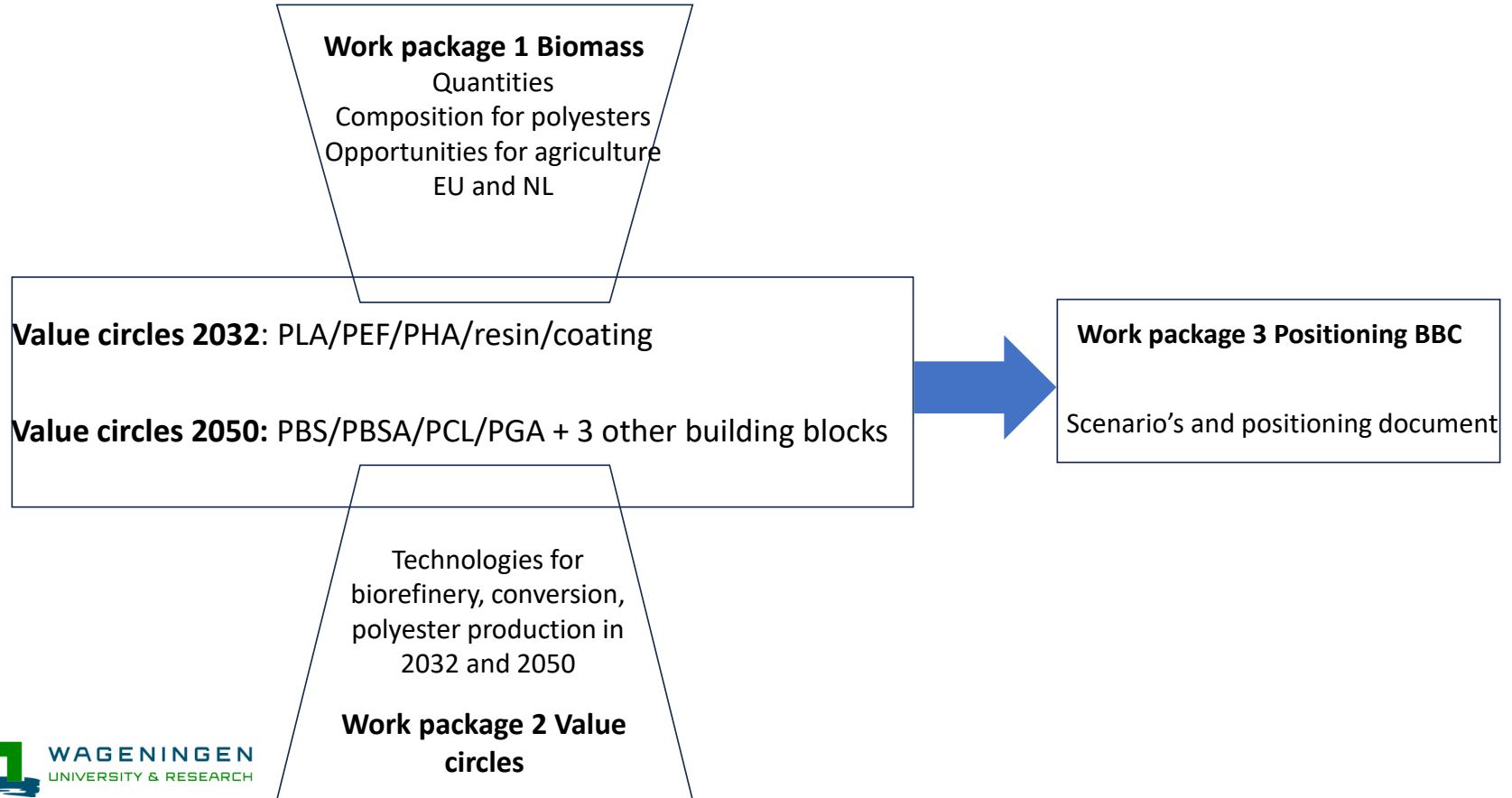
Making an inventory of available and suitable biomass (both NL and EU) for the Dutch biobased chemical industry and formulating a strategy to make this biomass actually available.

The expected results:

- Report on biomass availability now and in the future (scenario's)
- Report on technologies to set up value circles from biomass to polyesters in 2032 and 2050
- Positioning document which includes rationale, assessment framework and strategy for making biobased raw materials available for the biobased chemical industry

Execution: Wageningen Research (WFBR, WEnR, WPR)

# Approach



# Results WP1: Ranking biomass for polyesters

# Biomass composition analysis

- Type of bioresource: Sugar/starch; Lignocellulose; Heterogeneous
- 'Type' of intermediate: C6; C5/C6; none
- Amount of 'inhibitor': % Lignin
  - Review other potential inhibitors later

	PLA, PEF, PHA	PLA, PHA		PEF		PHA	
Pretreatment	Minimum	Mild	Severe	Mild	Severe	Mild	Severe
Requirement		Lignin ≤	Lignin >	Lignin ≤	Lignin >	Lignin ≤	Lignin >
		50	50	50	50	100	100
Ideal	650	300	550	300	400	500	
Desired	500	150	350	150	300		500
	Zetmeel + Suiker	Cellulose + Hemicellulose		Cellulose + Inuline		OM - Lignin	
	g/kg DM	g/kg DM		g/kg DM		g/kg DM	

# Results WP1: Ranking Starch + Sucrose resources

For production  
of:  
**PLA, PEF, PHA**

	PLA, PEF, PHA
Pretreatment Requirement	Minimum
Ideal	650
Desired	500
	Zetmeel + Suiker g/kg DM

Biomass	Starch + Sucrose (g/kg DM)
Sorghum grain	764
Corn	735
Barley	642
Potato starch (grey)	617
Sugar beet	600
Wheat	566
Molasses (sugar beet)	512

# Results WP1: Ranking (Hemi)Cellulose resources, Lignin < or > 50 g/kg

Rich in Cellulose + Hemicellulose  
For production of **PLA and PHA**  
**Mild pre-treatment.**

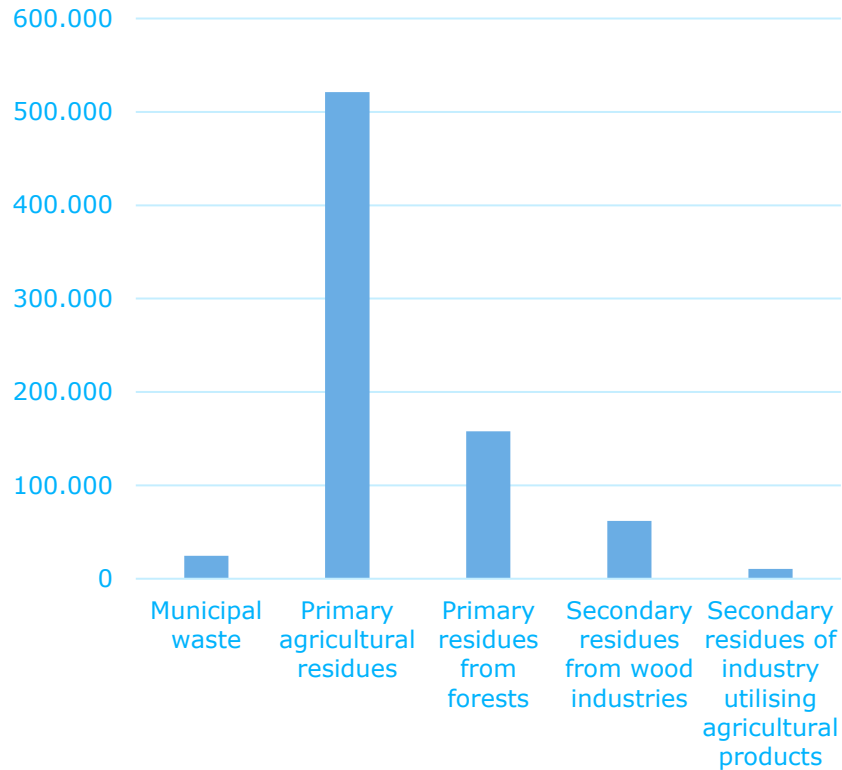
Biomass (lignin < 50 g/kg)	Cellulose + Hemicellulose (g/kg DM)
Grass hay	572
Sugar beet pulp, pressed	471
Manure - Pigs	447
Rye grass	429
Sugar beet pulp, dried	317
Sugar beet leaves	299
Potato pulp, pressed	283
Distillers Dried Grains with Solubles (maize)	253
Potato pulp, dried	196
Barley	167
Sugar beet	160

Pretreatment Requirement	PLA, PHA	
	Mild	Severe
	Lignin ≤ 50	Lignin > 50
<b>Ideal</b>	300	550
<b>Desired</b>	150	350
	Cellulose + Hemicellulose g/kg DM	

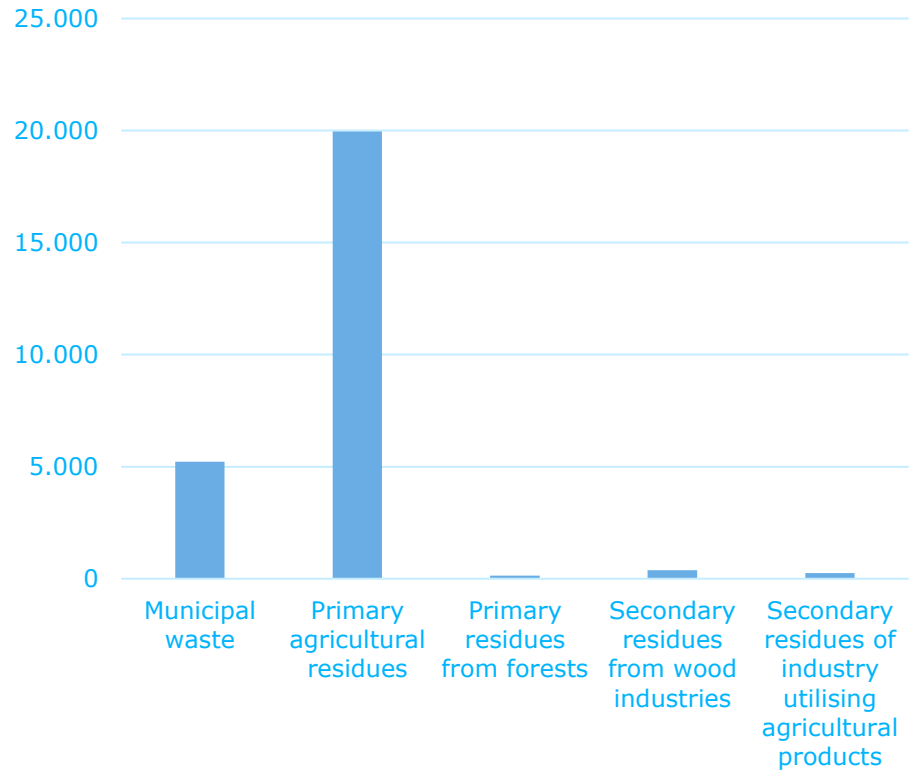
Rich in Cellulose + Hemicellulose  
For production of **PLA and PHA**  
**Severe pre-treatment**

Biomass (lignin > 50 g/kg)	Cellulose + Hemicellulose (g/kg DM)
Oak stem wood	729
Sorghum biomass type	709
Norway spruce stem wood	701
Wood from constr. demolition	701
Miscanthus	687
Rye straw	686
Poplar, Birch, Beech stem wood	640
Oat straw	622
Wheat straw	611
Barley straw	576
Corn stalks	574
Beech, Birch prunings	557

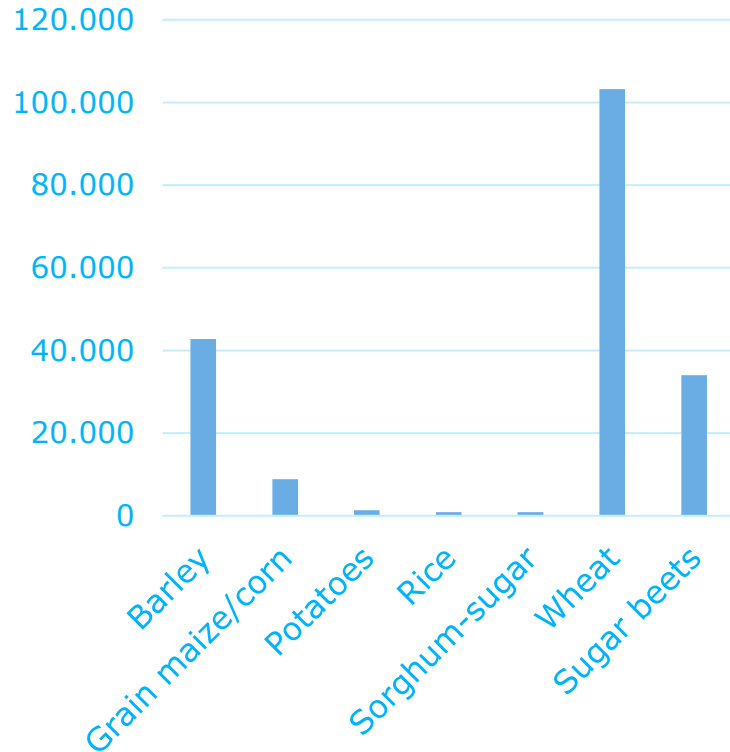
### Total Technical Potential for EU27 in 2030 (Kton dry mass)



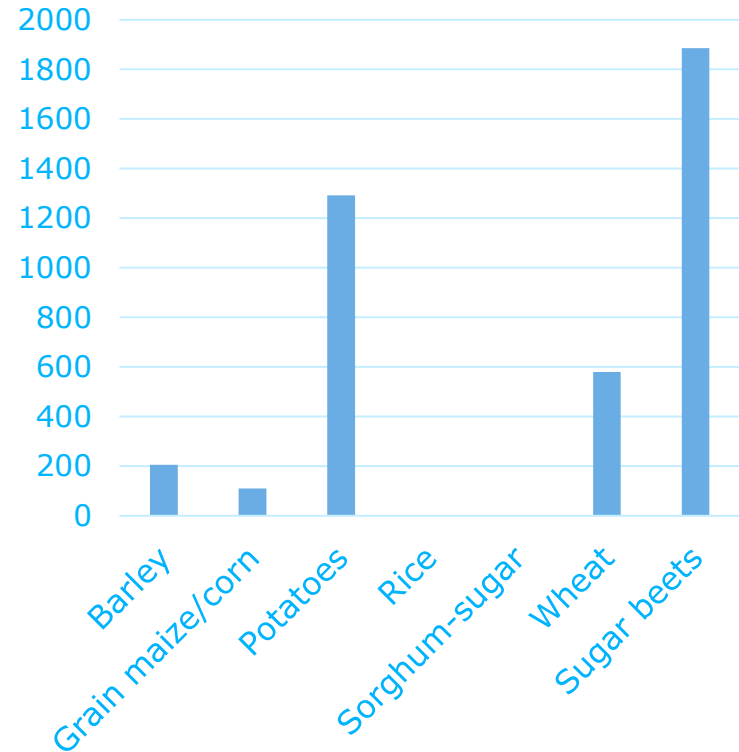
### Total Technical Potential for NL in 2030 (Kton dry mass)



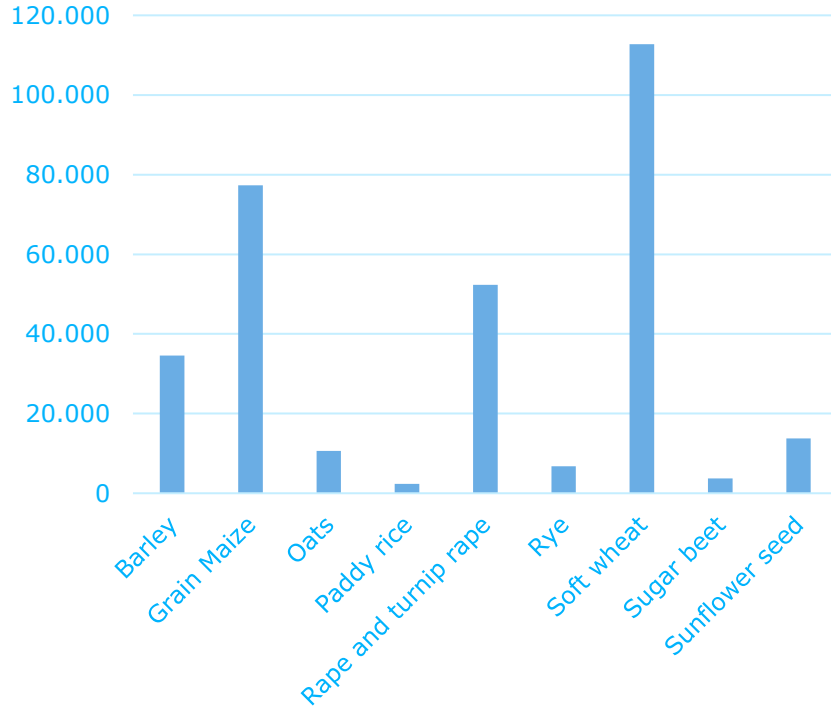
Technical potential of primary crop production for EU27 in 2024 (Kton dry mass)



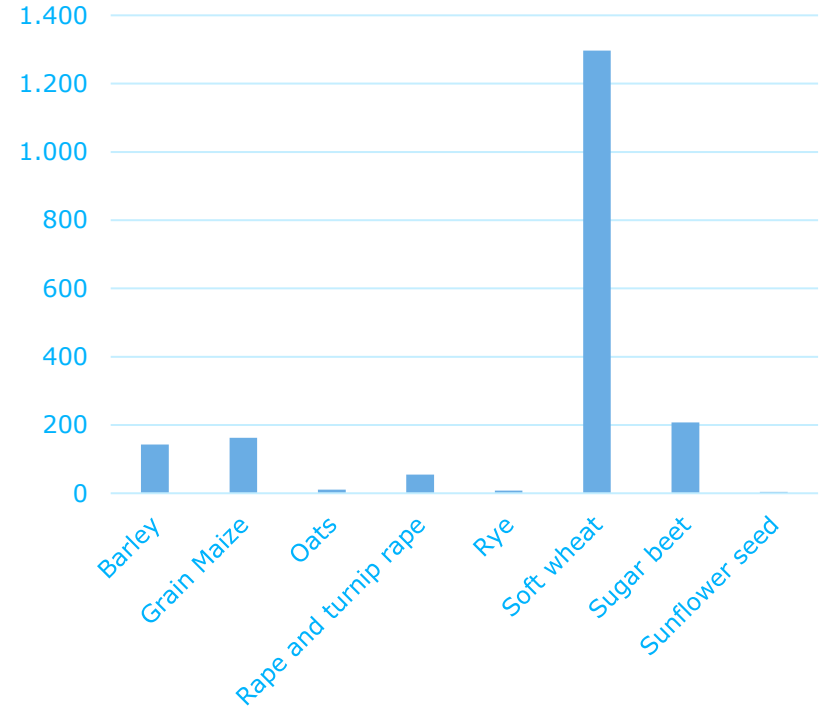
Technical potential of primary crop production for NL in 2024 (Kton dry mass)



Technical potential straw residues from primary production for EU27 (Kton dry mass)



Technical potential straw residues from primary production for NL (Kton dry mass)



# Perspective for Dutch agriculture to increase relevant feedstocks for polyesters

- Limited potential for introducing sugar rich crops *dedicated* to biobased plastics production.
- Potential new crop for biobased polyester: *Sorghum*
- Sugar beet is highest carbohydrate yielding crop; conservation of current acreage is key to securing carbohydrate supply for biobased polyesters
- Dutch agro-industry with imported feedstocks (grains/corn) could play a role in supplying biobased chemical industry

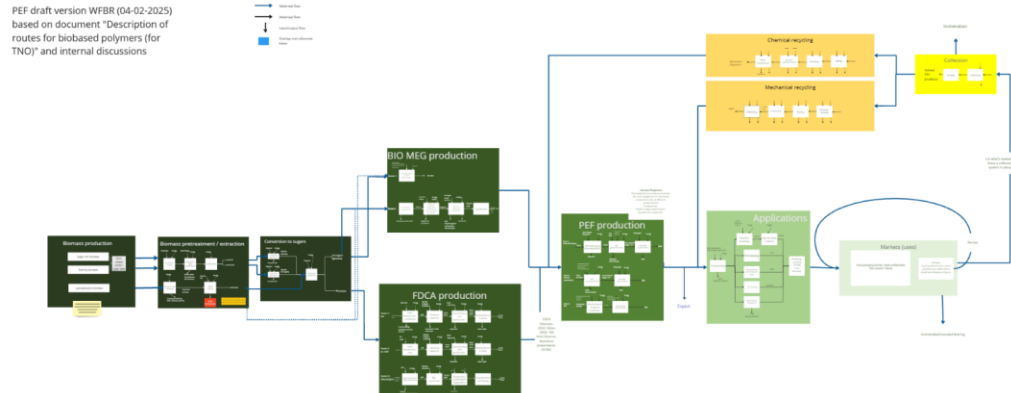
# Synergies with other agricultural trends

- Residues from protein transition like fava beans and other protein rich beans/crops
- Residues from fibre crops (Miscanthus, hemp/flax shives)
- Rejects from agricultural clusters (horticulture, fruit cultures)

# Results WP2: Value Circle State-of-the-art

# Progress so far

- Description of five (priority) value circles: PLA, PEF, PHA, Plantics and MPA
- Description of process steps on unit operations level
- Processes expected full scale/demo scale in 2023
- Description of conversion and recovery factors for these five biobased polymers



# Conversion efficiencies for 2032 priority VC's

Process	Conversion efficiency
Directly from carbohydrate	0,2 – 0,8 g polyester/g sugar
Based on cellulose (e.g. woody biomass, textiles, paper)	20% or more loss of carbohydrate during cellulose extraction)
Directly from organic streams (Volatile Fatty Acid Route)	0,2 g polyester/g organic matter

# General situation feedstocks vs conversion routes

- 1G (sucrose, starch): full scale possible in 2032 for PLA, PEF and Plantics; now high TRL, high conversion efficiencies, but high-cost feedstocks
- 2G (lignocellulose): for PLA, PEF, Plantics and MPA: low TRL, challenges with purity, process costs, complexity, reliability; but extension to low-cost feedstock pools
- 2G (heterogeneous feedstocks, waste): ideal for PHA, medium TRL, full scale possible in 2032; low conversion factors and costly Downstream processing (DSP) makes production costs high

# Preliminary conclusions and outlook

# Approach for initial estimate 2050

- Target by BBC: 1,5 Mton biobased plastics by 2050
- BBC aims for a well-balanced mix of EU and Dutch bioresources:
- If bioresources are obtained from EU:
  - there are currently enough feedstocks available.
  - Prediction of feedstock availability in EU for 2050 more difficult  
=> scenario study (task 3.1 needed)
- Remaining question: what is possible with Dutch feedstocks?

# Towards 1,5 Mton biobased plastic with maximal use of NL-feedstocks in 2050

Main current NL bioresources	Technical potential	Actual potential	Conversion to polymer	Conversion calculation	Biob. Plastic production
<b>Eerste generatie</b>	kton	kton	%		kton
2050: 50% sugar beet area available for biobased plast	950	950	30%	60% suiker * 50% conversie naar polymeer	285
<b>Lignocellulose biorefinery wood (1000 kton)</b>					
Woody waste streams	600	100	24%	60% suikers * 80% yield * 50% conversie polymeer	240
Imported wood chips	900	900			
<b>Lignocellulose biorefinery straw/grass (1000 kton)</b>					
Miscanthus, hemp shives, reed, straw (cultivation area of 50-100 kha)	1.000	1.000	24%	60% suikers * 80% yield * 50% conversie polymeer	240
<b>Tertiaire sidestreams</b>					
Urban biowaste <sup>1</sup>	5.000	1.000	20%	20% conversie org stof => polymeer VFA route	200
Municipal waste water <sup>2</sup>	400	200	20%	20% conversie org stof => polymeer VFA route	40
Liquid manure <sup>3</sup>	3.500	500	20%	20% conversie org stof => polymeer VFA route	100
Recycled paper <sup>4</sup>	2.000	333	40%	80% yield glucose uit cellulose * 50% conversie p	133
Reyclced textiles <sup>5</sup>	340	100	40%	80% yield glucose uit cellulose * 50% conversie p	40
Imported commodity sugars					200
			Totaal		<b>1.478</b>

1. Broad and highly diverse group of sidestreams, actual potential of 20%
2. Not realistic to assume that all waste water is converted, actual potential of 50%
3. Very difficult stream, actual potential of 15%
4. Only the lowest quality paper is used for glucose production, 1/6 of total recycled paper (assuming one fiber is recycled 6 times)
5. Only taking into account, complex garments with highly diverse (including plastic) fiber content

# Preliminary conclusions

- For the short-term, commodity sugars (excess sugars from food production) are available as a feedstock for biobased polyester plants
- A full-scale transition to replace our current plastic consumption by biobased alternatives *using Dutch feedstocks* requires:
  - Maximum use of Dutch primary carbohydrate crop potential (sugar beet, cereal processing, sorghum?)
  - Integrate with other industries (paper, textiles, food processing, organic waste, waste water, building materials)
- European availability of commodity sugars can only be determined by using scenario's => task 3.1

# Thank you!

Next: a poll on biobased polyesters

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Insert code: **1419 7753**

