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8th CONFERENCE ON SUSTAINABLE DEVELOPMENT
OF ENERGY, WATER AND ENVIRONMENT SYSTEMS
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Low Carbon Technologies for the Agro-Food Sector

Hans Schnitzer
Graz University of Technology
Hans.schnitzer@tugraz.at

Sources, projects and partnerships used for the preparation of this presentation:

UNIDO: Regional LOW CARBON Project Participants on Balkan:

National Cleaner Production Centers (NCPC) of

- **Macedonia www.ncpc.com.mk**
- Serbia www.cpc-serbia.org
- Albania www.ecat-tirana.org
- Croatia www.cro-cpc.hr
- Montenegro
- Moldova www.ncpp.md

AEE Intec, Gleisdorf Austria

GREENFOODS (IEE-Project)

IEA-SHC Task 33 and Task 49

Cooperation with Ho Chi Minh University in Vietnam

And others, …

A critical challenge

- One of the EU's key ambitions must be to develop a low-carbon economy. The EU has put in place a comprehensive policy framework, including among others: the climate and energy targets for 2020 and a carbon price through the Emissions Trading System. Now, we have to deliver, both in terms of the 2020 targets and, in the longer term, aiming for an 80% cut in greenhouse gas emissions by 2050 compared to 1990 levels.

Source: **COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Investing in the Development of Low Carbon Technologies (SET-Plan)**

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A critical challenge

- Reinventing our energy system on a low carbon model is one of the critical challenges of the 21st Century. Today, in the EU, our primary energy supply is 80% dependent on fossil fuels.
- Networks and supply chains have been optimised over decades to deliver energy from these sources to our society. Economic growth and prosperity has been built on oil, coal and gas.
- But, they have also made us vulnerable to energy supply disruptions from outside the EU, to volatility in energy prices and to climate change.
- There are different possible pathways to a low carbon economy. Clearly, no single measure or technology will suffice, and the precise mix in each country will depend on the particular combination of political choices, market forces, resource availability and public acceptance.

Source: **COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS. Investing in the Development of Low Carbon Technologies (SET-Plan)**

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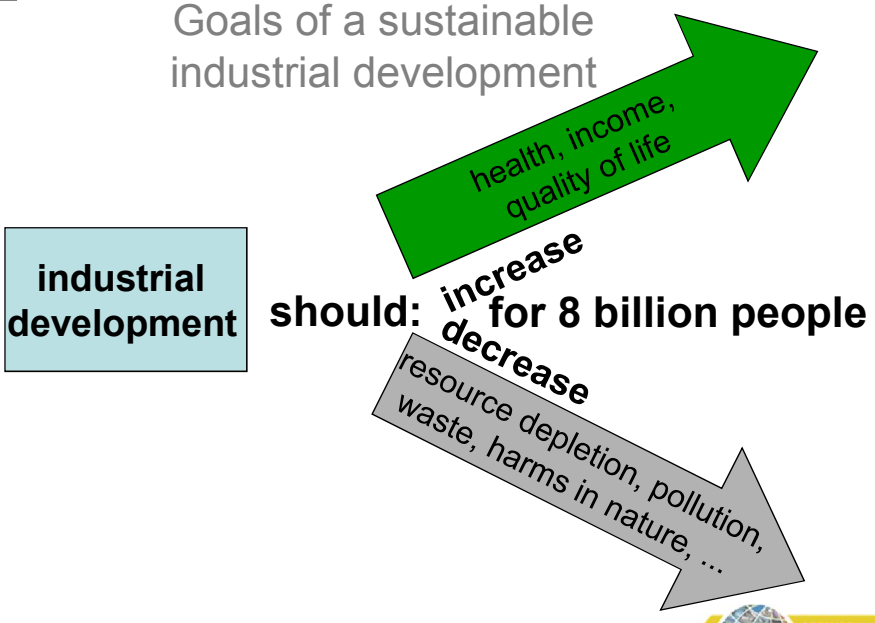
The leaders of the Group of Eight expressed the need for a reduction of Global Warming Gases (GHGs) like this

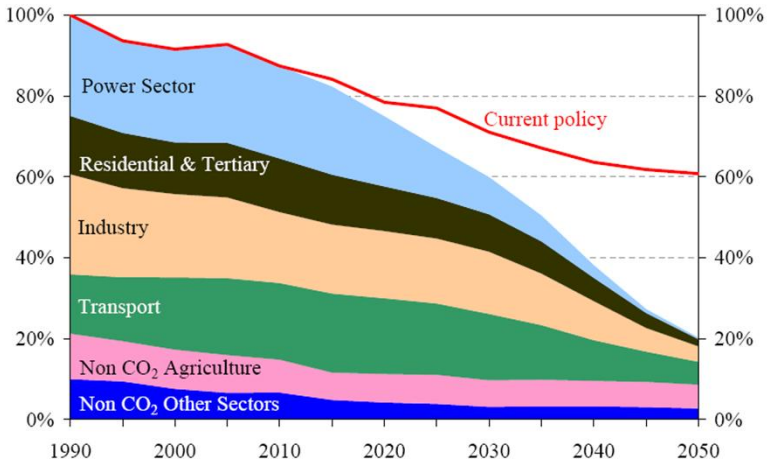
Source: G8 summit at L'Aquila, Italy, 2009 RESPONSIBLE LEADERSHIP FOR A SUSTAINABLE FUTURE

- *65. We reaffirm the importance of the work of the Intergovernmental Panel on Climate Change (IPCC) and notably of its Fourth Assessment Report, which constitutes the most comprehensive assessment of the science. We recognise the broad scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2°C. Because this global challenge can only be met by a global response, we reiterate our willingness to share with all countries the goal of* ***achieving at least a 50% reduction of global emissions by 2050****, recognising that this implies that global emissions need to peak as soon as possible and decline thereafter. As part of this, we also support a goal of* ***developed countries reducing emissions of greenhouse gases in aggregate by 80%*** *or more by 2050 compared to 1990 or more recent years. Consistent with this ambitious long-term objective, we will undertake robust aggregate and individual mid-term reductions, taking into account that baselines may vary and that efforts need to be comparable. Similarly, major emerging economies need to undertake quantifiable actions to collectively reduce emissions significantly below business-as-usual by a specified year.*

Goals of a sustainable industrial development

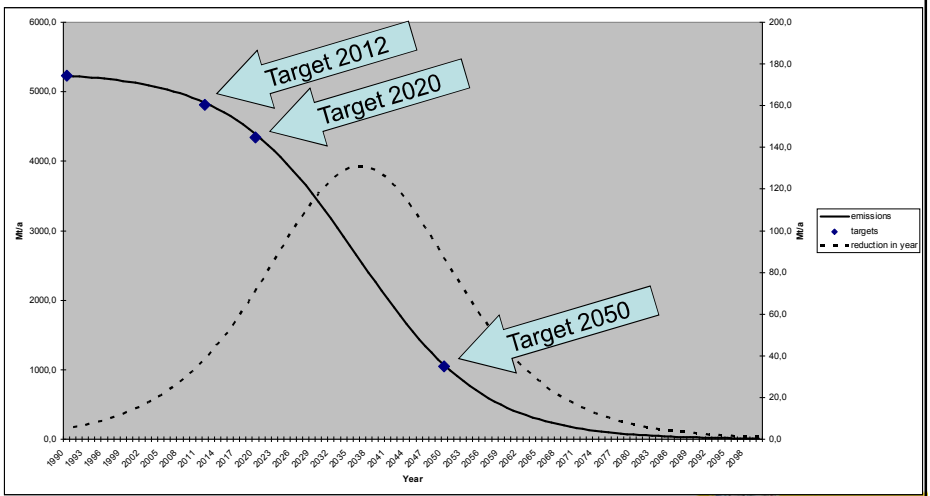


EU GHG emissions towards an 80% domestic reduction (100% = 1990)

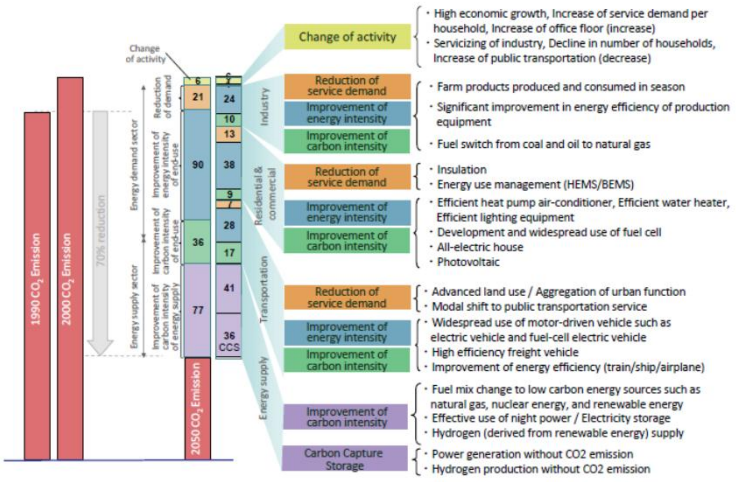


Source: EUROPEAN COMMISSION (2011): A Roadmap for moving to a competitive low carbon economy in 2050.

S-shaped scenario for CO_2-emissions reduction in Europe (Tg/a = Mt/a)



Japan's Low Carbon Strategy



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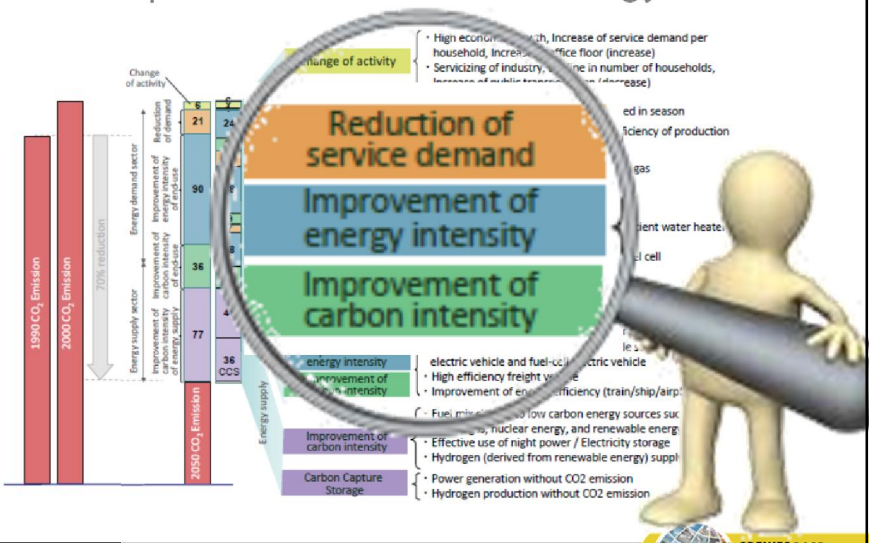
Japan's Low Carbon Strategy



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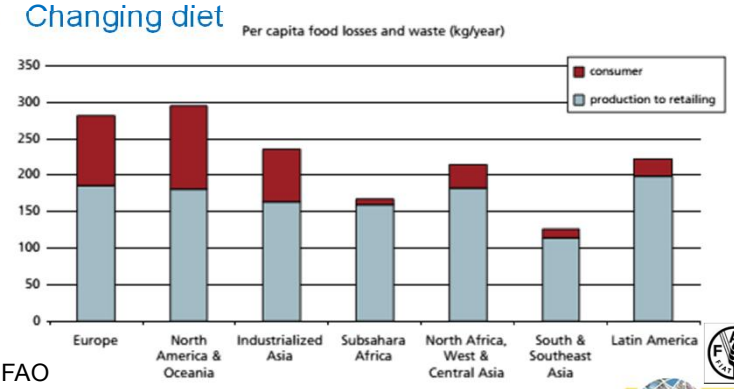
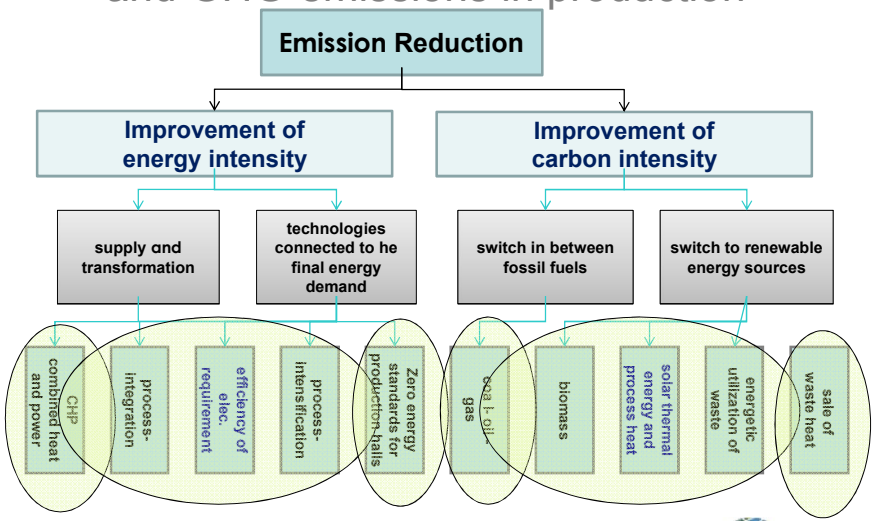
Reduction of service demand

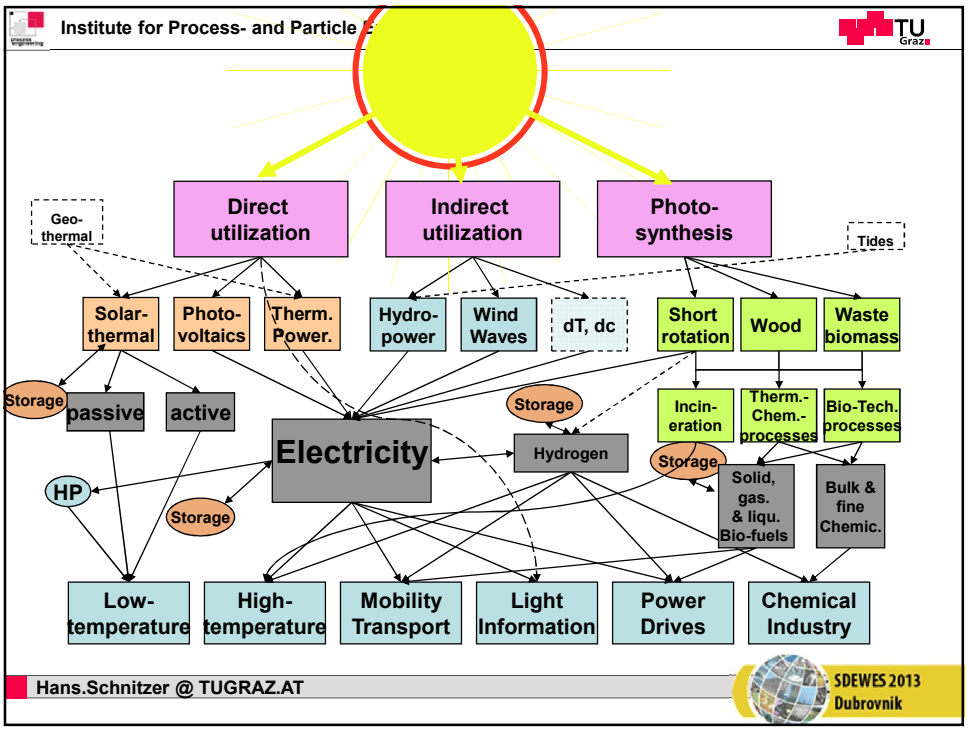
- Reduction of post-harvest food losses (production to retailing)
- Reduction of food waste (retail and consumer)
- Changing diet



Souce: FAO

Ways to reduce energy consumption and GHG-emissions in production

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TU Graz
Geo-thermal
Direct utilization
Indirect utilization
Photo-synthesis
Tides
Solar-thermal
Photo-voltaics
Therm. Power.
Hydro-power
Wind Waves
dT, dc
Short rotation
Wood
Waste biomass
Storage
passive
active
Electricity
Storage
Hydrogen
Incin-eration
Therm.-Chem.-processes
Bio-Tech. processes
Storage
Solid, gas. & liqu. Bio-fuels
Bulk & fine Chemic.
HP
Storage
Low-temperature
High-temperature
Mobility Transport
Light Information
Power Drives
Chemical Industry
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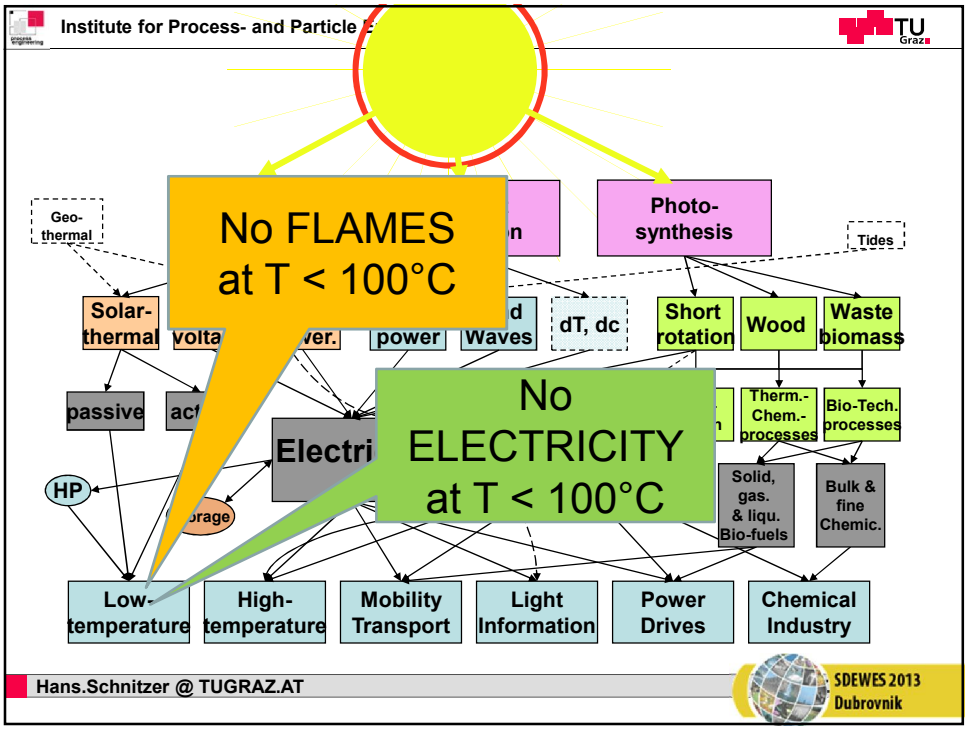
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TU Graz
No FLAMES at T < 100°C
No ELECTRICITY at T < 100°C
Geo-thermal
Photo-synthesis
Tides
Solar-thermal
power
Waves
dT, dc
Short rotation
Wood
Waste biomass
passive
Therm.-Chem.-processes
Bio-Tech. processes
HP
Solid, gas. & liqu. Bio-fuels
Bulk & fine Chemic.
Low-temperature
High-temperature
Mobility Transport
Light Information
Power Drives
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Why did we select the agro-food sector?

- The raw materials for the food sector are renewable. The food sector is based on plants, produced out of CO_2 and water with the help of sunlight – a process called photosynthesis.
- Only a small fraction of the plant material harvested ends finally up at the consumer's table. The majority of the mass (including carbon) is "lost" or "wasted" along the production chain and can be used for valuable by-products and useful energy.
- At the same time, this sector uses great amounts of fossil energy for processing, storage and transport.
- The agro-food sector offers possibilities for the recovery of organic and organic components for recycling to and reuse in the agriculture.
- Waste water from the food processing can be recycled to the agriculture as well.
- New business opportunities in this sector are in the production of fine chemicals and energy (gaseous, liquid and solid biofuels).

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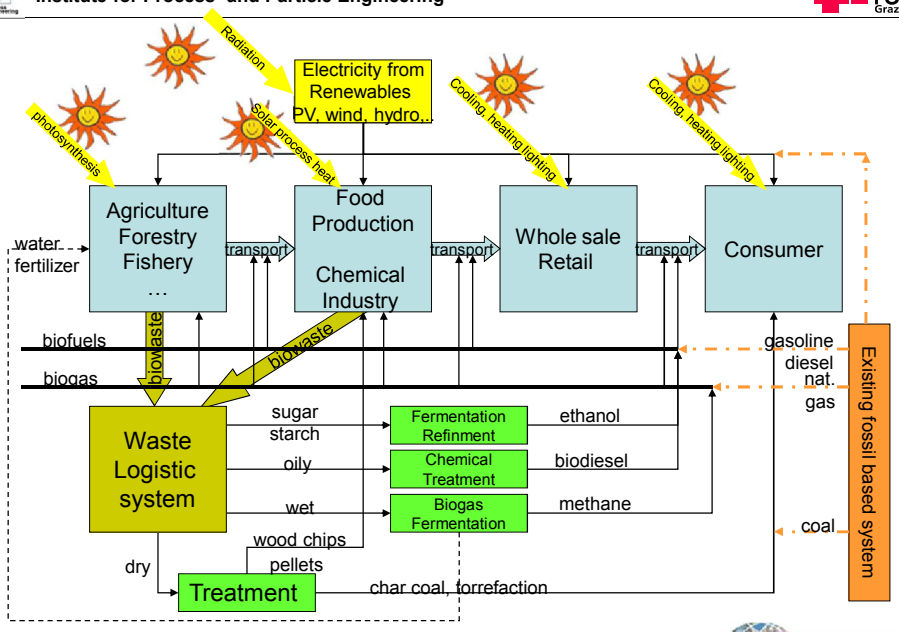

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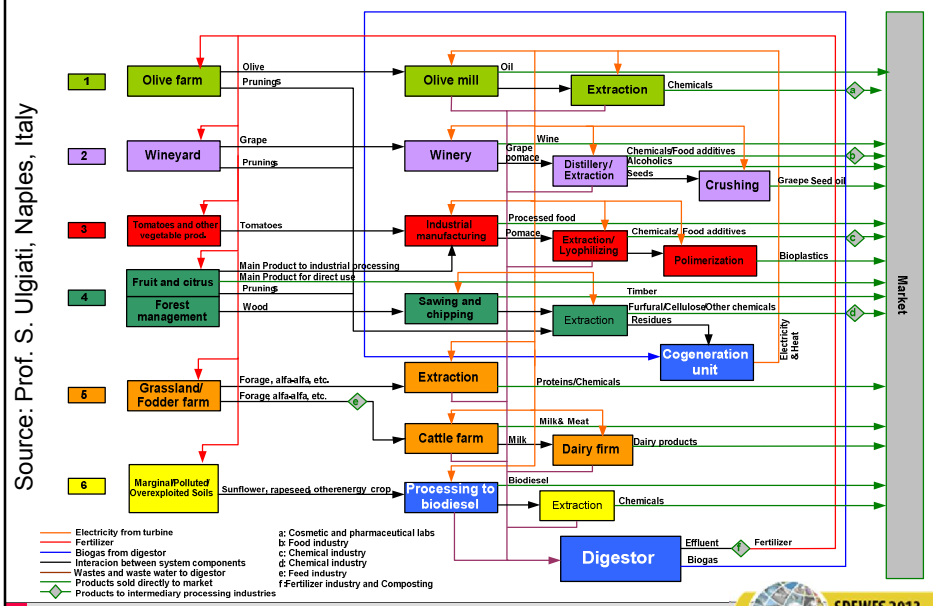

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Processes and Temperature Levels

Industry sector	Process	Temperate level °C
food and beverages	Drying Washing Pasteurising Cooking Sterilising Heat treatment	30 - 90 40 – 80 80 – 110 95 – 105 140 – 150 40 – 60
Textile industry	Washing Bleaching Dying	40 –80 60 – 100 100 – 160
Chemical industry	Evaporation Distillation various chem. processes	95 – 105 110 – 300 120 - 180
all	preheating of boiler feed water, heating of production halls	30 – 100 30 – 60

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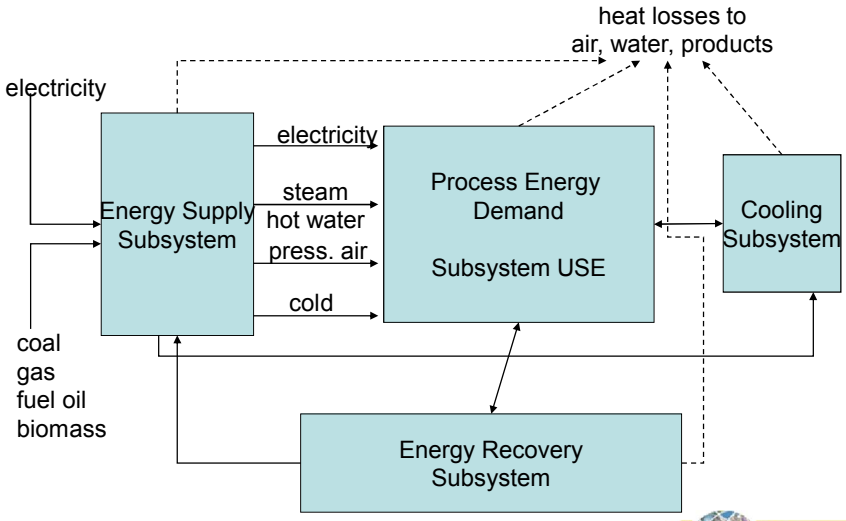
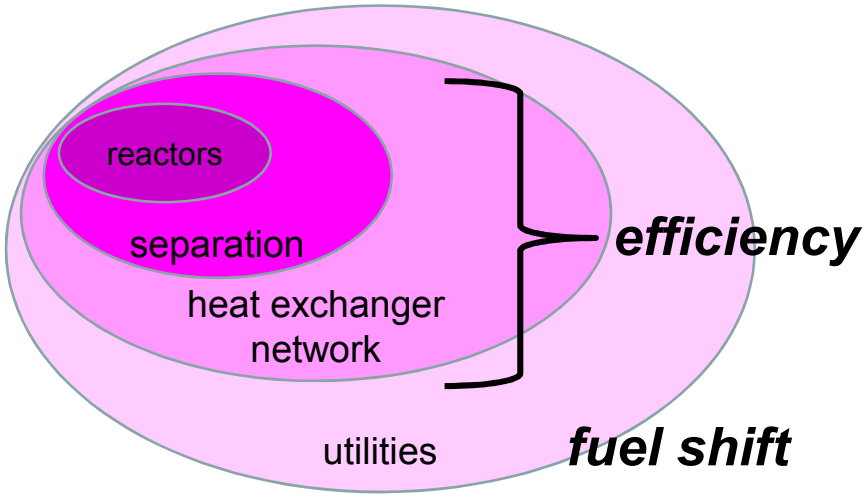
Industrial environment



Hierarchy of measures

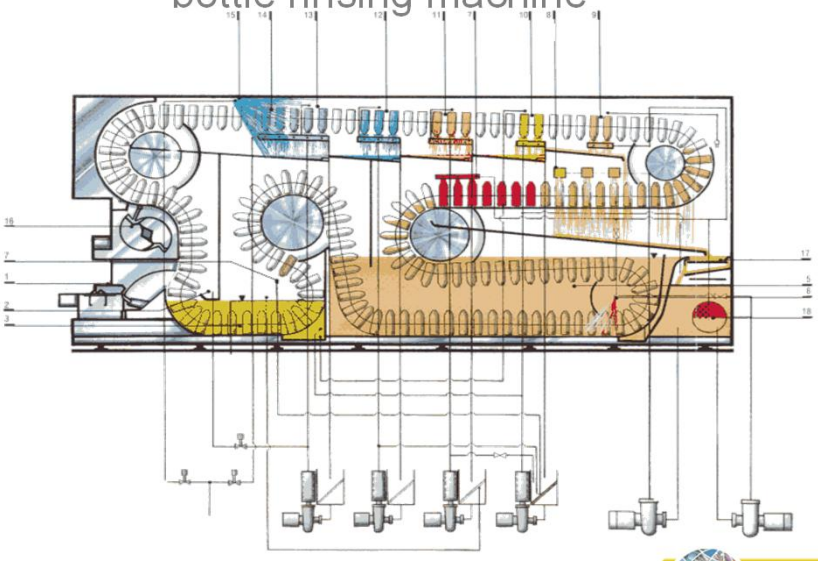


Improve efficiency of technologies

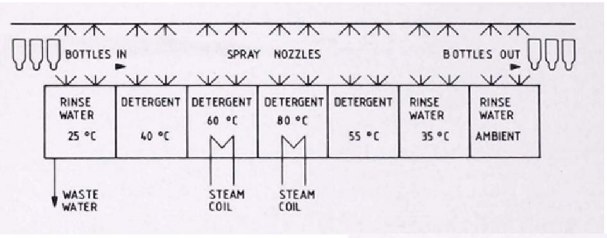
Typical processes in the food sector

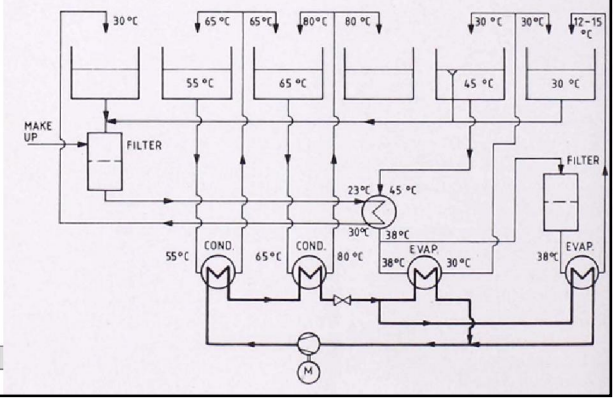
- pasteurization, sterilization
- bio-chemical reactions, fermentation
- drying
- evaporation, distillation
- washing, rinsing
  - bottles, kegs, boxes, ...
  - CIP
  - cars, tanks, …

bottle rinsing machine

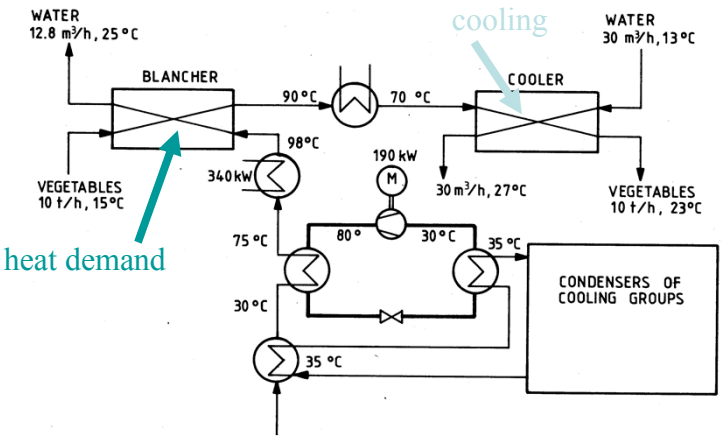


Heat integration with heat pumps in a bottle rinsing machine

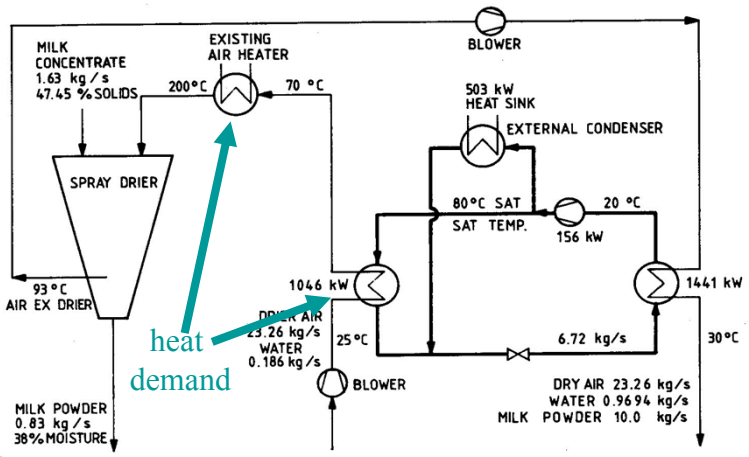




blanching line for vegetables



spray drier for milk



Heat integration and energy recovery, process intensification

- Heat recovery from hot streams within the production process
- Heat exchange with an other process in the company, but in an other production line
- Heat pumps (compression and absorption)
- Waste heat driven ORCs
- Heat delivery to customers outside company (other company, fish farm, district heating, …)

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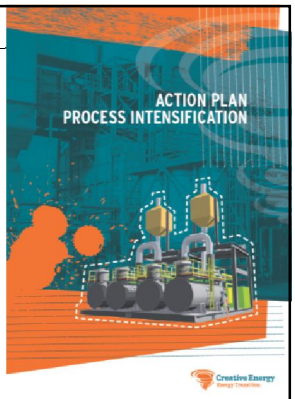
Process intensification



Process intensification addresses the need for energy savings, CO_2 emission reduction and enhanced cost competitiveness throughout the process industry.

The potential benefits of PI that have been identified are significant:

- Petro and bulk chemicals (PETCHEM): Higher overall energy efficiency – 5% (10-20 years), 20% (30-40 years)
- Specialty chemicals, pharmaceuticals (FINEPHARM): Overall cost reduction (and related energy savings due to higher raw material yield) – 20% (5-10 years), 50% (10-15 years)
- Food ingredients (INFOOD):
  - Higher energy efficiency in water removal – 25% (5-10 years), 75% (10-15 years)
  - Lower costs through intensified processes throughout the value chain – 30% (10 years), 60% (30-40 years)
- Consumer foods (CONFOOD):
  - Higher energy efficiency in preservation process – 10-15% (10 years), 30-40% (40 years),
  - Through capacity increase – 60% (40 years)
  - Through move from batch to continuous processes – 30% (40 years)

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Integration of operations:

- Several processes occur in a sequence, like milling and mixing (e.g. cacao beans, sugar and milk powder). The integration of these process steps would not only reduce the operation time and energy consumption but also the need for cleaning the equipment.

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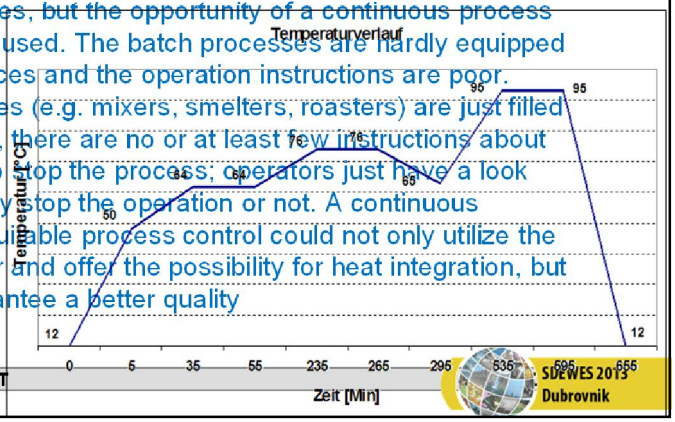
Shift from batch processes to continuous operation

- Most processes in the agro-food sector are operated in batch mode. We hardly found any continuous processes for the treatment of raw materials or the production of the final products. Drying, roasting, milling, mixing and sieving are used in most companies, but the opportunity of a continuous process is practically not used. The batch processes are hardly equipped with control devices and the operation instructions are poor. Many apparatuses (e.g. mixers, smelters, roasters) are just filled and switched on, there are no or at least few instructions about when and why to stop the process; operators just have a look and decide if they stop the operation or not. A continuous process with a suitable process control could not only utilize the equipment better and offer the possibility for heat integration, but also would guarantee a better quality



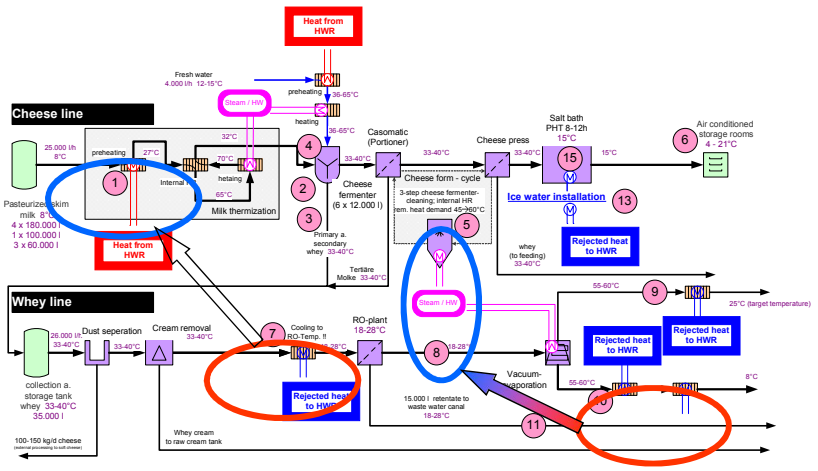
Heat recovery from effluents.

- Based on the fact that most operations are in batch mode, but also due to missing equipment and awareness, heat recovery or heat integration are hardly applied. In food processing we have on the one side large amounts of waste heat from cooling and freezing devices and on the other hand a large demand for warm water for cleaning purposes. We hardly found any installation for that. Many materials have to be heated and cooled in sequence (e.g. for pasteurisation, melting, roasting, …), where heat integration could take place.

Aims of Pinch Analysis

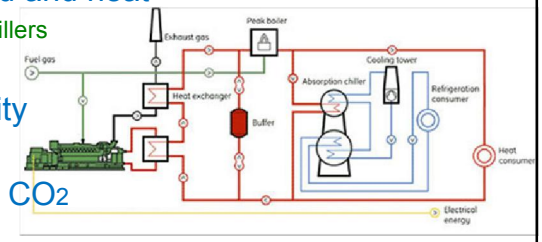
- Visualization of the total cold- and heat demand of a system in one diagram – energy demand of single processes and which temperature level the energy has to be supplied
- Maximum of heat recovery
- Heat exchanger network – combination of the process streams
- Be aware of existing piping systems and heat exchnagers and the location of the buildings and processes

Production processes - process flow sheet



Improve system efficiency – cogeneration

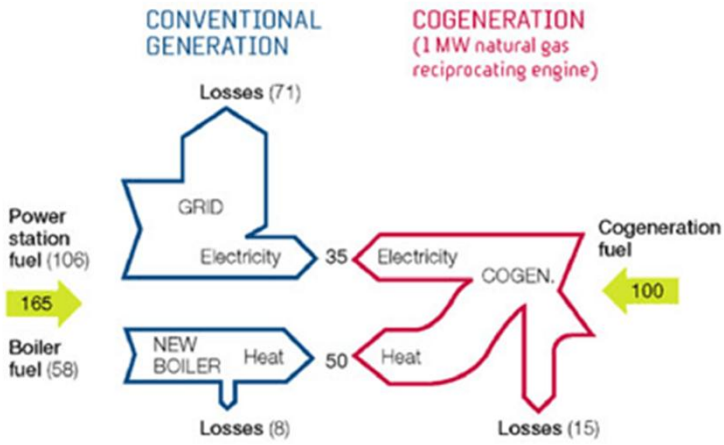
- Cogeneration of heat and electricity
  - No heat without electricity
  - All fuels (oil, bio-gas, biomass,…)
- Cogeneration of compressed air and heat
  - Heat recovery from compressed air
- Cogeneration of cold and heat
  - Heat recovery from chillers
- Tri-generation of heat / cold / electricity
- Quatrogeneration = heat / cold / power / CO_2



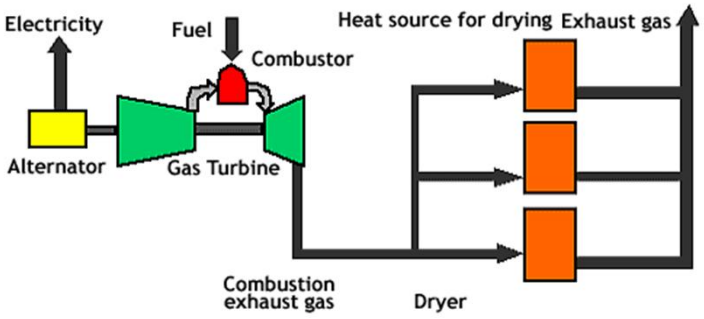
Cogeneration of power, heat and cold

- In practically every company there is a need for electricity, heat and cold. Most thermal processes run at rather low temperatures, so that their heating by fuels offers a very low 2nd law efficiency. “Thermodynamic heating” – taking the energy from the environment and only the exergy from the fuel – will become more and more important in future. In some cases this could conflict with the promising technologies of volumetric heating, but high exergetic sources of energy should not be used at low temperature applications if possible. So could “in plant” cogeneration of heat and power be done in spray drying plants

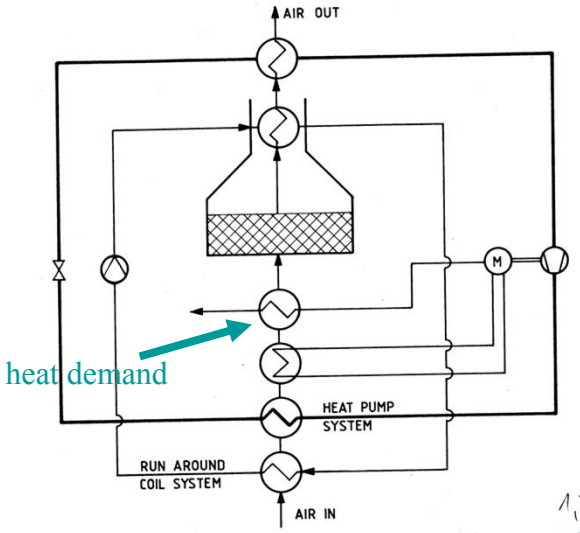
Cogeneration – combined production of power and heat (and cold)



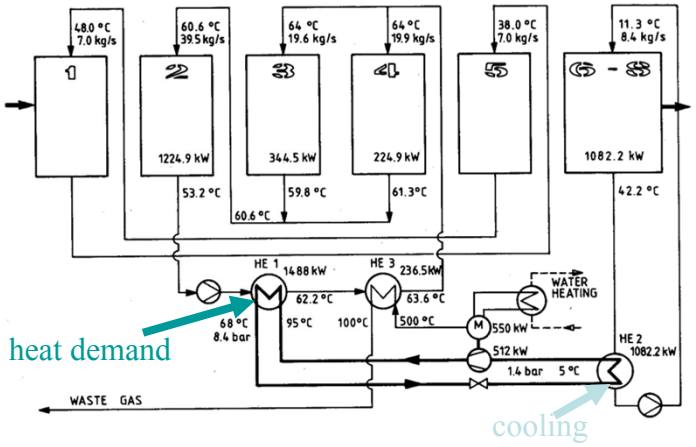
Process integration for drying processes

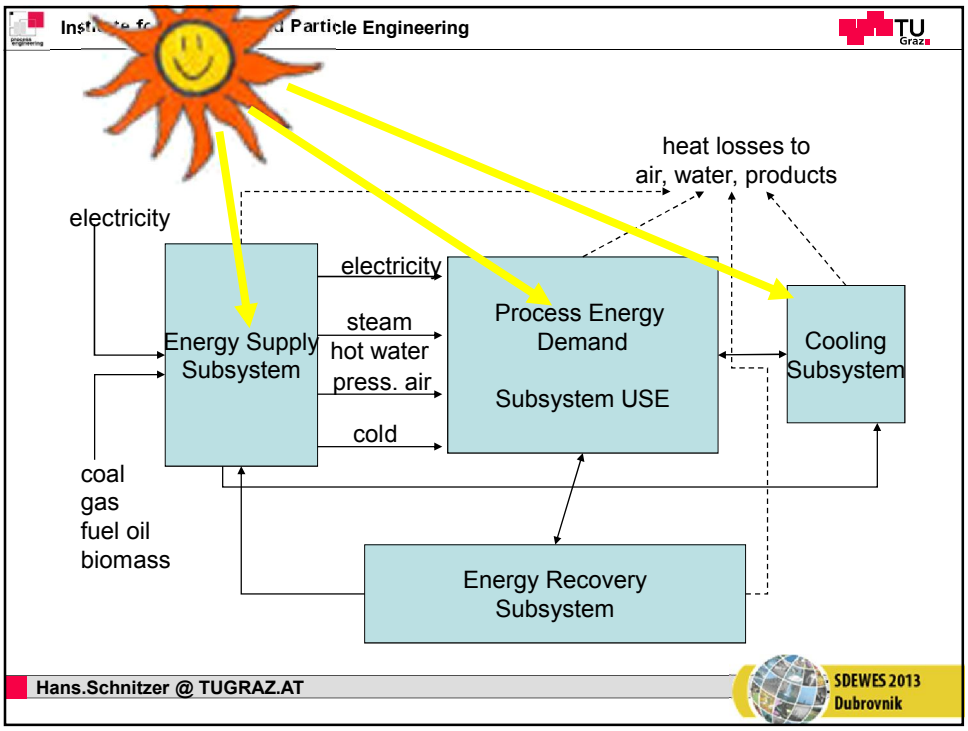


Heat pump in malt kiln



Heat pump in pasteurizer




Particle Engineering
heat losses to
air, water, products
electricity
Energy Supply
Subsystem
electricity
steam
hot water
press. air
cold
Process Energy
Demand
Subsystem USE
Cooling
Subsystem
coal
gas
fuel oil
biomass
Energy Recovery
Subsystem
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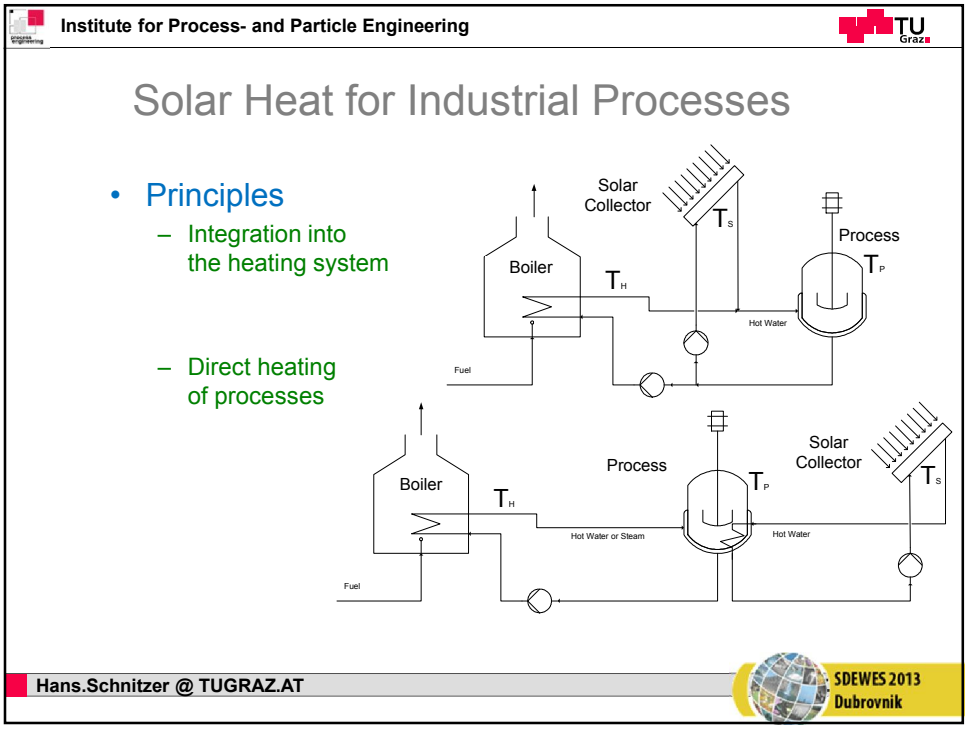
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Solar Heat for Industrial Processes
• Principles
– Integration into
the heating system
– Direct heating
of processes
Solar
Collector
Boiler
Process
Hot Water
Fuel
Hot Water or Steam
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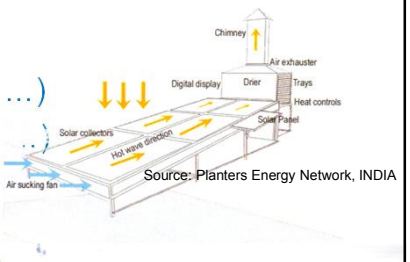
Industrial sectors for solar process heat

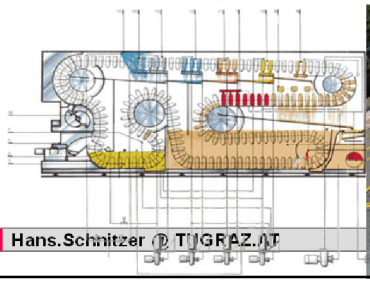
process / industry sector	food	textile	building materials	galvanising anodising	fine chemicals	Pharmac. biochemical	service. sector	pulp & paper	automob. supplyer	tanning	painting	timber & wood prod.
cleaning	X	X	x	X	x	X	X		x	x	X	
drying	X	X	x		x	X	X	x	x	X	X	X
evaporation and distillation	X				x	X						
pasteurisation	X					X						
sterilization	X					X						
cooking	X											
general process heating	x	x	x	X	x	x	X		x			x
boiler feed water preheating	X	X	x		x	x		x		x		
heating of production halls	X	X		x	x	x	x		X	X	X	X
solar absorption cooling	X			x		X	X					

Potential solar powered operations in the food industry

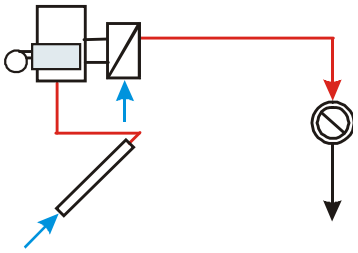
- Drying (fruits, tea, meat, fish, …)
- Pasteurization (liquids solids, …)
- Evaporization, distillation
- Hot water for cleaning
- Pre heating of boiler feed water
- Cooling



Source: Planters Energy Network, INDIA



Drying process with air



Fields of application

- Coffee
- Tea
- sweet corn
- Tobacco

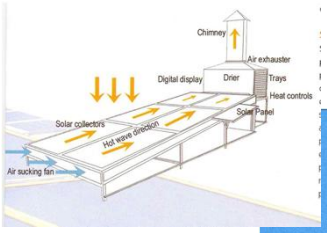
Typical process temperature: 30 - 80°C

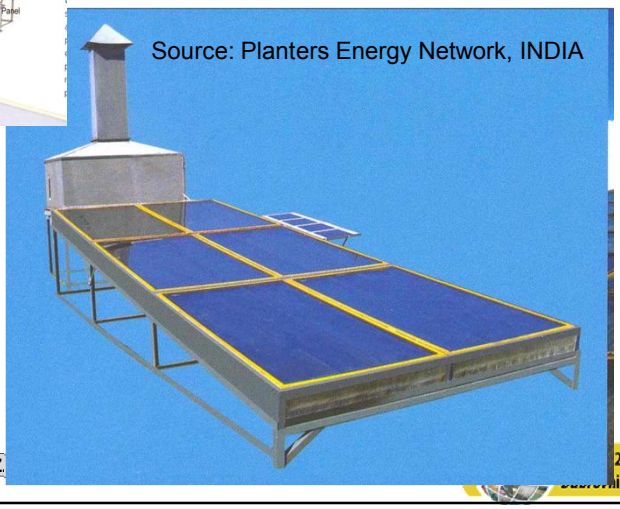
Heat carrier: air

collector:

- **glazed or non glazed air collectors**
- **Solar Wall ®**

Solar fruit dryer

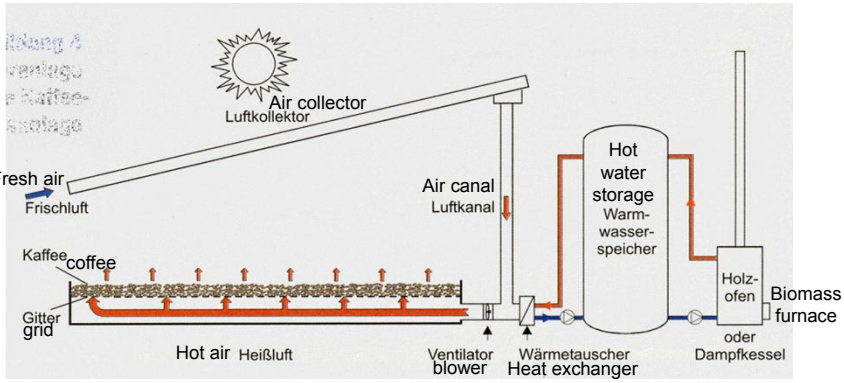




Source: Planters Energy Network, INDIA

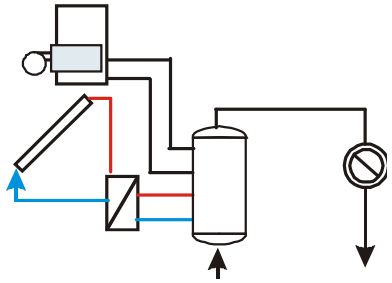
Tea dryer in India

Solar coffee dryer



Drying of coffee, Zimbabwe

Washing processes



Fields of application

- bottle
- textiles
- cars, containers

Typical operation temperatures: 40 - 90°C

Heat carrier: water

collectors: flat plate collector

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Rinsing water for food industry

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Plant:
Tyras

Location:
Trikala (Greece)

Solar field:
1040 m2 (flat plate)

Process:
dairy

Working temp.:
80 °C

Source:
CRES / Solenergy Hellas SA

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Pasteurizing of juice

Gangl, Austria

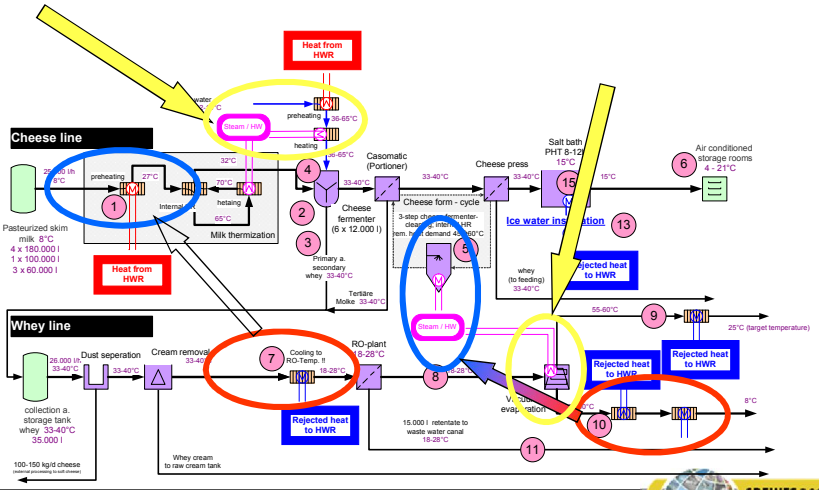
60 m² Flat plate collectors
storage: 21,9 m³ (1 x 20 m³ , 1 x 1,9 m³)

Pasteurization of fruit juice
bottle rinsing
production of vinegar and sider

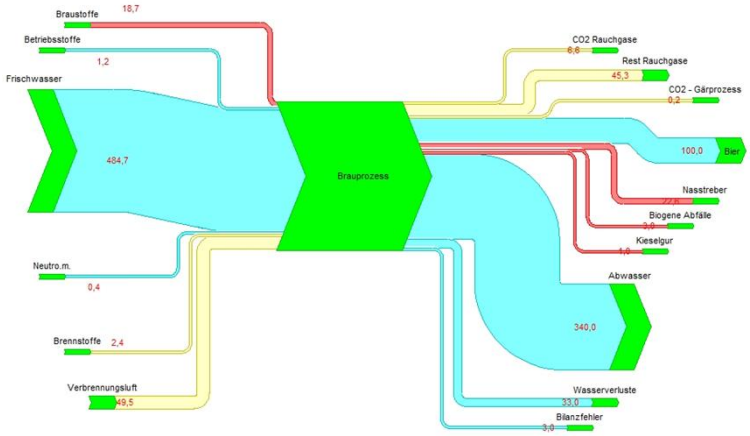
Back-up: oil

installation: 2004

Production processes - process flow sheet



mass balance of a brewing process



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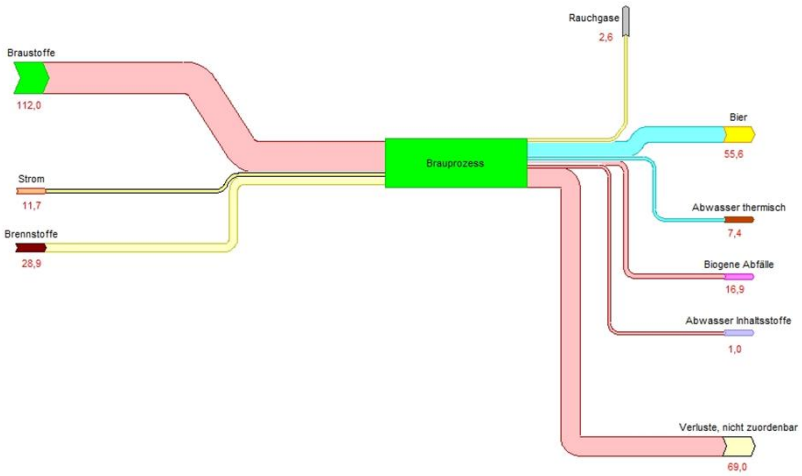
energy balance of a brewing process



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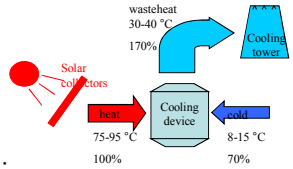
Göss – Green brewery

1.500 m² solar thermal collectors

Hot water storage tank

Solar Cooling

Solar thermal absorption system ? Photovoltaic + compression system



Questions:

- Stand alone or grid connection?
- Heat needed
  - Same time or
  - Different time
- Deep freeze needed
- Other constrains

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	general description	solar integration schemas	integration of biomass	industry sectors			
				Subsection DA food	Subsection DB textiles	Subsection DJ metals	Subsection DG chemicals
		INFO	INFO	INFO	INFO	INFO	INFO
CP, EE, RE, PI				x	x	x	x
UNIT OPERATIONS							
CLEANING	info	info		x	x	o	o
DRYING	info	info		x	x	o	o
EVAPORATION AND DISTILLATION	info	info		x			o
BLANCHING	info	info		x			
PASTEURIZATION	info	info		x			o
STERILIZATION	info	info		x			o
COOKING	info	info		x	x		
OTHER PROCESS HEATING	info			x	x	o	o
GENERAL PROCESS HEATING	info			x	o	o	o
HEATING OF PRODUCTION HALLS	info	info		x	o	o	o
COOLING OF PRODUCTION HALLS	info			x			o
COOLING PROCESSES	info			x		o	o
MELTING	info	info		x			
EXTRACTION	info			x			
BLEACHING	info			x	x		
PAINTING	info	info			x	o	o
SURFACE TREATMENT	info	info				o	

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WIKI.ZERO-EMISSIONS.AT - Subsection food

		milk products	fruits/ vegetables/ herbs	sugar	beer	fats/ oils	chocolate/ cacao/ coffee	starch/ potatoes/ grain mill products	bread/ biscuits/ cakes	wine/ beverage	meat	fish	aroma	solar integration	emerging technologies	proces intensification	heat integration
Unit Operations	Typical processes	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO	INFO
CLEANING	Cleaning of bottles and cases	x	x		x	x				o	o	o					
	Washing products		x	x		x		x		x	x	o					
	Cleaning of production halls and equipment	x	x	x	x	x	x	x		x	x	o	o				
DRYING	Drying	x	x	x		x	x	x	x		x						
EVAPORATION AND DISTILLATION	Evaporation	x	x	x		x	x	o		o	o	o					
	Distillation					x		o		o			x				
	Deodorization					x	x										
BLANCHING	Blanching		x					x									
PASTEURIZATION	Pasteurization	x	x							o	o	o					
STERILIZATION	Sterilization	x	x					o		x	o	o					
COOKING	Cooking and boiling		x		x		x	x		o	o	o					
OTHER PROCESS HEATING	Pre-heating	x	x		x												
	Soaking		x				x	o									
	Thawing										o	o					
	Peeling		x														
GENERAL PROCESS HEATING	Boiler feed-water preheating	x	x	x	o	o	o	o	o	o	o	o	o				
HEATING OF PRODUCTION HALLS	Heating of production halls			x			o	o		o			o				
COOLING OF PRODUCTION HALLS	Cooling of production halls	x	x							o	o	o					
COOLING PROCESSES	Cooling, chilling and cold stabilization	x	x	x	x	x	x	x		o	x	o					
	Ageing	x								o							
MELTING	Melting	x				x	o			o							
EXTRACTION	Extraction		x	x		x	x			o			o				
BLEACHING	Bleaching					x											

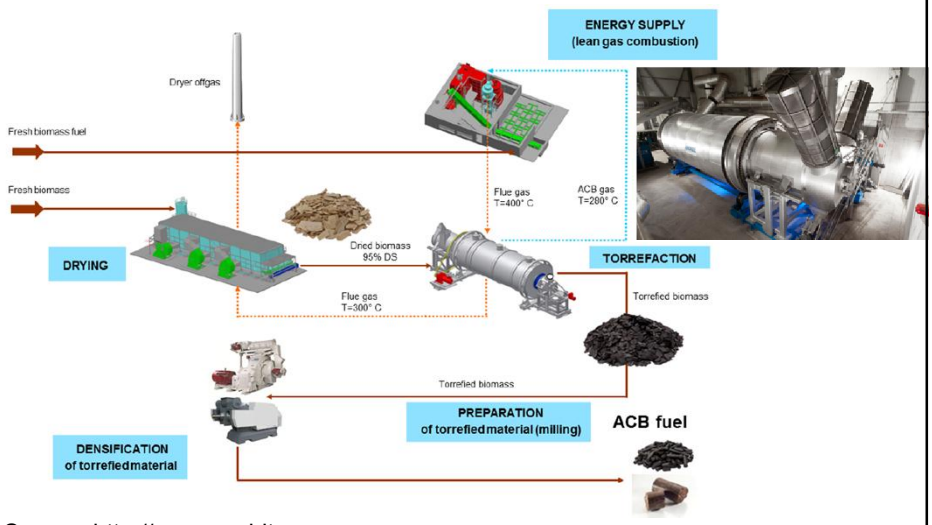
Temperaturelevel	milk products	fruits / vegetables / herbs	sugar	beer	fats / oils	chocolate / cacao / coffee	starch / potatoes / grain mill products	bread / biscuits / cakes	wine / beverage	meat	fish	aroma
20-40°C	x	x		x		x			x			
40-60°C	x	x		x		x			x	x		x
60-80°C	x	x	x	x	x	x	x		x	x		x
>80°C	x	x	x	x	x	x	x		x			x

Potential for solar process heat in Europe

Country	Industrial Final Energy Consumption. [PJ/year]	Indutrial heat demand * [PJ/year]	Solar process heat potential at L&M temperature [PJ/year]	Solar process heat/ Indutrial heat demand	Potential in terms of capacity [GW_{th}]	Potential in terms of collector area [Mio m^2]	Source of the data used for calculation
Austria	264	137	5.4	3.9%	3	4.3	Eurostat energy balances, year 1999; PROMISE project
Spain	-	493	17.0	3.4%	5.5 - 7	8 - 10	POSHIP project
Portugal	-	90	4.0	4.4%	1.3 - 1.7	1.9 - 2.5	POSHIP project
Italy	1653	857	31.8	3.7%	10	14.3	Eurostat energy balances, year 2000
Netherlands	89	46	1.95	3.2%	0.5 - 0.7	0.8 - 1	Onderzoek naar het potentieel van zonthermische energie in de inustrie. (FEC for 12 branches only)
EU 25	***12994***	***6881***	***258.2***	***3.8%***	***100 - 125***	***143 - 180***	Eurostat energy balances, year 2002

Quelle: Vannoni, C. et al.: Task 33/IV SHIP Potential Studies Report

Torrefaction of (waste) biomass



Source: http://grz.g.andritz.com

Captive power generation at rice mill in Cambodia

(a) (b)

(a) Three sets of gasifier and gas cleaning system (b) Duel fuel D.G sets

Source: www.cambodian-cpc.org

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Biogas – organic waste from agriculture

- Animal waste from
  - cows
  - pigs
  - chicken
  - …
- renewable crops
  - corn
  - elephant grass
  - green waste from vegetable production
  - …

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Biogas – organic waste from food processing

- Food processing industry
- fruit processing industry
- beverage industry (breweries, …)
- dairies
- distilleries
- …

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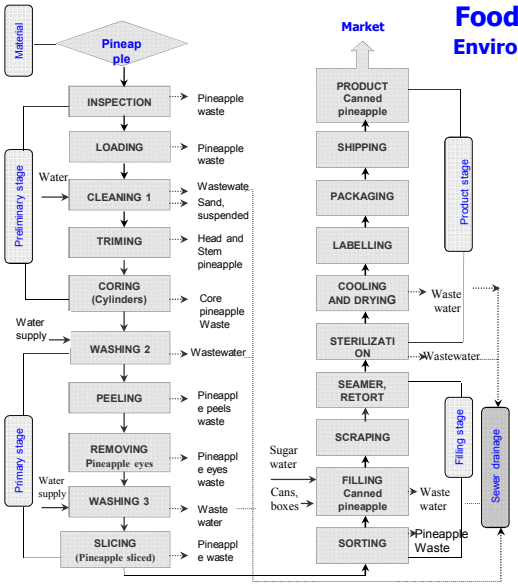
Food processing industry

Environmental aspects and waste management



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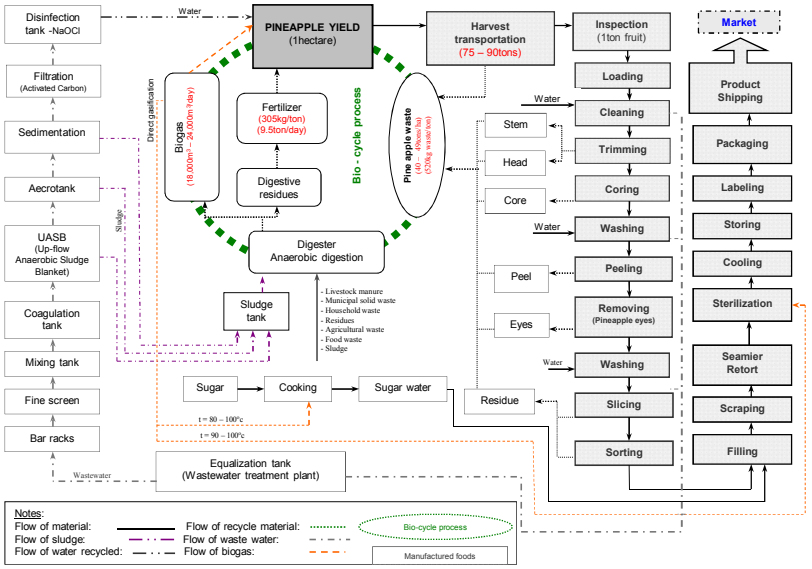
Zero emissions pineapple processing industry



Model of a zero emissions agro-based industrial system on canned pineapple production.

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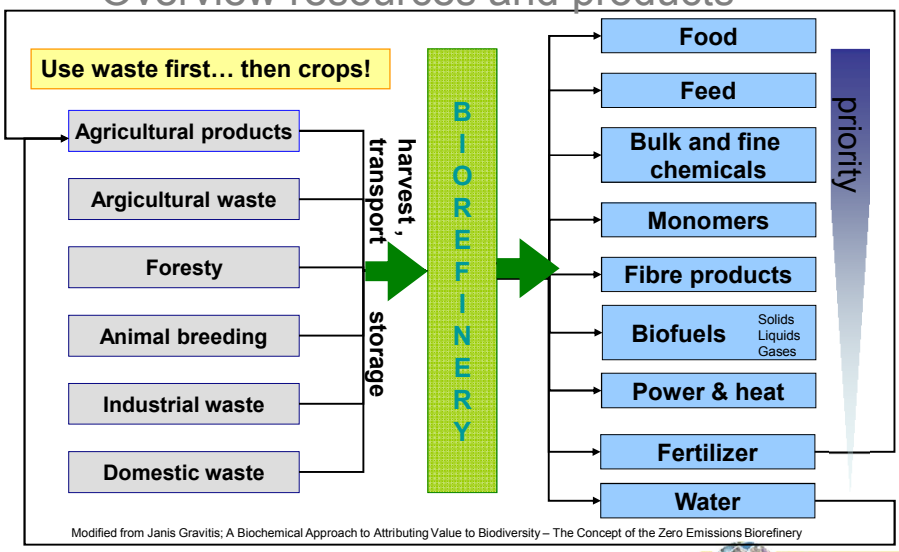
Greenhouses with 950 kWp PV on the roof in Mureck / Austria

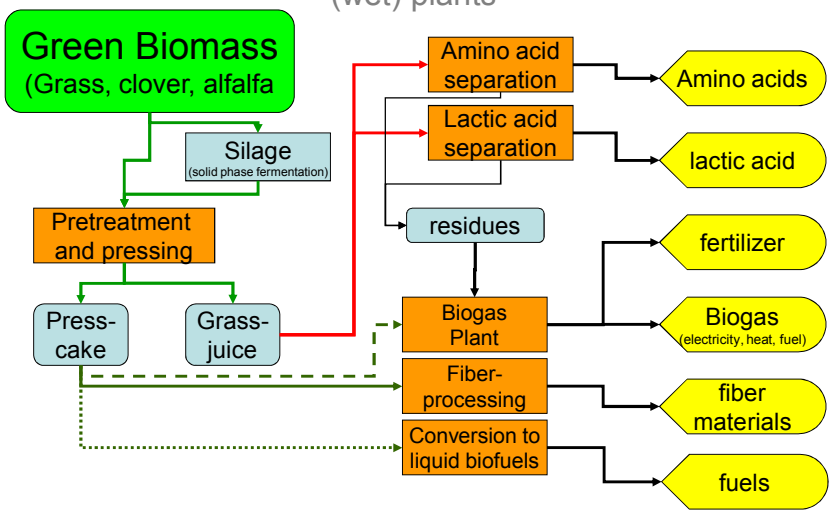
Quelle: http://www.riebenbauer.at/ger/Unsere-Projekte/Photovoltaik/Photovoltaik-Buergerbeteiligungs-Grossanlage-Region-Mureck-ABS2

Overview resources and products

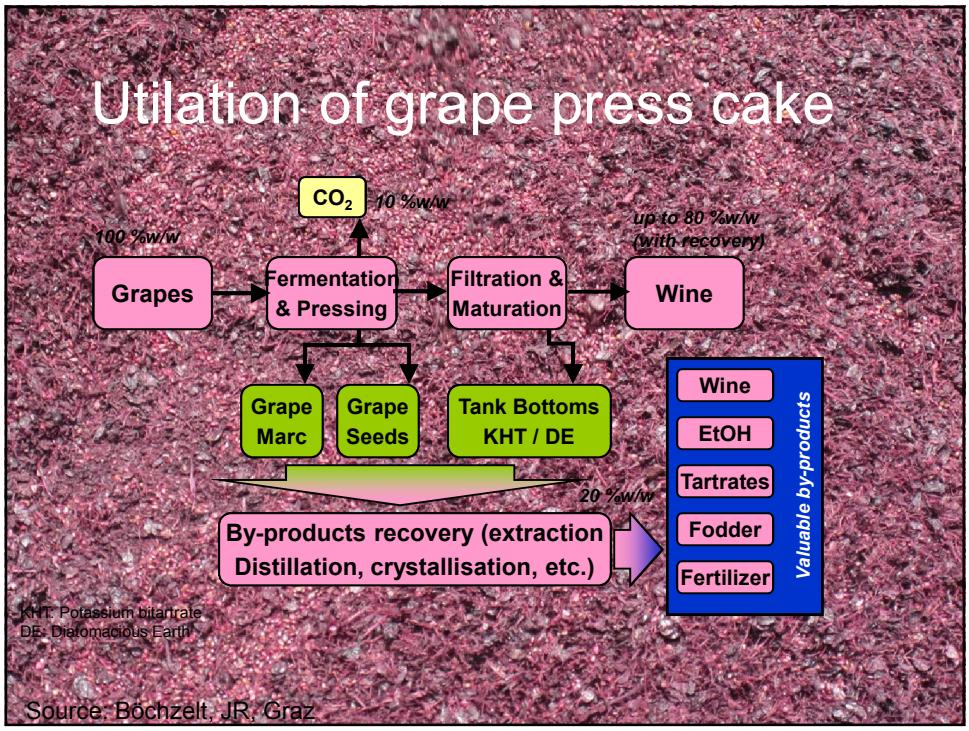


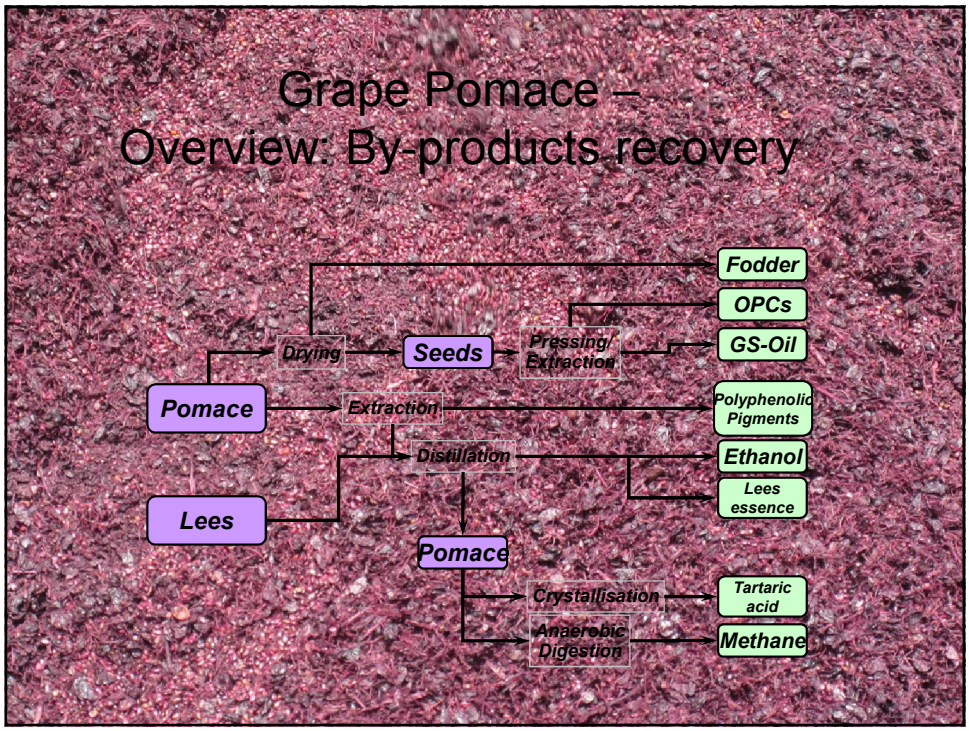
Modified from Janis Gravitis; A Biochemical Approach to Attributing Value to Biodiversity – The Concept of the Zero Emissions Biorefinery

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



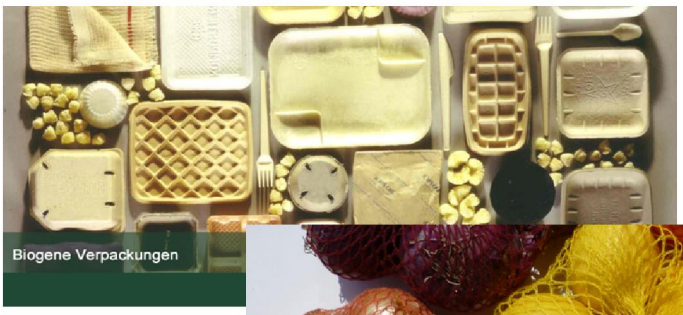
Source: M. Mandl. JR, Graz, Austria


Utilation of grape press cake
CO_2
10 %w/w
100 %w/w
up to 80 %w/w
(with recovery)
Grapes
Fermentation & Pressing
Filtration & Maturation
Wine
Grape Marc
Grape Seeds
Tank Bottoms KHT / DE
20 %w/w
By-products recovery (extraction Distillation, crystallisation, etc.)
Wine
EtOH
Tartrates
Fodder
Fertilizer
Valuable by-products
KHT: Potassium bitartrate
DE: Diatomacious Earth
Source: Böchzelt, JR, Graz


Grape Pomace –
Overview: By-products recovery
Fodder
OPCs
GS-Oil
Drying
Seeds
Pressing/ Extraction
Pomace
Extraction
Polyphenolic Pigments
Distillation
Ethanol
Lees essence
Lees
Pomace
Crystallisation
Tartaric acid
Anaerobic Digestion
Methane

(waste) Biomass ➔ Fuels

Bio-based packaging



Biogene Verpackungen

Source: www.vpz.at

Bio-Netzschläuche aus Zellulosefasern

Bio-plastics for packaging

Packaging blister made from cellulose acetate

Packaging peanuts made from bioplastics (thermoplastic starch)

Bioplastic for deep-freeze packaging

Tea bags made of polylactide (PLA), (peppermint tea)

The existing geo-centric system

- In the existing geo-centric system resources are taken from the earth crust, processed, diluted and deposited again
  - crude oil
  - coal
  - gas
  - uranium
  - landfills
  - carbon storage

- Some emissions are stored in the atmosphere and cause serious problems there (CO_2, CFCs,…)

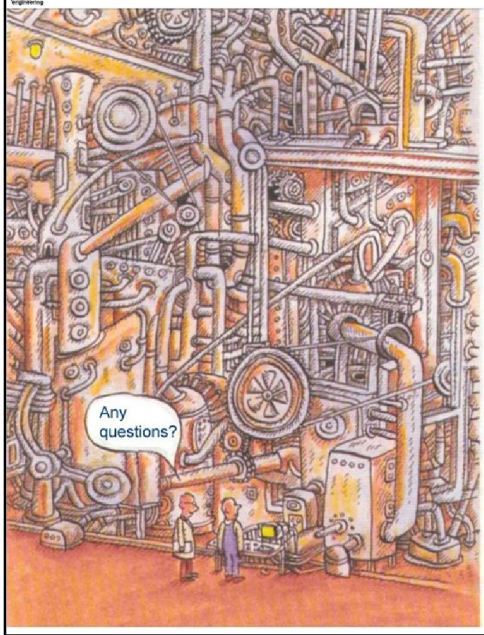
The upcoming helio-centric system

- In the to-be heliocentric system, the economy will be driven by solar energy:
  - Indirect utilization of solar radiation as biomass, wind, waves, hydro power,…
  - Direct utilization of solar radiation through photo voltaic and solar thermal heat
  - Biorefineries as a basis for an agro-based economy

The Copernican Revolution in economics: from a geo-centric to a helio-centric system

- So far: Geo-centric
- To-be: Helio-centric

This change will face similar problems like the Copernican Revolution in natural science, although it comes 500 years later!



THANK YOU !

Hans **Schnitzer**

Prof. Dr.
Vice Chair

Graz University of Technology
Institute for Process and Particle Engineering
8010 Graz, Inffeldgasse 21a, Austria
p. +43(0)316/873-7467
f. +43(0)316/873-107467
hans.schnitzer@tugraz.at
www.ippe.tugraz.at