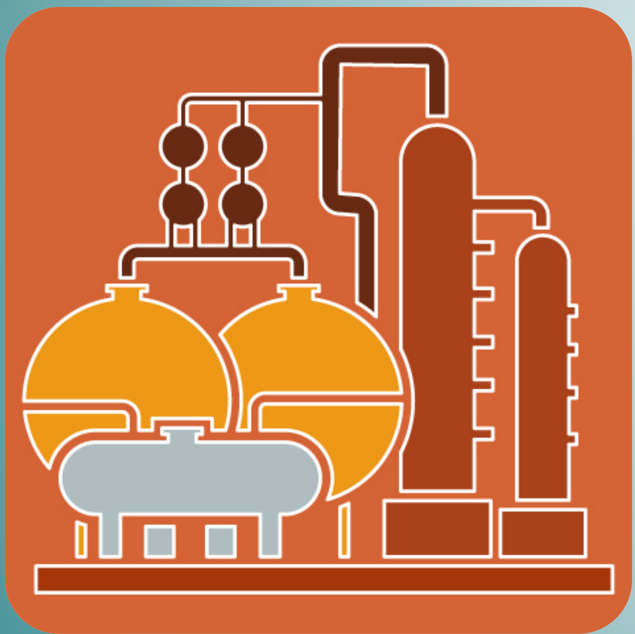
Chemical Process Design / Diseño de Procesos Químicos

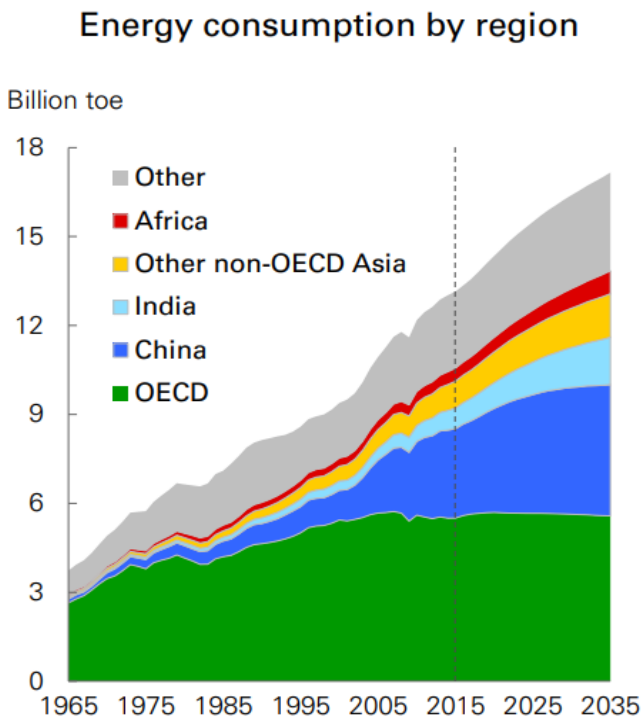
Design Project. Definition of the Design Project



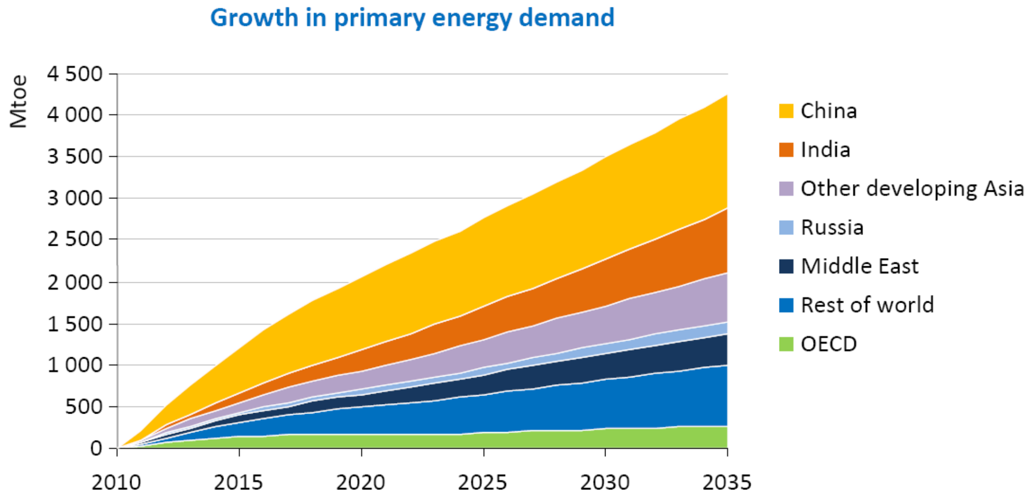
Javier R. Viguri Fuente
Eva Cifrian Bemposta

Department of Chemistry and Process and Resource Engineering
GER Green Engineering and Resources Research Group

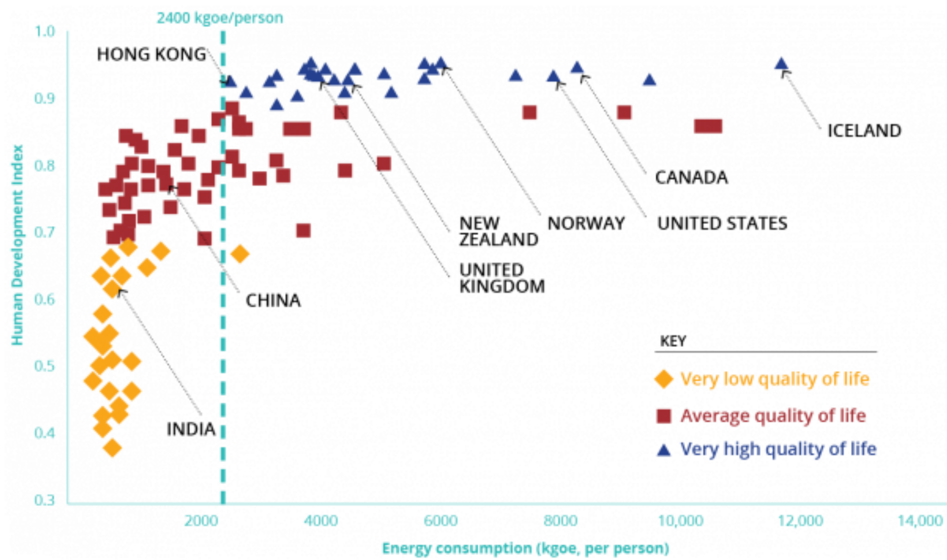
Increasing Global Energy Demand



BP 2017 Energy Outlook

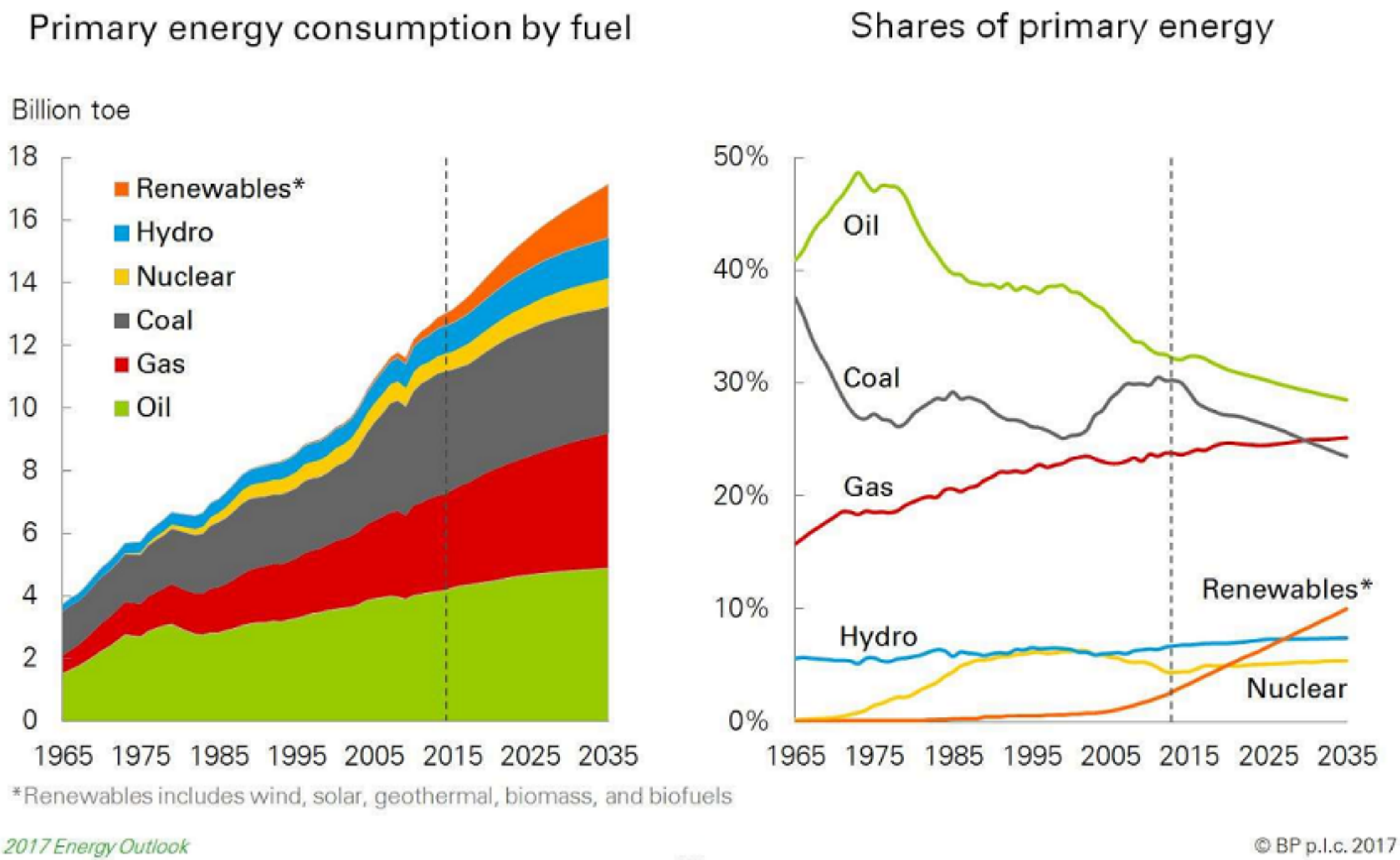


World Energy Outlook 2012, IAE



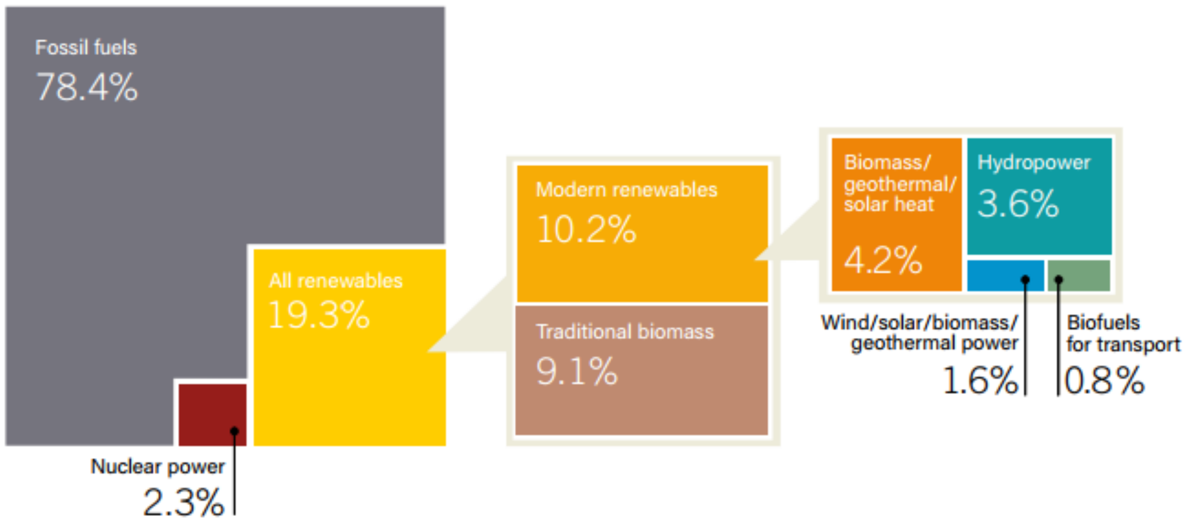
PEPANZ - Petroleum Exploration & Production Association New Zealand website

Global production of primary energy sources

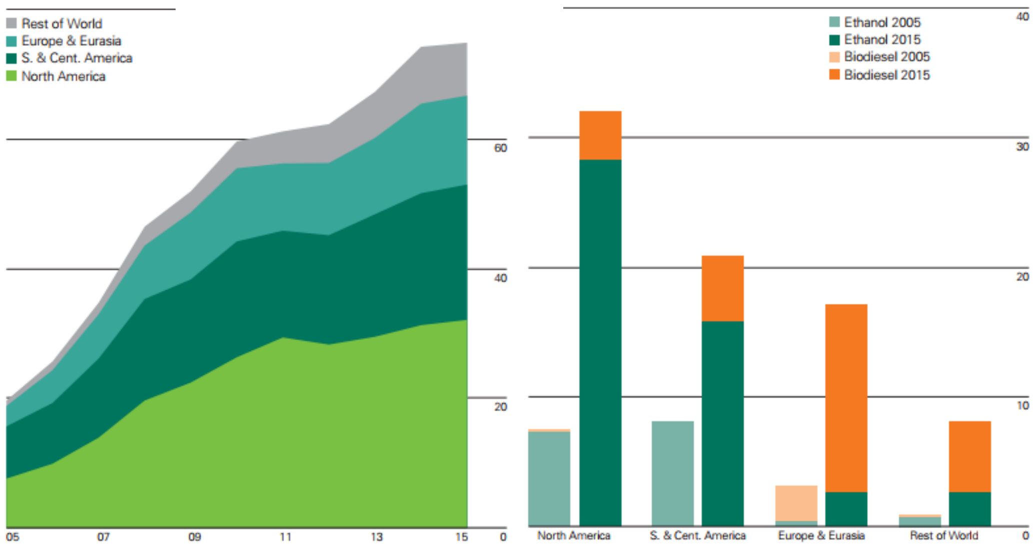


Biomass emerging as important renewable

Estimated Renewable Energy Share of Total Final Energy Consumption, 2015

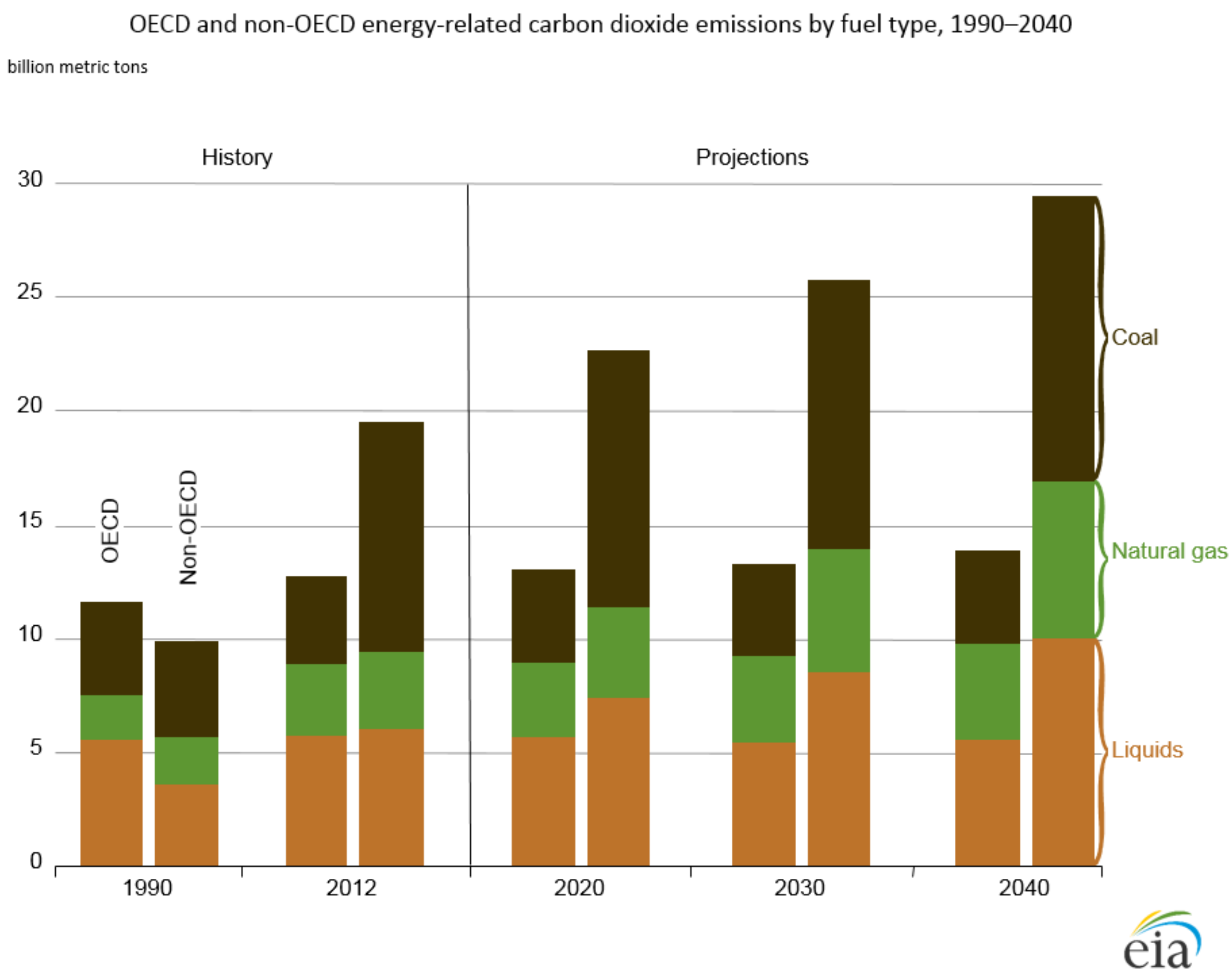


RENEWABLES 2017 · GLOBAL STATUS REPORT



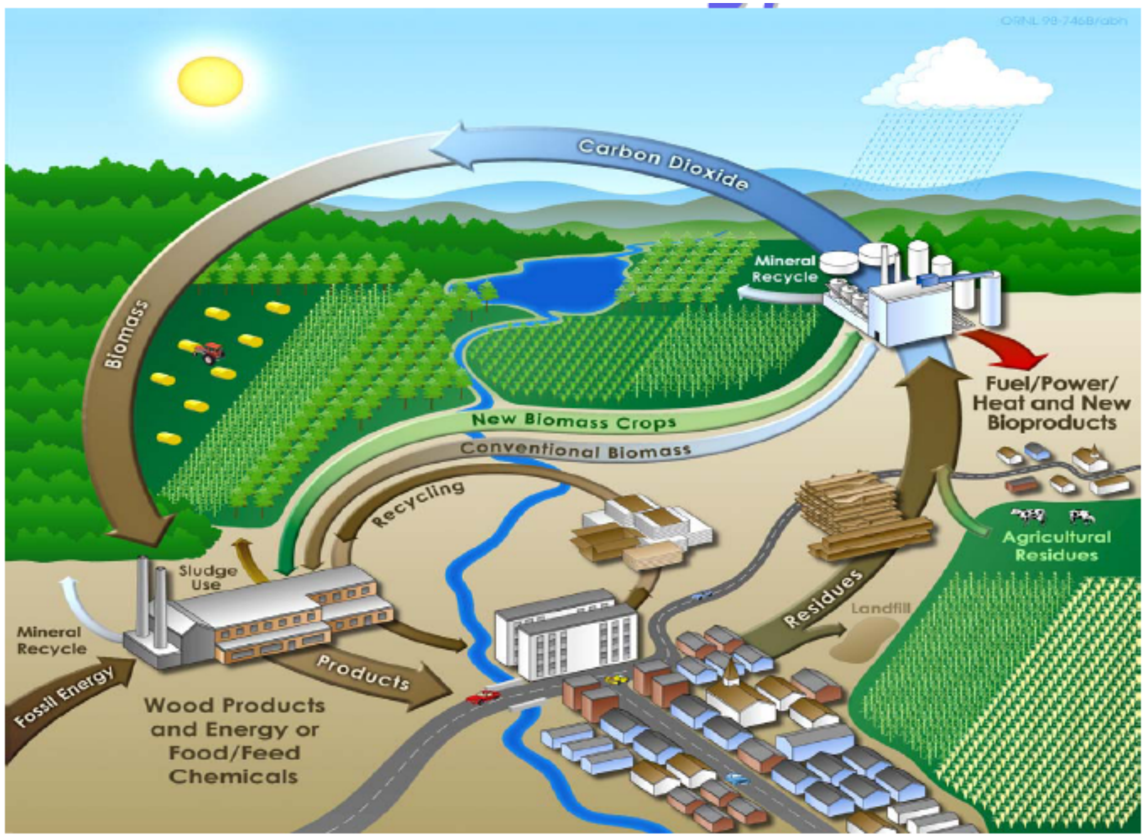
World biofuels production increased by 0.9% in 2015, the slowest rate of growth since output declined in 2000. Global ethanol production increased by 4.1%, the third consecutive year of growth, led by increases from Asia Pacific, South & Central America, and North America. Biodiesel production declined by 4.9% in 2015, with output declining in all of the major producing regions.

CO_2 emissions



EIA: INTERNATIONAL ENERGY OUTLOOK 2016

Biomass Cycle: “carbon neutral”



Photosynthesis: CO_2 + H_20 + light + chlorophyll → CH_2O + O_2

Some net output of CO_2 due to energy needed.

Legal framework

EUROPE

Directive 2009/28/CE

Goal: Achieving 20% share of energy from renewable sources in total energy consumption in the EU in 2020 and a mandatory minimum of 10% of biofuels over all transport fuels consumed in 2020 for all Member States.

Reduction of greenhouse emissions in bioethanol process using different feedstock

Feedstock	Reduction Greenhouse emissions
Wheat	32%
Corn	56%
Sugar cane	71%
Wood waste	80%

Directive 2015/1513, amending Directive 2009/28/CE
New goals: Reaching at least 27% renewables use by 2030.
Contribution of conventional biofuels in transport from a maximum of 7% in 2021 to 3.8% in 2030.

UNIVERSIDAD DE CANTABRIA

Legal framework

First World Climate Conference
- 1979

- 1997
The Kyoto Protocol was adopted

1G

The Kyoto Protocol came into force
- 2005 - 2012

2G

- 2008
European strategy 20/20/20

Directive 2009/28/CE
- 2009

- 2015
Directive 2015/1513

3G

Paris Agreement
- 2015

... it is a TOP ISSUE

theguardian

Biofuels: could agave, hemp and saltbush be the fuels of the future?

Oilier plants, new processing technologies and multipurpose crops could put the biofuel industry back in the race for transport fuels

Dyani Lewis

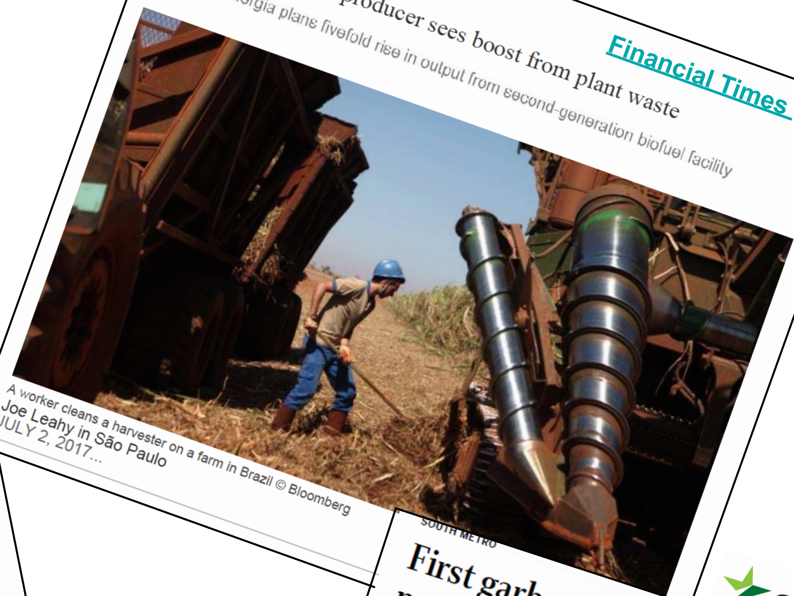
Wed 10 Ma...

Biofuels

Brazilian ethanol producer sees boost from plant waste

Raízen Energia plans fivefold rise in output from second-generation biofuel facility

Financial Times



A worker cleans a harvester on a farm in Brazil © Bloomberg

Joe Leahy in São Paulo

JULY 2, 2017...

CHINADAILY 中国日报网 .COM.CN

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China planning nationwide use of biofuel b... 2020

By Zheng Xin and Zou Shuo | China Daily | Updated: 2017-09-14 07:18

China has for the first time set a targeted timeline to roll out the use of ethan... nationwide for cars by 2020, part of its efforts to clean up pollution and opti... energy mix.

The plan was unveiled as the country is promoting the use of biofuel, a... fossil fuel, according to the National Energy Administration.

According to a plan jointly released by the National Development... the National Energy Administration, and the Ministry of Finance... nation-wide use of ethanol-added gasoline by 2020, while targ... of cellulose ethanol and advanced biofuel technologies by 20...

The Telegraph

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Business

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Business

Shell plans UK's first 'no-petrol' stat... as journey towards clean motoring continues

share

SOUTH METRO

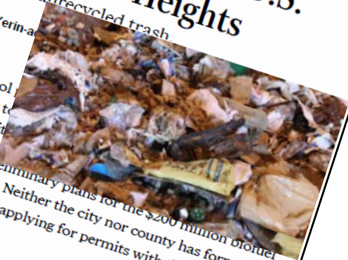
StarTribune

First garbage-to-ethanol plant in U.S. proposed for Inver Grove Heights

Facility could take all of county's unrecycled trash.

By Erin Adler (http://www.startribune.com/erin-a...

APRIL 9, 2017 — 11:32PM



What would be the first garbage-to-ethanol ... for Inver Grove Heights, with the capacity t... solid waste each year into the gasoline addi...

Enerkem, a Canadian company, delivered preliminary plans for the $200 million biofuel facility at a City Council meeting in February. Neither the city nor county has formally looked at the proposal, but the firm has begun applying for permits with the state Pollution Control Agency.

The privately financed facility wouldn't be built for at least three years.

Council members and officials are "cautiously optimistic" about the project, said City Administrator Joe Lynch. "It's quite exciting, if it works, to have that in our community, to be known for that in the U.S. and maybe the world," he said.

The facility would generate taxes on a now-vacant property and create more than 100 jobs, Lynch said, that would pay $40,000 to $70,000 a year. The 10-acre site is a mile west of Hwy. 52 near the Pine Bend and Dawn Way landfills, he said.

INNOVADORES Wolfgang Warnecke

'En 2050, las refinerías no producirán gasolina para el transporte nunca más'

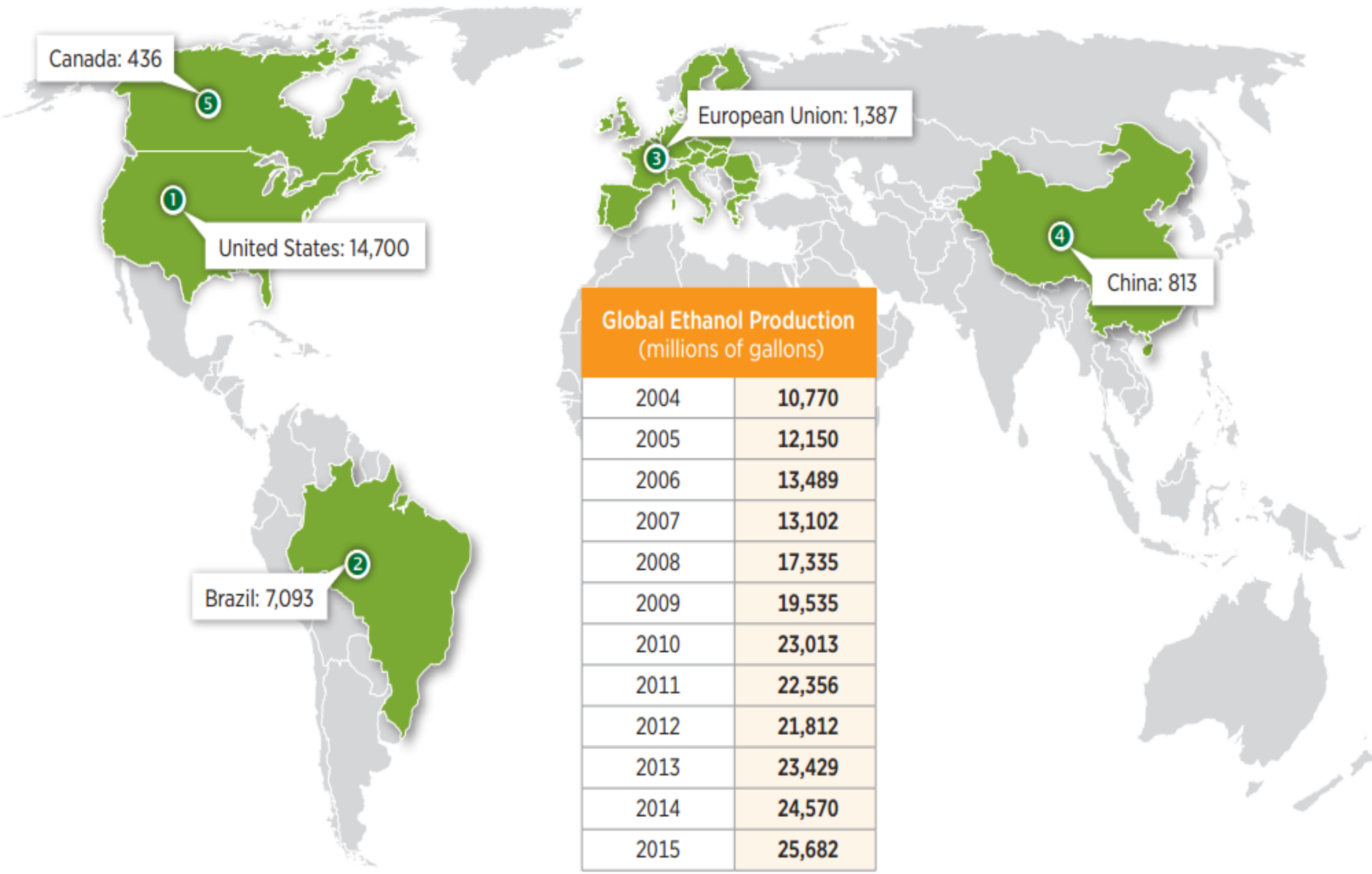
- El jefe científico mundial del área de movilidad de Shell prevé que dentro de 35 años todos los vehículos serán 100% sostenibles

MARÍA CLIMENT > Enviada especial > Róterdam (Países Bajos)
Actualizado:30/05/2015 **12:37 horas**
7

Los coches han guiado la vida del doctor Wolfgang Warnecke. Tanto en el plano profesional como en el personal. En su esfera privada se declara un apasionado de la industria. Disfruta conduciendo su moto de carreras y coleccionando coches antiguos (que, por cierto, también restaura). Su hobby no deja de estar presente en su trabajo; en este caso, en una de las mayores multinacionales del mundo. El ingeniero es el responsable científico del área de movilidad en Shell (o, en inglés, 'Chief Scientist Mobility'). Warnecke conoce la industria del combustible a fondo. Trabaja como científico para Shell desde 1987 y en 2005 ganó, junto al doctor Wolfgang Steiger, el Premio Professor Ferdinand Porsche, unos de los reconocimientos más

Ethanol Production

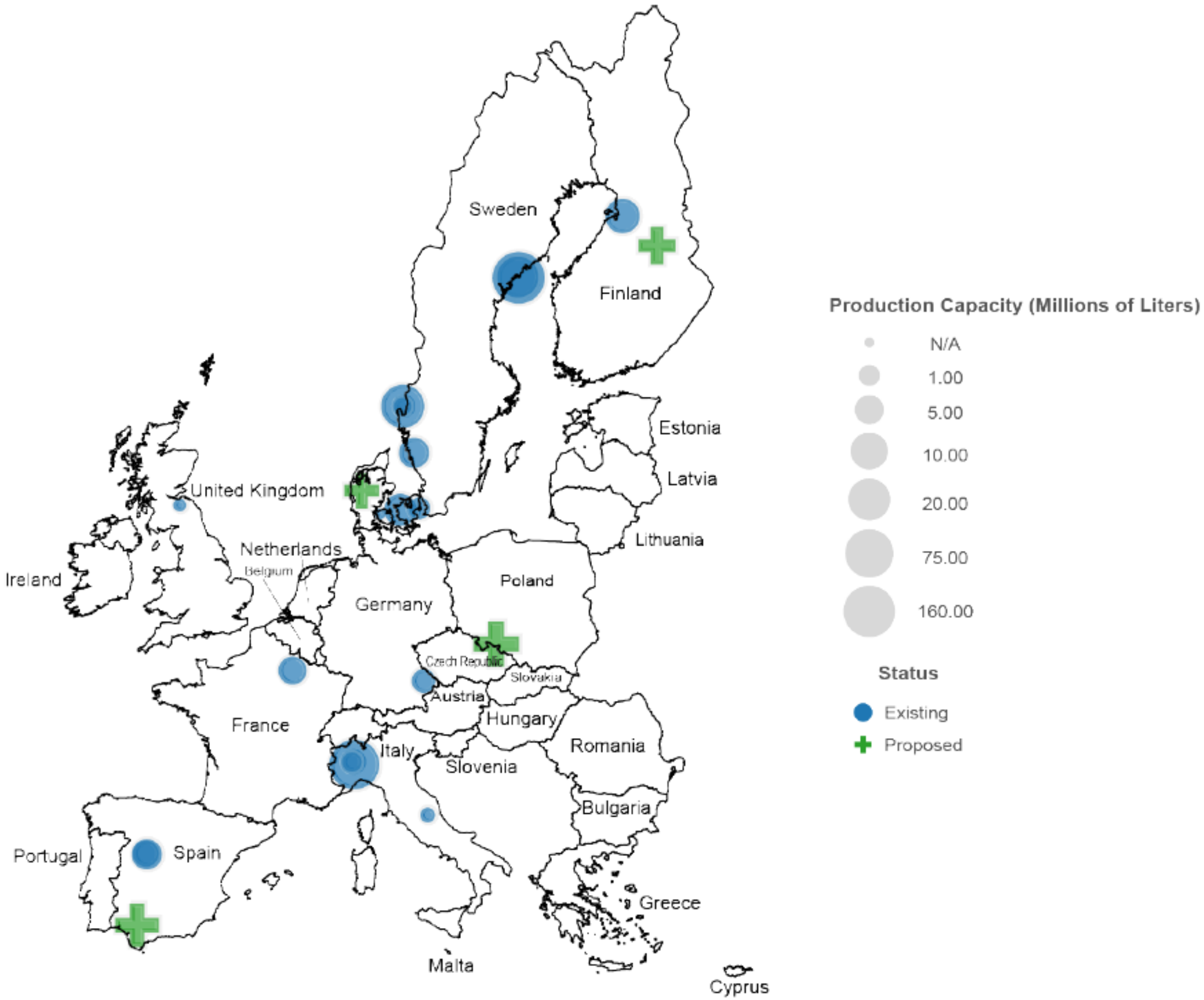
Top Five Regions (2015) Ethanol Production (millions of gallons)



Global Ethanol Production (millions of gallons)	
2004	**10,770**
2005	**12,150**
2006	**13,489**
2007	**13,102**
2008	**17,335**
2009	**19,535**
2010	**23,013**
2011	**22,356**
2012	**21,812**
2013	**23,429**
2014	**24,570**
2015	**25,682**

Renewable Energy Data Book, 2015

Ethanol Production



UN Conference on trade and development "Second generation biofuel markets" 2015

Design Project:

Preliminary design and cost estimation to produce cellulosic ethanol via hydrolysis

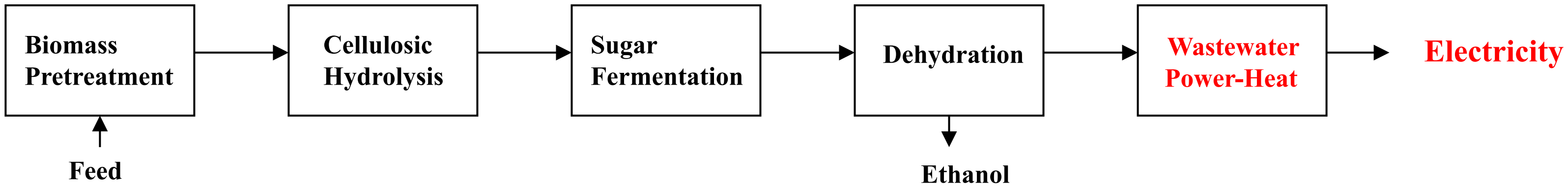
Demand : 200 ML bioethanol / year
(Plant: Biocarburantes Castilla y León, Biofuel plant located in Salamanca, Spain
http://www.abengoabioenergy.com/web/es/acerca_de/oficinas_e_instalaciones/bioetanol/europa/biocarburantes_cast_leon/index.html).

Ethanol Specs (fuel grade):

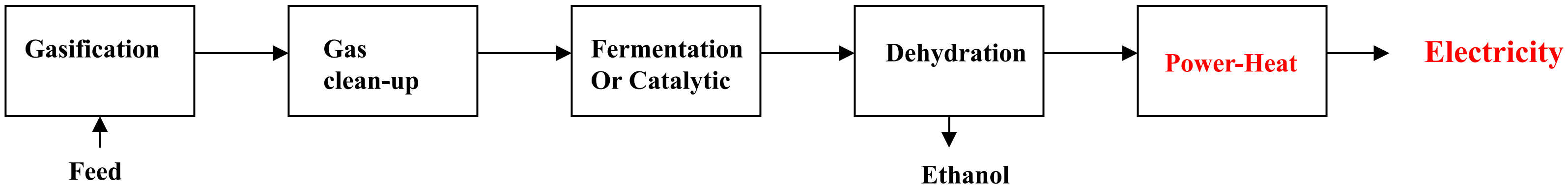
Ethanol content 99.85% by weight min
Water content 0.1% by weight max
Other impurities 0.05% by weight max

Production for bioethanol: Two major routes

a) Hydrolysis (fermentation) THIS PROJECT



b) Thermochemical (gasification)



Project: Hydrolysis route

Challenges:

a) <u>Alternatives for flowsheets</u>

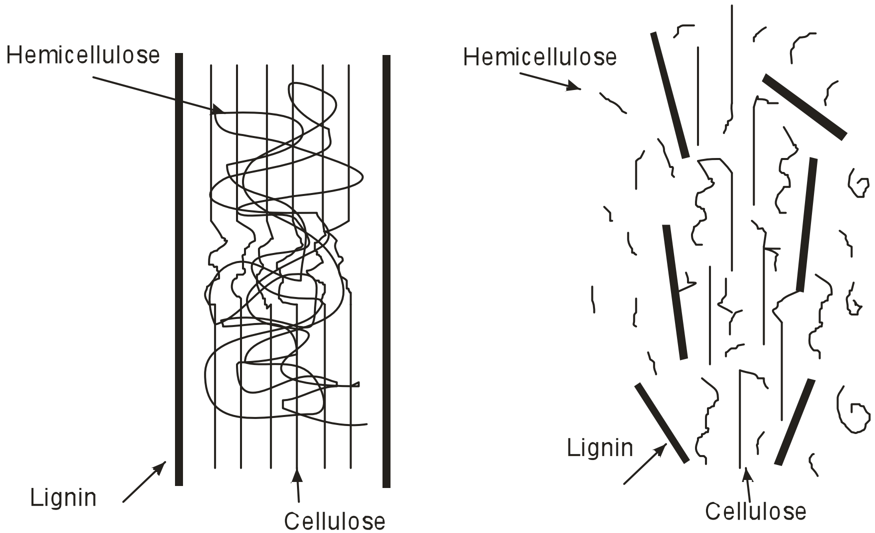
b) Difficult to achieve economic feasibility

Pretreatment alternatives

Alternatives

- Physico-Chemical (AFEX, Steam explosion, CO_2 explosion)
- Chemical (acid, Alkali, Ozone, peroxides) ?
- Physical (milling, grinding…)
- Biological (Enzymes) ?

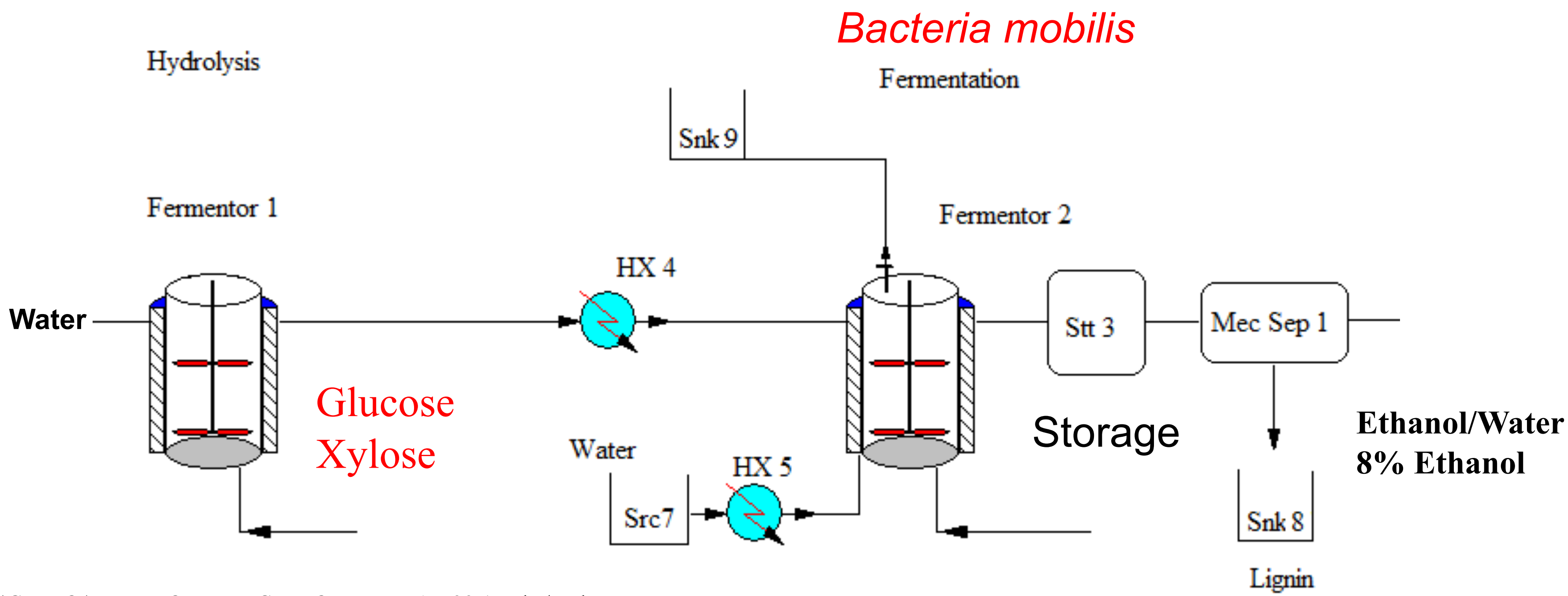
AFEX = Ammonia Fiber Explosion



Before Pretreatment   After Pretreatment

Goal: Break Cellulose and Hemicellulose

Hydrolysis and Fermentation



$$(C_6H_{10}O_5)_n + nH_2O \longrightarrow nC_6H_{12}O_6 \qquad \Delta H = 22.1n \text{ kJ/mol}$$

$$(C_5H_8O_4)_m + mH_2O \longrightarrow mC_5H_{10}O_5 \qquad \Delta H = 79.0m \text{ kJ/mol}$$

~ 1 day res. time

Lignin source of energy

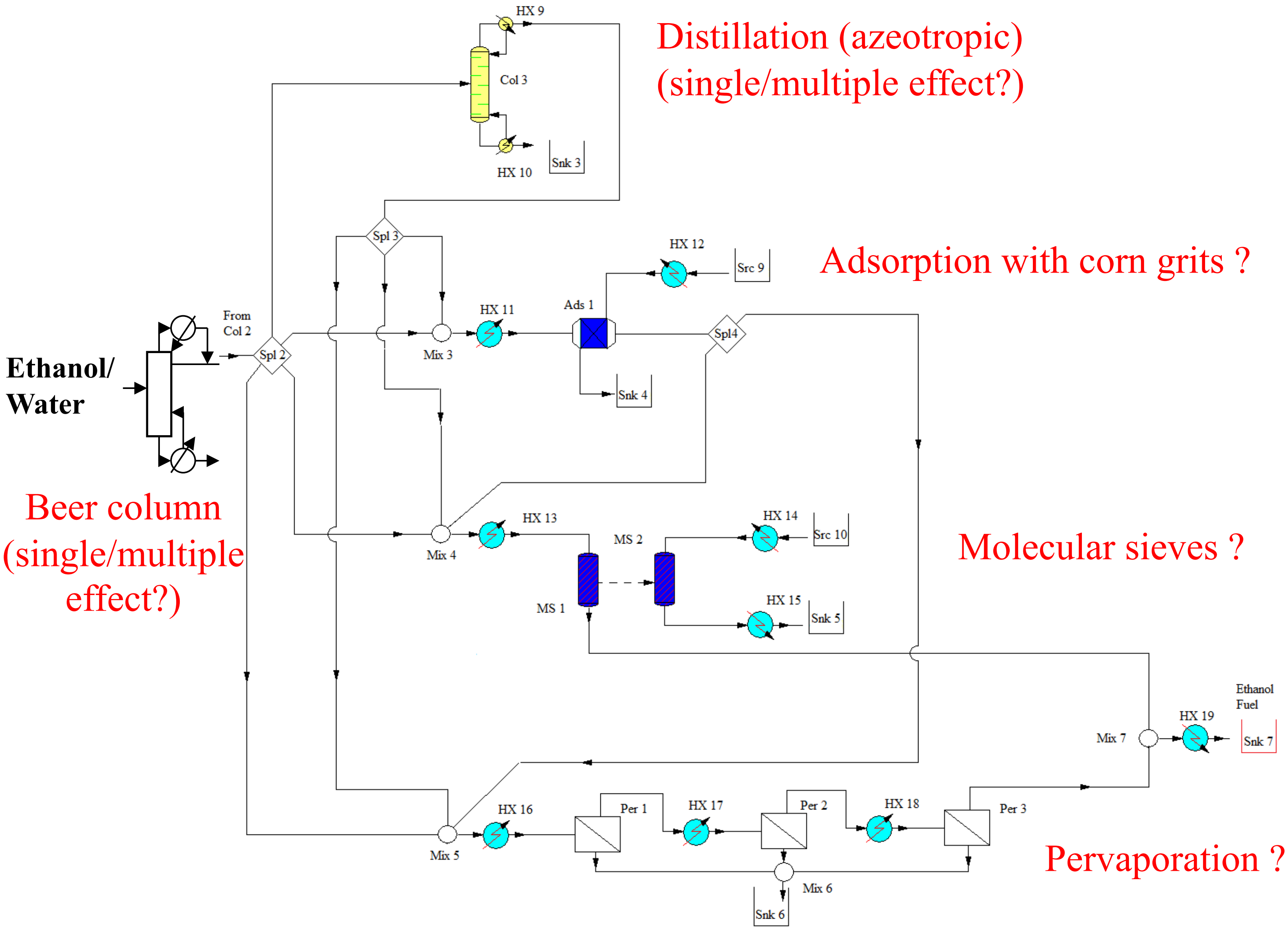
~ 3 days res. time

Fermentation Reactions

Reaction	Conversion
Glucose → 2 Ethanol + 2 CO_2	Glucose 0.92
Glucose + 1.2NH_3 → 6 Z. mobilis + 2.4 H_2O + 0.3 O_2	Glucose 0.04
Glucose + 2 H_2O → Glycerol + O_2	Glucose 0.002
Glucose + 2 CO_2 → 2 Succinic Acid + O_2	Glucose 0.008
Glucose → 3 Acetic Acid	Glucose 0.022
Glucose → 2 Lactic Acid	Glucose 0.013
3 Xylose → 5Ethanol + 5 CO2	Xylose 0.8
Xylose + NH_3 → 5 Z. mobilis + 2 H_2O + 0.25 O_2	Xylose 0.03
3Xylose + 5 H_2O → 5Glycerol + 2.5 O_2	Xylose 0.02
3 Xylose + 5 CO_2 → 5 Succinic Acid + 2.5 O_2	Xylose 0.03
2 Xylose → 5 Acetic Acid	Xylose 0.01
3 Xylose → 5 Lactic Acid	Xylose 0.01

Neglect acetic acid, succinic acid, lactic acid (organics)

Separation alternatives



Preliminary Design Project

❖**Memo 1: Literature Review, Initial Flowsheet** (discuss alternatives, select flowsheet), **Gross economic evaluation**

❖**Memo 2: Mass and energy balance**

❖**Memo 3: Economic evaluation**

❖**Oral presentations: Global summary of the project**

Memos in general: **Cover letter (memo)**
Main Text
Refs: articles, patents, encyclopedias, web
Appendix: Flowsheet; Tables; Calculations.

Note: Flowsheet symbols → Aspen Software
References → Library of University of Cantabria

Application of formative assessment: each Memo will be reviewed by the teacher and returned to the student. The student will learn from the mistake made and will apply the knowledge obtained to the next Memo.

Project Leaders & Consultants

Project Leaders:

- ❖Javier Viguri vigurij@unican.es (Office 313)
- ❖Eva Cifrian cifriane@unican.es (Office 388)

Consultant group:

Each group of consultants must have a record of the working hours outside the classroom. Each week the group must report to the teacher about this.