GLOBAL BIOENERGIES

From carbohydrates to hydrocarbons

March 2013

Disclaimer

This presentation contains certain forward-looking statements that have been based on current expectations about future acts, events and circumstances. These forward-looking statements are, however, subject to risks, uncertainties and assumptions that could cause those acts, events and circumstances to differ materially from the expectations described in such forward-looking statements.

These factors include, among other things, commercial, technical and other risks e.g. associated with estimation of the price of carbohydrate resources, oil and modeling costs, the meeting of development objectives and other investment considerations, as well as other matters not yet known to the Company or not currently considered material by the Company.

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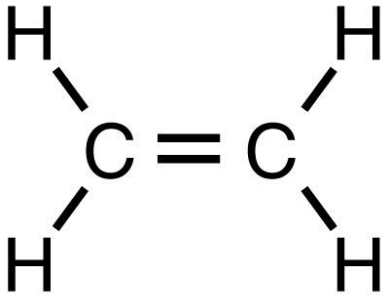
Mission statement

Converting renewable resources into **light olefins** through **direct** fermentation

Producing olefins in a different way

Yesterday:
Fossil resources

Petrochemistry



Olefins: gaseous hydrocarbons, key building blocks of the chemical industry

Industrial Biology

Tomorrow:
Renewable resources

1 Ethylene

2 Propylene

3 N-Butenes

4 Butadiene

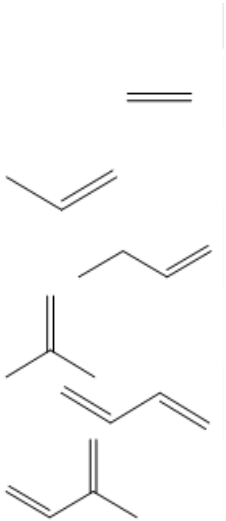
5 Isobutene

6 Isoprene

A small number of molecules constitute the heart of petrochemistry

Why is it interesting?

- Because these molecules are the key building blocks of the petrochemical industry
- Huge markets – wide product trees in plastics, elastomers and fuels – drop in

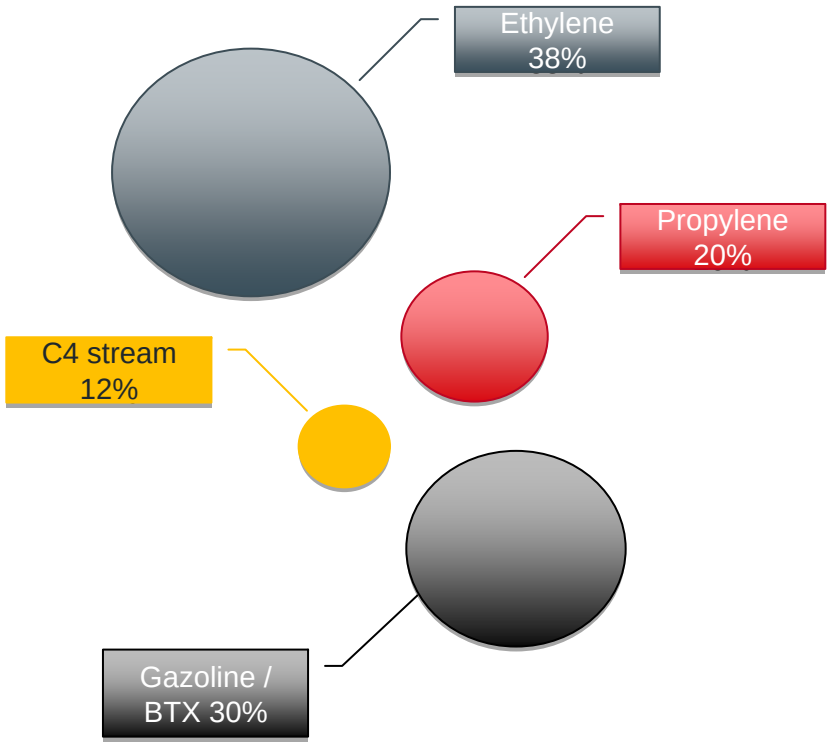


	Existing Market (b$)	Potential Market (b$)	Main applications
Ethylene	144		Polyethylene (60%)
Propylene	88		Polypropylene (65%)
Linear butenes	37-74		Co-monomers in various plastics
Isobutene	29	>400	Tires, organic glass, PET, fuels
Butadiene	14.6		Tires, nylon, coating polymers
Isoprene	2	10	Tires, adhesives

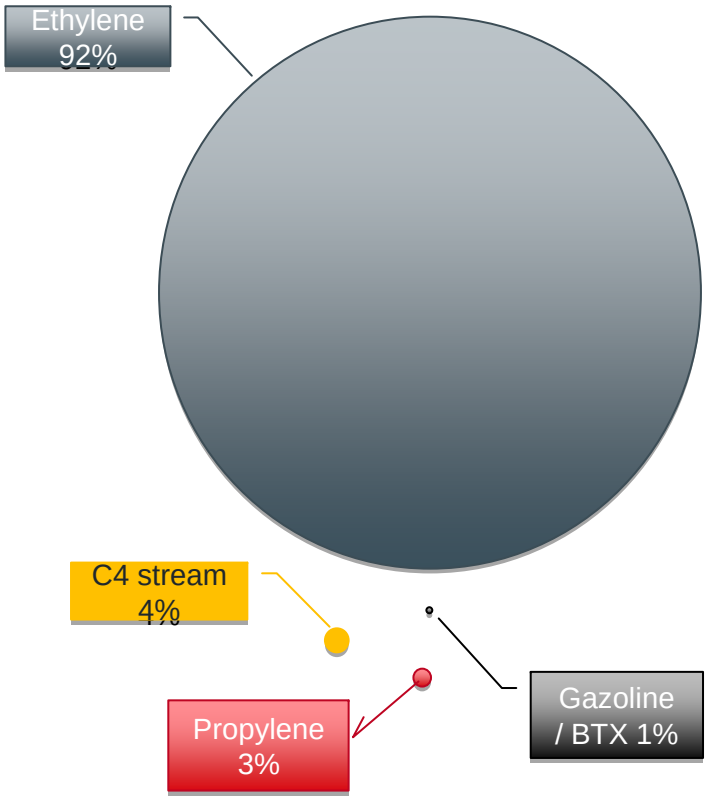
[1]: ICIS statistics – 29th january 2010
[2]: SRI reports

Market unbalance

Conventional Naphtha Cracking



Shale gas Cracking



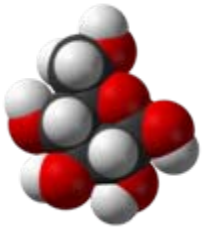
- The growth of shale gas will lead to a shortage in propylene, C4 olefins and BTX stream and create the opportunity for alternative routes

A unique opportunity

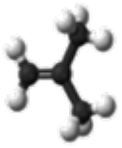
- Approaches based on classical industrial biology techniques can not be applied to light olefins
- There wasn’t any process development to bio-produce light olefins undertaken before the creation of Global Bioenergies
- This situation was paradoxical: The scientific and business community had left untouched one of the most promising opportunities
- A breakthrough was necessary to overcome the technical barrier and biologically produce light olefins
- This breakthrough innovation has been achieved by Global Bioenergies

Designing artificial metabolic pathway

No natural pathway to light olefins



Glucose



Isobutene

Creation of totally new metabolic pathways

-Enzymatic reactions never described

-Metabolic intermediates absent on earth

New « synthetic biology » approach

Strong IP Protection

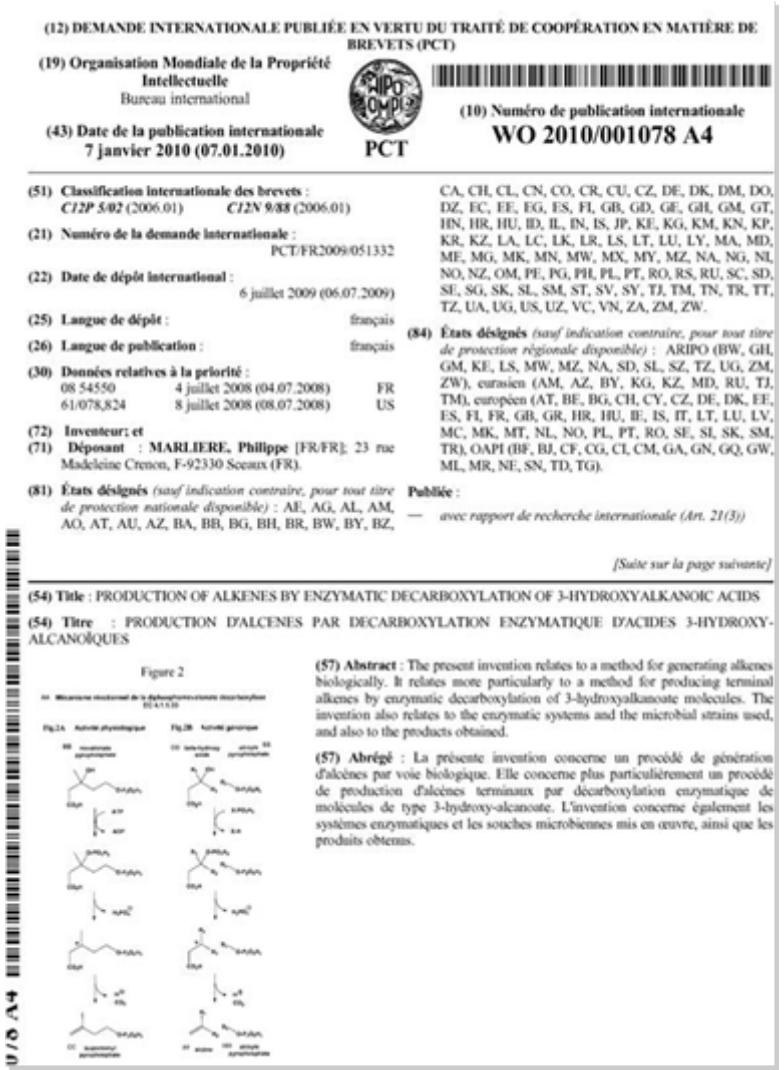
- Sound Intellectual Property

  Exclusive rights on 14 patent applications protecting different aspects of the technology

- Product is traceable (^{14}C content)

- Additional know-how barrier:

  strains & process book



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Publiée :
— *avec rapport de recherche internationale (Art. 21(3))*

[Suite sur la page suivante]

(54) Title : PRODUCTION OF ALKENES BY ENZYMATIC DECARBOXYLATION OF 3-HYDROXYALKANOIC ACIDS

(54) Titre : PRODUCTION D'ALCENES PAR DECARBOXYLATION ENZYMATIQUE D'ACIDES 3-HYDROXY-ALCANOÏQUES

Figure 2

(57) Abstract : The present invention relates to a method for generating alkenes biologically. It relates more particularly to a method for producing terminal alkenes by enzymatic decarboxylation of 3-hydroxyalkanoate molecules. The invention also relates to the enzymatic systems and the microbial strains used, and also to the products obtained.

(57) Abrégé : La présente invention concerne un procédé de génération d'alcènes par voie biologique. Elle concerne plus particulièrement un procédé de production d'alcènes terminaux par décarboxylation enzymatique de molécules de type 3-hydroxy-alcanoate. L'invention concerne également les systèmes enzymatiques et les souches microbiennes mis en œuvre, ainsi que les produits obtenus.

Design of synthetic metabolism

Natural metabolism

GBE Artificial Pathway

Patents
WO2011032934
EP2304040

Glucose **Acetyl-CoA** **Acetone** **Isobutene**

Heterologous pathway

GBE artificial pathway

HmG-CoA synthases

EC 2.3.3.10

(patent WO/2011/032934)

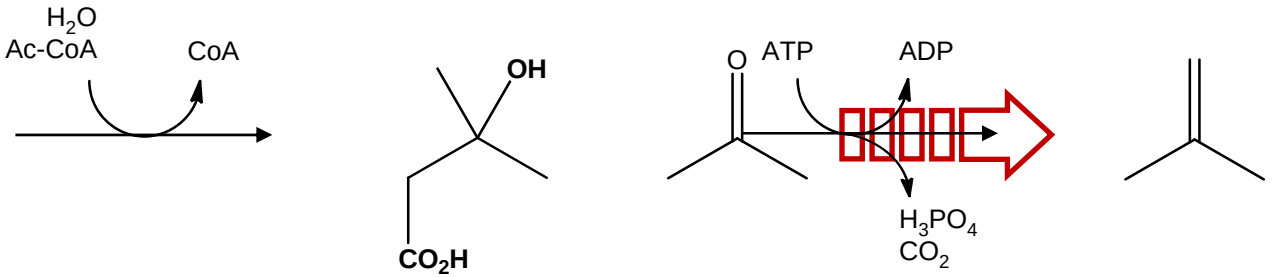
DiP-MVD decarboxylases

EC 4.1.1.33

(patent WO/2010/001078)

GBE Artificial Pathway

Patents
WO2011032934
EP2304040



3-Hydroxyisovalerate **Acetone** **Isobutene**

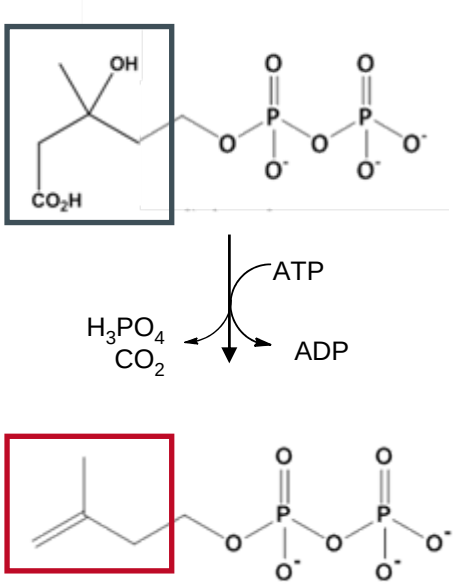
Enzyme discovery

DiP-MVD decarboxylases

EC 4.1.1.33

Natural reaction

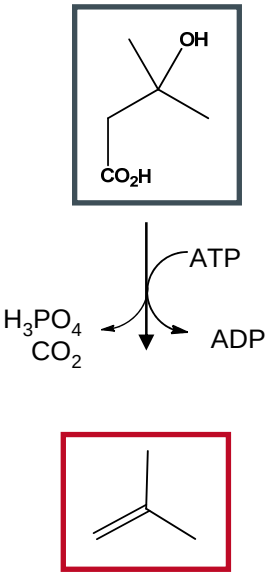
Mevalonate-5-diphosphate



Isopentenyl-diphosphate

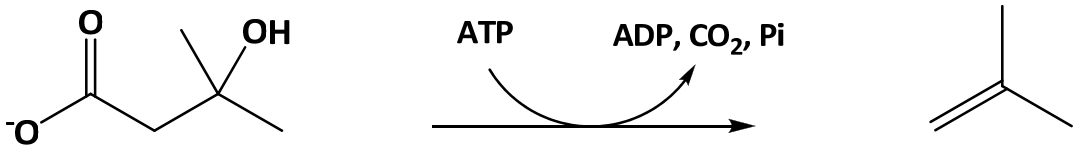
Artificial reaction

3-Hydroxyisovalerate



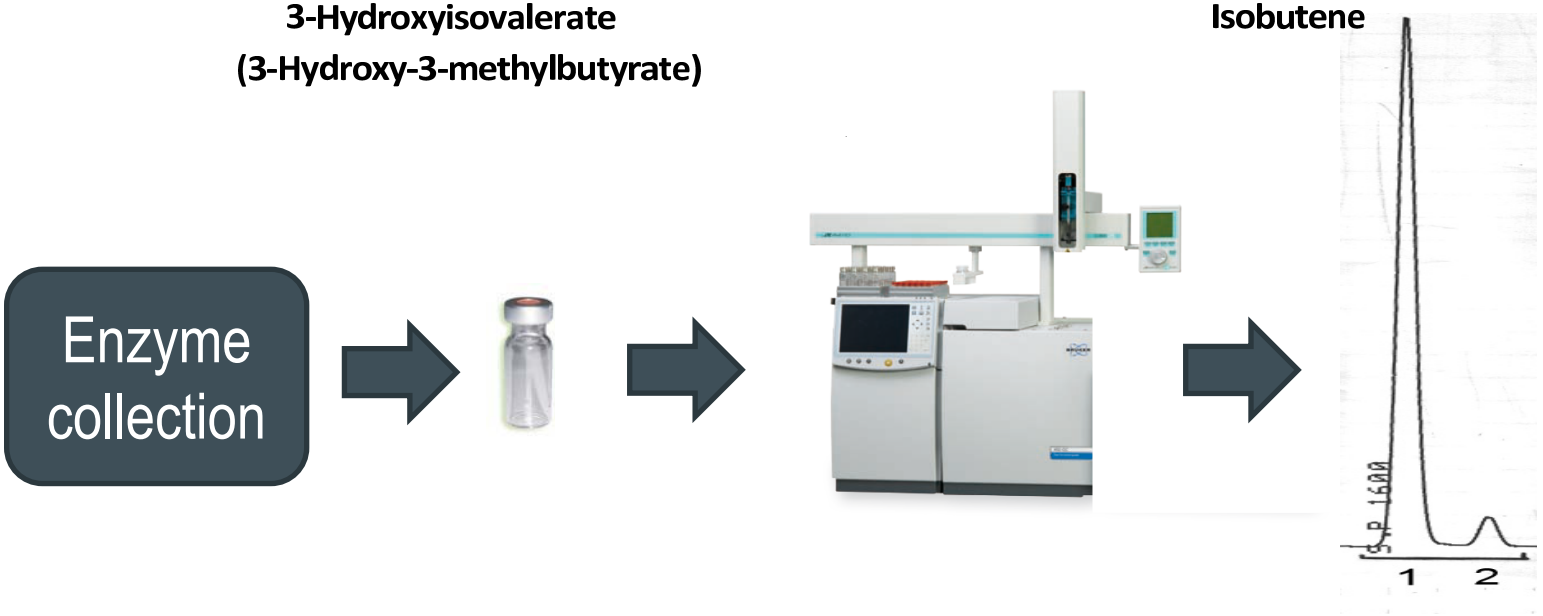
Isobutene

Screening



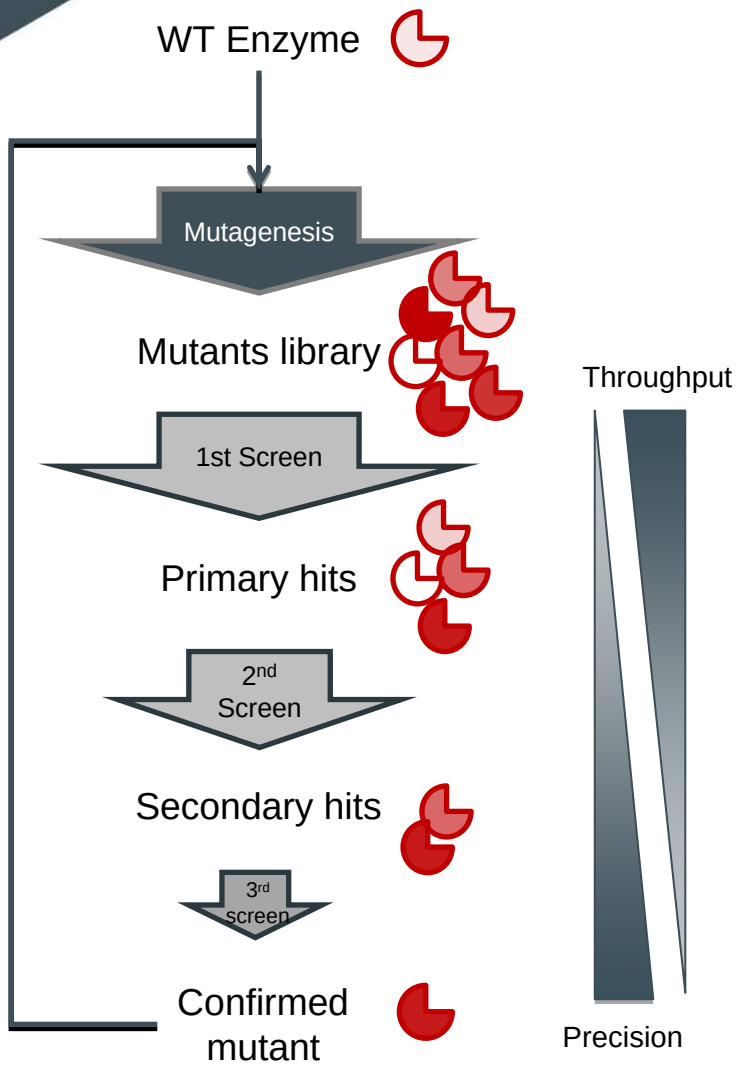
3-Hydroxyisovalerate
(3-Hydroxy-3-methylbutyrate)

Isobutene

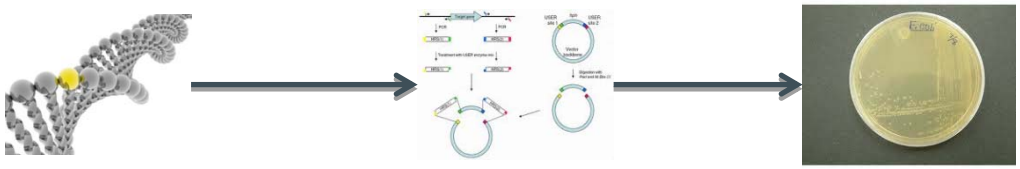


- HTS technology platform adapted to the identification of enzymatic activities involved in the synthesis of light olefins
- Similar results were obtained for the « HIV synthase » segment

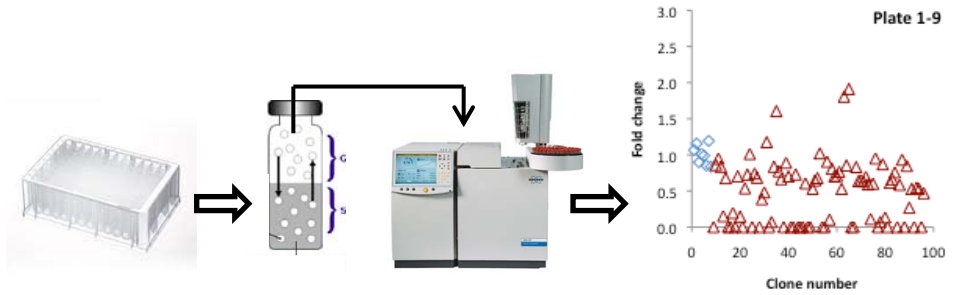
Directed evolution strategy



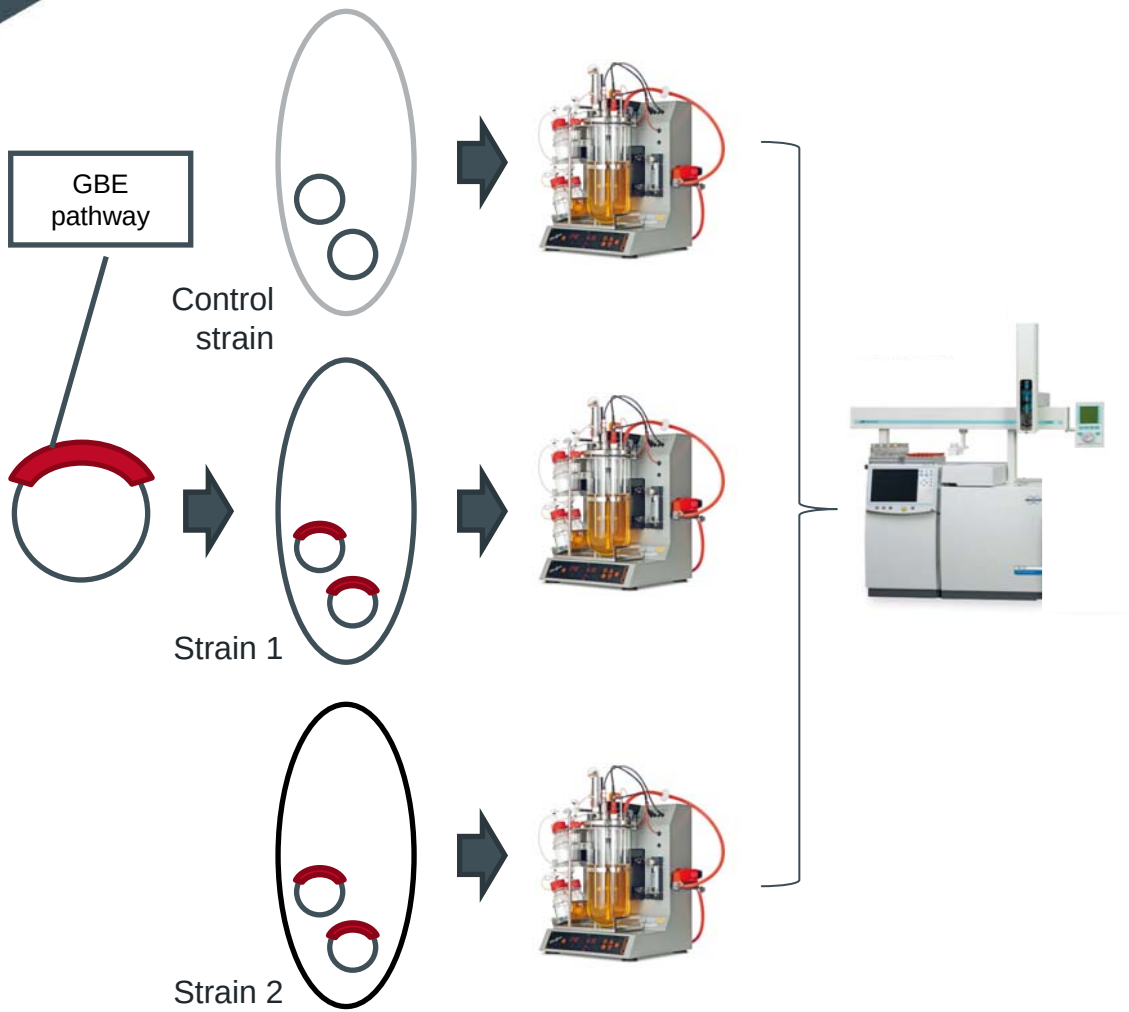
Library creation

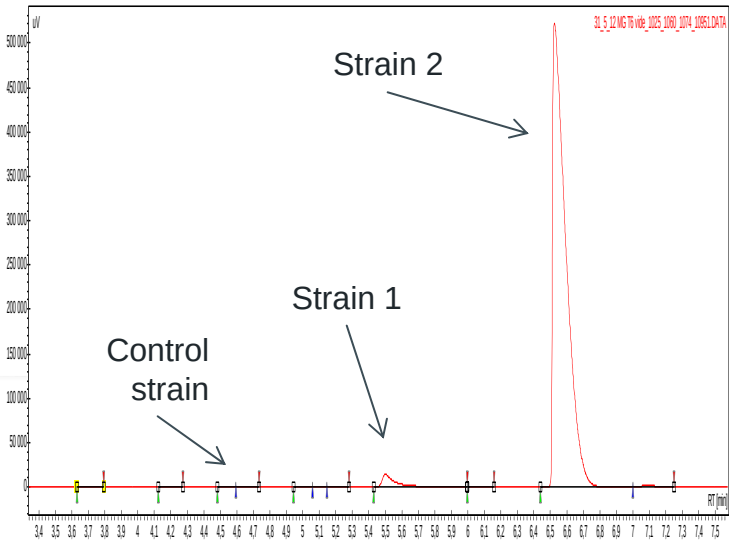


Selection assay



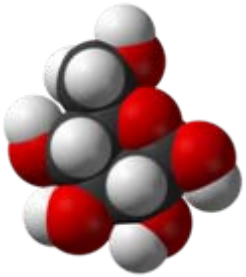
in vivo implementation – strain optimisation



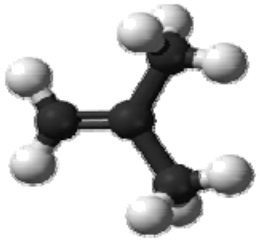


Cloning → Fermentation → GC Analysis

Process development



Glucose



High purity gaseous Isobutene

1. No toxicity
2. No distillation

Low cost and excellent environmental balance

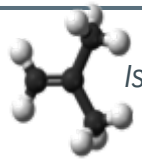
A major competitive advantage

1 Direct route — GLOBAL BIOENERGIES

Glucose

Gaseous fermentation

One single step allows the direct production of a high-purity gaseous isobutene



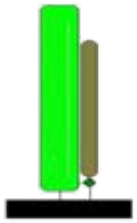
Isobutene

2 Indirect route: complex and costly

Glucose

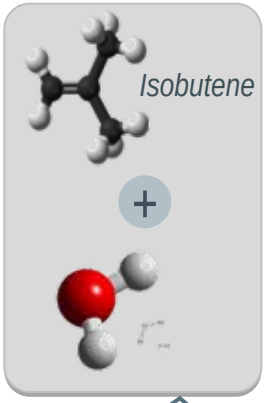
Liquid fermentation

Isobutanol



Purification

Thermochemical dehydration

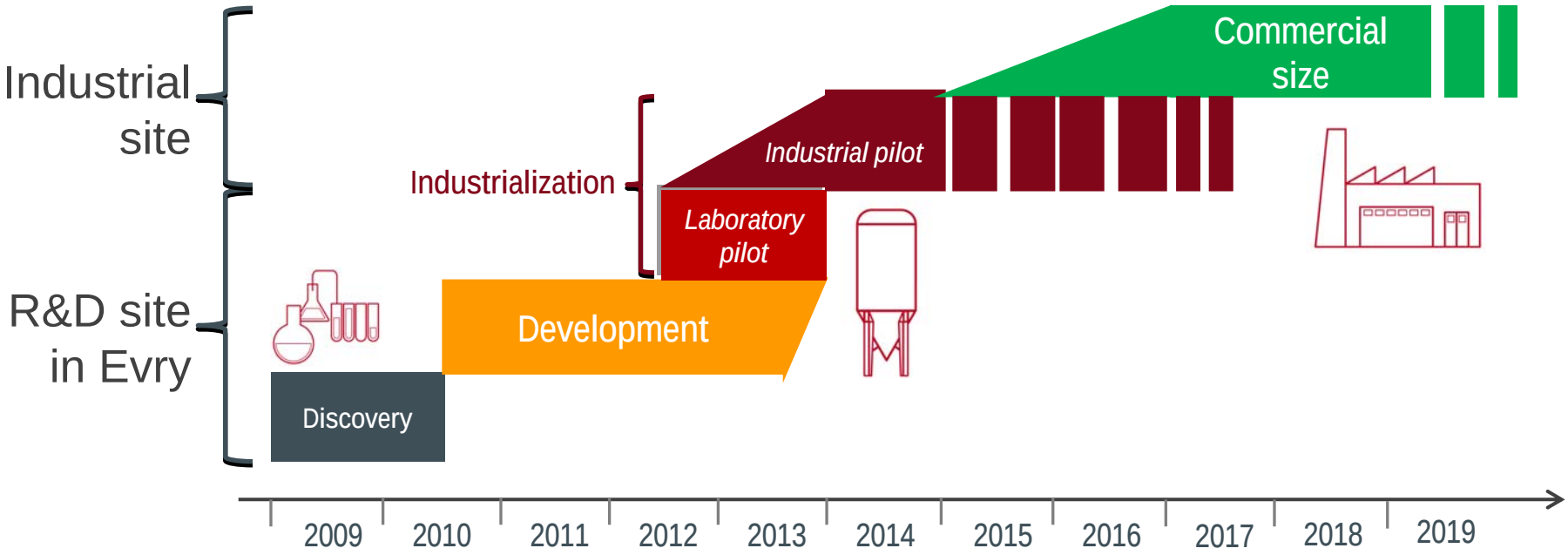


Two additional complex and energy-consuming steps

Lower purity

Global Bioenergies' process presents major advantages

Isobutene industrialization schedule



Jan 2013: *- more than half of the development has been accomplished*
- lab pilot in operation; industrial pilot in preparation

An experienced management team…

Liliane Bronstein
CFO

Since 1997, CFO in public fast-growing and innovation companies.
Led several IPOs and M&A operations.

Marc Delcourt
CEO

Thomas Buhl
Head of Business Development

Former positions in technology transfer at CEA, business development in the white biotech sector and strategic development at TecDAX company MorphoSys.

…gathering scientific experts and industry veterans

Industrialization

Dr. Charles E. Nakamura
Metabolic engineering

25 years at DuPont.
Received ACS award in 2007

Dr. Richard E. Bockrath
Chemical engineering

Former technical director at DuPont

Development

Dr. Sabine Mazaleyrat
Enzyme optimization

PhD in molecular biology at Manchester University (UK), subsequently in charge of a protein engineering platform at Astra-Zeneca.

Dr. Romain Chayot
Strain engineering, fermentation

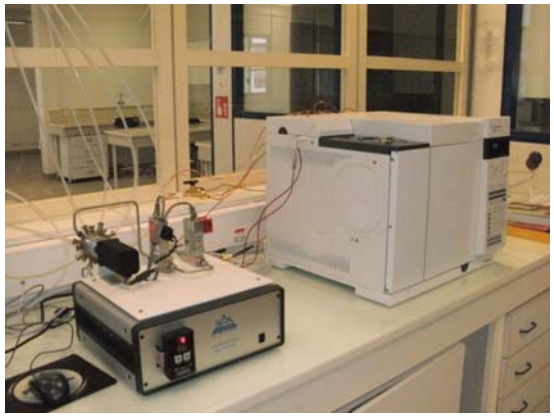
PhD in microbiology at Institut Pasteur in strain engineering.

Research

Dr. Macha Anissimova
Discovery

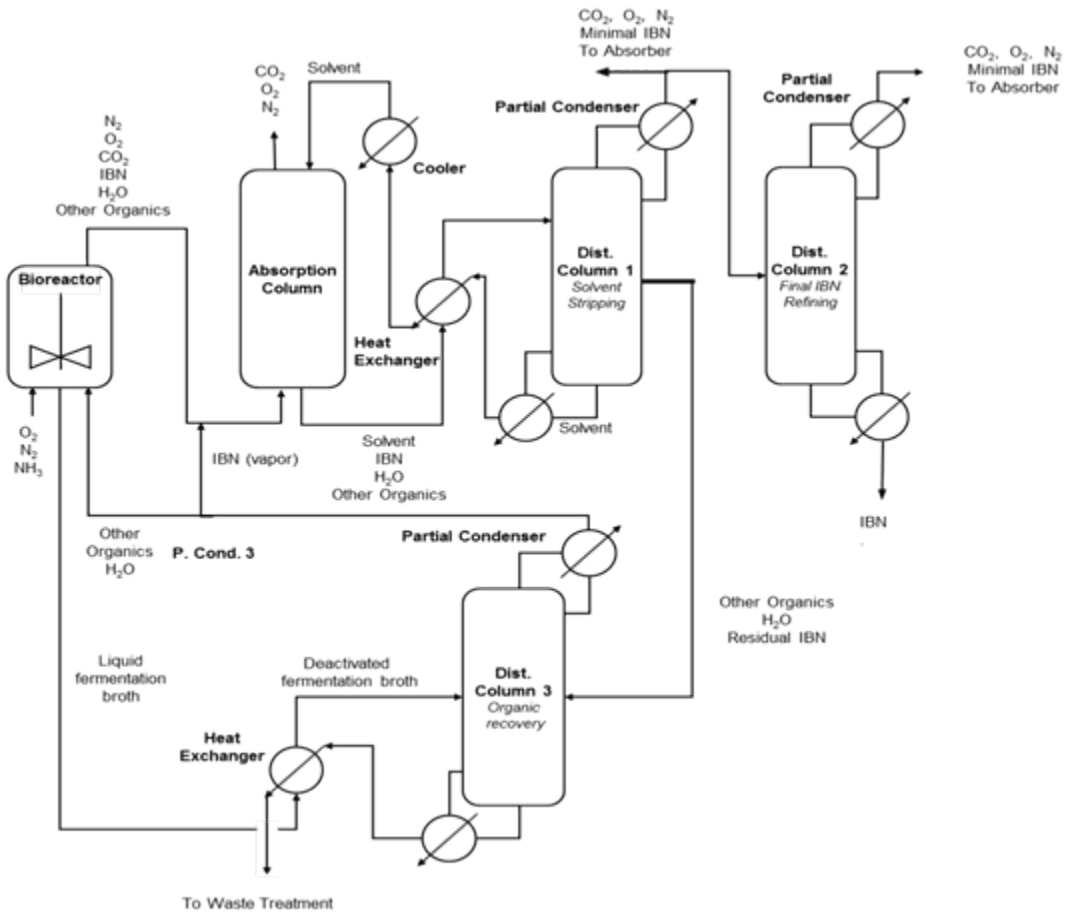
PhD in Enzyme Engineering at UTC Compiègne. 10 year experience at CEA and ICSN.

Lab pilot



- 42L fermenter + online detection installed in Evry
- Kg samples to be obtained in 2013

Industrial pilot



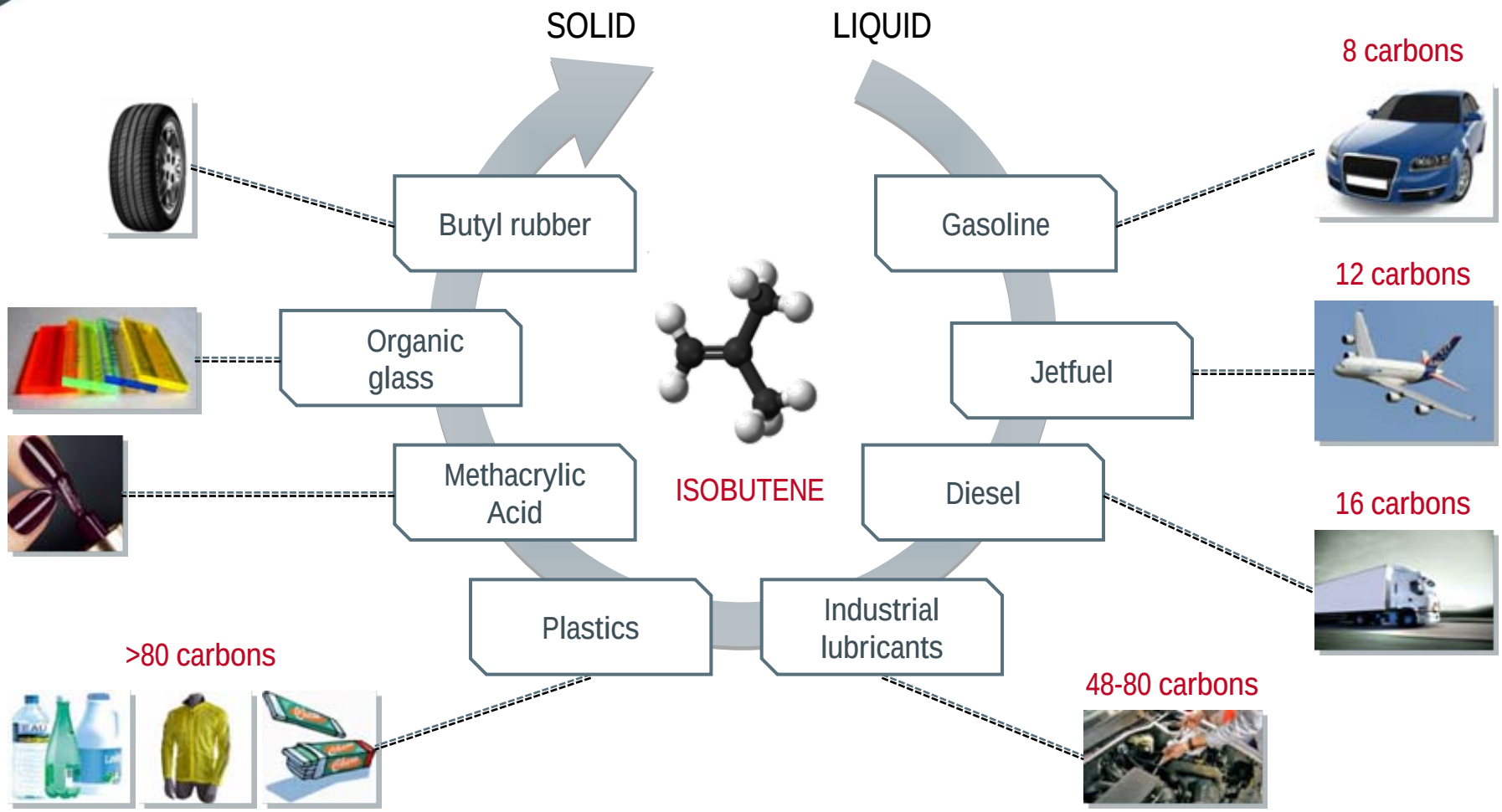
Process Flow Sheet

- Ton scale samples to be produced in 2014 and transferred to industrial prospects

Why did we choose to start with isobutene?

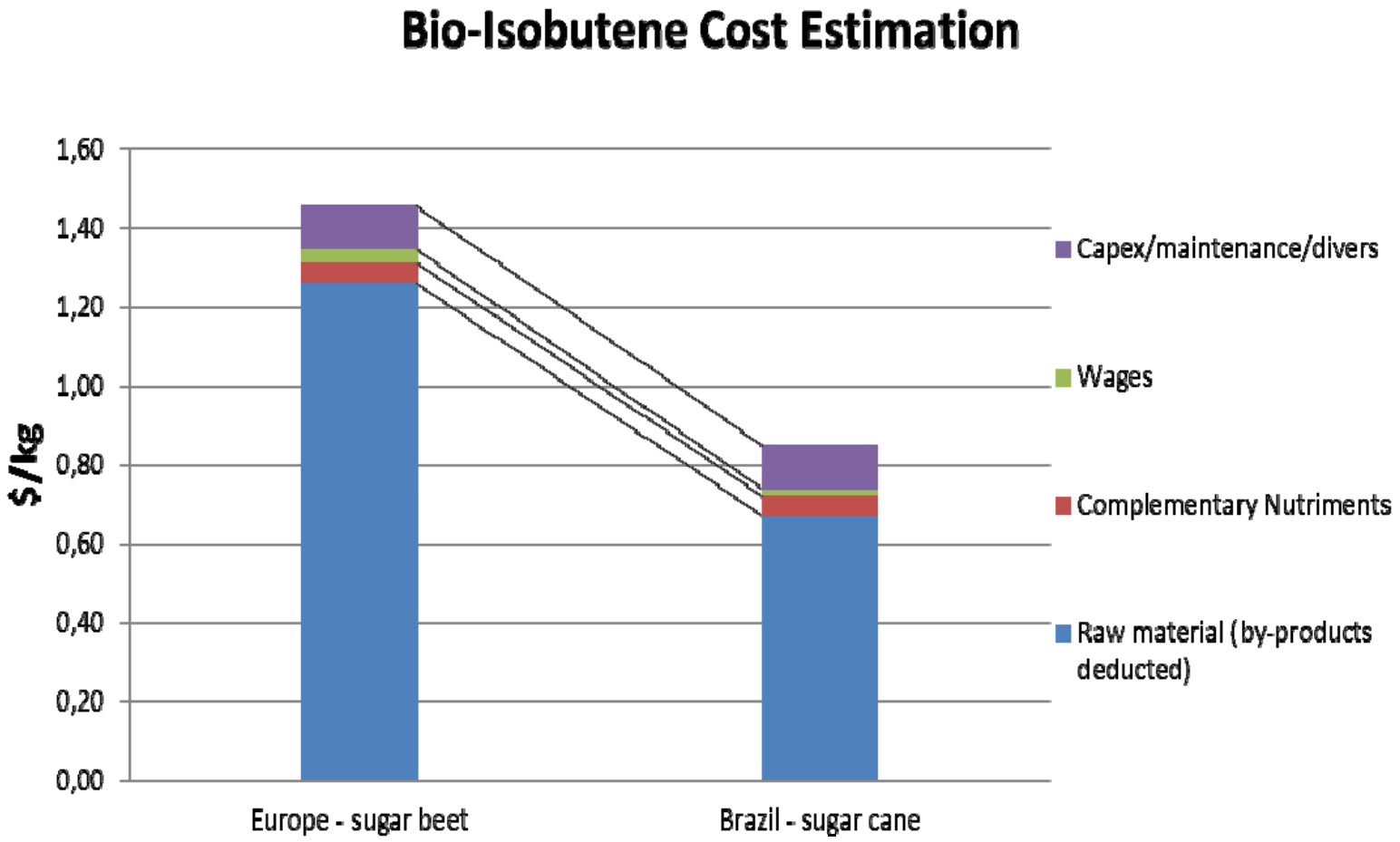
- Since 2008 :
  - Ethylene prices are decreasing (due to the shift to shale gas and natural gas crackers)
  - Prices of other olefins are increasing (due to reduced capacities of Naphtha crackers)
- Adjustment of prices for n-butene, propylene and butadiene ongoing or expected due to existing/developing methods to derive them from ethylene
- Isobutene can not be produced from ethylene ➔ no adjustment of price increase expected
- The market is expecting an alternative route for isobutene manufacturing

Isobutene: a large product tree



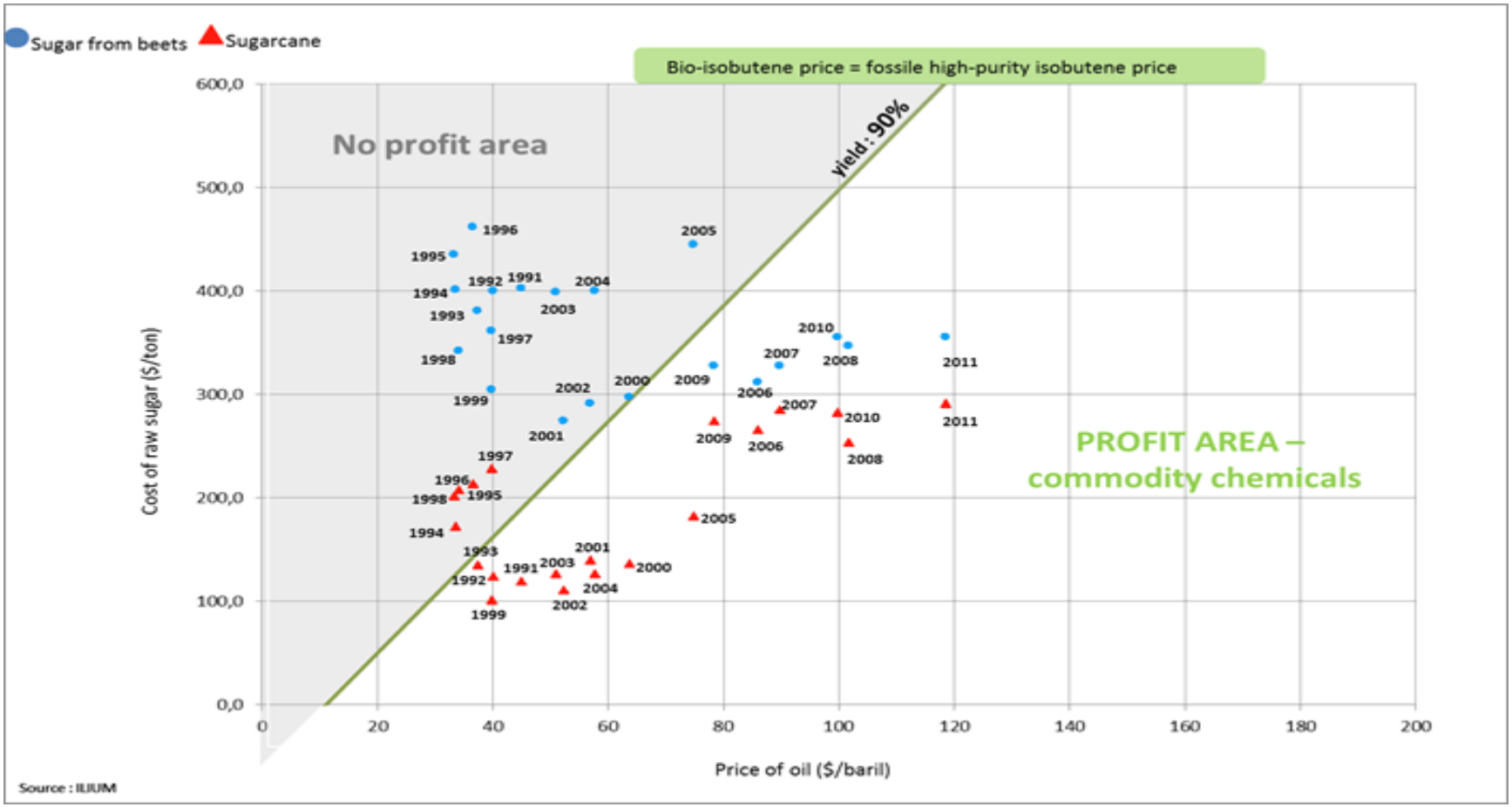
Numerous products and markets based on a single olefin

Estimated costs



Feedstock is the principal cost-driver

Profitability – preliminary analysis



Market conditions would translate into an increasingly profitable usage of the bio-isobutene process for commodity chemicals applications.

Biofuels applications

- In the field of fuels, profitability will be more difficult to achieve in the short term as fuel price is low (close to crude oil price).

- The production of biofuels remains essential:
  - The oil peak is close and worldwide demand is increasing
  - There is no satisfactory alternative to liquid fuels.

- The market will adapt and the best technologies will prevail.

- The use of 2nd generation biomass, less expensive, will enable the development of biofuels on a large scale.

Collaboration: Global Bioenergies and LanzaTech : development of a process for the bioproduction of isobutene from domestic and industrial waste

Modeling of a typical production site

Amortization: $10m/year

(Investment: ~ $100-200m amortized over 10-20 years)

Feedstock

(700kT molasses for 350kT sugar)

$140m/year

Revenues

(100kT High purity isobutene)

$200m

Operational cost: $10m/year

Operating profit $40m (20% margin)

"specialty chemistry margins for commodity chemicals markets"

Source: company

A license-based business model

- Non-exclusive licenses, for 1 plant
- Expected revenues for Global Bioenergies:
  - €10m upfront payment per 100kT production capacity at construction of the production site,
  - 2-5% royalties (€3-8m per year per 100kT).
- Licensing phase to start in 2014 (Two option licenses already signed)
- Existing market: 15MT isobutene, i.e. 150 plants
- Such a licensing-based business model
  - is only possible because the existing market of isobutene is huge
  - eliminates the risk linked to transiting from R&D to Industrial exploitation

Targeted licensees

Biomass transformation industrialists

Sugar

Tereos, Cristal Union, Tate&Lyle, SudZucker, …

Starch

Roquette, ADM, Cargill, …

Petrochemical industrialists

Dow, BASF, Evonik, Mitsubishi, Arkema,…

Fuel companies

Oil companies

Total, Exxon, Chevron, BP, Shell, …

Fuel distributors

Independent distributors, retail store chains

Producers of down-stream products

Packaging producers, tire producers, cosmeticians, ...

Addressing some of the most important industrial sectors

Diverse feedstocks…

Sugar
170mT

Sugar beet

Sugar cane

Starch
2.070mT

Corn

Wheat

Rye, rice, barley, Potatoes….

Ligno-cellulose
To be industrialised in the near future

Potential x10.000mT

Forestry waste

Straw

Energy crops

CO (+H_2)

Steel mills

Municipal waste

Biomass (all types)

Business model: other molecules

- Running in parallel several R&D programs would represent a huge financial burden.
- Dedicated financing (grants or industrial partnerships) are sought for R&D programs on molecules other than isobutene.
- First example: butadiene.

Butadiene: a second vast product tree

$10bn market

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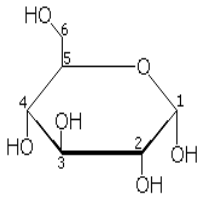
Nylon, Plastics, Latex

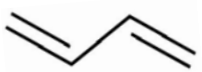
Carpet protectors, coating

Nylon

Glucose



BUTADIENE



$20bn market

synthos
chemical innovations

Rubber

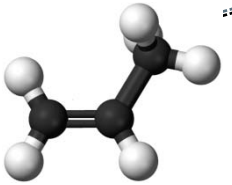
Pipes, joints…

Opportunities for a number of licenses in industrial applications other than rubber

Propylene

Glucose

PROPYLENE



Acrylic acid
Superabsorbent for diapers

Polypropylene
Dashboard

Cumène
Phenol Acetone

Oxo-alcohols / aldehydes
Plasticizers

Propylene oxide
Polyurethane

Acrylonitrile
Elastomers

Advantages of a “drop-in” product

- Currently, several tens of production sites worldwide use isobutene, butadiene or propylene as a feedstock.
- Possibility to install bio-olefins plants close to these sites.
- Production, storage and distribution infrastructures already exist and do not need to be rebuilt.

At a glance

Capital increase **€3 M** Opening in the **United States** (Iowa)	**2012**	**EuropaBio** award «most innovative European biotech SME» Validation of **bio-sourced propylene** Start of laboratory **pilot phase** Two Vice-Presidents named: **Metabolic Engineering and chemical Engineering**
OSEO **475 K€** Synthos becomes a shareholder **€1,4 M** IPO **€6,6 M**	**2011**	Collaboration agreement with **Lanzatech** Collaboration agreement with a German **car manufacturer** Collaboration with Synthos on **butadiene**
Opening in **Munich** OSEO **€760 K**	**2010**	Licence option is granted for a **major American industrialist** Frist isobutene production **prototype**
Raising **€3,2 M** Seventure Partners	**2009**	**Proof of concept** for the bioproduction of isobutene
Foundation of the company	**2008**	GLOBAL BIOENERGIES