Taller internacional biorrefinerías de pequeña escala,
Buenos Aires, November 23rd, 2016

The SMIBIO Project

DEVELOPMENT OF FLEXIBLE SMALL-SCALE INTEGRATED BIOREFINERIES TO PRODUCE AN OPTIMAL RANGE OF BIOPRODUCTS FROM A VARIETY OF RURAL AGRICULTURAL AND AGRO-INDUSTRIAL RESIDUES/WASTES WITH A MINIMUM CONSUMPTION OF FOSSIL ENERGY

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SMIBIO Coordinator

OIL REFINERY vs. BIOREFINERY

PETROchemical refinery

BIOrefinery

GranBio

Feedstock: Crude Oil

Feedstock: Sugar cane straw

LNEG

BioMCN

IN OPERATION
Local: Farmsum (Netherlands)
Start-up: 2009
Raw material: Crude glycerine, biogas (CO_2)
Product: Bio-methanol (200.000 ton/year)
Production process: Purification of glycerine, conversion into synthesis gas, bio-methanol synthesis

www.biomcn.nl

PLANNED
Local: Farmsum (Netherlands)
Start-up: 2015 or later
Raw material: 1,5 Mton/year of imported forest waste
Product: 413.000 ton/year Bio-methanol
Production process: pretreatment by torrefaction, gasification, syngas purification, chemical synthesis of bio-methanol

LNEG

Biochemtex/BetaRenewables

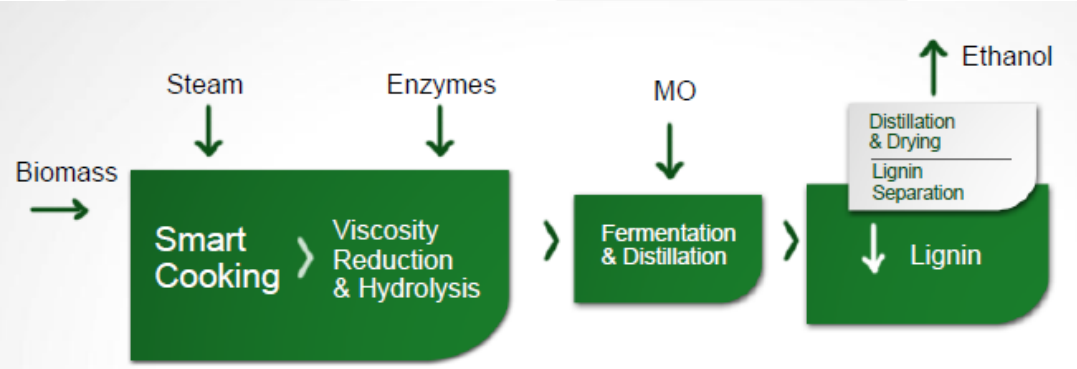
- First comercial cellulosic bioetanol plant in Europe has been deployed in Crescentino, Italy, since end 2013

Raw material: 270.000 ton/year cereals straw, (*in future*: *arundo donax)*

Product: Ethanol (60.000 ton/year), biogas, H_2, lignin for energy

Production process: uncatalyzed two-stage steam explosion, enzymatic hydrolysis and co-fermentation of C_5 and C_6

Proesa® technology



DuPont

Local: Nevada - Iowa, USA
Start-up: 2015

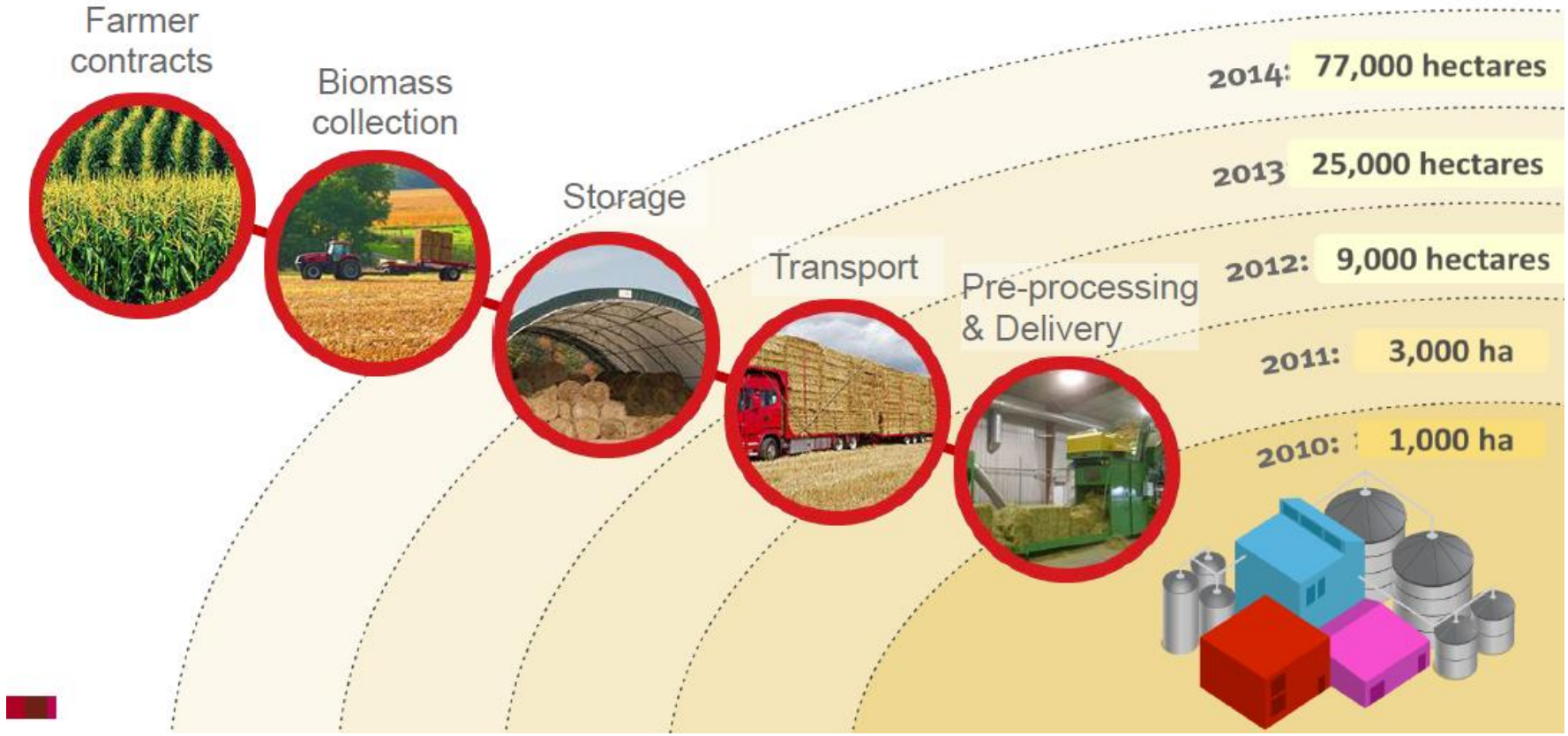
Raw material: corn stover (350,000 ton/year)

Product: Ethanol (100,000 ton/year) + CHP (from lignin)

Production process: Diluted ammonia pretreatment, Enzymatic Hydrolysis, Bacterial Fermentation (recombinant Z. mobilis); no waste water (total water recycle)

DuPont Feedstock Collection Program

Contracting with more than 500 local farmers to gather, store and deliver over 349,000 dry tonnes of stover per year into the Nevada, Iowa facility.



Biorrefinerie´s Challenges

- Price, logistics and availability of large scale biomass supply
  - Some conversion processes requires regular supply of large biomass amounts
  - Biomass production is **variable by nature**, competes with other end-uses, and is increasingly constrained
  - Most feedstocks for biorefineries today are produced from crops that need productive land and water
  - Feedstock price typically makes up 30 to 70% of total production costs...
- High CAPEX costs usually lead to design large-sale biorefinaries aiming at cost decrease due to scale
- The today´s challenge should be to ensure that Biomass production takes place in a sustainable manner

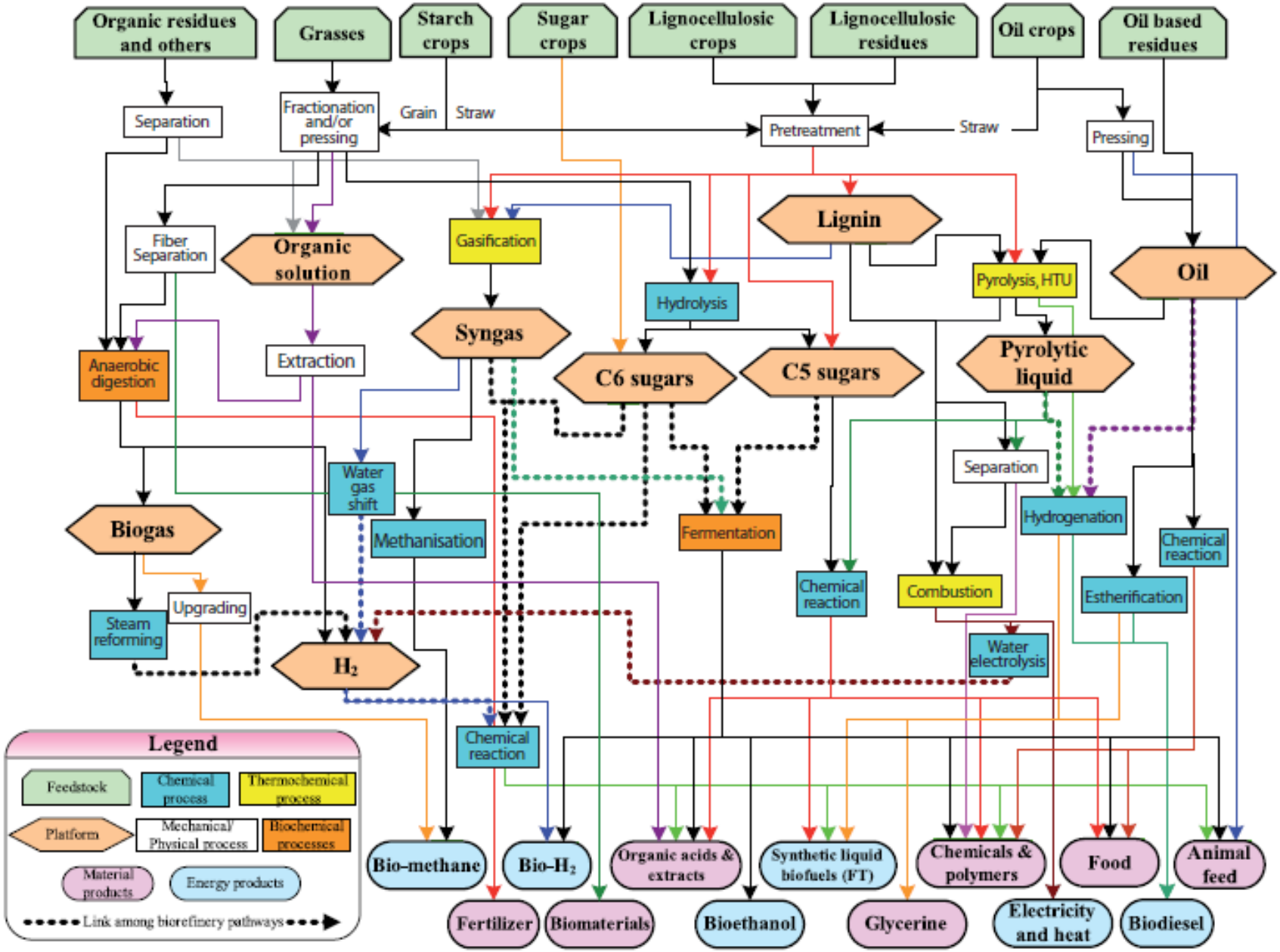
LNEG

Multiproduct Biorefinery is the key!!

- The heterogeneity of lignocellulosic material allows **to produce a range of products** as broad **as the existing in petrochemical industry**
  - However, there are **few chemical products** with **markets large enough** to absorb the production of a large-scale biorefinery

- In Lignocellulose-based Biorefineries, **bio-based products** are mainly derived from:
  - Lignin
  - Hemicellulose
  - Cellulose

MULTI-PLATFORM CONCEPT



Source: **IEA Bioenergy: Task 42- Biorefineries**

SMIBIO´s challenges

Starting date: Nov 2015 **Closing date: Oct 2018**

- Make… “small is beautiful” a reality!
- Contribute for a positive social impact, creating jobs, solving environmental issues, improving quality of life at regional level (particularly outside of major urban areas)
- Contribute for making “bioeconomy” a meaningful business for Europe and for Latin America as well

SMIBIO Participants

www.smibio.net

Partners:

PORTUGAL

SPAIN

GERMANY

COLÔMBIA

CHILE

MEXICO

ARGENTINA

Associate Partners:

PORTUGAL

PORTUGAL

COLÔMBIA

COLÔMBIA

OBJECTIVES

- Technical-economic and environmental analysis of the feasibility of deployment **small scale biomass-based biorefinery** plants in Europe and in Latin American countries.

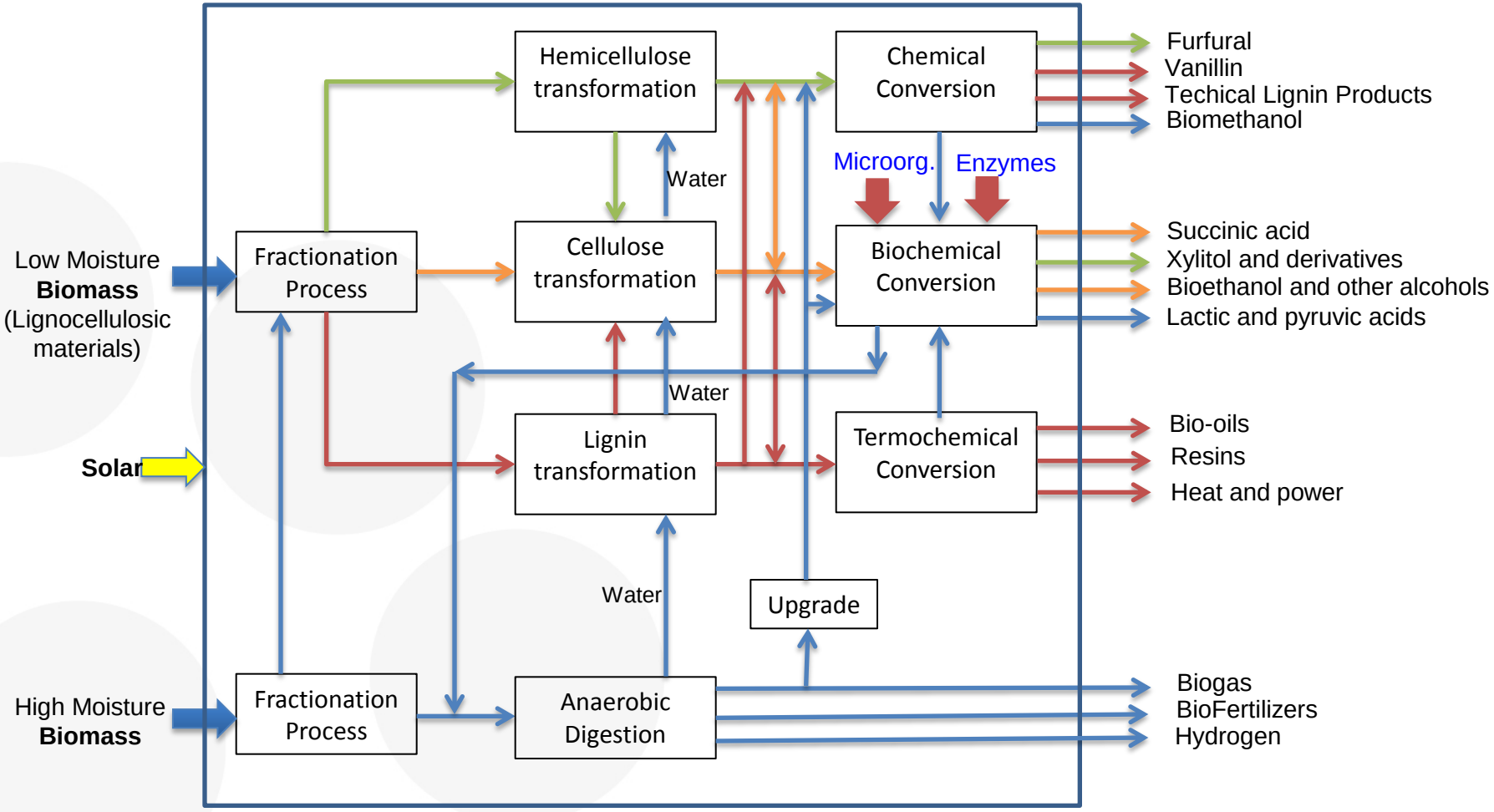
Specific objectives:

- These small-scale biorefineries should be economically feasible by processing **different kinds of biomass available** in short radius catchments of rural and small urban áreas → Local Feedstocks/wastes = **local solutions**

- Modelling the **best technological solutions under proper and real conditions**, for different rural/urban regions (at least, two in EU and two in LAC countries), considering optimal processing of local biomass in each selected region.

- The project will simultaneously develop appropriate **tools and methods** to properly assess the technologies and optimize **overall energy efficiency**, **environmental** (LCA), **economic** (IRR, NPV and production costs), and **social impacts** (improvement in living conditions, job creation and new opportunities for rural development identification) for all small-scale multi-product biorefinery to be modelled and simulated.

SMIBIO CONCEPT DESIGN



Legend:

- Cellulose flow
- Hemicellulose flow
- Lignin flow
- AD flow

Developing Business Case Studies
SMALL-SCALE BIOREFINERIES

Average biomass input: 30,000 ton /year

CASE STUDY 1 - SPAIN

Feedstocks: Olive tree prunnings and wastewaters from olive oil extraction plant

Biorefinery Products: Ethanol, Lignin, Bioproducts

CASE STUDY 2 - PORTUGAL

Feedstocks: Corn stover and swine manure

Biorefinery Products: Ethanol, Lignin, Bioproducts

CASE STUDY 3 - CHILE

Feedstocks: Cereal residues (stover and straw) and swine manure

Biorefinery Products: Butanol/Isobutanol, Biogas, Stabilized sludge for fertilizers

CASE STUDY 4 - MEXICO

Feedstocks: Agave bagasse and corn stover

Biorefinery Products: Ethanol, Xylitol, Furfural

CASE STUDY 5 - GERMANY

Feedstocks: Grass

Biorefinery Products: Lactic acid, Aminoacids, Biogas

Biorefinery conceptual design

Heuristic Analysis in six-steps
(before process modelling and simulation)

- 1-Feedstocks
- 2-Biorefinery Design
- 3-Preliminary Mass Balance
- 4-Process Scale selection
- 5-Process Unit Operations /Technologies choice
- 6-Evaluation of product competitors

Biorefinery conceptual design – PT case study

Feedstocks: Corn stover and swine manure

HEURISTIC ANALYSIS Biorefinery Design (Different Scenarios)

SCENARIO A	**Ethanol (C6 sugars) + Pentose Molasses + Lignin (CHP)**
Pentose molasses for animal feed; Local costumers	

SCENARIO A'	**Ethanol + Xylooligosaccharides (XOS) + Lignin (CHP)**
XOS to be used as food or feed additive (1% wt.); e.g. prebiotic; World costumers	

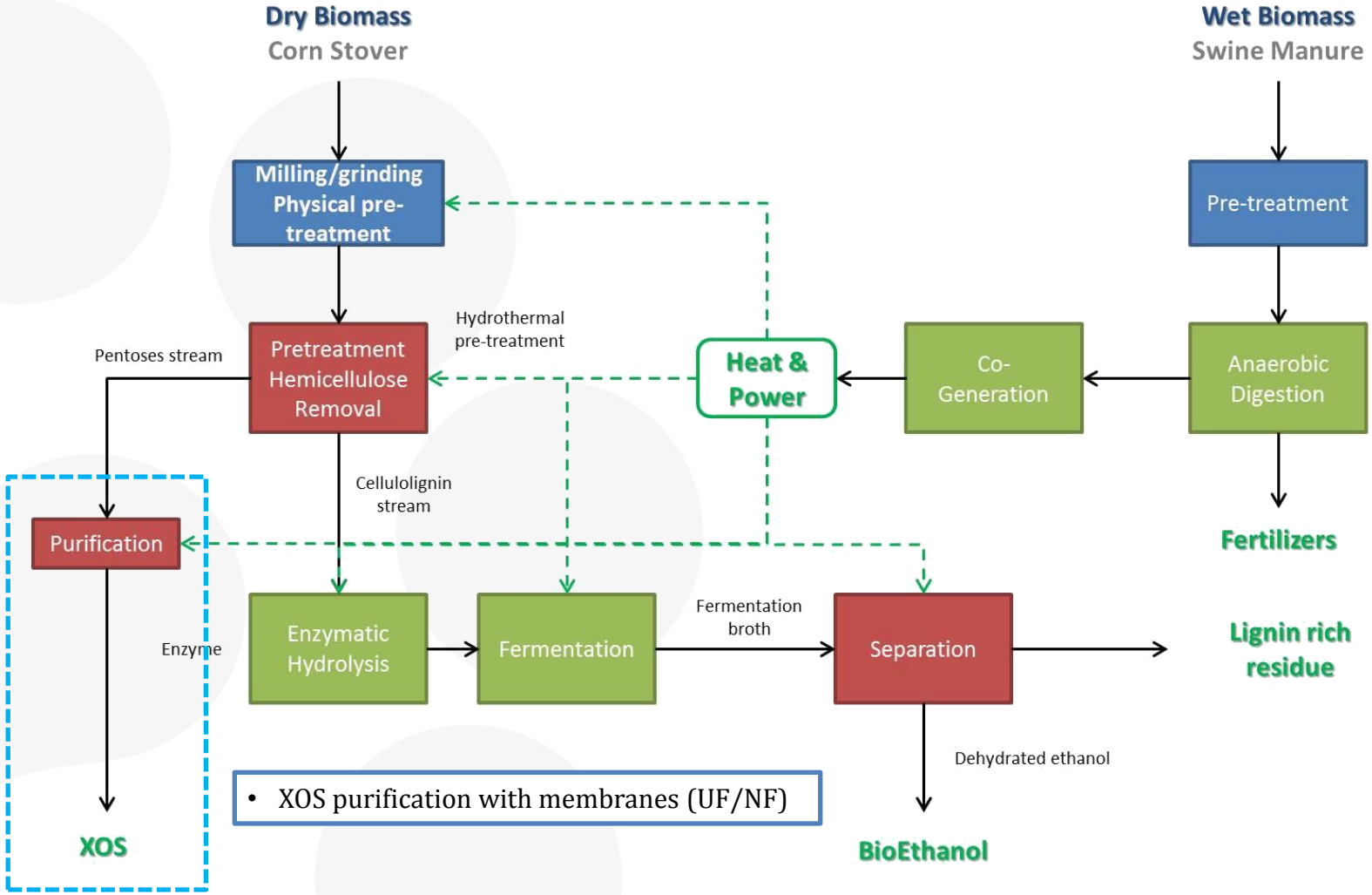
SCENARIO B	**Ethanol (C5/C6 sugars) + Lignin (CHP)**
Ethanol from C5/C6 sugars; EU costumers	

SCENARIO C	**Ethanol (C6 sugars)+ Xylitol (XOH) + Lignin (CHP)**
Xylitol production from C5 sugars; World costumers	

Biorefinery conceptual design – PT case study

HEURISTIC ANALYSIS Biorefinery Design

SCENARIO A' Ethanol + XOS + Lignin (CHP)



- XOS purification with membranes (UF/NF)

Biorefinery conceptual design – PT case study

HEURISTIC ANALYSIS Preliminary Economic Analysis (OPEX)

SCENARIO A EtOH + C5 Molasses + Lignin

	Cost	Units
1) Feedstock		
Corn Stover	45	€/ton
Enzymes	152	€/ton EtOH
2) Operating Costs		
Distillation	65	€/ton
Steam (Pretreat./Evapor.)	10	€/ton
3) Labour		
Personnel costs	2500	€/month
# workers	20	

SCENARIO A' EtOH + XOS + Lignin

	Cost	Units
1) Feedstock		
Corn Stover	45	€/ton
Enzymes	152	€/ton EtOH
2) Operating Costs		
Distillation	65	€/ton
Steam (Pretreat./Evapor.)	10	€/ton
Purification (XOS)	8*	€/ton hydrolysate
3) Labour		
Personnel costs	2500	€/month
# workers	20	

SCENARIO B EtOH (C5/C6) + Lignin

	Cost	Units
1) Feedstock		
Corn Stover	45	€/ton
Enzymes	152	€/ton EtOH
2) Operating Costs		
Distillation	65	€/ton
Steam (Pretreatment/Drying)	10	€/ton
3) Labour		
Personnel costs	2500	€/month
# workers	20	

SCENARIO C EtOH + XOH + Lignin

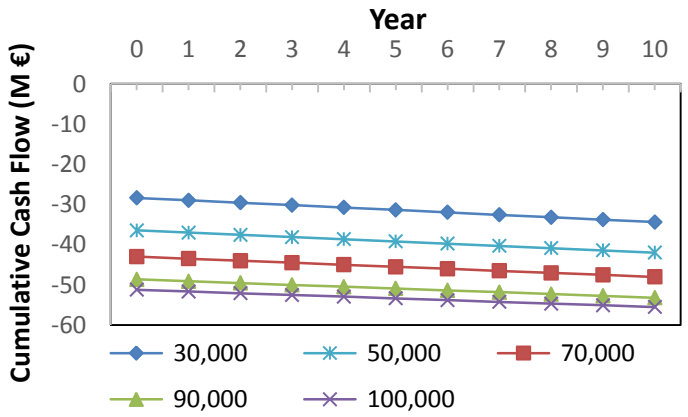
	Cost	Units
2) Operating Costs		
Distillation	65	€/ton
Steam (Pretreat., Post-Hydrol.)	10	€/ton
Acid Hydrolysis (H_2SO_4)	86	€/ton
Post-Hydrolysis treat.	4	€/ton
Neutralization ($Ca(OH)_2$)	70	€/ton
Xylitol Prod. & Purific.	1237**	€/ton XOH
3) Labour		
Personnel costs	2500	€/month
# workers	30	

* To be refined; **it already includes some considered costs

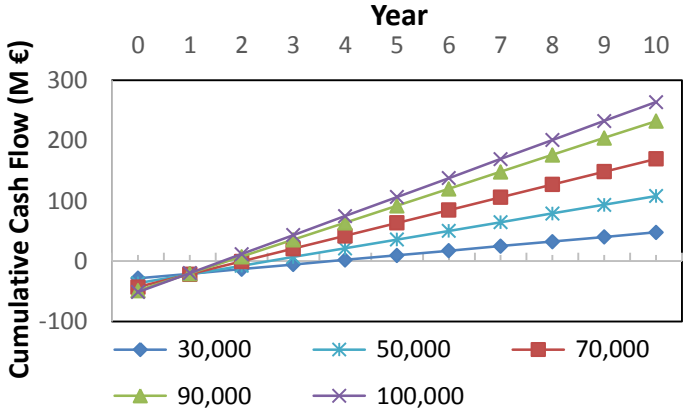
Biorefinery conceptual design – PT case study

HEURISTIC ANALYSIS Preliminary Economic Analysis (Cash Flow)

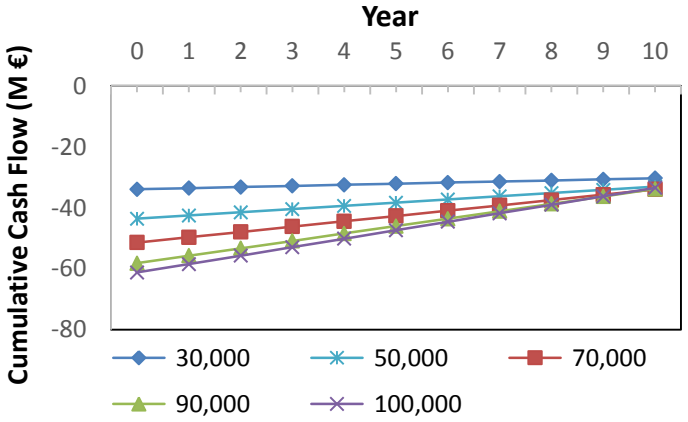
SCENARIO A EtOH + Molasses + Lignin



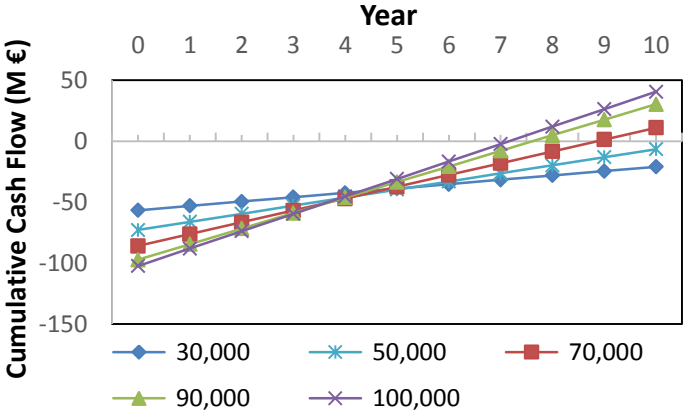
SCENARIO A' EtOH + XOS + Lignin



SCENARIO B EtOH (C5/C6) + Lignin

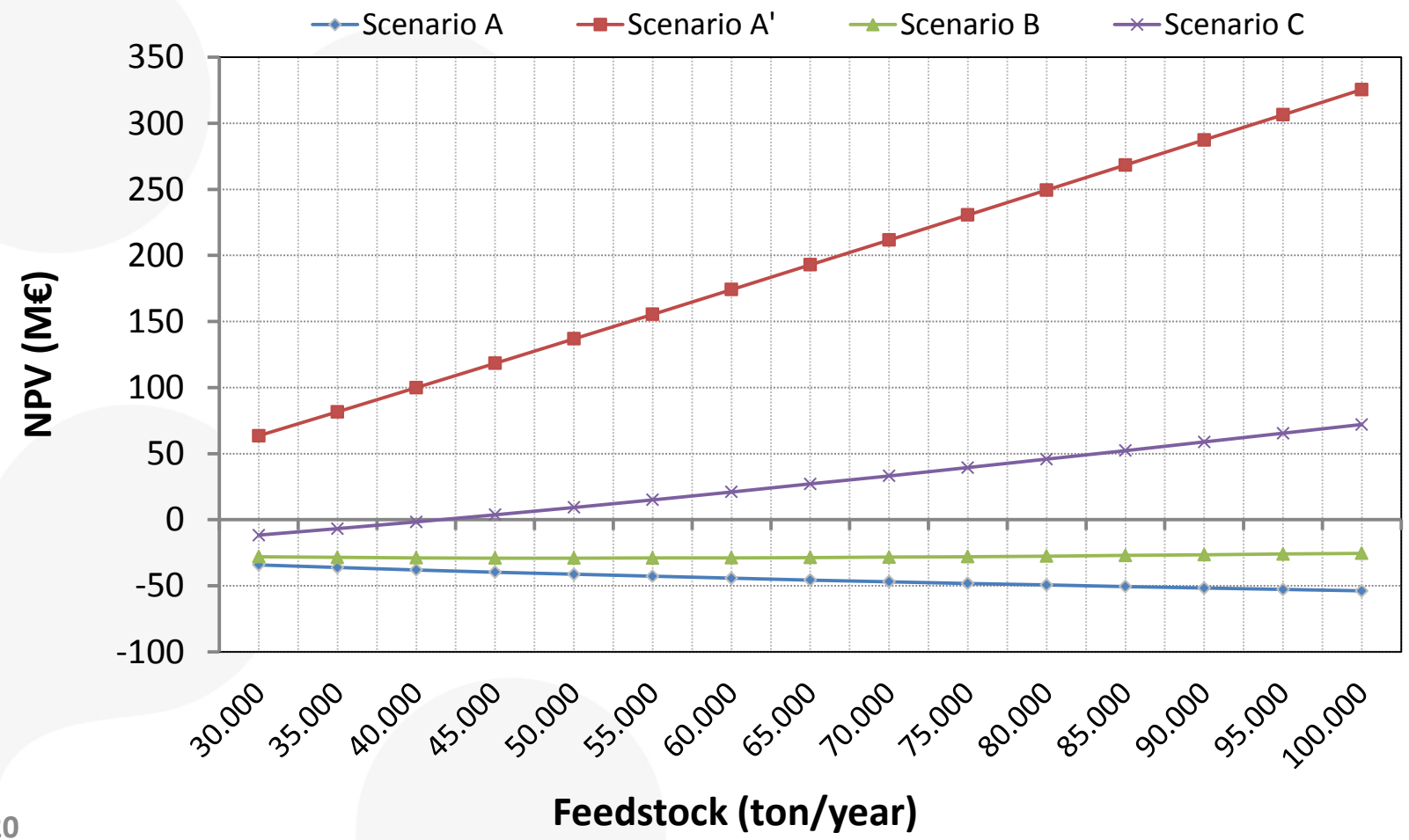


SCENARIO C EtOH + XOH + Lignin



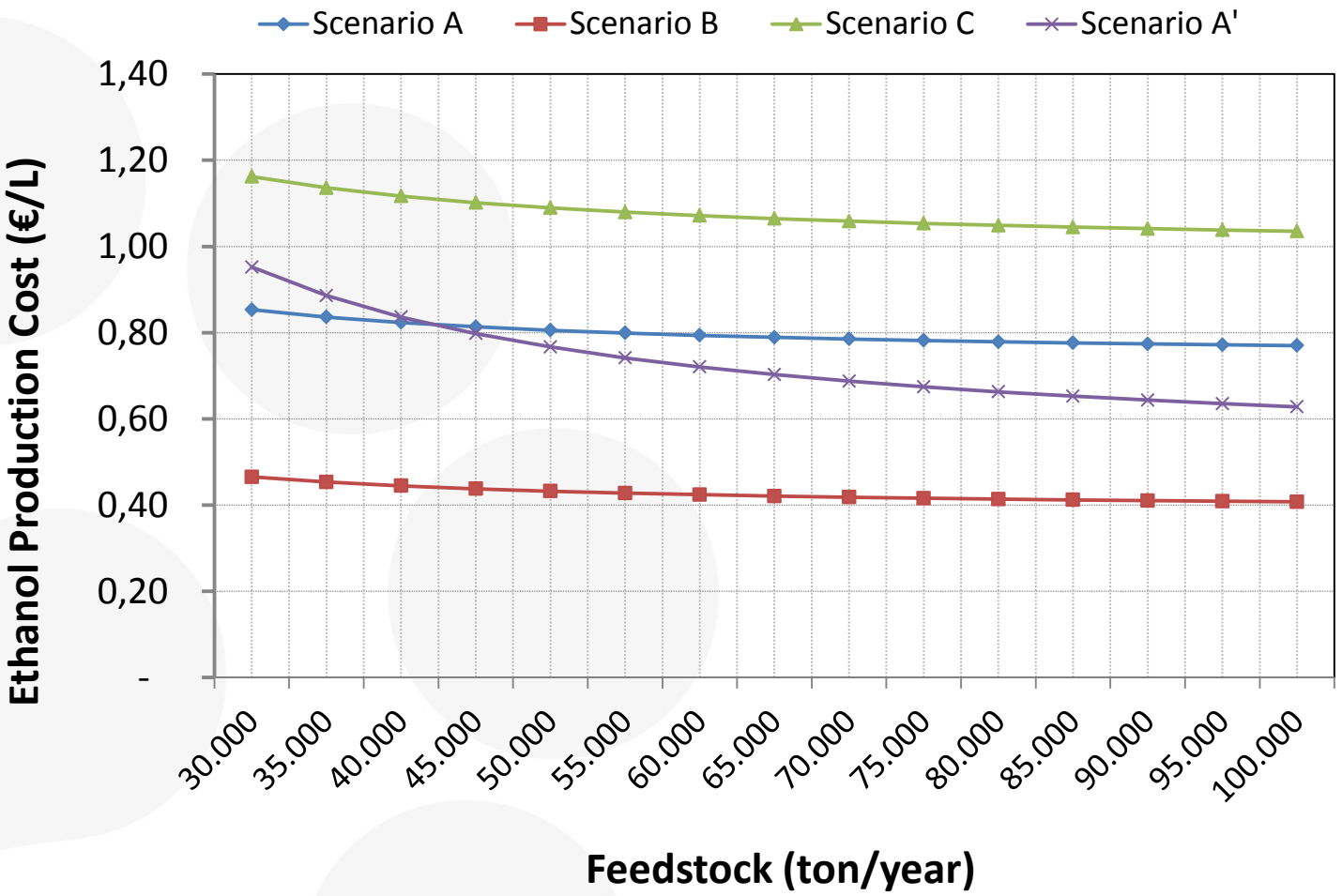
Biorefinery conceptual design – PT case study

HEURISTIC ANALYSIS Net Present Value vs. Scale (from 30,000 to 100,000 ton/year)



Biorefinery conceptual design – PT case study

HEURISTIC ANALYSIS Ethanol Production Cost vs. Scale



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Thanks for your attention

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