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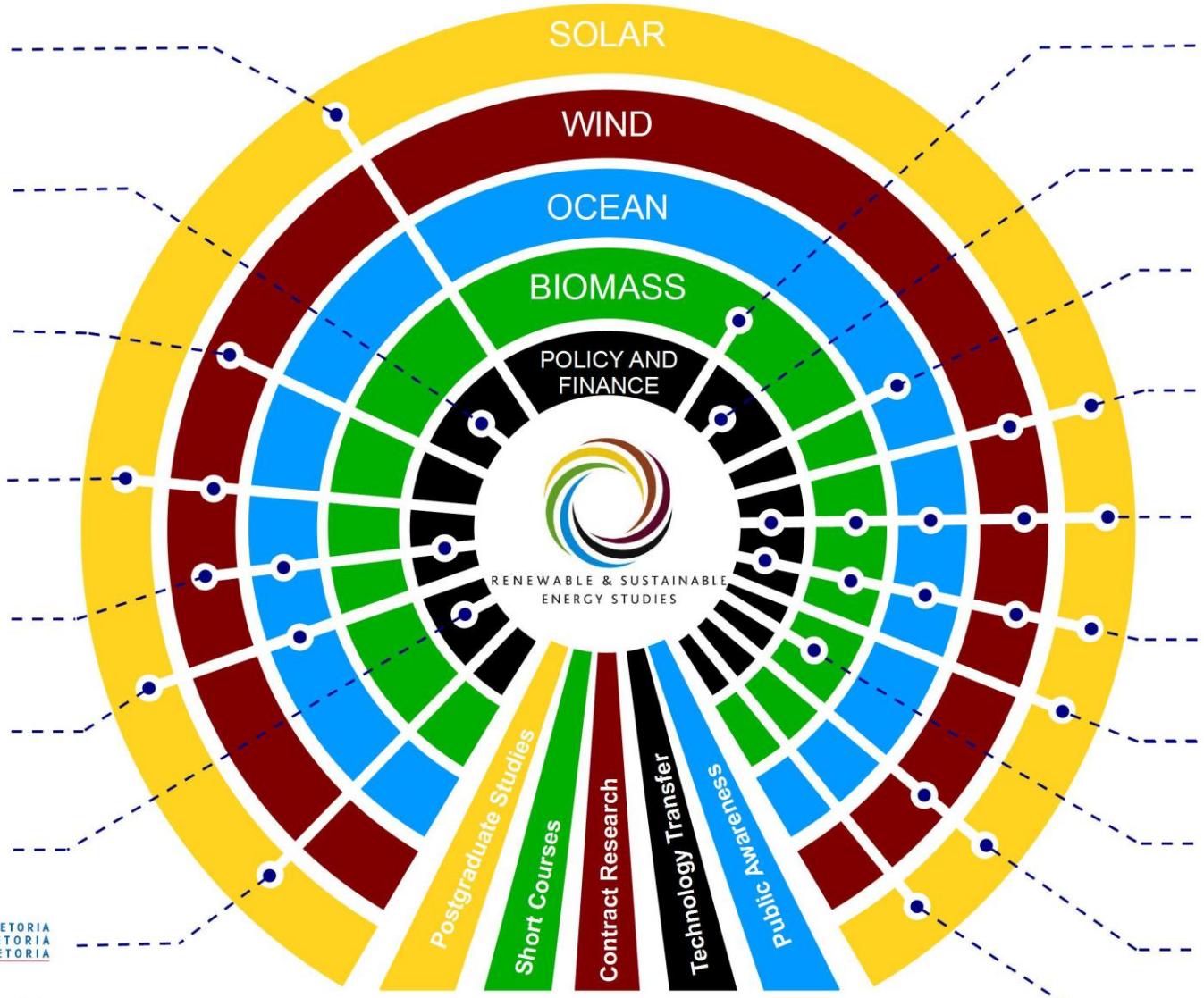
SOLAR HEAT IN INDUSTRIAL PROCESSES

Billy de Lange

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

CRSES ACADEMIC NETWORK



SOLAR THERMAL ENERGY RESEARCH GROUP

SPL

WIND ENERGY RESEARCH

Cape Peninsula University of Technology

University of Cape Town • Universiteit van Kaapstad • iYunivesithi yaseKapa

University of the Witwatersrand, Johannesburg

USB University of Stellenbosch Business School

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

UNIVERSITEIT STELLENBOSCH UNIVERSITY

BIOFUELS RESEARCH CHAIR

SUSTAINABILITY INSTITUTE

OCEAN ENERGY RESEARCH

CSIR our future through science

sanedi South African National Energy Development Institute

FORT HARE Institute of Technology

NORTH-WEST UNIVERSITY
YUNIBESITI YA BOKONE-BOPHIRIMA
NOORDWES-UNIVERSITEIT

Nelson Mandela Metropolitan University for tomorrow

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Eskom

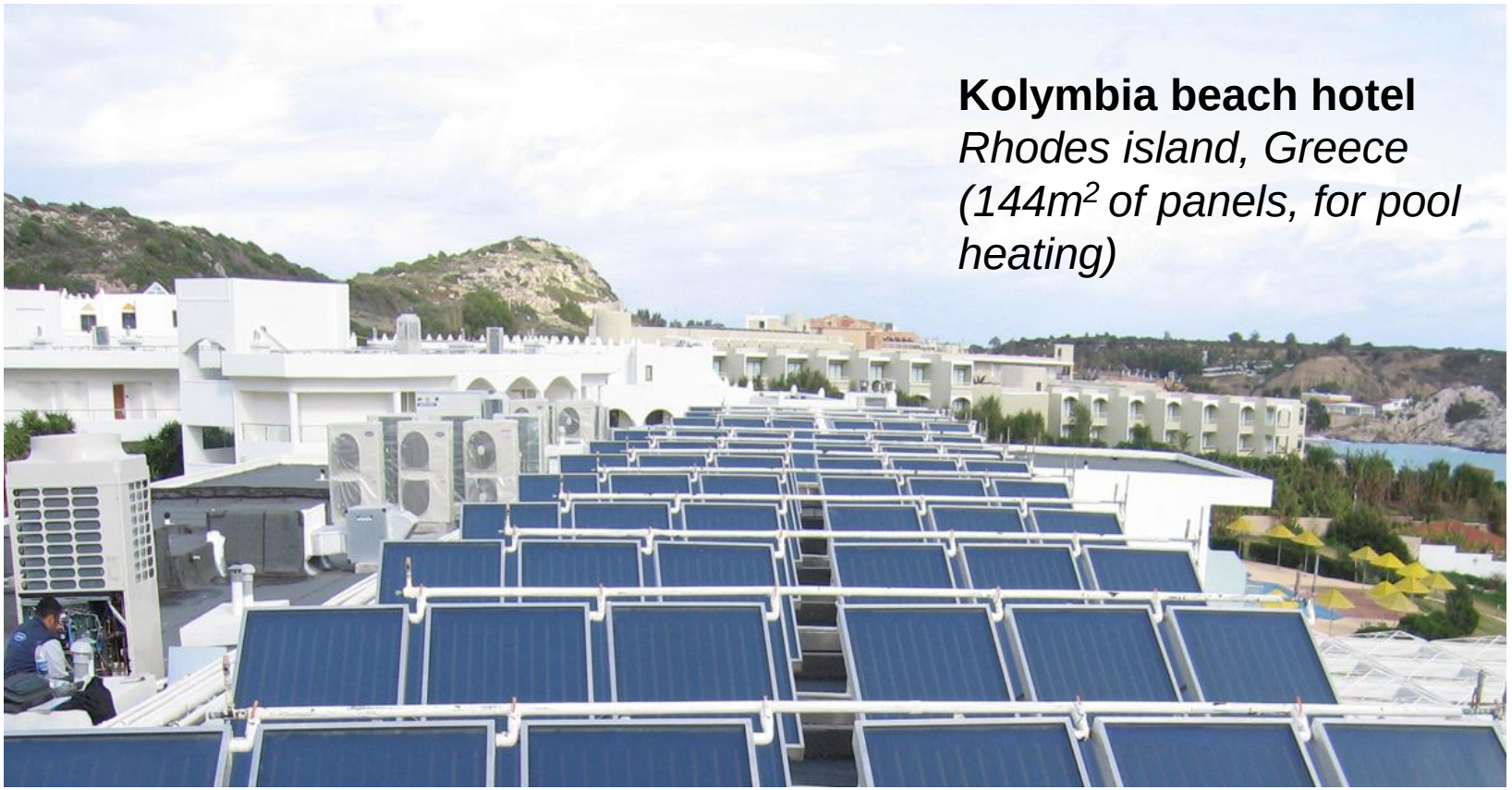
sasol reaching new frontiers

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

What if you need more hot water?

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Large scale solar thermal systems



Kolymbia beach hotel
Rhodes island, Greece (144m^2 of panels, for pool heating)

- What happens if an entire hotel needs hot water? It becomes inefficient to have many small SWH's. It's better to have one big integrated system.

Large scale solar thermal systems

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Large scale solar thermal systems

Solar thermal for district heating

Large scale solar thermal systems

Currently world's largest system is at Princess Noura Bint Abdul Rahman University near Riyadh in Saudi Arabia:

- 36,305m^2 of flat-plate collectors
- 25MW$_{thermal}$

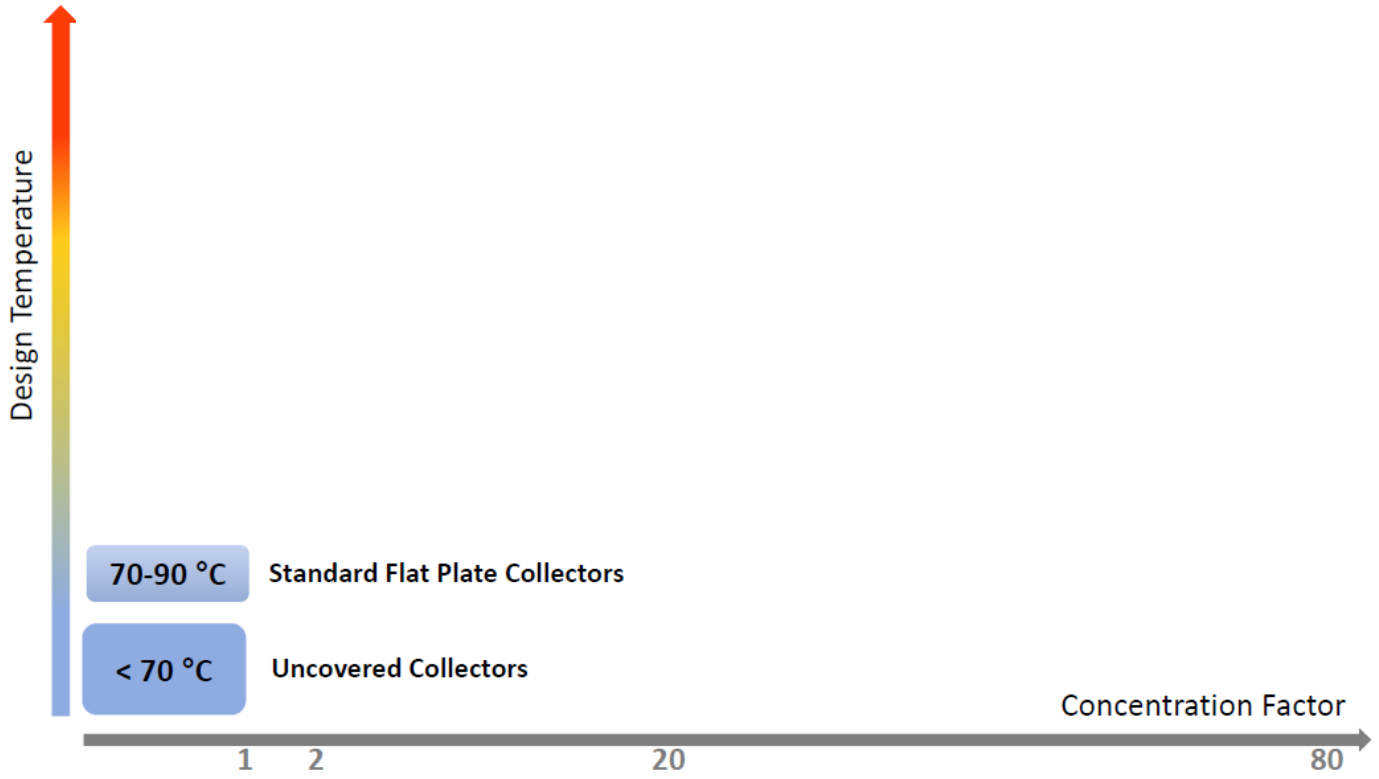
Size is not the issue

Different collector operating temperatures

HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL
FHO Fachhochschule Ostschweiz

SPF INSTITUT FÜR SOLARTECHNIK

Collectors and Operating Temperatures



Most common collectors

Flat-plate

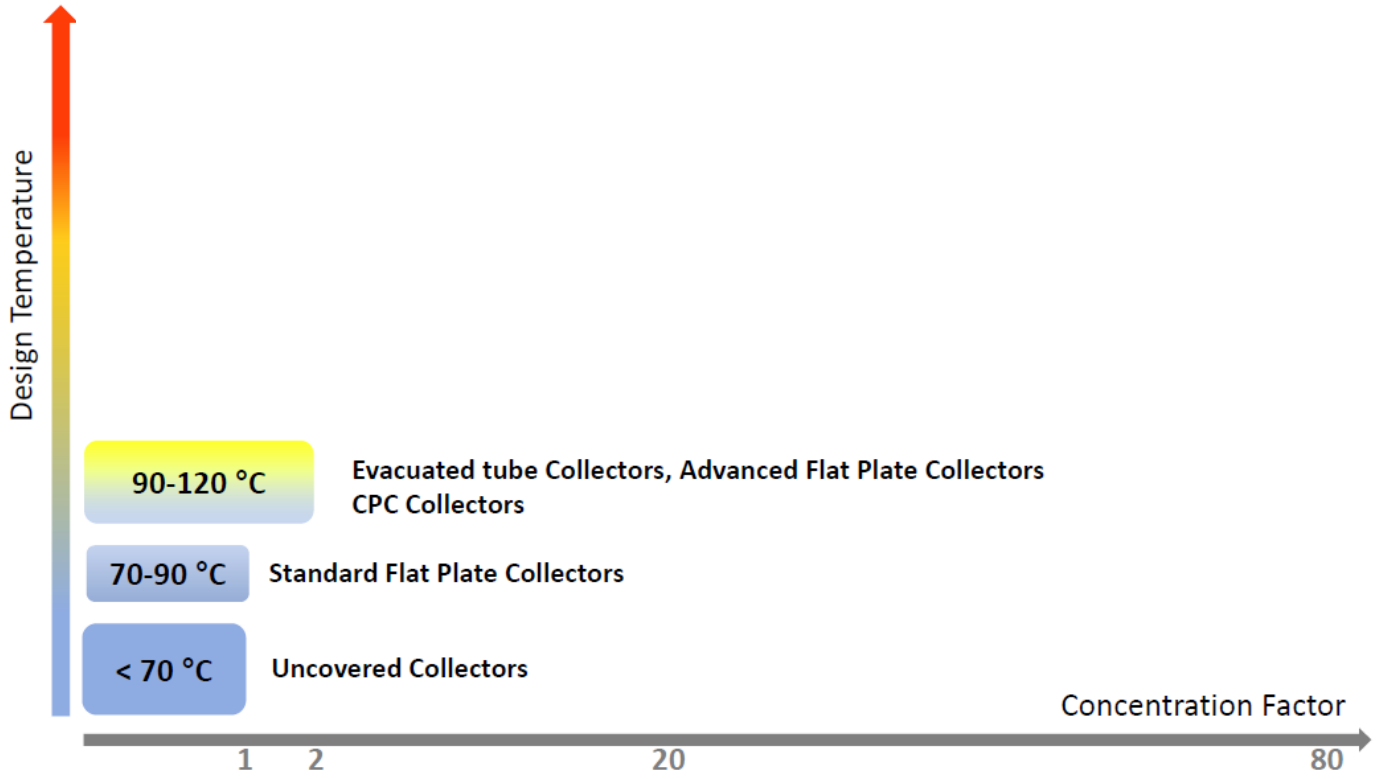
Evacuated tube

Different collector operating temperatures

HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL
FHO Fachhochschule Ostschweiz

SPF INSTITUT FÜR SOLARTECHNIK

Collectors and Operating Temperatures



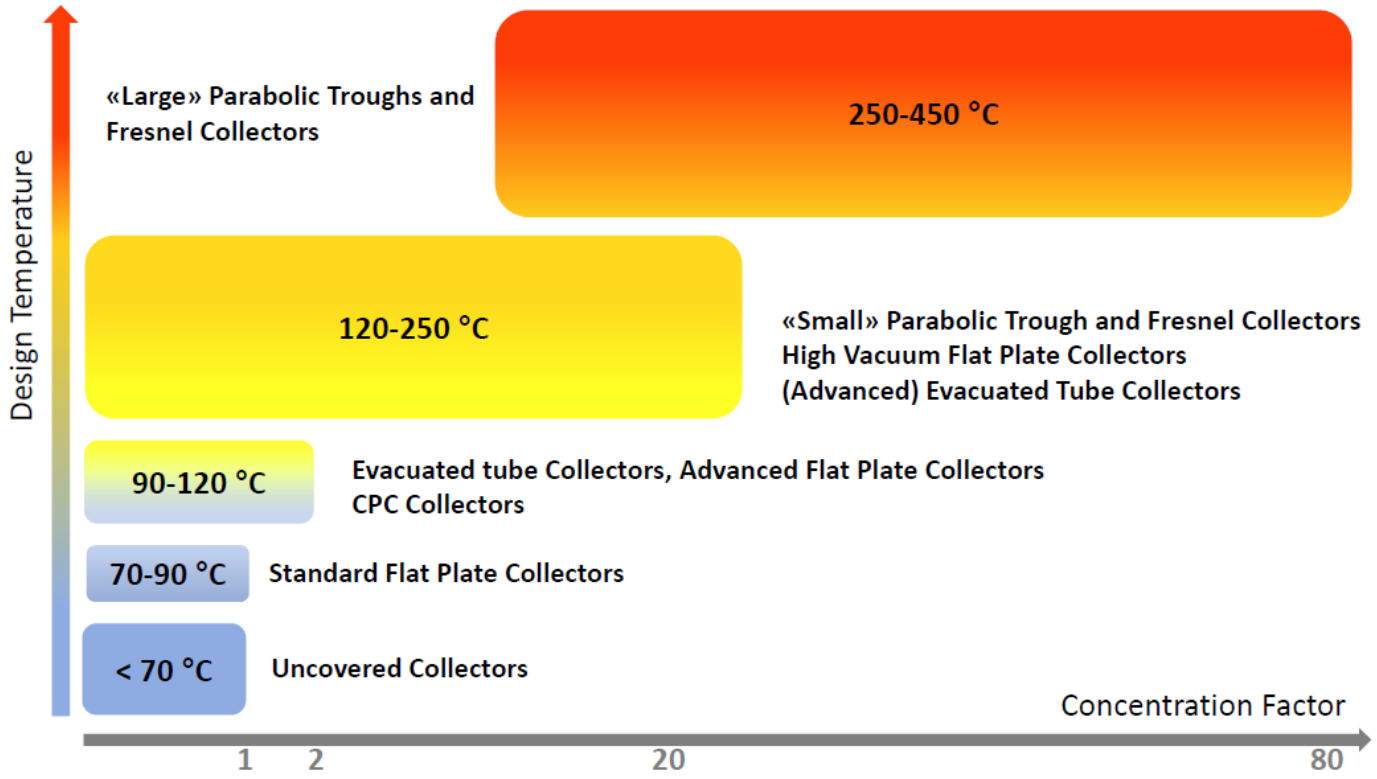
Compound Parabolic Collector (CPC)

Different collector operating temperatures

HSR HOCHSCHULE FÜR TECHNIK RAPPERSWIL
FHO Fachhochschule Ostschweiz

SPF INSTITUT FÜR SOLARTECHNIK

Collectors and Operating Temperatures



Collectors

Parabolic trough

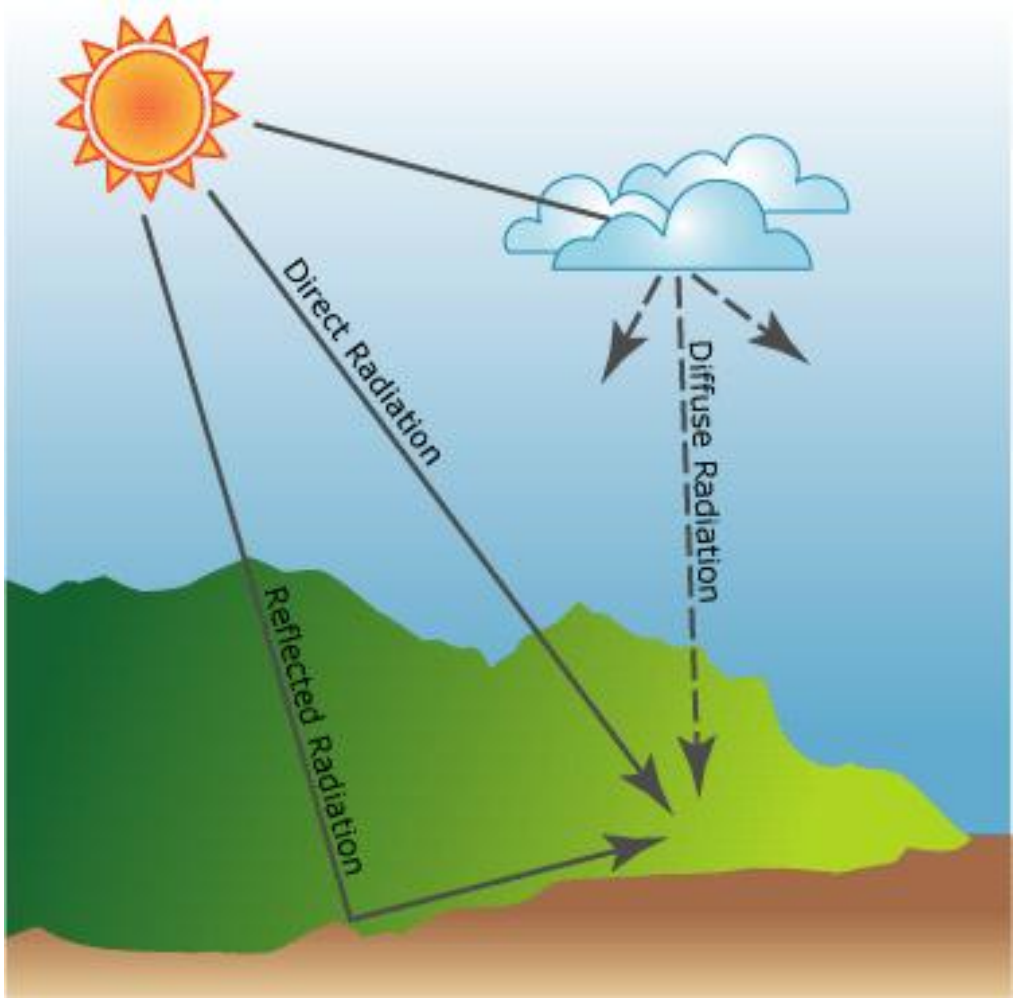
Linear Fresnel

- Temperatures from 60˚C up to 400˚C, some claim even higher
- Only makes use of direct component of solar energy
  - Therefore requires tracking

BBE Linear Fresnel at ERIC

RENEWABLE & SUSTAINABLE ENERGY STUDIES

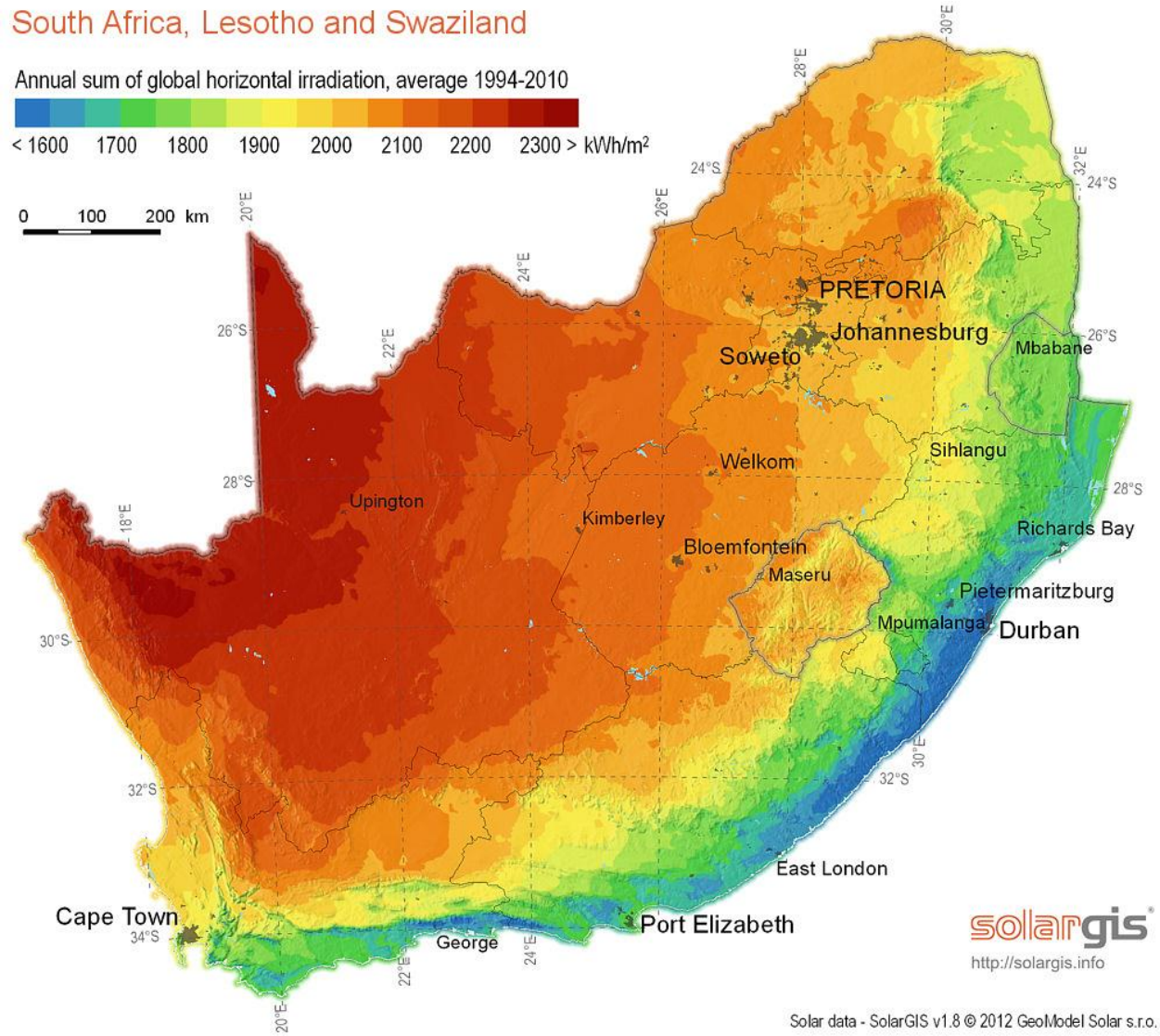
GHI and DNI



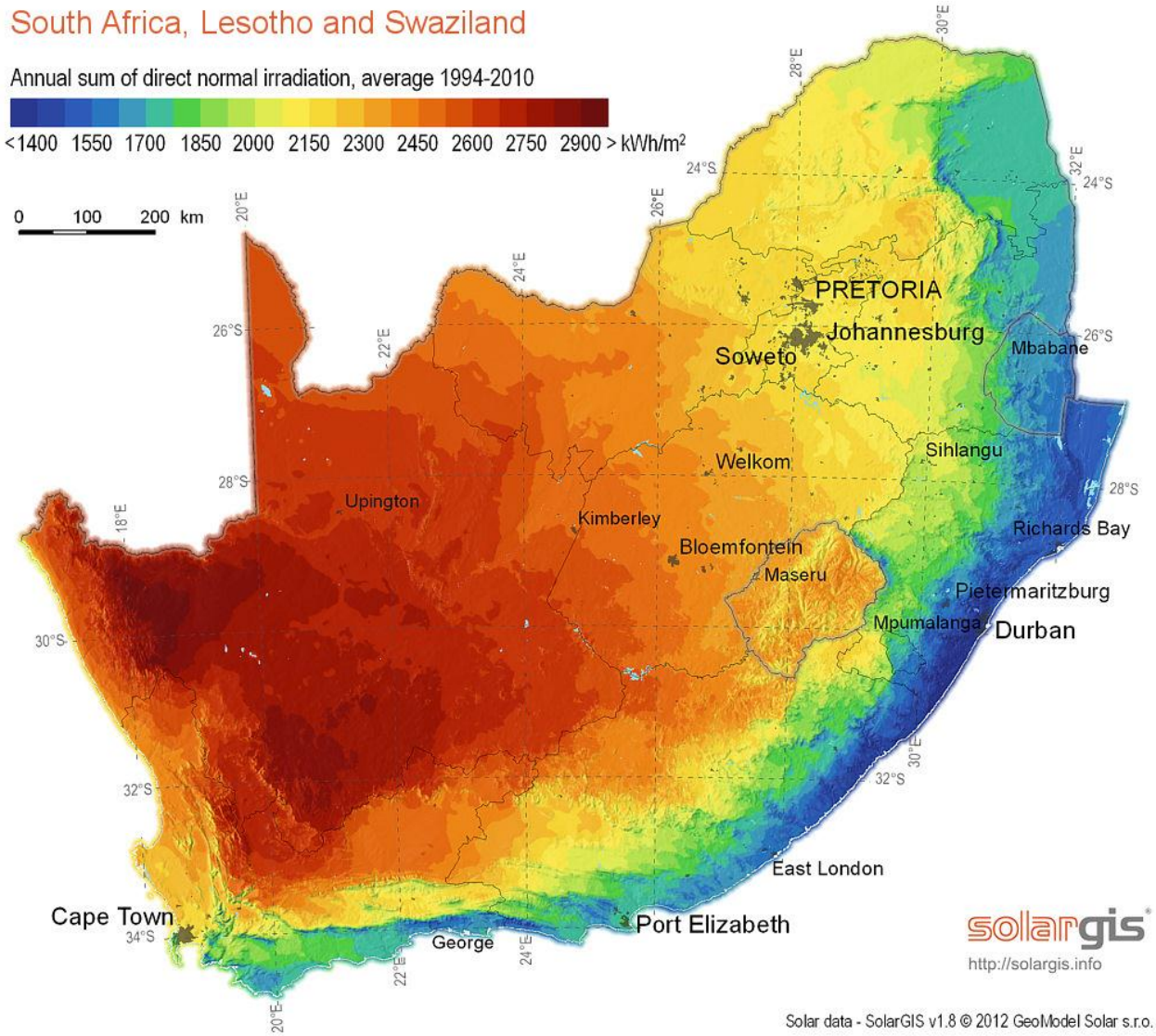
	diffuse
+	direct
=	global

GHI and DNI

RENEWABLE & SUSTAINABLE ENERGY STUDIES



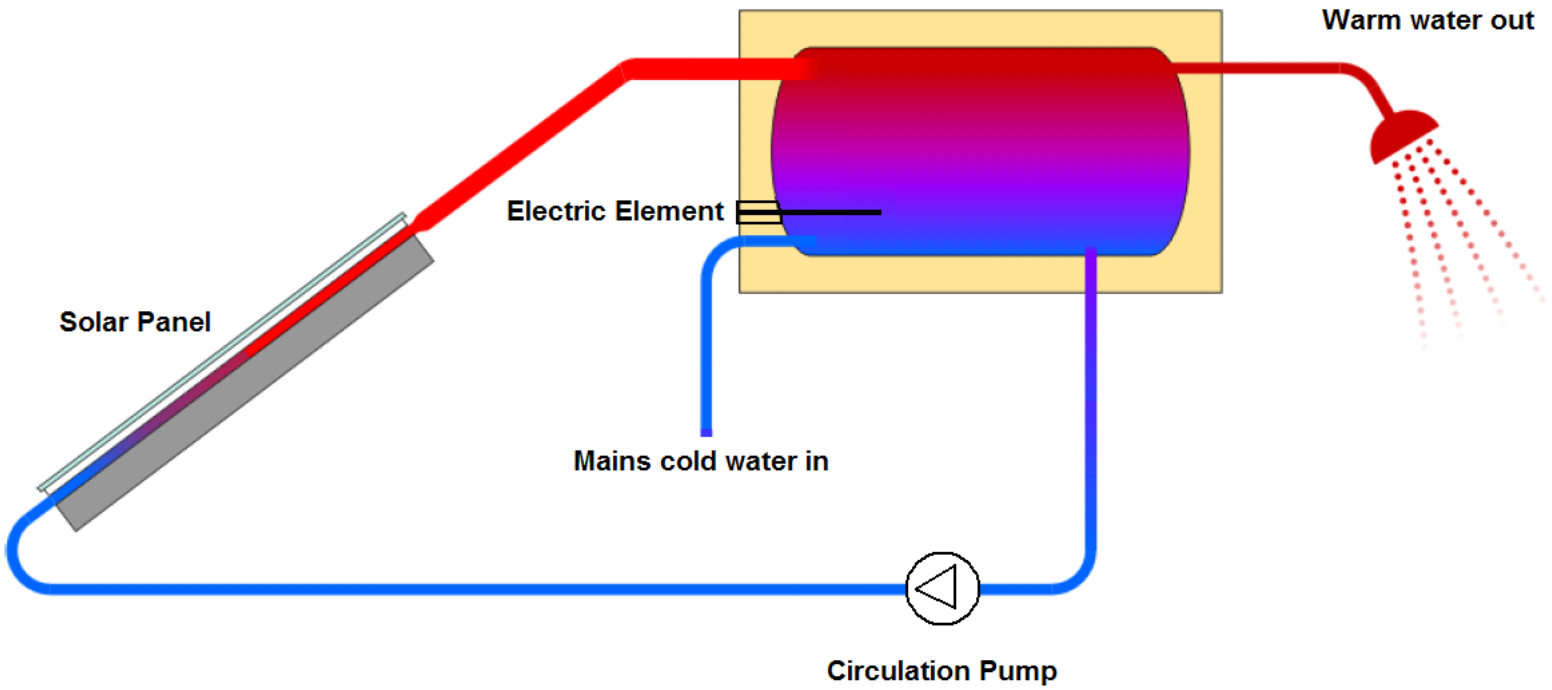
GHI and DNI


South Africa, Lesotho and Swaziland
Annual sum of direct normal irradiation, average 1994-2010
<1400 1550 1700 1850 2000 2150 2300 2450 2600 2750 2900 > kWh/m²
0 100 200 km
PRETORIA
Johannesburg
Soweto
Mbabane
Welkom
Sihlangu
Upington
Kimberley
Bloemfontein
Maseru
Richards Bay
Pietermaritzburg
Mpumalanga
Durban
East London
Cape Town
George
Port Elizabeth
solargis
http://solargis.info
Solar data - SolarGIS v1.8 © 2012 GeoModel Solar s.r.o.

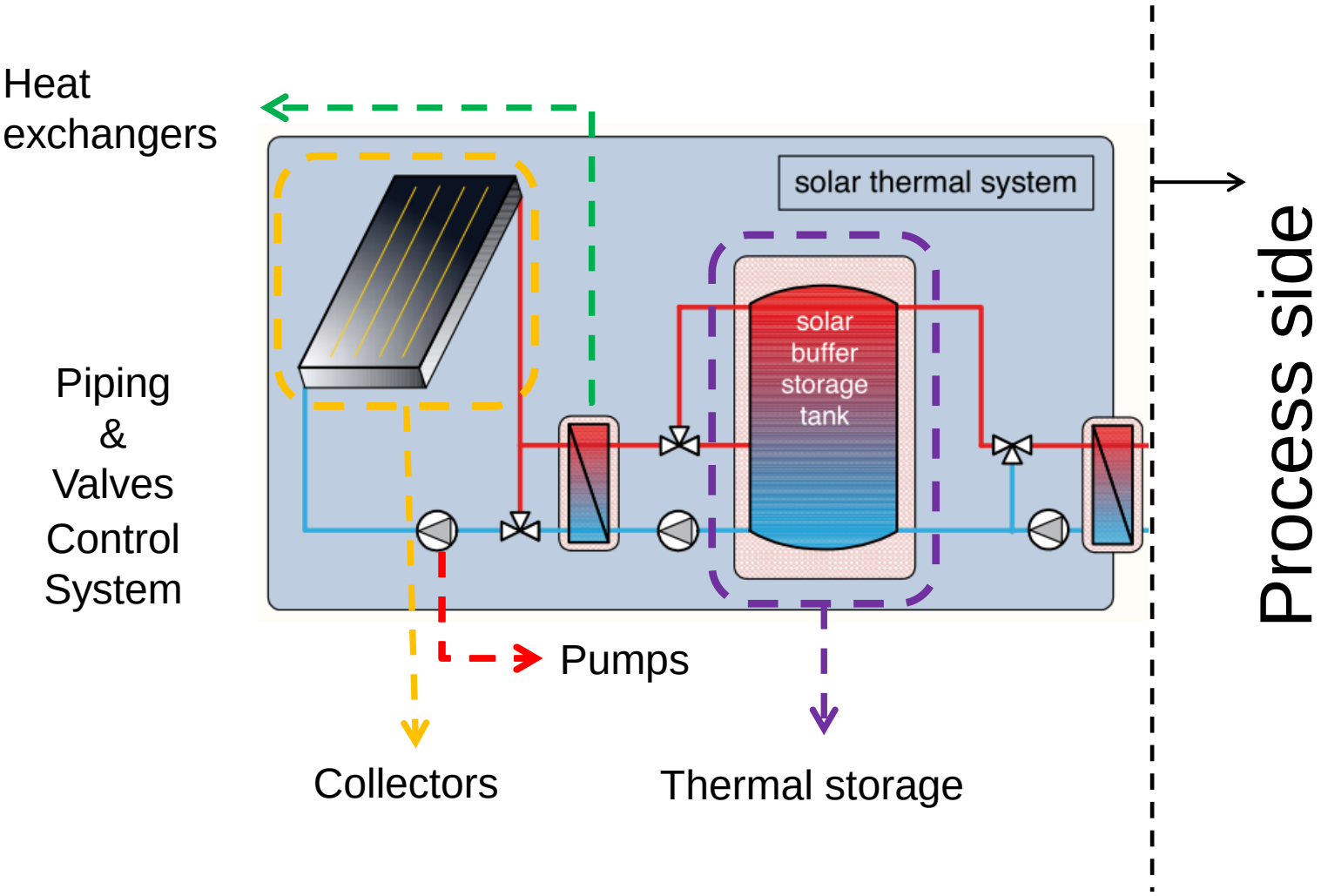
Collectors

Non-imaging	Imaging
• Flat-plate • Evacuated tube • Unglazed collectors	• Linear Fresnel • Parabolic trough • Compound parabolic collector (CPC)
• Usually does not need tracking	• Many, but not all, need tracking
• Simple, inexpensive	• Complex, expensive
• Lower temperatures	• Higher temperatures

Typical residential system

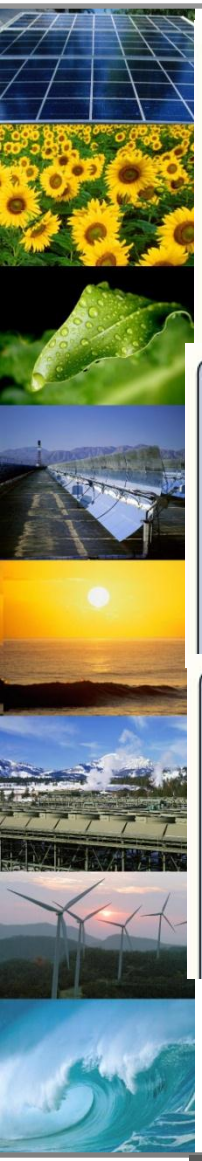


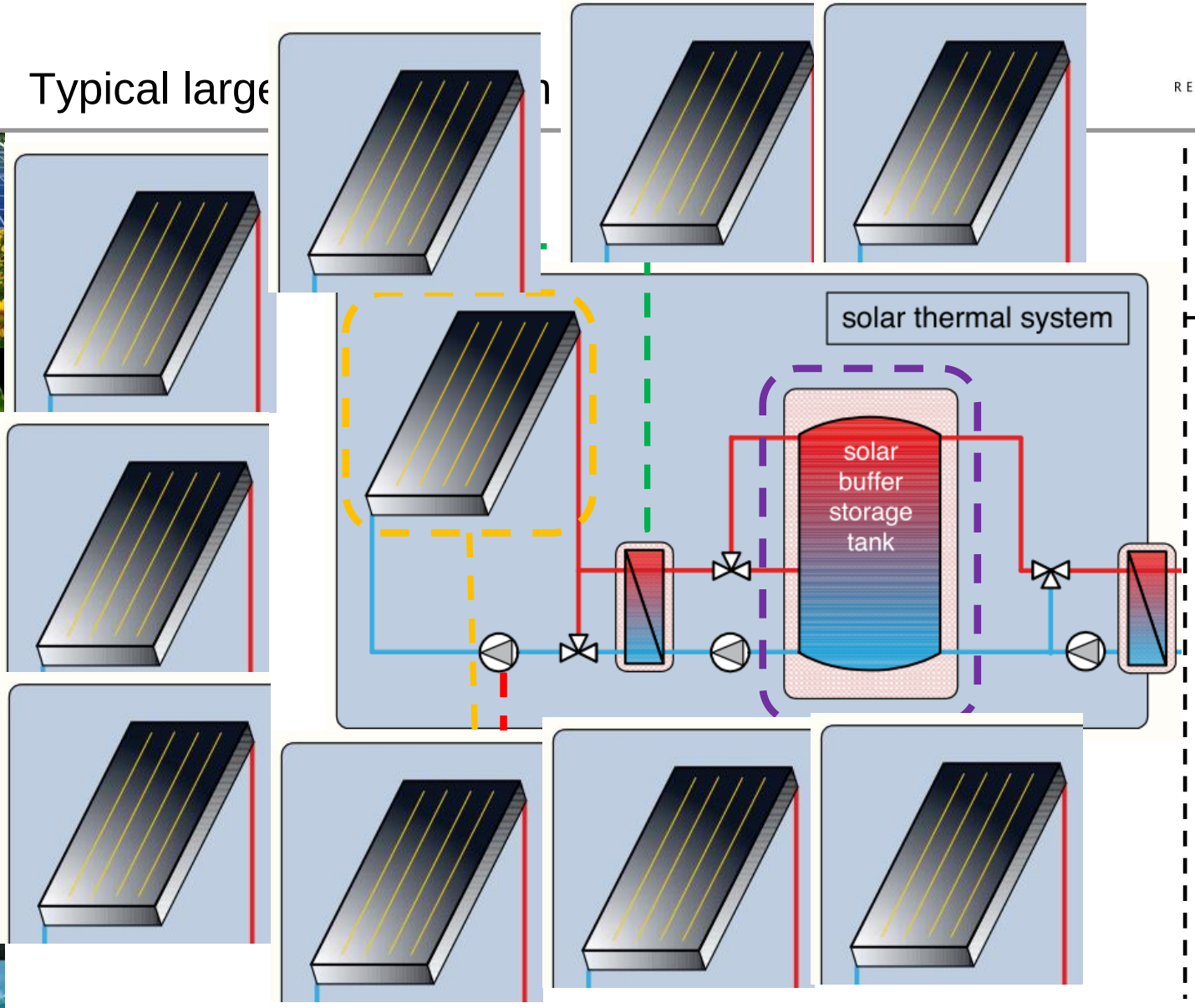
Typical large scale system layout



Source: Solar Process Heat Generation: Guide to Solar Thermal System Design for Selected Industrial Processes, S. Heß, A. Olivia, Fraunhofer ISE, Germany

Typical large

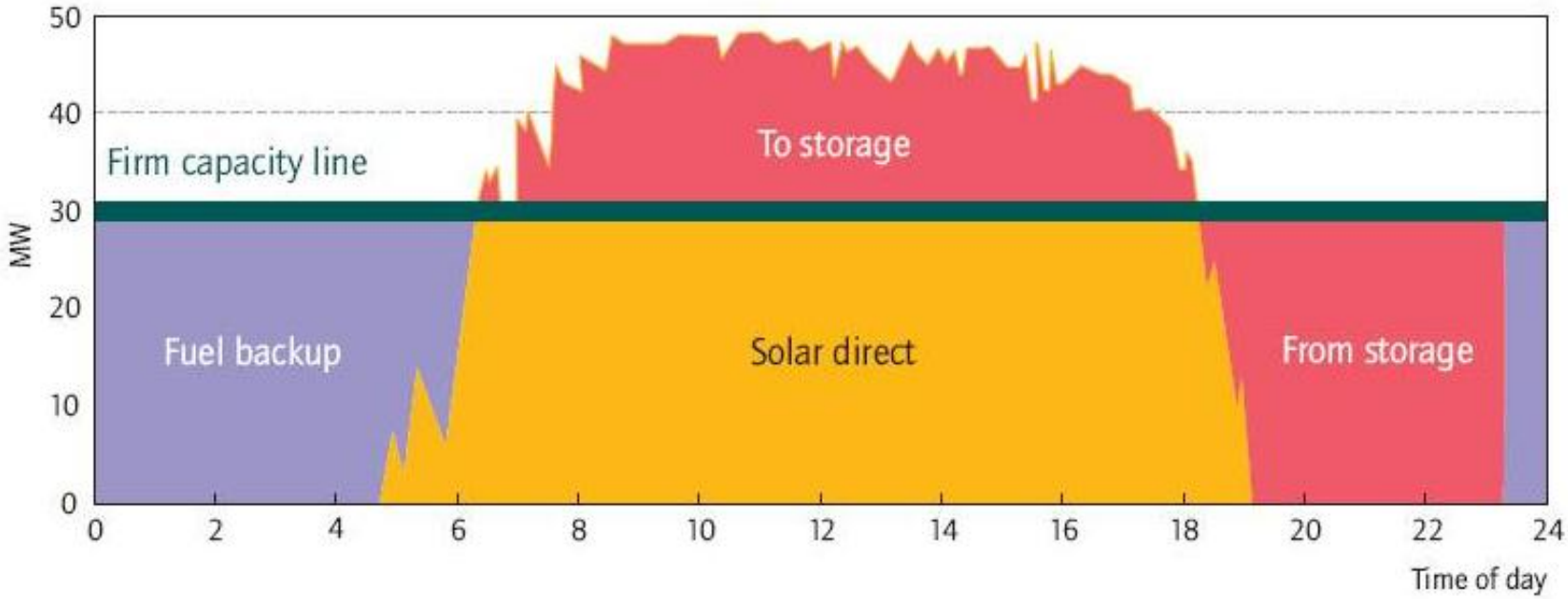




Source: Solar Process Heat Generation: Guide to Solar Thermal System Design for Selected Industrial Processes, S. Heß, A. Olivia, Fraunhofer ISE, Germany

Thermal storage

- Store energy for later use
- Add stability to system
- It's like a battery, but for thermal energy

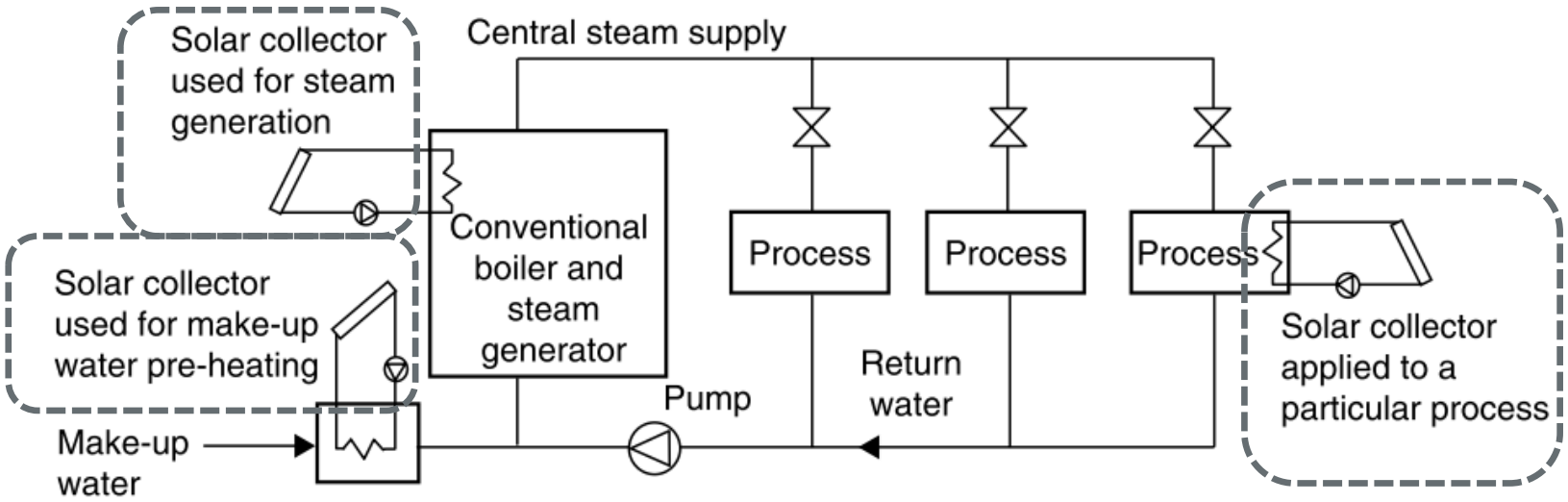


Thermal Storage

Thermal Storage

RENEWABLE & SUSTAINABLE ENERGY STUDIES

System integration



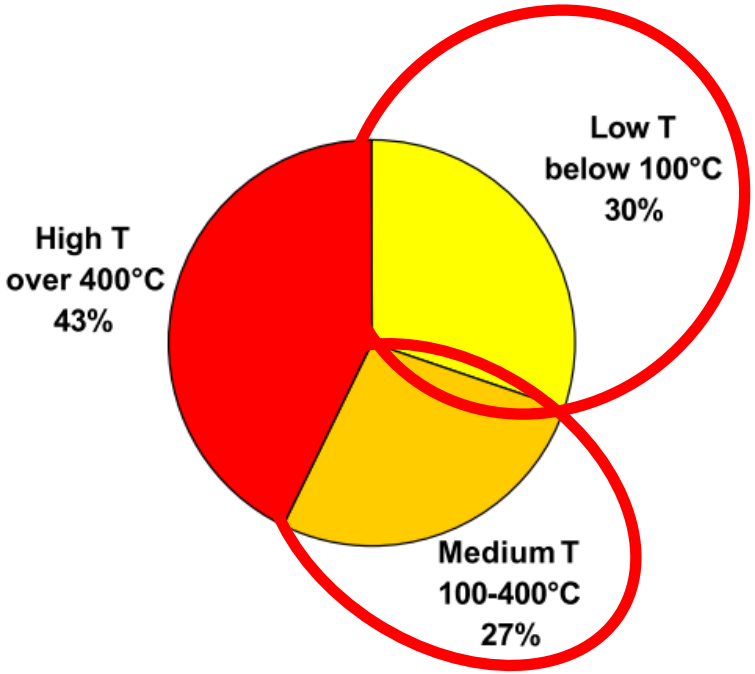
Source: Solar Energy Engineering: Processes and Systems, S.A. Kalogirou, 2009

What it is solar process heat?

- Thermal energy
- Anything from hot air to hot water, steam and hot oil
- Typically larger scale systems

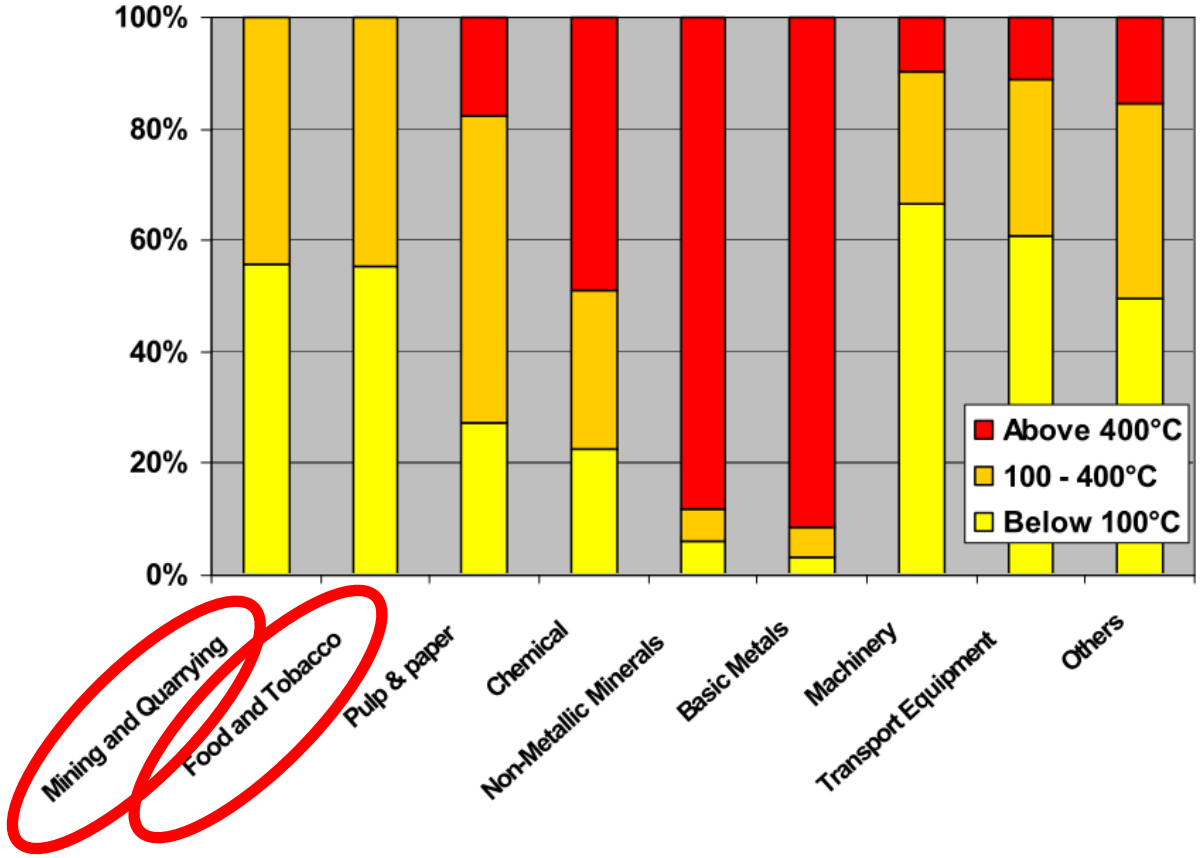
Potential in the industry?

- 1/3 of final energy demand in industry is for heat
- Temperature ranges are suitable for solar
- Can be combined with solar cooling



Source: IEA SHC Task33 and SolarPACES TaskIV report: Potential for Solar Heat in Industrial Processes

Potential

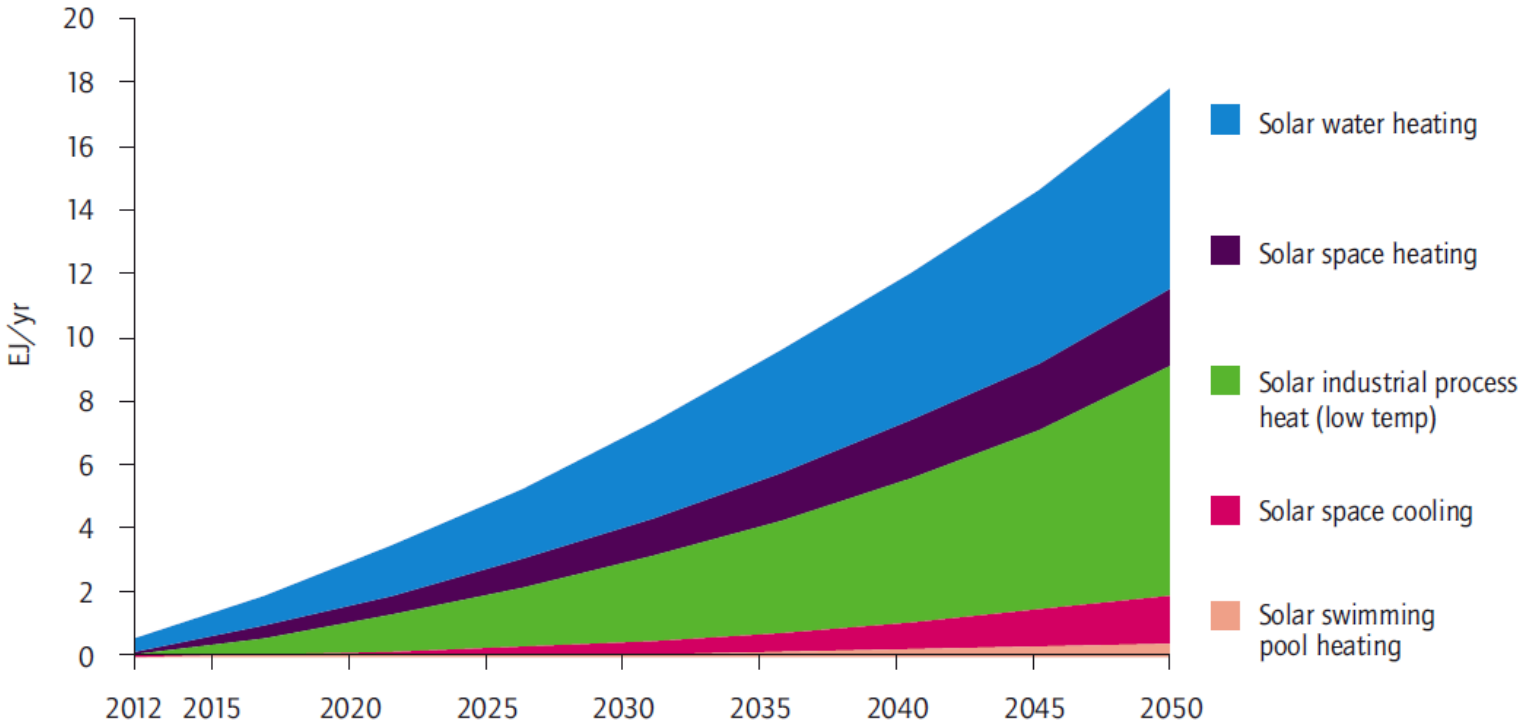


Source: IEA SHC Task33 and SolarPACES TaskIV
report: Potential for Solar Heat in Industrial Processes

Potential

It's important to note that solar cooling should also be considered, especially if used in combination with process heat!

Roadmap vision for solar heating and cooling (Exajoule/yr)

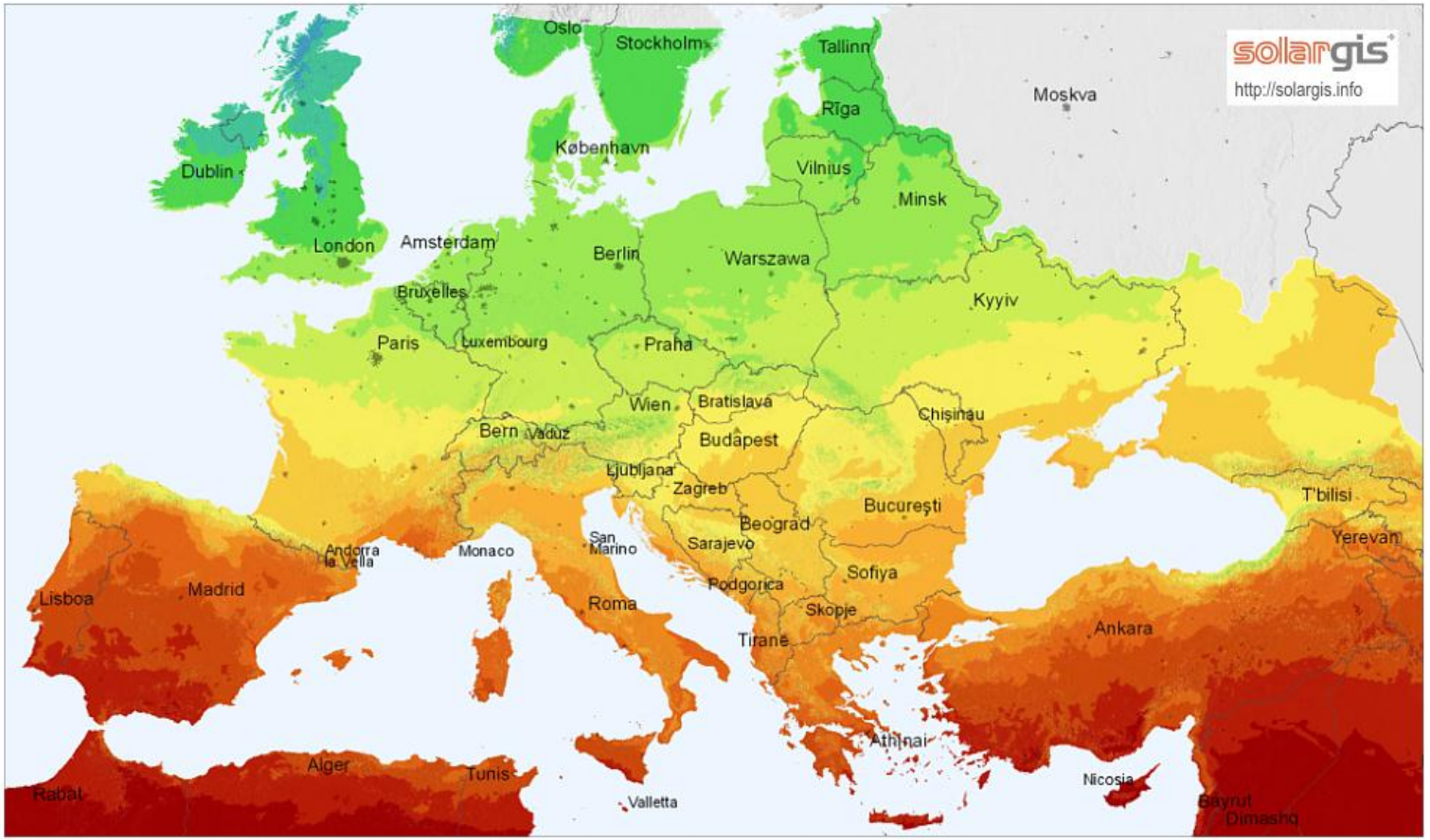


Source: IEA Technology Roadmap for Solar Heating and Cooling, 2012

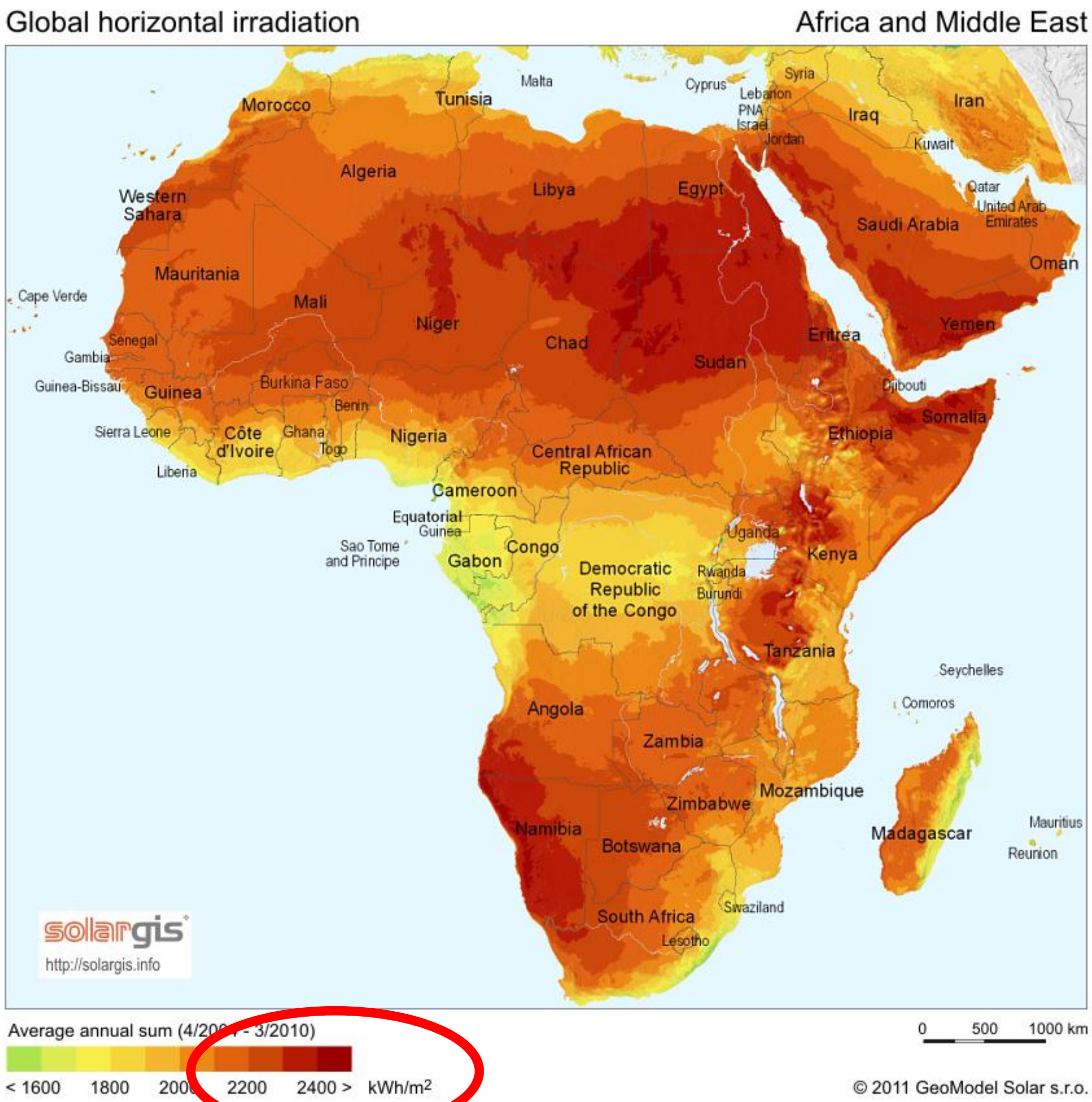
Potential

Global horizontal irradiation

Europe



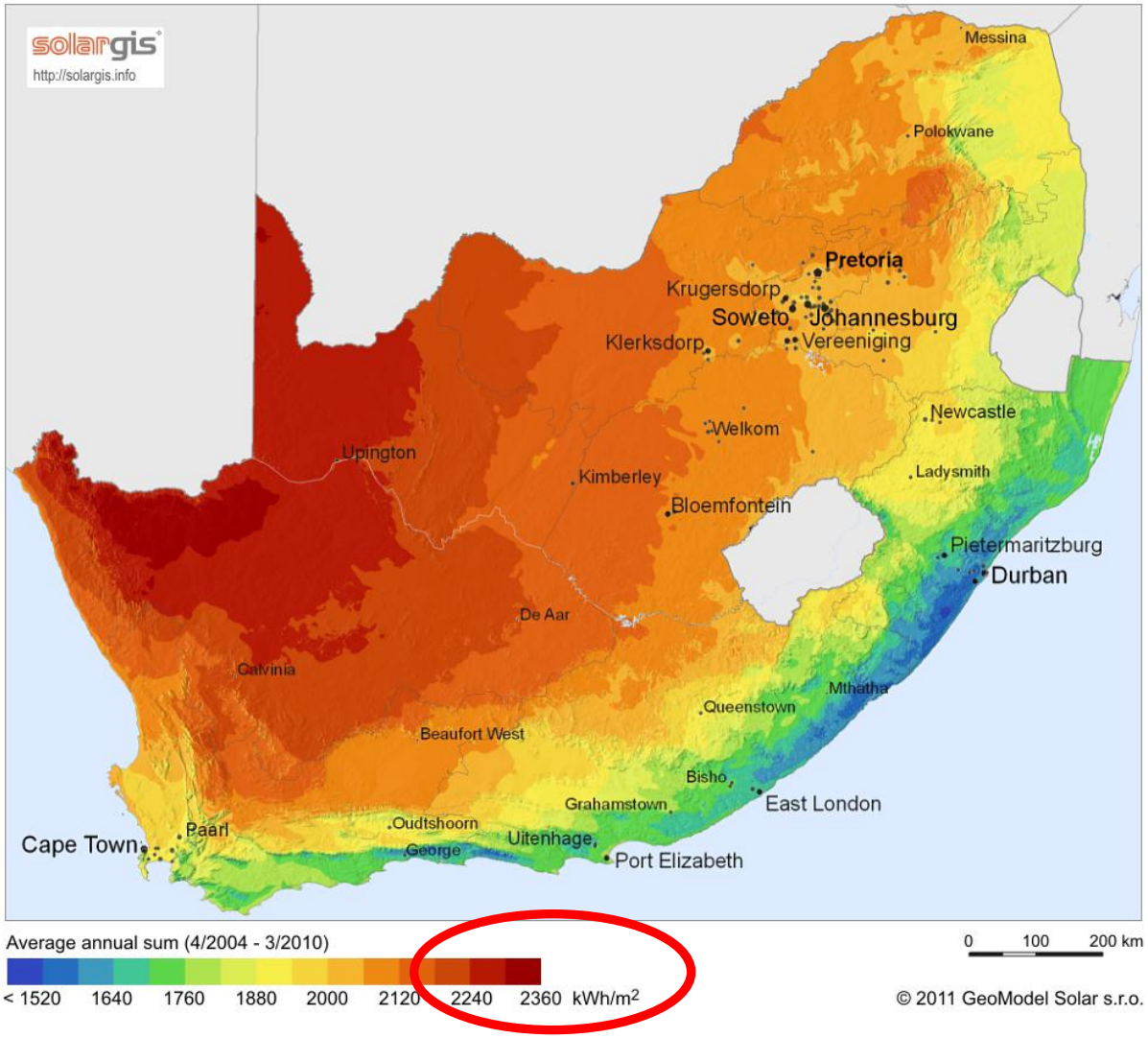
Potential


Global horizontal irradiation
Africa and Middle East
Morocco
Tunisia
Malta
Cyprus
Syria
Lebanon
Iraq
Iran
Algeria
Libya
Egypt
Kuwait
Western Sahara
Qatar
Saudi Arabia
United Arab Emirates
Oman
Mauritania
Mali
Niger
Chad
Sudan
Eritrea
Yemen
Cape Verde
Senegal
Gambia
Guinea-Bissau
Guinea
Burkina Faso
Benin
Djibouti
Somalia
Sierra Leone
Côte d'Ivoire
Ghana
Togo
Nigeria
Central African Republic
Ethiopia
Liberia
Cameroon
Equatorial Guinea
Sao Tome and Principe
Gabon
Congo
Uganda
Kenya
Democratic Republic of the Congo
Rwanda
Burundi
Tanzania
Seychelles
Comoros
Angola
Zambia
Mozambique
Zimbabwe
Namibia
Botswana
Madagascar
Mauritius
Reunion
South Africa
Swaziland
Lesotho
solargis
http://solargis.info
Average annual sum (4/2004 - 3/2010)
< 1600 1800 2000 2200 2400 > kWh/m2
0 500 1000 km
© 2011 GeoModel Solar s.r.o.

Potential

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Global horizontal irradiation — South Africa

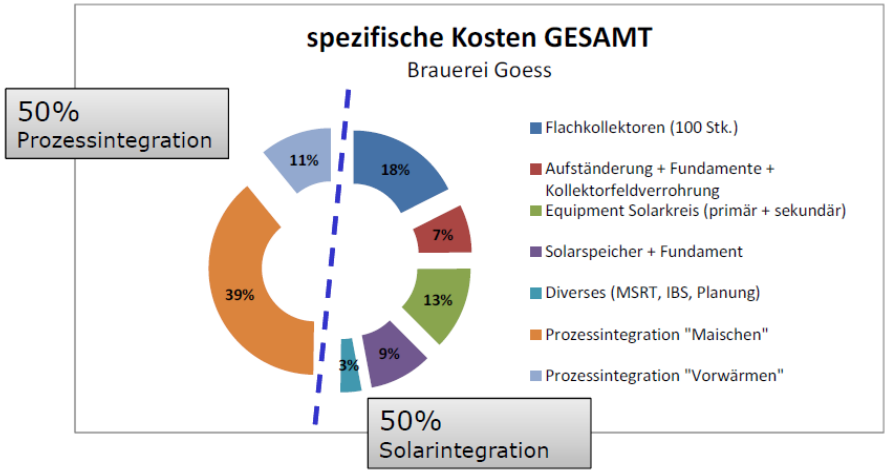


Example: Gösser Brewery in Austria

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Study by AEE INTEC on Gösser Brewery in Austria

- 1500m^2 Flat-plate collectors
- 200m^3 Thermal Storage
- Estimated cost: R11,418,750
- Annual GHI 1070kWh/m^2
- Expected payback <10years



If this was in Johannesburg:

- Annual GHI 2200kWh/m^2
- Roughly 50% saving in collectors

AEE INTEC
INSTITUT FÜR NACHHALTIGE TECHNOLOGIEN

Gösser

AEE INTEC

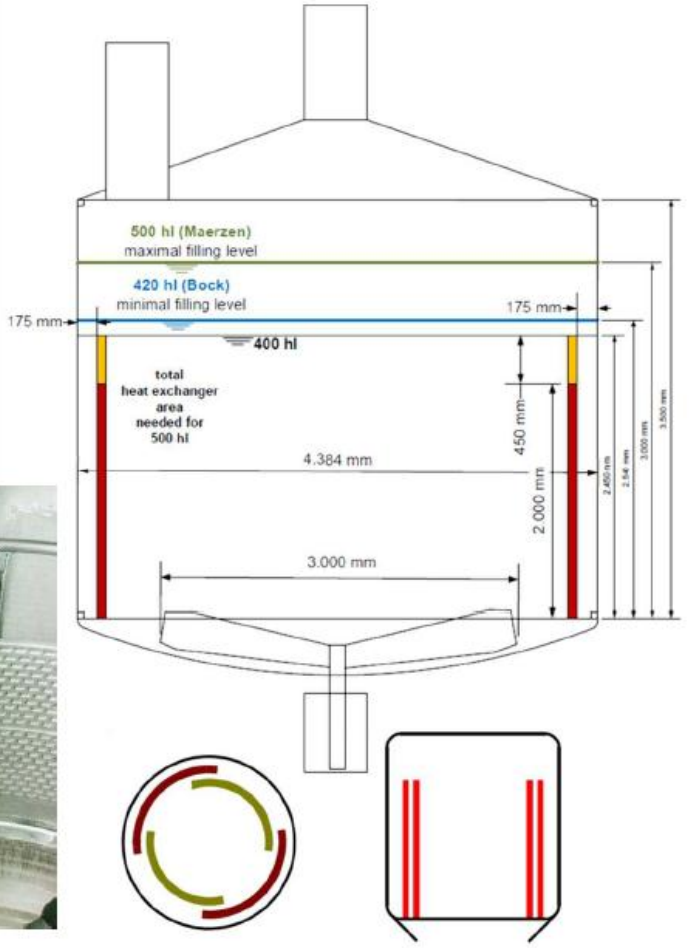
Gleisdorf Solar 2012 - 13.09.2012

Brauerei Göss - Österreich

Gösser

Solare Wärmeintegration

- 20 – 27 Sude/Woche
  - min. 400 hl/Sud
  - ca. 75 – 90 min/Sud
- Nachrüstung von „dimple plates"

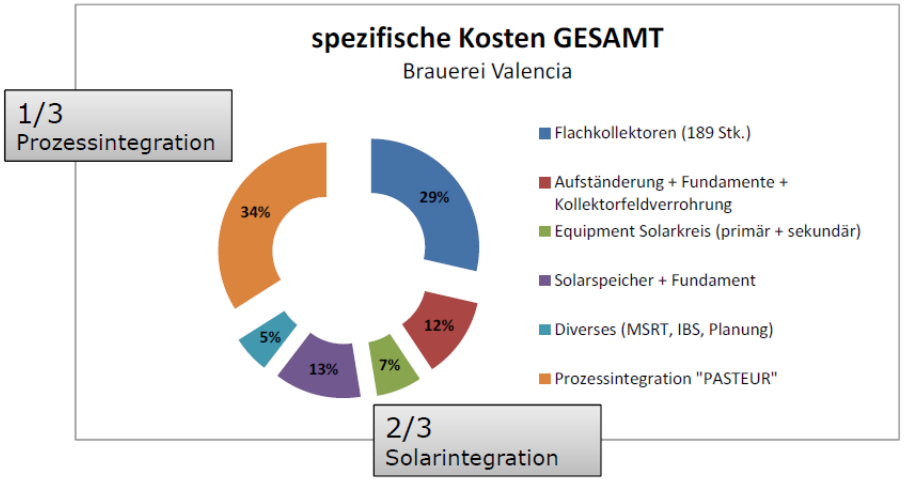


Example: Heineken Brewery in Spain

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Study by AEE INTEC on Heinken Brewery in Spain

- 2835m^2 Flat-plate collectors
- 350m^3 Thermal Storage
- Estimated cost: R14,139,562
- Annual GHI 1610kWh/m^2
- Expected payback <8years



If this was in Cape Town:

- Annual GHI 2025kWh/m^2
- Roughly 26% saving in collectors

AEE INTEC
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TRADE MARK Heineken®

Example: Heineken Brewery in Spain

AEE INTEC

Gleisdorf Solar 2012 - 13.09.2012

Brauerei Valencia - Spanien

Pasteur 1 Dose

Pasteur 2 Flasche

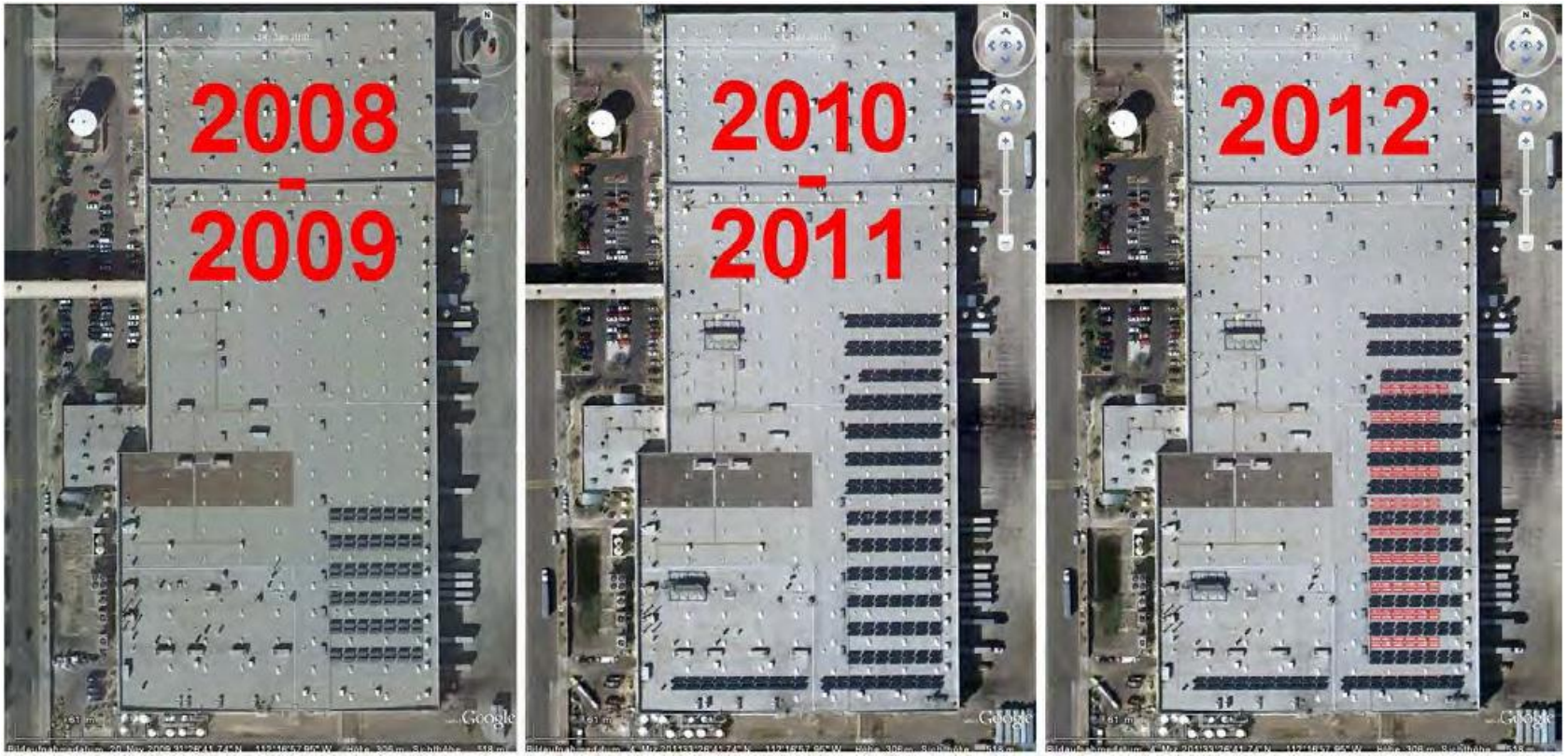
Dampf-WT Bestand

Besprühen der Flaschen

Gatorade PepsiCo – Phoenix

RENEWABLE & SUSTAINABLE ENERGY STUDIES

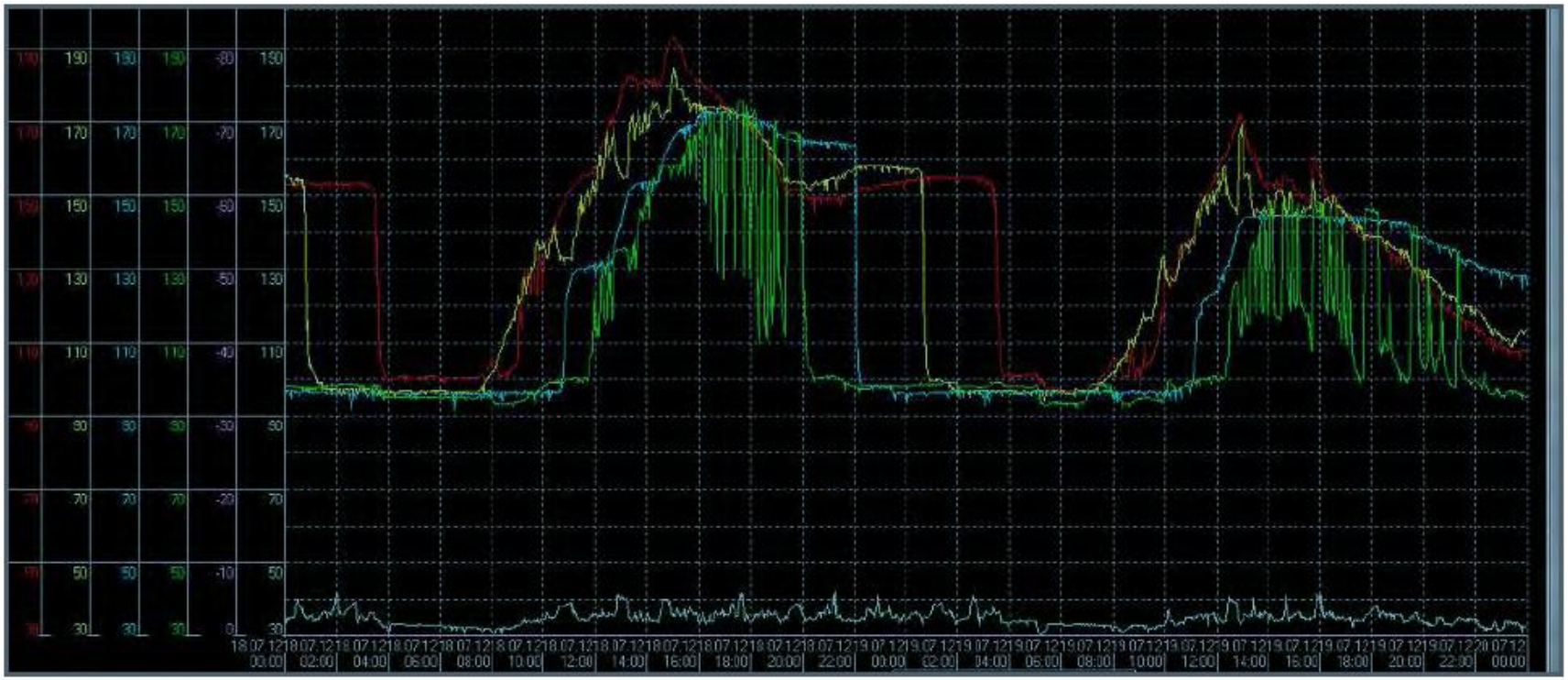
892m^2 | 2,568m^2 | 3,774m^2



1,200,000kWh | >3,000,000kWh | >4,200,000kWh

Source: Dr. C. Holter, CEO of S.O.L.I.D. Gesellschaft für Solarinstallation und Design mbH, Presented at Gleisdorf SOLAR 2012

Gatorade PepsiCo – Phoenix



- Lowest level in tank cooled down at 8pm already
- Middle and top level satisfy energy demand until 4am

Schulte Paint Shop, Germany

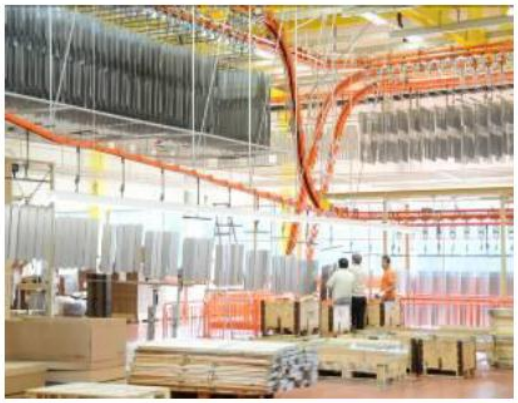
- Operational since April 2009
- 136m^2 evacuated tube collectors
- Two 5m^3 thermal storage tanks
  - One for painting chamber requiring constant temperature of 23˚C
  - Other for drying chamber requiring constant temperature of 70 ˚C
- Investment: R1,218,000 including heat recovery
  - Had a 30% investment grant
- Payback expected to be 7 to 8 years

Galvanization Blum, Austria, 2011

RITTER XL SOLAR

Process heat for galvanization
(5 working days per week)

Temperatures	75 / 85 ° C
Gross collector area	459 m²
Buffer tank volume	8 m³
Max. continuous power	230 kW
Yield / Year	150 MWh

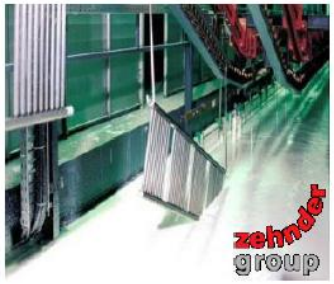


Galvanization Zehnder, Switzerland, 2012

RITTER XL SOLAR

Process heat for galvanization (5 working days per week)

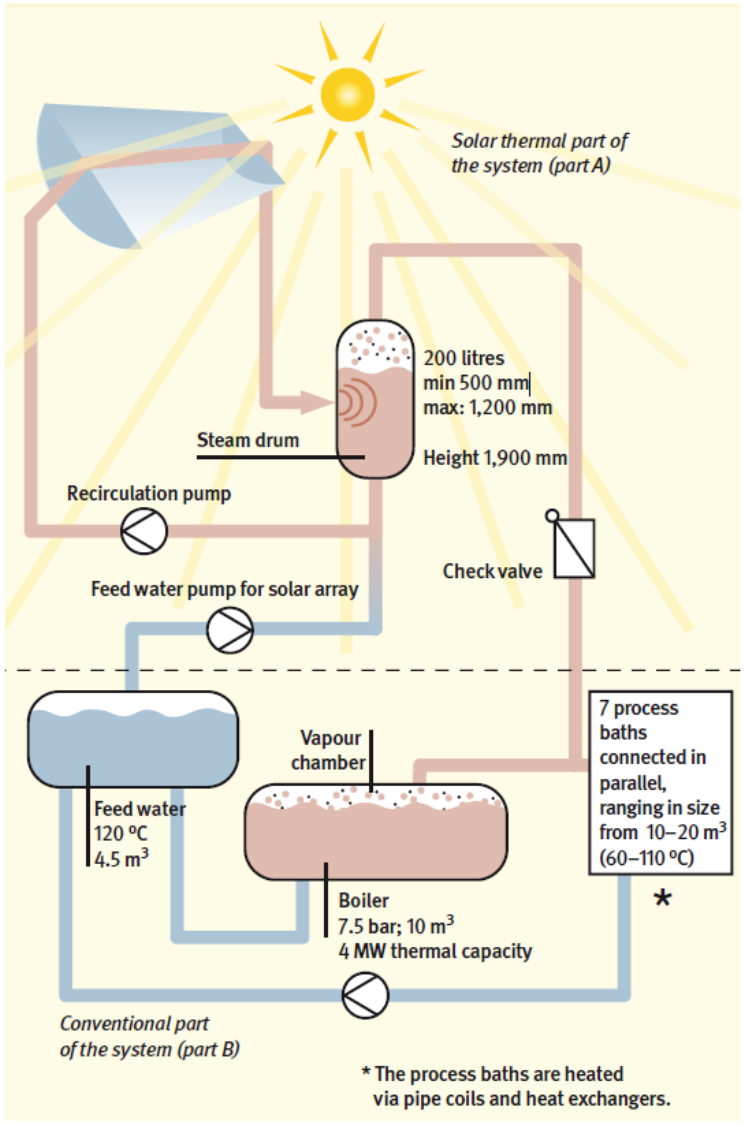
Temperatures	70 / 95 ° C
Gross collector area	400 m²
Buffer	5 m³



ALANOD GmbH & Co., Germany

- 108m^2 Parabolic trough
- 143˚C at 4bar
- Used for oxide coating (anodisation) in finishing process
- Automatic operation since 2010

Source: Solar Steam Supply: Initial operation of a plant, D. Krüger et al., DLR



Dürr/Industrial Solar for automotive paint shops

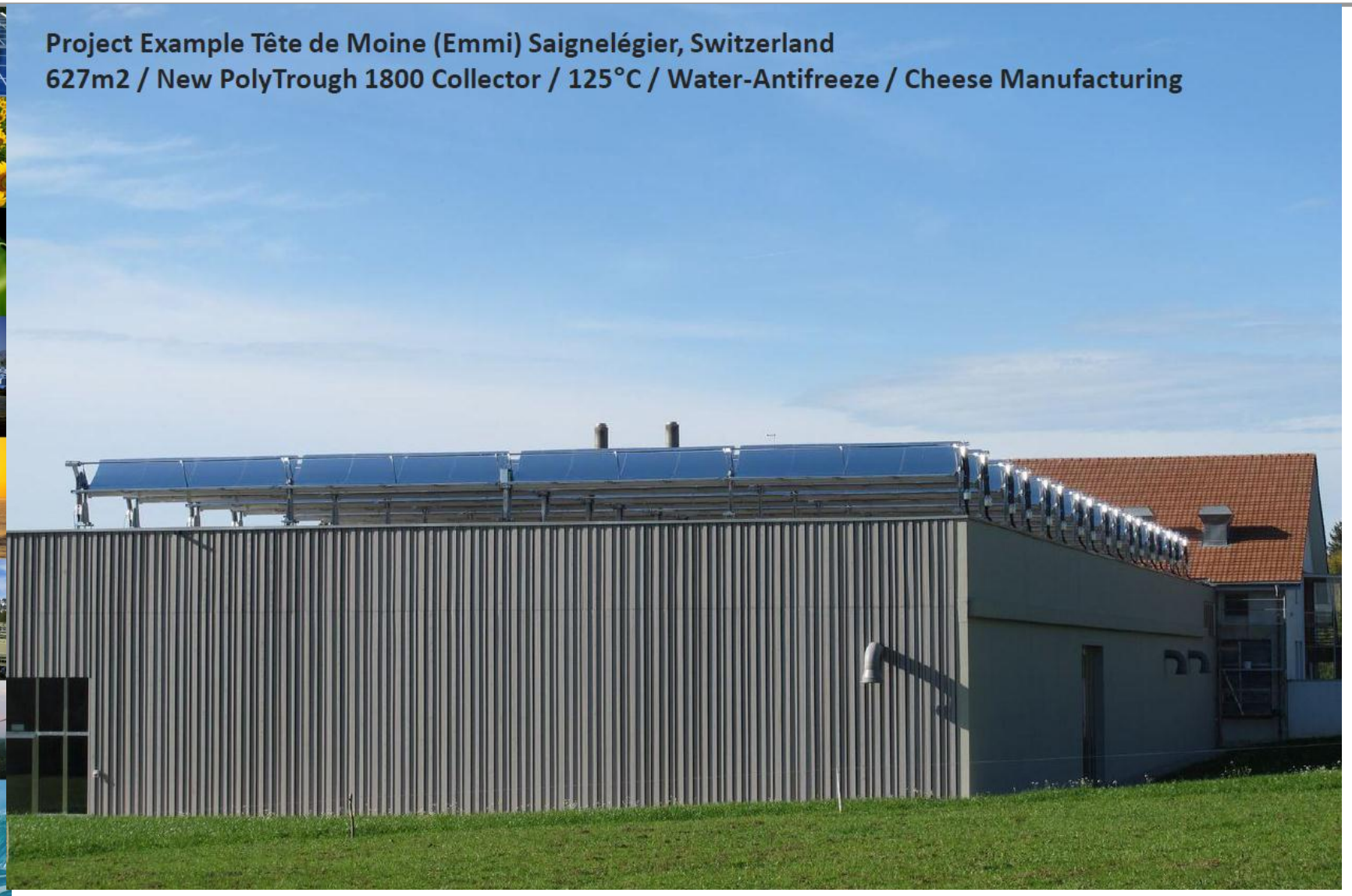
Pilot system for curing process in convection oven

- 132m^2 linear Fresnel collector
- 180˚C water at 13 bar
- Uses pressurized water to air heat exchanger
- Backed-up with fossil fired boiler

Source: Solar Process Heat for Sustainable Automobile Manufacturing, O. Iglauer (Dürr), C. Zahler (Industrial Solar), Presented at Gleisdorf SOLAR 2012

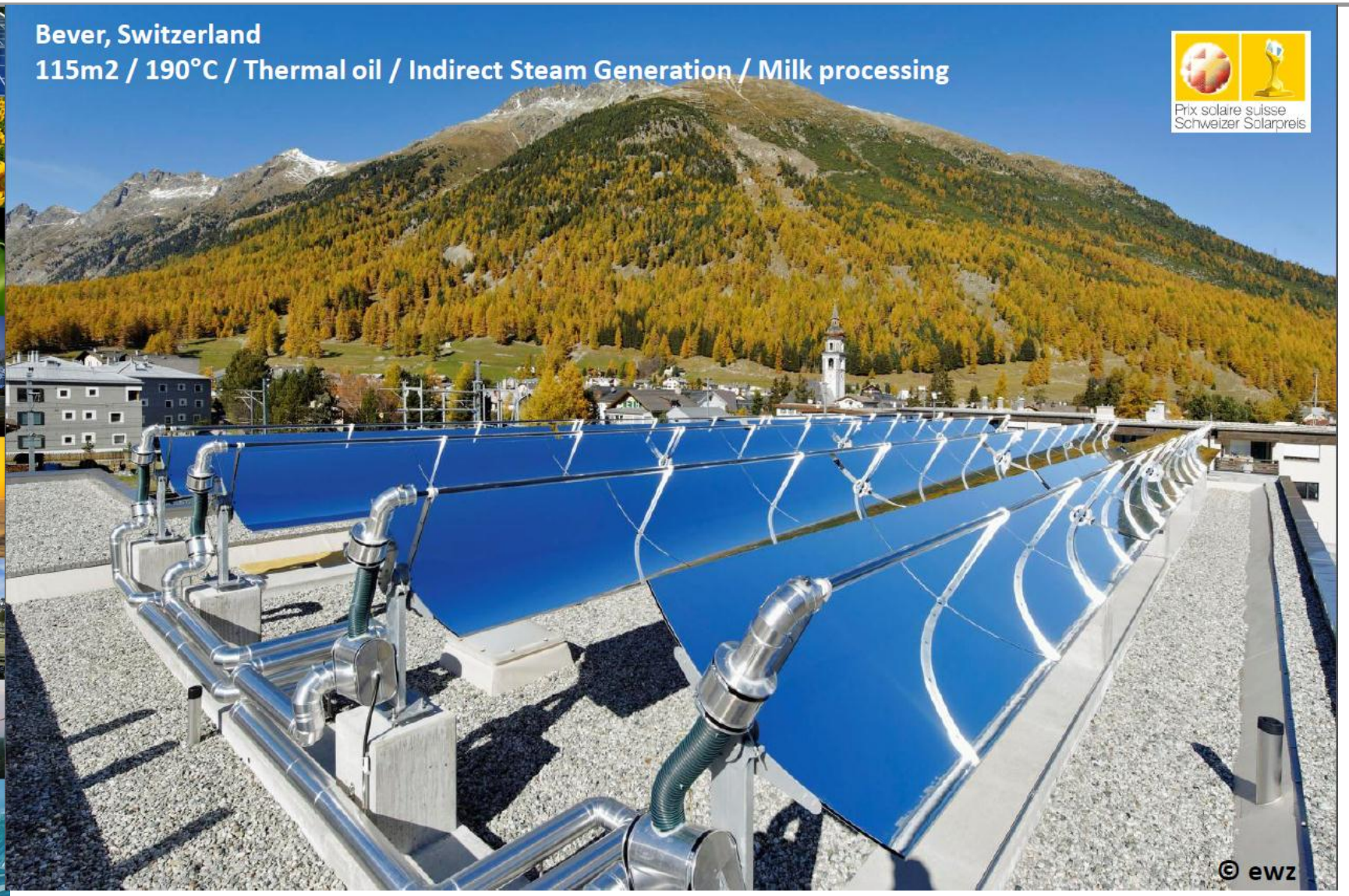
Dairy Industry, Switzerland

RENEWABLE & SUSTAINABLE ENERGY STUDIES



Dairy Industry, Switzerland

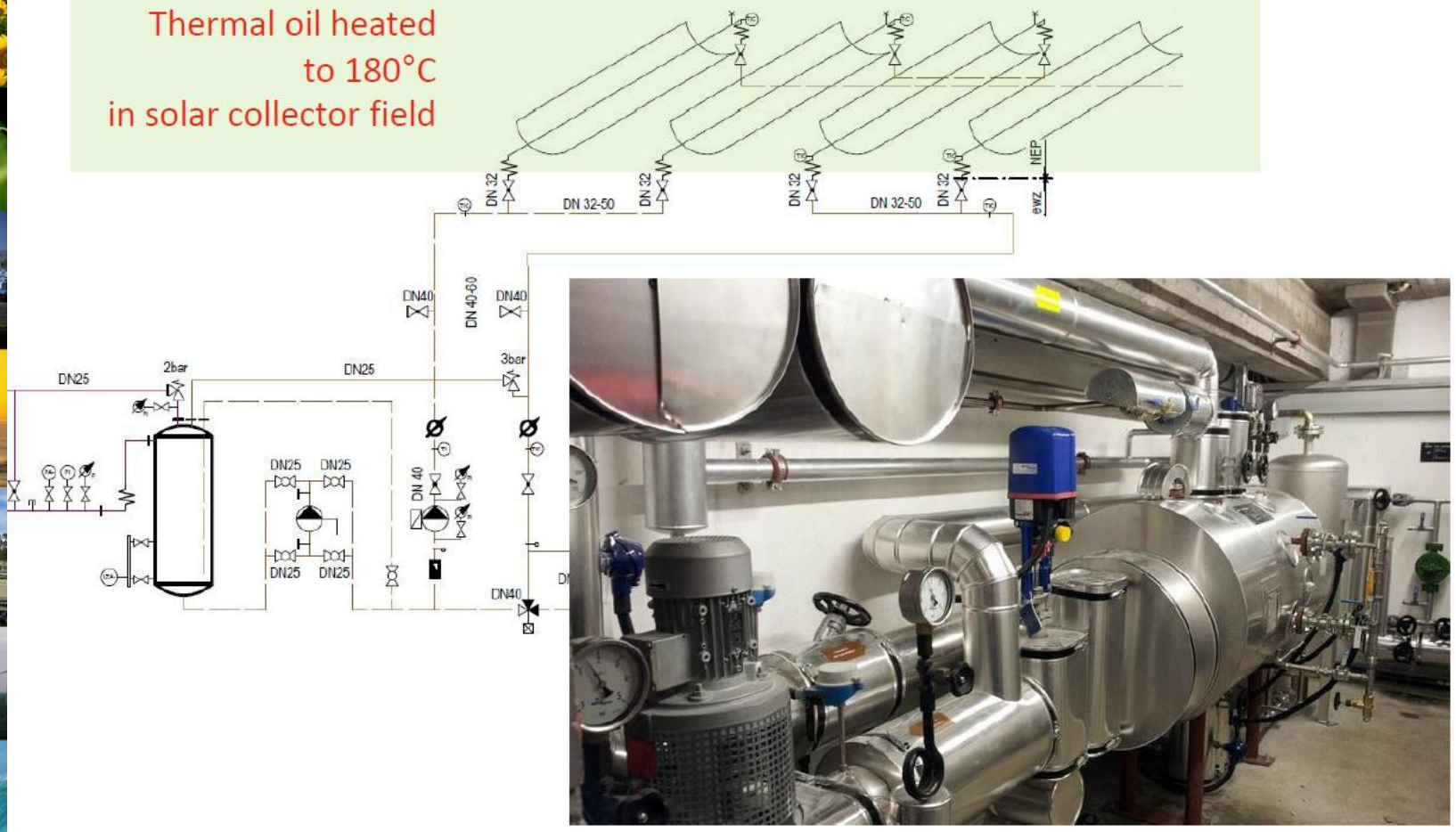
RENEWABLE & SUSTAINABLE ENERGY STUDIES



Dairy Industry, Switzerland

LESA Bever Project: Integration

Thermal oil heated
to 180°C
in solar collector field



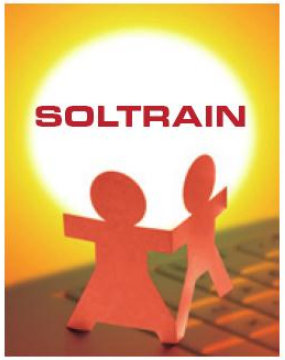
What's happening in SA?

Soltrain II

AEEINTEC

financed by

Austrian Development Cooperation



- Awareness campaigns
- Centres of Competence
- Flagship Demonstration Districts
- Solar Thermal Technology Platforms

Solar Roof Laboratory and Test Facility

Demonstration System

Control Room

Current R&D activities in SA

- Stellenbosch University (SU)
- Tshwane University of Technology (TUT)
- Cape Peninsula University of Technology (CPUT)
- Nelson Mandela Metropolitan University (NMMU)
- North-West University (NWU)
- Durban University of Technology (DUT)
- University of the Witwatersrand (WITS)
- University of Pretoria (UP)
- South African Bureau of Standards (SABS)
- Eskom Research and Innovation Centre (ERIC)/BBEnergy

Areas of Activity

RENEWABLE & SUSTAINABLE ENERGY STUDIES

Thermal Performance Testing

- Stellenbosch – DIN EN12975
- TUT Systems and components
- SABS – System testing only
- DUT (Planned Technology Station)
- CPUT – For private firms
- NMMU – Systems

Development

- TUT – Low cost systems, large scale systems, measurements
- NMMU – Measurement and control
- BBE Energy – Linear Fresnel
- WITS – Selective coatings
- CPUT – Low cost SWH, evacuated tubes

Training

- TUT (Installation, maintenance)
- DUT (Planned)
- FET Colleges
- SARETC at CPUT (SWH?)

Under- and/or postgraduate student projects

- Stellenbosch
- NWU
- NMMU
- CPUT
- WITS

GeoSUN Africa

GeoSUN AFRICA

- Site selection
- Satellite Derived Data
- On-site Solar Measurements
- Bankable Solar Resource Reports
- Bankable Generation Forecast
- Bankable Solar Data for Operating plants

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