"Experiences with the use of renewable energy in industry, especially in the food processing sector"

Prof. Hans Schnitzer, Graz University of Technology

Introductory presentation to: Innovative Approaches to Energy Efficiency and Application of Renewable Energy in Industry

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

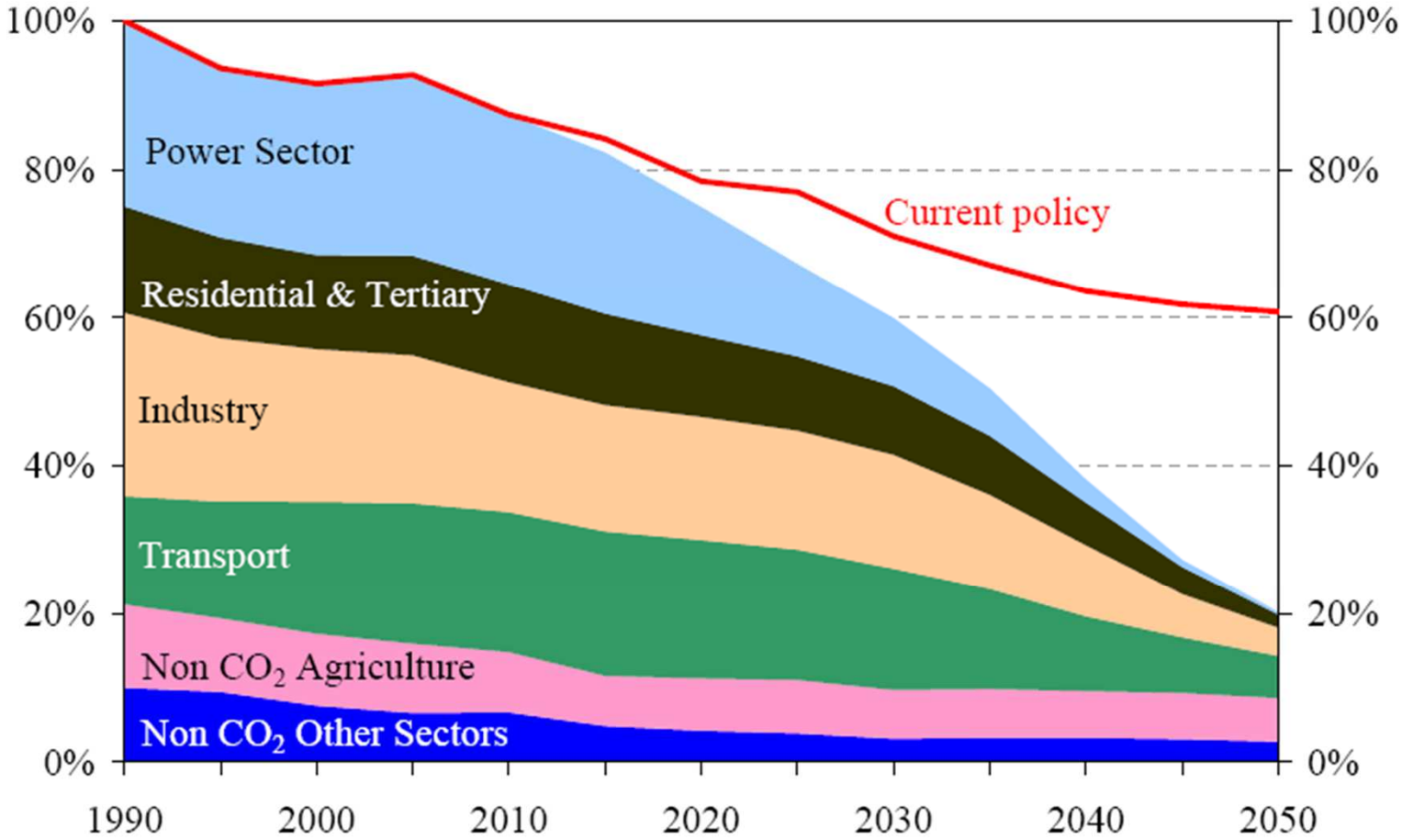
GREENFOODS (IEE-Project)

IEA-SHC Task 33 and Task 49

Cooperation with Ho Chi Minh University in Vietnam

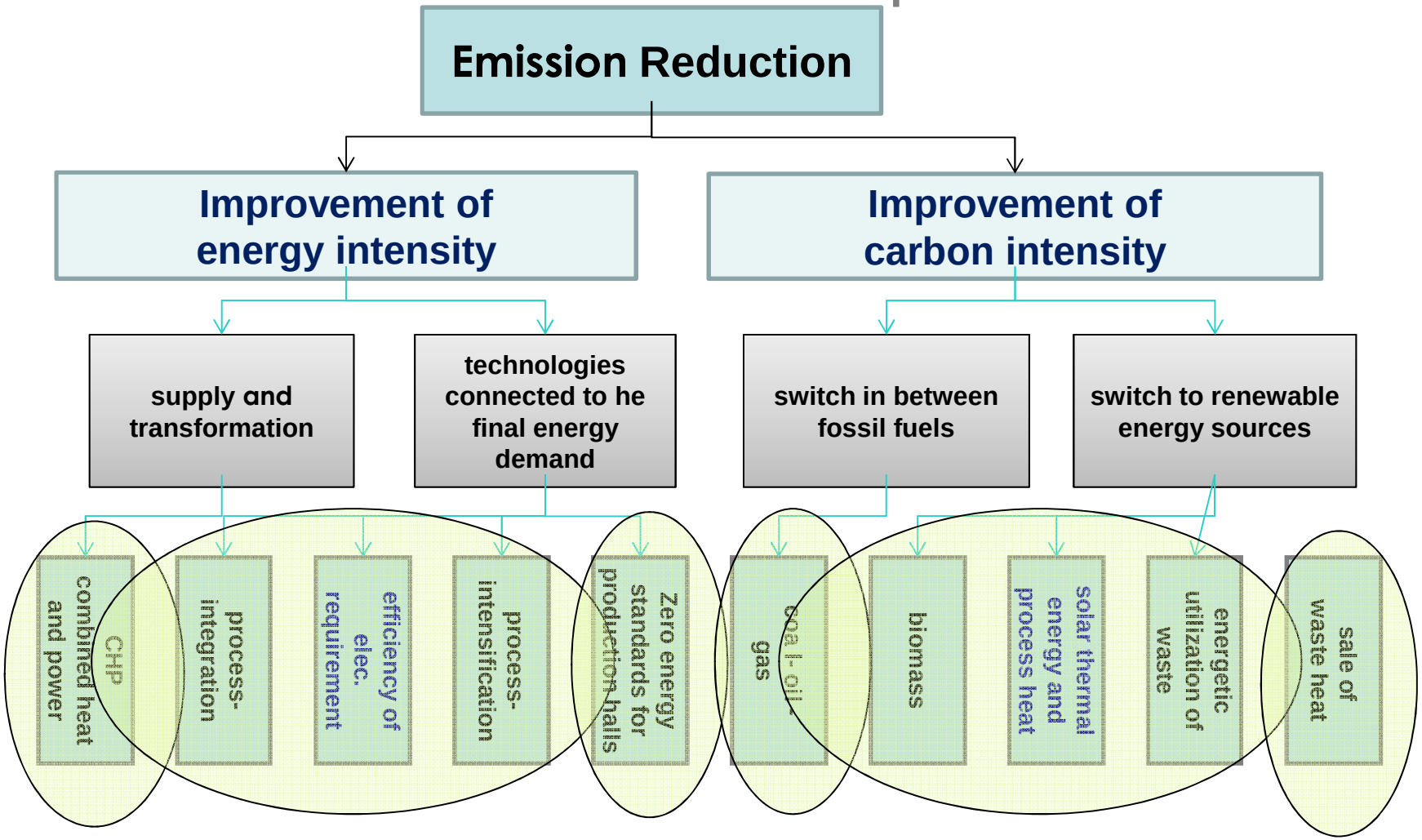
And others, …

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



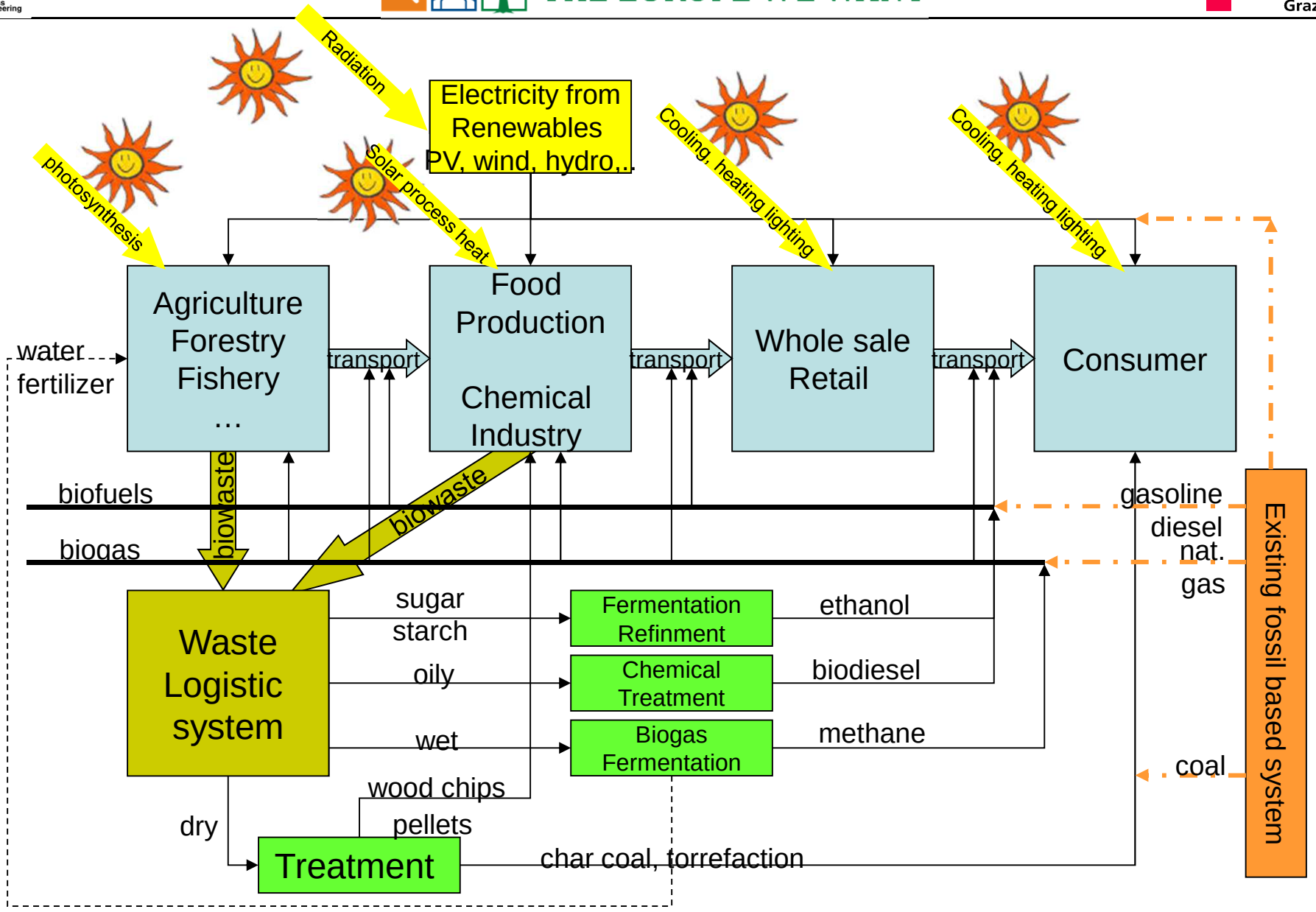
Source: EUROPEAN COMMISSION (2011): A Roadmap for moving to a competitive low carbon economy in 2050.

Ways to reduce energy consumption and GHG-emissions in production



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).


Radiation
Electricity from Renewables PV, wind, hydro,..
photosynthesis
Solar process heat
Cooling, heating lighting
Cooling, heating lighting
Agriculture Forestry Fishery ...
Food Production
Chemical Industry
Whole sale Retail
Consumer
water
fertilizer
transport
transport
transport
biofuels
biogas
biowaste
biowaste
gasoline
diesel
nat. gas
Existing fossil based system
Waste Logistic system
sugar
starch
oily
wet
Fermentation Refinment
Chemical Treatment
Biogas Fermentation
ethanol
biodiesel
methane
coal
wood chips
pellets
dry
Treatment
char coal, torrefaction

Processes and Temperature Levels

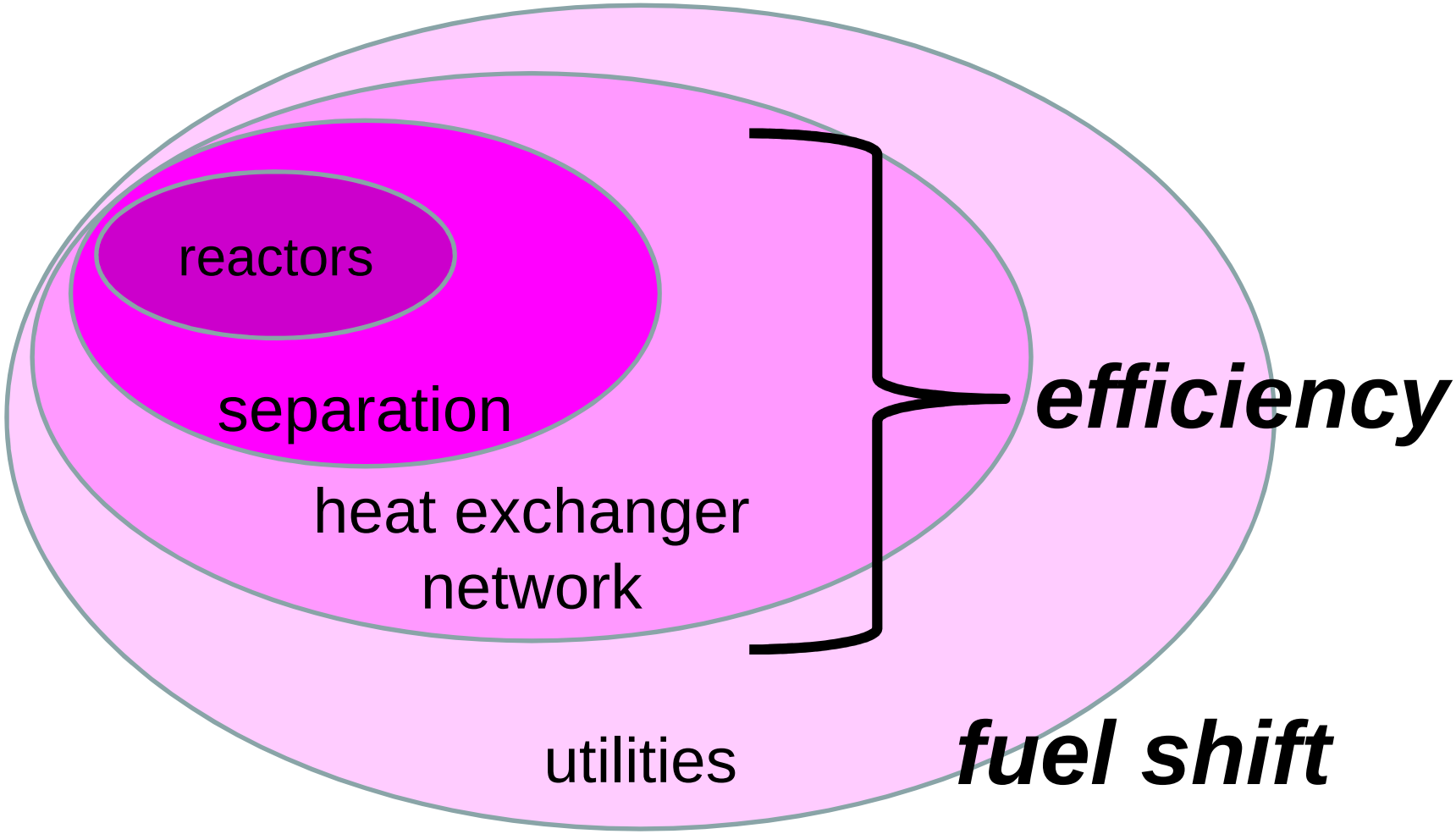
Industry sector	Process	Temperate level °C
food and beverages	Drying Washing Pasteurising Cooking Sterilising Heat treatment	30 - 90 40 – 80 80 – 110 95 – 105 140 – 150 40 – 60
Textile industry	Washing Bleaching Dying	40 –80 60 – 100 100 – 160
Chemical industry	Evaporation Distillation various chem.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

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, …

Hierarchy of measures

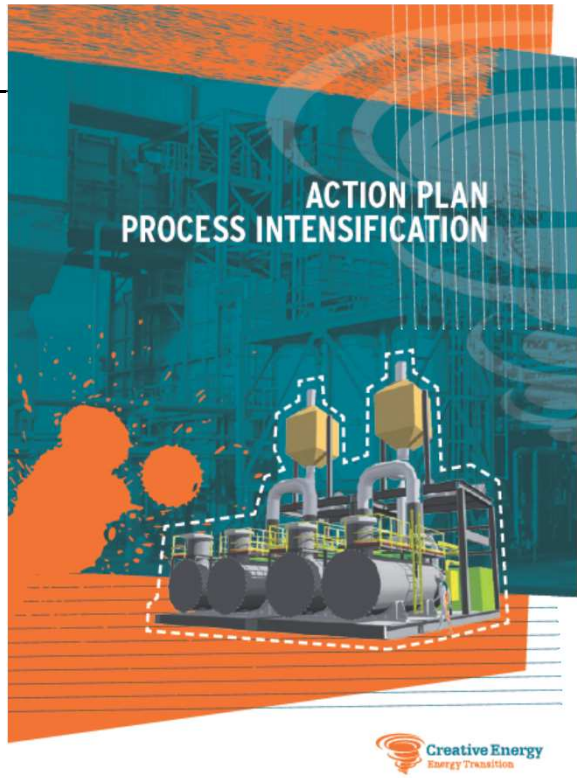


Process intensification

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)

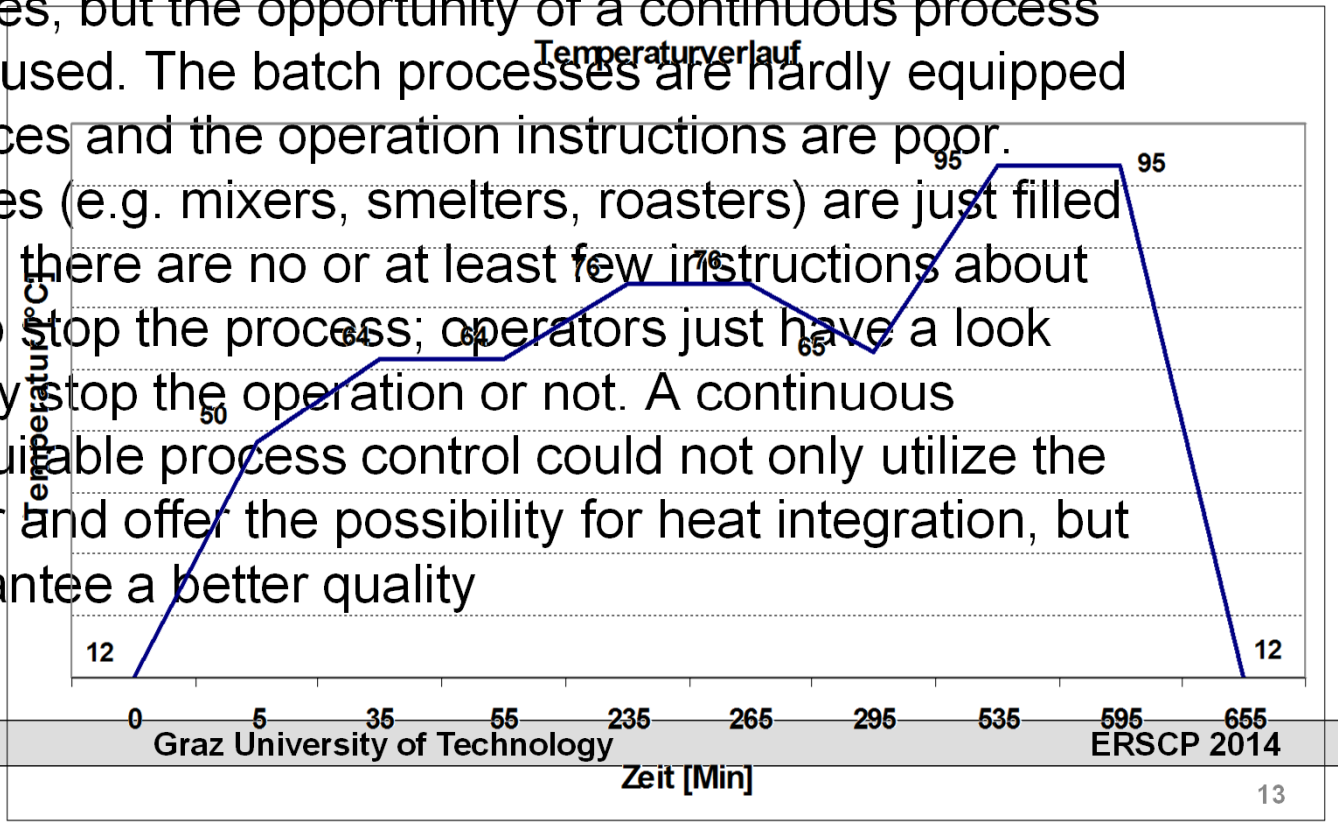


Integration of operations:

- 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.

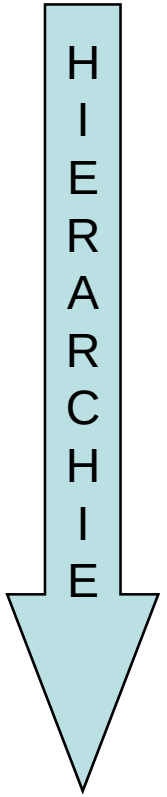
Shift from batch processes to continuous operation

- 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

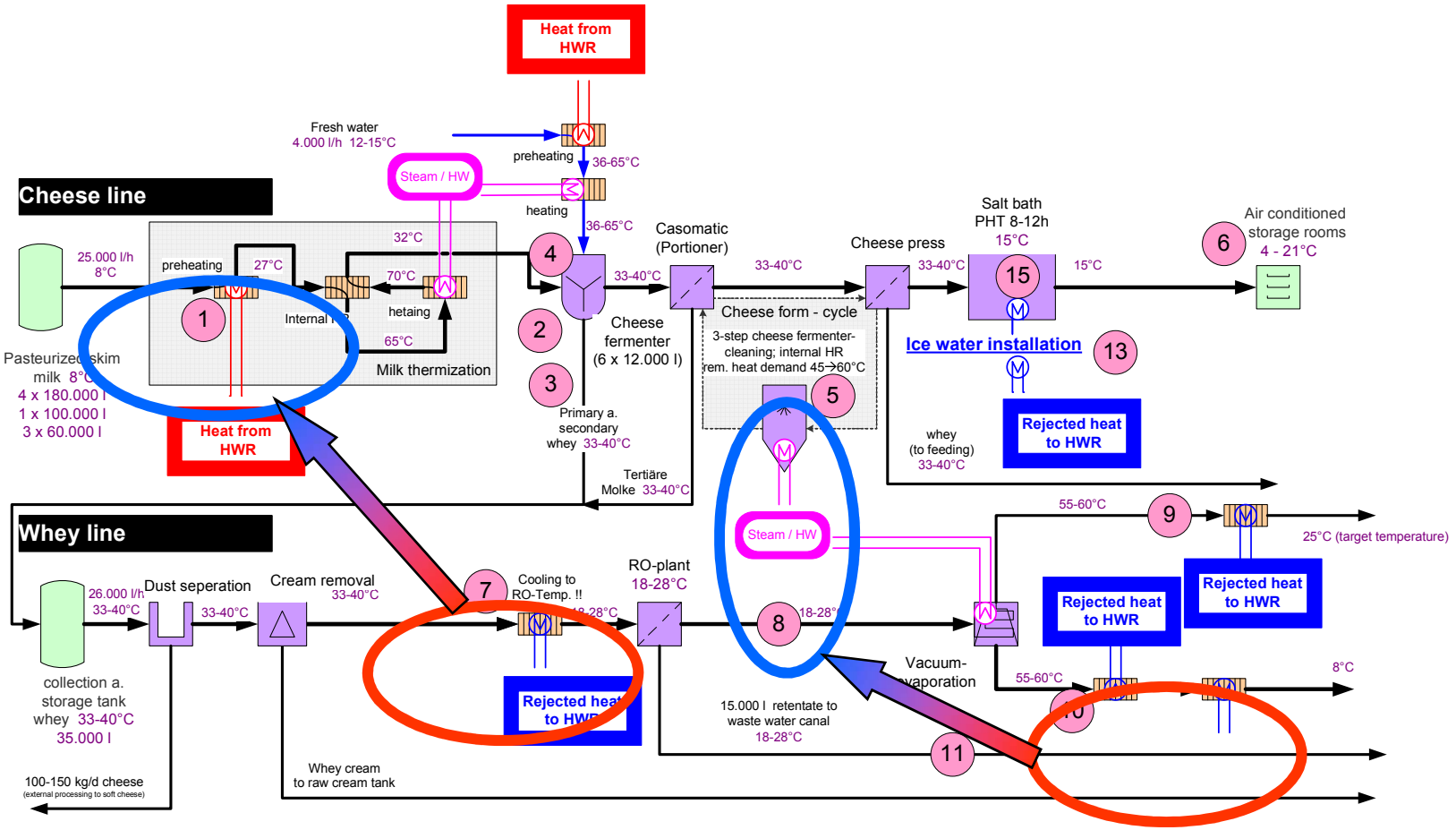


Heat integration and energy recovery, process intensification

- 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, …)

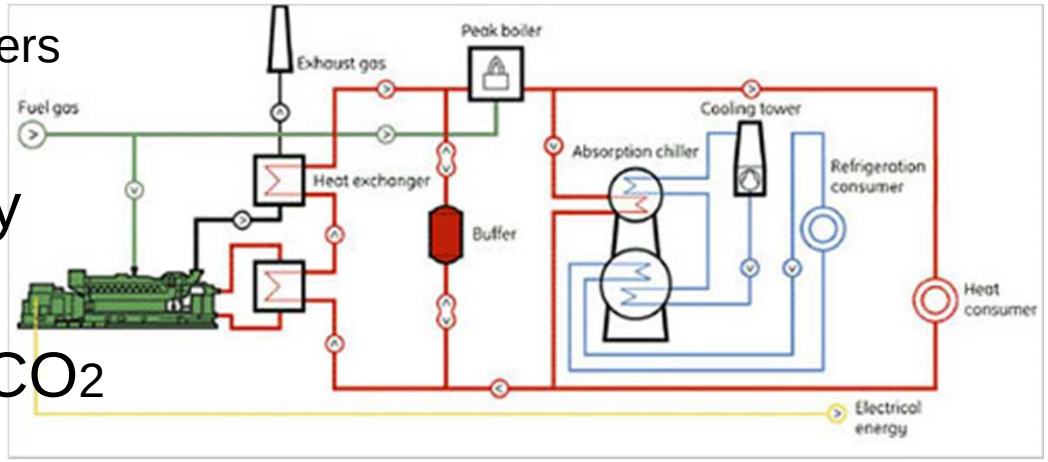


Production processes - process flow sheet



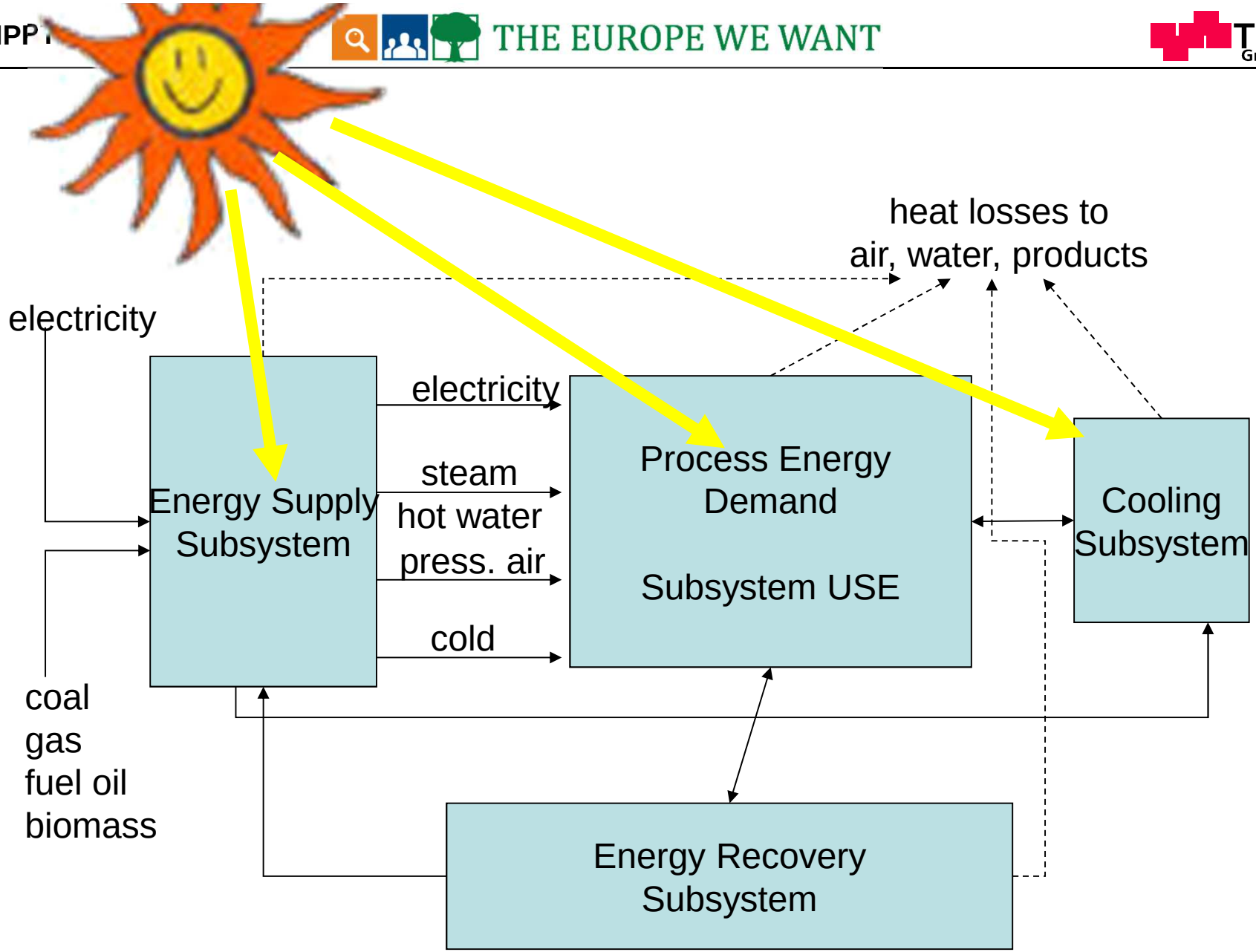
Improve system efficiency – cogeneration

- 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



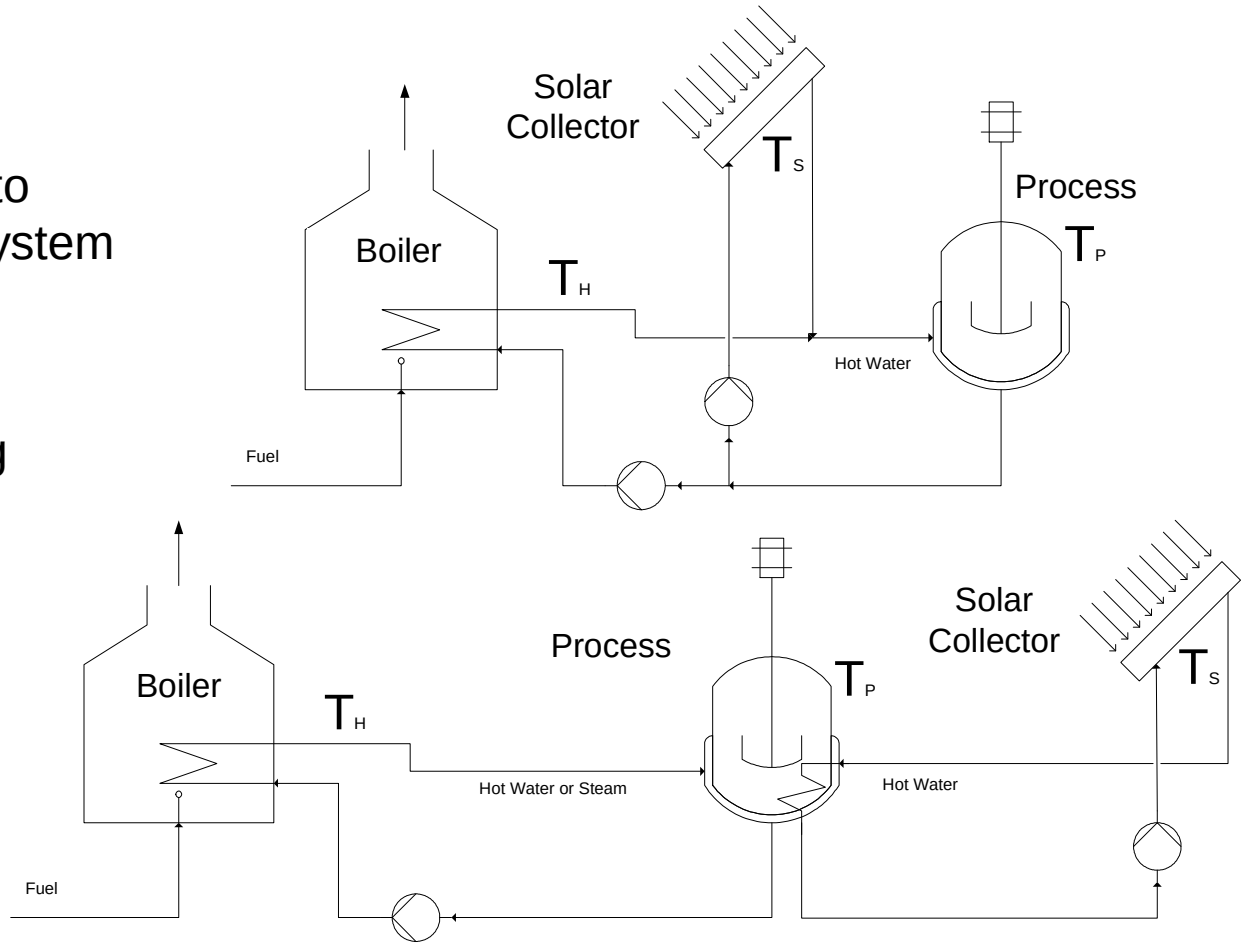
Heat recovery from effluents.

- 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.


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

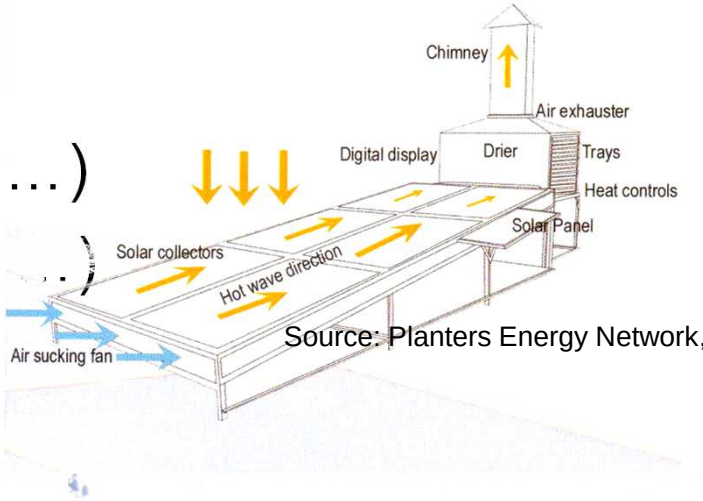
Solar Heat for Industrial Processes

- Principles
  - Integration into the heating system
  - Direct heating of processes

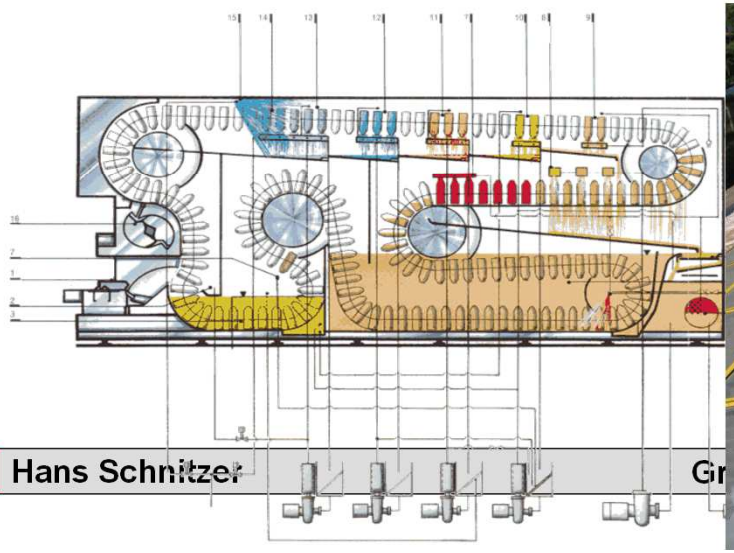


Potential solar powered operations in the food industry

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

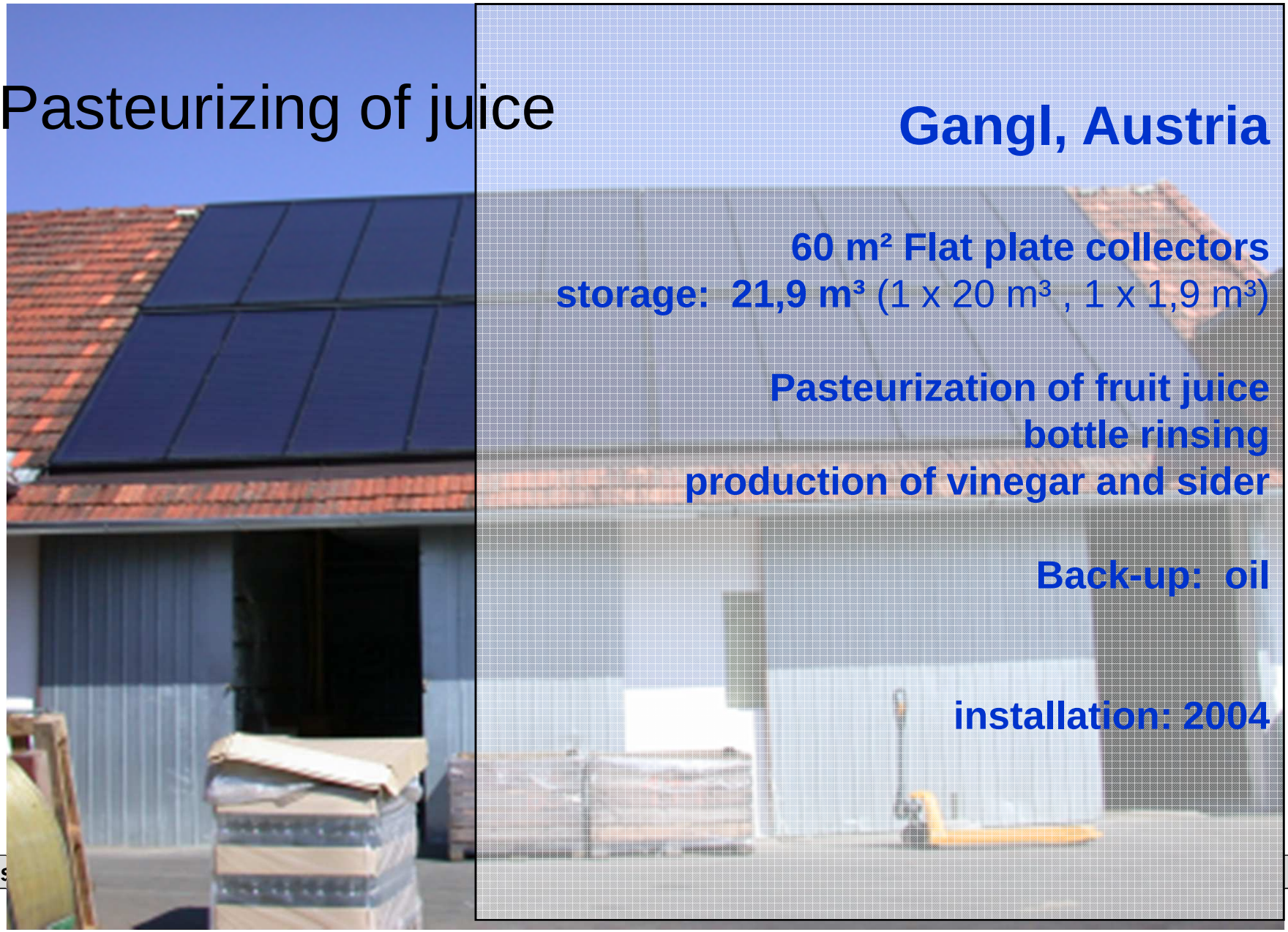


Source: Planters Energy Network, INDIA



Rinsing water for food industry

Pasteurizing of juice



Gangl, Austria

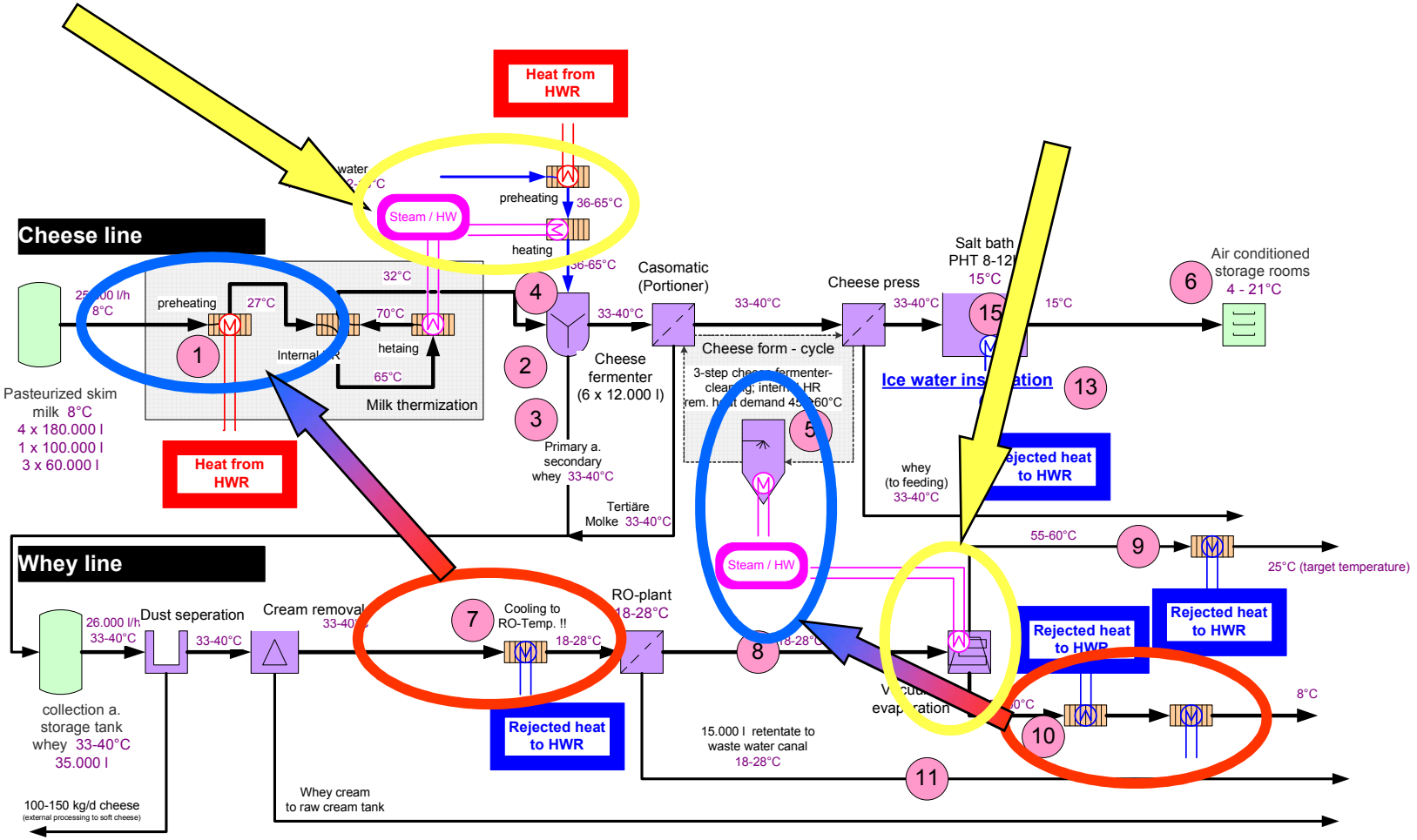
60 m² Flat plate collectors
storage: 21,9 m³ (1 x 20 m³ , 1 x 1,9 m³)

Pasteurization of fruit juice
bottle rinsing
production of vinegar and sider

Back-up: oil

installation: 2004

Production processes - process flow sheet

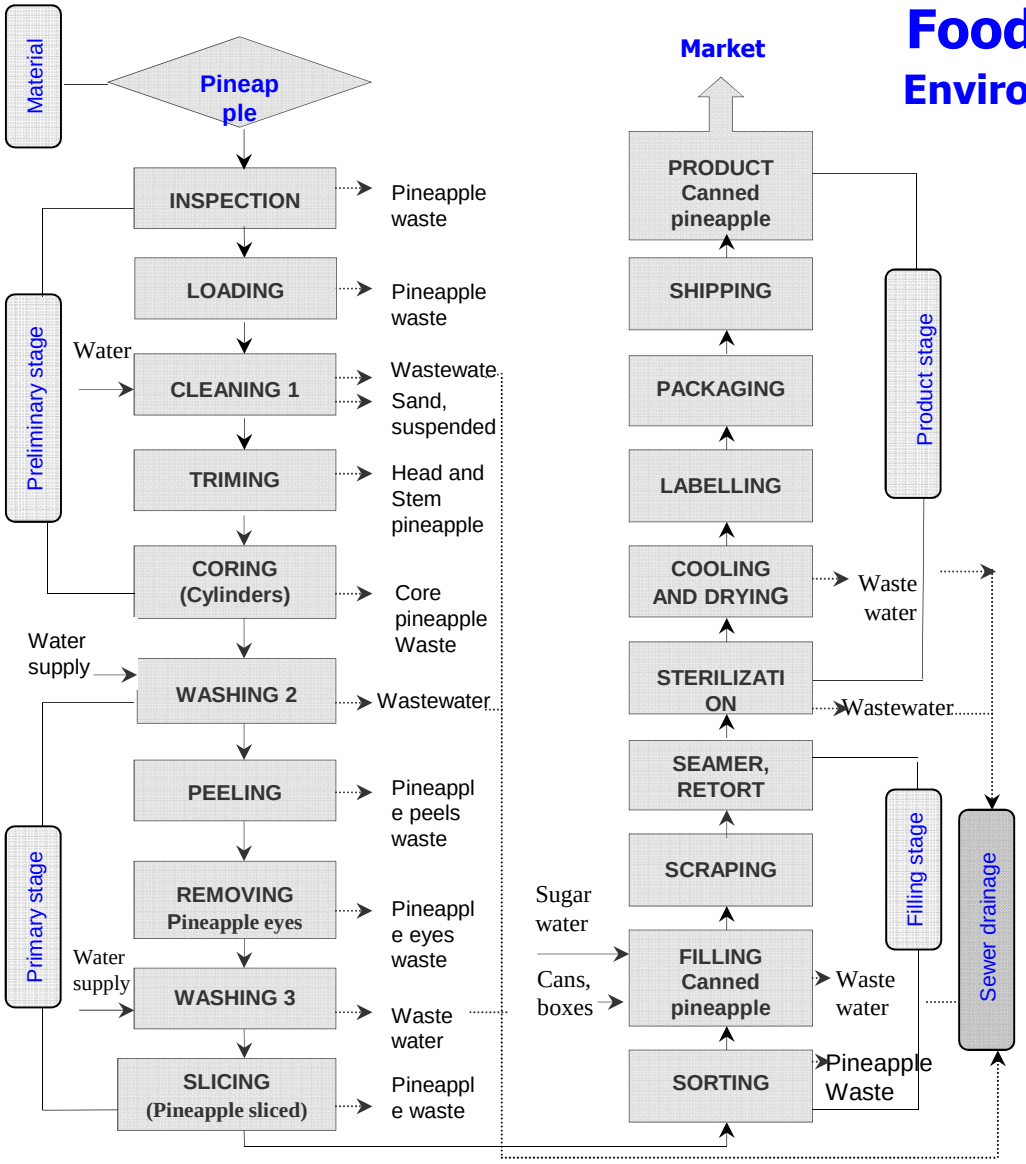


Biogas – organic waste from food processing

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

Food processing industry

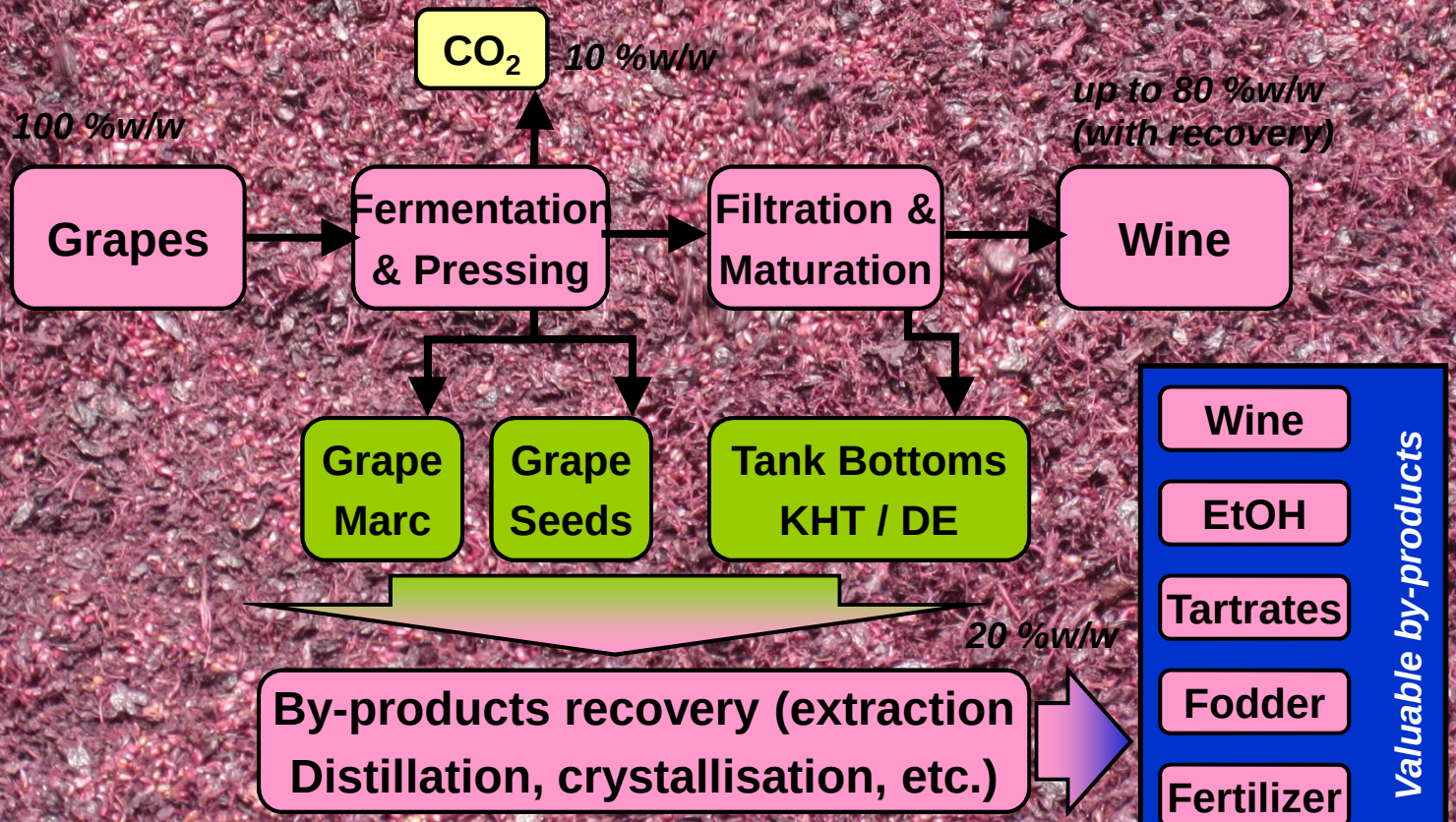
Environmental aspects and waste management



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

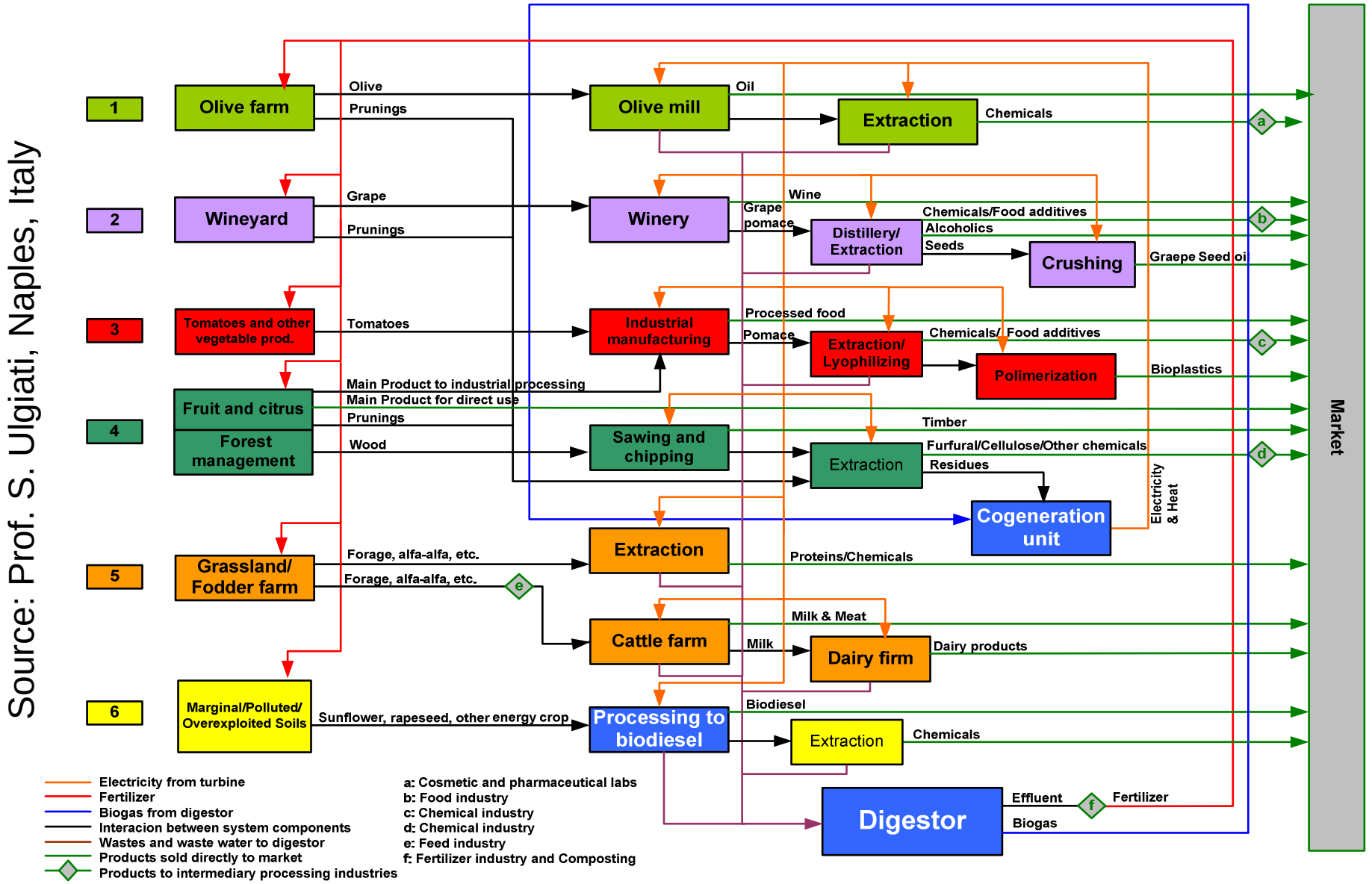
Utilation of grape press cake



KHT: Potassium bitartrate
DE: Diatomacious Earth

Source: Böchzelt, JR, Graz

(waste) Biomass ➔ Fuels


Source: Prof. S. Ulgiati, Naples, Italy
1
Olive farm
Olive
Prunings
Olive mill
Oil
Extraction
Chemicals
a
2
Wineyard
Grape
Prunings
Winery
Grape pomace
Wine
Distillery/ Extraction
Chemicals/Food additives
Alcoholics
Seeds
Crushing
Graepe Seed oi
b
3
Tomatoes and other vegetable prod.
Tomatoes
Industrial manufacturing
Processed food
Pomace
Extraction/ Lyophilizing
Chemicals/ Food additives
Polimerization
Bioplastics
c
4
Fruit and citrus
Forest management
Main Product to industrial processing
Main Product for direct use
Prunings
Wood
Sawing and chipping
Timber
Extraction
Furfural/Cellulose/Other chemicals
Residues
d
Cogeneration unit
Electricity & Heat
5
Grassland/ Fodder farm
Forage, alfa-alfa, etc.
Forage, alfa-alfa, etc.
e
Extraction
Proteins/Chemicals
Cattle farm
Milk & Meat
Milk
Dairy firm
Dairy products
6
Marginal/Polluted/ Overexploited Soils
Sunflower, rapeseed, other energy crop
Processing to biodiesel
Biodiesel
Extraction
Chemicals
Digestor
Effluent
Biogas
f
Fertilizer
Market
Electricity from turbine
Fertilizer
Biogas from digestor
Interacion between system components
Wastes and waste water to digestor
Products sold directly to market
Products to intermediary processing industries
a: Cosmetic and pharmaceutical labs
b: Food industry
c: Chemical industry
d: Chemical industry
e: Feed industry
f: Fertilizer industry and Composting

Some links:

- Wiki.zero-emissions.at
- www.green-foods.eu
- Task49.iea-shc.org
- www.einstein-energy.net
- Ship-plants.info

Thank you

But now, you have to work!