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

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

Acknowledgement:

This paper has been produces on the basis of several projects in cooperation with a number of people and institutions:

- GREENFOODS (IEE-Project)
- 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
- IEA-SHC Task 33 and Task 49
- Cooperation with Ho Chi Minh University in Vietnam

And others, …

1. European goals regarding energy and GHG-emissions from industry A critical challenge[1]:

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. 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 optimized 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.

[1] 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)

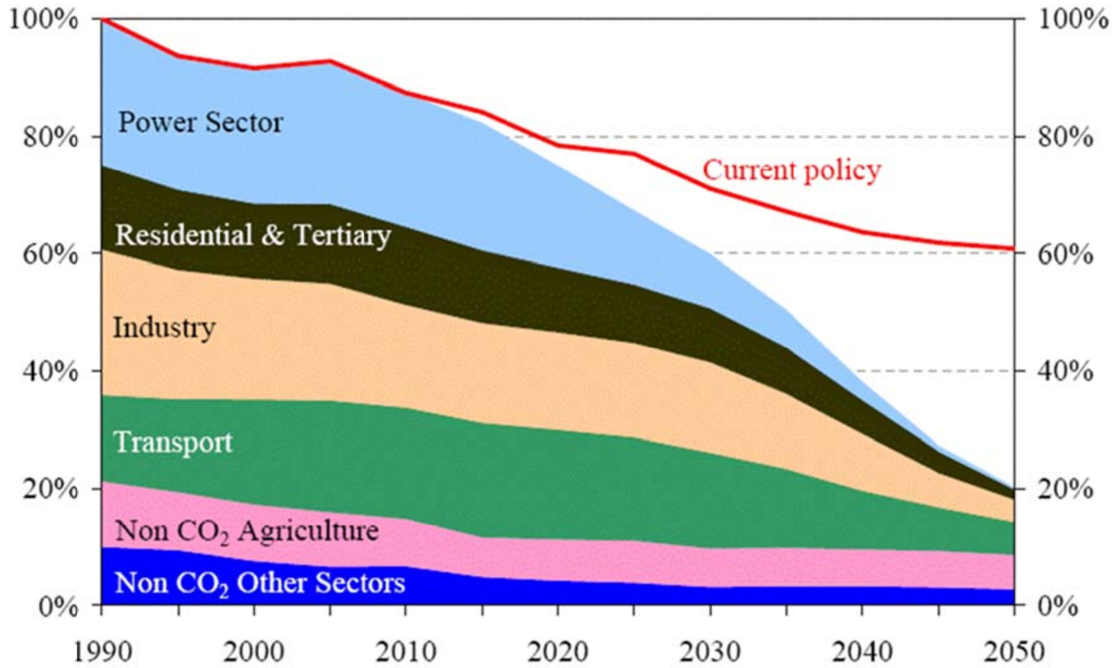


Figure 1-1: EU GHG emissions towards an 80% domestic reduction (100% = 1990); Source: EUROPEAN COMMISSION (2011): A Roadmap for moving to a competitive low carbon economy in 2050.

A need for a transition:

Out of several circumstances, there is a need for a transition of the whole energy system. Squandering resources, climate change and critical political dependencies from a small number of states with non-democratic regimes should be argument enough to work on a new energy system with high power.
The European Union as well as other bodies asks for a reduction of Green House Gases (GHG) of at least 80% till 2050. Figure 1-1 shows the European goals for different sectors. While the power sector has to reduce GHG totally, industry has to aim for a reduction of around 80%.
The reduction of the energy consumption can be seen separated from the fuel shift from fossil fuels to renewables (comp. Figure 1-2). It is important to consider the improvement of the energy intensity before the improvement of the carbon intensity.
Up to now, the main goals of projects regarding cleaner production and energy efficiency concentrated on the improvement of the existing system. If one is aiming at an improvement of 80% (factor 4), improvements will not be enough: we need radical innovations.
So the question arises, how radical innovations can be reached. Innovation is always more risky than improvement.

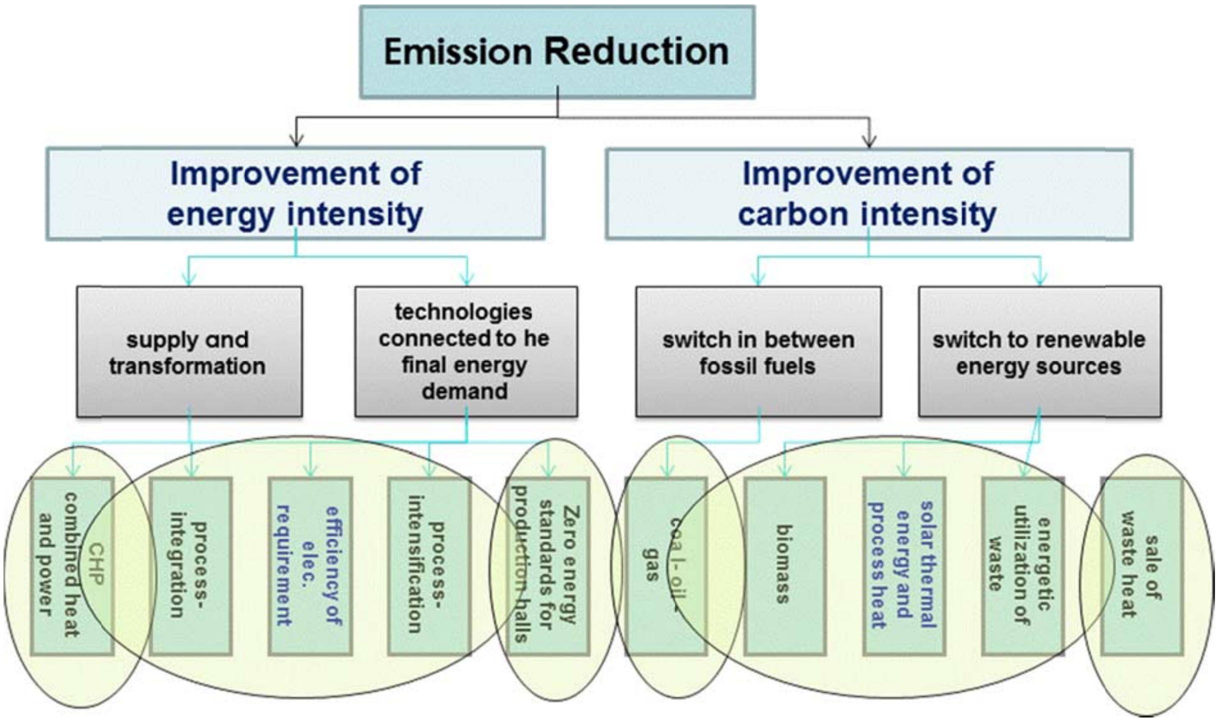


Figure 1-2: Ways to reduce energy consumption and GHG-emissions in production

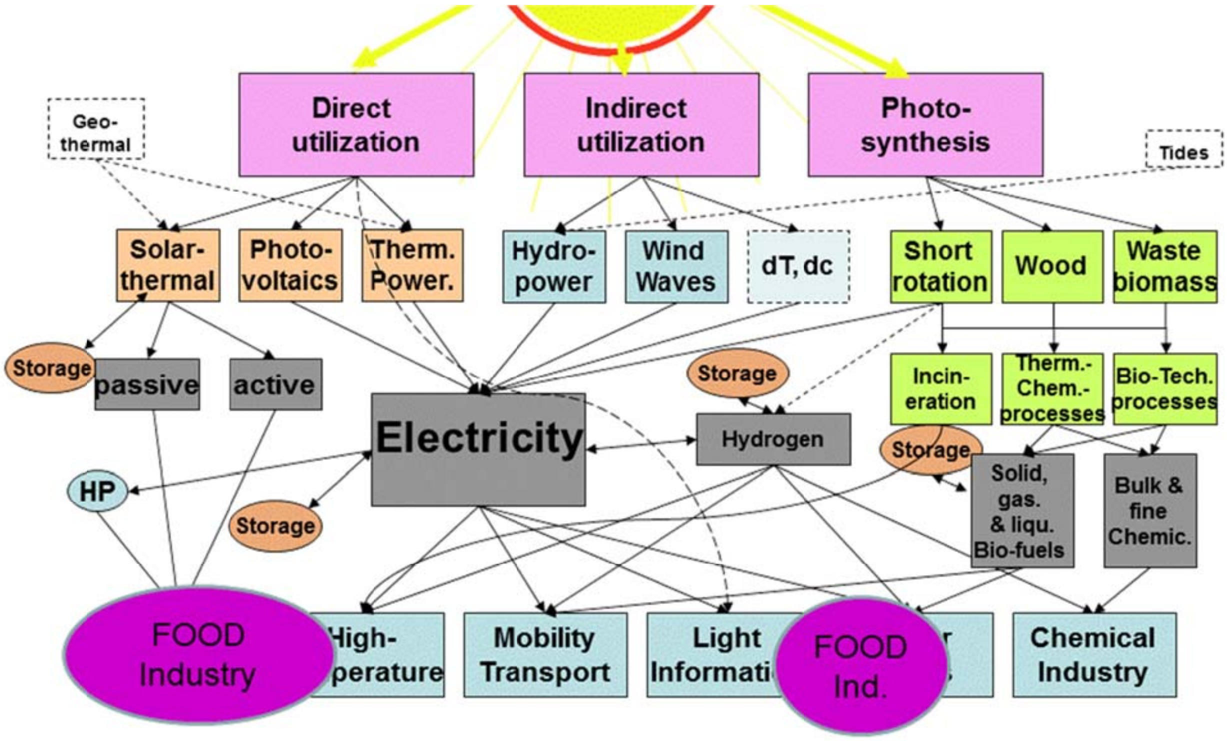


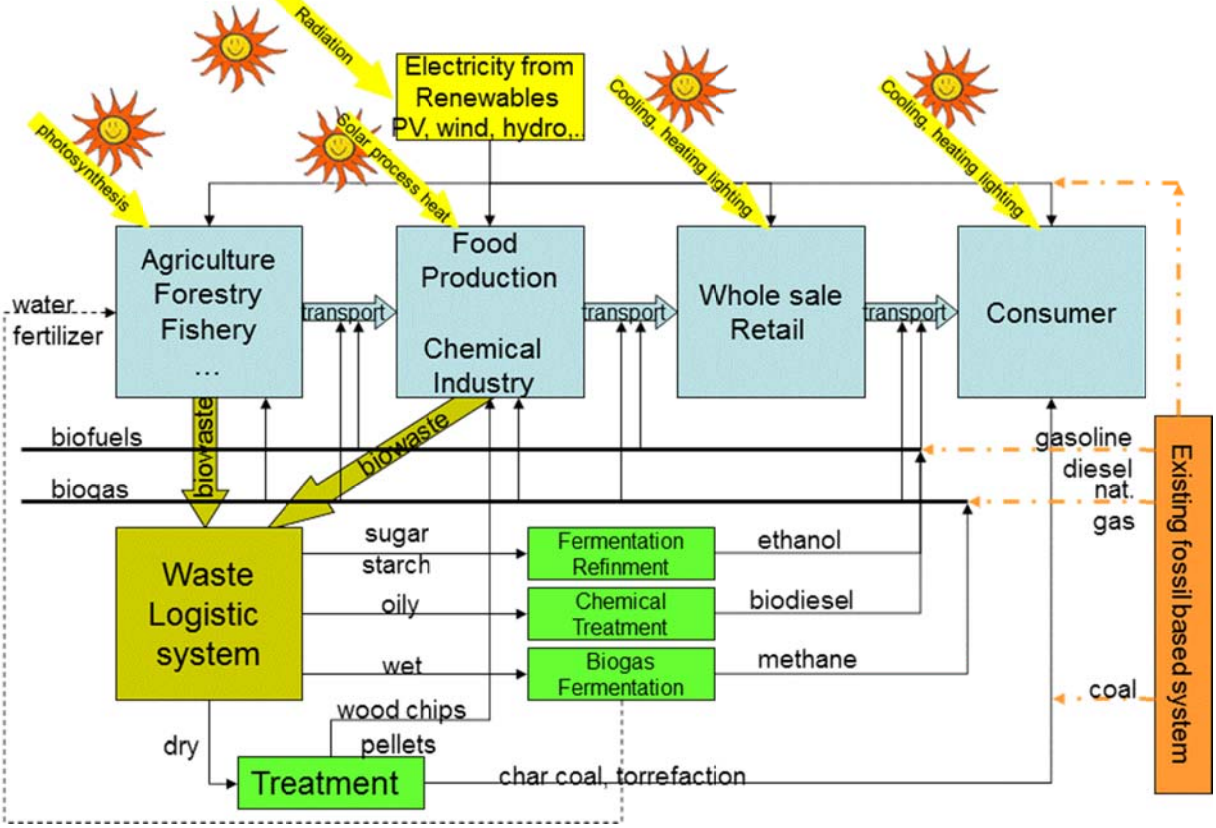
Figure 1-3: Technological pathways from solar radiation to energy services

2. Typical processes and temperature levels in food processing

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).

Typical processes in the food sector

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

3. Approaches to reduce energy consumption and GHG emissions in food processing

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 another process in the company, but in another production line
- Heat pumps (compression and absorption)
- Waste heat driven ORCs
- Heat delivery to customers outside company (other company, fish farm, district heating, …)

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 exchangers and the location of the buildings and processes

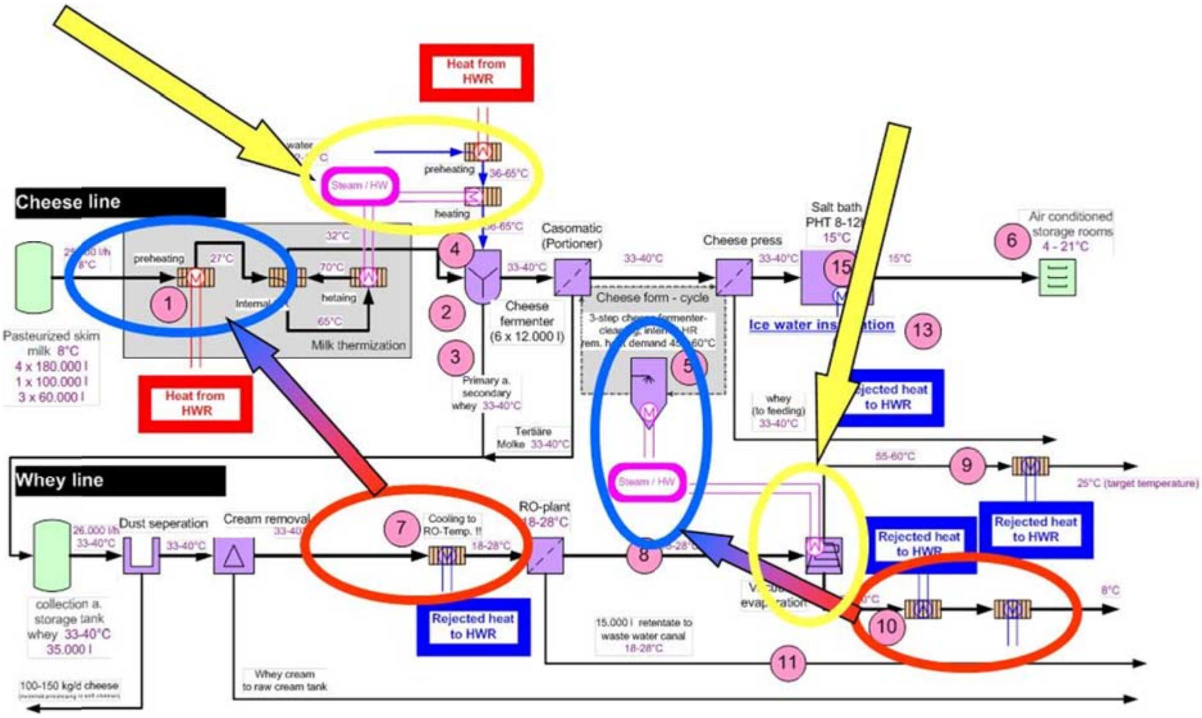


Figure 3-1: Possibilities for the integration of heat recovery and solar thermal heat for a cheese production plant

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

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.

Integration of solar thermal energy

The food sector is especially well suited for the integration of solar thermal heat, since most of the process that require heat operated at rather low temperature levels.

Figure 3-2: Solar thermal energy can be integrated into energy supply, processes and cooling systems

It is more efficient, but at the same time more difficult, to integrate solar thermal energy in the processes direcly than to integrate it to the energy supply system. The reason is that the temperature levels are always much higher in the hot water or steam net than at the final user`s place.

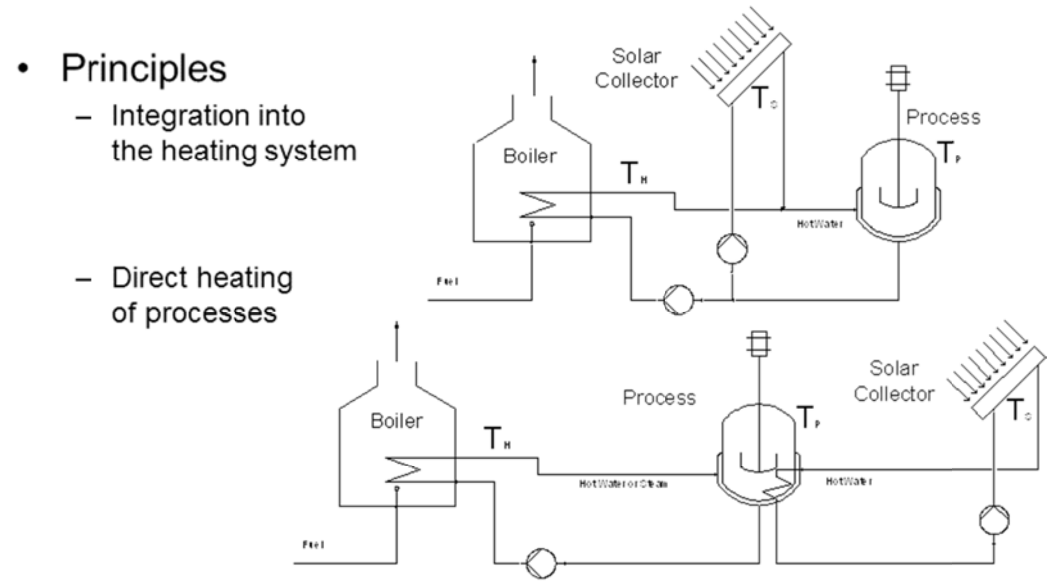


Figure 3-3: The difference between process integration and energy systems integration

4. GREENFOODS and IEAtask 49

In the project GREENFOODS, funded by the European Union, the expertise of 14 Partners from 6 countries in the area of greening the food industry is summarised. GREENFOODS (www.green-foods.eu) mainly targets the sectors meat industry, drink industry (breweries and fruit juice), bakery, baby food, cereal producer, animal food and the fish industry.

Through the implication of eco-efficient production patterns, the position of the European food and beverage industries should be strengthened. By increasing energy efficiency and the reduction of fossil based emissions the path towards a sustainable processing of food and beverages in Europe will be trodden. To realize this vision this project takes several actions. 200 companies in the 6 countries are analysed by a basic audit, in which the current energy situation and the main processes are surveyed. The results show on the one hand optimization proposals and on the other hand the status quo of the energy supply and demand patterns. From these 200 audits 20 are chosen for a detailed audit. Concurrently a core part, the GREENFOODS branch concepts for the sectors, will be developed and evaluated.

A branch concept in this project is defined as the combination of calculation tools and guidelines. After the energy balance calculation of the current system, step by step - heat integration, process optimization, efficient heat and cold supply and the integration of renewable energy (solar process heat, CHPs, biomass and biogas boilers, industrial heat pumps and absorption chillers) will be analysed by considering economic and environmental aspects as well as country-specific funding and restrictions. In order to enhance the realisation potential new country and sector specific funding schemes will be developed.

The International Energy Agency has launched a Task to state the latest state of research and application in solar thermal heat in industries. The main goals of the IEA_SHC Task 49activity will are (http://task49.iea-shc.org/objectives):

- Further develop and improve solar process heat collectors and components
- analyze and provide new knowledge on high temperature behavior of process heat collectors and solar loops
- develop a testing procedure and to provide a basis for the comparison of collectors under certain conditions
- provide engineering tools for optimized heat integration and optimized planning of solar thermal integration by advanced pinch analysis and storage management
- identify new applications for solar thermal energy in several production processes through the combination of process intensification technologies
- develop planning tools, calculation tools for solar yields in large scale plants
- gain proven solutions for stagnations behavior
- install and monitor large-scale demonstration systems
- develop guidelines for solar process heat
- to lower the barriers for market deployment

5. Case studies

Currently, 120 operating solar thermal systems for process heat are reported worldwide, with a total capacity of about 88 MWth (125,000 m^2). The first applications have been of an experimental nature with relatively small scale. In recent years, significantly bigger solar thermal fields have been applied and are currently in the project pipeline.

The Solar Heat for Industrial Processes – SHIP database has been created in the framework of the IEA Task 49/IV. This online database contains a worldwide overview on existing solar thermal plants which provide thermal energy for production processes for different industry sectors. Each plant description contains a number of informations about e.g. the size of the collector field, collector technology or integration point in the production process.

An initial survey has been developed and sent out to different solar companies by AEE INTEC. The returned data has been collected, structured and integrated into the database by them. All the programming work for the database's structure and design has been done by the PSE AG.

The user of the database has now the possibility to extract detail information from all identified solar thermal plants and create statistics like the share of collector technologies, size of the collector field per country or industry sector and cost per square meter. The SHIP database is a living platform and will grow continuously.

6. Conclusions

Industry has to contribute to slowing down climate change. This mainly will be done by increasing the energy efficiency and the switch to renewable energies.

On the other hand, industry has also a great responsibility regarding the products manufactured. The energy efficiency of the products might be more important than the energy spend at the production process.