Av. de l'Armée 6 - 1040 Brussels, Belgium
Tel.: +32 2 735 03 13 - Fax: +32 2 735 49 60
Web site: www.europabio.org - E-mail: mail@europabio.org

White Biotechnology: Gateway to a More Sustainable Future

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FOREWORD

White biotechnology, also called industrial biotechnology, has large potential to substantially impact industrial production and thereby contribute to a more sustainable future.

This booklet provides a brief summary of a study conducted by six innovative companies who are amongst the pioneers of white biotechnology. Together with the Oeko Institute, McKinsey & Company, and a scientific advisory board, the companies have documented their achievements to date with white biotechnology, and have estimated its potential for creating a more sustainable society – a society in which a profitable industry can deliver better products with a lower environmental impact.

The study demonstrates that social, environmental, and economic benefits go hand-in-hand.

Reductions in greenhouse gas emissions, energy, and water usage are examples of the benefits brought about by cleaner, greener, and simpler bio-processes. White biotechnology can also reduce the dependency on fossil fuels through the utilisation of renewable resources.

White biotechnology is already part of our daily life – vitamins and medicines as well as enzymes in washing powders are only a few of the many examples. Today, the application of biotechnology in large-scale industrial production is (technologically) coming within reach.

It is clear that the potential for a more sustainable society cannot be fulfilled by industry alone – we need the support of all stakeholders to realise our innovative endeavours. While the United States has endorsed a very progressive position towards white biotechnology, Europe has yet to define its policies to support this positive transformation.

The study outlines the advances, potential, and progressive actions required to make white biotechnology a success. This booklet is an invitation to all concerned stakeholders to work together with industry to create a more sustainable society for this and future generations.

Lyon, April 10, 2003

Feike Sijbesma
Chairman of EuropaBio and
Member of the Managing Board
of Directors of DSM NV

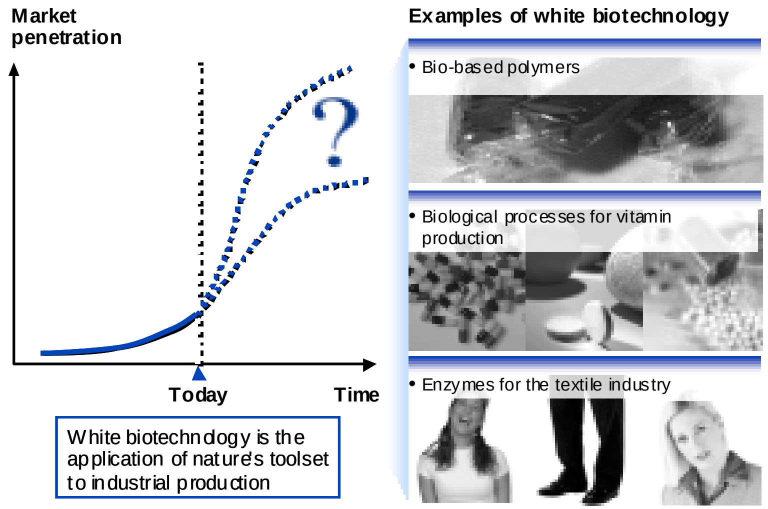
Hugo Schepens
Secretary General,
EuropaBio

What is White Biotechnology?

Biotechnology is not new – its underlying processes have been used by mankind for thousands of years, for example, in the production of wine and cheese. Modern biotechnology uses, amongst others, enhanced micro-organisms like yeast, moulds, and bacteria as “cell factories,” along with the enzymes derived from them, to produce a variety of goods. Biotechnology has found its entry into medicine (red) and agriculture (green), and now a new wave of modern biotechnology is gaining momentum – “white biotechnology” is the application of nature’s toolset to industrial production.

White biotechnology has become much more broadly applicable due to recently developed genetic techniques. Multiple enzyme variants, for example, can now be created at high speed, which are then screened for fit with the desired application.

DEFINITION WHITE BIOTECHNOLOGY



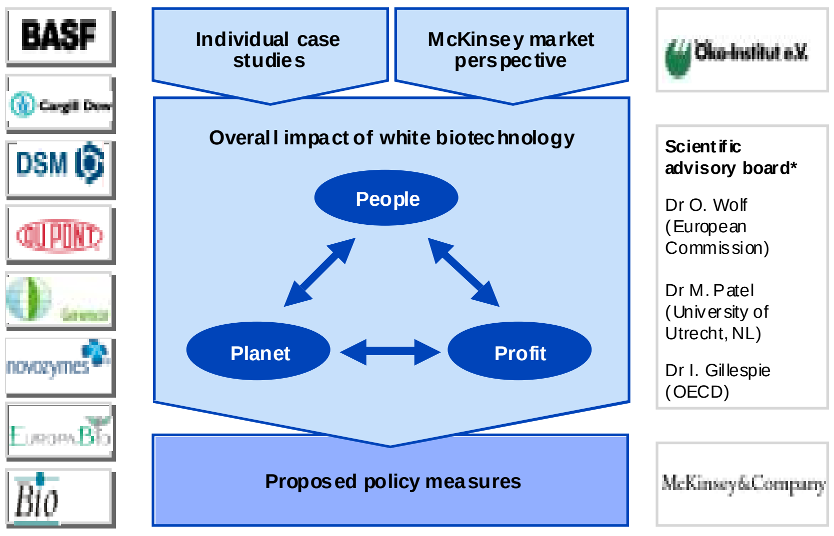
Benefits Seen in All Dimensions of Sustainable Development

Recently, a number of leading companies operating in white biotechnology joined forces with independent third parties to conduct an assessment of the potential impact of white biotechnology.

Detailed case studies were combined with a market analysis by McKinsey & Company to estimate the impact on the three elements of sustainable development: People, Planet, and Profit ("Triple P"). The results demonstrate that the social, environmental, and economic benefits of white biotechnology go hand-in-hand. If all stakeholders work together in a self-reinforcing cycle, white biotech could create new jobs, while reducing the impact on the environment and even creating economic value.

The study drafted recommendations for policymakers to capture the full potential of white biotechnology in the European market.

PROJECT SET-UP



* Not involved in policy recommendations

CASE STUDIES

Individual case studies were selected from a variety of white biotechnology applications and industrial sectors. A validated life cycle assessment was conducted by independent third parties such as the Oeko Institute in Germany. The analyses compared the white biotechnology application to traditional processes along a broad range of environmental impact factors (energy, raw materials, emissions, land use, and toxicology) as well as cost. The life cycle assessments spanned the value chain from "cradle to gate" (i.e., starting from raw materials and working through to the final product).

In summary, the case studies show that white biotechnology has a beneficial impact on both the environment and the economy. Energy efficiency is boosted, raw materials consumption is decreased, CO_2 emissions are substantially reduced, and production costs are usually lowered. This booklet presents just a brief summary of the case studies and examples of the impact found in a comprehensive analysis.

OVERVIEW CASE STUDIES

Case studies	Environmental impact*			Economic impact*
	Energy efficiency	Raw materials consumption	CO_2 emissions	Production costs
• Vitamin B2 (BASF)	+	++	+	+
• Antibiotic Cephalexin (DSM)	++	++	+	+
• Scouring enzyme (Novozymes)	+	+	0	+
• NatureWorks™ (Cargill Dow)	+	++	++	0
• Sorona® (DuPont)	+	++	+	+
• Ethylene from bio-mass (future scenario)	0	++	++	–

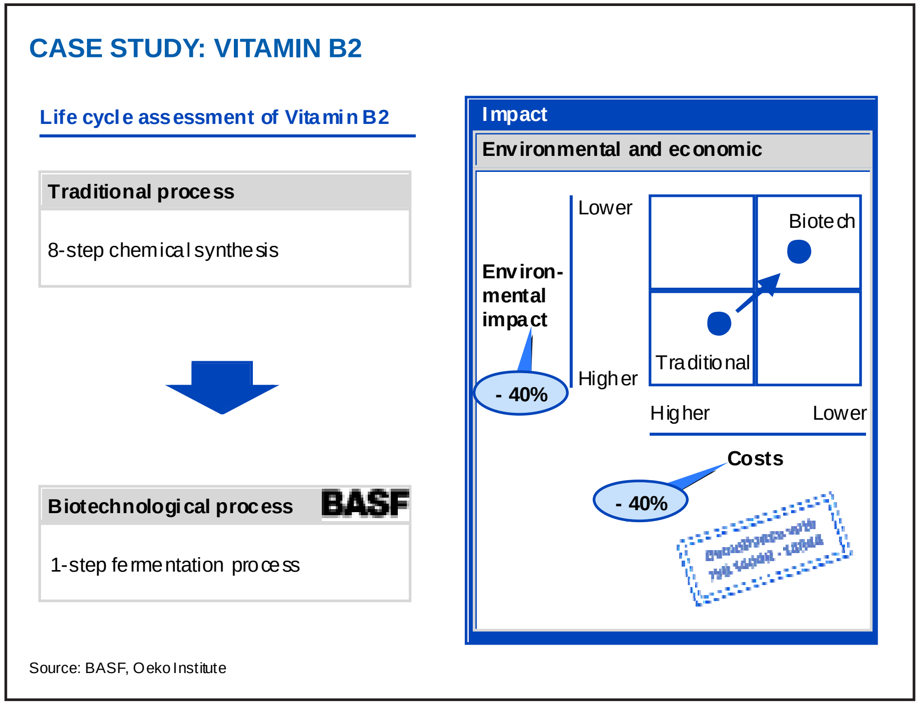
* Reduction for biotechnological process using ++ for more than 50% reduced, 0 for neutral (+/- 10%) and – – for more than 50% increased

Vitamin Bio-synthesis Benefits Environment and Economics

The first case study is BASF's Vitamin B2. Traditionally, Vitamin B2 is produced using a complex eight-step chemical process.

BASF's new biotech process reduces production to a one-step process. This single step is a fermentation whereby the raw material is fed to a micro-organism – in this case mould – that transforms it into the finished product. Vitamin B2 is recovered as yellow crystals directly from the fermentation.

This biotech process reduces overall costs by up to 40% and the overall environmental impact by 40%. The environmental impact is a weighted average of all key environmental factors based on the eco-efficiency methodology developed by BASF and the Oeko Institute. In this case, for example, it includes a reduction of CO_2 emissions by 30%, resource consumption by 60%, and of waste by 95%.

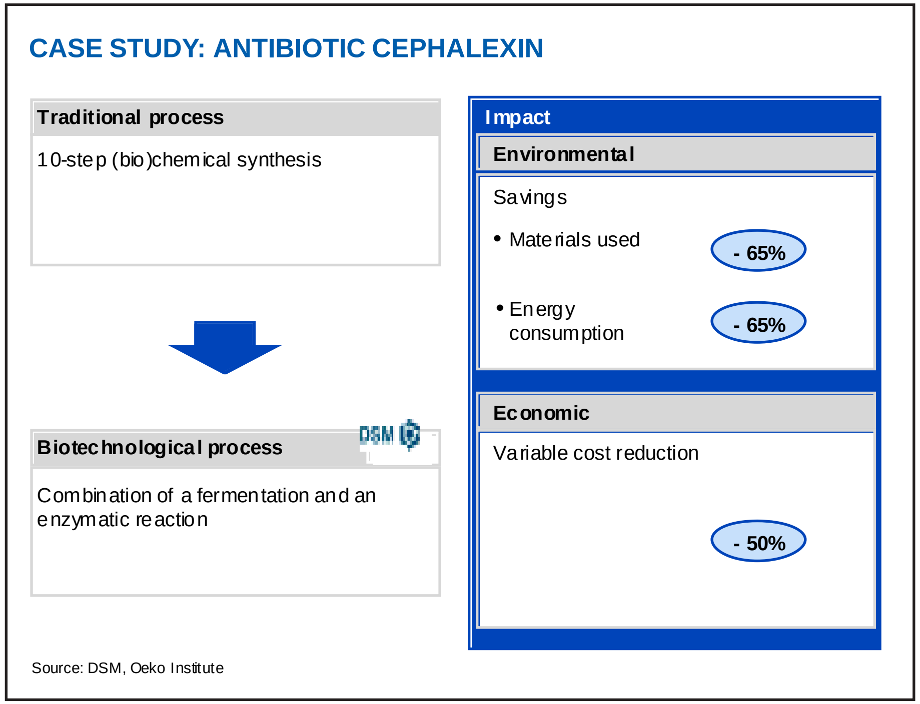


Using White Biotechnology in Antibiotic Production Reduces Energy, Materials, and Costs

Another good example is DSM's route to the antibiotic Cephalexin, practised on an industrial scale for several years.

The complex, traditional chemical process involved many steps. Metabolic pathway engineering helped to establish a mild bio-transformation route which has reduced the process steps substantially. The new route is based on a fermented intermediate linked enzymatically with a side chain to the final end product.

The biotechnological process uses less energy and less input chemicals, is water-based, and generates less waste in the process.

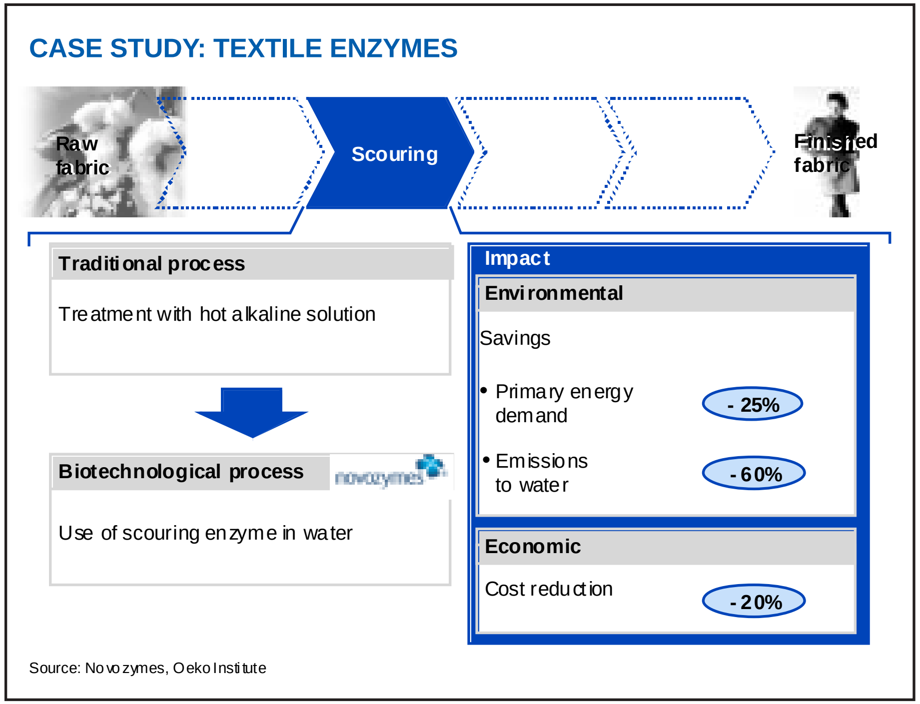


Enzymes Make Processes More Sustainable in Various Industries

Biotechnological products can contribute to more sustainable processes in a number of industries. One example is enzymes, which are, amongst others, nature's tools for digesting materials and catalysing reactions. Enzymes are already being applied today in chemicals, pulp and paper, food processing, mining, consumer goods, and textiles.

The company Novozymes provides, amongst others, enzymes for the scouring process in the textile industry. Scouring is the removal of the brown, non-cellulose parts of cotton, which in the traditional process involves the use of relatively harsh chemical solutions.

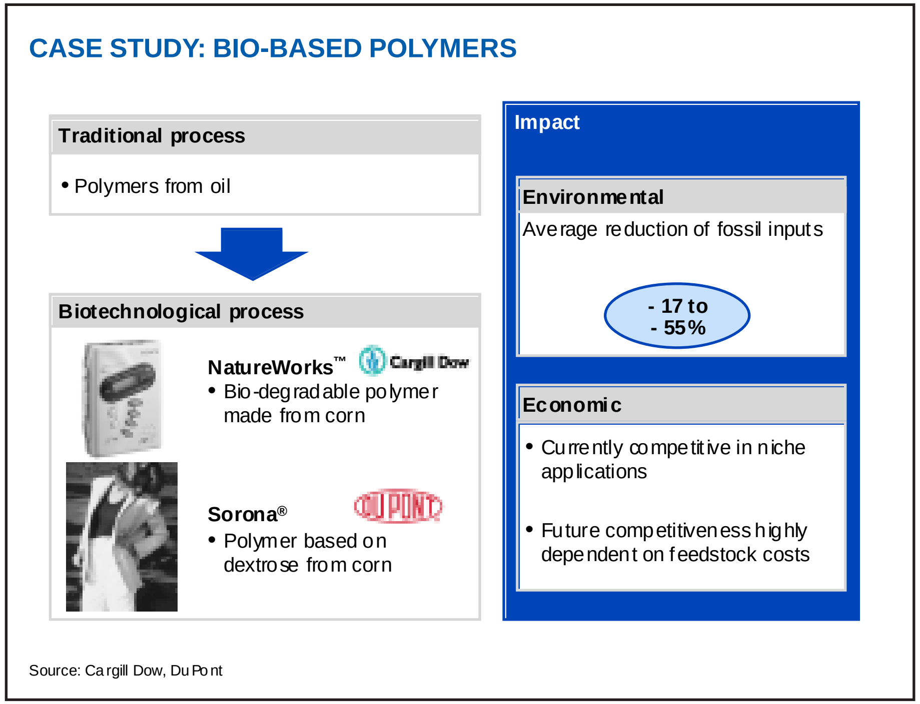
The life cycle assessment shows that the application of enzymes in the water-intensive textile industry can lead to fewer emissions into the water and reduced primary energy demand at 20% lower cost.



Bio-based Polymers Require Less Fossil Resources

Polymers are traditionally produced from limited fossil resources such as oil and natural gas. Bio-based polymers use renewable resources like sugars or corn as raw material. The first bio-based polymers are already on the market today. For example, NatureWorks™ from Cargill Dow is used to produce clothing, packaging materials, and electronic goods. A new product from DuPont, Sorona®, will incorporate the use of dextrose as one of its key feedstocks in the near future, based on a process developed in collaboration with Genencor.

The environmental benefits are eye-opening: NatureWorks™ already requires 25 to 55% less fossil resources, and it is targeted to replace fossil resources completely in the next five to eight years. Today, these polymers are competitive in niche applications and show high potential. Once they are being more widely produced on a global scale, bio-based polymers may even become cost-competitive with traditional fossil-based mass polymers.

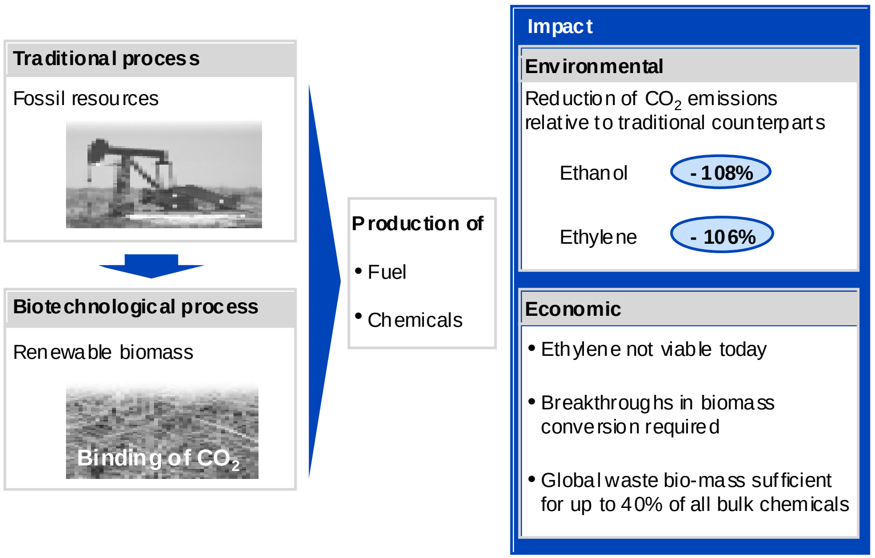


Future: Large-scale Reduction of CO_2 Emissions Due to Bio-mass Use

One of the largest contributions to CO_2 reduction might come from the use of renewable bio-mass in large-volume chemical production. The important difference to the use of traditional, fossil-based feedstock is the binding of atmospheric CO_2 during growth of bio-mass (plants). Consequently, the CO_2 that is emitted at the end of a product's life cycle is environmentally neutral.

In order for this to become a reality, companies need to have access to cheap biological feedstocks. This depends on the cost-effective conversion of waste bio-mass such as straw or corn stover to sugars, the raw material for fermentation. However, key technological breakthroughs to make this happen are still in development. It is estimated that we could see a breakthrough in bio-mass conversion processes towards the end of this decade, provided there is sufficient support for the necessary research and development activities.

CASE STUDY: BULK CHEMICALS



Source: Oeko Institute, McKinsey

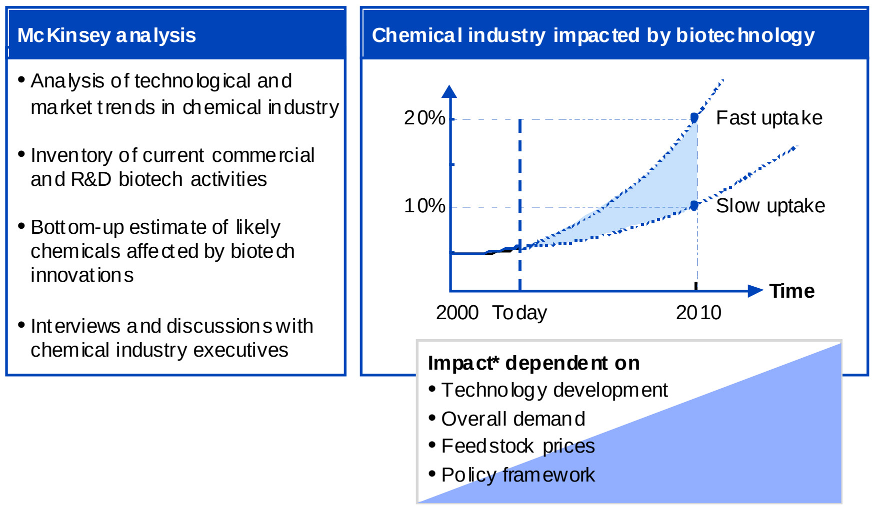
OVERALL MARKET POTENTIAL

What is the Overall Market Impact of White Biotechnology?

An estimate by McKinsey & Company shows that biotechnology could be applied in the production of 10 to 20% of all chemicals sold by the year 2010. This estimate is based on the analysis of technology and market trends as well as on an inventory of current R&D activities. The market share was calculated bottom-up by estimating the potential for white technology applications amongst key chemical products and product groups.

Starting with the chemical industry, white biotechnology will make inroads into a number of other industries. For example, enzymes will transform production processes in the pulp and paper industry, and new polymers will find multiple applications in the automotive and consumer industries.

MARKET POTENTIAL



* Impact means the use of biotechnological process steps such as fermentation or biocatalysis

Source: McKinsey

McKinsey Analysis: Uptake of White Biotechnology by the Chemical Industry

Different chemical markets introduce and use biotechnology at different rates. The study shows that the greatest impact of white biotechnology may be on the fine chemicals segment, where up to 60% of products may use biotechnology by 2010. A key driver here is the growth of biological pharmaceuticals such as antibodies for cancer treatment – drugs for which no traditional chemical synthesis exists. The impact on the specialty chemicals segment will vary broadly. For instance, enzymes and fermentation are already used in the production of flavours and fragrances, while other markets may still be dominated by traditional chemistry through 2010 and beyond.

The first applications of white biotechnology in the largest volume segments – polymers and bulk chemicals – have been commercialised. However, in these largely cost-driven segments, a number of technological advances and policy measures will determine the ultimate uptake of white biotechnology.

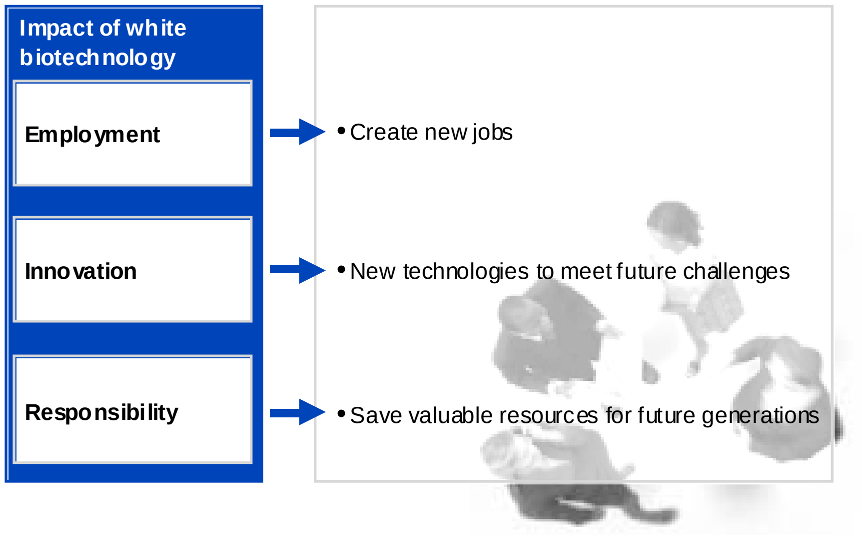
THE ELEMENTS OF SUSTAINABLE DEVELOPMENT

The results of the case studies in this project and others (e.g., OECD report on sustainable production using biotechnology) were combined with the McKinsey market perspective to assess the overall potential impact of white biotechnology. The limited number of case studies and the nature of any forward-looking analysis imply that only an indication of the total potential to be realised can be given. However, a clear trend emerges: Biotechnology has a tremendous potential to improve industrial production along all three dimensions of sustainable development: Society, environment, and economy.

Employment, Innovation, Responsibility: The Impact on Society

As white biotechnology makes industry more sustainable, it is expected that the benefits will be seen across a range of critical society-based areas: Job retention/creation, development of new technology platforms, and a reduction of society's dependence on valuable fossil resources, thus conserving them for future generations.

IMPACT ON SOCIETY

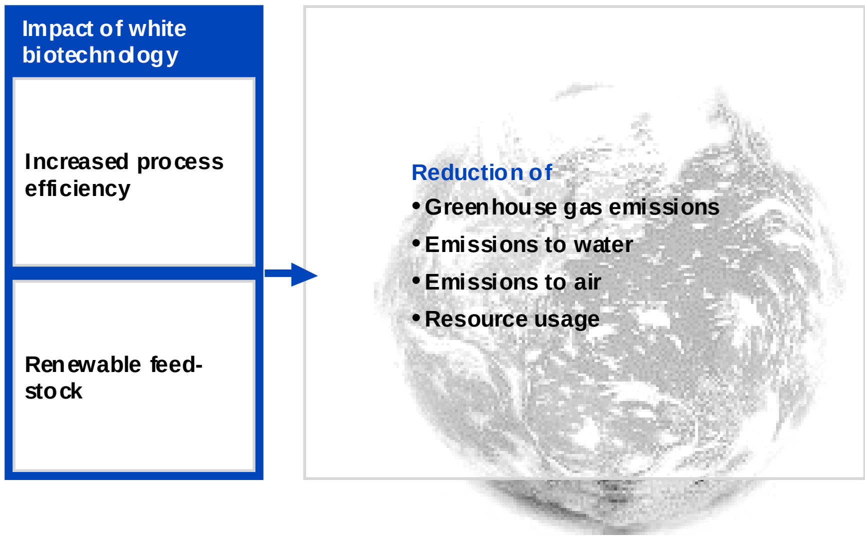


Decreasing the Footprint: The Impact on Environment

White biotechnology is not an end-of-the-pipe cleaning technology: It is a clean production process that minimises waste before it is even produced. As the case studies have shown, white biotechnology has substantial potential to reduce environmental impact. Air and water pollution could be reduced, energy use lowered, fewer raw materials needed, and waste could be diminished or substituted by bio-degradable materials.

An environmental indicator that is relevant for all case studies on a global scale is greenhouse gas emissions. In this study, we estimate that the application of white biotech in the chemical industry could reduce global greenhouse gas emissions considerably by 2010. This positions white biotechnology amongst the key technologies that can help to address global warming, one of the world's most pressing environmental challenges.

IMPACT ON ENVIRONMENT – DECREASING THE FOOTPRINT



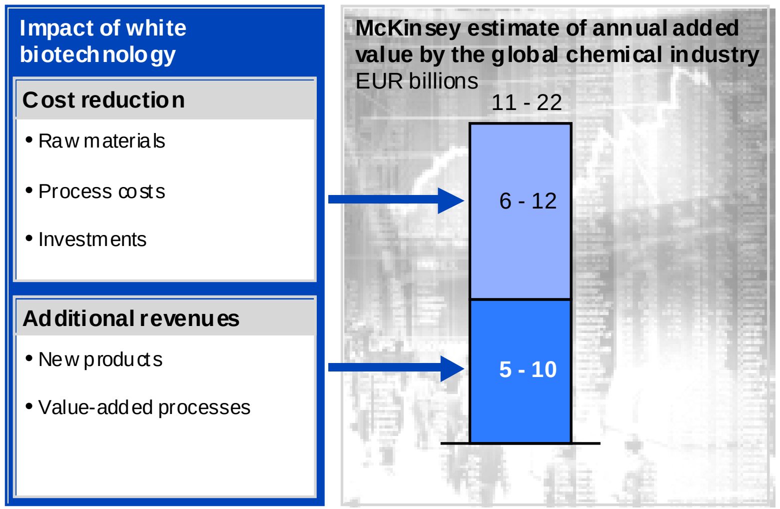
Added Value Creation by the Chemical Industry: The Impact on Economy

White biotechnology will be key to the competitiveness of many of Europe's industries that are already using biotechnology processes, including chemicals, textiles and leather, animal feed, pulp and paper, energy, metals and minerals, as well as waste processing.

McKinsey estimates show that the chemical industry alone could generate additional added value of up to EUR 11 to 22 billion per annum by 2010, depending on whether uptake is fast or slow (see page 15).

Two sources would contribute to this. One is lower costs for raw materials and processing, combined with smaller scale investments in the fermentation of plants. The other is additional revenues from innovative, new, or performance-enhanced products.

IMPACT ON ECONOMY – CHEMICAL INDUSTRY



Source: McKinsey

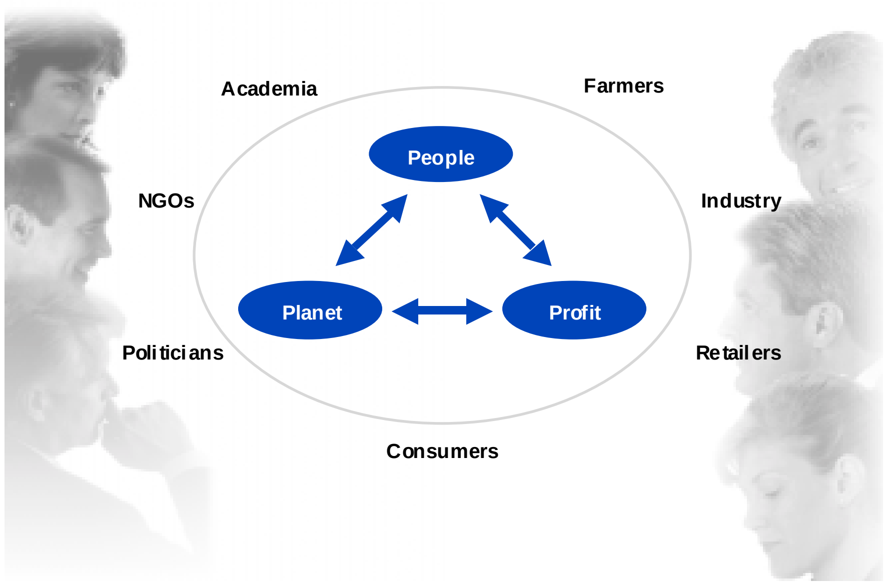
A Great Potential to Be Captured

It is clear that there are great benefits to be realised with the increased use of white biotechnology in industrial applications. This technology has the potential to contribute to a more sustainable future for society as a whole.

However, white biotechnology cannot achieve its full potential without a coordinated effort on the part of all stakeholders – either directly or indirectly – to support the technology.

Only through cooperation will we be able to capture and develop the true potential of this exciting technology to create a more livable and environmentally stable society. As a first step, a dialogue amongst stakeholders needs to be started to share the facts and information as well as to discuss the opportunities, but also the concerns related to this new technology.

POTENTIAL TO BE CAPTURED



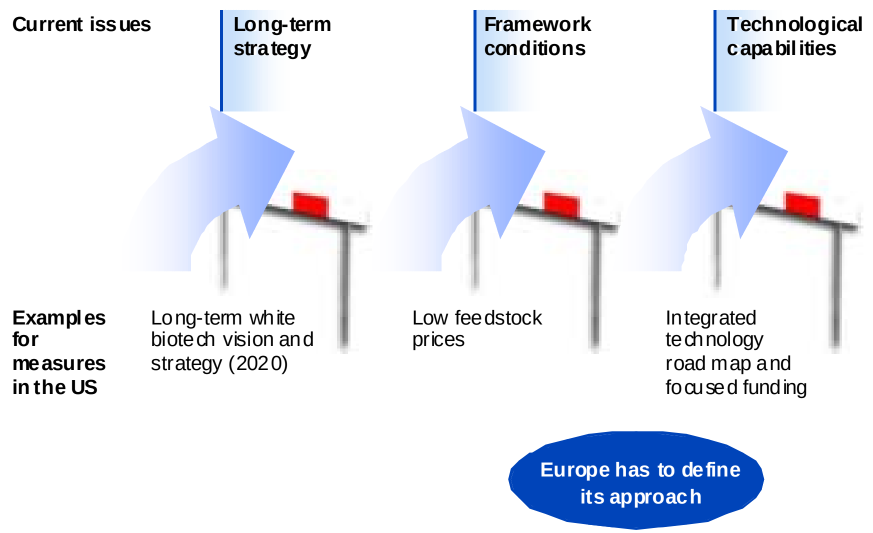
PROPOSED POLICY MEASURES

White Biotechnology Obstacles Need to Be Addressed

The road to a broad application of white biotechnology in industry is not always smooth, as there are many issues that hinder its full-scale rollout. In Europe, there are three key issues concerning the progress of white biotechnology: Development of a long-term strategy, setting favourable economic and regulatory framework conditions, and stimulating key technological capabilities.

Other countries have made more progress in addressing and breaking down these hurdles. In the US, for example, representatives from different governmental bodies, industry, agriculture, and academia worked together on a project called "Vision 2020" with the aim to boost white biotechnology usage over the next decades. In parallel, low feedstock prices and the support of the agricultural community in the US encourage the use of white biotechnology.

HOW TO CAPTURE THE POTENTIAL



What Europe Can Do to Support the Progress of White Biotechnology

As opposed to other OECD countries, and particularly the US, European countries' current policies do not foster the development of white biotechnology. Five key areas of necessary change could help Europe to address the main issues for widespread adoption and to remain competitive.

We propose to the European Commission to form a strategic alliance to define its own approach for white biotechnology, as a so-called Technology Platform. Based on a benchmark with other OECD countries' policies, an integrated white biotechnology road map should be developed. In order to stimulate global companies to invest in this field and in Europe, bridging incentives, more effective regulatory processes, and low-cost feedstock are key. Finally, the European Commission could help to build broad public support for white biotechnology by increasing the awareness of its benefits along the three pillars of sustainability: Society, environment, and economy ("Triple P").

PROPOSED POLICY MEASURES

Create a stakeholder Technology Platform to build a strategic alliance for white biotechnology

- Benchmark Europe with other OECD countries on development of bio-based economy
- Create European white biotechnology vision and road map
- Create financial incentives and supportive regulatory framework
- Encourage competitive biological feed-stock prices
- Build public awareness and support

WHERE DO WE GO FROM HERE?

We like to see this project as the beginning of a dialogue amongst all stakeholders towards the development of a technological advance that can have substantial implications for the improvement of life and business together. This dialogue should, in our opinion, be initiated and guided by the European Commission. Questions and critical points which need clarification should be addressed in order to reach consensus on the path forward in creating and adopting policies that will encourage the increased application of white biotechnology.

We are committed to discuss the necessary changes with policymakers, NGOs, and other industry groups in the coming months and years. We firmly believe that these discussions will be to the benefit of us all in working towards a more sustainable society for this and future generations.

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CONTACT INFORMATION

	Participants	E-mail
EuropaBio	Hugo Schepens	h.schepens@europabio.org
Bio	Brent Erickson	berickson@bio.org
BASF	Harald Mahnke	Harald.Mahnke@central-europe.basf.org
Cargill Dow	Erwin Vink	erwin_vink@cargilldow.com
DSM	Philip van Lelyveld	philip.lelyveld-van@dsm.com
DuPont	Ian Hudson	ian.hudson-2@usa.dupont.com
Genencor	Jack Huttner	jhuttner@genencor.com
novozymes	Kirsten Staer	kirs@novozymes.com
Öko-Institut e.V.	Wolfgang Jenseit	jenseit@oeko.de
McKinsey&Company	Jens Riese	jens_riese@mckinsey.com
	Oliver Wolf	Oliver.Wolf@jrc.es
Universiteit Utrecht	Martin Patel	m.patel@chem.uu.nl
OECD	Iain Gillespie	iain.gillespie@oecd.org

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