Solar Process Heat and Co-Generation
a review of recent developments

Klaus Hennecke

DLR

Content

- Motivation
- Mid-Term Status Task 49/IV
- Co-Generation Concepts
- Conclusions

The presenter greatfully acknowledges the valuable contributions from several colleagues, in particular Christoph Brunner (Task 49/IV) and Eduardo Burin (Co-Generation Project in Brazil).

Renewable Energy Technologies for Power Generation

Geothermal

Hydro

Solarthermal

Biomass

Tidal

Wave

Photovoltaic

Wind

Renewable Energy Technologies for Process Heat

Geothermal

Concentrating Solar

Biomass

Non-concentrating Solar

Challenges in Solar Process Heat

- Heat cannot be transported easily over long distances
  - Meteorological conditions at the site
  - Availability of suitable areas for collectors (ground, roof, facades)
- Solar field size (= investment cost) proportional to heat demand
  - Rational use of energy minimizes heat demand
  - Process optimization more cost effective than “free” solar energy
- Collector efficiency temperature dependent
  - Selection of suitable collector technology
  - Integration of solar heat at appropriate temperature
- Annual, daily and stochastic variations of radiation
  - Load management, heat storage and fossil or renewable back-up
  - Similar load and radiation profiles may increase solar share
- O&M effort and perceived risks of “new” technology
  - Priority for O&M personnel: Efficient and secure production process
  - Intelligent integration of solar system

Task 49/IV Solar Process Heat for Production and Advanced Applications

- Industrial processes:
  - All processes with a thermal energy demand at temperatures up to 400°C
  - Technologies for industrial application which can be driven by sunlight or specific spectrums (e.g. UV)
- Solar thermal collectors:
  - Working temperature up to 400°C; concentrating and non-concentrating technologies
- Solar thermal systems:
  - No restrictions in the system integration and heat carriers (air, water, thermo oil, low pressure steam)

Source: GEA Brewery Systems

Source: Smirro GmbH

Task 49/IV Sub-Tasks and Objectives

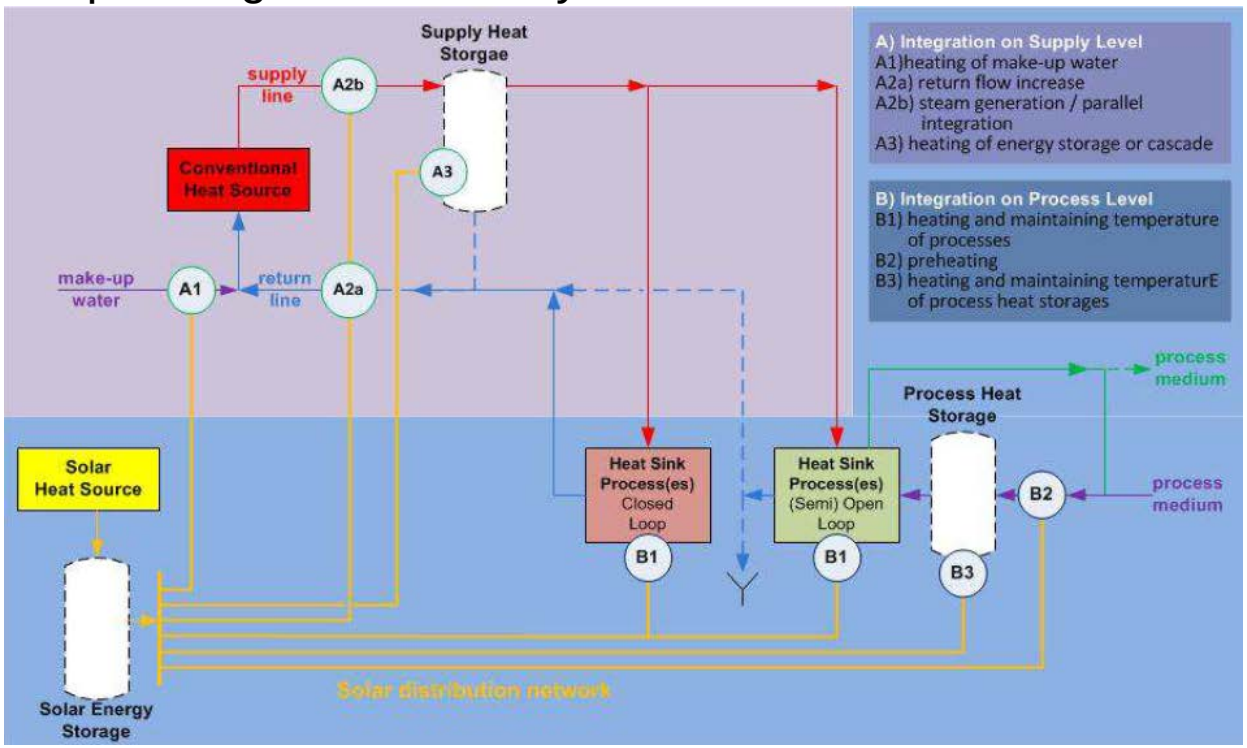
Start: February 2012, Duration: 4 years

- **Subtask A: Process heat collector (SPF)**
  - Improving solar process heat collectors and collector loop components
  - Providing a basis for the comparison of collectors with respect to technical and economical conditions
  - Giving comprehensive recommendations for standardized testing procedures
- **Subtask B: Process integration and Process Intensification combined with solar process heat (AEE INTEC)**
  - Improved solar thermal system integration for production processes
  - Increase of the solar process heat potential by PI and solar chemistry
- **Subtask C: Design Guidelines, Case Studies and Dissemination (ISE)**
  - worldwide overview of results and experiences
  - Performance assessment methodology for a comparison and analysis of different applications, collector systems, regional and climatic conditions
  - Support future project stake holders by providing design guidelines, simplified fast and easy to handle calculation tools

Task 49/IV Mid-Term Status

Integration Guidelines first Version issued

- integration concepts are available
- guidance for solar planners, energy consultants and process engineers
- how to identify suitable integration points for a solar thermal system
- not: planning of the solar system itself



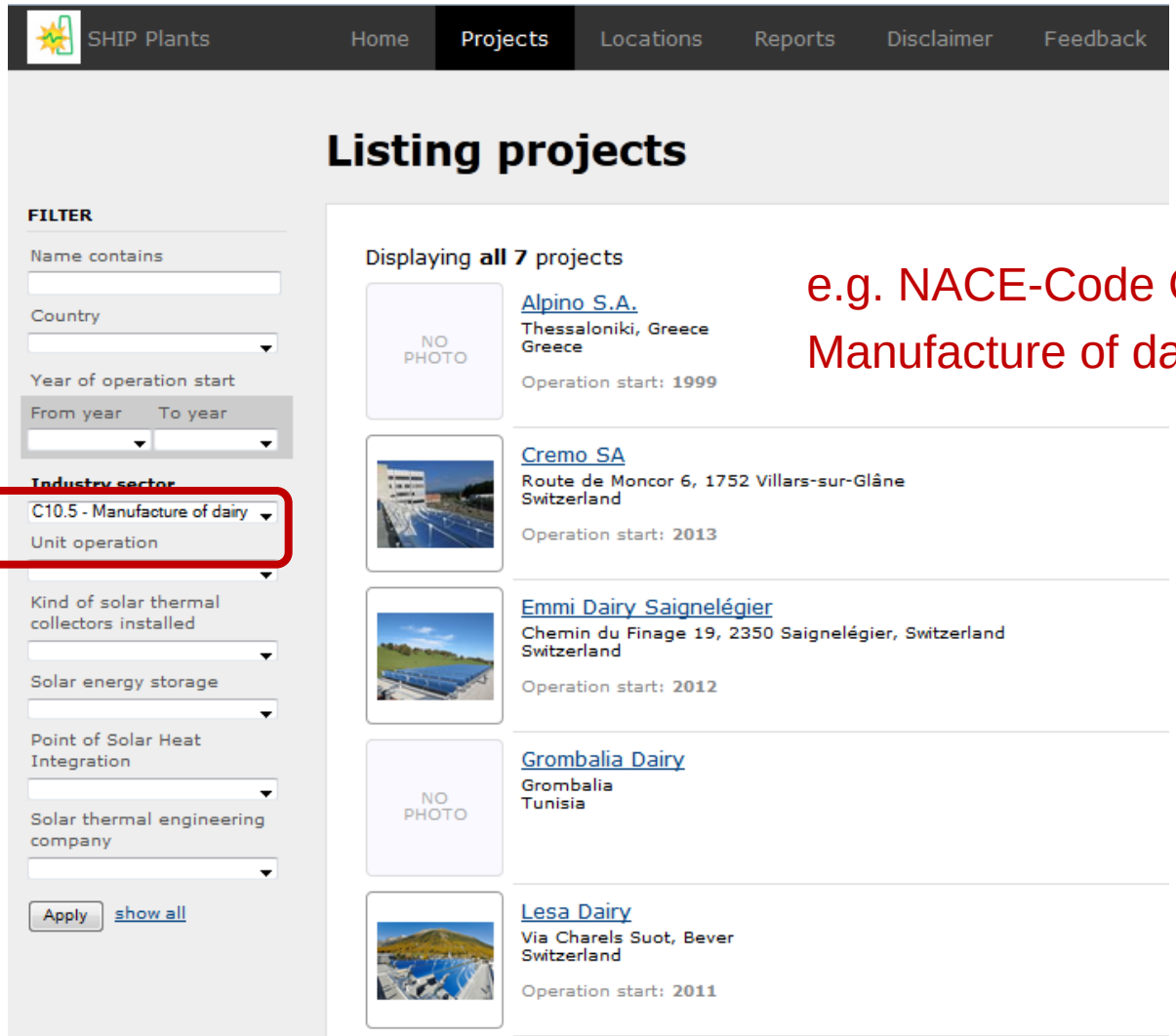
Source: AEE INTEC

Task 49/IV Mid-Term Status

Solar Heat for Industrial Processes – SHIP database online:

- www.ship-plants.info
- based on initial survey from AEE INTEC
- programming of structure and design by PSE
- designed as a living platform to grow continuously
- How to participate *(e.g. to enter your SHIP application)*:
  - Register with your e-mail address
  - Log-In
  - Add new data
    - add new project
    - edit existing project (by clicking on “request responsibility”-button)
    - upload pictures
  - AEE INTEC will perform plausibility check
  - Data will be published
- presently 134 projects presented
  - 15 Parabolic Trough systems in Mexico (6), Switzerland (3), USA (2), Germany (2), Egypt (1), Sweden (1)
  - 4 Linear Fresnel systems in Tunisia (2) Italy (1) India (1)

SHIP Database: Filter functions



e.g. NACE-Code C10.5
Manufacture of dairy products

SHIP Database: Detailed project data

Emmi Dairy Saignelégier

ECONOMIC PARAMETERS

Total investment costs (excl. VAT), €	300,000.00 (Turnkey costs including solar collectors, piping, support construction, storage, design, commissioning reduced with subsidies)
Solar loop (excl. VAT), €	315000.0 (Solar collectors, piping, support construction)
Solar energy storage (excl. VAT), €	0.0
Others (excl. VAT), €	156000.0 (Design, commissioning, others)
Process integration (excl. VAT), €	129000.0
Subsidy, € or % of total investment costs	Approx.. 200k€ from Swiss Federal Office of Energy Approx. 100k€ from Kanton Jura (not exactly disclosed)
Cost for fuel replaced, €/MWh$_{fuel}$	Not exactly known. Cost of fuel approx. 80€/MWh, cost of heat approx. 100€/MWh
Calculated solar thermal system life	20

General
Solar
Process
Eco
Lessons
Source

Task 49/IV ongoing activities

Comparison of performance simulation tools (Co-ordinated by FhG ISE)

- 6 different numerical tools: TRNSYS, TSOL, ColSim, POLYSUN, GREENIUS (Download: **http://freegreenius.dlr.de**), Excel
- 5 test cases:
  - Preheating of make-up water
  - Heating of process baths
  - Return flow temperature lift
  - Process steam generation (via oil HX / DSG)
  - Air drying
- 3 locations: Graz, Seville, Mumbai (METEONORM 8)
- **More Information:** see Simon Dieckmann: *Annual Performance Calculations for CSP Plants under different Feed-In-Tariff Schemes* (Poster C01)

System Integration

- Heiko Schenk: *SolSteam - Innovative Integration Concepts for Solar-Fossil Hybrid Process Steam Generation* (Commercial and Demonstration Projects Session, Friday, 11:10 / Function C)

Task 49/IV ongoing activities: Expert meetings

Most recent expert meeting:

- 5th IEA Task 49/IV meeting: Stellenbosch University, South Africa 23th and 24th of January 2014
- The meeting was attended by 25 participants from following countries: Austria, Germany, Israel, Portugal, Swiss, France, Japan, Tunis and South Africa

Interested to participate?
Contact:
c.brunner@aee.at

Planned next expert meetings:

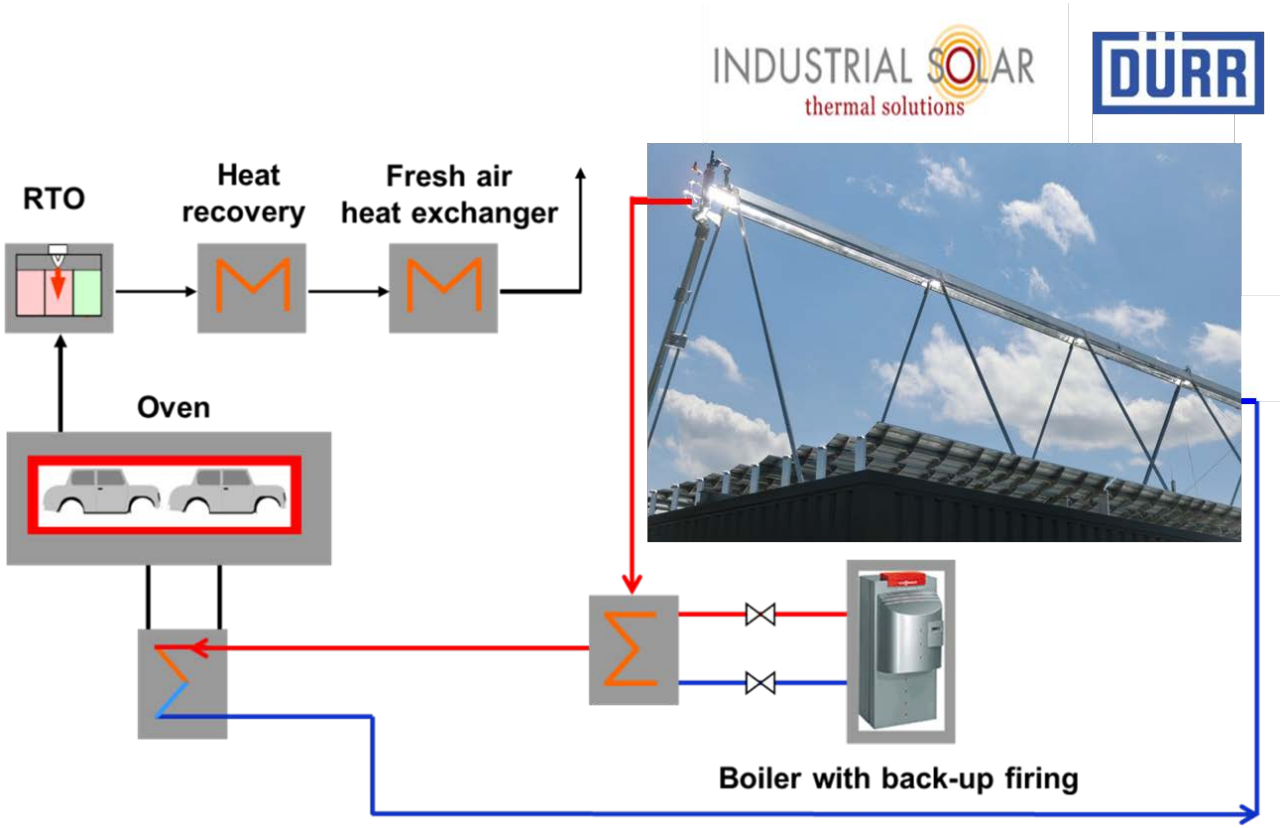
- 6th IEA Task 49/IV meeting: 25th/26th of September 2014, Milano Italy
- Standardization workshop on the 24th of September

- 7th IEA Task 49/IV meeting: 19th/20th of March 2015, Spain (Tecnalia)

DLR

Solar Process Heat for Automobile Industry

Air heating for paint shop

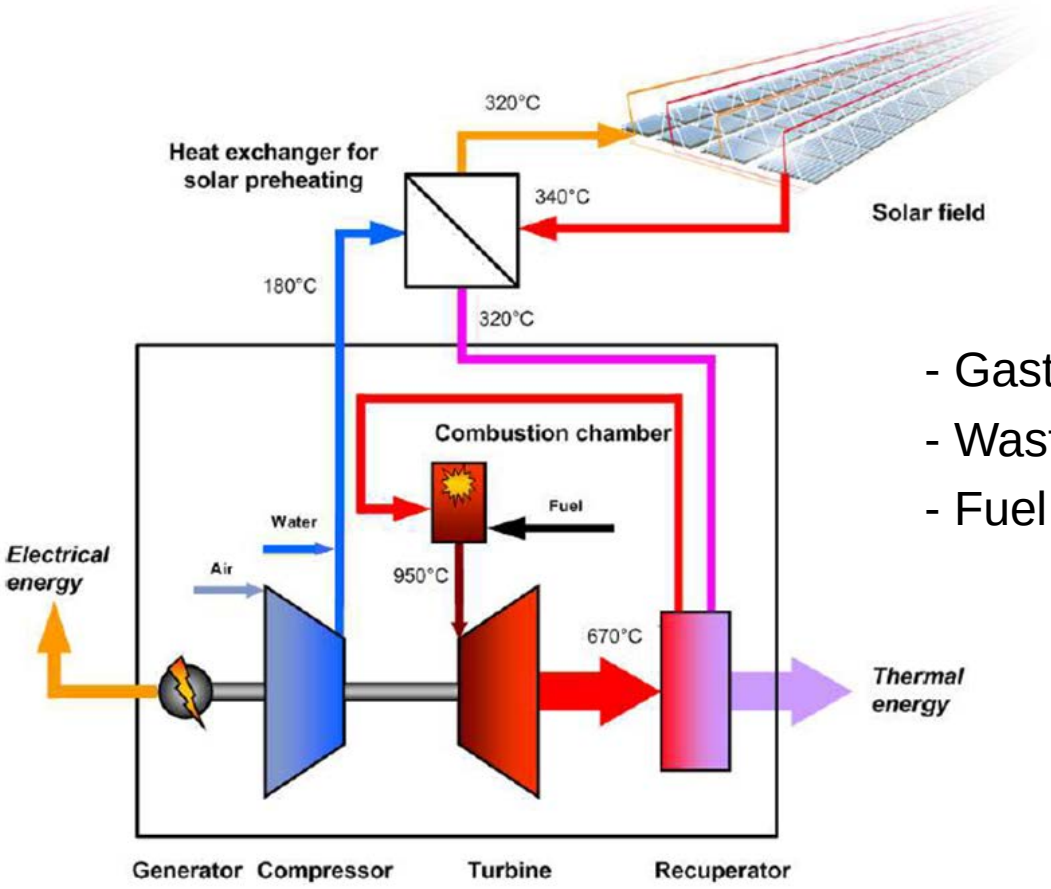


- Pilot plant at DÜRR Technikum near Stuttgart
- 132 m² solar field
- 180º C hot water
- Start-up 2012

Source: Dürr / Industrial Solar

Co-Generation for Automotive Industry

Solar preheating for micro-gasturbine



- Gasturbine 100 – 500 kWe
- Waste heat utilization 200º C
- Fuel saving up to 35% at full load

Source: Dürr / Industrial Solar

Solar-aided cogeneration
for Brazilian sugar cane industry

Background:

- Sugar and alcohol production from sugar cane is an important industry sector in Brazil
- Residual bagasse is used in biomass combined heat and power plants
- About 360 plants providing 6% of installed capacity
- Typical parameters:
  - 30 MW (20 MW own consumption, 10 MW into grid)
  - Live steam 67 bar / ~ 500 °C
- Operation during harvest season April – December

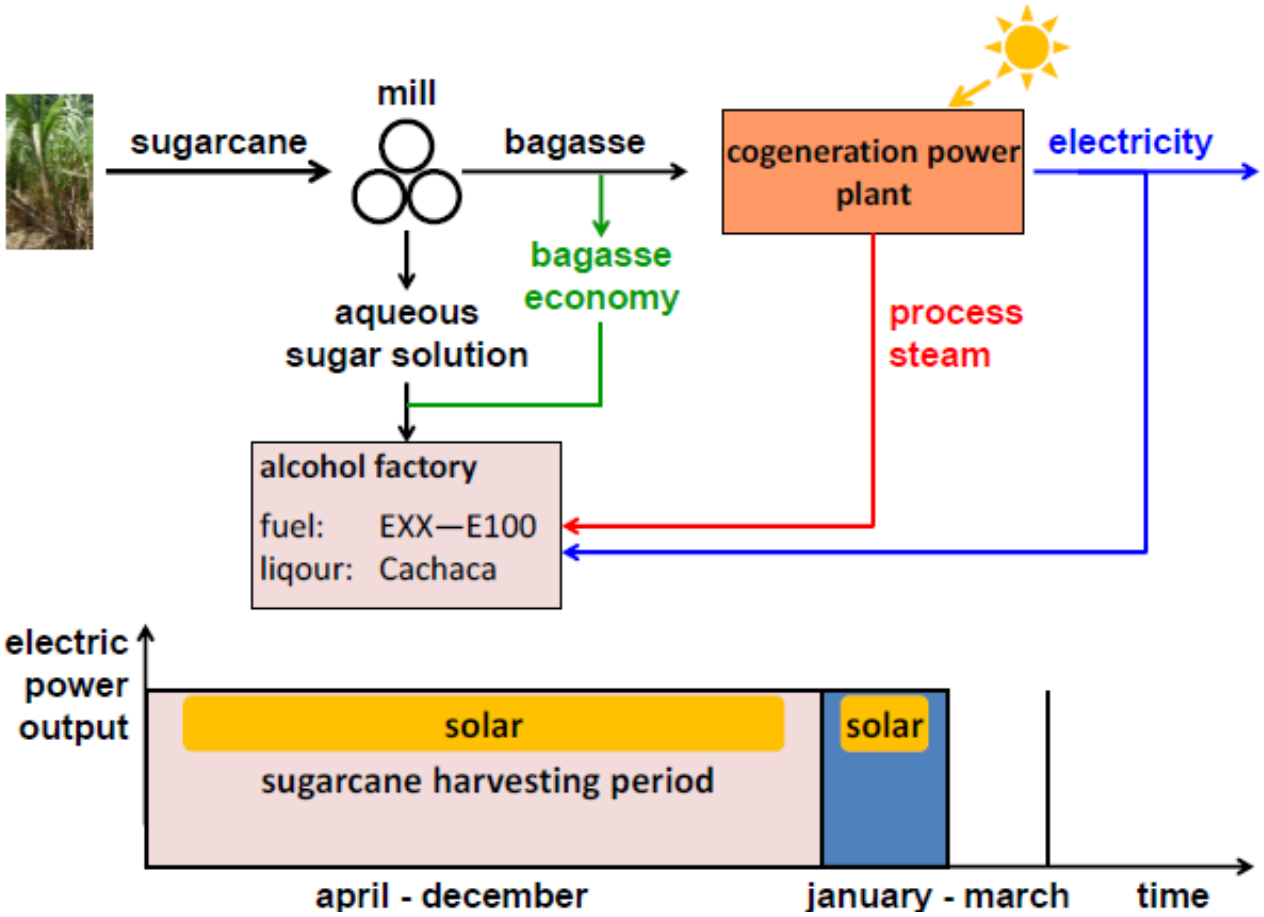
Aim:

- Extend operating time into off-season
- Improve capacity factor

Funded in the framework of
Brazilian-German i-NoPa Cooperation Program Concentrated Solar Power (CSP) by:

Solar-aided cogeneration
for Brazilian sugar cane industry

Concept idea

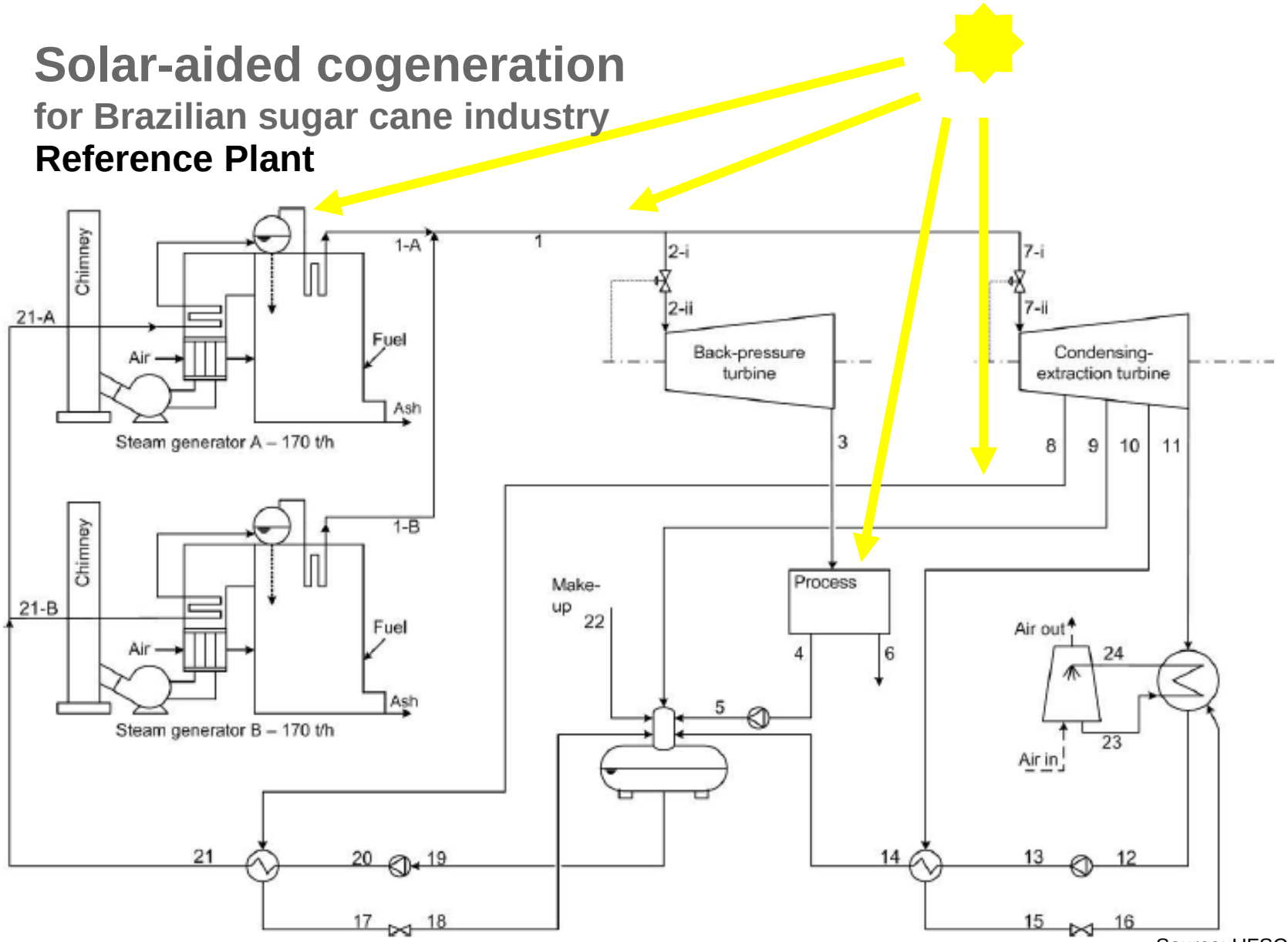


Source: UFSC

Solar-aided cogeneration

for Brazilian sugar cane industry

Reference Plant



Source: UFSC

Solar-aided cogeneration
for Brazilian sugar cane industry

Next Step

- „Research-into-Use“ Workshop

- Florianópolis, Brazil, October 28th 2014

- Presentation of results of present
- Discussion with potential users, equipment suppliers and energy suppliers
- Definition of next steps to application

Interested to participate?

Contact
- Eduardo Burin UFSC: burin@labcet.ufsc.br
- Tobias Vogel UDE: tobias.vogel@uni-due.de

Conclusions

- Solar Process Heat and Co-Generation are increasingly seen as interesting potential markets for concentrating solar technologies

- The joint SHC/SolarPACES Task 49/IV made good progress and provides a good forum for cooperation

- Emerging co-generation concepts aim to create technical and economic synergies with other „green“ technologies

- Contact: klaus.hennecke@dlr.de