INNOVHUB
STAZIONI SPERIMENTALI
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Innovazione e ricerca

STAZIONE SPERIMENTALE
PER LA SETA

Biotecnologie e Sostenibilità

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AICTC
Associazione Italiana di
Chimica Tessile e Coloristica

AICTC
Italian Association of
Textile Chemists and Colourists

Il Tessile da sostenere: rispettoso della salute e dell'ambiente
Busto Arsizio (Va), 15 novembre 2013

OUTLINE

1. Industrial Biotechnology and the Textile Industry
2. Biocatalysis for Textile Wet Processing: LCA Case Studies
3. Renewable Raw Materials for the Textile Industry
4. Bioeconomy: the Biorefinery Concept
5. Bio-based chemicals from Biomass to the Textile Industry: Biosurfactants

Industrial Biotechnology

Industrial Biotechnology uses enzymes and microorganisms to make bio-based products in sectors as diverse as chemicals, food and feed, healthcare, detergents, pulp and paper, textiles, bioenergy, ...

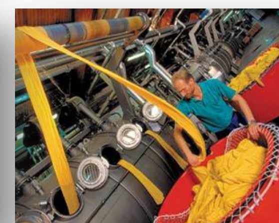
Healthcare

Chemicals

Food

Pulp and Paper

Detergency



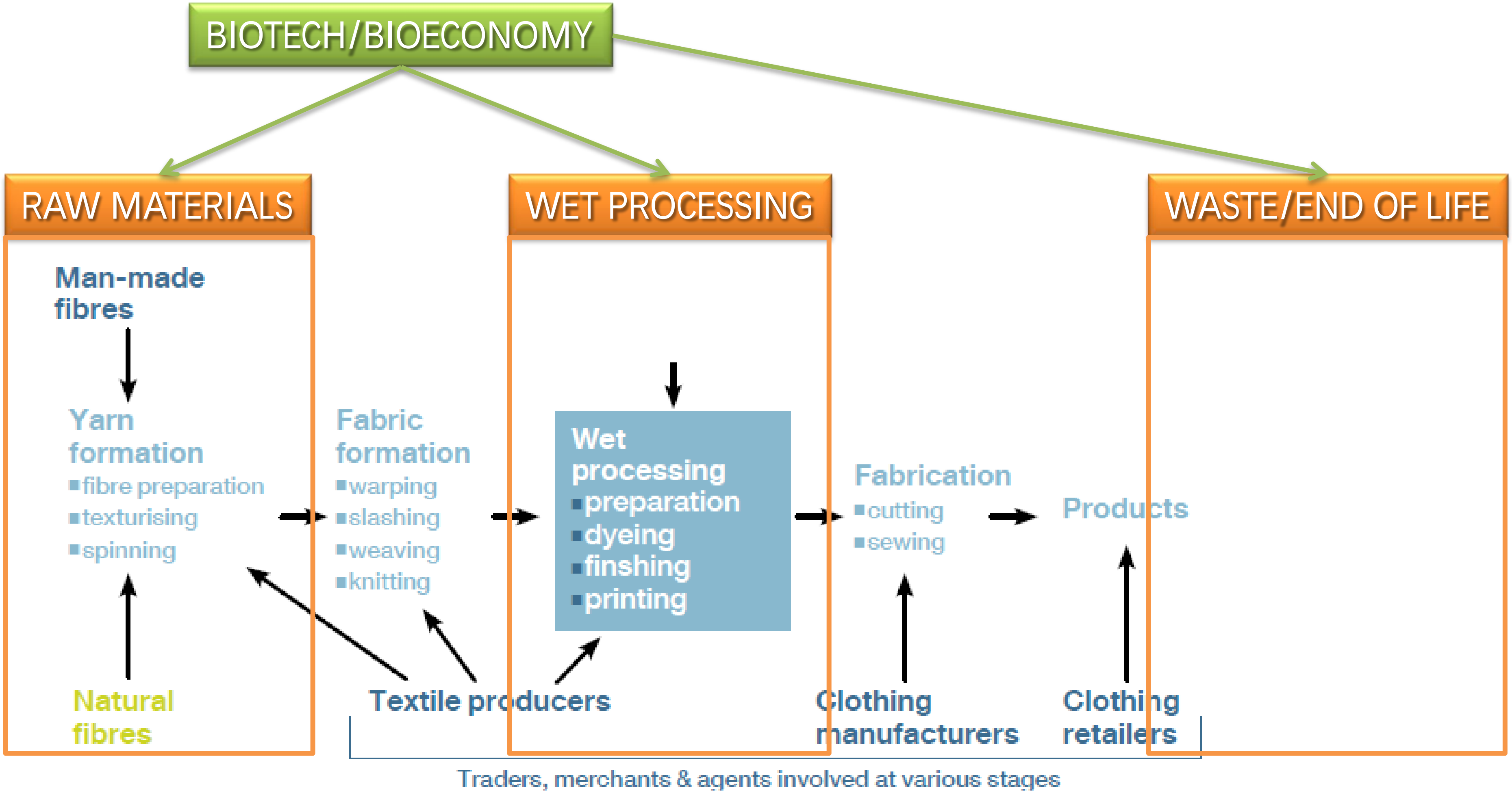
Textile

Fuels

Energy

Industrial Biotechnology can save water and energy in production processes, decrease wastes, and lead to significant reduction in greenhouse emissions, helping to fight global worming. It can also lead to improved performance and sustainability for industry and higher value products.

The Textile Value Chain



Source: Dirty Laundry, GreenPeace

Biocatalysis for Textile Wet Processing

Biotecnology

Biocatalysis (enzymatic processes) →

Textile Industry

Desizing	• Removal of starch or starch-based sizes from cotton or blend fabrics • Amylase
Bioscouring	• Removal of pectins, waxes and mineral impurities from cotton • Pectinase, cutinase
Bleach Clean-up	• Decomposition of hydrogen peroxide after bleaching • Catalase
Biopolishing	• Removal of fuzz from cotton fabrics (softer and smoother handle) • Cellulase
Denim Abrasion and Finishing	• Abrasion of Denim to give a worn look • Cellulase

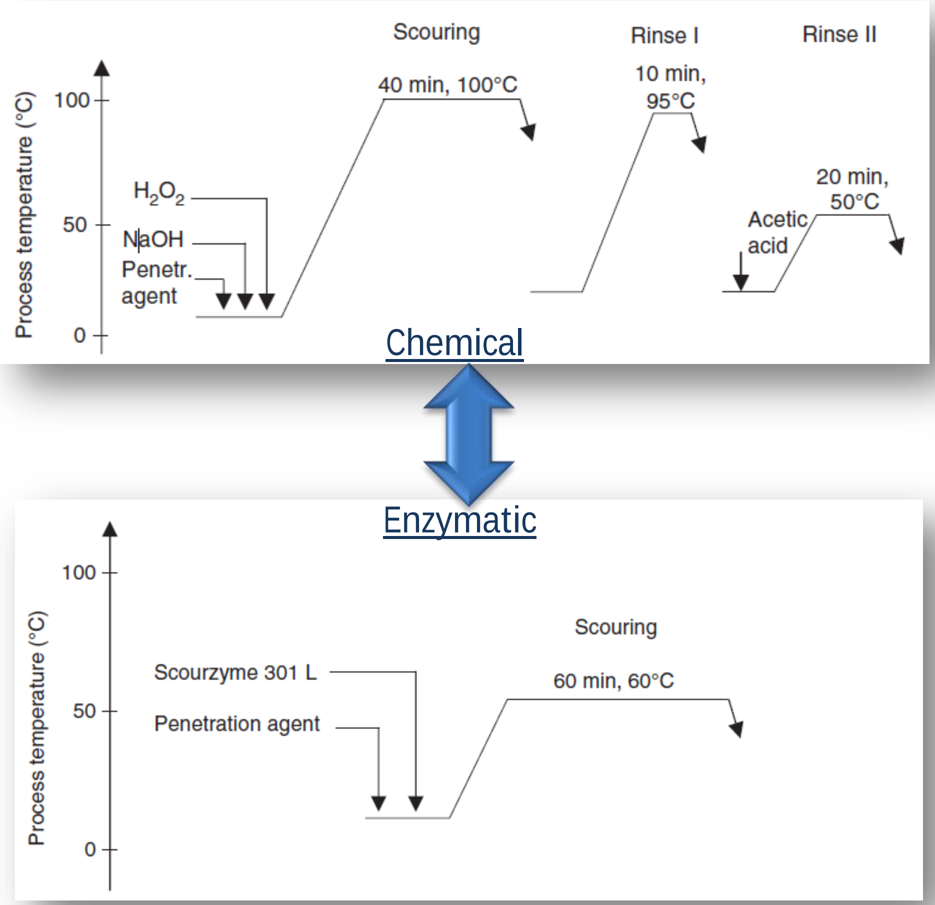
Benefits of Enzymatic Processes

	Chemical Processes	Enzymatic Processes
Quality	High temperature, extreme pH values, high pressure are often required Chemicals lack specificity (high stoichiometric ratios)	Medium-to-low temperature, neutral pH, atmospheric pressure (product quality, reduction of energy costs) Enzymes are highly specific and selective (lower negative impact on fibres properties)
Sustainability	High consumption of water, energy, chemicals High impact of wastewater (high environmental costs)	Enzymes are used in low quantities (catalysts) and are biodegradable (proteins) (reduction of environmental costs, recovery and recycling of process water) No investments on new machines and plants are needed
Health/Safety	Safe use of chemical in workplaces (protection of workers health) Possible presence of dangerous residues on textile products (protection of consumer health)	Enzymes fulfil the IPPC 96/61/EC directive (Best Available Techniques) Enzymes can replace chemicals dangerous for health and environment (REACH rules)

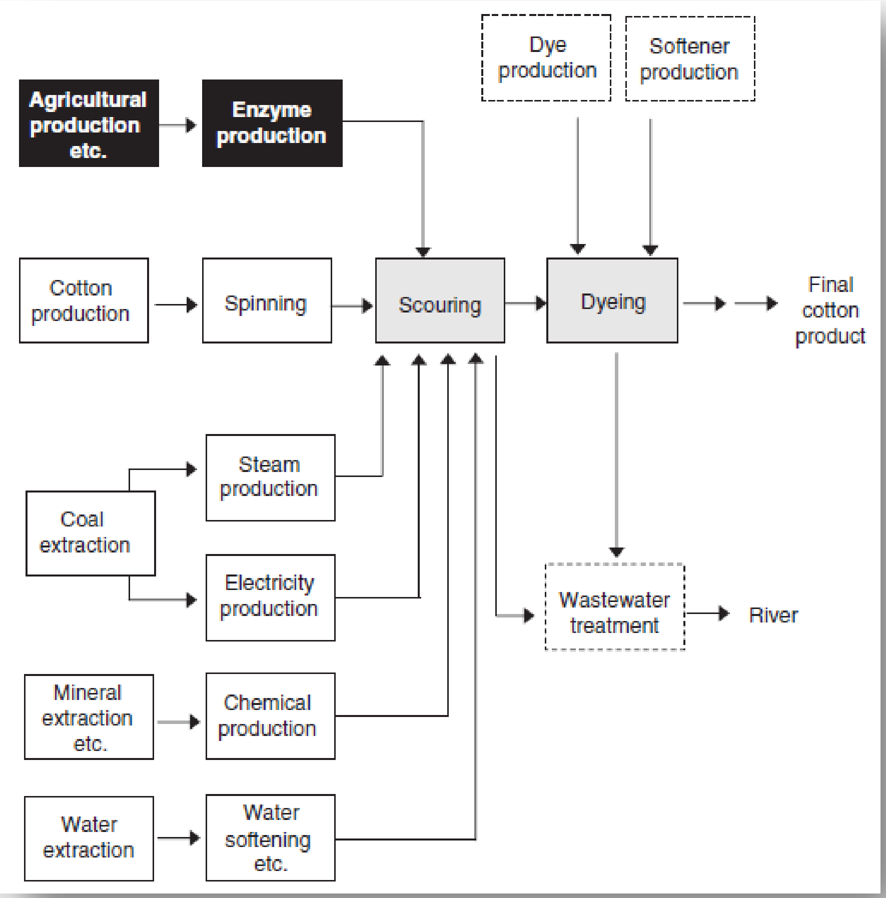
LCA: to understand impact of biotech in textile manufacturing

LCA: Bioscouring *vs* Chemical Scouring – The Study

Processing diagrams: scouring of cotton yarn



System boundaries for environmental assessment



Source: P. H. Nielsen et al. Enzyme biotechnology for sustainable textiles. Sustainable textiles. Life cycle and environmental impact. Ed. R.S. Blackburn. Woodhead Publishing in Textiles, N. 98, 2009.

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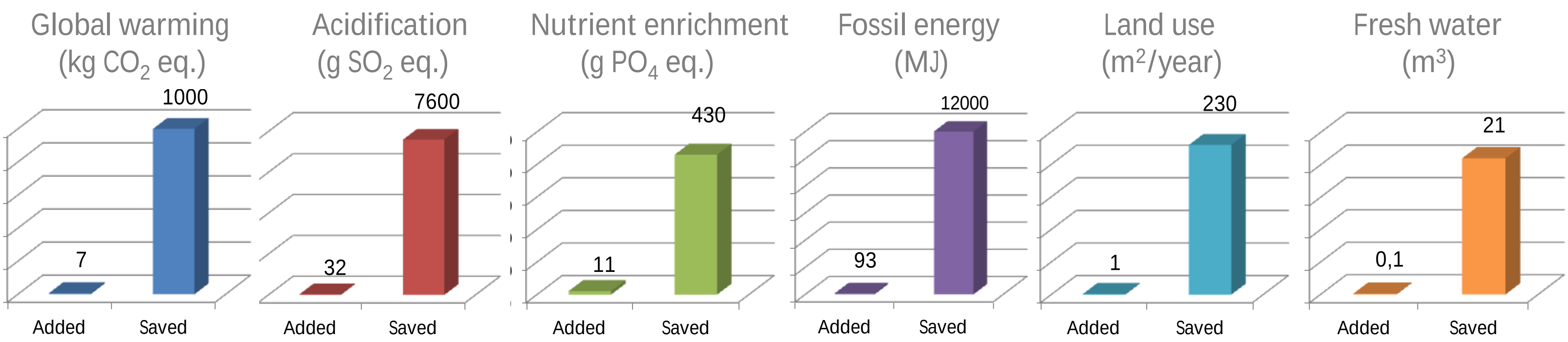
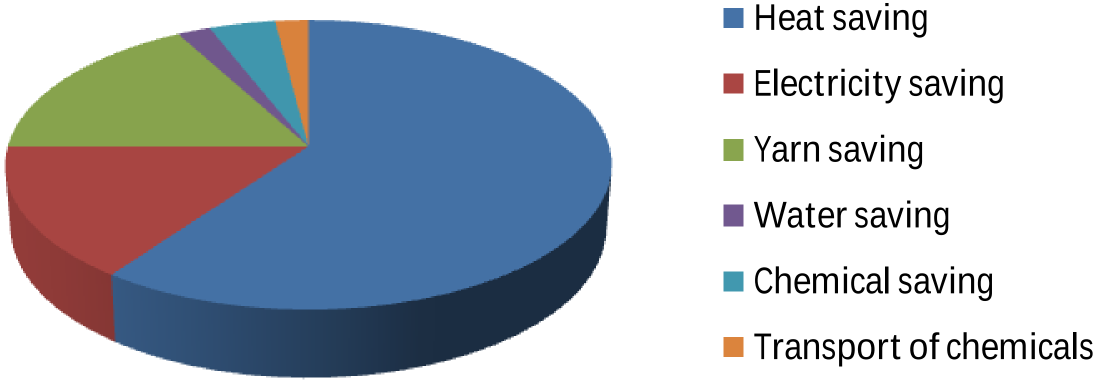
LCA: Bioscouring *vs* Chemical Scouring – The Results

Added and saved resource consumption and environmental impact

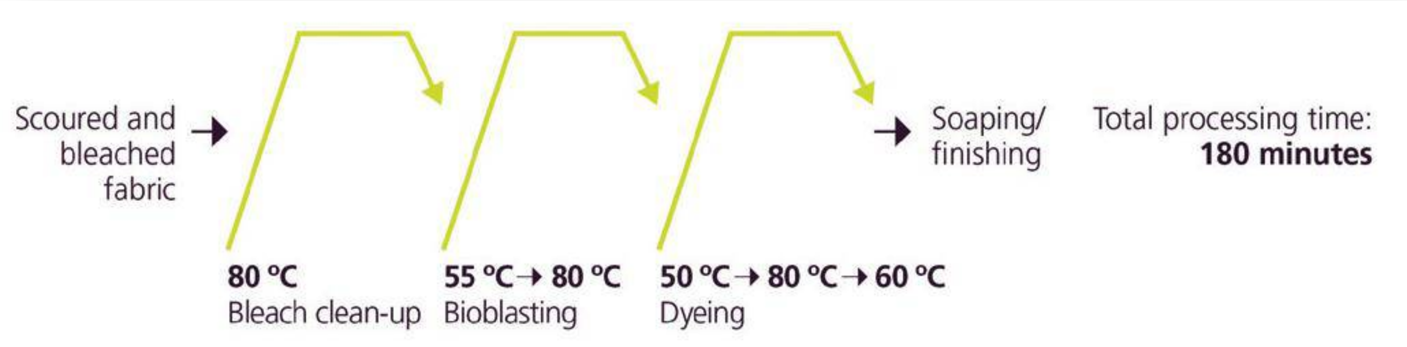


Factors behind saved contribution to global warming



Source: P. H. Nielsen et al. Enzyme biotechnology for sustainable textiles. Sustainable textiles. Life cycle and environmental impact. Ed. R.S. Blackburn. Woodhead Publishing in Textiles, N. 98, 2009.

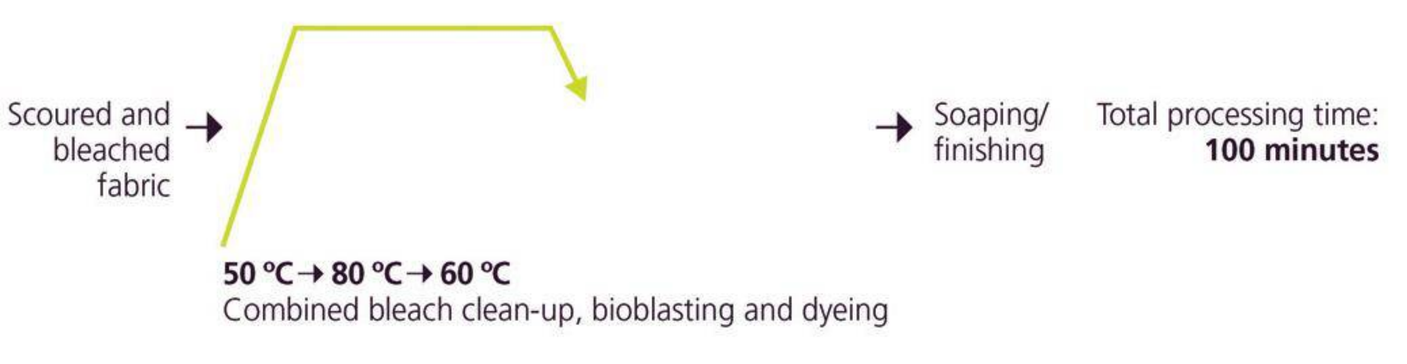
LCA: 1 Step *vs* 3 Steps Biopolishing Process – The study



Pre-treatment and dyeing of knit fabrics

Conventional

Combined



Source: R. K. Nagaraju et al. The combined bioblasting concept: save energy, greenhouse gases and water. *International Dyer*, Issue 4, 2013, 34-38.

LCA: 1 Step *vs* 3 Steps Biopolishing Process – The Results

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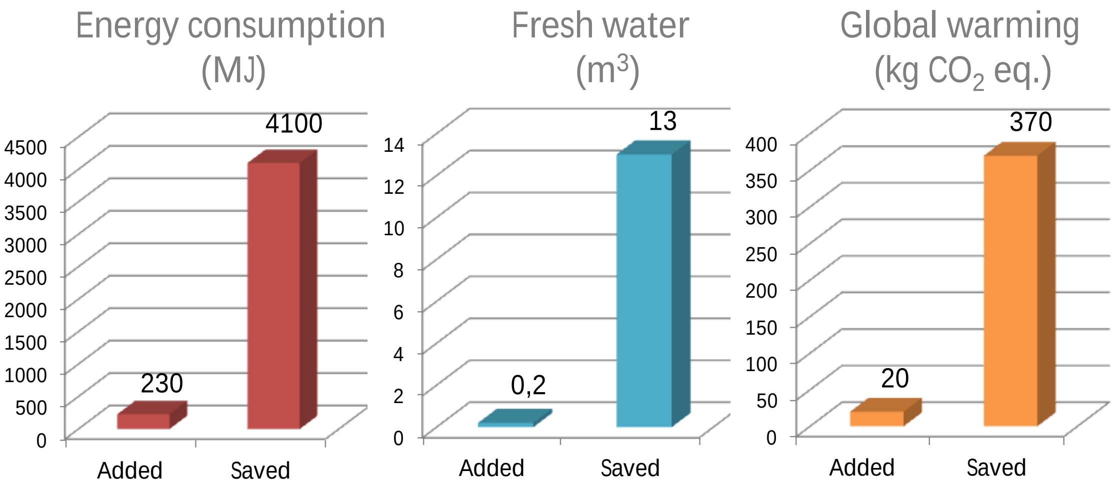
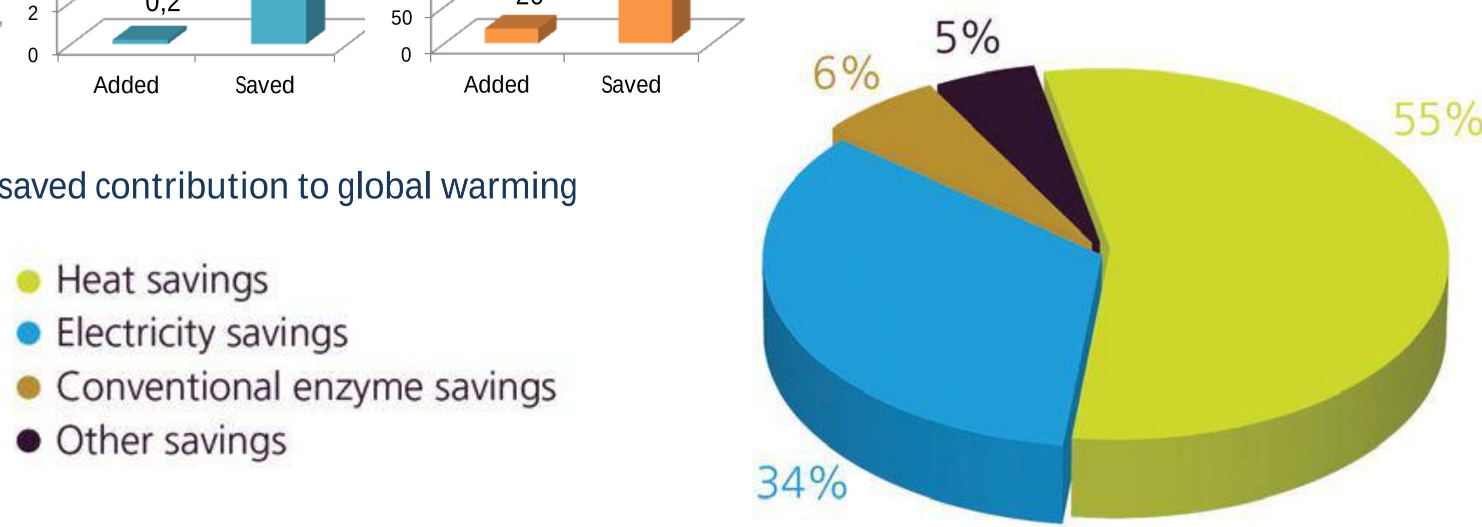


Factors behind saved contribution to global warming



Source: R. K. Nagaraju et al. The combined bioblasting concept: save energy, greenhouse gases and water. *International Dyer*, Issue 4, 2013, 34-38.

Renewable Raw Materials for the Textile Industry

Precursors/Polymers from:

Biomass →

Polysaccharides (Cellulose, Chitin/Chitosan, Starch)

Crabyon.it  Lenpur ingeo BambroTex

DuPont The miracles of science Sorona® (1,3-propanediol)

Proteins (Soya, Casein)

milkofil 

Recombinant DNA Techniques →

Man-made silks

nexia BioSteel®

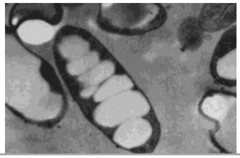
Biotechnology →

Man-made fibres (PAN)

DiaNitrix MITSUBISHI RAYON CO.,LTD. (acrylamide from an acrylonitrile)

Microorganisms →

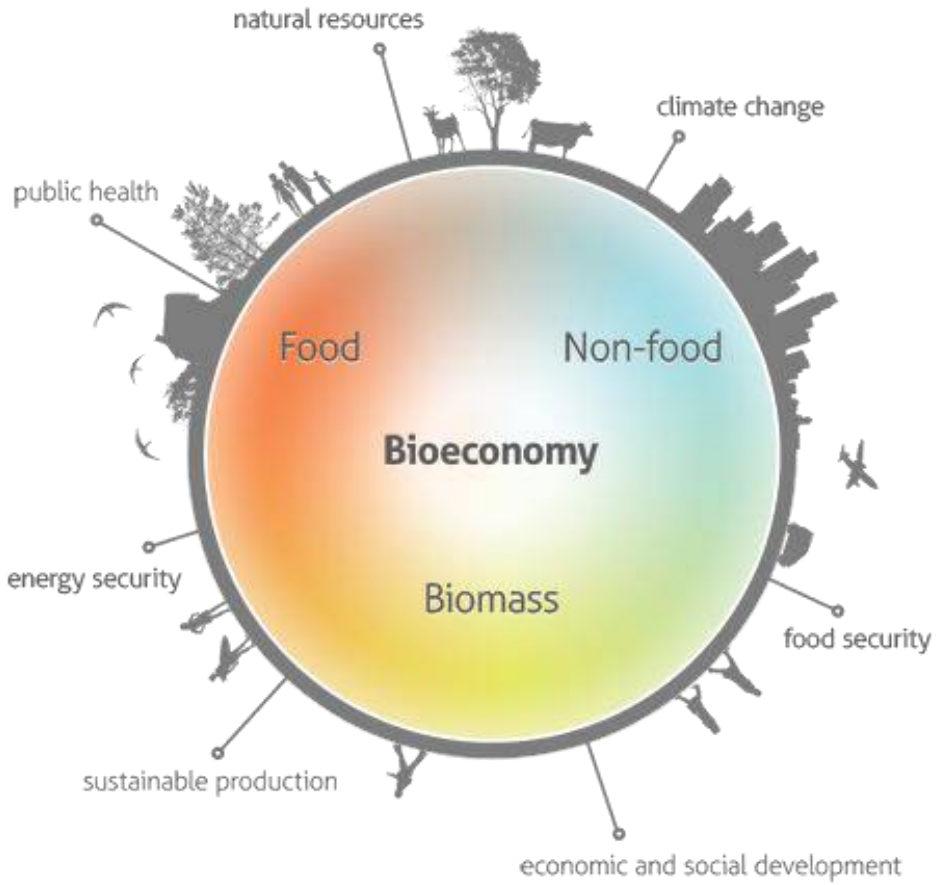
Polyhydroxy alkanoates (PHA, PHB, PHVB)



The Bioeconomy

- Sustainable production of renewable biological resources
- Conversion of non-food renewable feedstocks (biomass and organic waste) into biobased products (bioplastics, biofuels, bioenergy)

  - Reduce dependence on fossil fuel
  - Reduce greenhouse gas emission
  - Generate less waste
  - Use less fossil fuel and water

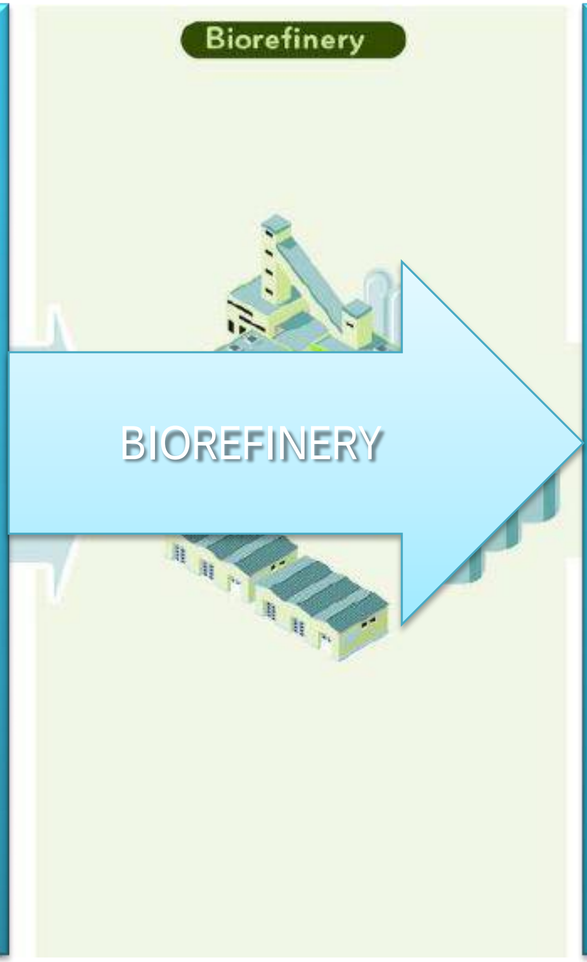


Source: EuropaBio

The Biorefinery Concept

BIOMASS

- Forestry waste
- Industrial side-streams (wood/saw mills)
- Agricultural residues and crops (dedicated or surplus)
- Aquatic biomass, algae
- Process and waste water
- Municipal organic waste
- Animal manure



BIO-BASED PRODUCTS

- Biobased chemicals
- Bioplastics, Biomaterials
- Packaging
- Advanced biofuels
- Specialities (Biosurfactants, Lubricants)
- Pharmaceuticals
- Food and feed ingredients
- Bioenergy

Source: (1) D. Carrez. Entering the Biobased Economy. 6th Annual EFIB 2013.
(2) Bridge 2020. Biobased and Renewable Industries for Development and Growth in Europe Strategic Innovation and Research Agenda.

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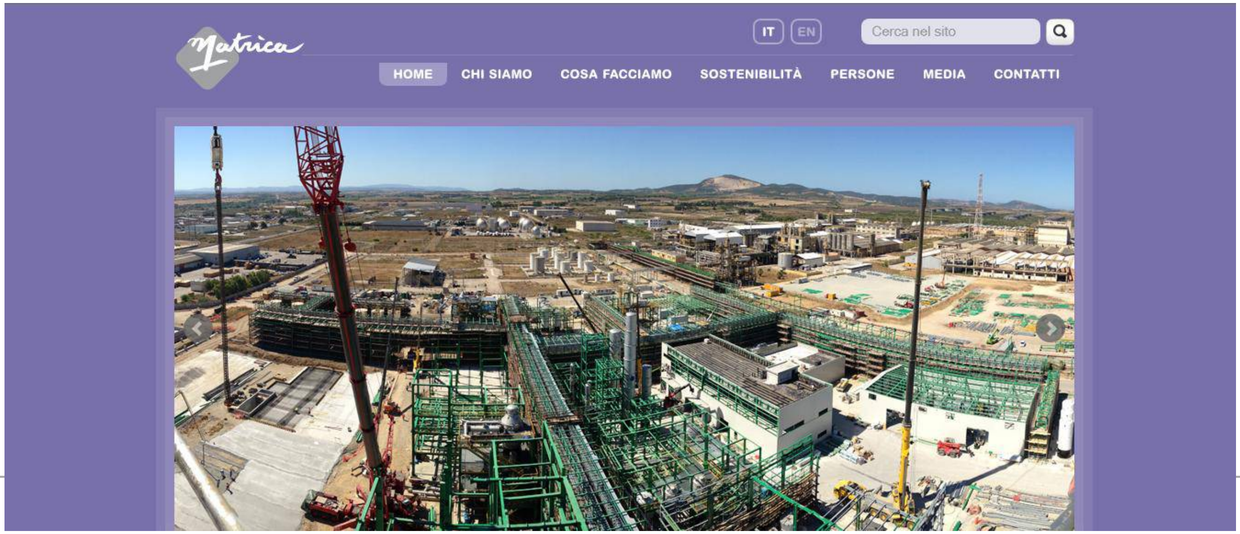
Biorefineries in Italy

http://www.betarenewables.com/

Biomass (270 Kt/y) : non-food crops/aste from agricultural production (Arundo Donax, Rice straw, Corn cob, Sugar cane bagasse)

Production of:
- biofuels (40 Ktons of bioethanol/year)
- biochemicals
- lignin chemicals



http://www.matrica.it/

Biomass: Thistle

Production of monomers (Azelaic acid and other dicarboxylic acids) as precursors of
- bioplastics
- biolubricants
- bioadditives for elastomers

Biosurfactants from Urban Biowaste

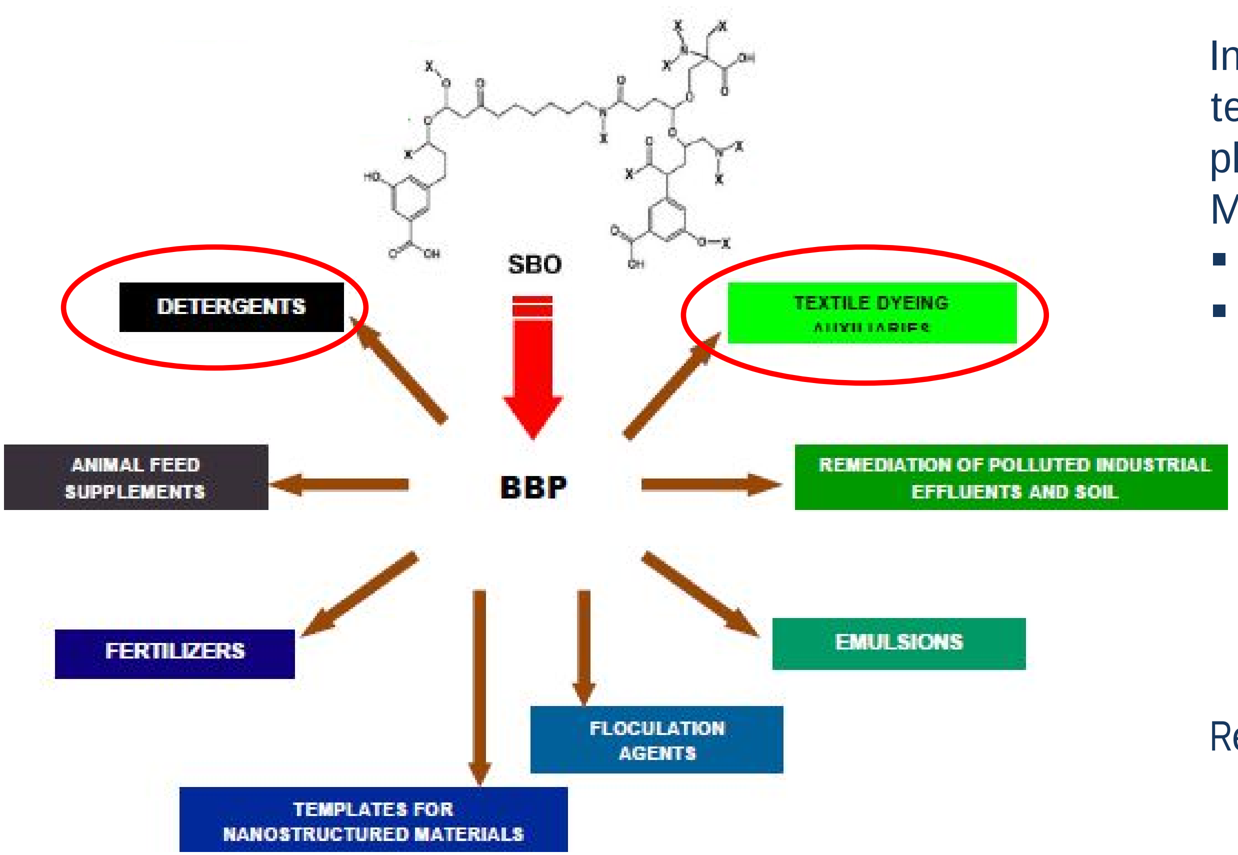
Waste management plant treating Urban Bio-Wastes (UBW) by aerobic and anaerobic microbial digestion according to the current technology.

Main products:
- Biogas
- Compost

UBWs contain Soluble Bio-Organics (SBO) with excellent surfactant properties

Source: Montoneri et al. Biochemenergy: a project to turn an urban wastes treatment plant into biorefinery for the production of energy, chemicals and consumer's products with friendly environmental impact. *Int. J. Global Environmental Issues*, Vol. 11, No. 2, 2011

Biosurfactants from Urban Biowaste



Integration of SBO production technology in a UBW management plant.
Main products:

- Biogas
- SBO

Revenues from SBO = x 6 times

Source: Montoneri et al. Biochemenergy: a project to turn an urban wastes treatment plant into biorefinery for the production of energy, chemicals and consumer's products with friendly environmental impact. *Int. J. Global Environmental Issues*, Vol. 11, No. 2, 2011

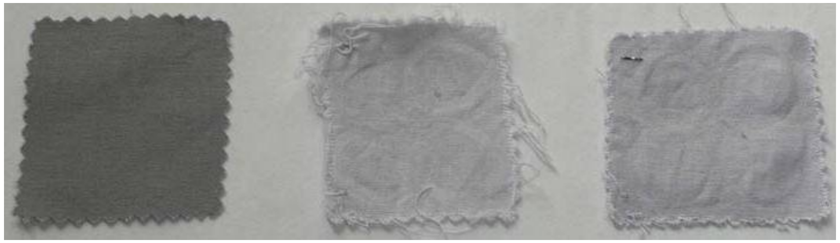
Biosurfactants for Textile Dyeing and Detergency

SBO

- SBO are liphophilic compounds
- Chemical composition of SBO depends on nature, composition and aging time of starting waste
- Surface tension properties are suitable for surfactants technological applications
- SBO display great power of enhancing hydrophobic dye solubility

Detergency (1)

Detergent performance: power to remove soil



Soiled cotton fabric | Biosurfactant ($\Delta E = 18.9 \pm 1.1$) | Commercial Surfactants ($\Delta E = 16.1 \pm 0.9$)

- When used above critical micellar concentration (CMC), performance of SBO is similar to the commercial surfactant
- The degree of whiteness (ΔE) of the washed cloth is improved without significant difference between SBO and commercial surfactant

Dyeing (2)

Dyeing of Cellulose acetate fabric

Standard Dyeing | Biosurfactant Dyeing

- Biosurfactants rank at the same level of the best synthetic surfactants
- Significantly improvement of color uniformity was observed
- Biosurfactant from different sources display same performance
- Fastness tests proved good/excellent penetration of the dyes and satisfactory to excellent dye fixation to the dyed fabric

Source: (1) Savarino et al. Biosurfactants from Urban Wastes for Detergent Formulation: Surface Activity and Washing Performance. *J Surfact Deterg* (2010) 13:59–68. (2) Savarino et al. Biosurfactants from Urban Wastes As Auxiliaries for Textile Dyeing. *Ind. Eng. Chem. Res.* 2009, 48, 3738–3748

The Biorefinery Approach at Innovhub-SSI

R&D **Project:** **“**Biochemicals from Industrial Residuals of Bark and Compost**”** - Bio&Co

- ❑ The bark is a significant residue of the forest industry (wood and paper industry)
- ❑ Presently it is mostly used for energy production
- ❑ Bark is very rich in chemicals of considerable interest that can be exploited through the biorefinery approach

Aim of the study:

- To analyze the potential of the bark of poplar (Italian forest industrial waste) for the production of
  - bioactive substances (antioxidants and antimicrobials)
  - biosurfactants

These classes of chemicals were selected because they have potential applications in various industrial sectors related to the activity of Innovhub-SSI

The Bio&Co Project – Results

Characterization of poplar bark

	%
Bark ashes	14.9
Extractives in water	4.9
Extractives in esane	1.6
Acid insoluble lignin	29.0
Acid soluble lignin	3.6
Cellobiose	3.8
Glucose	27.0
Xilose	13.7
Galactose	5.2
Arabinose	4.5
Mannose	4.7
Total sugars	58.9

NREL/TP-510 Method

Characterization of aqueous extract

Trimethoxybenzoic acid	o-Coumaric acid
Coumaroil quinic acid	p-Coumaric acid
2-(3,4-dihydroxy) phenyl ethanol	Salicilic acid
Salicin	Ferulic acid
Protocathetic acid	iso-Ferulic acid
Dihydroxy benzoic acid	Helicin
2-(4-hydroxy) phenyl ethanol	Hydroxypinoresinol
Salireposide	Solicortin
Vanillic acid	Kaempherol-methylester
Syringic acid	Naringenin
Coumaroil glucoside	Kaempherol isomer
Vanillin	Tiandrin
Tremulacin	

HPLC-PDA and HPLC-PDA-MS

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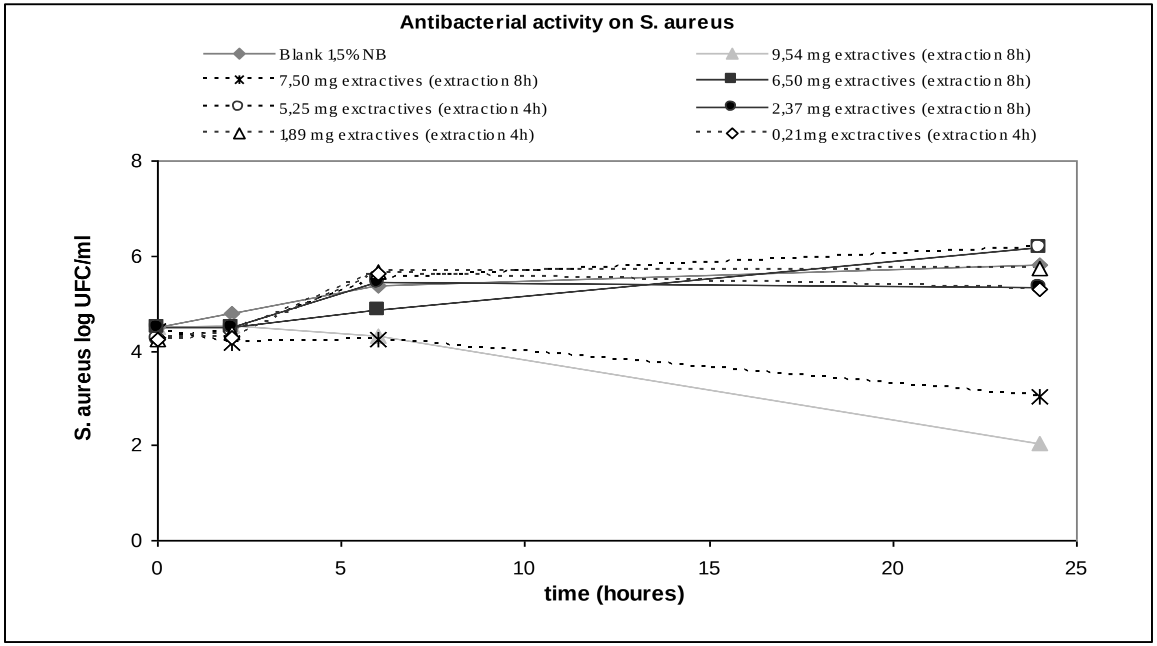
The Bio&Co Project – Results

Antioxidant effect

Sample	IC50 (mg/ml)
Reference Quercitine	2.31
Extract (EtOH:H2O = 1:1)	38.18

Antimicrobial effect



The Bio&Co Project – Conclusions

- The poplar bark is rich in hemicellulose of the class of arabinoxylans
- The extractives contain molecules with high added value with useful properties for the pharmaceutical industry and the possibility of various applications for their antimicrobial, antioxidant, antiviral and antimutagenic activity
- High concentration of aqueous extracts have limited antimicrobial effect but a significant antioxidant activity
- If composted, the poplar bark can produce molecules with surfactants activities, so it can be considered a source of biosurfactants

Thankyou for your attention

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