Lignocellulosic biomass as feedstock for biobased chemicals & materials in Europe

A quantitative estimate of biomass demand for 2020 and 2030

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Key question WP7

- **To what extent the additional biomass demand for chemicals and materials could be sufficiently significant to:**
  - **influence lignocellulosic biomass prices and**
  - **induce scarcity and competition issues with energy applications?**

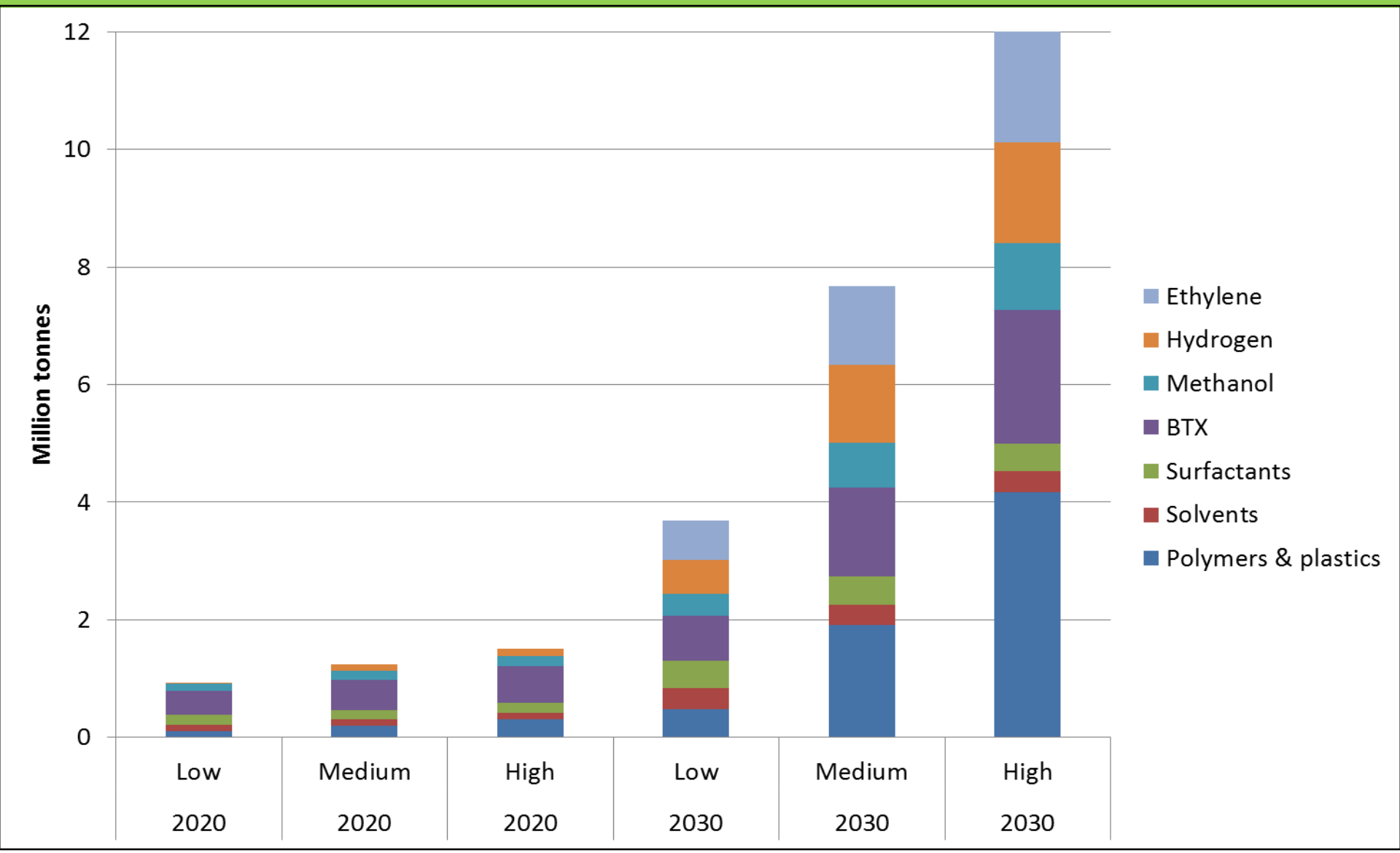
Focus

- **Sectors that can create significant biomass demand (relatively bulky chemicals markets)**
- **Specialties and fine chemicals:**
  - can have high added value => most relevant for a biorefinery business case
  - but their production will by definition not induce bulky amounts of biomass demand

PMCs of the market review

	Product	Market
1	Heat	District heating
2	Electricity	Power market
3	Advanced Biofuels	Transport fuel
4	C6 sugars	C6 chemistry: polymers & plastics, others
5	C5 sugars	C5 chemistry: polymers & plastics, others
6	Bio-methane	Grid, transport
7	BTX	Petrochemical industry
8	Methanol	Transport, chemical industry
9	Hydrogen	Transport, (petro)chemical industry
10	Ethylene	(petro)chemical industry

Projected total lignocellulosic biomass demand for PMCs 4-10 exclusive biomethane PMC



Comparison demand (PJ) lignocellulosic biomass EU

	2013	2020	2030
PMCs 1-3 Consumption of domestic lignocellulosic biomass for EU28 + Western Balkans + MD + TR + UA	4,055	5,175	6,781
PMCs 4-10 exclusive biomethane PMC		15 - 26	63 - 206
	-	0.3 - 0.5%	1 - 3%

Conclusions

- **Next to the demand for energy, lignocellulosic biomass demand for chemicals and materials can run into a few million tonnes by 2020, and more than ten million tonnes in 2030**
- **Uncertainties are substantial with respect to:**
  - **technologies that are to be further developed**
  - **supporting policies required**
  - **the future of (petro)chemical industry in EU**
  - **the oil price, being a strong factor affecting the prospects for biobased chemicals and materials**

Recommendation

- **As the review is indicative in many respects, both the review results and the outcomes of the integrated assessment for which they will be used (Tasks 7.3-5) should be subject to stakeholder consultation in WP10 of the project**

Approach

(hemi)cellulose and lignin (PMCs 4 & 5)

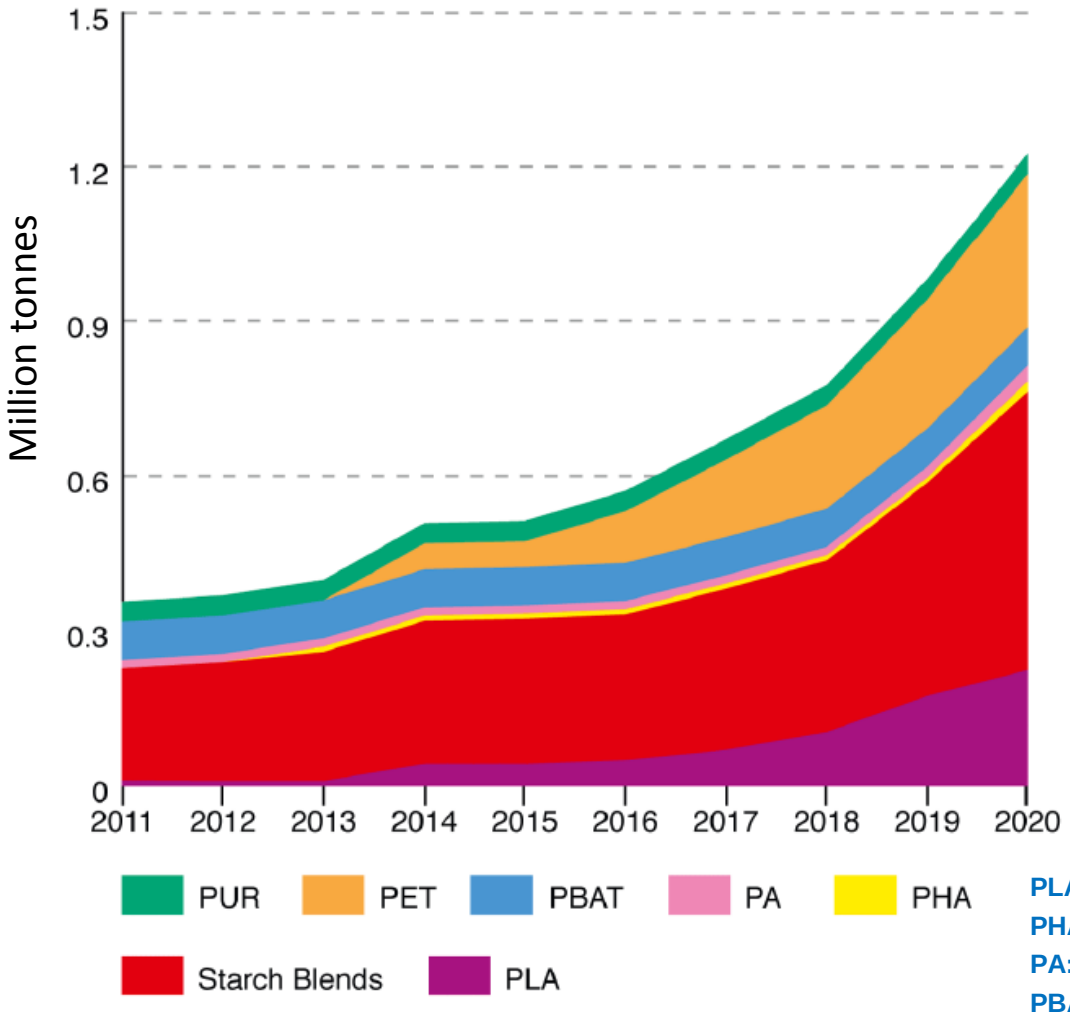
- **Various studies specifically on:**
  - **biobased polymers & plastics**
  - **other materials such as lubricants, solvents and surfactants**
- **Literature data and expert estimates translated into a corresponding biomass demand**

Biomethane, BTX, methanol, hydrogen, ethylene (PMCs 6-10)

- **Available estimates of developments in fossil-based reference material**
- **Estimation of a range of possible biomass shares for 2020 & 2030, based on experts judgments and logical reasoning**
- **Translation into a corresponding biomass demand, using conversion technology information from WP2 and other sources**

PMCs 4 & 5: Biobased polymers & plastics projection for Europe

excluding cellulose acetate and thermosets



Source: Dammer et al. (2013)

PLA: polylactic acid
PHA: polyhydroxyalkanolates
PA: polyamides (nylon)
PBAT: poly-butylene adipate-co-terephthalate
PET: polyethylene terephthalate
PUR: polyurethanes

Estimated EU production volumes biobased polymers & plastics for 2020

- Starting point: 1 Mt biobased polymers & plastics in 2020 (15% global production)
- Weighted average share of biomass-based components of 50%
- Considering general uncertainties => a range around 0.5 Mt: 12% resp. 18% of global biobased capacity
- By 2020 85% of polymers & plastics are non-ligno based and 15% lignocellulosic-based

Projections polymers & plastics for 2030

	Growth rate biobased polymers & plastics	Share biomass-based components	Ratio non-ligno lignocellulose-based
High variant	15%/a within 2020-2030	Increased from 50% to 70%	80% / 20%
Medium variant	10%/a within 2020-2030	Increased from 50% to 60%	85% / 15%
Low variant	10%/a within 2012-2030	50%	90% / 10%

Projected EU production capacity of biobased chemicals (Mtonnes)

2020	Polymers & plastics	Lubricants	Solvents	Surfactants
High	0.6	0.2	1.1	2.3
Medium	0.5			
Low	0.4			
		2008 cons.: total/biobased 5.2Mt/ 0.15 Mt (growth potential: 3.6 %/a)	2008 cons.: total/biobased 5.0 Mt / 0.63 Mt (growth potential: 4.8 %/a)	2008 cons. (total/biobased) 2.7 Mt / 1.52 Mt (growth potential: 3.5 %/a)
		Biomass feedstocks (products)		
		Vegetable oils (derivatives)	Vegetable oils (esters) Sugars (lactate esters) Citrus oils (D-limonene)	Vegetable oils and sugars (derivatives)
2030	Plastics	Lubricants	Solvents	Surfactants
High	5.0	0.3	1.8	3.2
Medium	2.7			
Low	1.3			

Additional assumptions biobased lubricants, solvents & surfactants

2020

- **Solvents: 40% based on sugars, with 90% derived from sugar or starch crops and 10% from lignocellulosic feedstocks**
- **Surfactants: 30% based on sugars, with 90% derived from sugar or starch crops and 10% from lignocellulosic feedstocks**

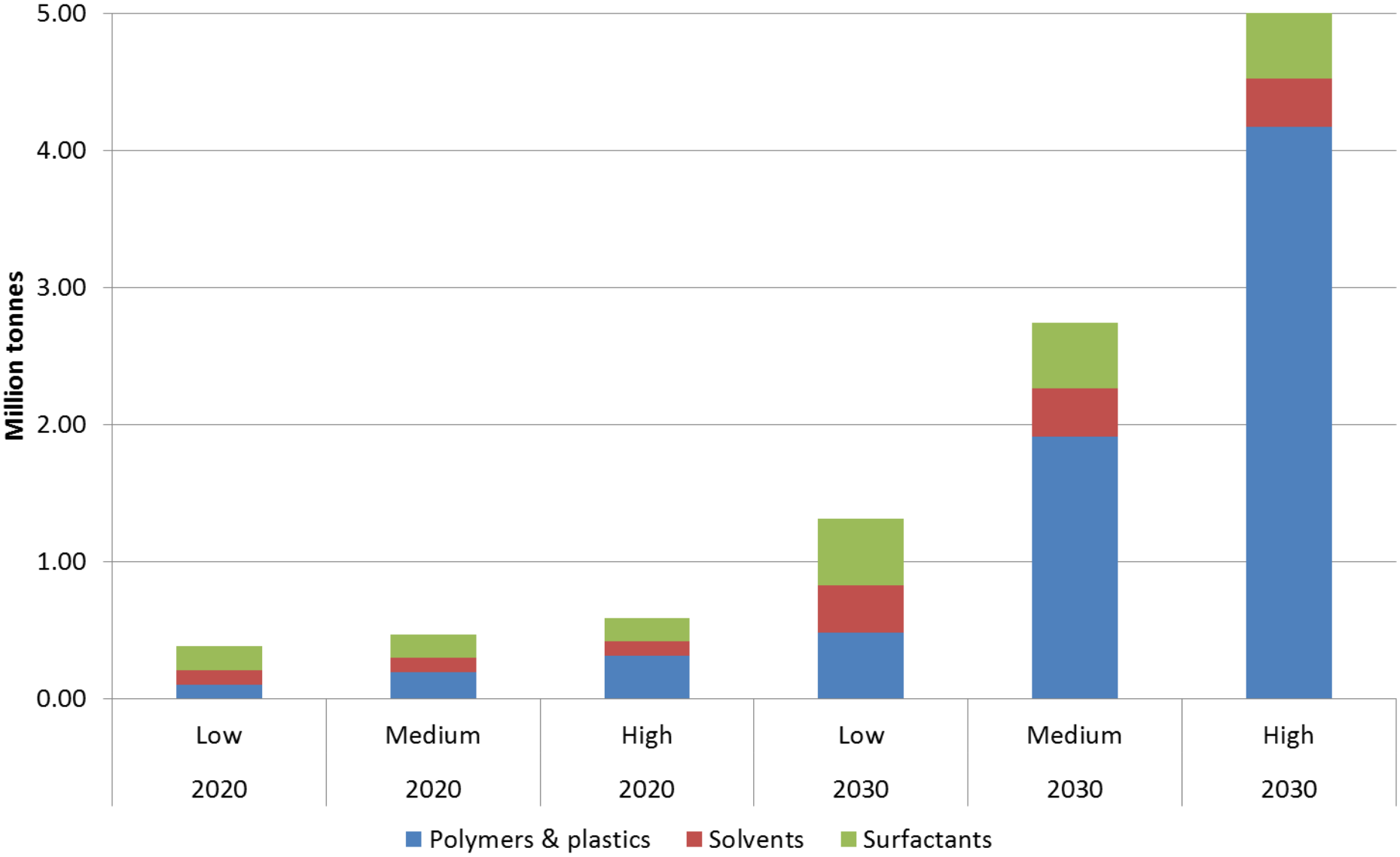
2030

- **The growth rates for 2012-2020 were extended until 2030**
- **Solvents: 40% based on sugars, with 80% derived from sugar or starch crops and 20% from lignocellulosic feedstocks**
- **Surfactants: 30% based on sugars, with 80% derived from sugar or starch crops and 20% from lignocellulosic feedstocks**

Assumptions feedstocks and conversion efficiencies

Subject	Assumption
Biomass	Lignocellulosic (dry matter content: 90%), 17 MJ/kg
Lignocellulosic biomass	• 70% (hemi)cellulose (currently used as feedstock) • 30% lignin (more complex resource/less biochemical pathways available today)
(hemi)cellulose hydrolysis	90% conversion efficiency to corresponding sugars
Sugars to product monomers	One overall conversion efficiency of 80%
Monomers to polymers	One overall conversion efficiency of 90%

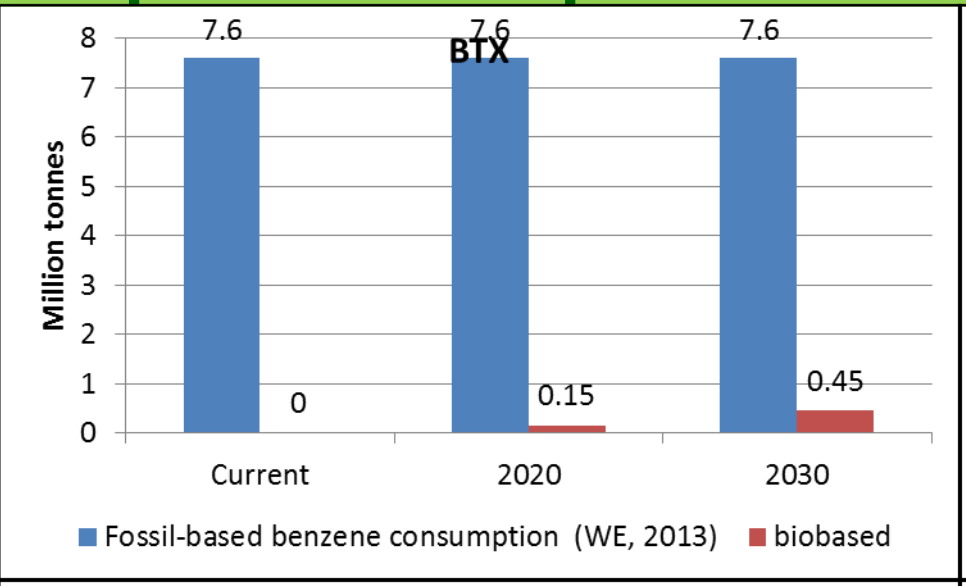
Projected EU's lignocellulosic biomass demand for biobased polymers & plastics, solvents and surfactants

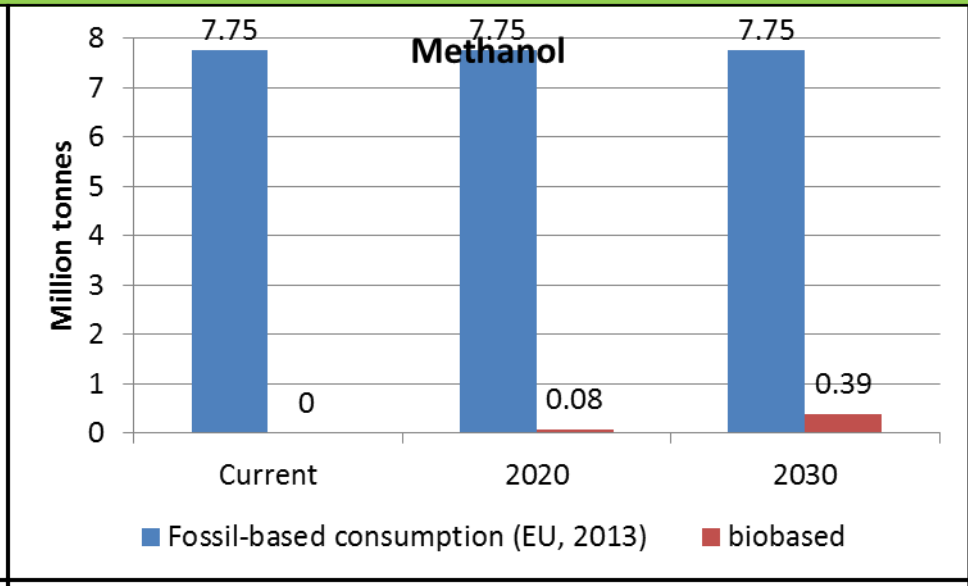


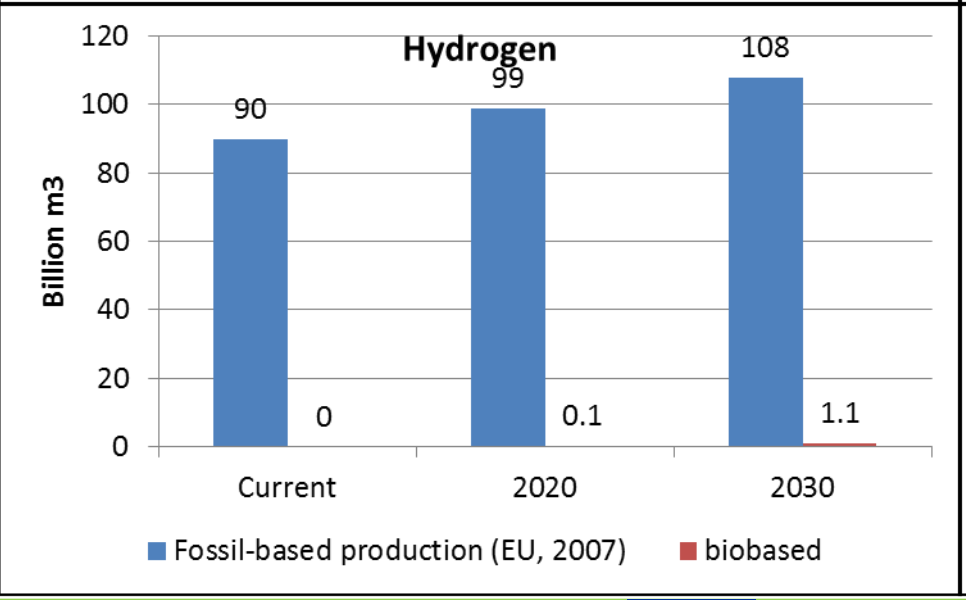
PMCs 6-10: biomethane, BTX, methanol, hydrogen and ethylene

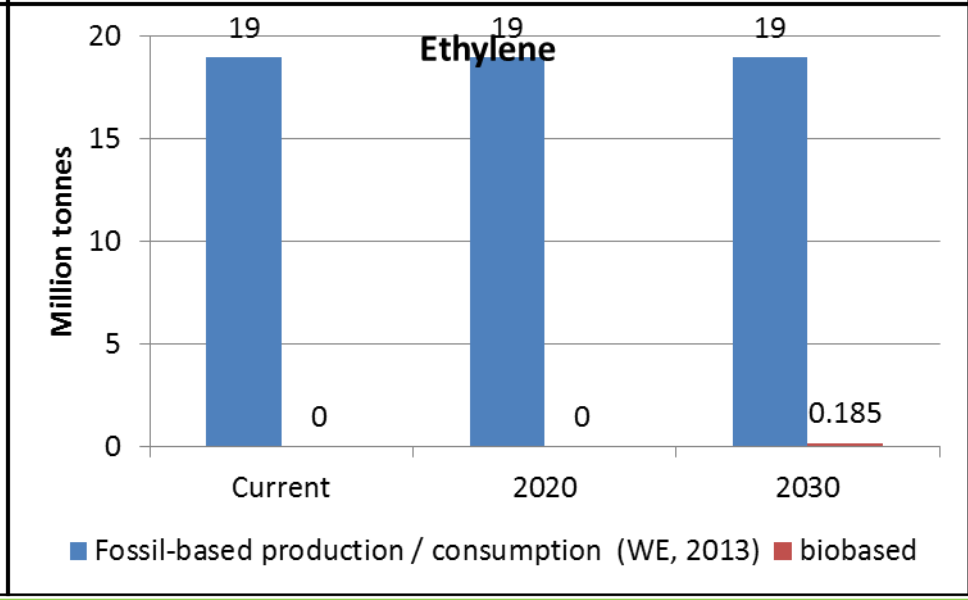
Product	Market
Biomethane	Replaces fossil-based methane /NG: in heat and/or power applications, as alternative fuel to gasoline, as feedstock for (petro)chemicals
BTX (aromatics)	Intermediates as feedstock in (petro)chemical industry: Benzene → polystyrene; Toluene as a solvent, high octane numbers gasolines; o- & p-xylene → polyester fibers, films & resins, p-xylene → PET (soft drink bottles)
Methanol	Intermediate as feedstock in chemical industry: → MTBE, DME, FAME (transport sector); → formaldehyde, acetic acid (chemical industry)
Hydrogen	Hydrogen / hydrogenates (transport sector), ammonia / hydrochloric acid synthesis (chemical industry)
Ethylene	One of the most important platform chemicals: → polyethylene, ethylbenzene, ethylene oxide, ethylene dichloride

Current and expected fossil-based resp. biobased production levels in EU





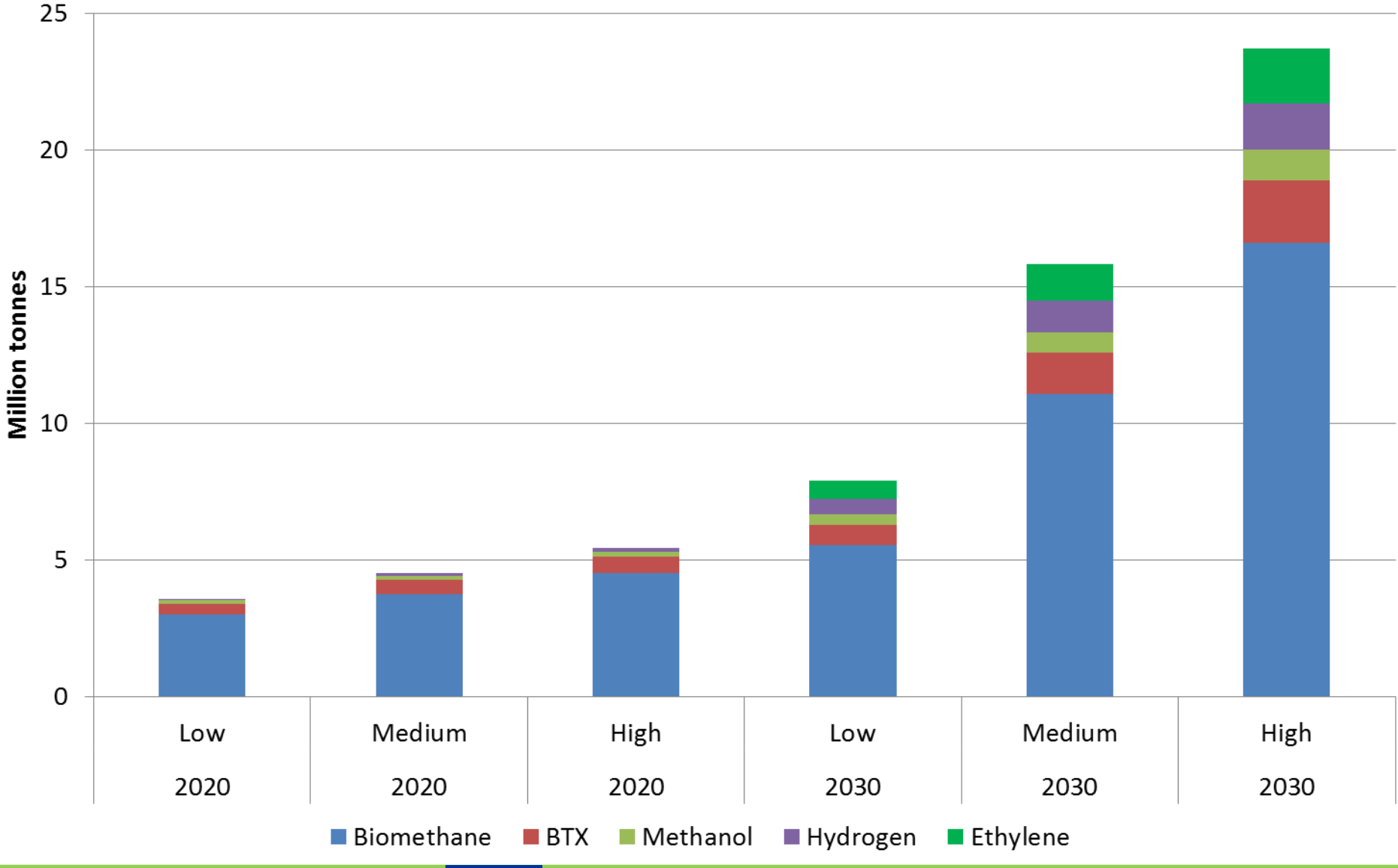




Additional assumptions PMCs 6-10

Subject	Assumption
Biomass	Lignocellulosic (dry matter content: 90%), 17 MJ/kg
Biomethane	Technology: indirect wood gasification Conversion efficiency: 70%LHV
BTX	Technology: indirect wood gasification Conversion efficiency: 15%LHV (BTX) & 55%LHV (biomethane)
Methanol	Technology: pressurised CFB gasification of wood Conversion efficiency: 60%LHV
Hydrogen	Technology: pressurised CFB gasification of wood Conversion efficiency: 60%LHV
Ethylene	Technology: biochemical production of bioethanol, followed by dehydration of ethanol to ethylene Conversion efficiency: 37%LHV (ethanol) 57%wt. (ethylene)
Uncertainties EU expected production	2020: 80%/100%/120% 2030: 50%/100%/150%

Projected lignocellulosic biomass demand for PMCs 6-10 in Europe



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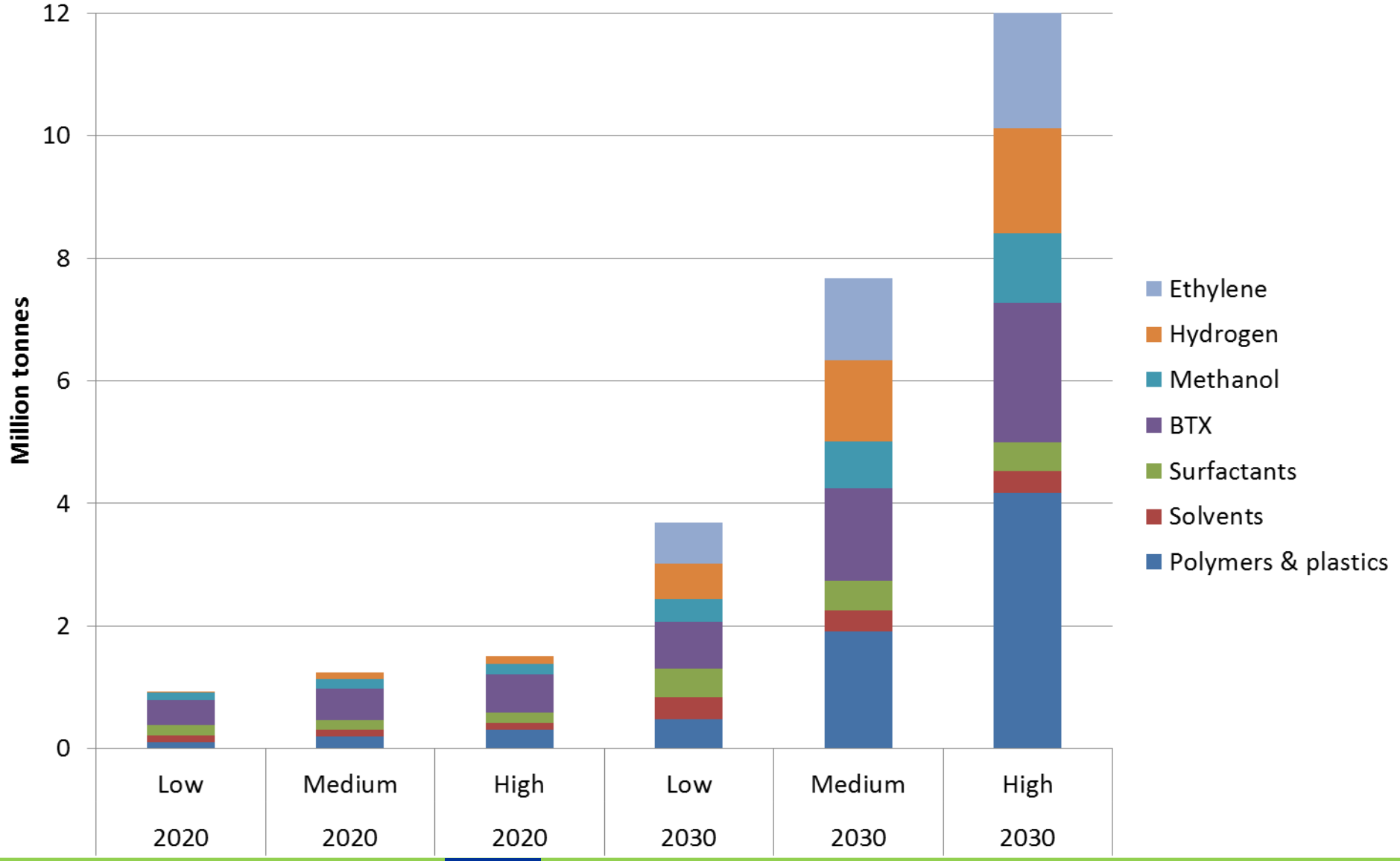

Projected lignocellulosic-based chemicals & materials in Europe

	Unit	2020	Impression	2030	Impression
Biopolymers & bioplastics	Kt	77	≈20% of EU biobased polymers & plastics production in 2012	778	≈200% of EU biobased polymers & plastics production in 2012
Solvents	Kt	44	7% of EU biobased solvent production in 2008	141	22% of EU biobased solvent production in 2008
Surfactants	kt	69	5% of EU biobased surfactant production in 2008	195	13% of EU biobased surfactant production in 2008
BTX	Kt	150	Requires 10 wood gasification plants of 150 MWth (input)	450	Requires 28 wood gasification plants of 150 MWth (input)
Methanol	Kt	77	Requires ≈ 1 wood gasification plant of 100 MWth (input)	387	Requires ≈ 5 wood gasification plants of 100 MWth (input)
Hydrogen	Bm3	0.10	Enough to fuel > 75,000 hydrogen vehicles	1.1	Enough to fuel ≈ 1,000,000 hydrogen vehicles
Ethylene	kt	0	-	185	44% of current global bio-ethylene production

Thank you for your attention !




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