BIOLYFE Workshop

21st European Biomass Conference and Exhibition

Copnhagen, Denmark
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Demo-plants from economic and financial perspective, R&D needs

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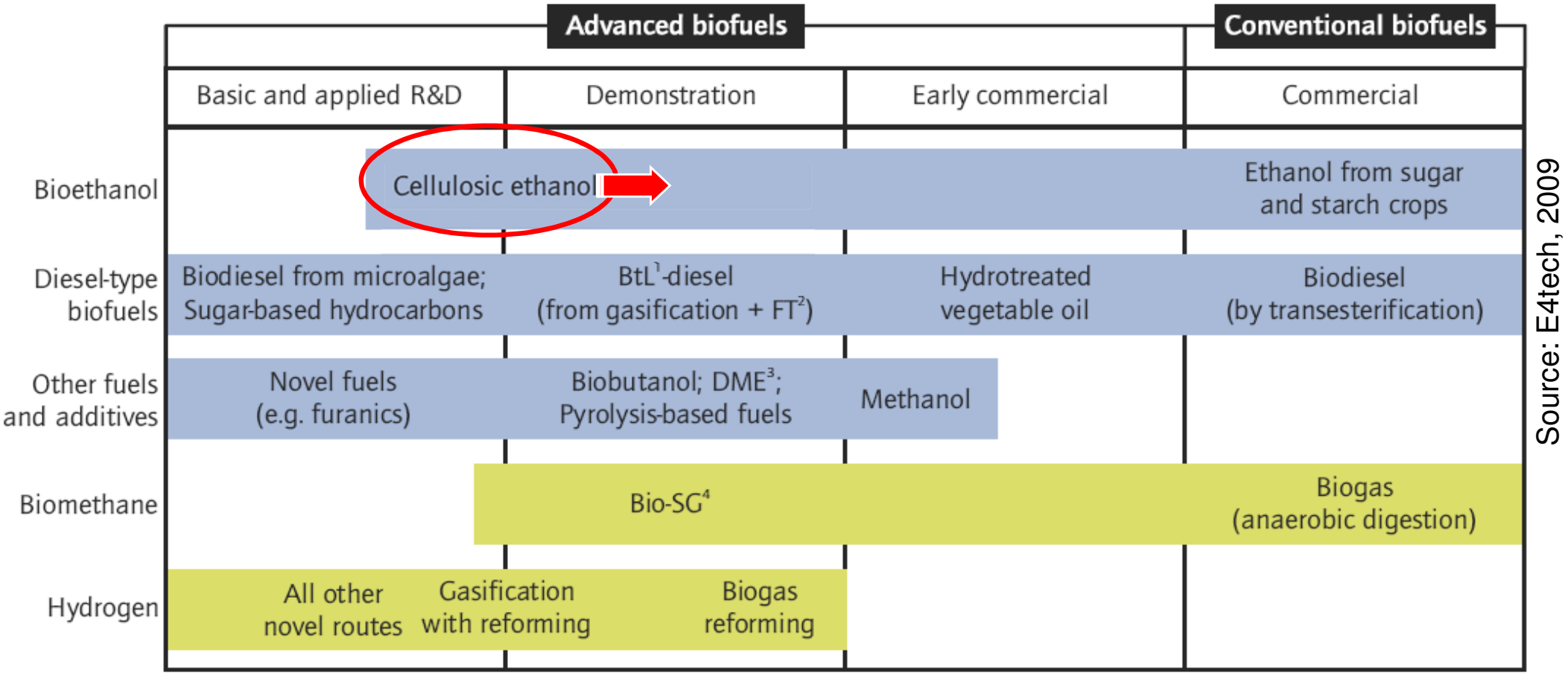
Overview

- EU, USA, Brasil, Asia: the context
- From Pilot to Demo: Biofuels and biorefineries in EU – US – Brasil
  - ⇨ Pilot and Demo projects
- Cost perspectives
- Conclusions

E4Tech-IEA (2009): Status of Biofuels - SUMMARY



Source: E4tech, 2009

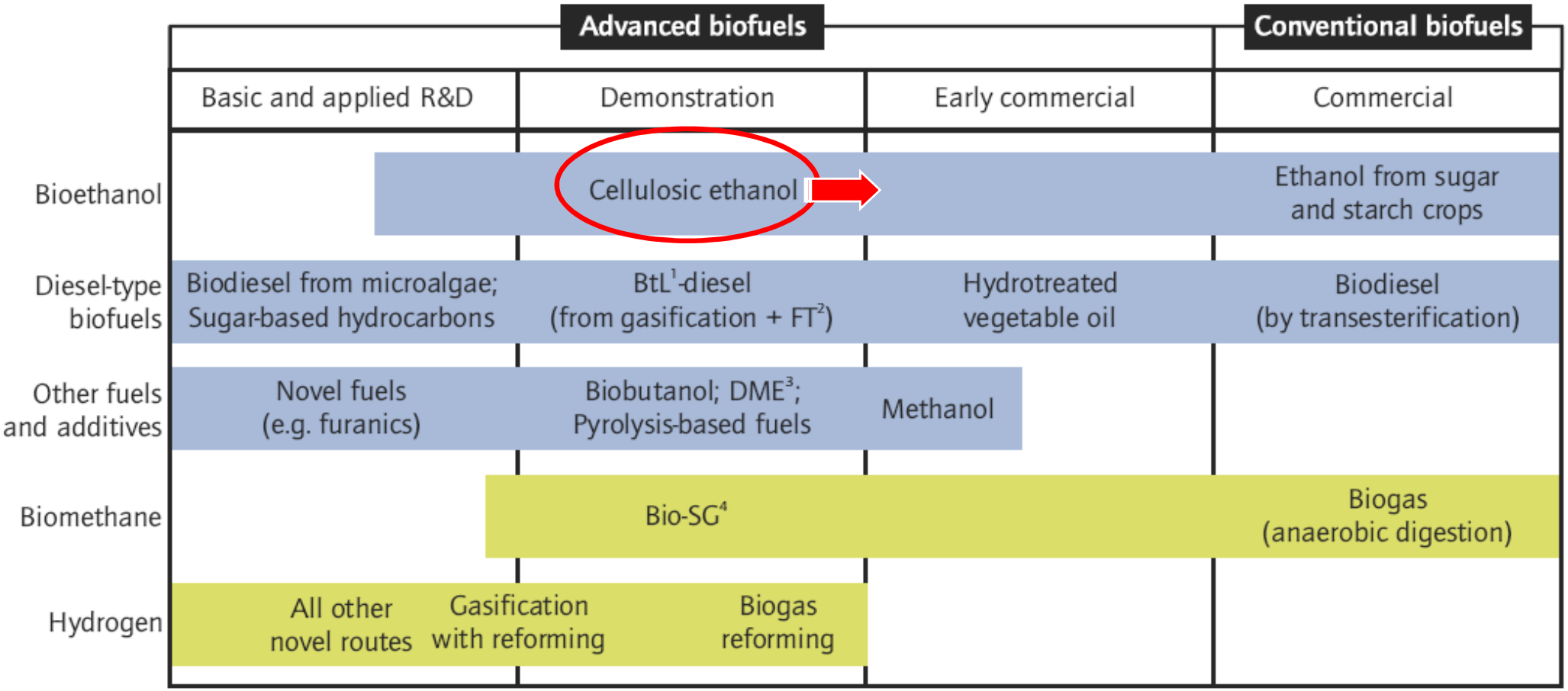
1. Biomass-to-liquids; 2. Fischer-Tropsch; 3. Dimethylether; 4. Bio-synthetic gas.

Source: Modified from Bauen *et al.*, 2009.

Source: IEA

IEA (2011): Status of Biofuels - SUMMARY

Commercialisation status of main biofuel technologies



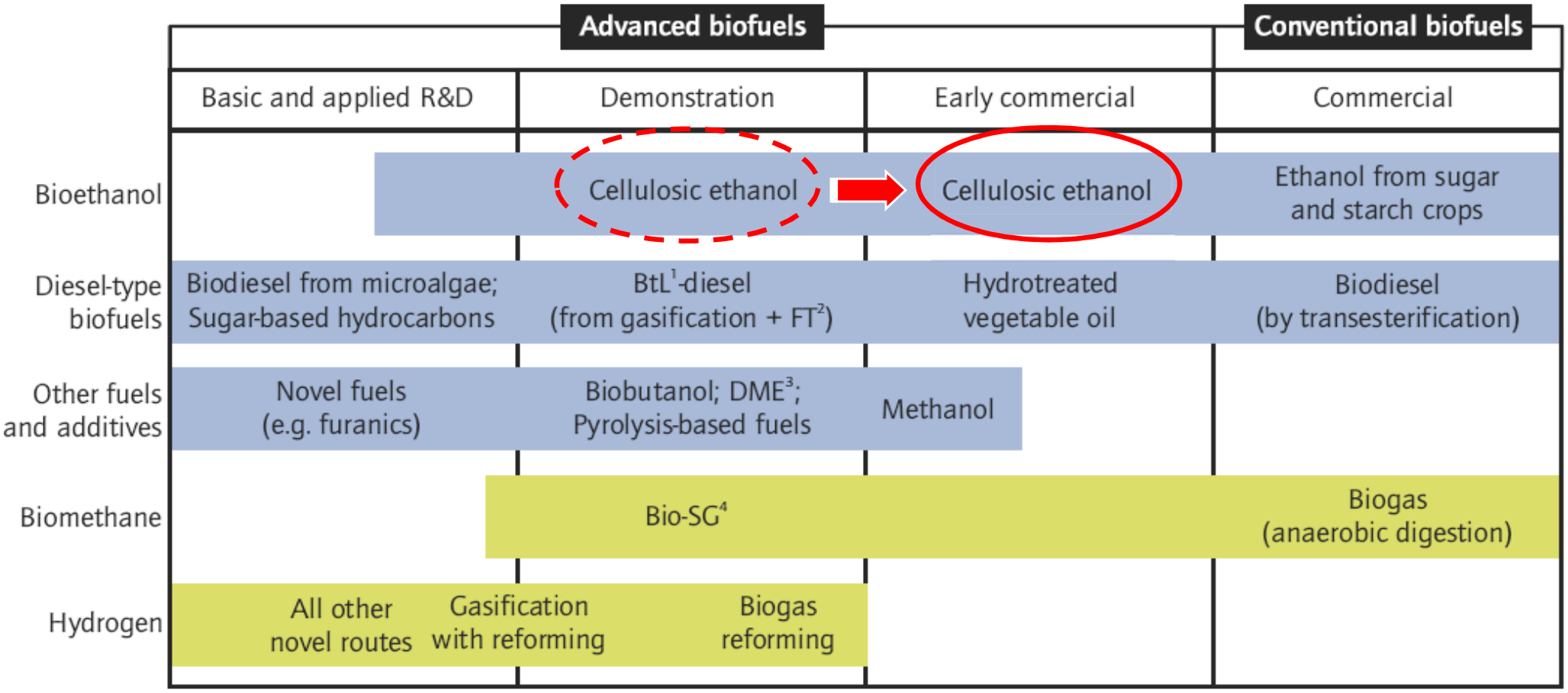
1. Biomass-to-liquids; 2. Fischer-Tropsch; 3. Dimethylether; 4. Bio-synthetic gas.

Source: Modified from Bauen *et al.*, 2009.

Source: IEA Biofuel Roadmap 2011

Update (2013): Status of Biofuels - SUMMARY

Commercialisation status of main biofuel technologies



1. Biomass-to-liquids; 2. Fischer-Tropsch; 3. Dimethylether; 4. Bio-synthetic gas.

Source: Modified from Bauen *et al.*, 2009.

The EU context

- **2007 climate and energy 20-20-20 targets** (20 % share of RES, 20 % energy efficiency and 20 % GHG emission reduction by 2020, with 10% contribution of renewable fuels in transport)
- **Policies** developed and put in place.
- **Sustainability** criteria where set for biofuels in the Renewable Energy Directive (RED), which mainly address minimum **GHG** saving requirements, and **protection of land** with high biodiversity or carbon stock.
- The major **European Commission (EC) programmes** supporting the development of R&D and demonstration in the field of biofuels are
  - ⇨ the 7th Framework Program (**7FP**)
  - ⇨ the European Industrial Bioenergy Initiative (**EIBI**) (addressing only large-scale industry-led projects)
  - ⇨ the **NER300** programme
  - ⇨ other programs as the **Intelligent Energy Program** (not supporting concrete implementation projects but market, barrier removal, information and dissemination actions).

Advanced Biofuel Projects supported under FP7 by DG ENER

- ✓ **12** large scale demonstration projects supported under FP7 + **3** more expected with the 2013 Call.
  - ***6 lignocellulosic ethanol***
  - ***2 synthetic biofuels*** *for diesel replacement*
  - ***3 algae*** *subsequently converted into biofuels for transport*
  - ***1 bio-oil from pyrolysis***
  - *Projects to be supported in the* ***2013 → kerosene replacement*** *biofuels, thus be considered as diesel replacement. Available budget is 36 M Euro*
- ✓ **Total ENER support** for large scale Demo on 2nd generation and **advanced biofuels** amount to about **154 M Euro**.

EC Biofuel Cluster	Contract Acronym	Coordinator	Technology Provider	Biofuel	EC Support € M	Biomass	Production Capacity
Synthetic	OPTFUEL	VW	Choren Industries	Fischer-Tropsch	7.8	Wood	15,000 t/y
	BIO DME	Volvo	Chemrec	Dimethyl-ether	8.2	Black Liquor	600 t/y -150 days operation)
LC Ethanol	BIOLYFE	Chemtex Italia	Chemtex Italia	Ethanol	8.6	Various	40,000 t/y
	FIBREEtOH	UPM	UPM	Ethanol	8.6	Fibre	20,000 t/y
	KACELLE	Dong Energy	Inbicon	Ethanol	9.1	Straw	20,000 t/y
	LED	Abengoa	Abengoa	Ethanol	8.6	Corn res.	50,000 t/y
	COMETHA*	Chemtex Italia	Chemtex Italia	Ethanol	19.0	Various	80.000 t/y
	SUNLIQUID*	Clariant	Clariant	Ethanol	19.0	Various	60,000 t/y
Pyrolysis	EMPYRO	BTG	BTG	Bio-oil	5.0	Wood	17,400 t/y
Algae	ALL-GAS	Aqualia	Feyecon	Biodiesel & biomethane	7.1	Algae	90t/ha.y algae on 10 ha
	BIOFAT	A4F - AlgalFuel	Alga Fuel	Biodiesel & ethanol	7.1	Algae	90t/ha.y algae on 10 ha
	INTESUSAL	CPI	CPI	Biodiesel	5.0	Algae	90t/ha.y algae on 10 ha
					Total = 113.1		

under negotiations
+ 15 M Euro for 3 contracts on Biorefineries → Total 128 M Euro
+ 38 M Euro for 2 contracts for paraffinic biofuels in aviation, 2013 FP7 Call

Lignocellulosic Advanced Biofuels Demo projects in EU

- 39 EU identified projects
  - ⇨ 22 on Biochemical processes
  - ⇨ 17 on Thermochemical
- Demo/Commercial projects (on liquid fuels, incl.PO) in EU (> 1,000 t/y)
  - ⇨ 12 projects Biochemical route
  - ⇨ 10 Thermochemical
- Other Demo plants on SNG/Biomethane

Lignocellulosic Advanced Biofuels Demo projects in EU

Source:
http://demoplants.bioenergy2020.eu/projects/mapindex - IEA Task 39

NER300

- December 2012: EC awarded over **1.2 b€ to 23 highly innovative renewable energy demonstration projects**

- **~ 629 M€ to Bioenergy**
  - ⇨ ~ **82 M€** (13%) to Biochemical Processes
  - ⇨ ~ **547 M€** (87%) to Thermochemical Processes

- Out of **8** projects, **5 to Advanced Biofuels**
  - ⇨ **3** Thermochemical, ~**457 M€** (88, 170, 199 M€)
  - ⇨ **2** Biochemical, ~**59 M€** (28, 31 M€)

- The other projects on Bioenergy are targeting pyrolysis oil, SNG (Thermochem) and Straw-to-Biomethane (Biochem), 112 M€ (59+31+22 M€)

Company *Proj.Acron.*	EU Site	Type (Technology)	Product(s)	Installed Capacity	Feedstock	Status	Short Notes on Process and Additional Information - Other remarks (web site)
Billerud ***Pyrogrot*** **(NER300)**	EU - Skärblacka (SE)	Demo (Thermochemical)	Pyrolysis Oil	• **160,000 t/y of pyrolysis oil**	**720 dry t/d** of lignocellulosic biomass		Biomass pre-treatment (both before and after drying), biomass drying, flash pyrolysis process including condenser, and storage of pyrolysis oil **31.4 M€ funding from NER 300**
BIOAGRA ***CEG Plant Coswinowice*** **(NER300)**	EU - Coswinowice (PL)	Commercial (Biochemical)	Bioethanol Lignin Biogas	• **60 Ml/y EtOH** • **70,000 t dry lignin** (moisture content 50-60%) • **biogas** (22.3 MNm^3 biogas, 75% methane)	**~250,000 t/y** of wheat straw (75%) and corn stover (25%)	Planned	BIOAGRA is owned by 49% of the polish Company BIOAGRA Bioagra produces 140,000 cubic meters of ethanol and 100,000 tons of DDGS (animal feed) annually from grain as the raw material. **30.9 M€ funding from NER 300** http://www.bioagra.pl/index.php?Lng=eng http://www.sekab.com/about-us/facilities/bioagra
BioMCN, Siemens, Linde, VS Hanab ***Woodspirit*** **(NER300)**	EU - Oosterholm, Farmsum (NL)	Commercial (Thermochemical)	Biomethanol	• **516 Ml/y Biomethanol (413,000 t/y)**	**1.5 Mt/y** of imported wood chips	Planned	Thermochemical torrefaction + entrained flow gasification to biomethanol ; **199 M€ funding from NER 300** http://www.biomcn.eu
CHEMTEX/ M&G/Beta ***FP7-Biolyfe*** **(NER300 -** ***BEST)***	EU - Crescentino (IT)	Demo (Biochemical)	Biothanol Power	• **40,000 t/y Bioethanol** • **13 Mwe**	**180,000 t/y** of straw, Arundo Donax, other lignocellulosic biomass	Under commissioning, start up beginning 2013	Proprietary pretreatment (PROESA™) + Viscosity reduction + EH + Fermentation (C5 and C6) **Also selected by the NER300 first round, with a support of 28,4 M€** PROESA™ Technology is licensed by Beta Renewables www.betarenewables.com www.chemtex.it
GOTEBORG Energy AB ***GoBiGas2*** **(NER300)**	EU - Rya Harbour (SE)	Commercial (Thermochemical)	Commercial SNG Thermal power to DH	• **800 GWh/y SNG**	**500,000 t/y** wet lignocellulosic biomass	Completion of the initial BoBiGas project. Planned by 2015	High quality synthetic natural gas (SNG) by indirect gasification at atmospheric pressure (FICFB, Repotec/Metso Power), gas cleaning, methane production (via nickel catalyst), pressurization and injecting the product into the regional gas network 100 MW installed capacity **58.8 M€ funding from NER 300** www.gobigas.se www.repotec.at/index.php/97.html

Company *Proj.Acron.*	EU Site	Type (Technology)	Product(s)	Installed Capacity	Feedstock	Status	Short Notes on Process and Additional Information - Other remarks (web site)
UMP *Stracel BtL* (NER300)	EU - Strasbourg (FR)	Commercial (Thermochemical)	FT products (biodiesel 80%, bionaphta 20%)	• **105,000 t/y FT products**	**1,000,000 t/y** woody feedstock	Investment decision 2014	Biomass drying + Gasification and Cleaning + FT synthesis and upgrading Novel pressurized oxygen blown gasification, Integration (exchange of energy and products) with the Stracel paper mill. Main process steps: feedstock handling, gasification, raw gas cleaning, gas-to-liquid conversion, liquid treatment and storage, and power generation **170 M€ funding from NER 300** Rauma (Ner300 reserve list) http://www.upm.com
VAPO/Forest BtL ***Ajos BtL*** **(NER300)**	EU - Kemi (Northern Finland)	Commercial (Thermochemical)	FT diesel	• **115,000 FT-Products (diesel, naphta)** (320 MWth total gasification capacity, two lines)	**950,000 t/y** woody feedstock + 31,000 t/y of tall oil	Planned 2016-2017	Preparation work carried out by Forest BtL project, by VAPO and Metsäliitto Main process steps: pretreatment and drying, gasification and air separation, gas conditioning and compression, FT synthesis, refining; Two gasification lines, 160 MW each. Carbo V technology® licensed by Linde Engineering Dresden **88.5 M€ funding from NER 300** http://forestbtl.com/
VERBIO (NER300)	EU - Schwedt (DE)	Demo (Biochemical)	Biogas-Biomethane	• **25.6 Mm3(s)/y**, containing 12.8 Mm3(S)/y biomethane	**7,000 t/y** straw	Planned	Main process phases: raw material handling, biomass pre-treatment of biomass by steam and enzyme successively, production of biogas by anaerobic fermentation, and biogas post-treatment and upgrading to biomethane and grid injection. **22.3 M€ funding from NER 300** http://weyland.no

NER300

Operational Advanced Biofuels Facilities (demo & commercial) - Europe

Inbicon

Borregaard

Chempolis

BioMCN

Neste Oil

Neste Oil

Clariant

Abengoa

M&G/Chemtex

Biomassekraftwerk Güssing

www.demoplants.bioenergy2020.eu

…..MAIN COMPETING REGIONS OF THE WORLD…..

USA

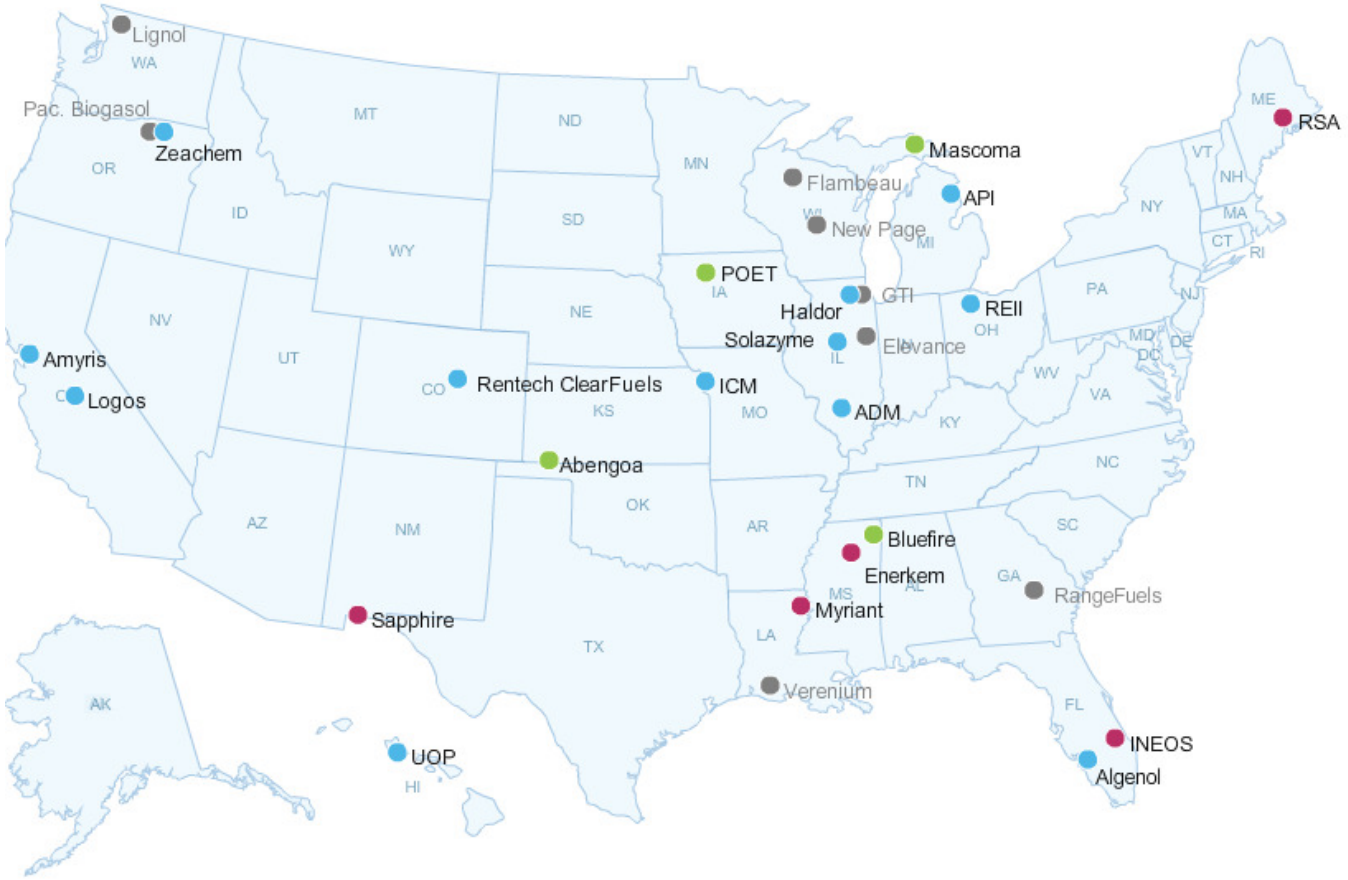
- Energy Independence and Security Act (2007) → **US target of 36 Billion gallon (~136 Mill.m^3) of Renewable Fuels per year** (BGPY) by 2022
  - ⇨ **15 BGY Cap** on Conventional **Corn Starch-based Biofuels**
  - ⇨ at least **15 billion gallon (~57 Mill.m^3) of cellulosic biofuels**
- As of Feb. 2012: US-DOE invested more than **1 billion US dollars in 29 integrated biorefinery projects** to advanced biofuels.
- Out of the **29** projects
  - ➔ ***16 cellulosic ethanol*** *projects with* ***766 M USD*** *support,*
  - ➔ ***11 hydrocarbon fuel*** *projects with* ***326 M USD*** *support,*
  - ➔ ***1 butanol*** *project with* ***30 M USD*** *support*
  - ➔ ***1 succinic acid*** *production facility with* ***50 M USD*** *support.*
  - ⇨ **2 R&D bench scale demonstration facility**, **12 pilot** scale demonstration facilities, **9 full scale demo** plants and **6 commercial** scale plants.
  - ⇨ Main bio-products: **ethanol, butanol, gasoline and diesel (FT liquid and FT waxes), Jet fuels, chemicals**, and **power**.

Source: US-EISA, 2007; J.McMillan, NREL, 2012

Bioenergy Technologies Office (BETO) *Integrated Biorefinery Platform*

IBR PROJECTS

Click on the project locations to see more information and locations are approximate



CONVERSION TECHNOLOGY

Select one...

PRIMARY PRODUCT

Select one...

PRIMARY FEEDSTOCK *(Click to select)*

- Agricultural Residues
- Algae
- Energy Crops
- MSW
- Forest Resources
- All

PROJECT SCALE *(Click to select)*

- Research and Development
- Pilot
- Demonstration
- Commercial
- All

Grey markers signify projects that are no longer active with BETO

BETO BIOREFINERY INVESTMENTS BY STATE

U.S. Dollars, in millions

0 | 1-25 | 26-50 | 51-75 | 76-100 | 101-175

DISPLAY PROJECT NAME

Use the drop down menu to find projects specific to that selection. Use the radio button to shade states by selected category.

Mouse over map or dots to see related data.
Click on the links under PROJECT SCALE and FEEDSTOCK to filter the map.

Source: DOE - http://www1.eere.energy.gov/biomass/integrated_biorefineries.html

BRASIL

PAISS: Theme Lines

- **Line 1: 2nd Generation Bioethanol**
  - 1.1 Straw Gathering and Transportation;
  - 1.2 Pre-treatment of biomass for hydrolysis;
  - 1.3 Processes for enzyme production and/or hydrolysis processes of
  - lignocellulosic material;
  - 1.4 Microorganisms and/or processes for C5 fermentation; and
  - 1.5 Integration and scaling of processes for cellulosic ethanol production.
- **Line 2: New Products from Sugarcane**
  - 2.1 New products from sugarcane biomass; and
  - 2.2 Integration and scaling of processes for the production of new products.
- **Line 3: Gasification**
  - 3.1 Pre-treatment of sugarcane biomass for gasification;
  - 3.2 Biomass gasification technologies for sugarcane;
  - 3.3 Gas purification systems; and
  - 3.4 Catalysts associated with the conversion of syngas into products.

BNDES FINEP AGÊNCIA BRASILEIRA DA INOVAÇÃO

- The 35 Business Plans approved will result in a potential investment of **BRL 3.1 billion** (~ USD 1.5 billion).

Significant growth of innovation projects in the sugarcane industry

Asia

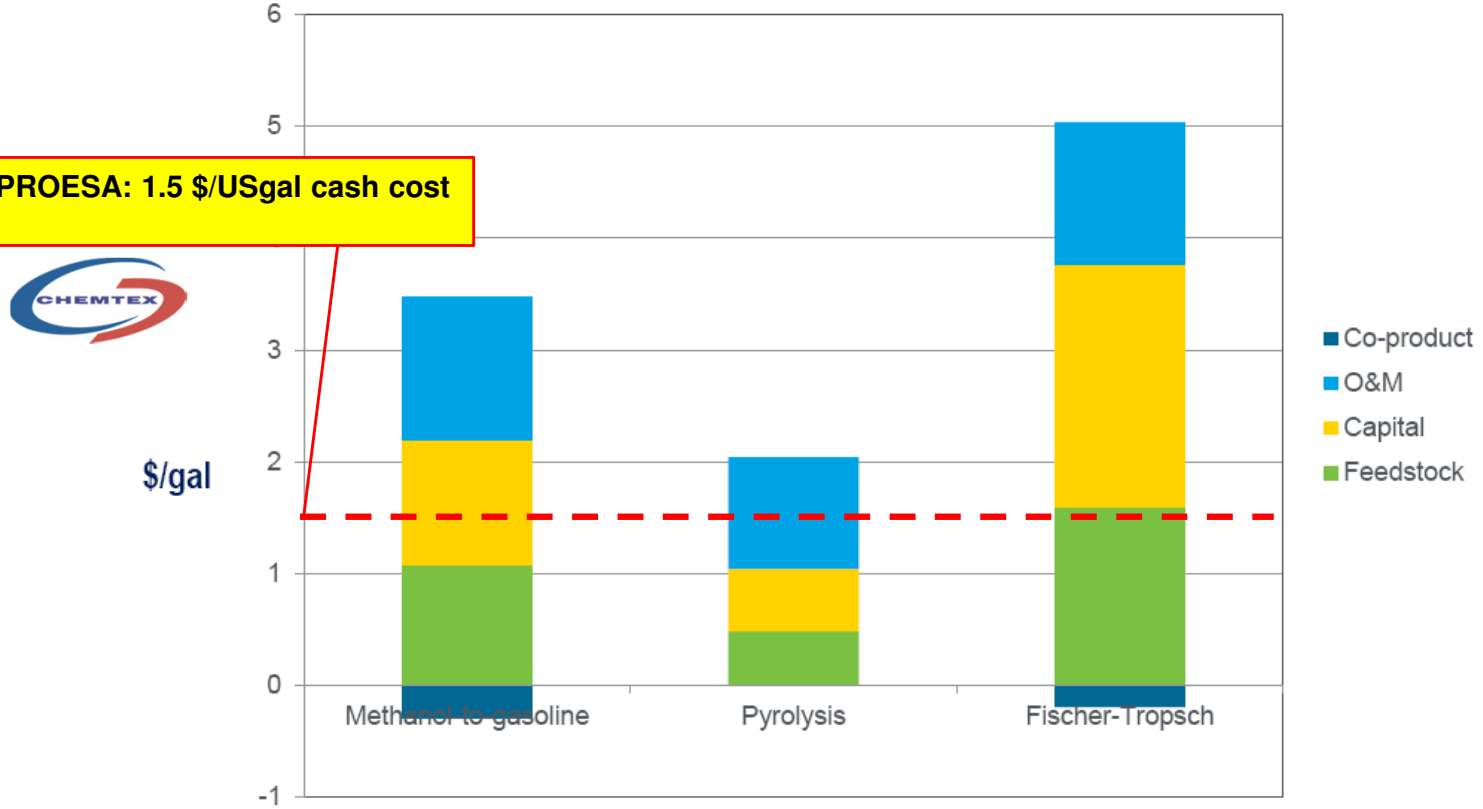
- A very promising and fast growing market, with huge potential for Advanced Biofuels and Green Chemicals
- India, Malaysia, Philippines, Thailand, Indonesia, China, Japan…

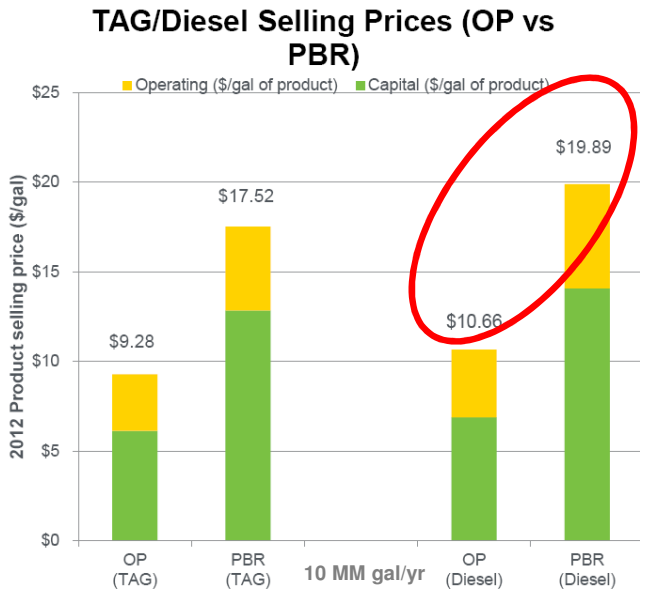
PROESA® scale up

Cost of Production for Hydrocarbon Biofuels

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

PROESA: 1.5 $/USgal cash cost





Source: Davis R et. al., "Techno-Economic Analysis of Autotrophic Microalgae for Fuel Production", Applied Energy 88 (2011) 3524 – 31.

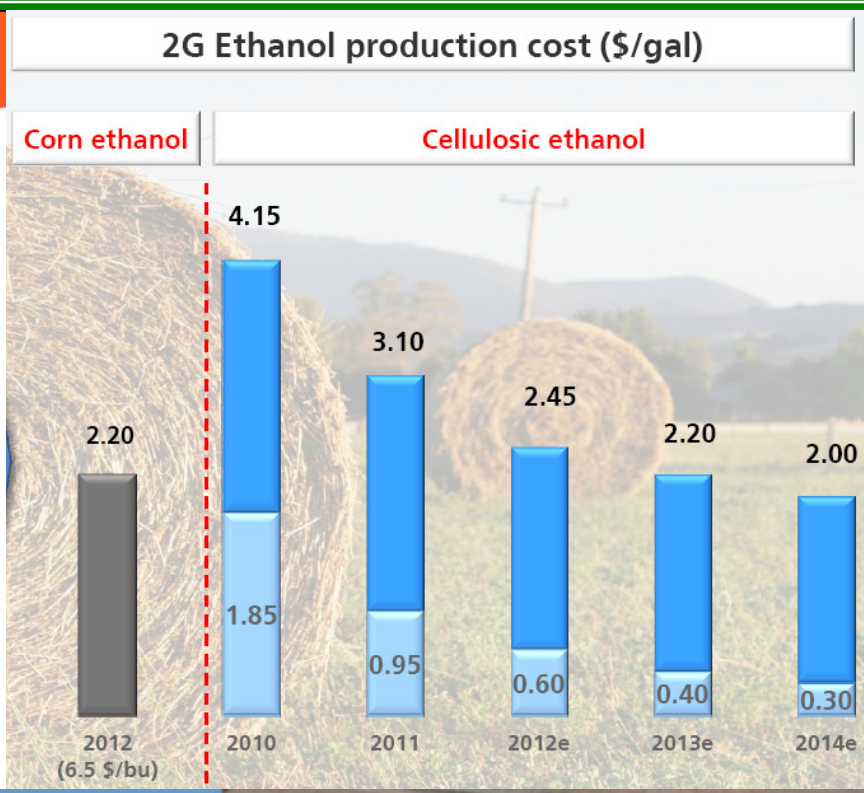
- Other economically viable technology routes for hydrocarbon biofuels exist, such as conversion of waste and plant oils, and sugar-to-hydrocarbons
- These costs are projected for the Nth Biorefinery Plant, after operation of initial commercial-scale Pioneer Plants

Source: Zia Haq, DOE HQ, 24 April 2012 – Biofuel Design Case

ABENGOA BIOENERGY

HUGOTON PROJECT

- ✓Estimated start-up: 2013
- ✓25 MGPY lignocellulosic EtOH
- ✓~320,000 dt per year (corn stover, switch grass) contracted fix price for 10yrs
- ✓21-MW electr. power.
- ✓First-of-its-kind commercial-scale to operate at 2.00 $/gal cost in 2015
- ✓DOE awarded 100 M USD grant
- ✓$132 million federal loan guarantee to help finance facility construction



Leaders of Sustainable Biofuels

CHEMTEX ITALIA
BRITISH AIRWAYS
DONG energy
CLARIANT
The Biofore Company UPM
CHEMREC
btg biomass technology group

Leaders of Sustainable Biofuels

- The European Advanced Biofuel Industry **is <u>today worldwide the most technologically advanced in a very competitive sector</u>**, heading the development and commercialisation of highly innovative technologies.

- This was possible thanks to **<u>significant private investment</u>** and considerable **<u>support from the European Commission and the Member States</u>**

- There's however **<u>need to identify and implement</u>** the most appropriate and effective **<u>strategies</u>** to mobilise investments and bring this joint public-private effort ahead

Leaders of Sustainable Biofuels

CHEMTEX ITALIA BRITISH AIRWAYS DONG energy CLARIANT The Biofore Company UPM CHEMREC btg biomass technology group

- **Risk**: The EU industry is leaving the EU to the US and Brazil due to lack of coherent EC policies….

- We will **fail** badly **to meet our climate and energy policy targets** unless urgent action is taken

Benefits from Advanced Biofuels development and deployment in the EU

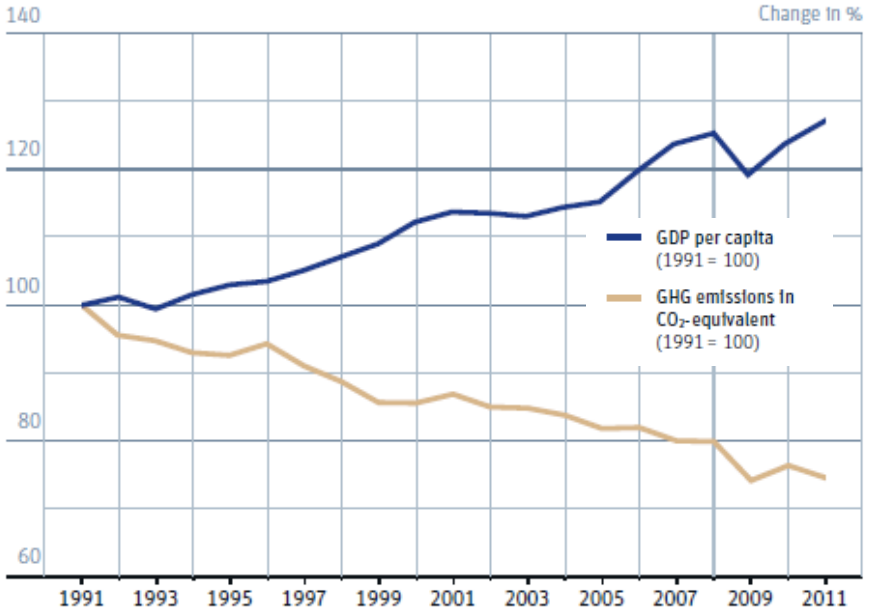
GROWTH ….which means….

- ⇨ EU **employment**: new jobs in all sectors of the chain
  - →**Today: 12 % EU unemployment – the largest share since the establishment of € (7.7 % US, decreasing)**
- ⇨ EU **know-how** development (IPRs)
- ⇨ Mobilization of **Investments** in the EU (**2%** target
  → **30** plants in operation, **200 kt/y** each – single counting – by 2020 → **~15 Bill.€** total investment)
- ⇨ **Export** of EU technologies (addressing the world market)

Germany: growing economy, declining emissions

Change of GDP and GHG emissions in Germany, 1991–2011

Source: BMU, BMWi, Destatis



http://energytransition.de

Thus.. → **Sustainable Development**

- **Social**
- **Economical**
- **Environmental**

Thanks for your attention

www.biolyfe.eu

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