Regional Workshop on Promoting Sustainable Biofuels Production and Use in Central and Eastern Europe
Dubrovnik, Croatia 12-13 November 2007

Review of established and emerging technologies for biofuels production and their evaluation

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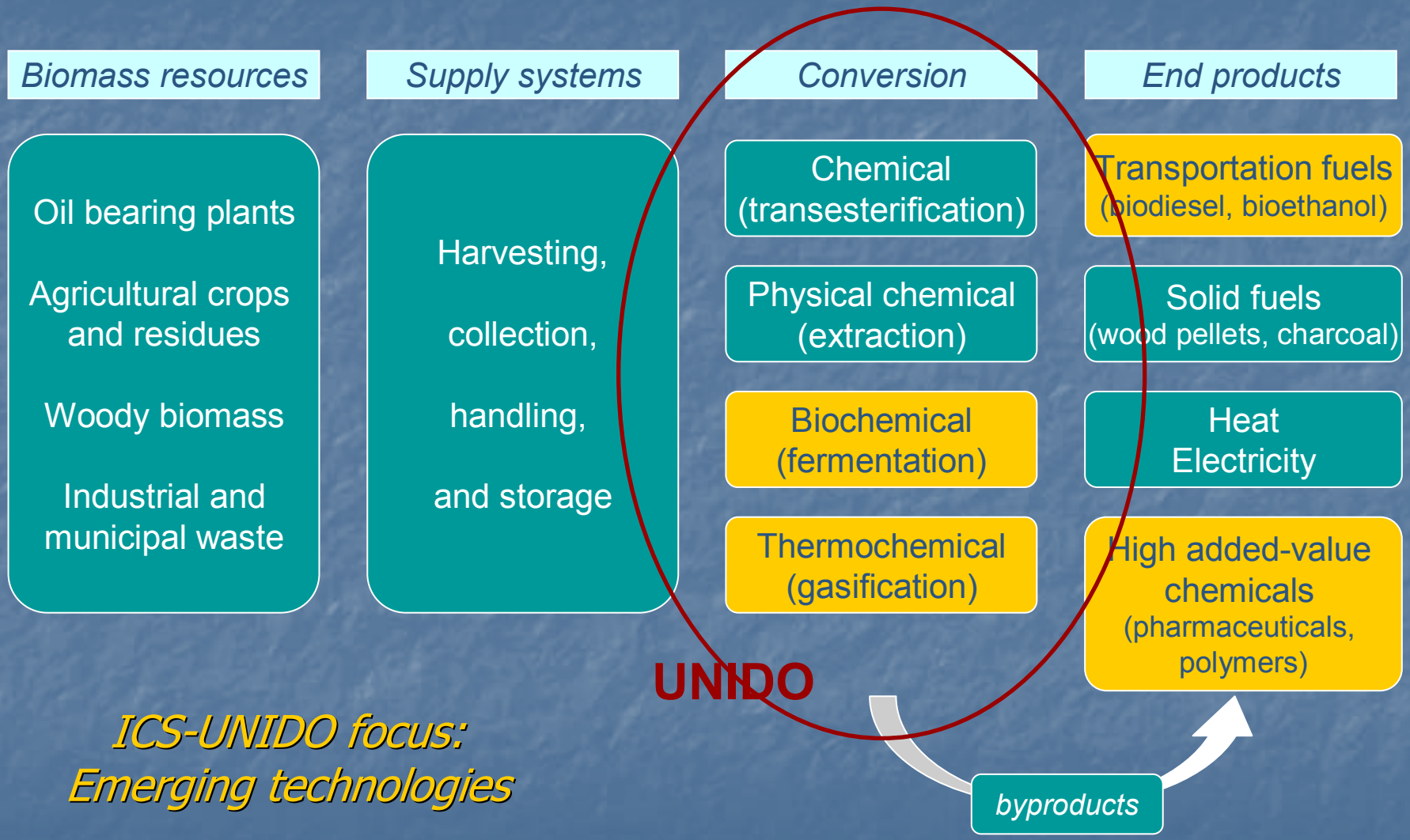
Presentation outline

- Introduction
- Biofuels: 1st and 2nd generations
- Chemicals from biomass and biorefineries
- Evaluation aspects
- Decision support tools
- ICS-UNIDO programme on biofuels

Drivers

- Fossil resource depletion
- Kyoto Protocol (reduction of CO_2 emissions)
- Key to sustainable industry: valorization of waste and byproducts, Green Chemistry based approaches
- Integrated development of both agriculture and industry
- Improvement of social economic conditions

Biofuel value chain and UNIDO radius of attention



ICS-UNIDO focus:
Emerging technologies

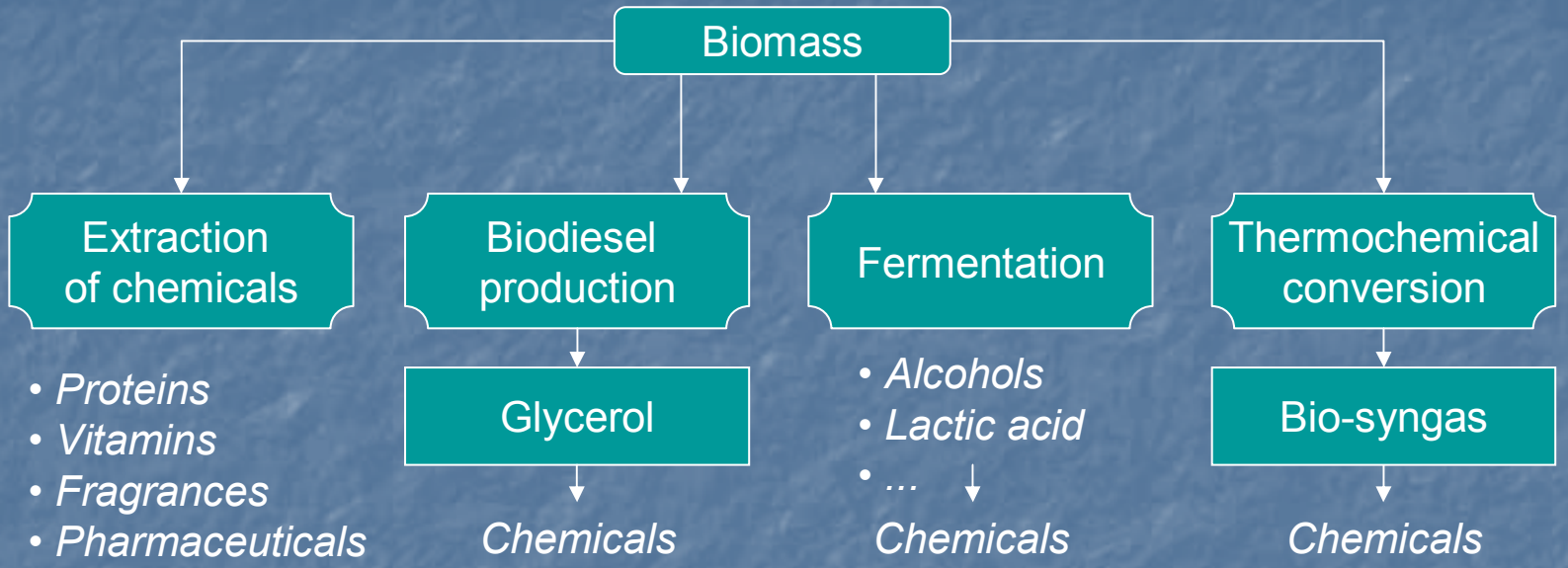
First generation biofuels

Generic name	*Chemical composition*	*Feedstocks*	*Technology*
Biodiesel	Methyl or ethyl esters of fatty acids (FAME); Hydrocarbons (products of cracking)	Oil crops (e.g. rape, palm, soya, jatropha, canola, colza etc.), waste oil (e.g. frying oil), and animal fats	Cold/hot pressing, extraction & transesterification (Homogeneous, heterogeneous, and bio-catalysis); Hydrogenation (hydrocracking)
Vegetable oil	Straight Vegetable Oil (SVO) – triglycerides of fatty acids	Oil crops (e.g. rape, palm, soya, jatropha, canola, colza etc.)	Cold/hot pressing, extraction, and purification
Bioethanol	Ethanol	Sugars (glycosides) and starch from bio-waste (sugarcane, sugar beet, cereals)	Hydrolysis & fermentation
Biogas	Methane, hydrogen and light hydrocarbons	Biomass (humid)	Anaerobic digestion

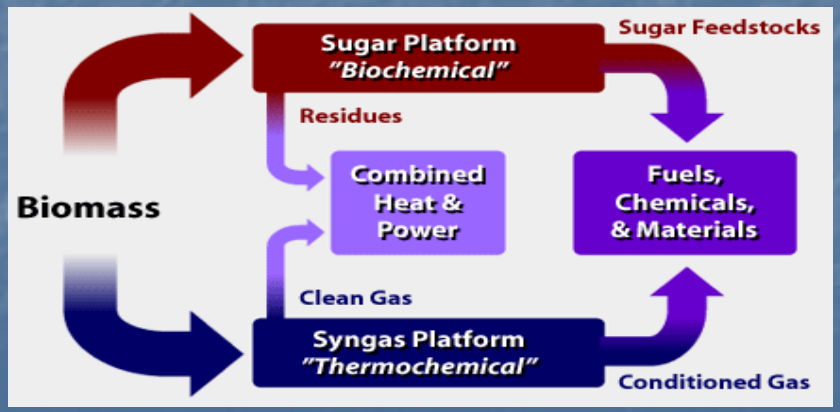
Second generation biofuels

Generic name	*Chemical composition*	*Feedstocks*	*Technology*
Cellulosic bioethanol	Ethanol	Lignin, cellulose and hemicellulose from bio-waste	Hydrolysis & fermentation
Bio-SNG	Synthetic (substitute) natural gas – methane	Lignocellulosic biomass	Pyrolysis, gasification, methanation
Synthetic biofuels	Hydrocarbons (BTL/FT), methanol (biomethanol), mixed heavy alcohols, dimethyl ether (bio-DME)	Lignocellulosic biomass	Pyrolysis, gasification, synthesis
Bio-hydrogen	Hydrogen	Lignocellulosic biomass	Pyrolysis, gasification, water gas shift reaction (WGSR)

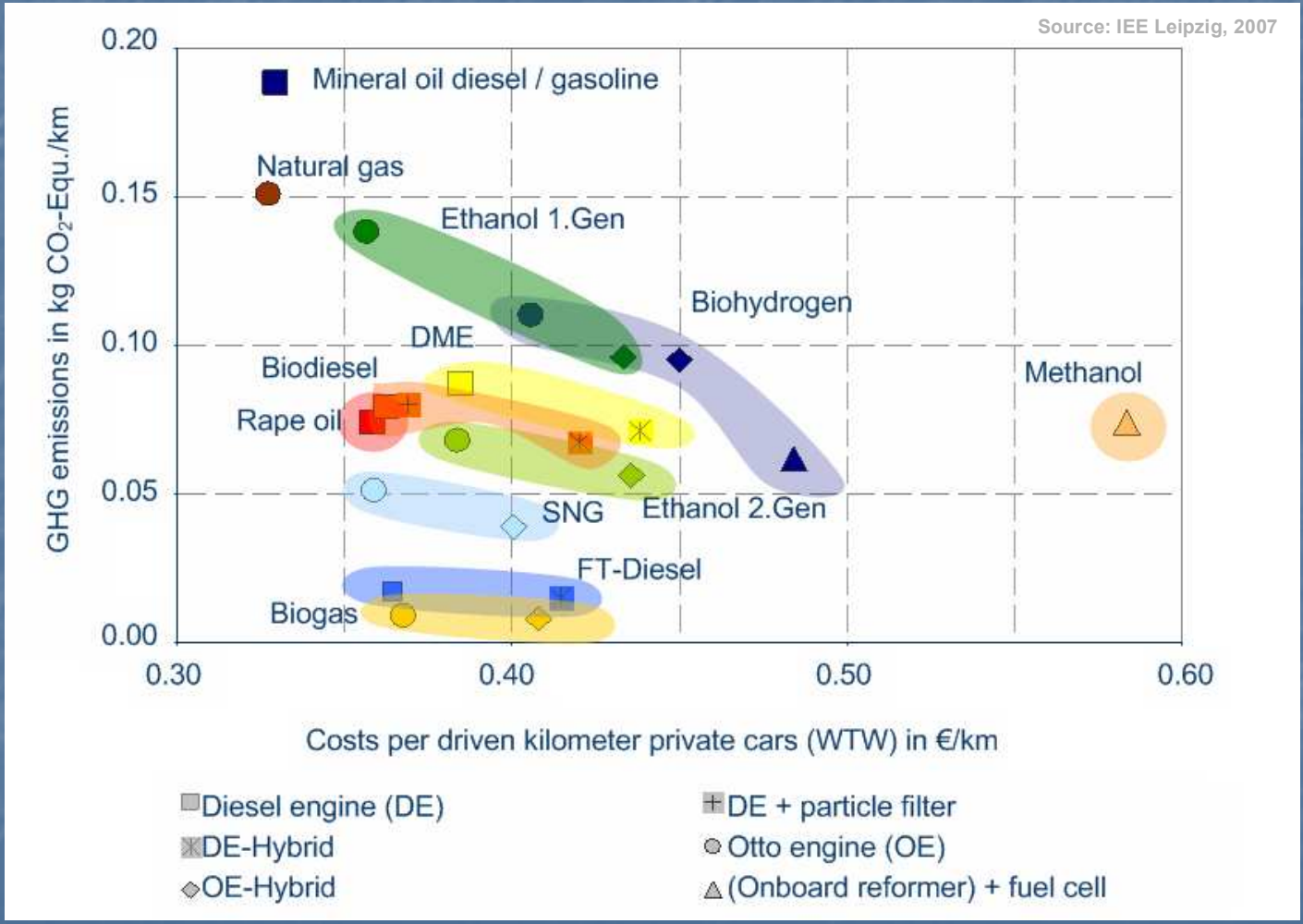
Biomass to added value chemicals: emerging chemistry



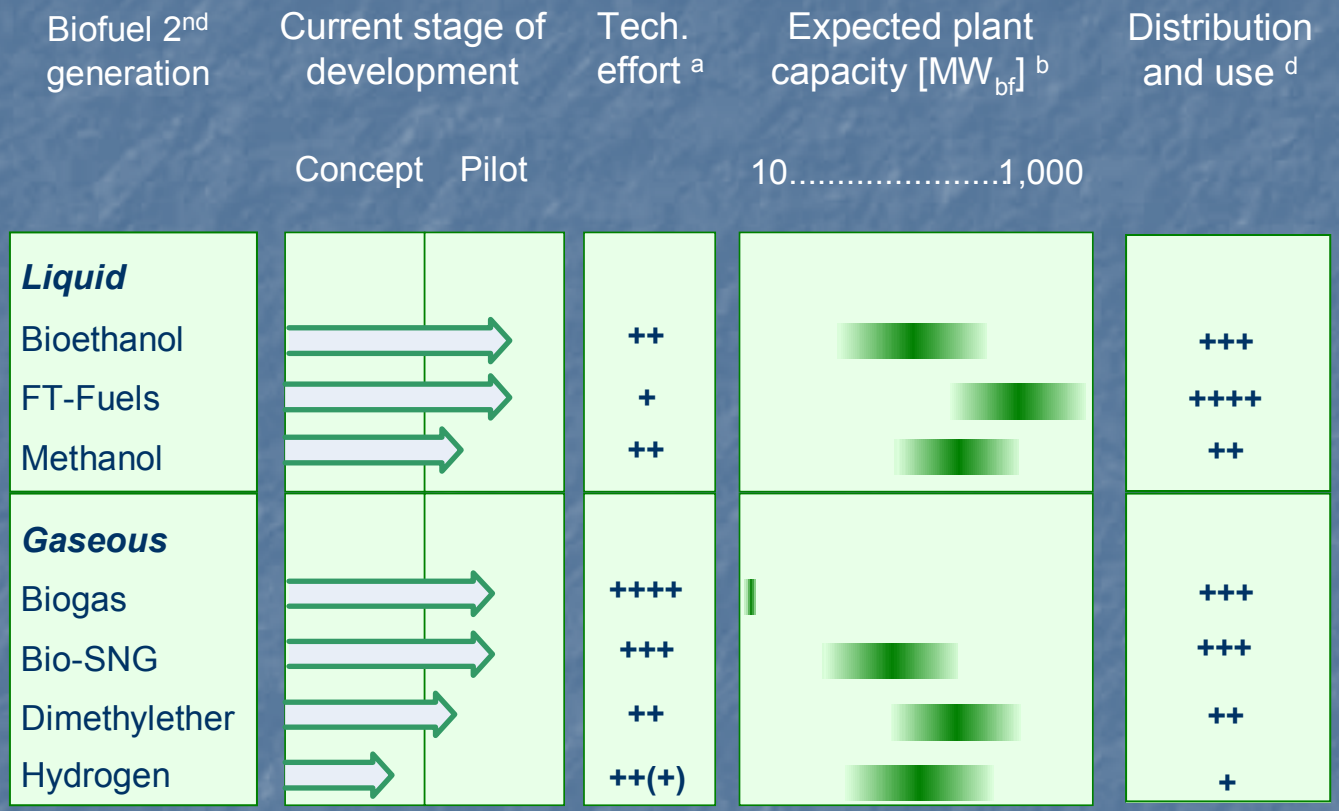
Biorefinery general concept



Biofuel production technology evaluation: economic aspects vs. environmental aspects



Biofuel production technology evaluation: technical aspects, 2nd generation



Source: IEE Leipzig, 2007

[a] regarding system complexity (+ less promising….++++ very promising)
[b] related to biomass feedstock
[c] suitability for current distribution and use (+ less promising….++++ very promising)

Problems related to technology transfer to developing countries

- Lack of capacity (R&D, industry, infrastructure, human resources)
- Lack of integrated approach in scenarios planning for technology adaptation (availability of resources, infrastructure, technology choice, sustainability, market, policy, …)
- …

Decision Support Tools (DST)

The DST are designed for local decision-makers, authorities, and academic stakeholders involved in technology transfer activities and are aimed to

- *help decision-makers in assessment and adoption the most environmentally friendly, efficient, and economical approaches*
- *create awareness towards environmental and sustainability issues*
- *optimize the existing practices*

DST developed in ICS-UNIDO:

- DARTS (Decision Aid for Remediation Technology Selection)
- DAWTS (Decision Aid for Water Treatment Technology Selection)
- SPORE (Spent Oil Regeneration Technology Selection)
- ALT-POP (Alternative Technologies for POP Destruction)
- MSW (Municipal Solid Waste Management)
- BioAS (Biofuel Assessment and Selection)

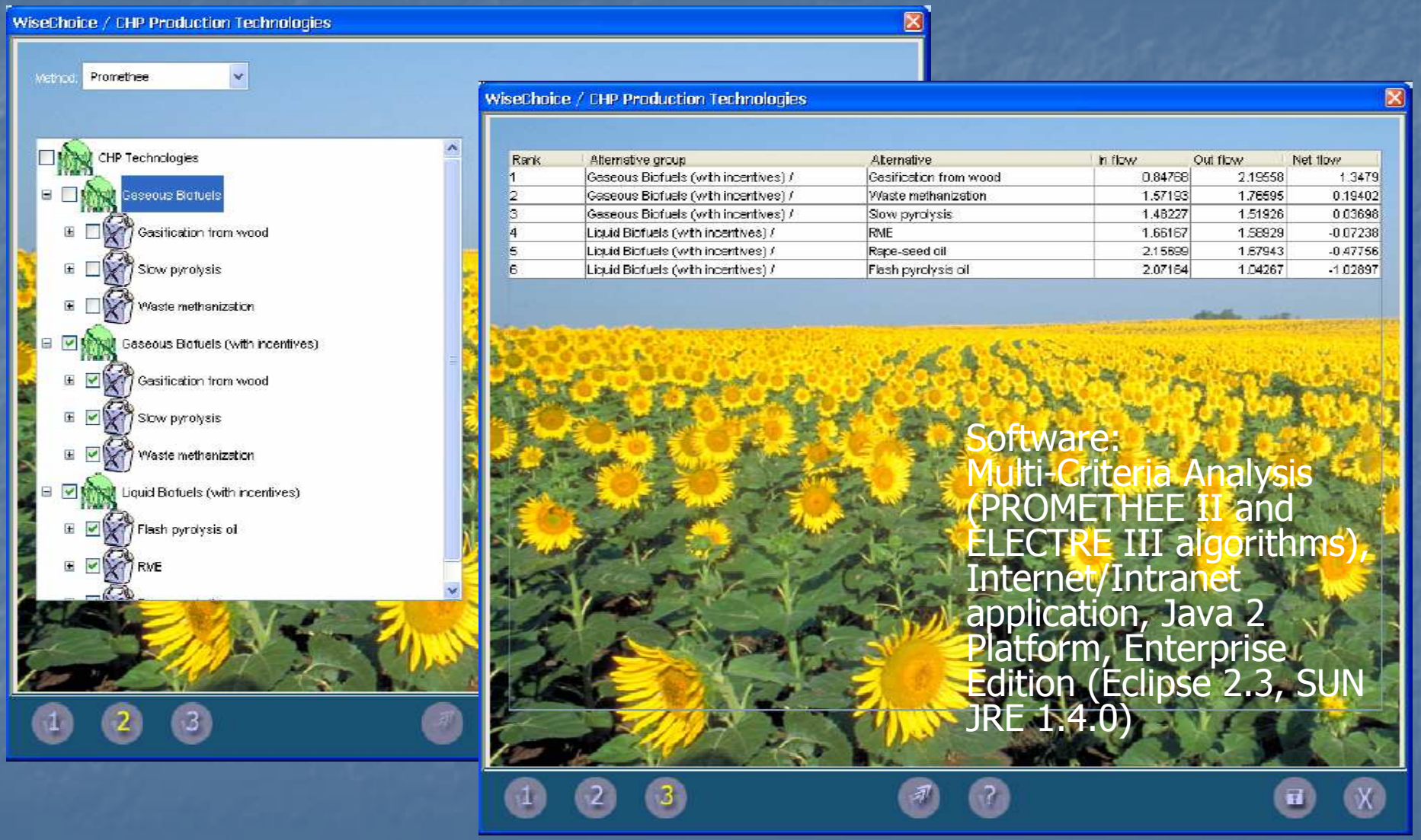
BioAs: DST for biofuel assessment and selection

- Developed in the framework of the AFTUR project (in cooperation of ICS-UNIDO with the Mihailo Pupin Institute, Belgrade, Serbia)

- Focuses on
  - liquid biofuels:
    - Vegetable oils (rapeseed)
    - Esters (Rapeseed Methyl Ester – RME)
    - Flash pyrolysis oils
  - gaseous biofuels:
    - Gasification from wood
    - Waste methanation
    - Slow pyrolysis (EDITTh process)

- Criteria for assessment (49 criteria total):
  - Technological criteria (energy content, non renewable energy consumed, availability, carbon residue, sulfur content, viscosity, density)
  - Environmental criteria (CO_2 , CO, NO_x, SO_2, etc.)
  - Financial criteria (static, dynamic, risk)
  - Socio-economic criteria (source: FIDES software)

BioAS prototype



DST for assessment of sustainability of buofuel production scenarios: a basic concept

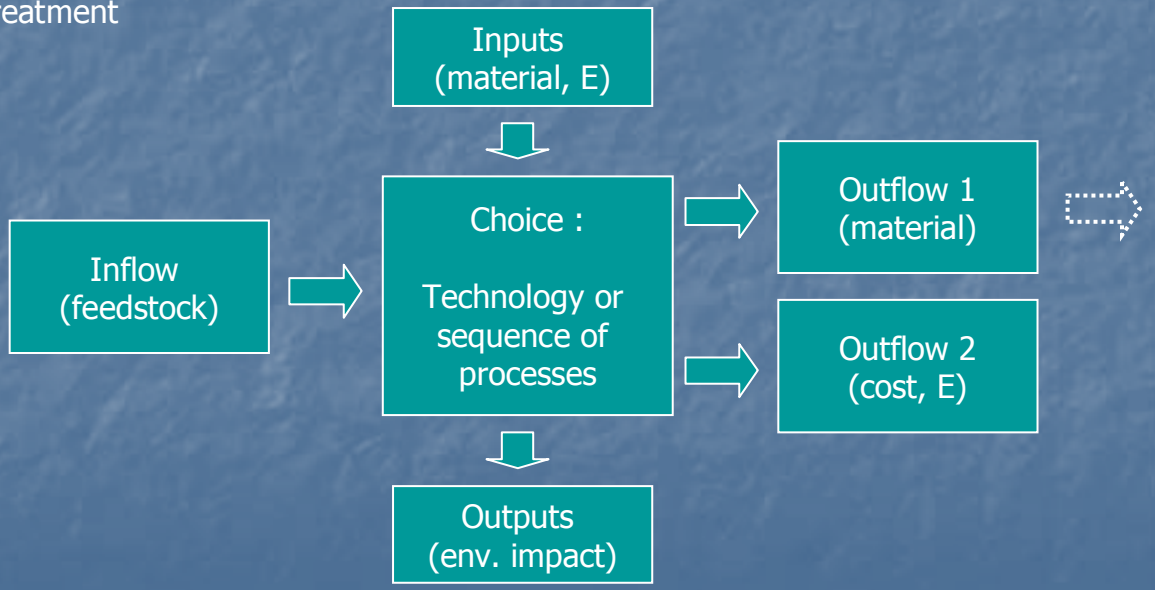
Objectives:

❑ to assess and compare environmental impacts (LCA) associated with different approaches of bio-resource exploitation, e.g. depending on feedstock, technologies choice, way of valorization of by-products

❑ to evaluate costs and benefits associated with the related production processes, which stem from valorization of products including energy, operational and capital costs, and consumable costs

❑ to suggest the appropriate treatment/processing options in order to obtain higher yields and quality of products, lower costs and impacts → a way towards the optimization of sustainability of production routes

- Inflows (feedstock amount, type/quality, treatment and scale choice)
- Outflows (product amount, quality)
- Connecting flows (intermediate amount, properties)
- Additional Outflows (cost and energy)
- Horizontal inputs/outputs:
  - Consumables (amounts and type of chemicals, fuel/energy)
  - Impacts (environmental impact indicators connected with consumable/energy production and process operation)



ICS-UNIDO

Mandate:

- Transfer of knowledge in applied sciences to developing countries
- Promotion and assistance in the development, selection, transfer and use of technologies
- Complementarities and Synergy with UNIDO Global Programme

Technical Areas:

1) Pure and Applied Chemistry
- Catalysis and Sustainable Chemistry/Biofuels
- Environmentally degradable plastics (EDP's)
- Remediation technologies
- Combinatorial chemistry/technologies, molecular design

2) Earth, Environmental and Marine Sciences and Technologies
- Decision-support systems for sustainable industrial development
- Coastal zone management
- Medicinal and aromatic plants

3) High Technology and New Materials
- Laser applications and optical technologies
- New materials
- Renewable Energies
- Telecommunication technologies

How ICS achieves its goals

- Awareness & capacity building
  - Training courses, workshops, meetings
  - Assessment of needs and priorities
  - Publications
  - Fellowships
- Project development, promotion and implementation
  - Preparation and promotion of project proposals
  - Participation in regional programmes
    e.g. UNIDO/GEF POPs Projects, Mediterranean Action Plan, Adriatic programme (MAE, CEI) …
  - In-house validation of project proposals and submission to international donors
  - Applied research projects
- In-house expertise
  - Development of IT tools (molecular modelling, CACC, DSS)
  - Surveys, compendia, assessments of chemical technologies
  - Research in selected sub-programmes
- Networking, focal points, cooperating centres
  - Long term research cooperation (Thailand, China, Malaysia, …)

Biofuel related events 2006/2007

- EGM on "Technologies for Exploitation of Renewable Feedstock and Waste Valorisation" Trieste, Italy, 20-30 May 2006
- Workshop on "Sustainable Plastics and chemical products from renewable resources" Belgrade, Serbia & Montenegro, June 2006
- Workshop on "Bio-fuels from palm oil: emerging technologies and their assessment" Kuala Lumpur, Malaysia, 4 July 2007
- Workshop on "Technologies for renewable feedstocks exploitation and bio-fuels production" Accra, Ghana, 12-13 December 2007

ICS-UNIDO work programme 2008: biofuels and biobased chemicals

- 3 projects in preparation in cooperation with MPOB – Malaysian Palm Oil Board
  - New catalytic systems for transesterification (1st generation biodiesel production)
  - Glycerol valorization
  - Second generation biodiesel from bio-waste
- Other projects in preparation in cooperation with IIR CSIR (Ghana), IC RAS (Novosibirsk, Russia), NCL (Pune, India), IC (Santa Fe, Argentina), Petrobras (Brazil)
- 3 projects under revision by GBEP & Italian Ministry of Foreign Affairs – India, Ghana
- GreenOlympics project in cooperation with the Science and Technology Committee for the Games of the XXIX Olympiad in Beijing – Environmentally Degradable Plastics
- Fellowships (60 person-months)
- Capacity building:
  - International Congress "Biofuels: A Global Challenge" - Trieste, June 2008
  - Workshop: LA – November 2008
  - Publications and DST
  - Networking (regional networks in Africa and SEA countries)

Recent publications

BIO-FUELS

- Technologies Status and Future Trends
- Feedstock and Product Valorisation
- Assessment of Technologies and DSTs

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Available on the ICS-UNIDO website:
www.ics.trieste.it

Recent publications

Background Paper

for the Regional Workshop on Promoting Sustainable Biofuels Production and Use in Central and Eastern Europe, Dubrovnik, Croatia 12-13 November 2007

Biofuel Production Technologies

WORKING DOCUMENT

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