
STERG
SOLAR THERMAL ENERGY
RESEARCH GROUP

Solar Process Heat for South Africa: Conditions and Current Research

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AGENDA

- International Examples
- Motivation: SPH for South Africa
- Technology
- SPH Projects at STERG/CRSES
  - International: Soltrain, IEA Task 49, STAGE STE
  - SA-financed: STEP-Bio, Helio 100

International Example

Mining: Codelco, the worlds largest non-tracking ST installation

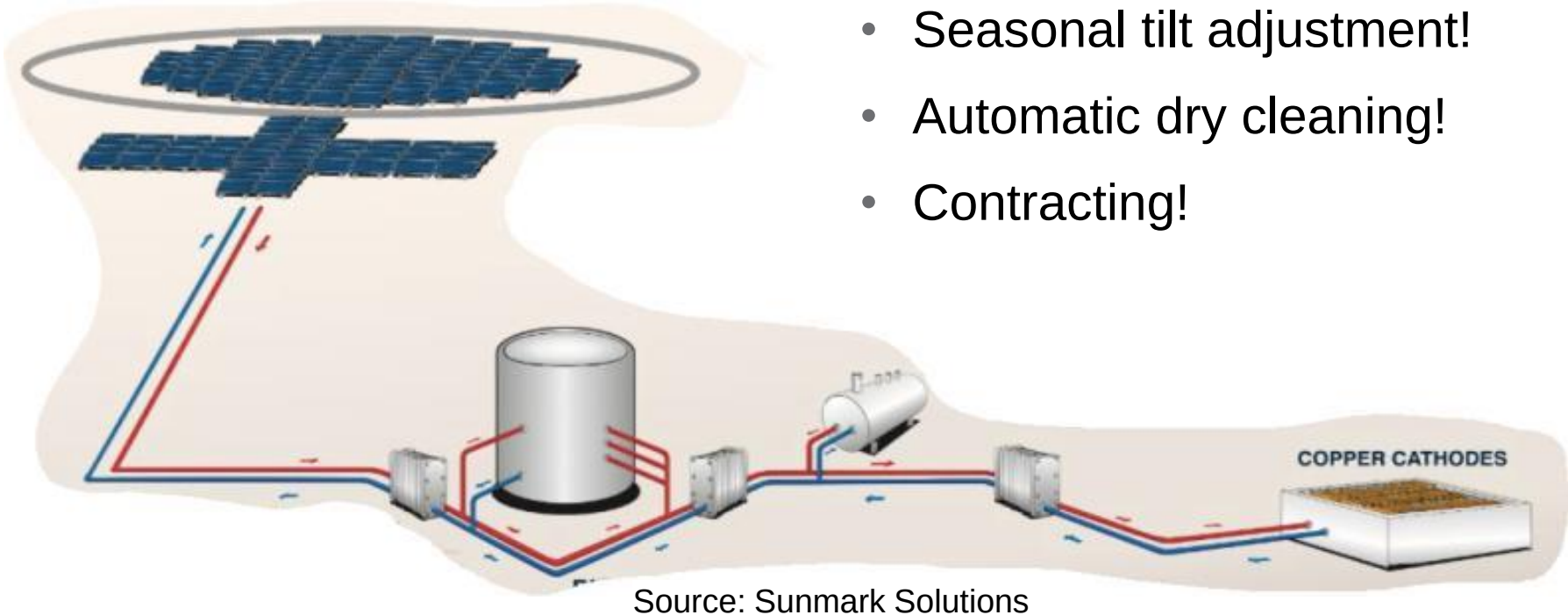
Source: Sunmark Solutions

Flat-plate collector field of 39,300 m² at Codelco's "Minera Gabriela Mistral" in the Atacama Desert, Chile (Source: Sunmark Solutions)

- Electrowinning of copper at 46 to 51 °C
- 39,300 m², 27.5 MW
- 4,000 m³ storage
- 1,272 kWh/m²a
- Saves 20,000 L oil per day, i.e. 250 trucks/year

International Example

Mining: Codelco, the worlds largest ST installation



- Seasonal tilt adjustment!
- Automatic dry cleaning!
- Contracting!

Source: Sunmark Solutions

International Example

Mining: Codelco, the worlds largest ST installation

Source: Sunmark Solutions

Source: Sunmark Solutions

International Example

Coalinga, California, at Chevron

Source: Brightsource Energy

- Largest plant for thermal use in the world (2011 – 2014)
- 194,000 m² reflector area (3,822 heliostats, each consisting of two reflectors with ca. 25.5 m²)
- Enhanced Oil Recovery, 29 MW_{th} steam production

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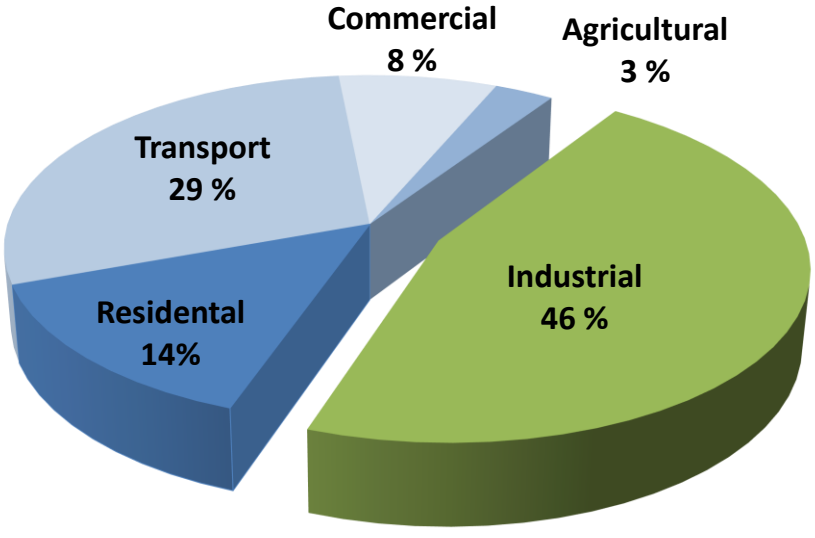
Motivation

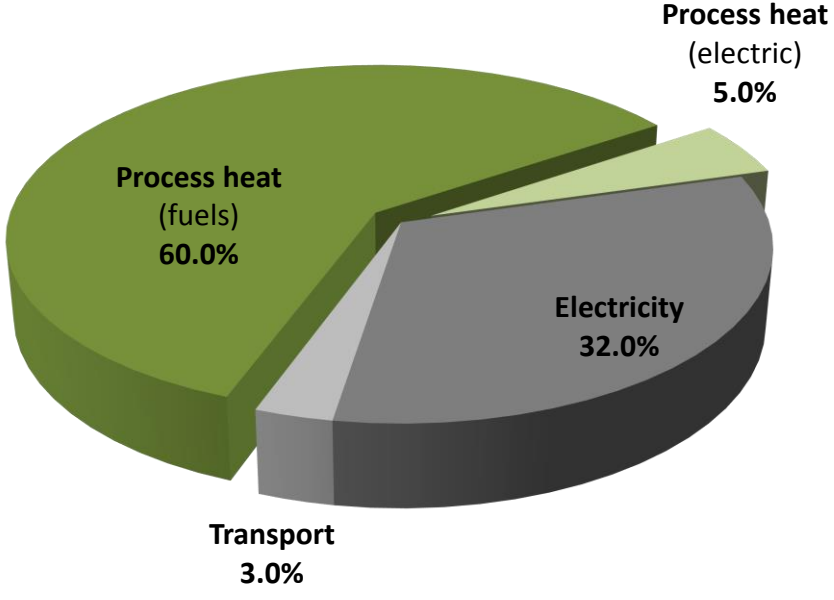
Demand in South Africa

Industrial process heat is 30 % of SA´s final energy consumption !!!



SA energy consumption by sector in 2006

(Based on values of: SATIM 2014, App. A)

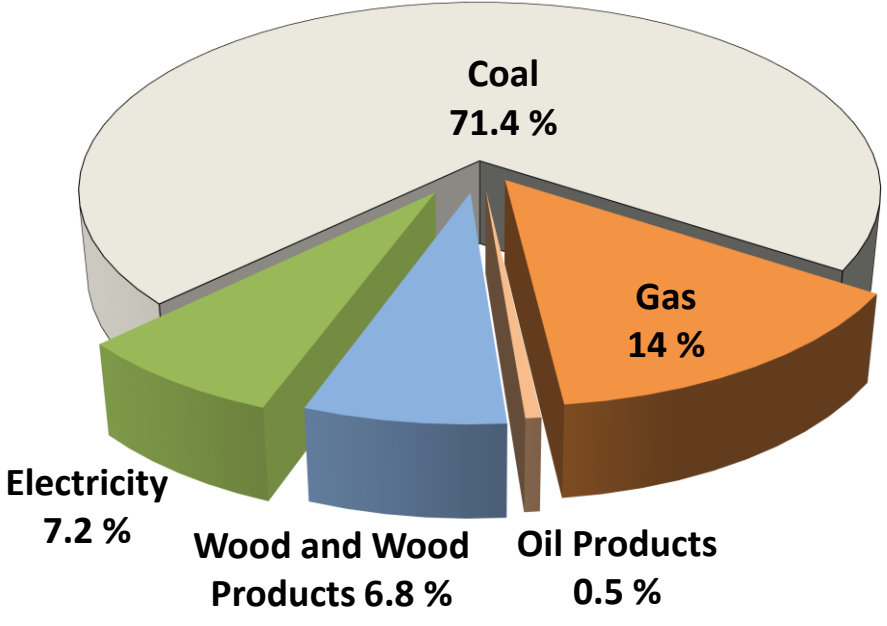


SA industrial final energy consumption in 2006

(Based on values of: SATIM 2014, App. B)

Motivation

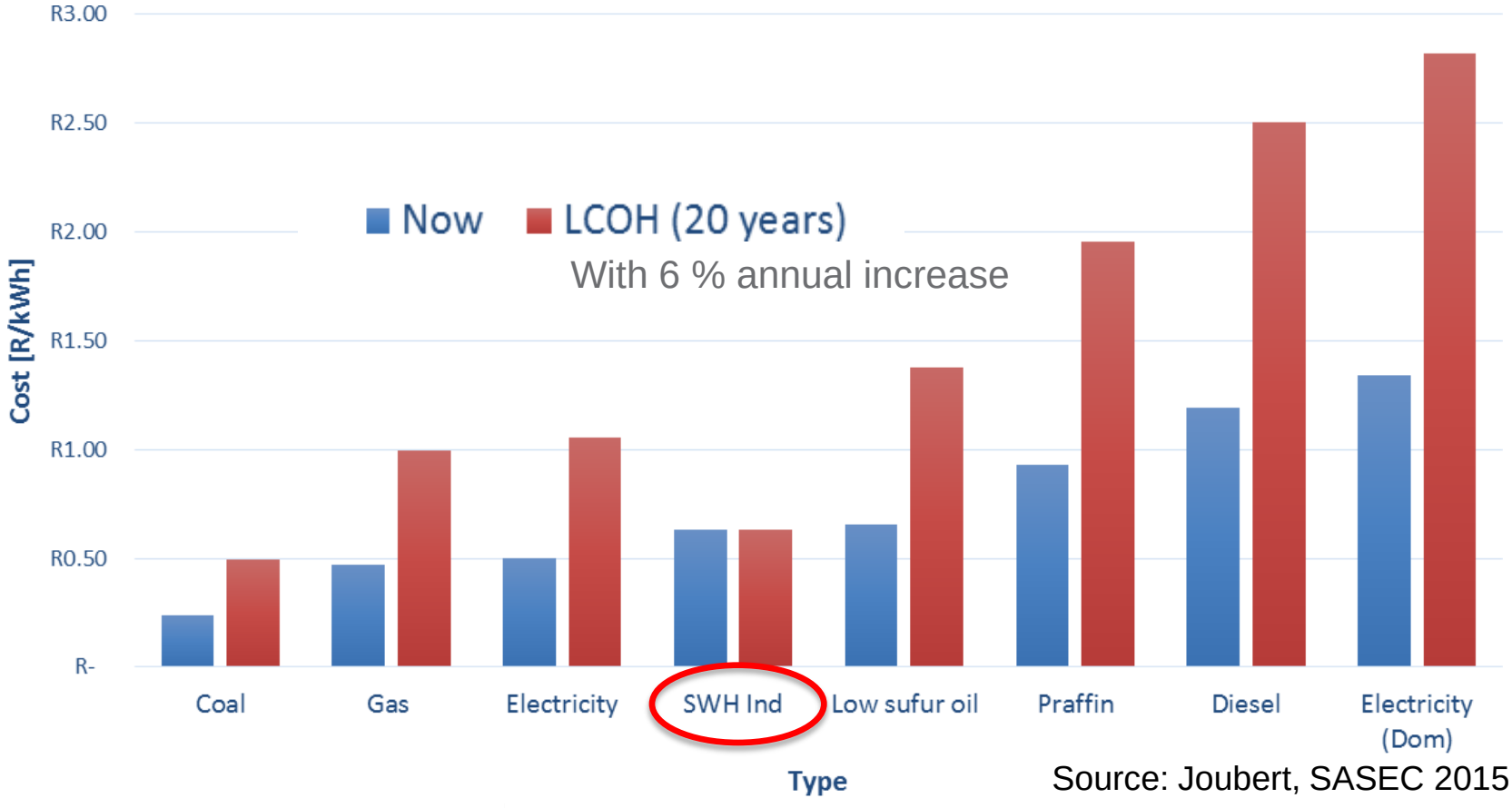
Fuel types used in South African industry



Fuel types used in South African industry in 2006 (based on values of: SATIM 2014, App. A)

Paraffin boiler at Cape Brewing Company (CBC), Spice Route, Paarl

Costs in SA: Future Increase?



Source: Joubert, SASEC 2015

Solar Process Heat

Temperature levels, status, barriers, perspectives

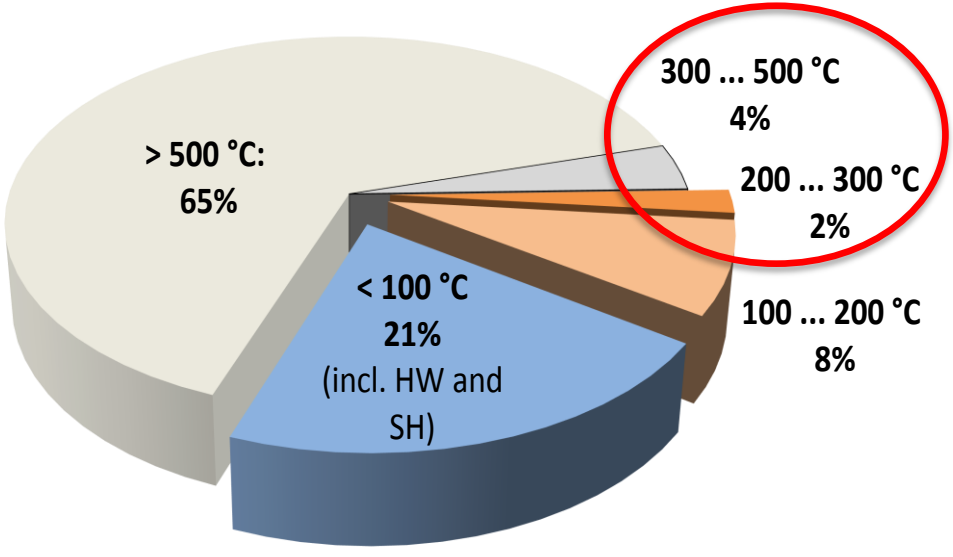
Status:

- Small market, recent growth
- Examples: www.ship-plants.info
  www.blackdotenergy.co.za

Barriers and perspectives:

- Technically complex
- Often amortization > 5 years
- Prices for conventional energy

- By 2030, 2 % of industrial heat demand supplied (IRENA 2015)
- By 2050, 20 % of industrial heat below 120 °C (IEA 2012)



Temperature ranges of Germany´s industrial heat demand (based on Lauterbach et al. 2012)

Solar Process Heat

„Low hanging fruits“ – most economic systems

- **High value conventional fuel** saved
  (most favourably diesel, heating oil, paraffin, liquefied petroleum gas LPG, but also electricity and gas…)
- **Heat demand when sun is shining**
  (at least five days per week)
- Heat recovery technically / economically not feasible
- Potential future changes unlikely to affect SPH installation.
- If stationary collectors: Process return **below 100 °C** (efficiency!)

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Technology

Solar Thermal Collectors

Flat-Plate Collectors

Evacuated Tube Collectors

Stationary Concentrating Collector

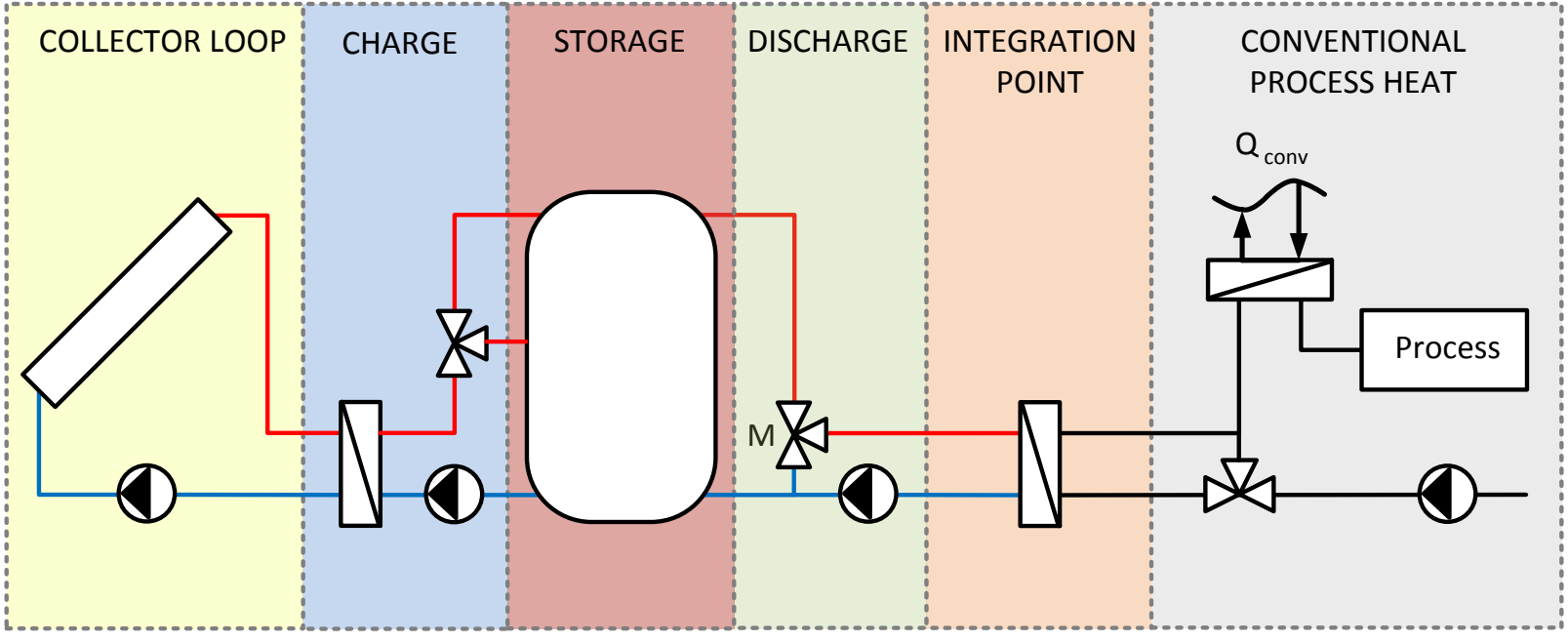
Fresnel Collector

Parabolic Trough Collector

Central Tower Receiver

System Concepts

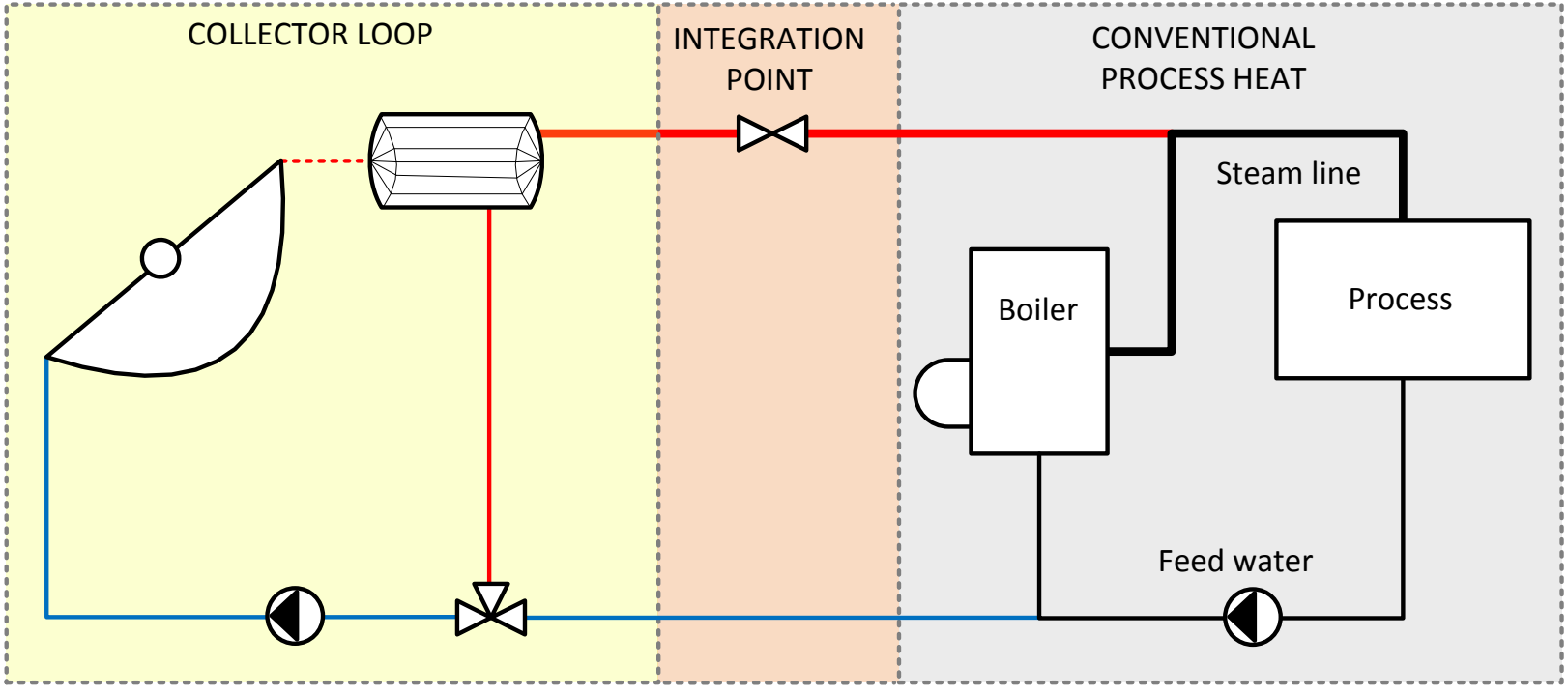
Pre-heating: discharghing by „fresh water station“



Source: Muster et al. 2015

System Concepts

Direct integration in heating network: solar steam



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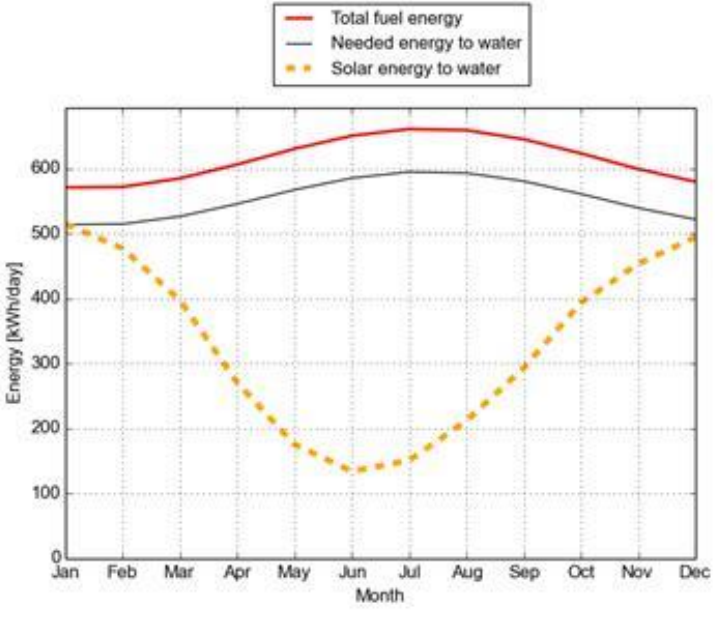
Soltrain: Pilot Plant at CBC Brewery

Planned system at Cape Brewing Company (CBC), Spice Route, Paarl

Soltrain: Pilot Plant at CBC Brewery

Pre-dimensioning – Built this winter by E3!

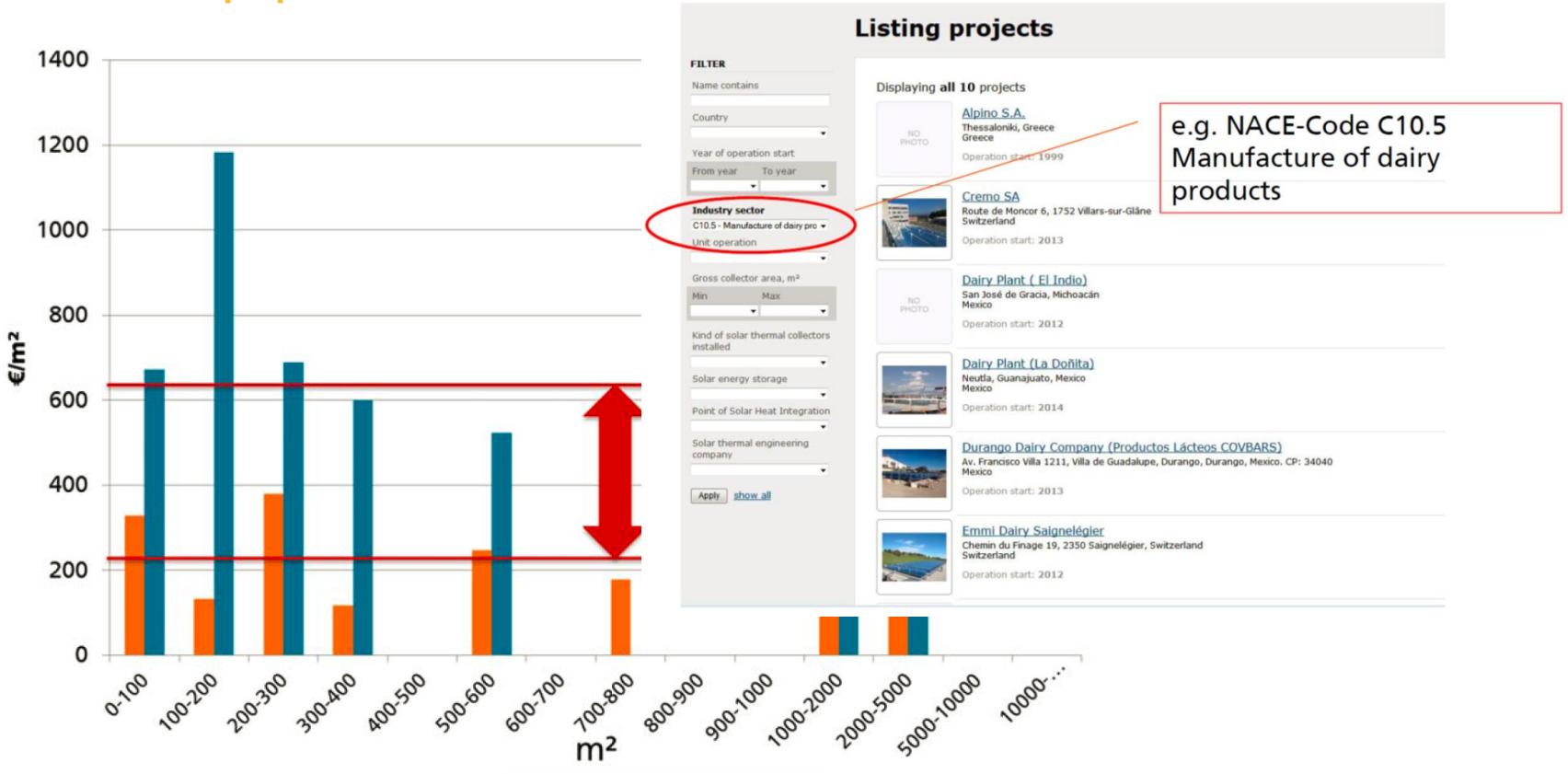
Parameters	System
Solar fraction	60%
Collector aperture area	125 m^2
Storage volume	10 m^2
Temperature lift	15 to 85 °C
Solar energy gained	81.4 MWh/year (650 kWh/m^2year)



Expected annual variation (Source: Joubert, CBC tender)

IEA-Task 49: www.task49.iea-shc.org

www.ship-plants.info



IEA-Task 49: www.task49.iea-shc.org

Integration Guideline, Handbook

- Industrial heat distribution networks
- SPH planning methodology
- Process integration and energy efficiency
- Integration point selection
- Exemplary SPH integration and system concepts

IEA SHC Task 49 Solar Process Heat for Production and Advanced Applications Deliverable B2
SolarPaces Annex IV December 2014

IEA SHC Task 49 SolarPACES Annex IV

Solar Process Heat for Production and Advanced Applications

Integration Guideline

Guideline for solar planners, energy consultants and process engineers giving a general procedure to integrate solar heat into industrial processes by identifying and ranking suitable integration points and solar thermal system concepts.

Deliverable B 2

February 2015

Coordinating author: Bettina Muster

Authors: Ilyes Ben Hassine, Annabell Helmke, Stefan Heß, Pierre Krummenacher, Bettina Muster, Bastian Schmitt, Hans Schnitzer

This Guideline has been developed based on meetings and discussions of several experts. The authors thank all the contributors for their scientific input and the following experts for their reviews (in alphabetical order):

Christoph Brunner, Marco Calderoni, Christoph Lauterbach, Franz Mauthner, Sandrine Pelloux-Payer, David Reay, Detlev Seidler.

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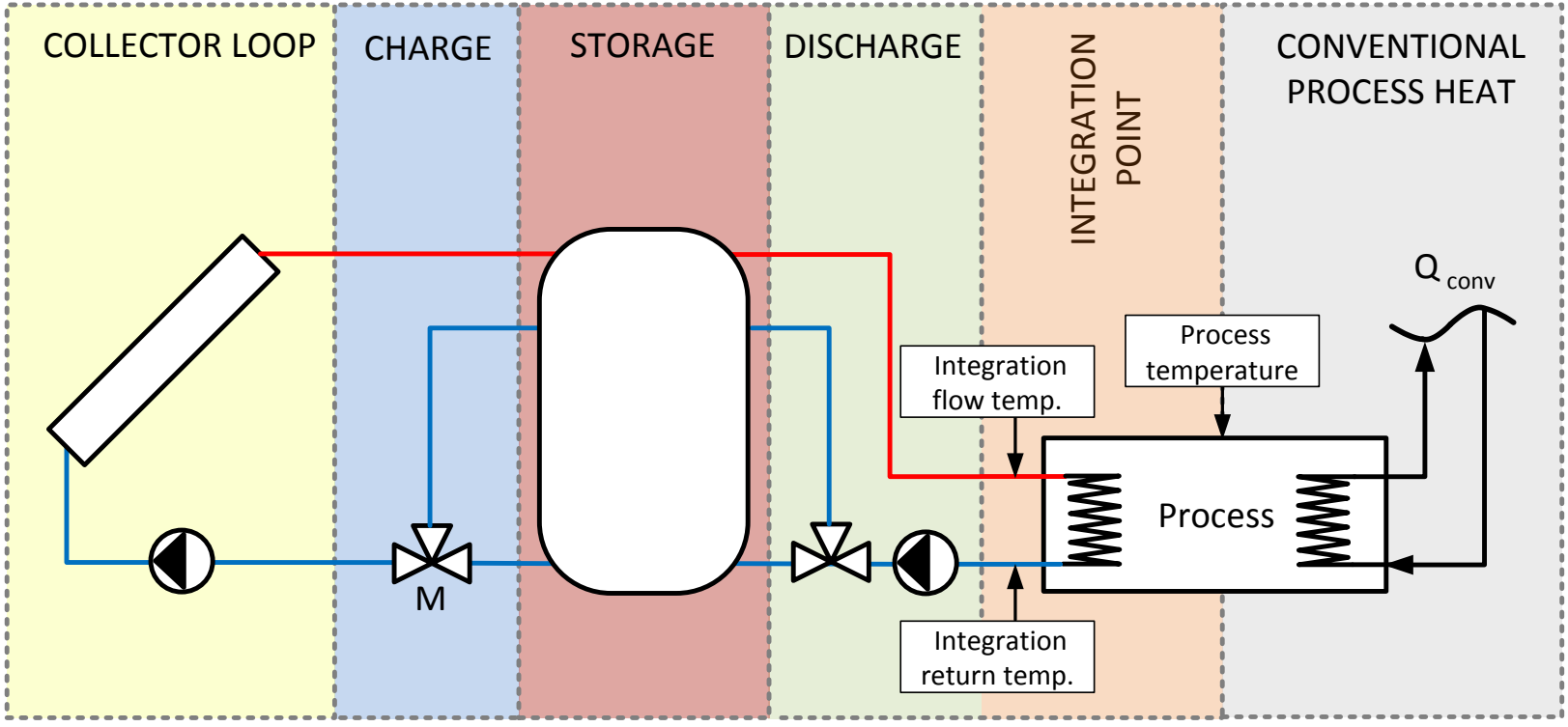
IEA-Task 49: www.task49.iea-shc.org

„MixCharge“: Heating of baths or vessels



Source: Muster et al. 2015

STAGE STE: EU FP 7 Project

Performance tests with FHG ISE and conceptual design

Source: Wilson, 2011

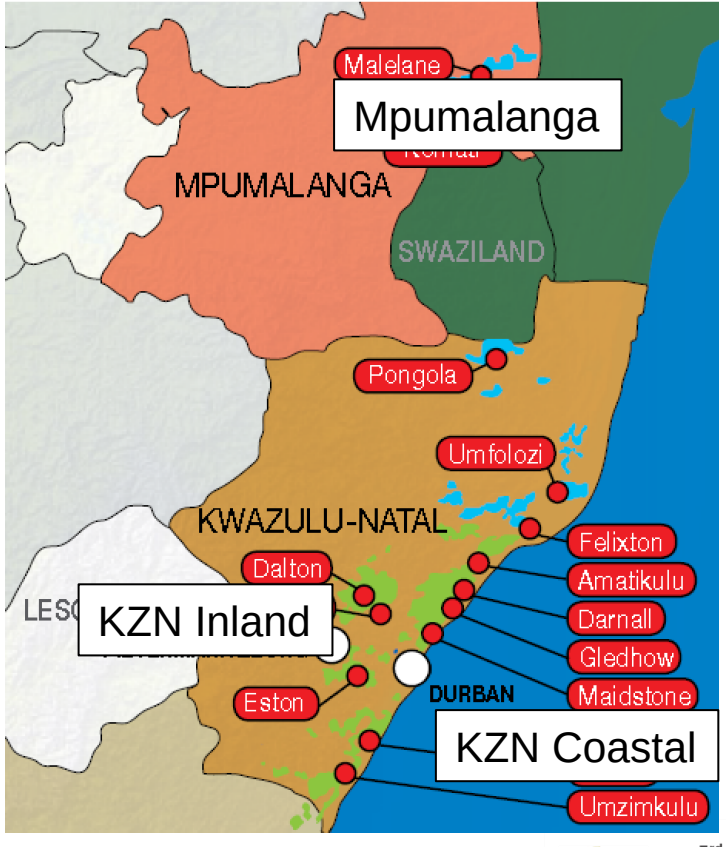
BBE, Johannesburg, Fresnel at testing site of Eskom. Source: R. Wilson, 2011

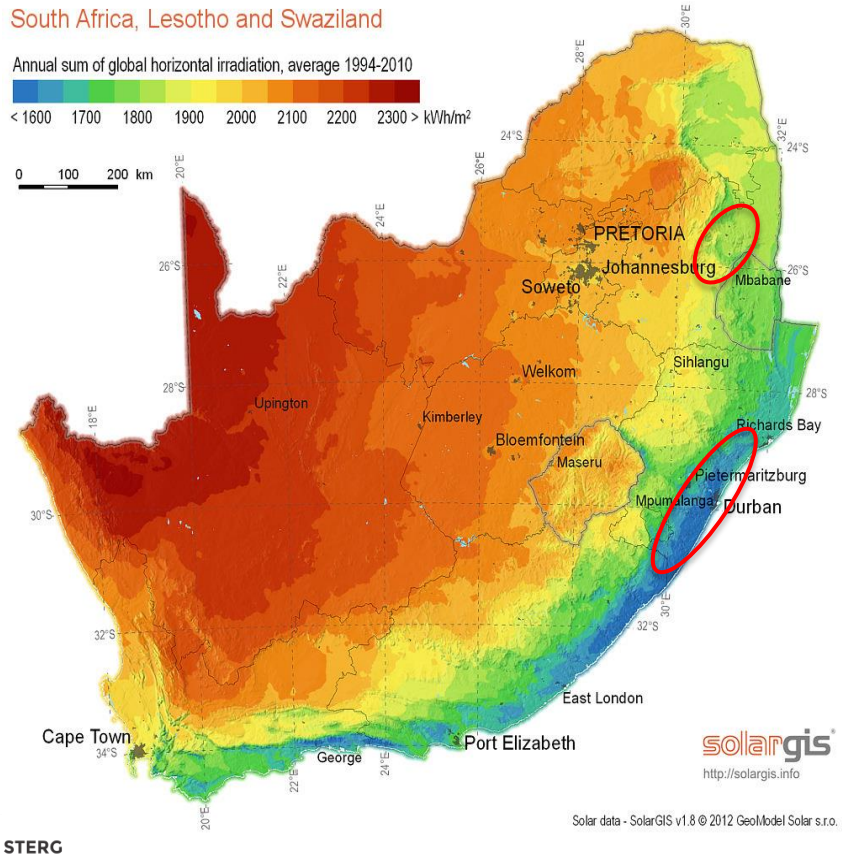
© Industrial Solar

MTN, Johannesburg, SA: Solar cooling with 484 m^2 Fresnel coll., 180°C, 16 bar

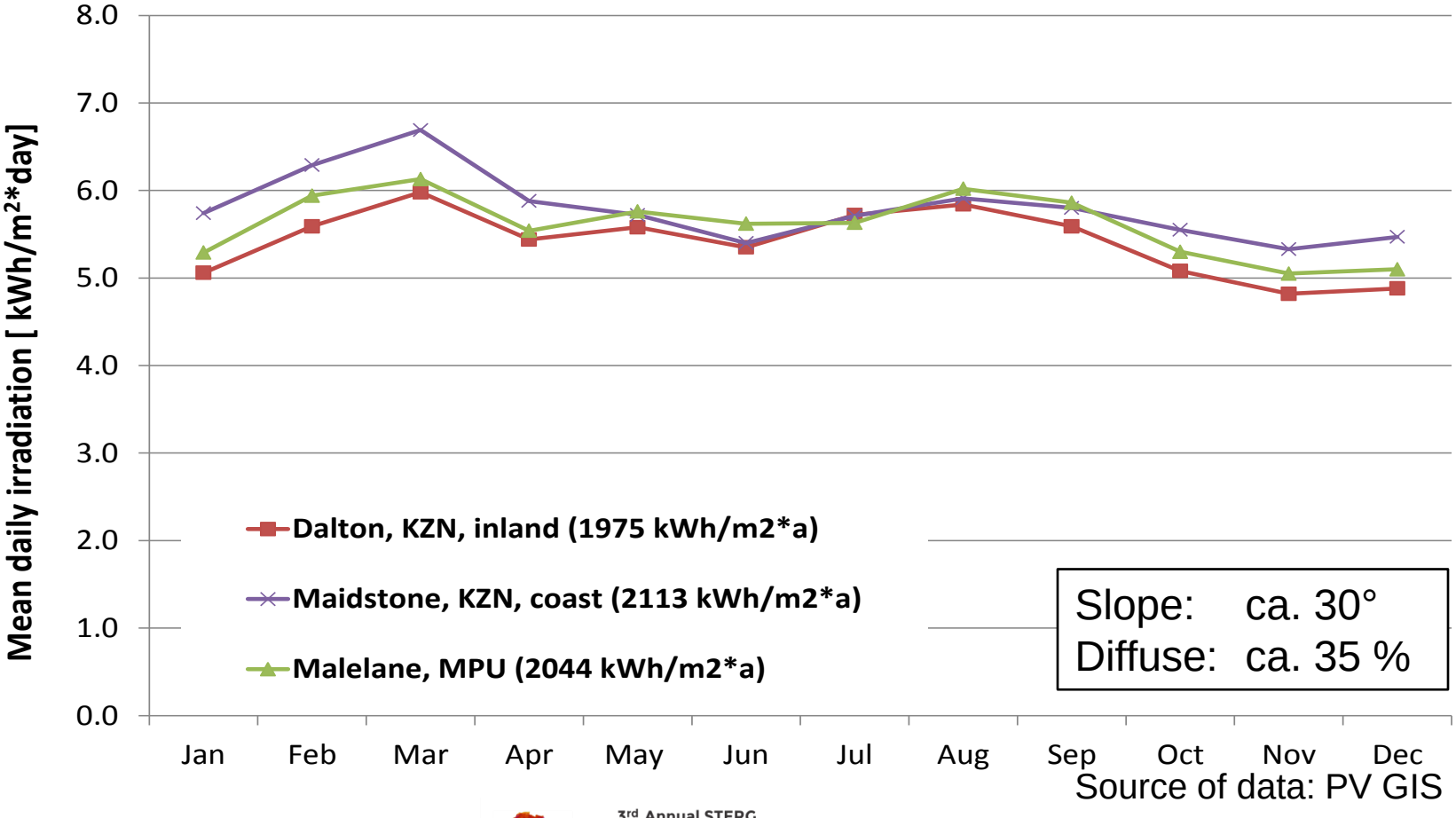
STEP-Bio: SPH for Sugar Mills

Contract Research for SMRI: 1/2015 to 06/2018





STEP-Bio: Global Tilted Irradiance (GTI)



Source of data: PV GIS

HELIO100

Spin-off of Stellenbosch University / STERG

- SA product, low-cost
- Medium to high SPH
- MOU with DLR to set up a pilot project using the particle receiver of DLR (sintered Bauxit particles)

Computer picture of Helio 100 prototype

Source: www.helio100.sun.ac.za

Summary and Next Steps

Summary:

- SPH is prooven technology, potential for SPH in SA expected but further research necessary
- Some realized projects, low-level research
- Dedicated funding and monitoring scheme needed!

Next steps:

- Look into Fish-meal, aquaculture in SA (Dr Neill Goosen)
- Look into Mineral mining (Dr Johann Steyl)
- Set up of SPH system simulations in MATLAB Simulink

Thank you!

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- CRSES
- SMRI, DST

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Blackdotenergy 2015. Commercial installations in SA: http://www.blackdotenergy.co.za

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Hess, S. and Hanby, V. I. (2014). Collector Simulation Model with Dynamic Incidence Angle Modifier for Anisotropic Diffuse Irradiance. Energy Procedia 48(0): 87-96

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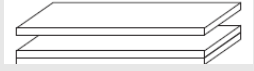
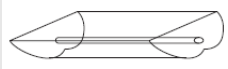
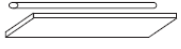
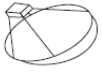
IRENA (International Renewable Energy Agency) 2015. Solar Heat for Industrial Processes. Technology Brief. Available from www.irena.org/Publications [Accessed 1 April 2015].

Lauterbach, C., Schmitt, B., Jordan, U. and Vajen, K. 2012. The potential of solar heat for industrial processes in Germany. Renewable and Sustainable Energy Reviews 16(7): 5121-5130.

Collectors, Storage, System Concepts

What is a process heat collector?

Tracking	Collector type	Symbol	Absorber type	Concentration	Indicative working temperature range (°C)
Stationary (none)	Standard flat plate collector (FPC)		Flat	No	30-90
	Standard evacuated tube collector (ETC)		Tubular	No	50-130
	Improved stationary collectors with and without reflectors		Tubular/Flat	Some yes, some no	80-150
Single axis	Linear Fresnel collector (LFR)		Tubular	Yes	60-400
	Parabolic trough collector (PTC)		Tubular	Yes	100-450
Two axes	Parabolic dish collector (PDC)		Point	Yes	100-500
	Heliostats with central receiver (HCR)		Point	Yes	150-2000

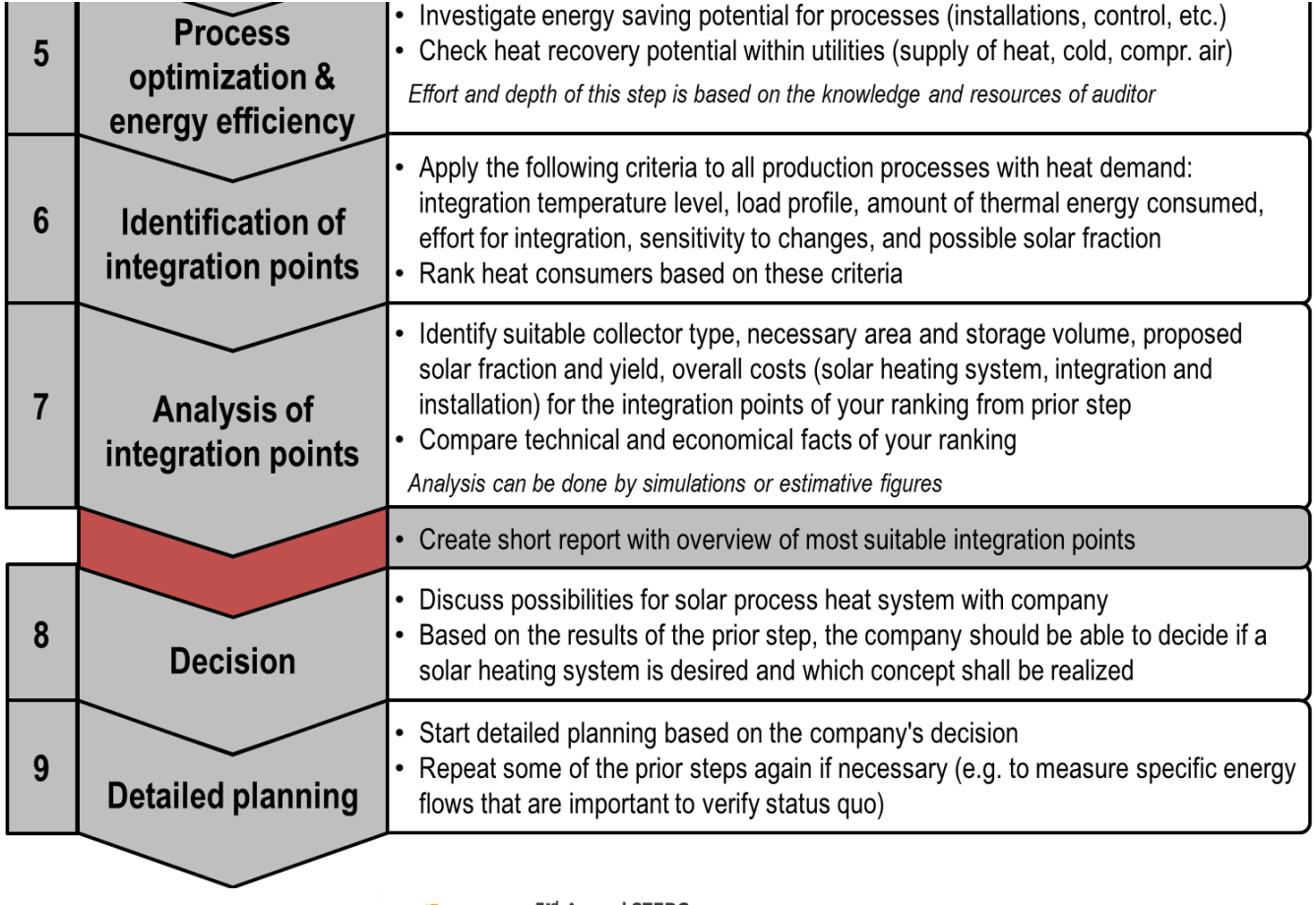
Applications and Consecutive Planning

Assessment methodology for SPH integration

1	Basic data acquisition	• Use simple questionnaire to get most important information before company visit • Questionnaire is applicable for all industry sectors and includes client´s motivation
2	Preparation	• Use solar- or branch specific information to get an overview • Review additional reports of realized projects or case studies • Call company to clarify questionnaire (data, motivation, future strategies)
		• Decide if potential for a solar process heat system is given
3	Company visit	• Get overview of production site, heat consumers, and heat supply system together with responsible technical staff of company • Find out about future plans and strategy of the company • Collect, draw and discuss sketches (production flow, possible integration points, roof area, location for storages, etc.) with technical staff
4	Analysis of status quo	• Crosscheck gathered data with available benchmarks • Draw energy balance and flow sheet of production, try to estimate energy consumption of single production sections or processes *Actual depth of this analysis is based on available data and resources of auditor*

Source: Muster et al. 2015

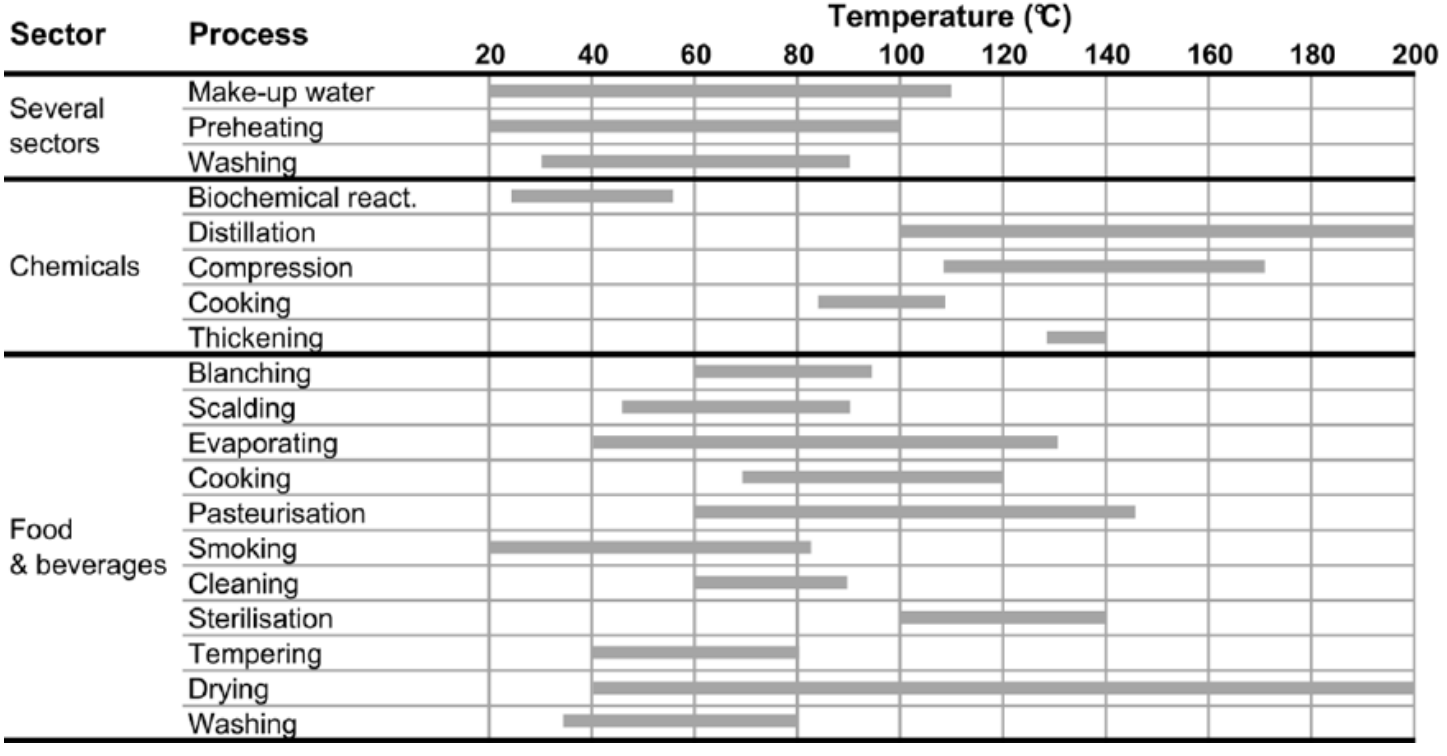
Applications and Consecutive Planning



Source: Muster et al. 2015

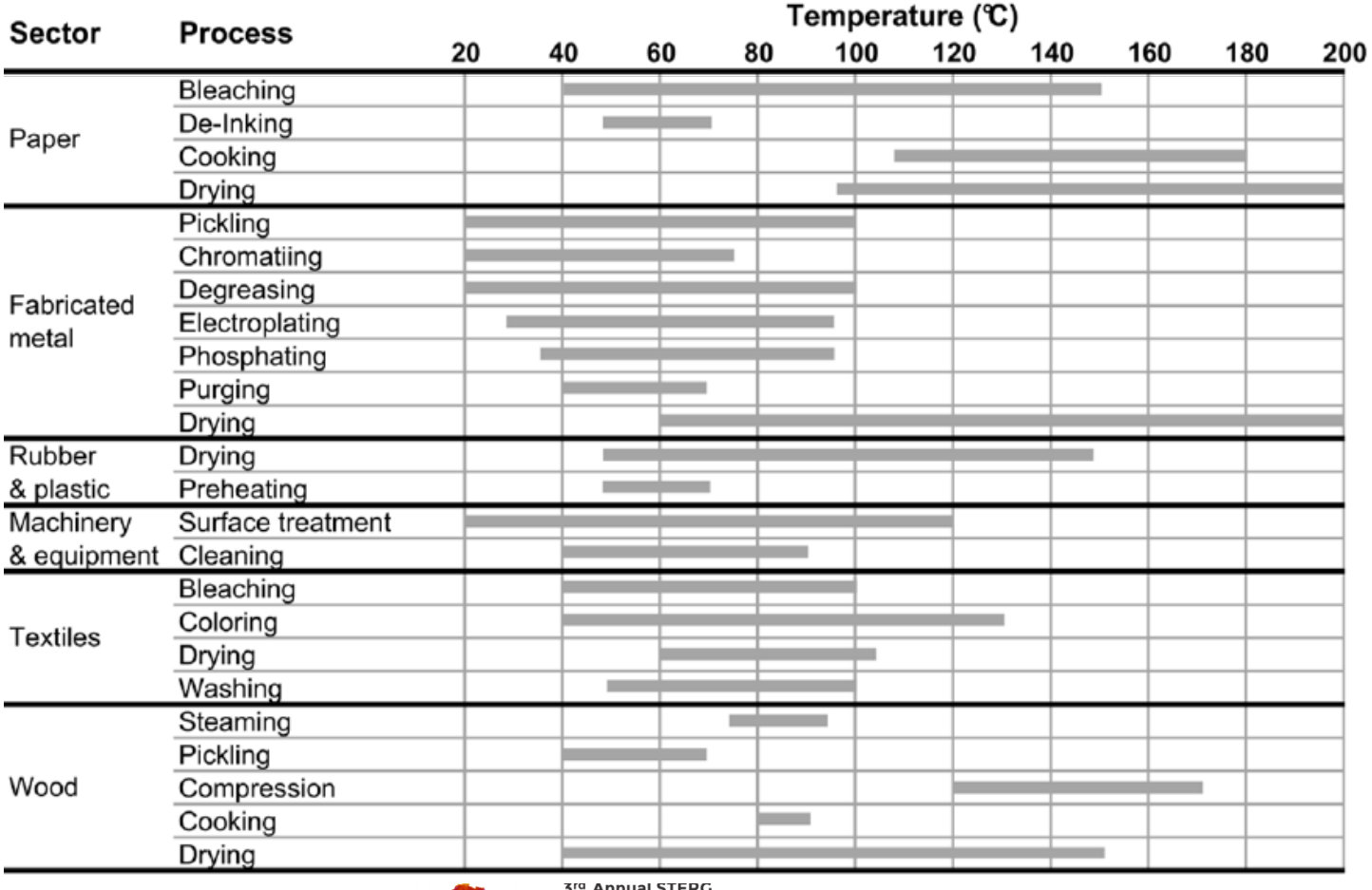
Applications and Consecutive Planning

High variety of promising applications



Source: Lauterbach 2012

Applications and Consecutive Planning



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