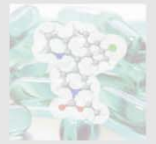



By-product utilization and local biobased business opportunities

Experiences with processing of grass silage and pomace to proteins, fibres and value added chemicals

Hans Schnitzer

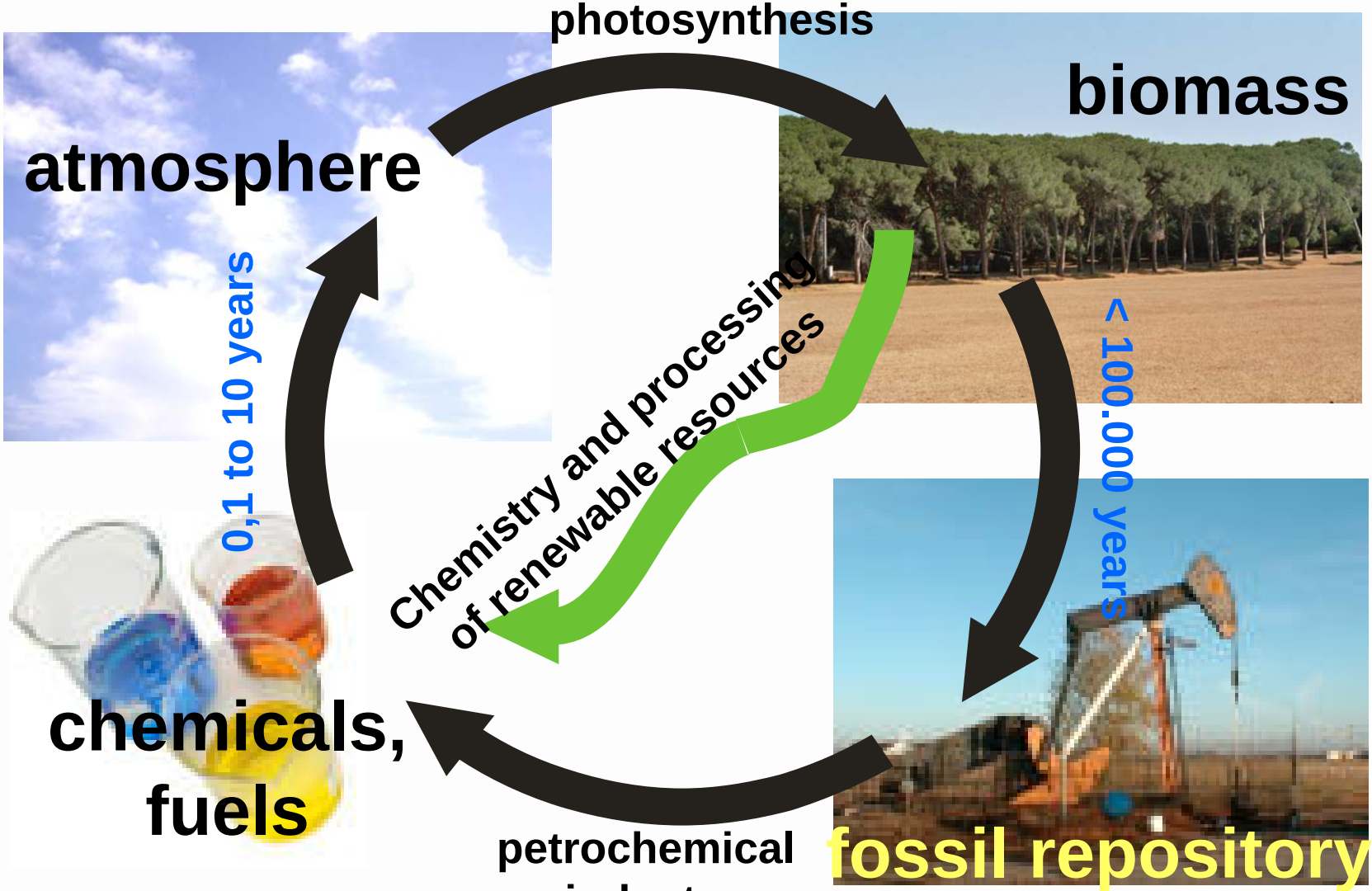
Graz University of Technology

Institute for Resource Efficient and Sustainable Systems

JOANNEUM RESEARCH

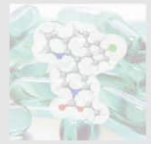
Institute for Sustainable Techniques and Systems

Organic chemistry is always based on biomass



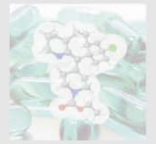
Bio-based economy

- Shift from depletable fossil resources to renewable plant-based ones
- Create jobs and income in the region
- Minimize emission of global warming gases
- Minimize global competition about limited resources




rns

JOANNEUM RESEARCH

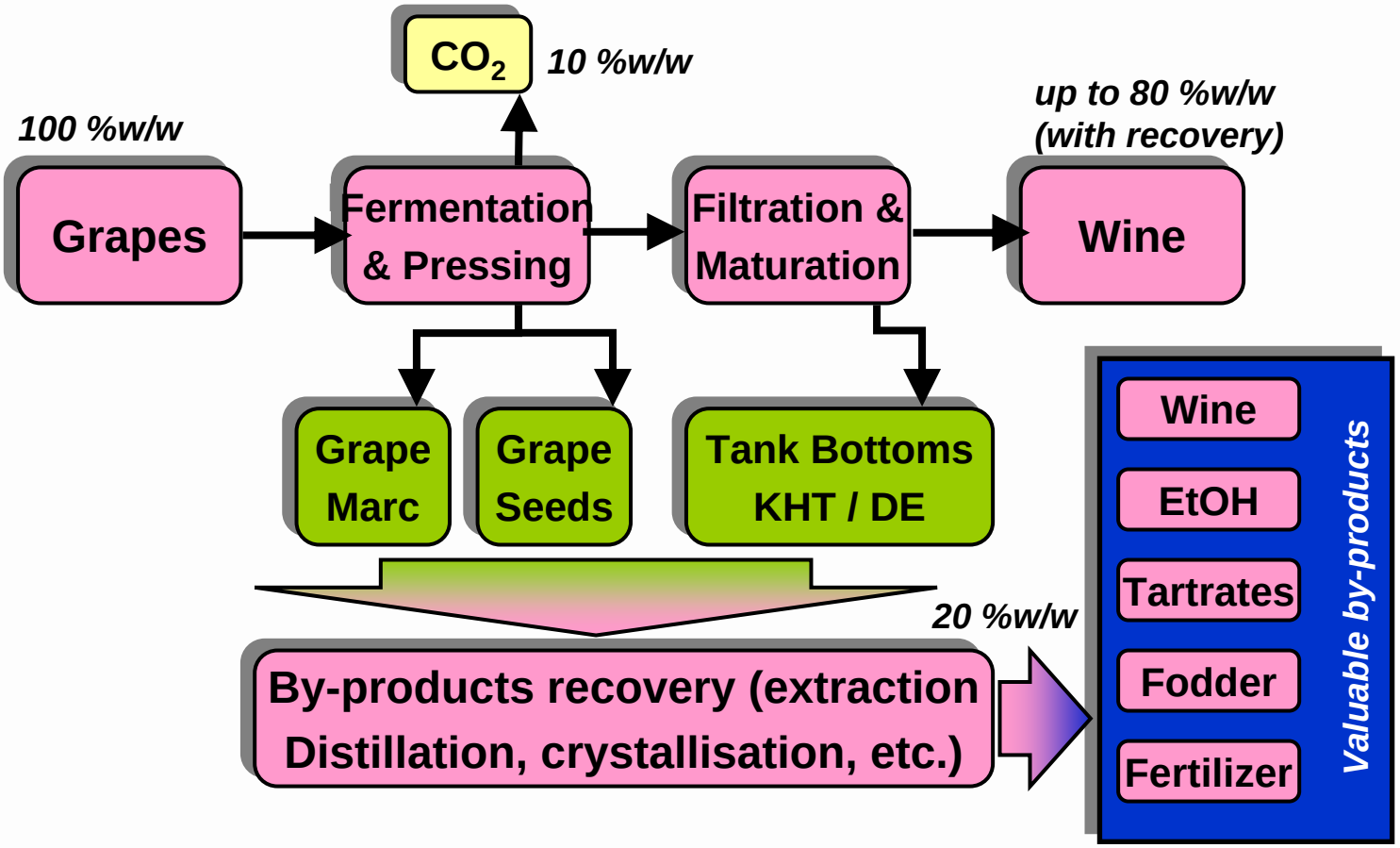



Step 1: value-added processing of organic waste / byproducts from existing food industry

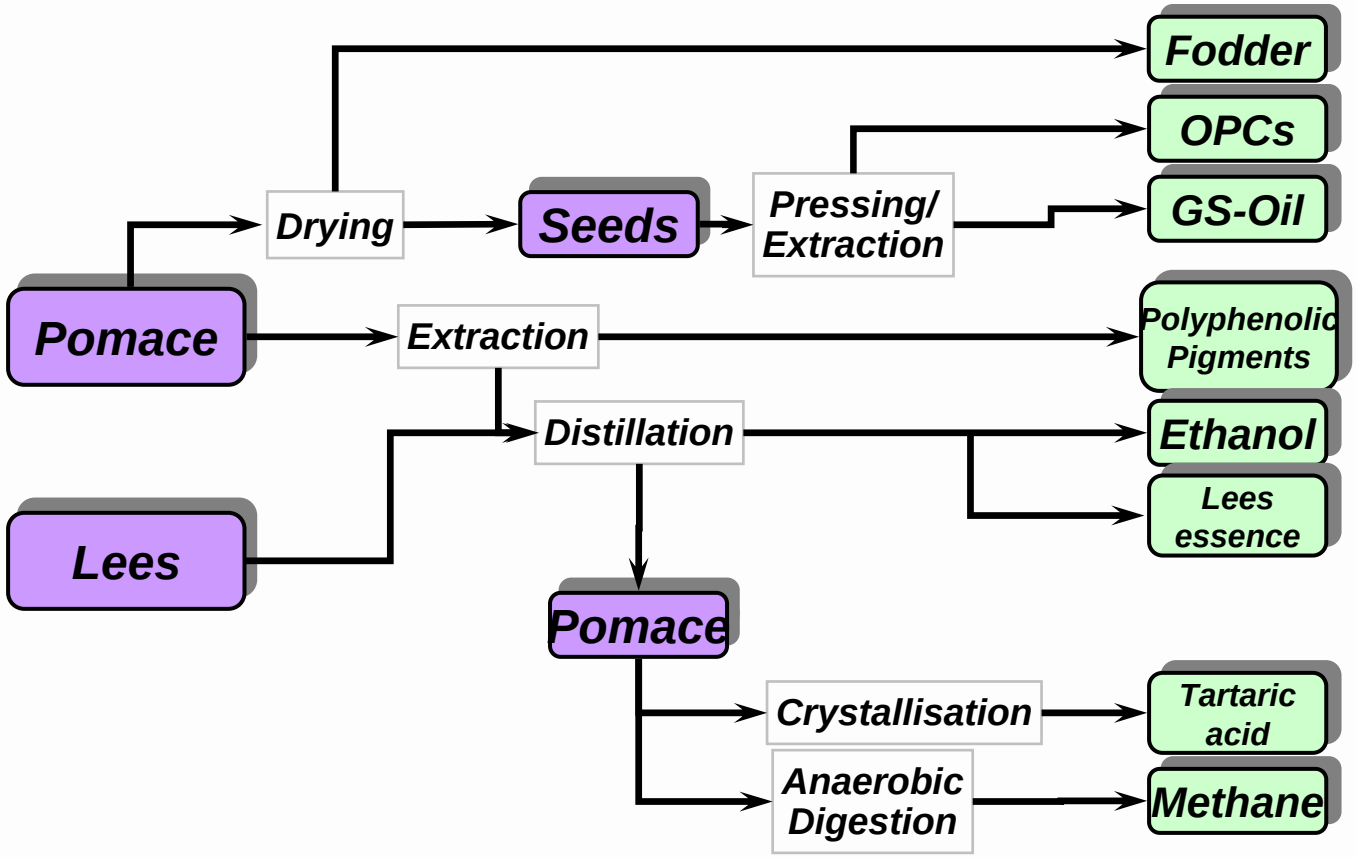
the example of grapes

Hans Schnitzer, http//:rns.tugraz.at and www.joanneum.at/nts

By-products recovery

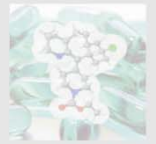


Grape Pomace – Overview: By-products recovery



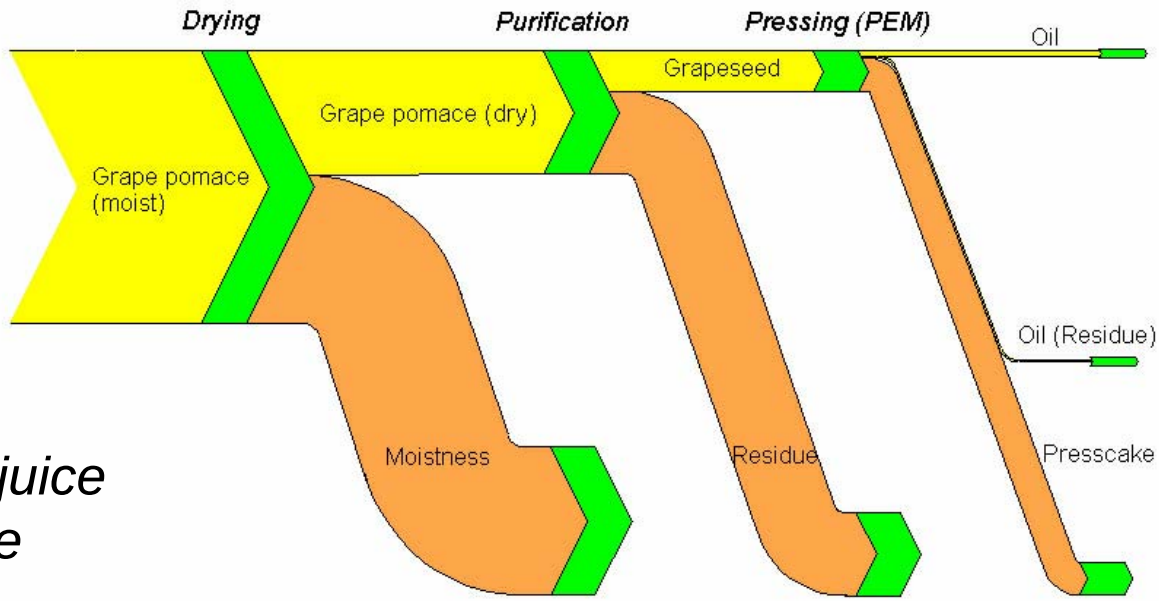
Grape Pomace – By-products recovery

- By-products recovery from grape pomace and wine lees includes:
  - *Ethanol (CH_3OH) production*
  - *Tartrate production (Ca-tartrate, Cream of tartrate, sodium/potassium tartrate, etc.)*
  - Edible Oil (Grape seed Oil) Antioxidants (OPC)
  - Utilization of left-overs as animal feed and/or fertilizer




Grape Pomace – Cascade processing

- **Example for "product-cascading" of grapes**



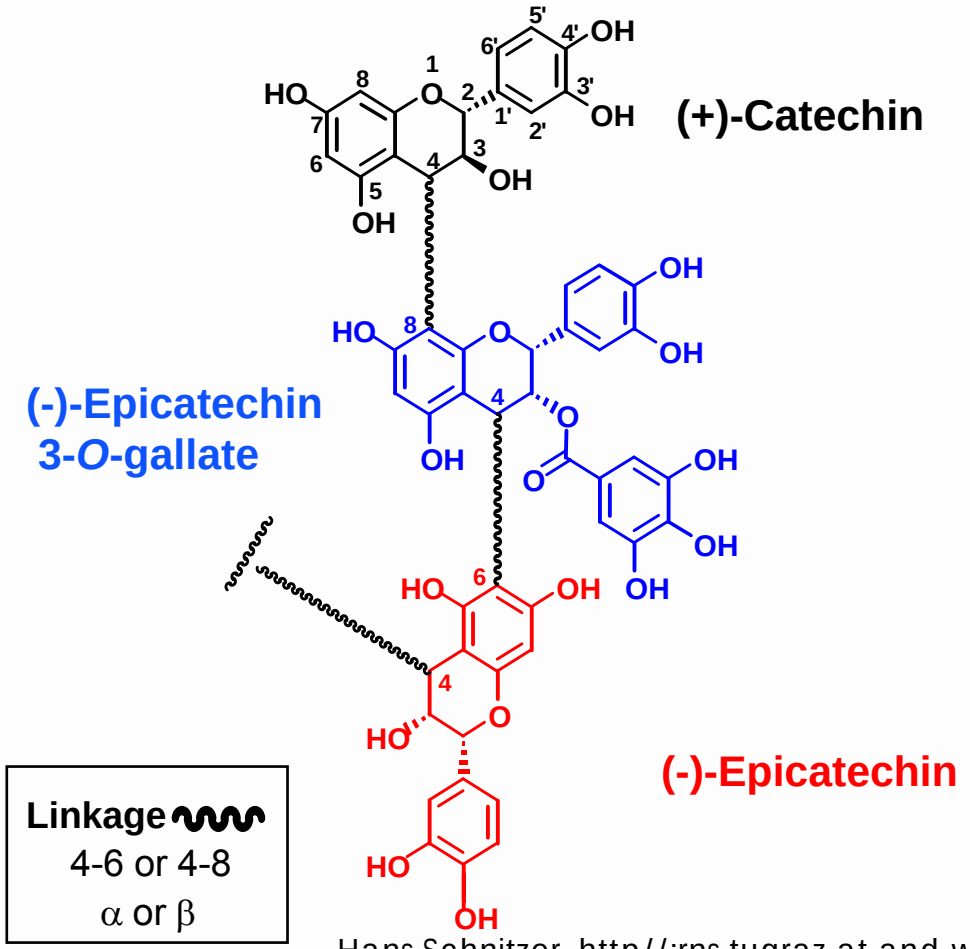
Edible oil

Grape juice → Wine

Antioxidant → Nutraceutical,...

Pet food Supplement, ...

Grape Seed Antioxidants (OPCs) of GSE (Grape Seed Extract)



- General structure of Oligomere Proanthocyanidines (OPCs)
- OPCs are known for their importance in human health and disease prevention and may be used for cosmetic purposes

Grape Seed Oil – Processing

- Two methods have been compared:
  - Pressing/expeller Method
    Semi-continuous; Temperature 25-70°C
  - Extruder/screw Method → conventional
    Continuous; Temperature > 60°C

→ Comparison of the quality was done on oil and press-cake extract [Quality and antioxidative capacity of grape seed extract]

→ Quality control on grape seed oil was performed after decantation and filtration

Grape Seed Oil – Economic considerations

- Pressing method
  - PEM (pressing expeller method)

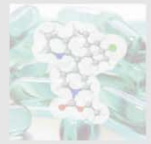
    3 or 6 pot system (semi continuous)

    Capacity: ~ 60 to150 kg/h (seed) Price: ~ 100.000.- / 160.000.- €
  - ESM (Extruder screw method)

    Capacity: ~ 150 kg/h Price: ~ 25.000.- €
- In case of grape seeds the better quality of the PEM press cake (PC) might be an positive argument if PC is used for further products (e.g. OPC-extract)
- PEM presses are generally used for high quality = high price cold pressed oils

Grape Pomace Products: Overview – Market prices

- Grape seed Oil:
  - Natural - cold pressed: up to 70 US$/litre
  - Raffinated: ~ 4 US$/Litre
- Bio-Ethanol: 24 - 35 US$-Cents/litre
- Tartaric Acids:
  - Cream of Tartar: up to 4,4 US$/kg
  - Tartaric Acid: up to 6,6 US$/kg
- Fodder, Fertilizer and Biogas: depend on local markets

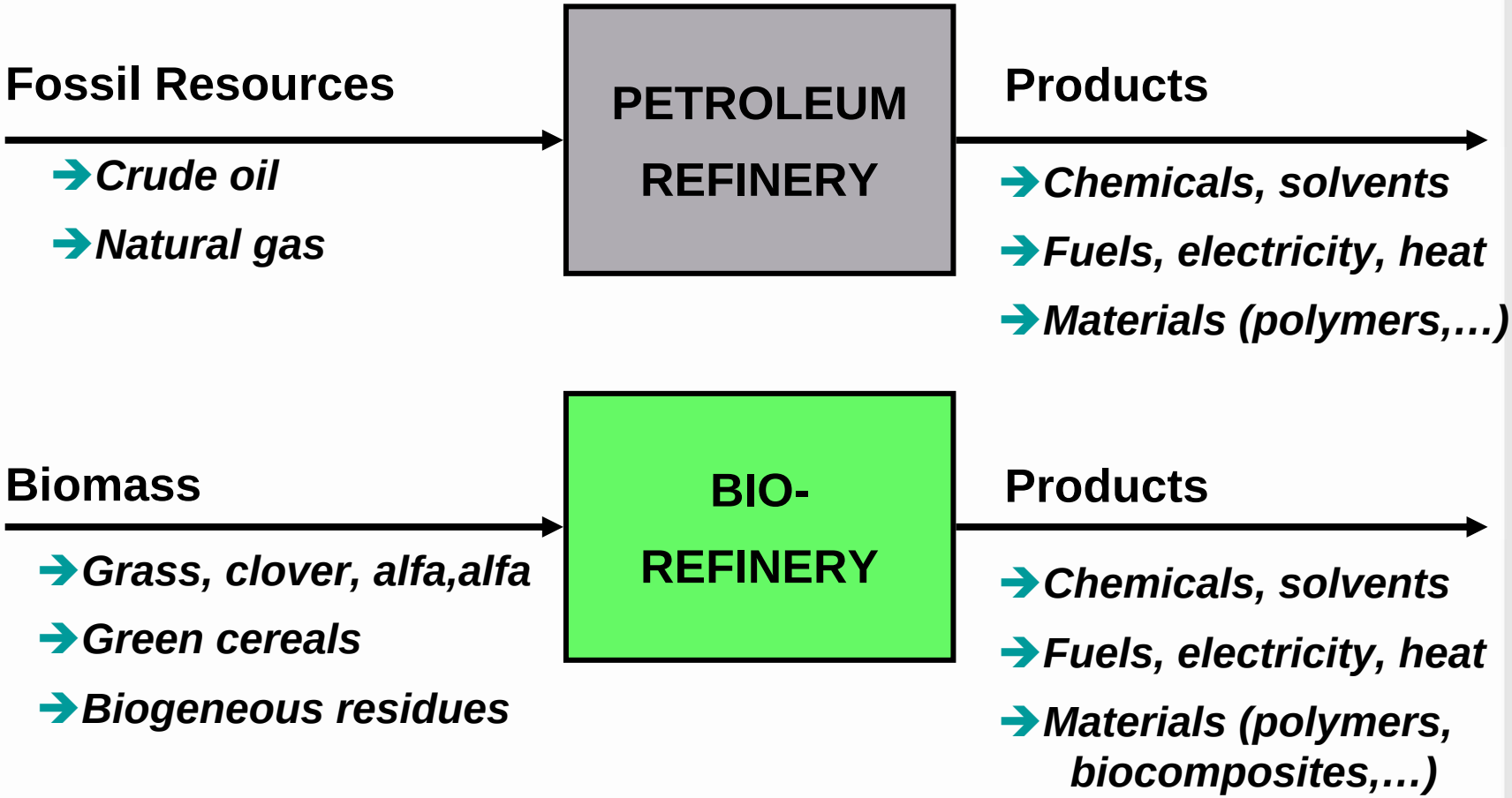



Step 2: Design of a biorefinery around available crops

The example of a green biorefinery based on grass

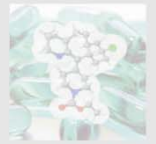
Principle of a BIOREFINERY:

Biomass is converted into a flexible mix of products



What Is a Biorefinery?

- A biorefinery is a facility that integrates biomass conversion processes and equipment to produce fuels, power, and chemicals from biomass.
- The biorefinery concept is analogous to today's petroleum refineries, which produce multiple fuels and products from petroleum.
- Industrial biorefineries have been identified as the most promising route to the creation of a new domestic biobased industry.



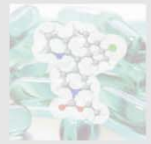



rns

JOANNEUM RESEARCH

What Is a Biorefinery?

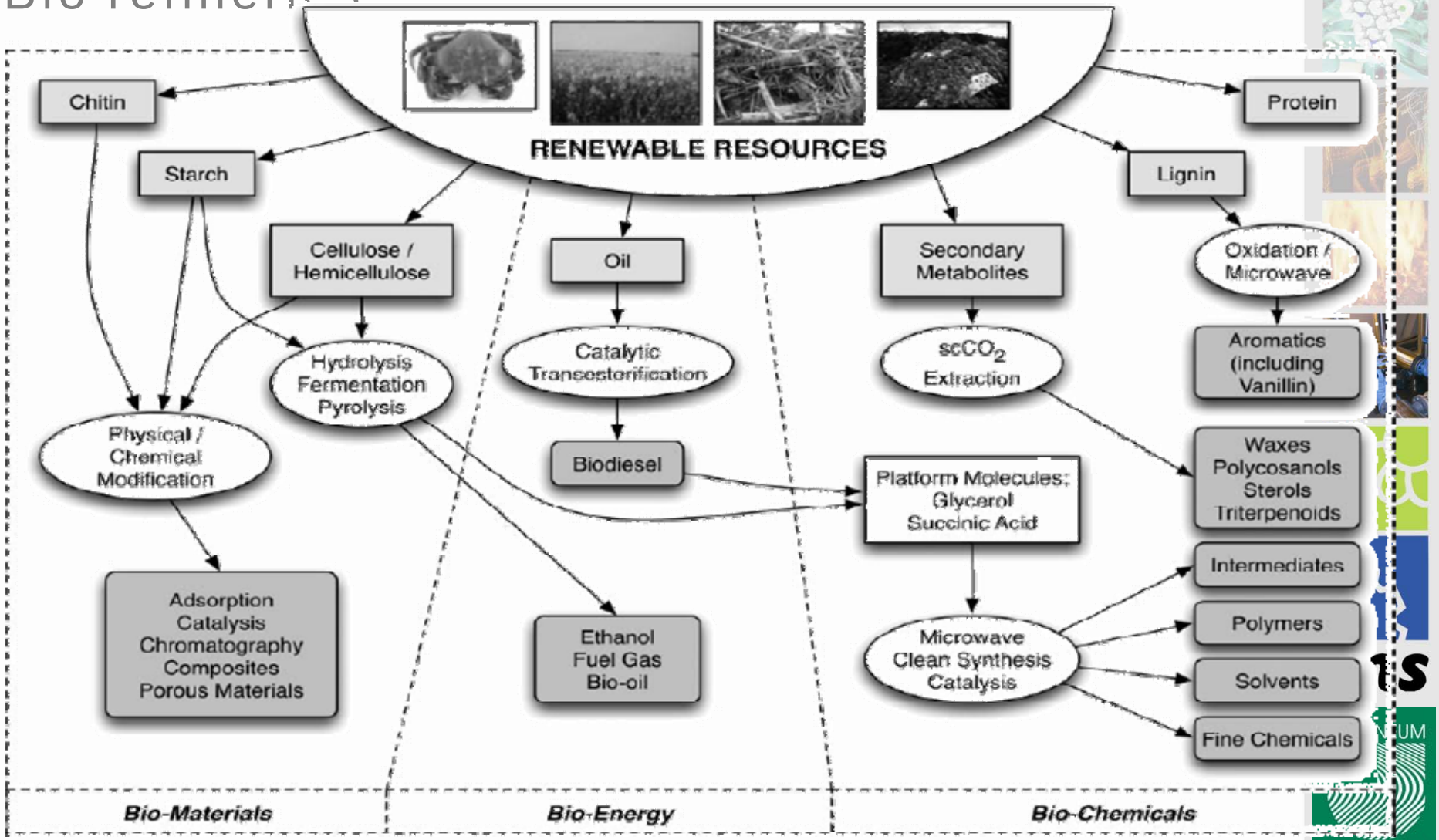
- By producing multiple products, a biorefinery can take advantage of the differences in biomass components and intermediates and maximize the value derived from the biomass feedstock.
- A biorefinery might, for example, produce one or several low-volume, but high-value, chemical products and a low-value, but high-volume liquid transportation fuel, while generating electricity and process heat for its own use and perhaps enough for sale of electricity. The high-value products enhance profitability, the high-volume fuel helps meet national energy needs, and the power production reduces costs and avoids greenhouse-gas emissions.




rns

JOANNEUM RESEARCH

Bio-refineries



Source: James H. Clark, et al.: Green chemistry and the biorefinery: a partnership for a sustainable future. Green Chem., 2006, 8, 853–860

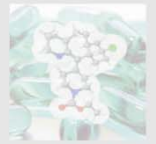
What is different in processing renewables?

Conventional chemical processes

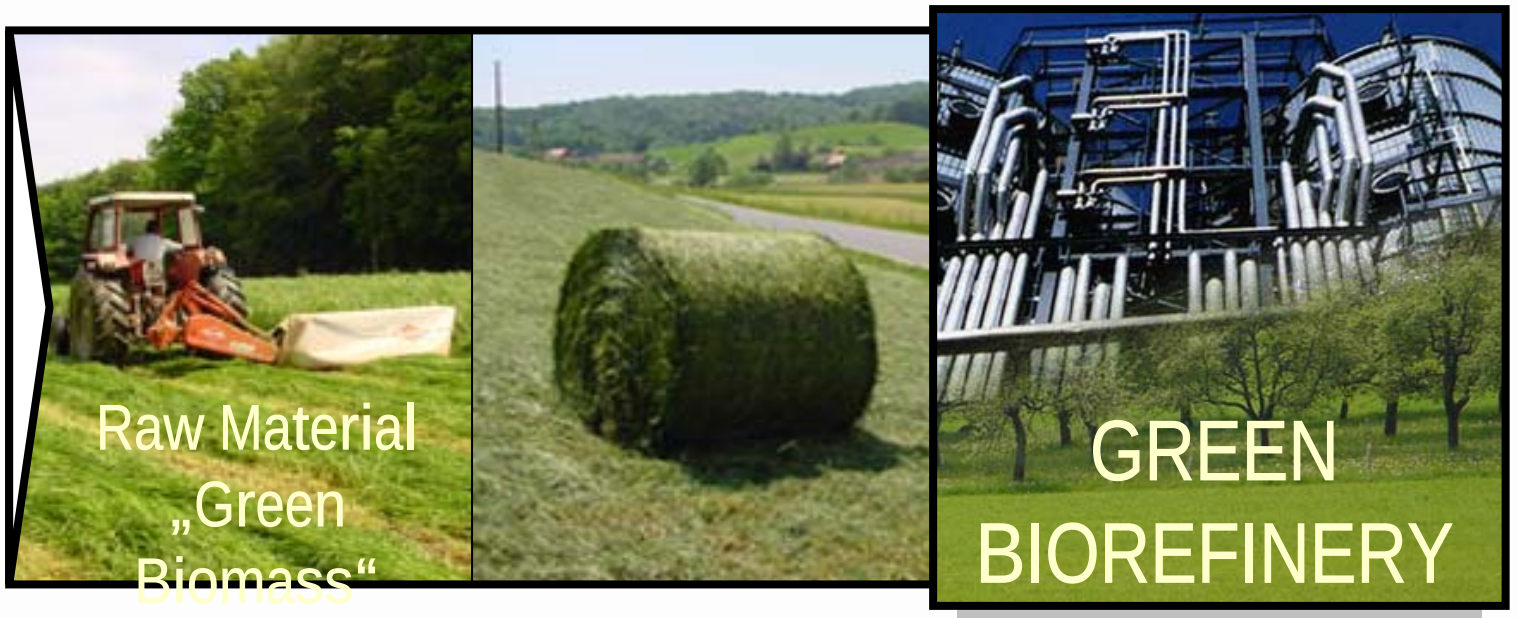
- Raw materials are standardised
- Raw materials are continuously available
- Raw materials have centralised sources
- Logistics play negligible role for process structure

Renewable resource processes

- Raw materials differ in quality
- Raw material availability shows strong time dependence
- Raw materials have decentral sources
- Logistics and storage have impact on process structure




Principle of the technology concept GREEN BIOREFINERY



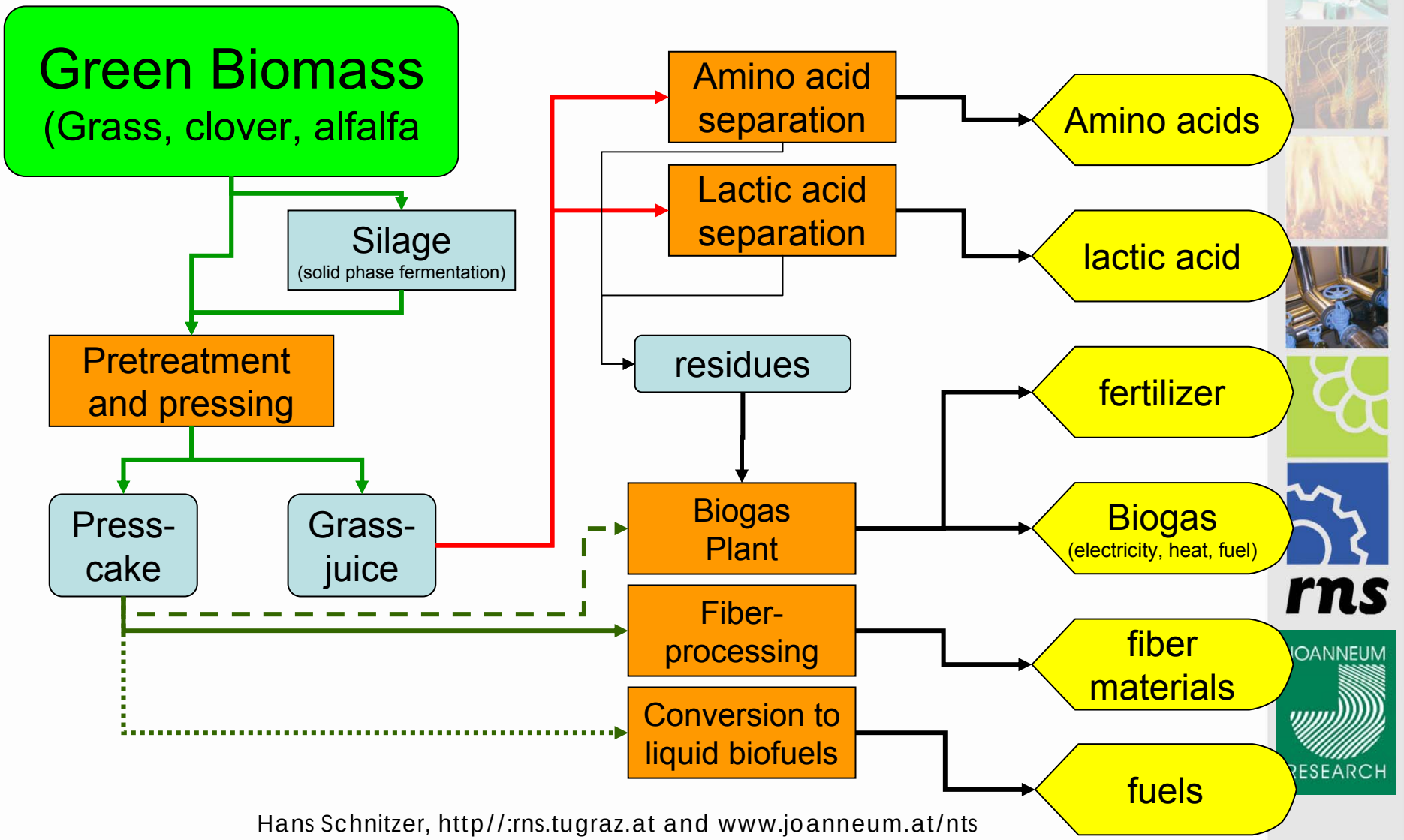
Bulk Chemicals
- *organic acids, e.g. lactic acid*
- *solvents*
- *plastics (monomers)*

Fuels
- *ethanol*
- *butanol*
- *acetone*
- *ester*

Food/Feed
- *amino acids*
- *protein products*
- *peptides*

Fibre Products
- *fibreboards*
- *biocomposites*
- *insulation material*

Green biorefinery: utilization of whole, green (wet) plants



Hans Schnitzer, http//:rns.tugraz.at and www.joanneum.at/nts

Mass- balance overview

ca. 0,1ha

Silage 3330 kg (1000 kg TS)

0,085€/kg TS

Fractioning

Press-cake 1250 kg (700 kg TS)

Optional drying and further fractioning

BIOGAS

0,065 €/kgTS

Plant juice 2083 kg (300 kg TS)

Amino acids

60 - 100 kg AA mixture

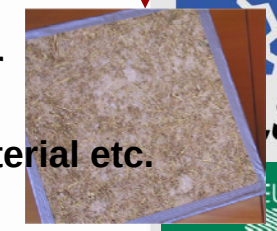
0,35-10 €/kg

Lactic acid

120 – 160 kg

0,56 - 1,0 €/kg

Fibres



Resource for fireboards, isolation material etc.

0,1- 0,15 €/kg

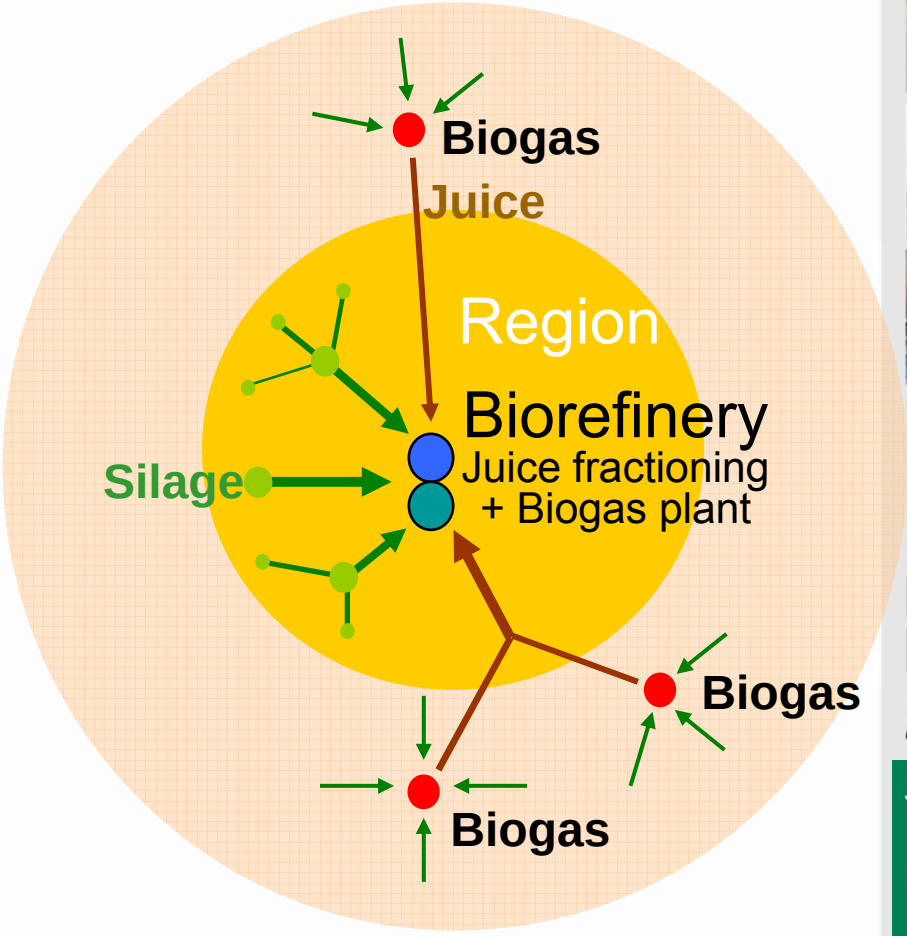
Residuals ca. 1850kg (40-120kg TS)

mechanical fractionation

Models for bio-refinery operation

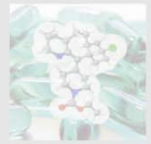
1.) **Bio-refinery in a core zone of a region**

2.) **Integration of surrounding region**



Products and status

- Lactic acid: an existing big market (bulk chemical)
- Amino acids: various applications in high price low volume segment
- Energy (biogas) out of liquid residues and fibers
- Utilization of fibers if grass fiber products are economically viable
- Future option: press cake as feedstock for other processes
- Status: preparing for demonstration plant




Potential market for lactic acid, PLA, solvents

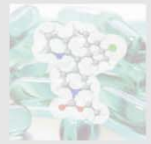
- **2001 Cargill Dow starts up LA –fermentation plant (140.000 t/a)**
- **2003: about 100.000 t/a MS are used worldwide**
- **Prognosis 2020 for PLA (USA only)**
  approx. 3.600.000 t/a of PLA ,
  about 33% of all technical possible field of PLA are covered
- **Prognosis 2020 for solvent (USA only)**
  approx. 450.000 t/a ethyl-lactate
  10% of all solvents are on the basis of ethyl-lactate

Possible fibre products

Hans Schnitzer, http//:rns.tugraz.at and www.joanneum.at/nts

Summary

- **Green Bio-refinery is a technology concept for using the whole plant.**
- **Green Bio-refinery applies future Key-technologies for gaining valuable Products. (LA, AA, energy, fibres)**
- **Green Bio-refinery can be easily linked to a process focusing on energy out of biomass (Biogas).**

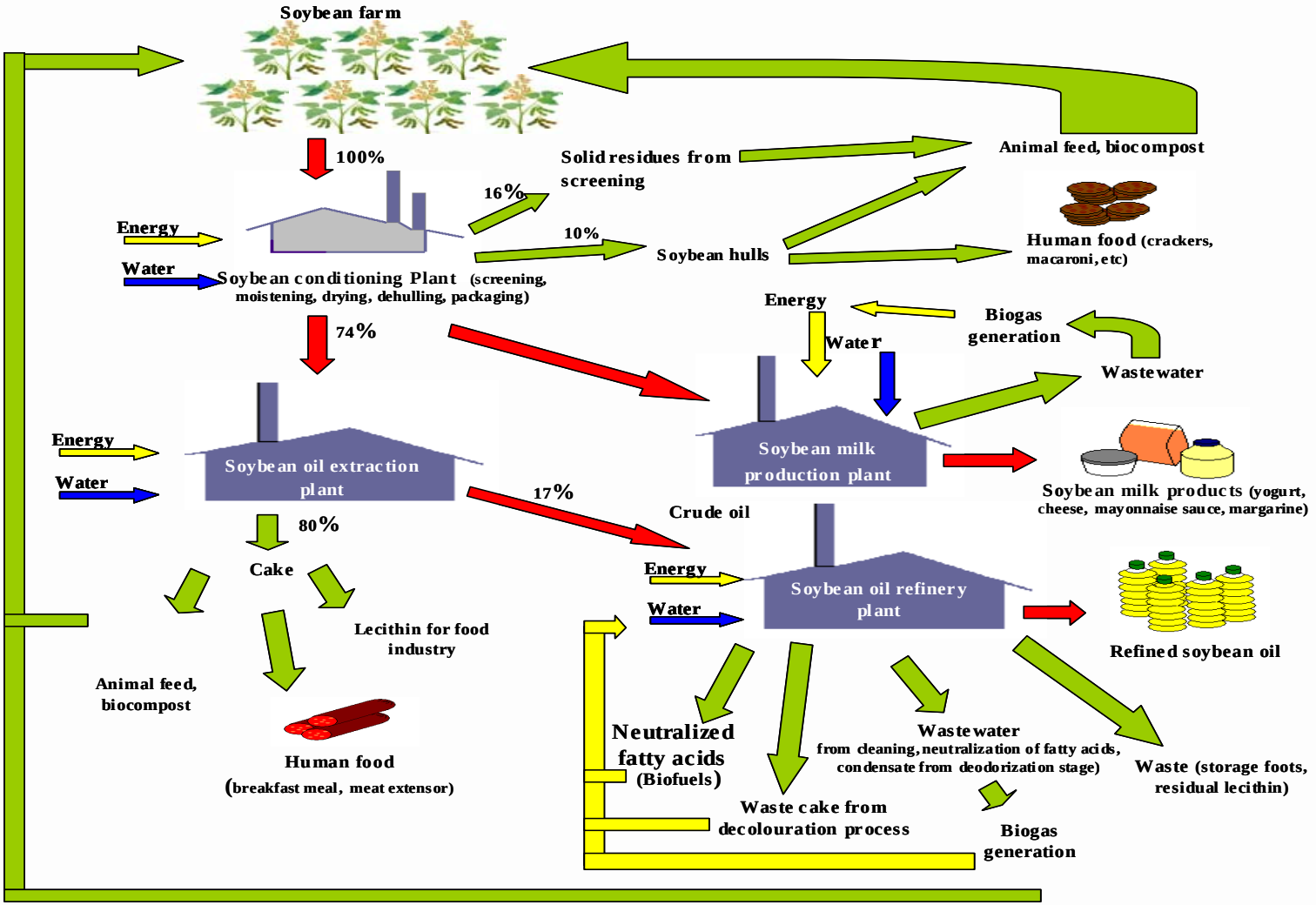





rns

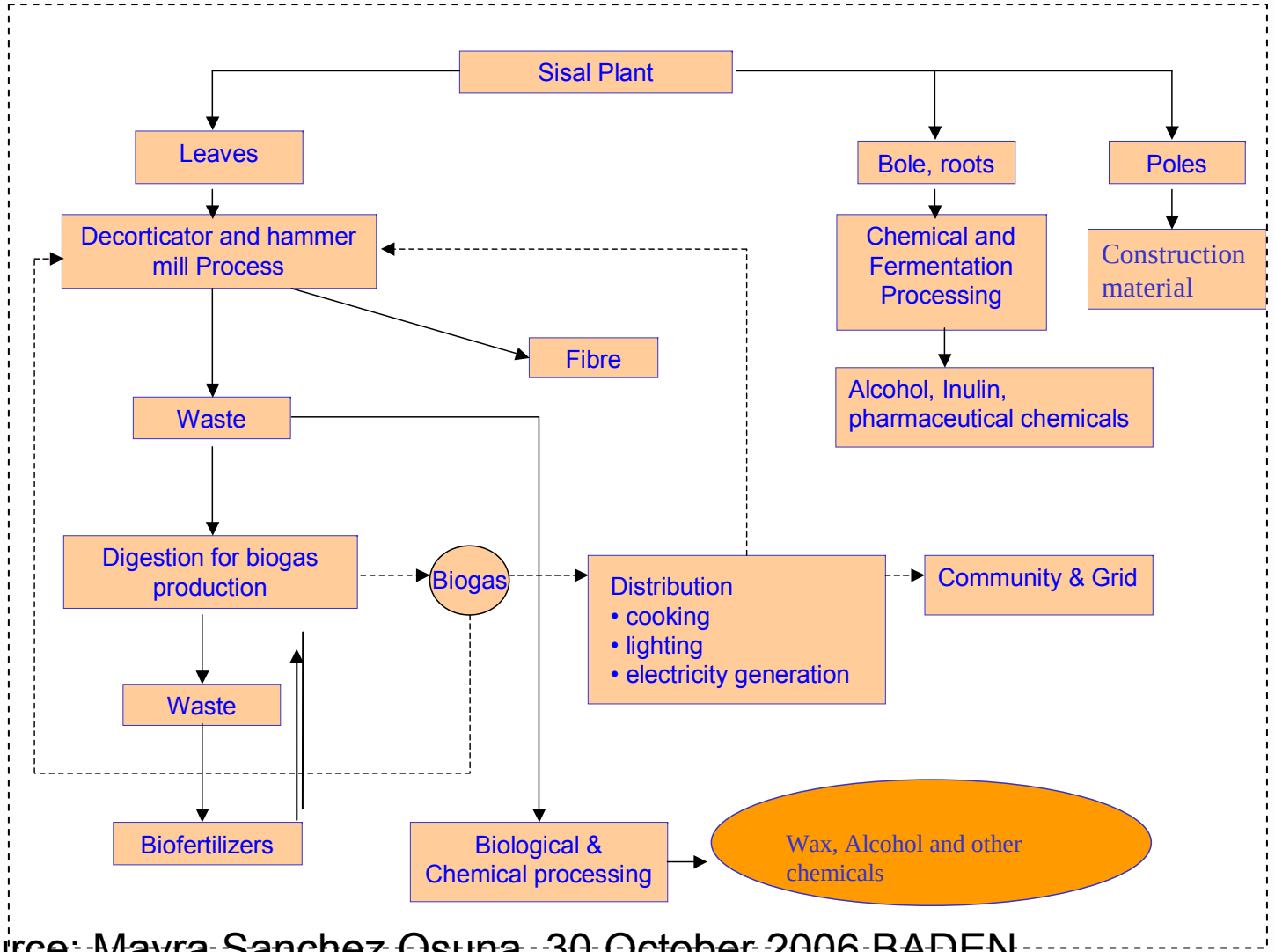
JOANNEUM RESEARCH

Soybean based Zero Emissions Biorefinery System

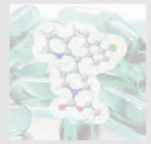


Source: Mayra Sanchez Osuna, 30 October 2006 BADEN

Sisal based Zero Emissions Biorefinery System



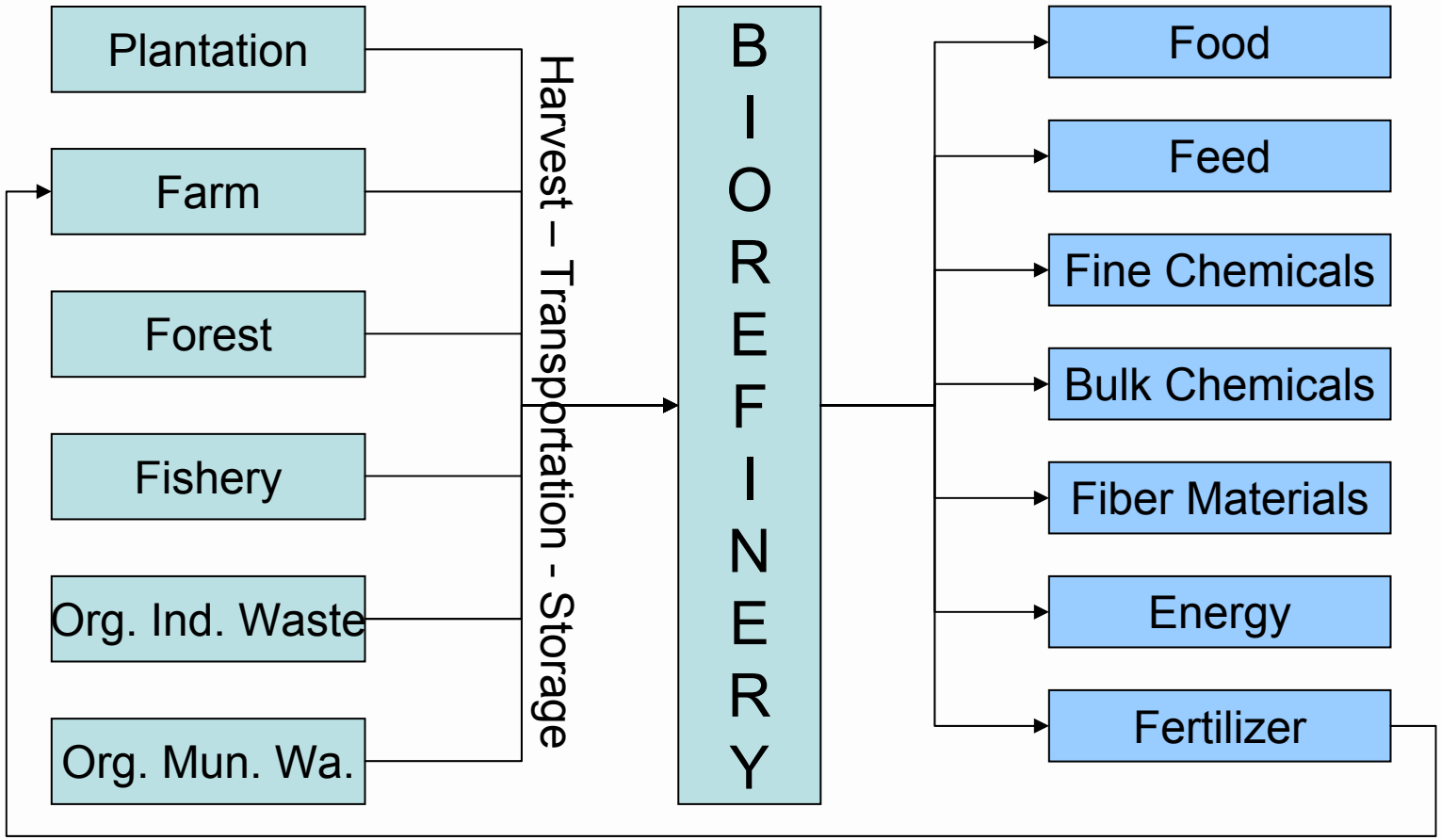
Source: Mayra Sanchez Osuna, 30 October 2006 BADEN




Step 3: Biorefineries based on new crops

just some examples

Product-Hierarchy



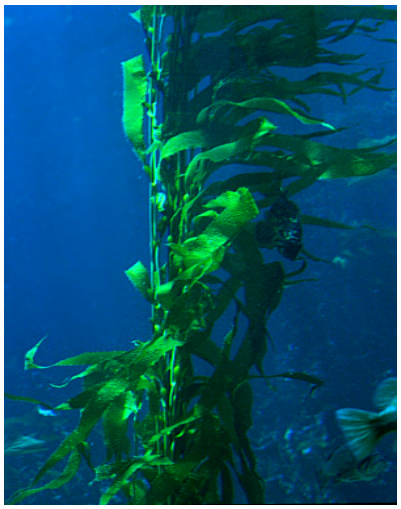
Modified from Janis Gravitis; A Biochemical Approach to Attributing Value to Biodiversity – The Concept of the Zero Emissions Biorefinery

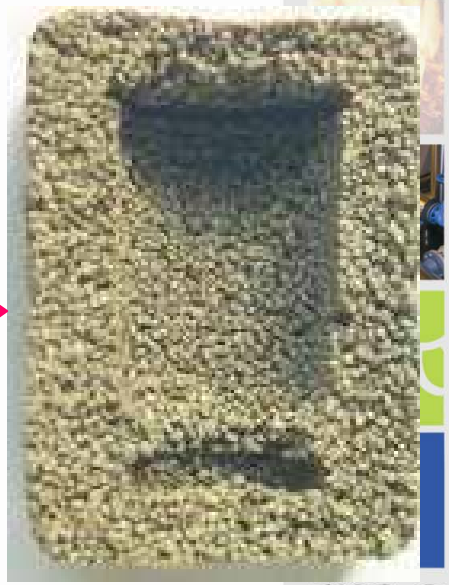
Feedstocks mentioned in literature as a basis for Biorefineries

- Agricultural, Forestry
  - grass, hay, straw, clover, alfalfa, green cereals
  - bamboo, cashew nut, moringa
  - animal farming, slaughter houses
  - eucalyptus, forestry residues
- Organic waste from industry
  - glucose syrup, beet molasses
  - fruits (pineapple pulp, grapes and canola seed press cake ...)
  - beverages (fruit juices, beer,...)
  - fish and seafood
- Other
  - water hyacinth

Various sources

Process of Producing the Alginsulat-foam

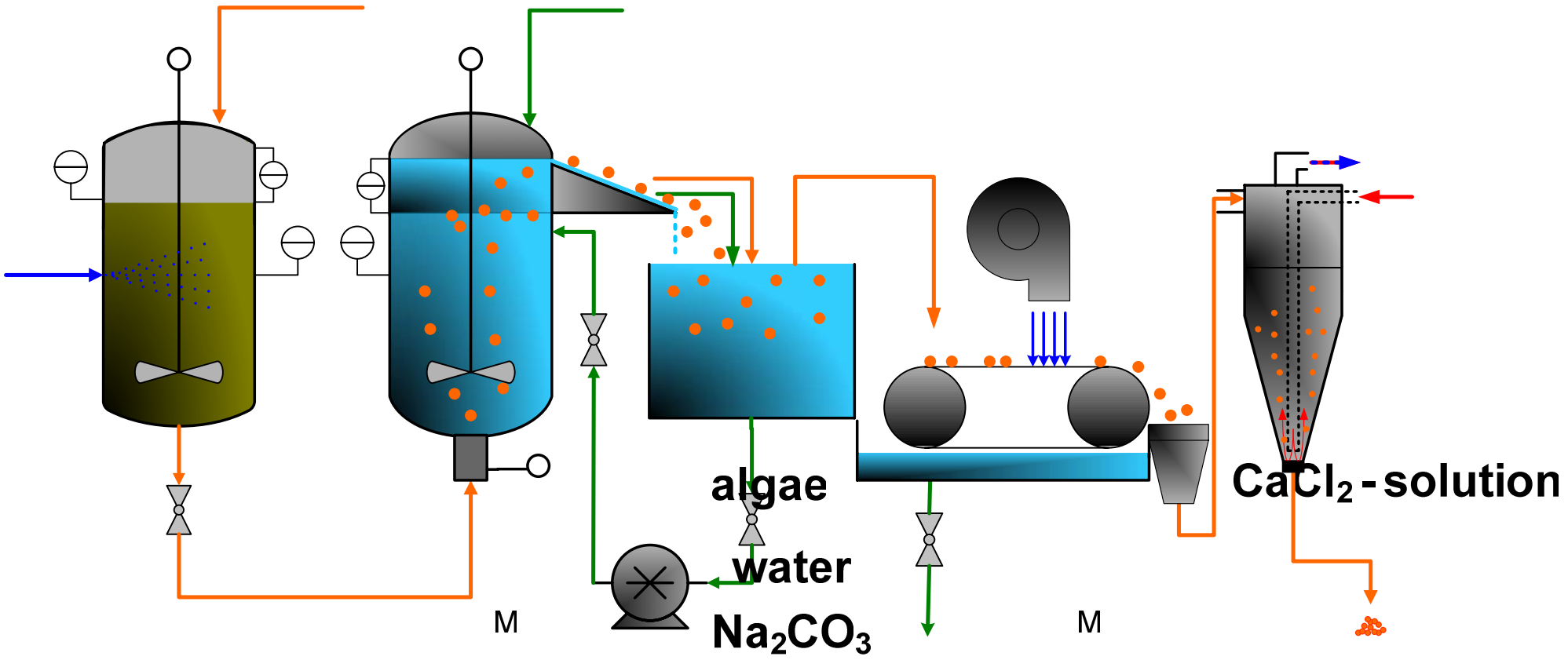




Source: Christine Riedl, Institute for Resource Efficient and Sustainable Systems, Graz University of Technology

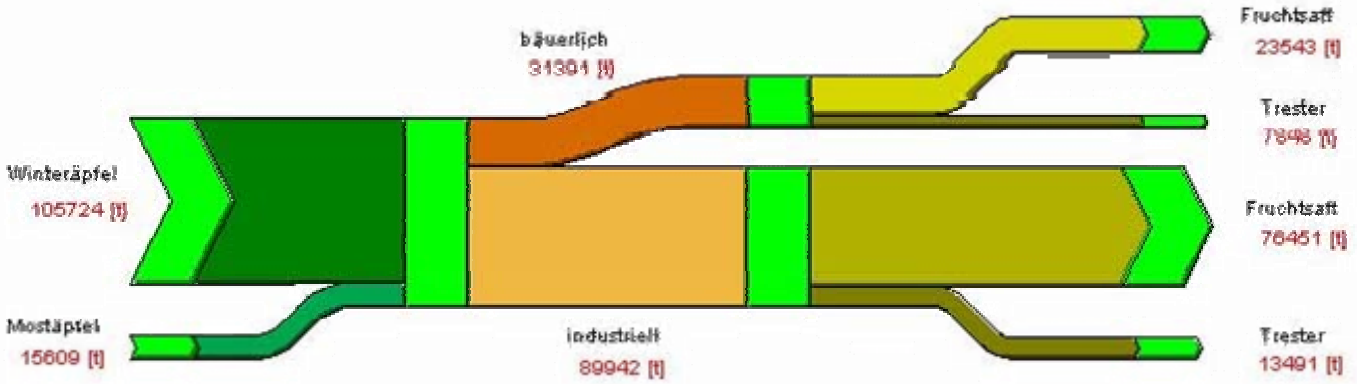
Production of Alginsulat-foam

Flow-chart of the process



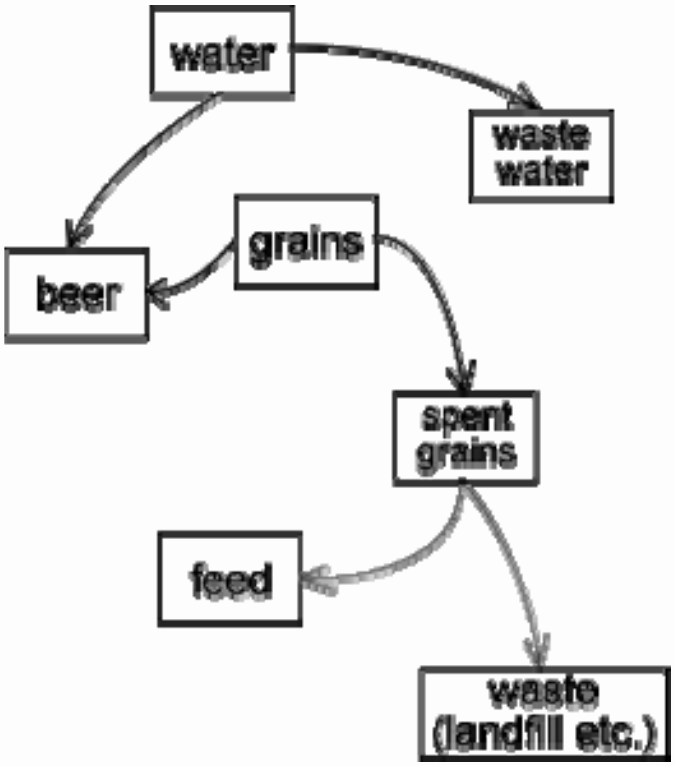
Value added processes for a juice production

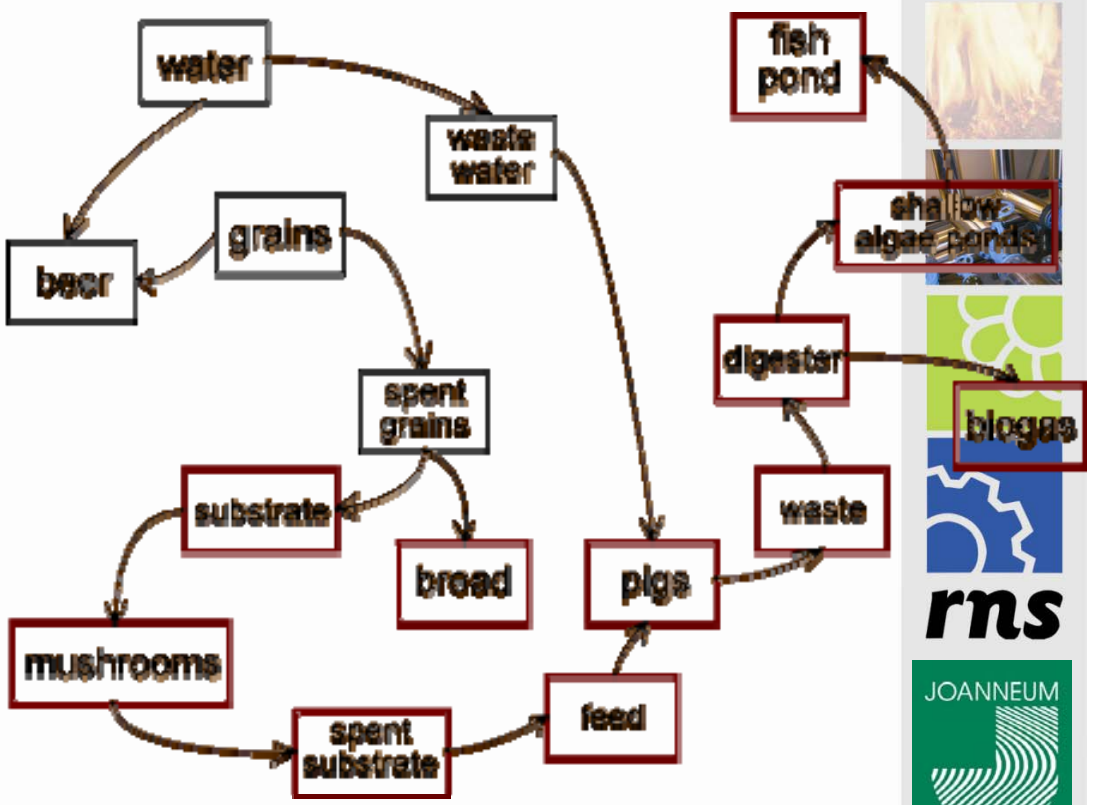
- Analysis of valuable contents of solid waste from juice producers
  - apple (Antioxidants)
  - red currant (Antioxidants und special oils)



Hans Schnitzer, http//:rns.tugraz.at and www.joanneum.at/nts

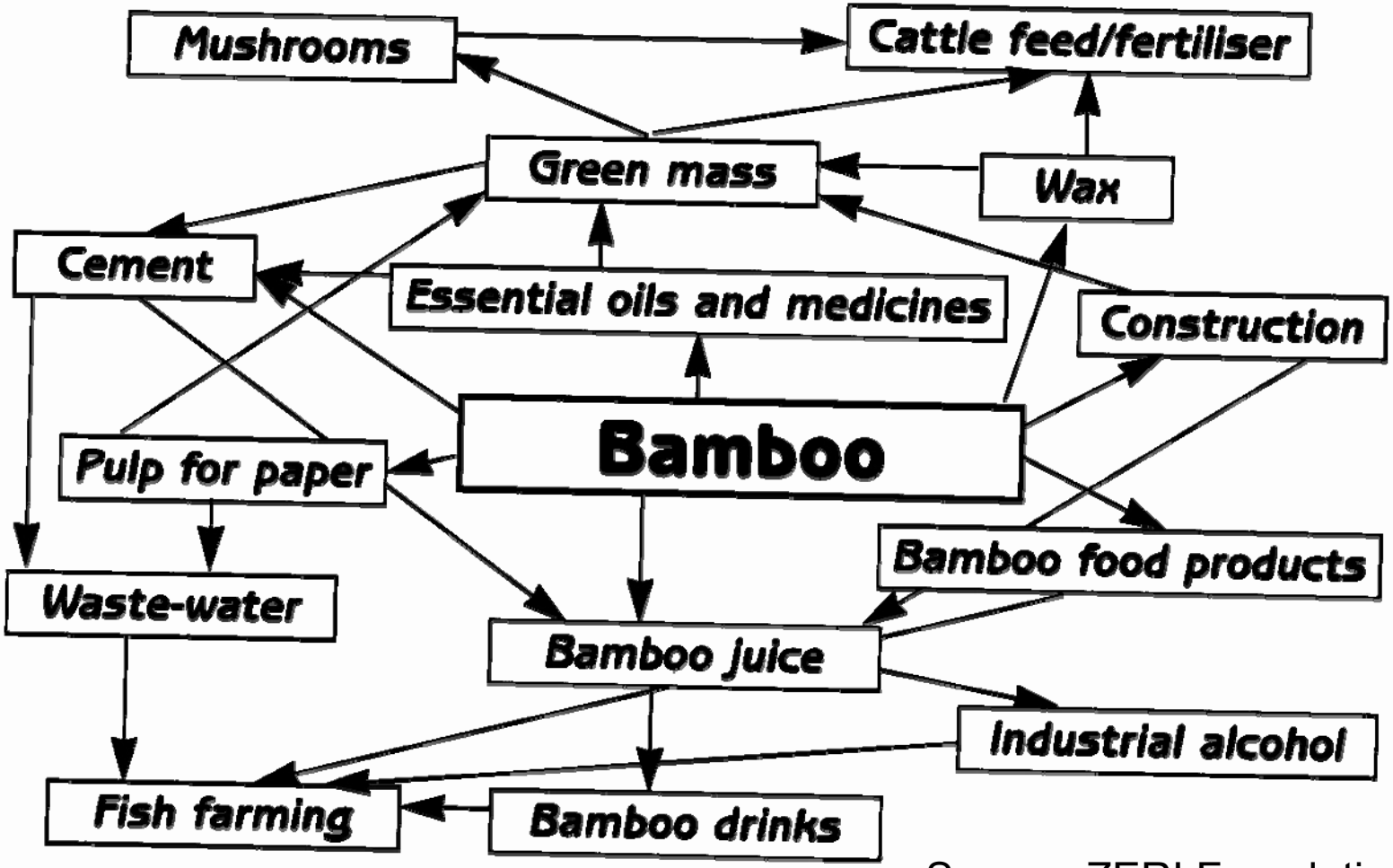
Traditional and ZERI brewery





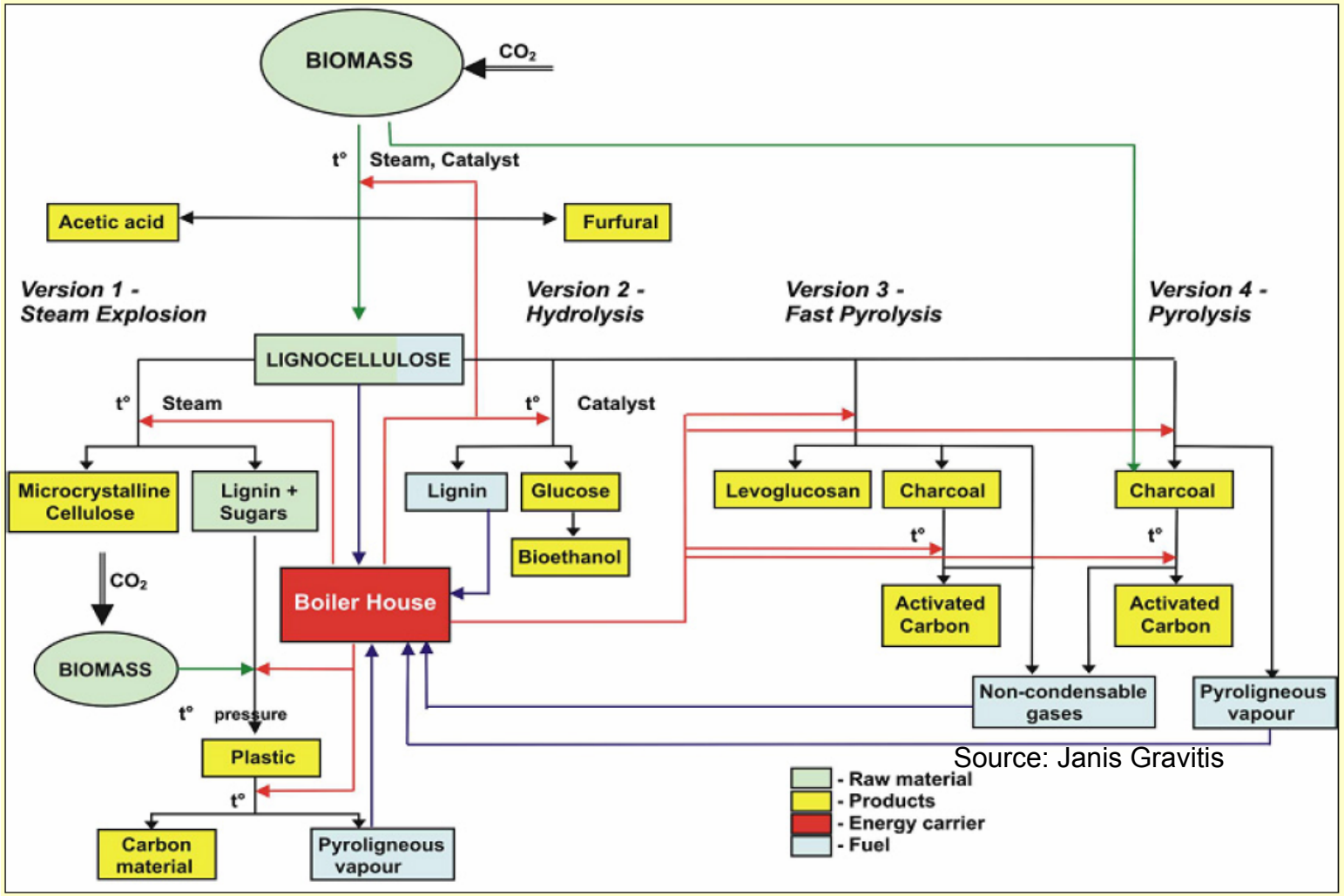
Hans Schnitzer, http//:rns.tugraz.at and www.joanneum.at/nts

Cluster of industries around Bamboo

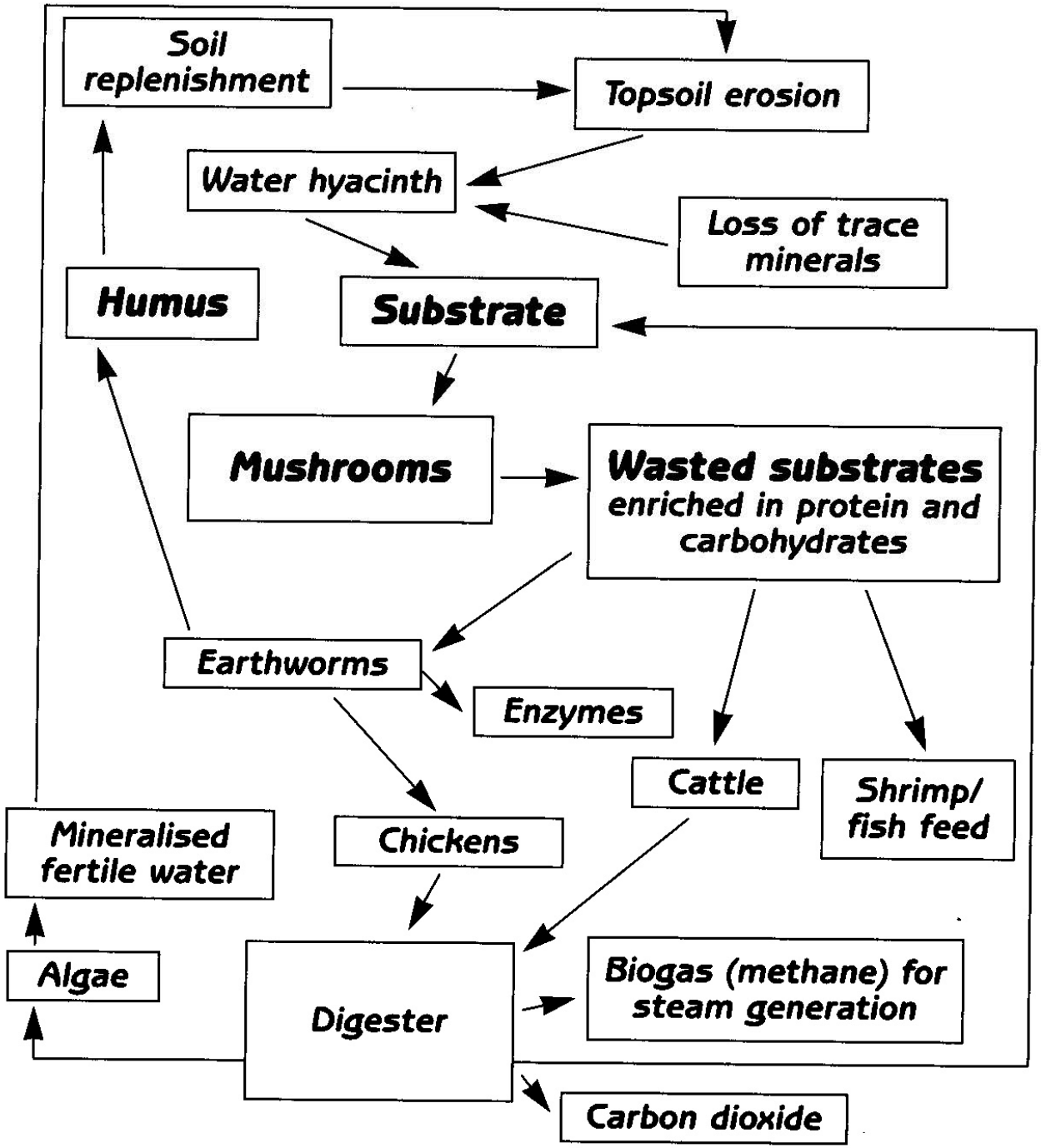


Source: ZERI Foundation, Geneva

Ligno-cellulose based Biorefineries



Source: Janis Gravitis



Integrated Bio-system for water Hyacinth

Source: ZERI Foundation, Geneva

Conclusions

- Based on present technologies and resources, it will not be possible to meet the needs of 8 billion people
- The oil age will not end due to a shortage of oil, but since there are better alternatives
- Cities and companies that start to change right now will be more competitive in future
- Technologies and systems suited for renewables are not a further development of knowledge from fossil resources but require an absolutely new approach (plant chemistry ≠ petrochemistry)

Conclusions

- The use of the whole plants from agriculture will face an increasing interest:
  - growing energy prices
  - more income for regions
  - environmental advantages
  - free fertilizes
- Growing special plants for biorefineries could be the basis for an agro-based industry
- Organic waste from industry and households will be more and more a source for energy (biogas, ethanol,...)