Energy Efficiency and Practical Experience

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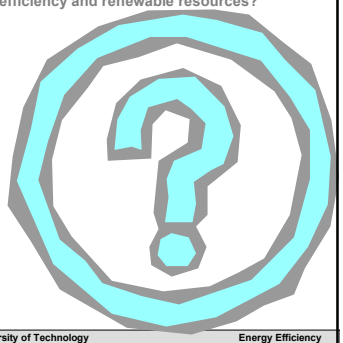
Why To Be Energy Efficient in Production Processes?

- Reduce operating costs.
- Stabilize atmospheric carbon & reduce global climate change impacts.
- Improve the quality of life in our buildings and communities.

The Energy Challenge

why do we deal with energy efficiency and renewable resources?

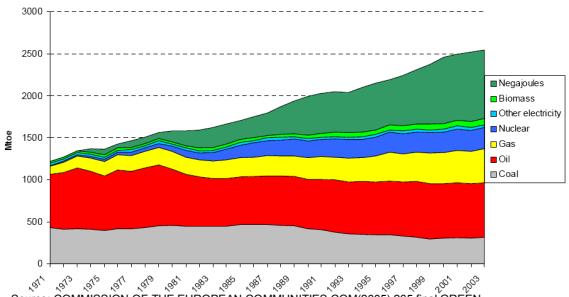


The Energy Challenge

why do we deal with energy efficiency and renewable resources?

- World energy demand will increase significantly due to:
  - Growing world population
  - Fast economic growth in large countries
  - Globalization
  - …
- World energy supply is mostly fossil-based and will remain so for decades, but fossil energy will rise in prices
- Energy-related worldwide environmental impacts will continue to grow: GLOBAL WARMING
- Access to affordable energy is not uniform

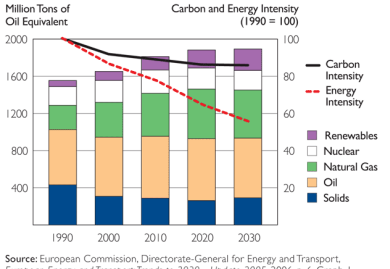
Development of the primary energy demand and of "negajoules" - EUR 25 ("negajoules" : energy savings calulated on the basis of 1971 energy intensity)



Source: COMMISSION OF THE EUROPEAN COMMUNITIES COM(2005) 265 final GREEN PAPER on energy efficiency or doing more with less, Brussels, 22.6.2005

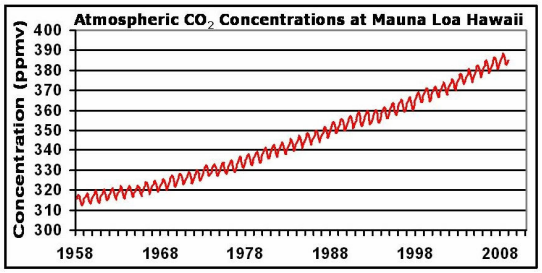
Chart 3 B 2083

Energy Consumption by Fuel and by Carbon and Energy Intensity



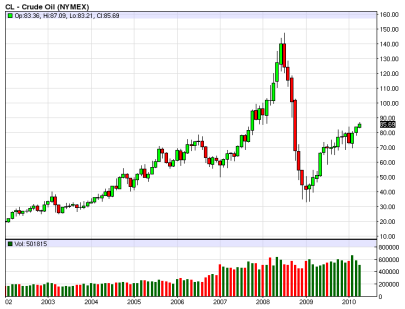
Source: European Commission, Directorate-General for Energy and Transport, *European Energy and Transport: Trends to 2030—Update 2005*, 2006, p. 6, Graph 1, at *http://ec.europa.eu/dgs/energy_transport/figures/trends_2030_update_2005/energy_transport_trends_2030_update_2005_en.pdf* (August 27, 2007).

Atmospheric CO_2 concentrations

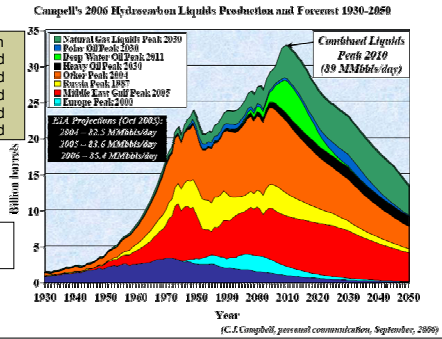


Source: http://cdiac.ornl.gov/trends/co2/sio-mlo.html

Crude oil prices and production

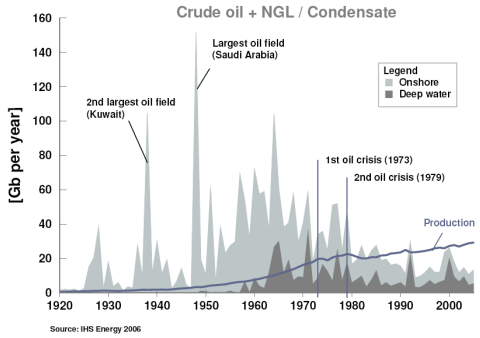


Actual Production
2003 – 79.62 Mbd
2004 – 83.12 Mbd
2005 – 84.63 Mbd
2006 – 84.60 Mbd
2007 – 84.34 Mbd

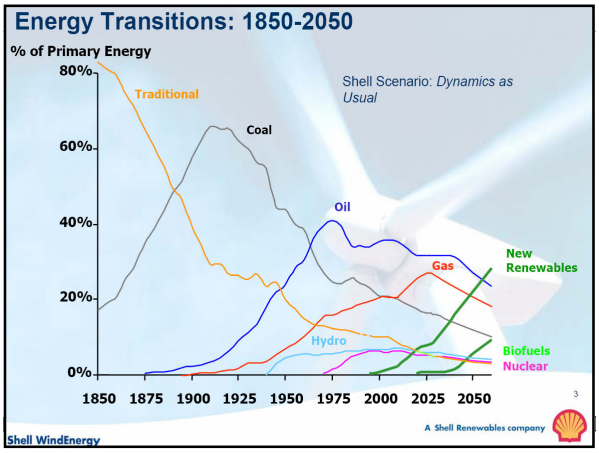


Source:
ASPO Sep 2006

History of oil discoveries and production



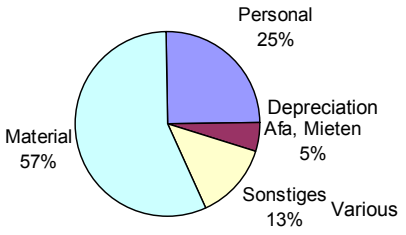
Source: IHS Energy 2006



Energy Efficiency

- The cost of saving energy is going down while the price of energy is going up.
- Efficiency is the cleanest, cheapest, safest, and most secure source energy we have.
- These savings from energy efficiency to date have not yet come close to tapping the full potential for savings.

Cost categories in the car supply industry



Quelle:
Statistisches Bundesamt, 2001

Daten für DM Fahrzeugbau

Where can companies optimize?

Thermal energy consumption in industry

Final Energy Consumption in industry: 28% of total in EU25

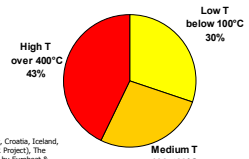
Data for 2004. Based on EUROSTAT statistics

Final Energy Consumption for heat production in industry: 69.5%

Data for 2004. Based on EUROSTAT statistics

Industrial Heat Demand at Low and Medium Temperature :

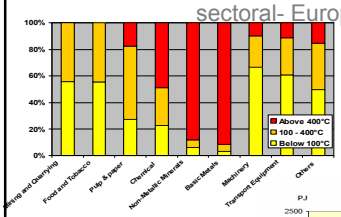
57% up to 400 °C



Data for 2003, 32 Countries: EU25 + Bulgaria, Romania, Turkey, Croatia, Iceland, Norway and Switzerland. Source: ECOHEATCOOL (IEE ALTENER Project), The European Heat Market, Work Package 1, Final Report published by Eurotheat & Power

- **high temperature area: 800 – 1700°C (iron and steel production)**
- medium temperature area 250 – 800°C
  oil industry (Cracken, Coken)
- low temperature area 50 – 250°C
  food industry, paper industry, chemical industry, textile industry

Energy consumption in industry - sectoral- Europe



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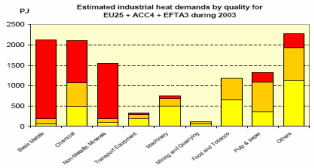
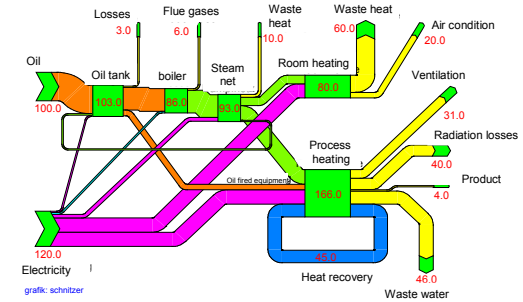


Start an Energy Efficiency Project with an Analysis of the Existing Situation

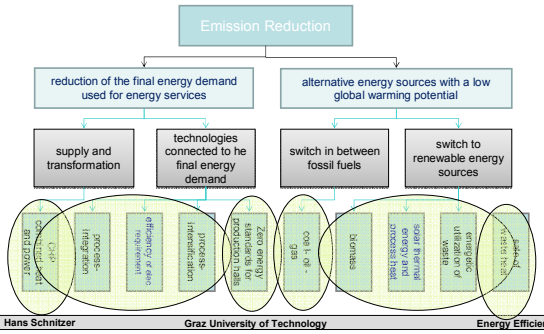
Sankey diagram of energy flow in an enterprise



Hypothesis

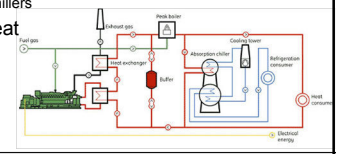
- Virtually every business enterprise could implement some energy conservation measures or use renewable forms of energy
  - to reduce production costs and/or
  - to reduce the emission of greenhouse gases

Ways to reduce energy in production



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



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, …)

HIERARCHIE

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)

Renewables for energy and materials

- Solar thermal heat for processes
- Biomass incineration
- Biogas from organic waste
- Bio-fuels for transportation and mobility
- Green electricity
- Biorefineries for plant based chemicals
- Materials from plants (fibers, bio-polymers,…)

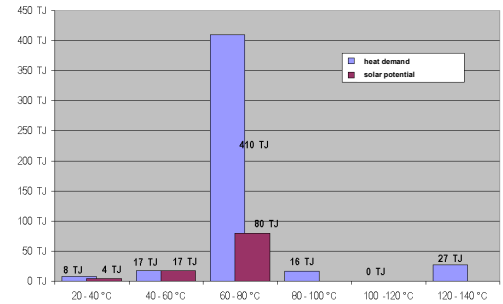
Principles for the efficient use of REs

- No fuels for temperatures below 100°C (only flameless technologies like solar energy, waste heat, heat pumps,…)
- No heat without cogeneration of electricity and vice versa
- No processing of agro-products (food, feed, materials, fuels,…) without utilization of the whole plant
- EFFICIENCY FIRST
- **REs is a systems aspect**

Typical low temperature processes

- Drying and dehydration processes
- Evaporation
- Pasteurization, sterilization
- Washing and cleaning
- Chemical reactions
- Pre-heating systems

Heat demand in Austria's milk processing industry

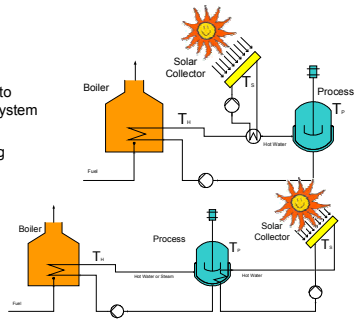


Energy services and temperature levels

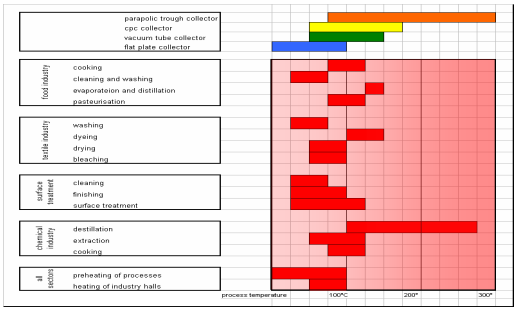
Industry sector	Process	Temperate level °C
food and beverages	Drying Washing Pasteurising Cooking Sterilising Heat treatment	30 - 90 40 – 80 80 – 110 95 – 105 140 – 150 40 – 60
Textile industry	Washing Bleaching Dying	40 –80 60 – 100 100 – 160
Chemical industry	Evaporation Distillation various chem.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

Solar Heat for Industrial Processes

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



Low temperature heat from solar collectors

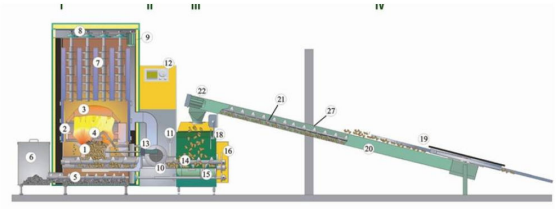


Fuel switch to biogene resources and organic waste

- Biomass heating systems
  - Wood
  - Annual plants
  - Waste biomass
- Biogas systems
  - Organic waste
- Bio-fuels
  - Ethanol
  - Bio-diesel
  - 2nd and 3rd generation BTL-processes

Biomass boilers

Cross section of KWB Multifire D 15 – 100 kW and KWB Multifire ZI 15 – 100 kW with stirrer



Transport und Mobility

- Changeover to Biodiesel
- Changeover to Biogas
  - trucks
  - Passenger cars
  - Fork lifters, …
- Changeover to green electricity
  - Fork lifter
  - Passenger cars (Plug-in Hybrid)

Biogas cars

- Passenger cars
- Trucks
- Fork lifters

Green electricity

- "Green supply"
  - Engage in large scale wind energy installations
  - Change to "green supplier"
  - …
- Generate green electricity by your own
  - Diesel engines, emergency generator (Biodiesel, Biogas,…)
  - Photovoltaic
  - Biomass plus ORC, Stirling or steam turbine
  - Small scale hydro power
  - (Wind)
  - (Geothermal)
  - …

400 kW ORC with biomass in Admont

hans.schnitzer@tugraz.at - www.joanneum.at/nts

Geothermal unit in spa „Bad Blumau"

Bad Blumau: Spa and outdoor pools.

ORC installation at well Blumau 2.

Installation for cleaning and drying CO_2 gas produced from well Blumau 2.

Daylighting

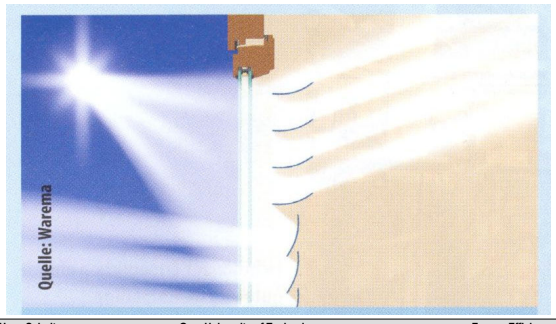
Quelle: www.baulinks.de/webplugin/2005/1070.php4

Photo Credit: Skating Club of San Francisco

Ice rink with daylighting

Die vier Elemente Sonnenschutz, Blendschutz, Lichtlenkung (oberer Lamellenbereich) und die künstliche Beleuchtung beeinflussen die Helligkeit im Raum.

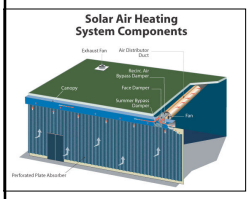
Design of day lighting systems

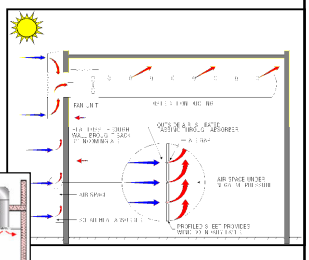


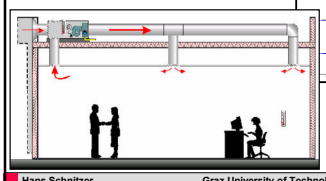
HVAC - passive house technologies for offices and production halls

- Heating accounts for about 15% of energy demand in industry in Austria
- Cooling gets more and more important
- Structural changes in industry require more production halls with heating, air conditioning and clean room technologies

Solar air heating systems for production halls and apartment buildings







Facades for active generation of electricity and heat

PV-Generator at Hartlauer

- 629 polycrystalline KYOCERA modules KC120-1with each 120 Wp. This results in a power of 75,48 kWp.

Solar Cooling

Office building

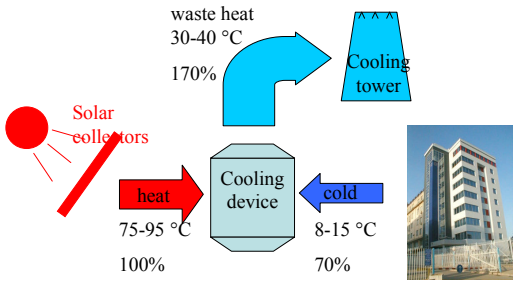
- 2 heat driven absorption chillers with 90 kW
- 226 m² /160 kW Solar collectors
- 4 m³ storage
- 220 kW back cooler
- Back up for peak demand: compression chiller with 30 kW.

Wine cooling

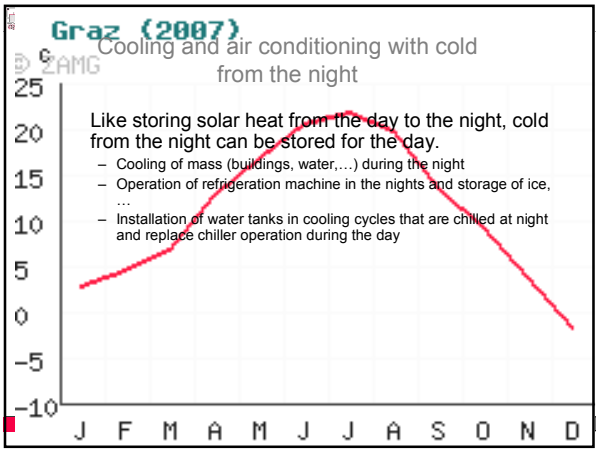
- 100,8 m² Flat plate collectors
- 40 kW wood chip boiler
- 2 x 2000 l Storage
- 10 kW Ammonia/Water Absorption Chiller
- 500 l cold brine storage
- Cooling cycle with micro-cooling tower
- Remote monitoring

Quelle: S.O.L.I.D.

Energy flow diagram



Source: S.O.L.I.D.



Cooling and air conditioning with cold from the night

Like storing solar heat from the day to the night, cold from the night can be stored for the day.

- Cooling of mass (buildings, water,…) during the night
- Operation of refrigeration machine in the nights and storage of ice, …
- Installation of water tanks in cooling cycles that are chilled at night and replace chiller operation during the day

Plant based materials

Petrochemicals will produce GHG at the end of their life; they can be substituted by plant based materials:

- Solvents
- Basic chemicals like lactic acids, ethanol
- Polymers
- Fibers
- Packaging materials
- Dyes
- …

Technologies should utilize the whole plant and represent ZERO emissions approaches

Case studies

- Food industry
  - Cheese
  - Beer
  - Meat
- Metal processing
  - Kegs
  - Gears
- Textile
  - Underwear
  - Car interiors
- Chemical
  - Pharmaceuticals

General approach for the case study investigation

- collecting all relevant data of the production process
- demonstration of the actual situation (flow sheet, Sankey diagram)
- pinch analysis and design of the heat exchanger network
- demonstration of the new optimized situation
- investigation of the solar integration
- calculation of the total energy savings (heat recovery and solar)
- TCA and demonstration of return of investment

Food industry

Site of Berglandmilch – Cheese-Dairy

Milk production:
- 913 Mio. kg milk from 15.312 farmers

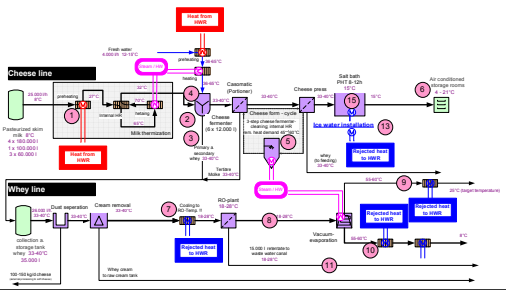
SCHÄRDINGER - ww.schaerdinger.at
DESSERTA - www.desserta.at
FIDUS - www.fidus.at

Company in Voitsberg:

producing special cheese

Most important products:
Moosbacher, Dachsteiner, Schlossdamer, Raclette, St. Patron

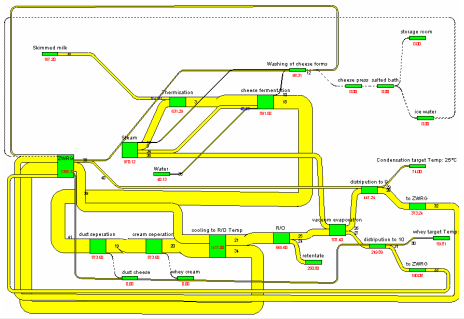
Production processes - process flow sheet



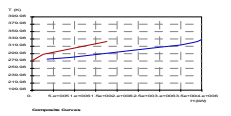
Temperature levels and energy demand of liquid streams

Nr.	Stream	Medium	Process	Temp.	Mass Flow	HE is possible with stream nr.
				°C	kg/h	
1	Preheating	milk	Preheating of milk	8 → 32	14108	7, 9, 10
4	Adwater	water	Adding water to cheese making process	12 → 57	1552	7, 9, 10,
7	Whey 1	whey	To RO cleaning of whey	42 → 12	14249	1, 8, 11
8	Whey 2	whey	Whey filtrate after RO to vacuum evaporation	12 → 50	6031	7, 9, 10
11	Whey 3	whey	Rest whey after RO to waste water treatment	12 → 25	8218	7, 9, 7
9	Whey 4	Whey	Cleaned whey	60 → 25	3837	1, 4, 8, 11
10	Whey 5	whey	Remaining whey	60 → 8	2193	1, 4, 8, 11
14	Cleaning 1	water	External cleaning	12 → 65	2822	7, 9, 10
5	Cleaning 2	water	Internal cleaning	45 → 60	1411	7, 9, 10

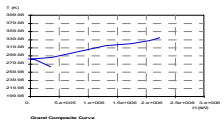
Berglandmilch Energy Flows (actual state at beginning)

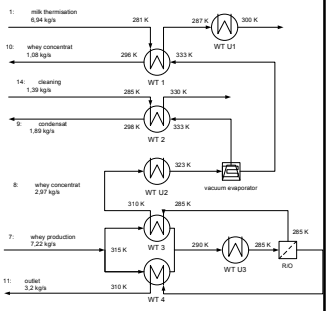


Proposed heat exchanger network

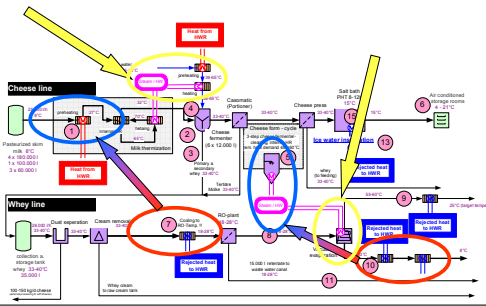


Pinch temperature: 292,5 K
Minimal heat demand: 623,86 kW
Minimal cooling demand: 95,28 kW

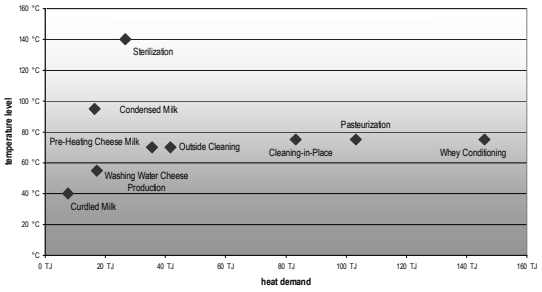




Production processes - process flow sheet



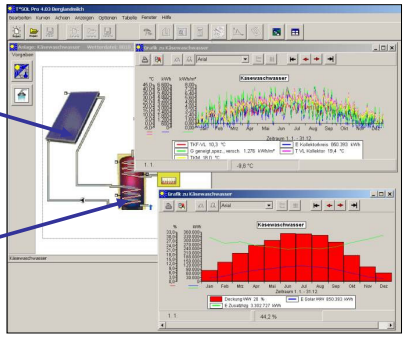
Heat demand of processes in the Austrian Dairy Industry



Simulation of two alternatives

1.000 m²
or
1.500 m²

100 m³



Vision of Gösser

- Aim of the brewery to cover 100% of thermal energy demand by REs
  - Biogas
  - Draft burner
  - Hot steam from ORC
  - Solar for processes and production halls
  - Rent the roof area for solar field for district heating


Green Brewery

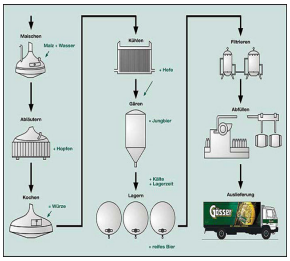
- **Zero Fossile Energy / Zero Net CO_2 Emissions in Breweries – Develpoment of a sectorial concept**
  - Heat integration
  - Biogas, Biomass
  - Transport

CO2-NEUTRAL Grüne Brauerei

klima:aktiv

Facts

- **Austrian Brewery**
- **Company of Brau Union (5 different breweries)**
- **Part of Heineken group**
- **780.000 hl beer per Year**
- **Benchmark of 34 kWh/ hl**

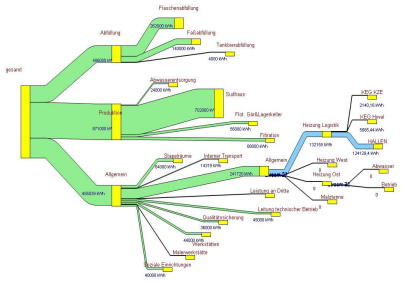


Target of the screening

- Identification of the gap between measurements and benchmark data
- Energy demand for space heating (production hall and storage)
- Water and Energy consumption for part of the production
- Possible energy savings and solar application



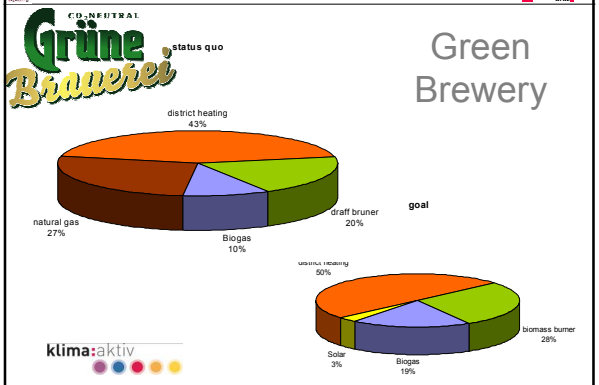
Thermal Energy distribution



Vision of Gösser

- Aim of the brewery to cover 100% of thermal energy demand by REs
  - Biogas
  - Draff burner
  - Waste heat from biomass ORC
  - Solar thermal for processes and production halls
  - Rent the roof area for solar field for district heating


Green Brewery



Findings

- Huge amount of warm water in circle (also on weekend)
- Temperature too high for the processes
- Warm water has to be cooled down by fresh water
- Hot water as overflow into canal

Mandrekas S.A.: Water heating by solar systems for yogurt maturing process

General Characteristics
Company name: Mandrekas SA
Activity: dairy
Staff: 15 employees
Location: Korinthos
Solar plant: 170 m²

Yogurt production

Source: Solar systems application in the dairy industry CRES, Greece

Mevgal S.A.: Solar systems for water heating for CIP washing machines and the water pre-heating in steam boilers

Source: Solar systems application in the dairy industry CRES, Greece

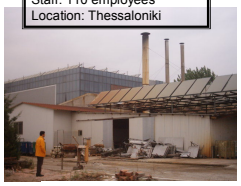
General Characteristics
Company name: Mevgal SA
Activity: dairy
Staff: 800 employees
Location: Thessaloniki
3 types of collectors: ~720 m²

Selective flat plate collectors on roof

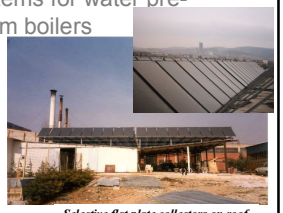
Process hot water requirements:
Factory operation: 24 hours a day, 7 days a week
Hot water consumption: 120 – 150 m³/day
Temperatures:
a) Washing machine: 20 – 80°C
b) Other processes: 20 -130°C

ALPINO S.A.: Solar systems for water pre-heating in steam boilers

General Characteristics
Company name: ALPINO SA
Activity: dairy
Staff: 110 employees
Location: Thessaloniki



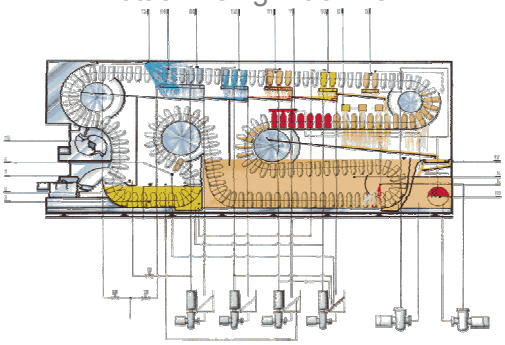
Source: Solar systems application in the dairy industry CRES, Greece



Selective flat plate collectors on roof

Process hot water requirements:
Factory operation: 8 ½ hours a day, 7 days a week
Hot water consumption: 30 – 40 m³/day
Temperatures:
a) Washing machines: 20 – 80°C
b) Other processes: 20 -130°C

Bottle rinsing machine



Solar application at Gösser

- 500m² solar field (total roof area of 12.800 m²)
- Winter:
  - solar 100.000 kWh
  - 35 kWh/m² a for the halls total demand of 350.000kWh
- Summer:
  - 30 m³/d with 45°C

Solar heat for a micro-brewery

Examples of intelligent use of thermal energy

Brauerei Neuwirth, Austria

- Manufacturing sector: brewery
- Annual beer production: 40,000 l
- Unit operation: brew process, bottle washing
- Process temperature: 50-95 °C
- **Energy efficiency measures:**
  - Optimized brew vessel (400 l) for solar thermal integration equipped with a double wall heating
  - Solar thermal plant for warm water generation for brew process and bottle washing
  - Heat recovery from the cooling process

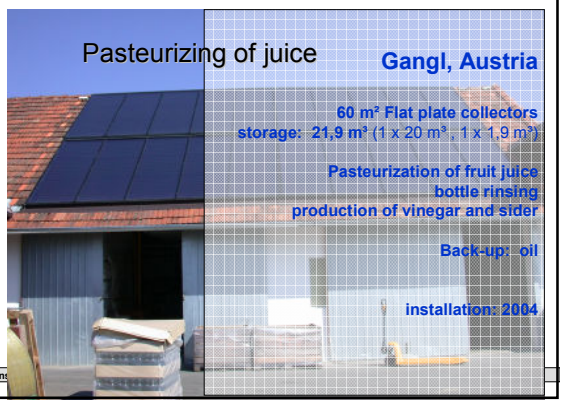
Source: AEE Intec

Dairy in Trikala /Greece

Solar field:
1040 m2 (flat plate)
Working temp.:
80 °C

Source:
CRES / Solenergy Hellas SA

Pasteurizing of juice

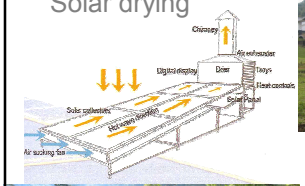


El NASR

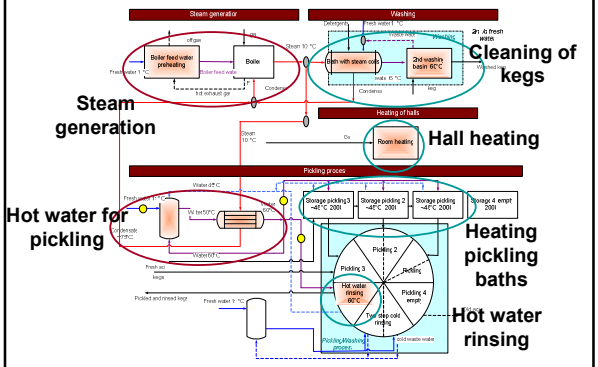
Location:
Egypt
Solar field:
1900 m2
(parabolic trough)
Process:
Saturated steam
(173 °C/8bar) for processes in the pharmaceutical industry
Working temp.:
173 °C

Source:
Fichtner Solar GmbH

Solar drying



Metal Surface Industry



Optimization possibilities

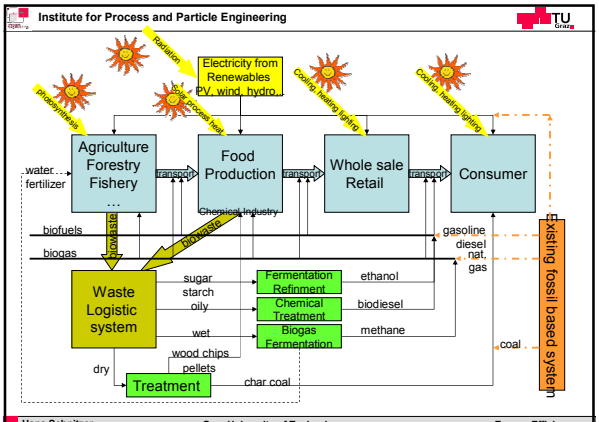
- **Insulation**
- **Change of old steam HEX**
- **Change of steam generator (air ratios ~ 15)**
- **Regulation of hot water system in pickling process**
- **Heating of pickling baths: ideal temperature not known – chemical savings with higher temperature?**
- **Reuse of boiler off gas / of hot ventilation air from washing**
- SAVINGS: 150.000 kWh + 200.000 kWh
- SOLAR FOR PREHEATING FRESHWATER

alternatives

Alternatives	Invest. [€]	savings [€/a]	Pay back [a]	ROI 20a [%]
A Solar 1, gas boiler, insulation	**272.700**	**22.780**	**11,5**	**9,5**
B Solar 1, biomass boiler, insulation	**302.200**	**29.677**	**7,8**	**11,8**
C Solar 1, biomass boiler	**137.200**	**15.273**	**6**	**13,5**
D Solar 2, biomass boiler, insulation	**266.220**	**29.054**	**7,3**	**12,5**
E Solar 2, biomass boiler	**101.220**	**14.609**	**4,6**	**15,1**

Conclusions

- Best (economical) option:
  - Biomass boiler with 300 kW (old gas boiler 1MW)
  - Solar plant 150m² for heating 1,3 m³/h fresh water, 8h per day
  - Specific collector yield: 449 kWh/m².a
  - Solar energy 67.000 kWh/a
- 60% of heating demand can be reduced **by proper insulation and new hall design – high investment costs of renovation, not economical favorable**



Thank you for your audience

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