Solar Heat in Industrial Processes

It's applicability in South Africa

Solar thermal power seminar

CENTRE FOR RENEWABLE AND SUSTAINABLE ENERGY STUDIES

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8 October 2013

Durban

UNIVERSITEIT STELLENBOSCH UNIVERSITY

science & technology
Department: Science and Technology
REPUBLIC OF SOUTH AFRICA

NRF National Research Foundation

Eskom

sasol reaching new frontiers

What if you need more hot water?

Large scale solar thermal systems

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

Large scale solar thermal systems

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:

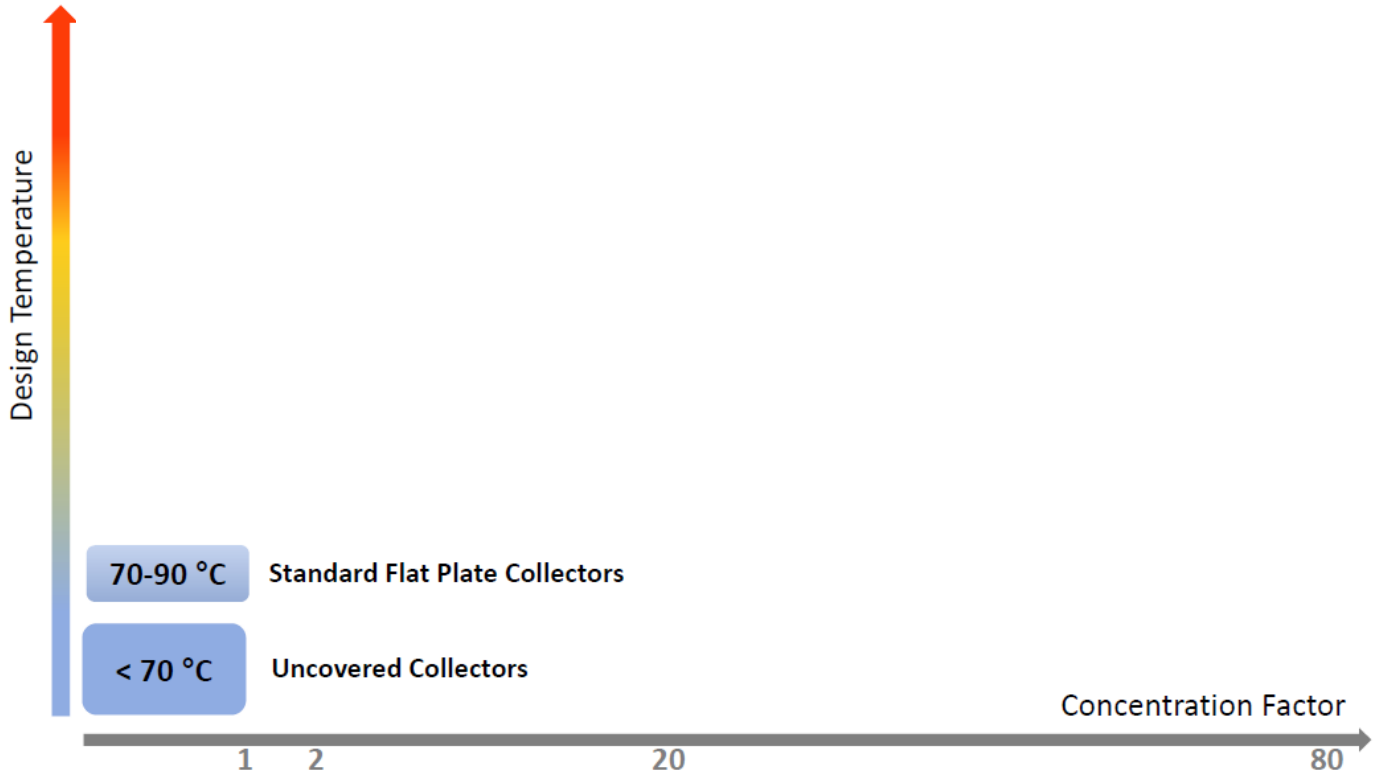
- 36,305m^2 of flat-plate collectors
- 25$MW_{thermal}$

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

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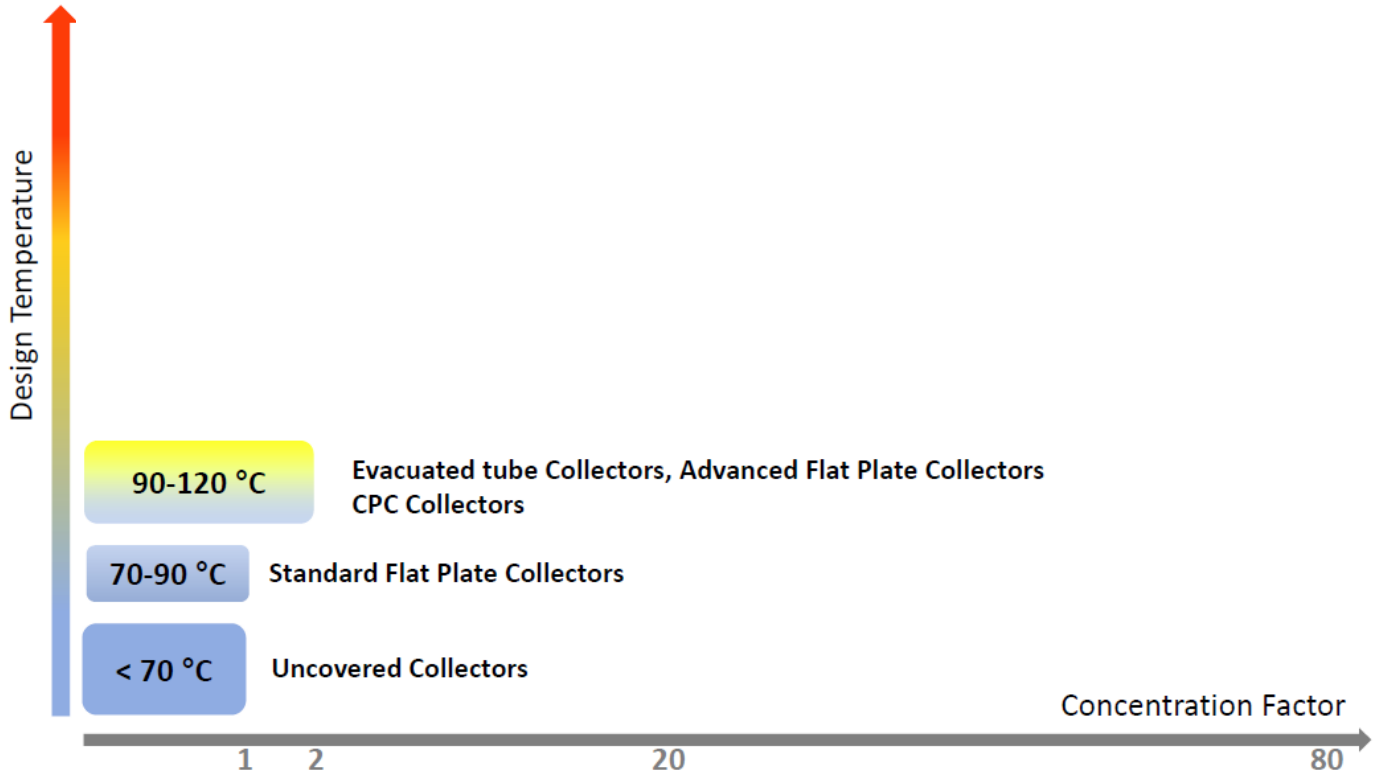

Collectors

Compound Parabolic Collector (CPC)

Different collector operating temperatures

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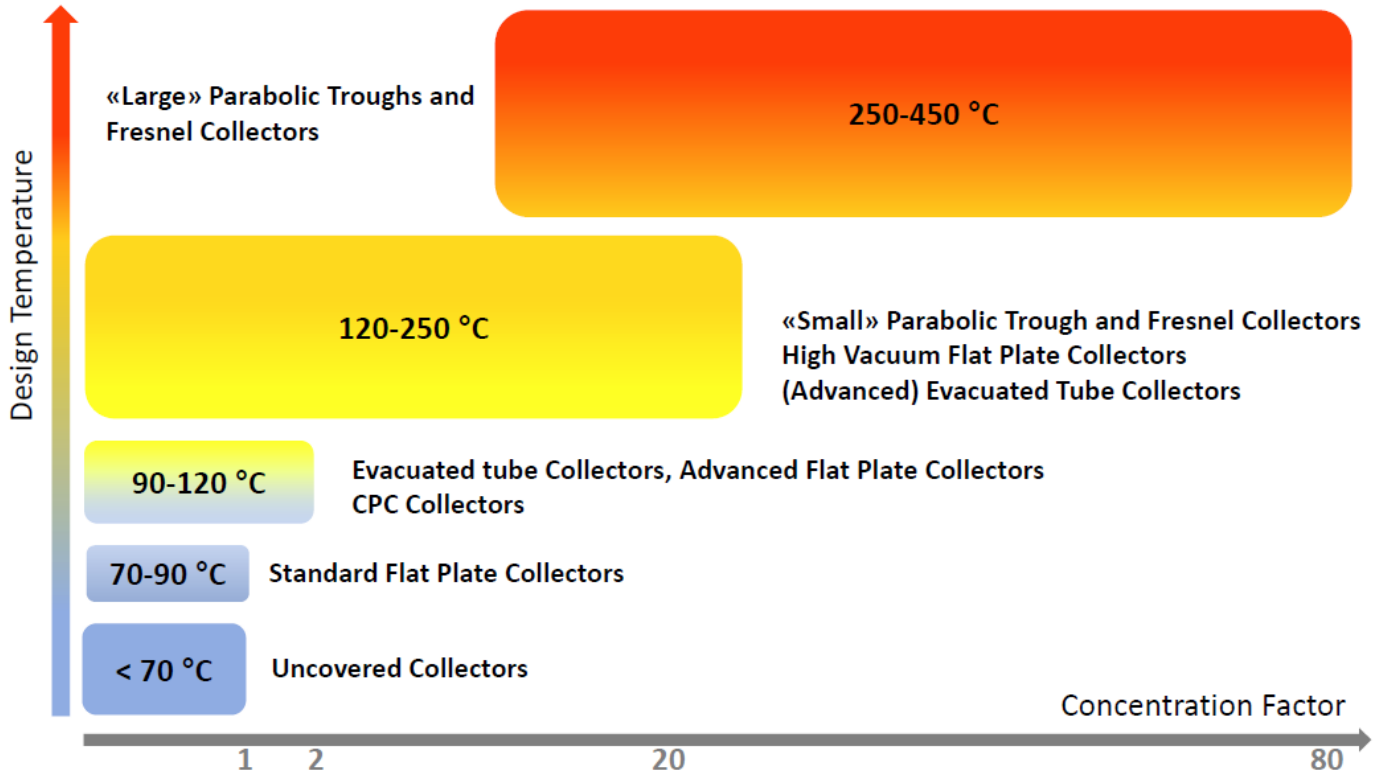
Collectors and Operating Temperatures



Collectors

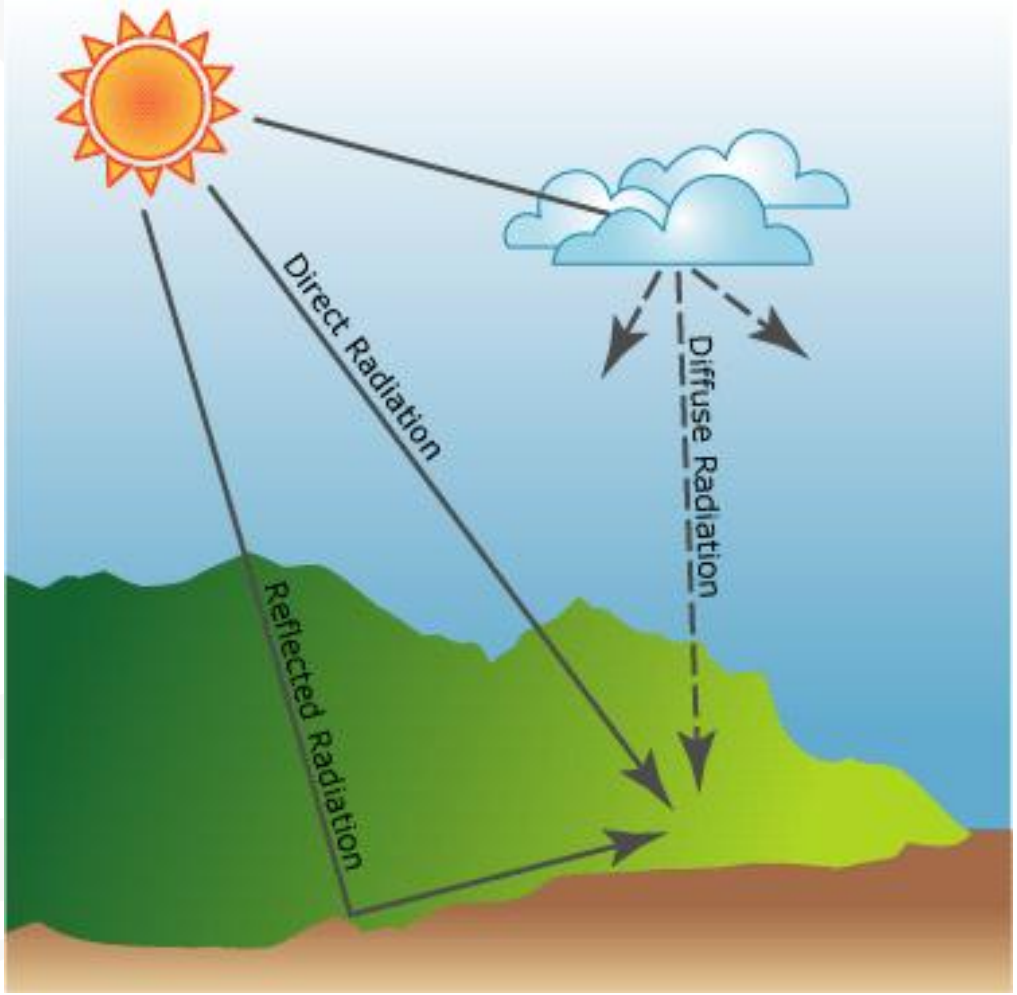
Parabolic trough

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

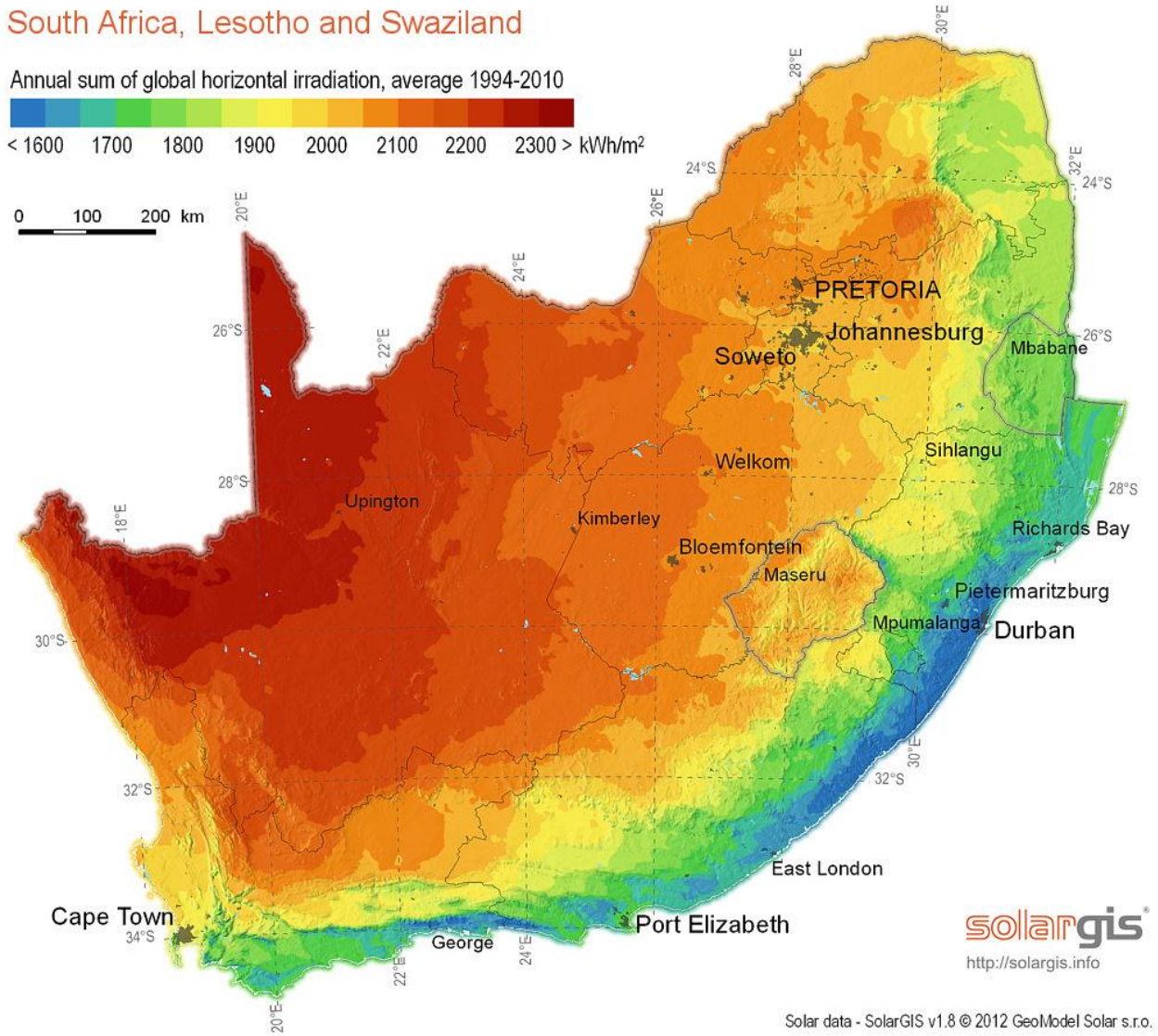
BBE Linear Fresnel at ERIC

GHI and DNI



	diffuse
+	direct
=	global

GHI and DNI


South Africa, Lesotho and Swaziland
Annual sum of global horizontal irradiation, average 1994-2010
< 1600 1700 1800 1900 2000 2100 2200 2300 > 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
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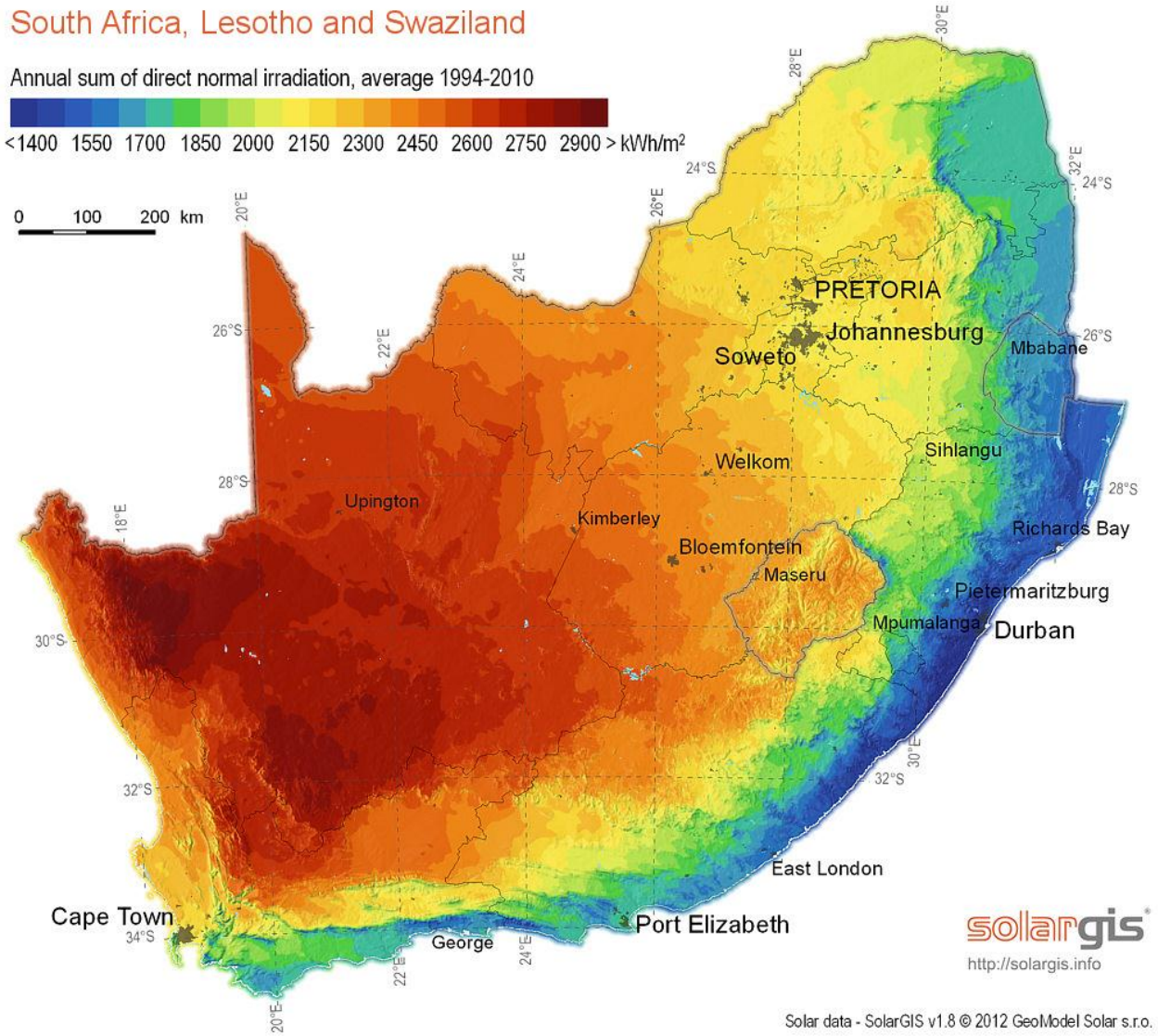
GHI and DNI


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
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East London
Cape Town
George
Port Elizabeth
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http://solargis.info
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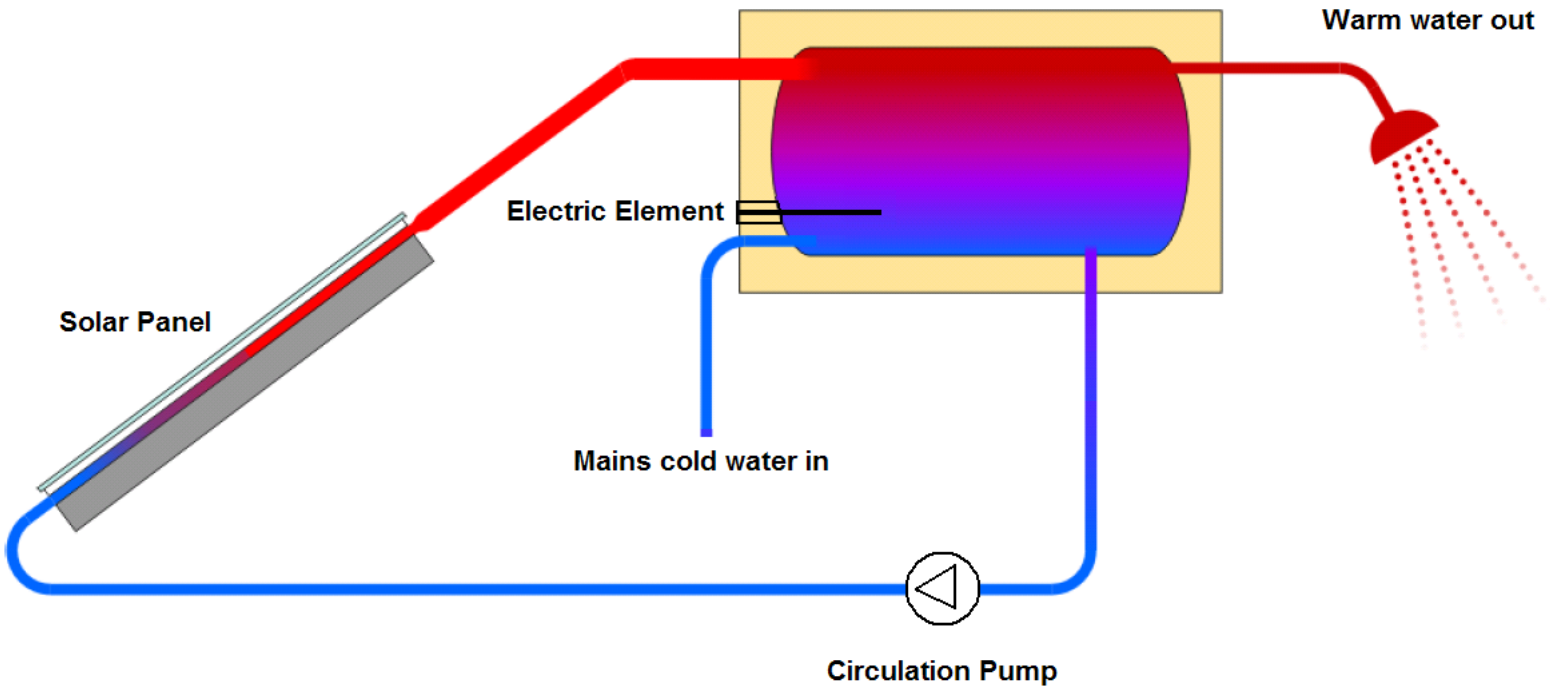
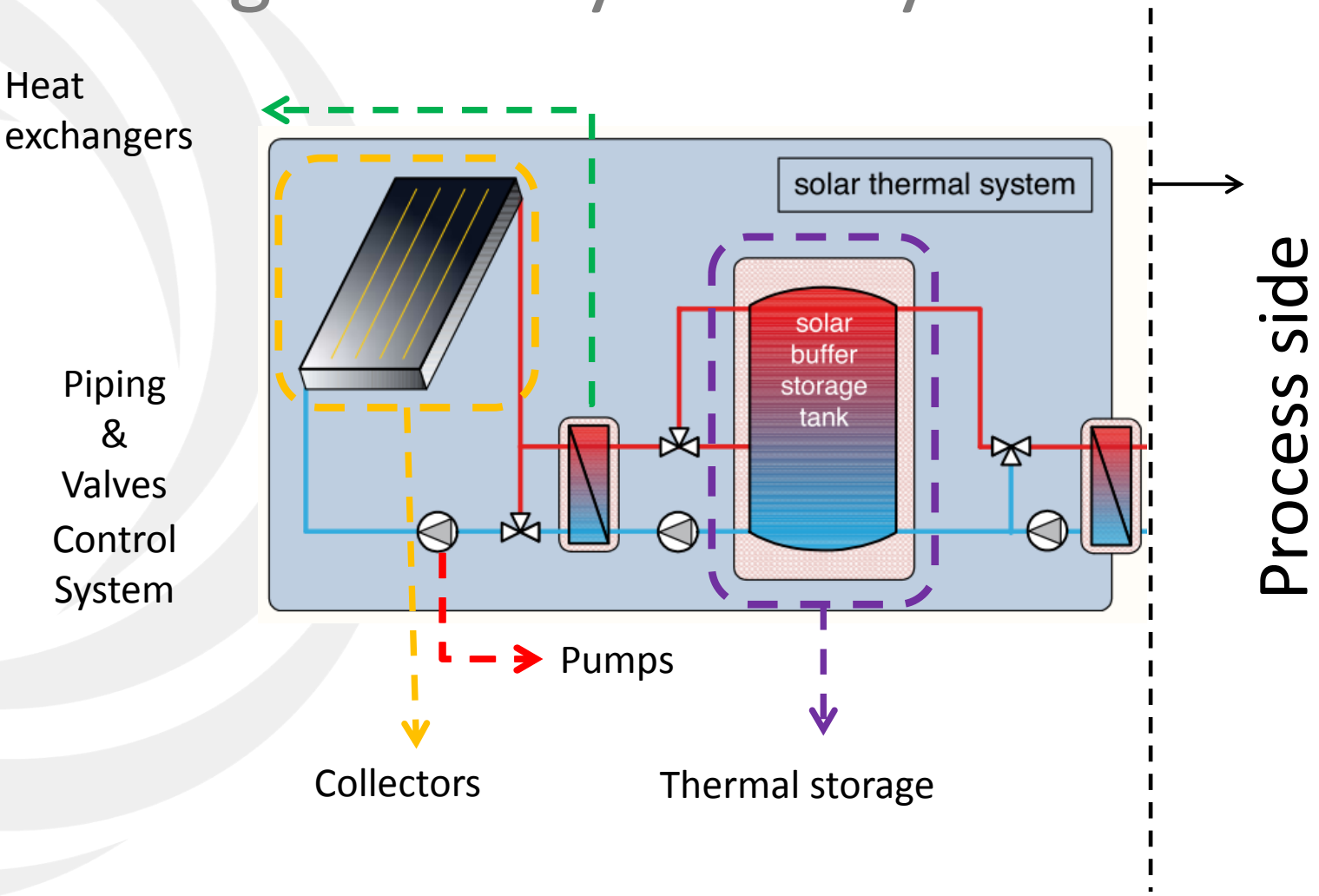
Collectors

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

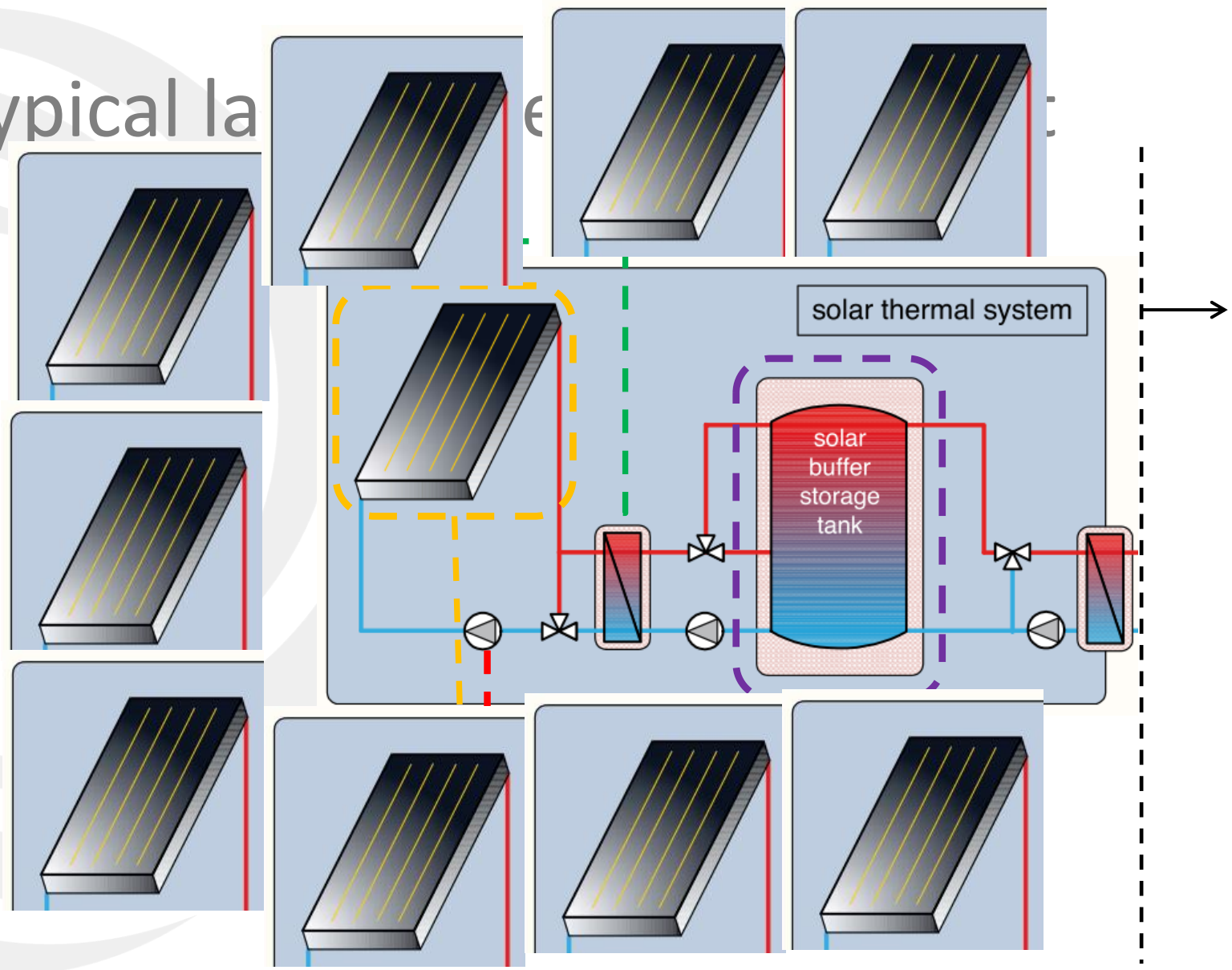


Typical large scale system layout



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

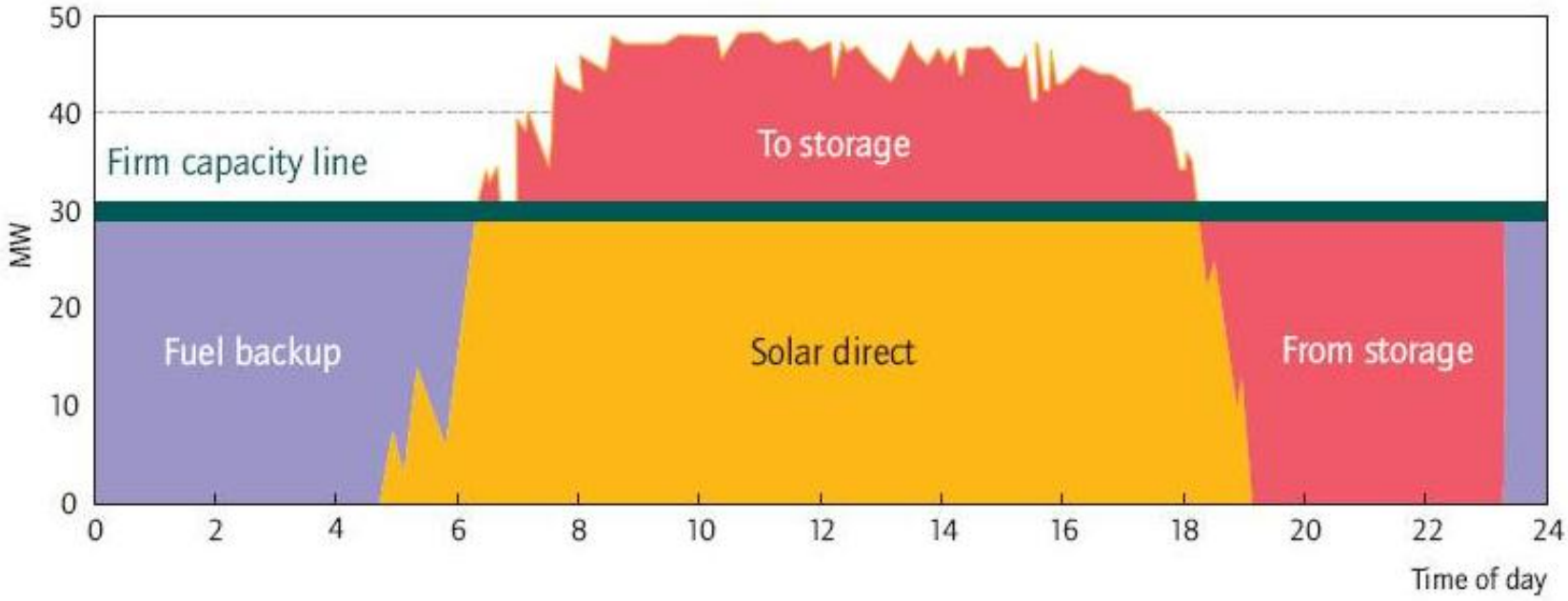
Typical la



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

Thermal storage

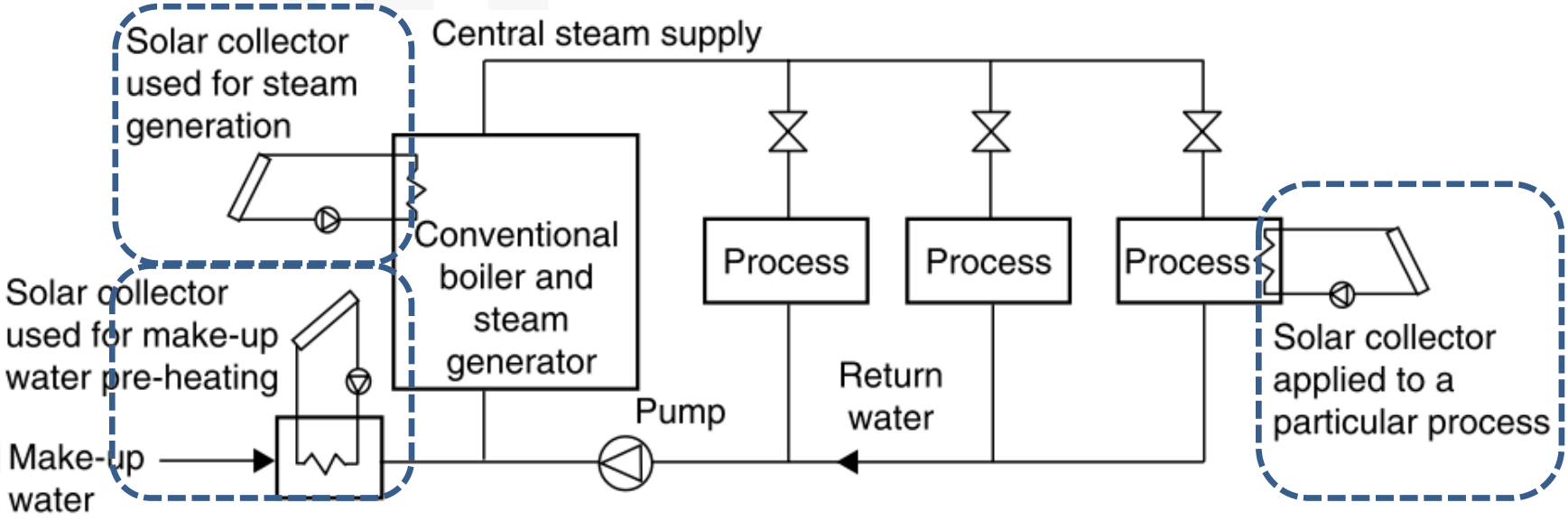
- Store energy for later use
- Add stability to system
- It's like a battery, but for thermal energy



Thermal Storage

Thermal Storage

System integration



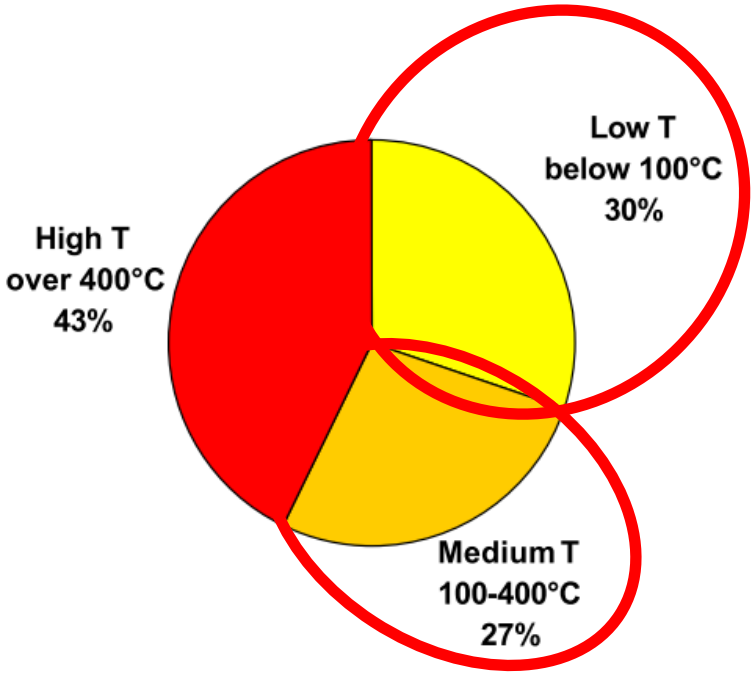
Source: Solar Energy Engineering: Processes and Systems, S.A. Kalogirou, 2009

What it is solar process heat?

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

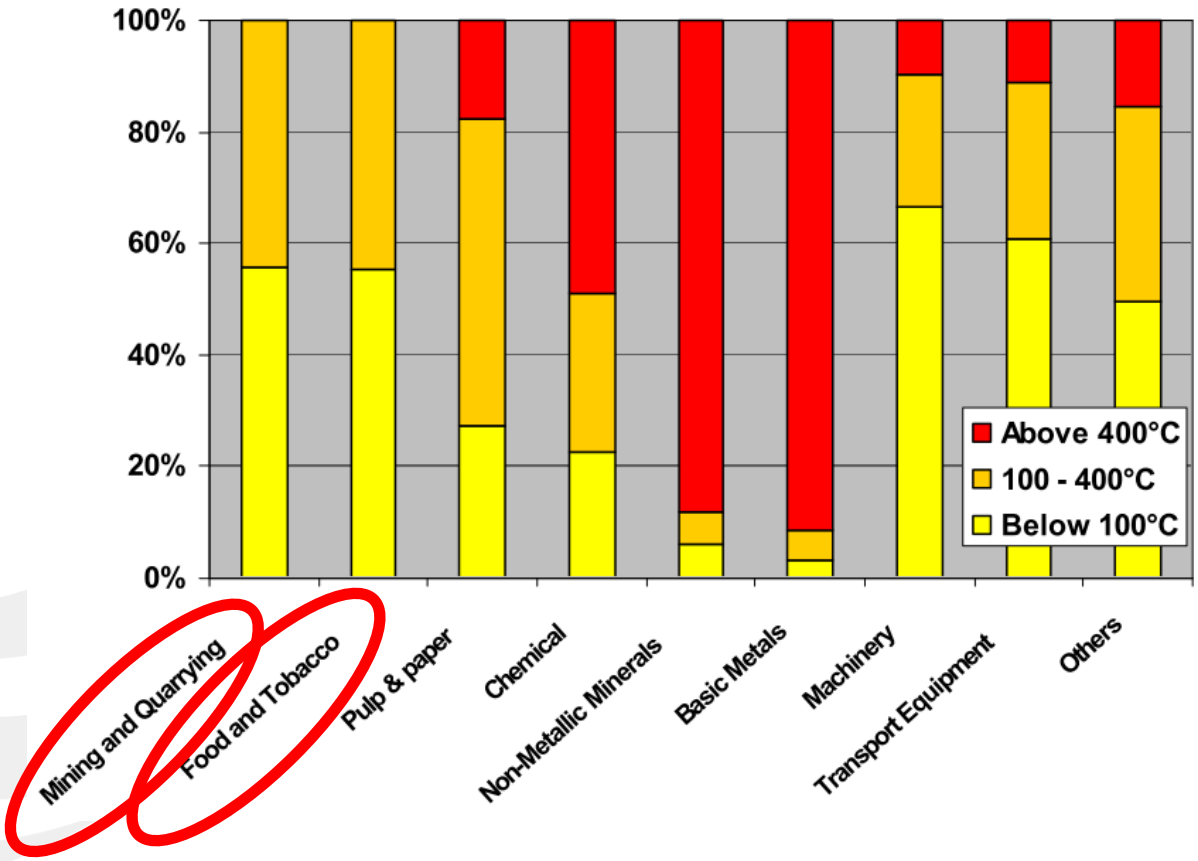
Potential in the industry?

- 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

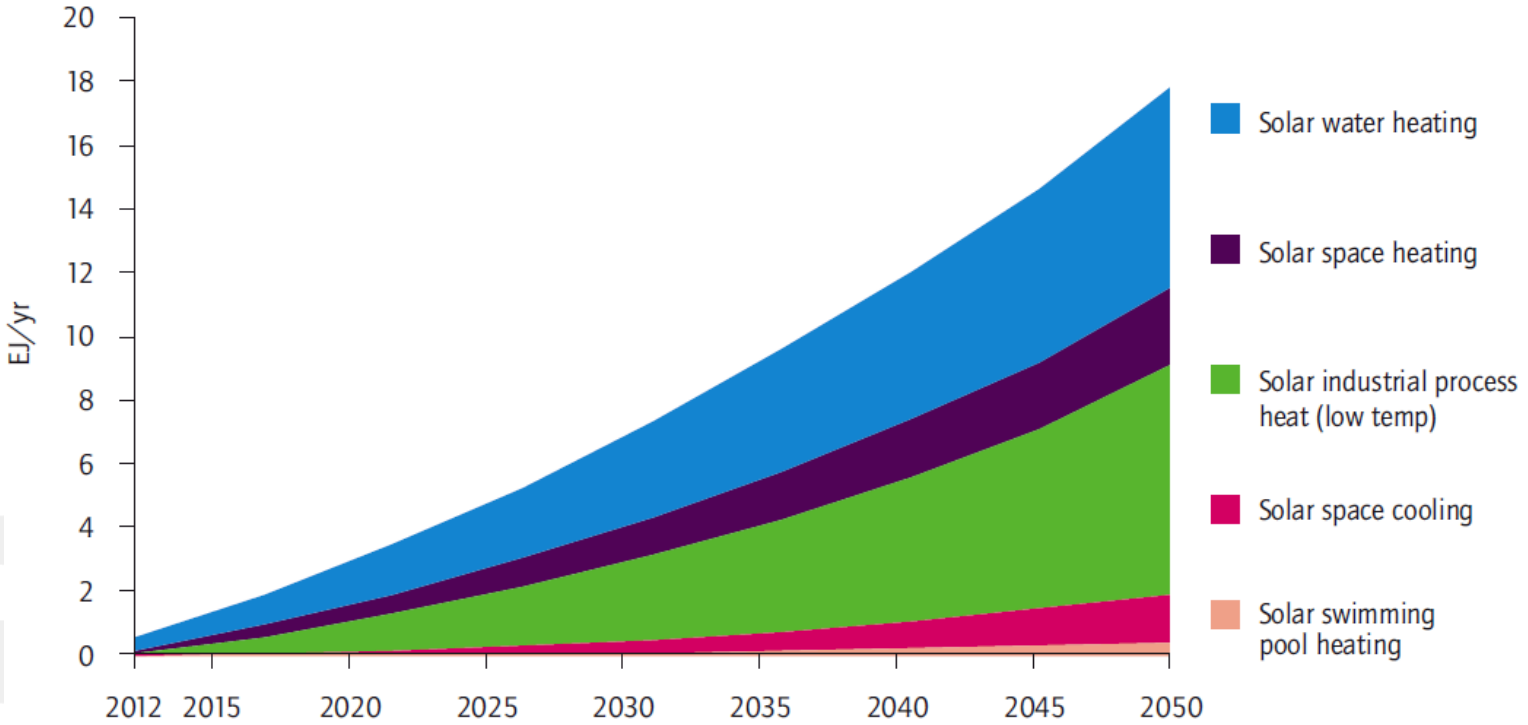


Source: IEA SHC Task33 and SolarPACES TaskIV report:
Potential for Solar Heat in Industrial Processes

Potential

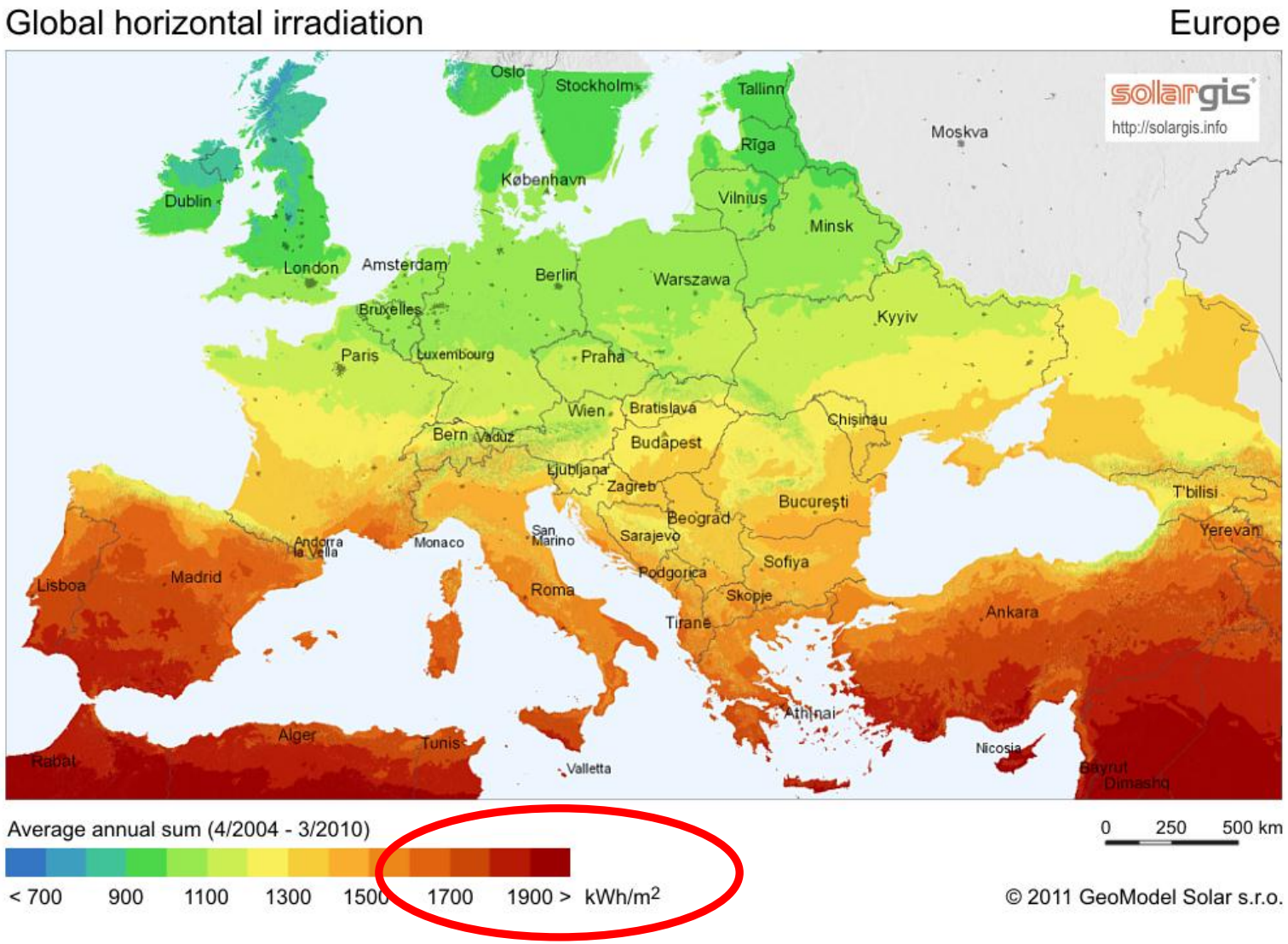
It's important to note that solar cooling should also be considered, especially if used in combination with process heat!

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

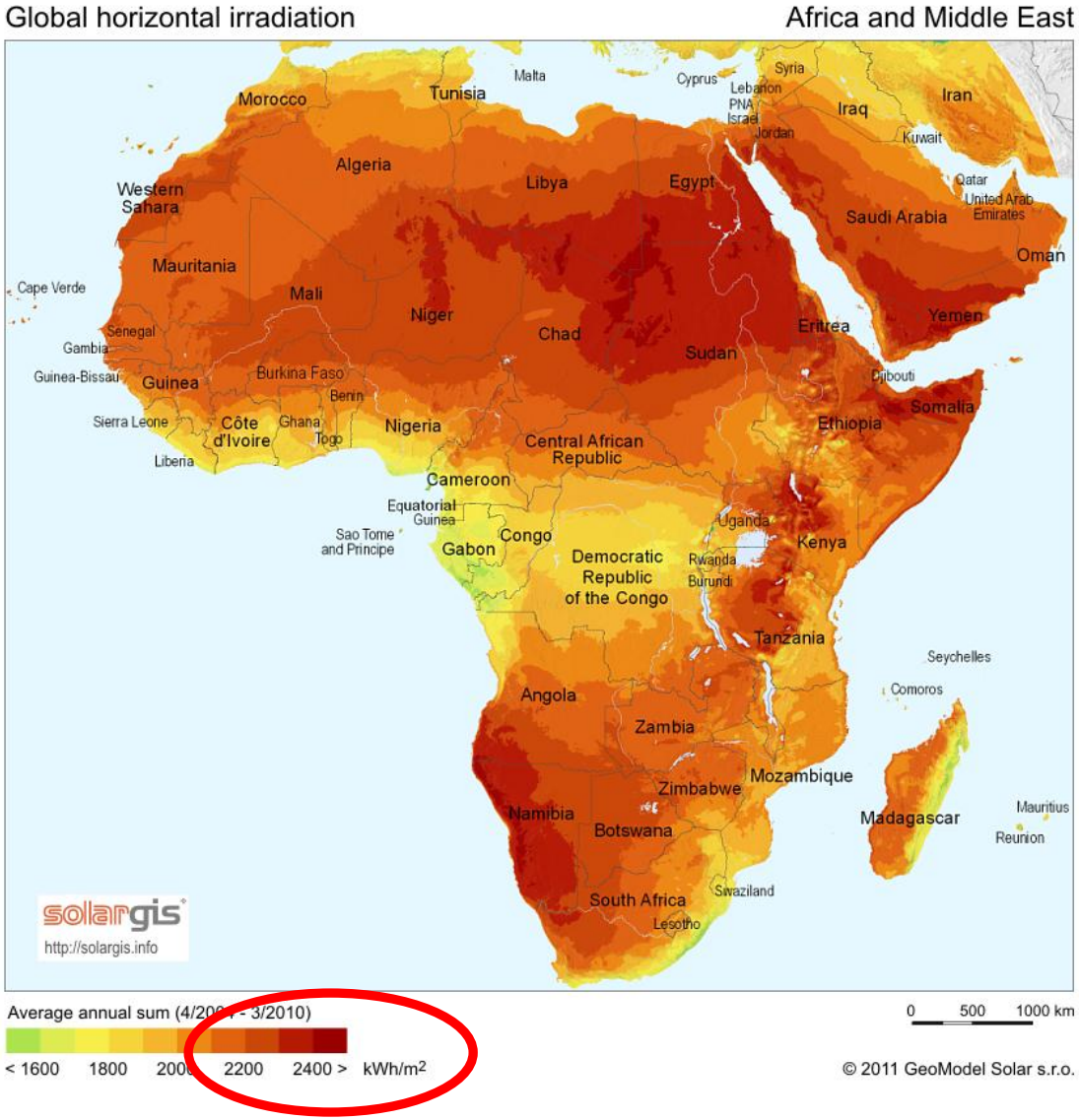


Source: IEA Technology Roadmap for Solar Heating and Cooling, 2012

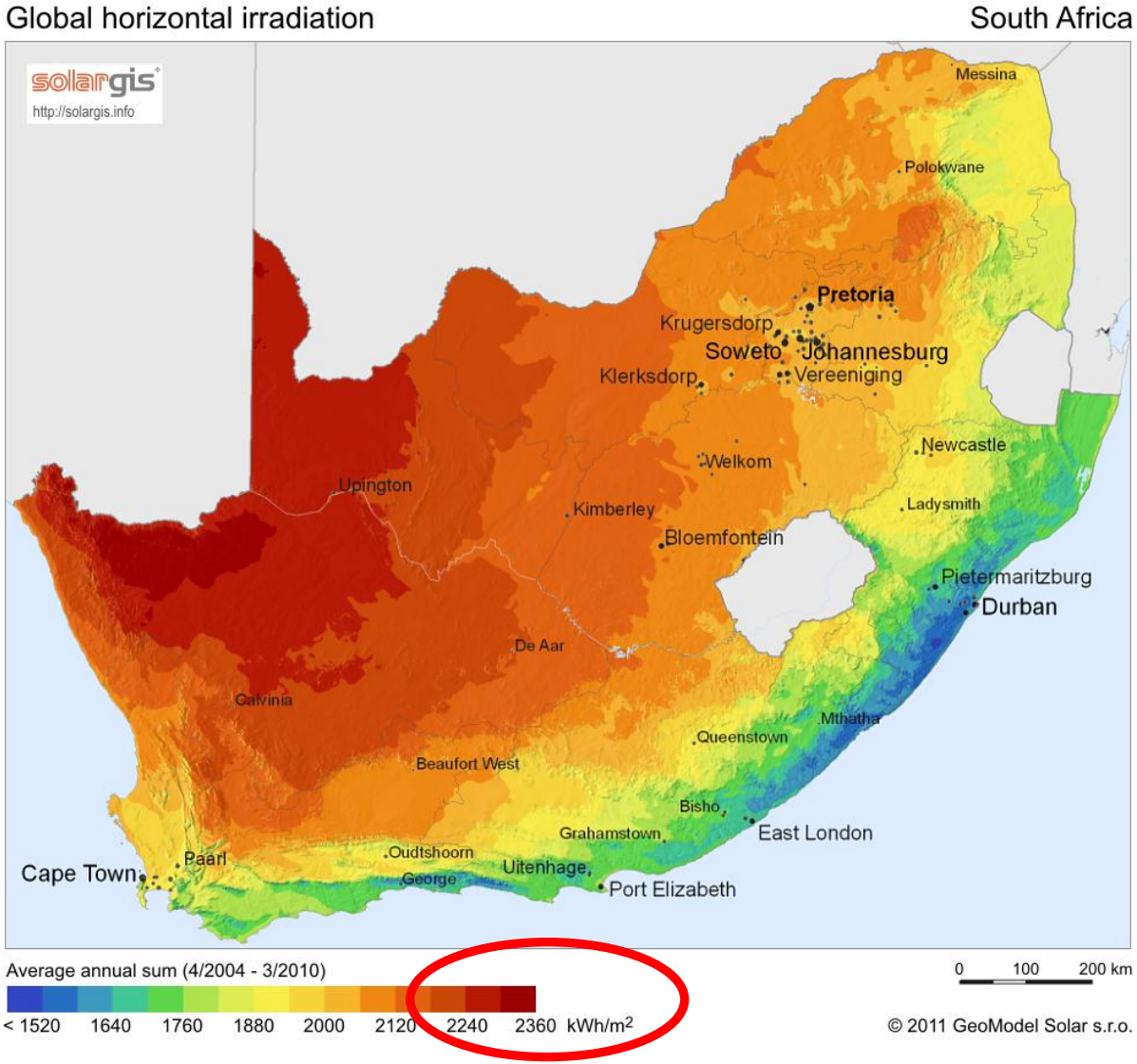
Potential


Global horizontal irradiation
Europe
solargis
http://solargis.info
Oslo
Stockholm
Tallinn
Moskva
Rīga
København
Dublin
Vilnius
Minsk
London
Amsterdam
Berlin
Warszawa
Bruxelles
Kyyiv
Paris
Luxembourg
Praha
Wien
Bratislava
Chişinău
Bern
Vaduz
Budapest
Ljubljana
Zagreb
Bucureşti
T'bilisi
Beograd
Yerevan
San Marino
Andorra la Vella
Monaco
Sarajevo
Madrid
Sofiya
Podgorica
Lisboa
Roma
Skopje
Ankara
Tirane
Athinai
Alger
Tunis
Nicosia
Rabat
Valletta
Bayrut
Dimashq
Average annual sum (4/2004 - 3/2010)
< 700
900
1100
1300
1500
1700
1900 >
kWh/m2
0
250
500 km
© 2011 GeoModel Solar s.r.o.

Potential


Global horizontal irradiation
Africa and Middle East
Malta
Cyprus
Syria
Lebanon
PNA
Israel
Jordan
Iraq
Iran
Kuwait
Qatar
United Arab Emirates
Saudi Arabia
Oman
Yemen
Morocco
Tunisia
Algeria
Libya
Egypt
Western Sahara
Mauritania
Cape Verde
Mali
Niger
Chad
Sudan
Eritrea
Djibouti
Senegal
Gambia
Guinea-Bissau
Guinea
Burkina Faso
Benin
Sierra Leone
Côte d'Ivoire
Ghana
Togo
Liberia
Nigeria
Central African Republic
Ethiopia
Somalia
Cameroon
Equatorial Guinea
Sao Tome and Principe
Gabon
Congo
Democratic Republic of the Congo
Uganda
Rwanda
Burundi
Kenya
Tanzania
Seychelles
Comoros
Angola
Zambia
Zimbabwe
Mozambique
Namibia
Botswana
Madagascar
Mauritius
Reunion
South Africa
Swaziland
Lesotho
solargis
http://solargis.info
Average annual sum (4/200 - 3/2010)
< 1600
1800
200
2200
2400 >
kWh/m2
0
500
1000 km
© 2011 GeoModel Solar s.r.o.

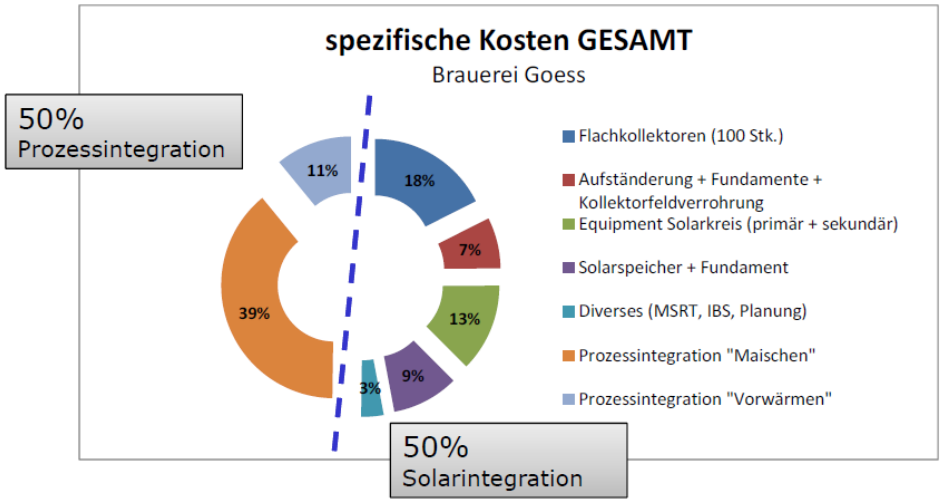
Potential


Global horizontal irradiation
South Africa
solargis
http://solargis.info
Messina
Polokwane
Pretoria
Krugersdorp
Soweto
Johannesburg
Klerksdorp
Vereeniging
Newcastle
Welkom
Upington
Kimberley
Ladysmith
Bloemfontein
Pietermaritzburg
Durban
De Aar
Calvinia
Mthatha
Queenstown
Beaufort West
Bisho
East London
Grahamstown
Oudtshoorn
Paarl
Cape Town
George
Uitenhage
Port Elizabeth
Average annual sum (4/2004 - 3/2010)
< 1520 1640 1760 1880 2000 2120 2240 2360 kWh/m2
0 100 200 km
© 2011 GeoModel Solar s.r.o.

Example: Gösser Brewery in Austria

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

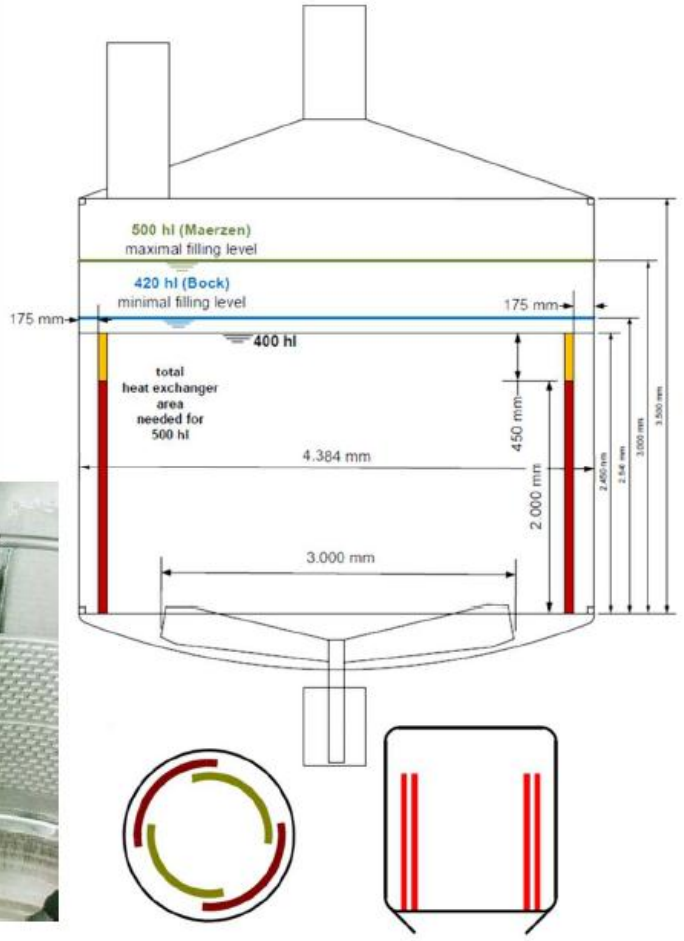
Example: Gösser Brewery in Austria

Gleisdorf Solar 2012 - 13.09.2012

Brauerei Göss - Österreich

Solare Wärmeintegration

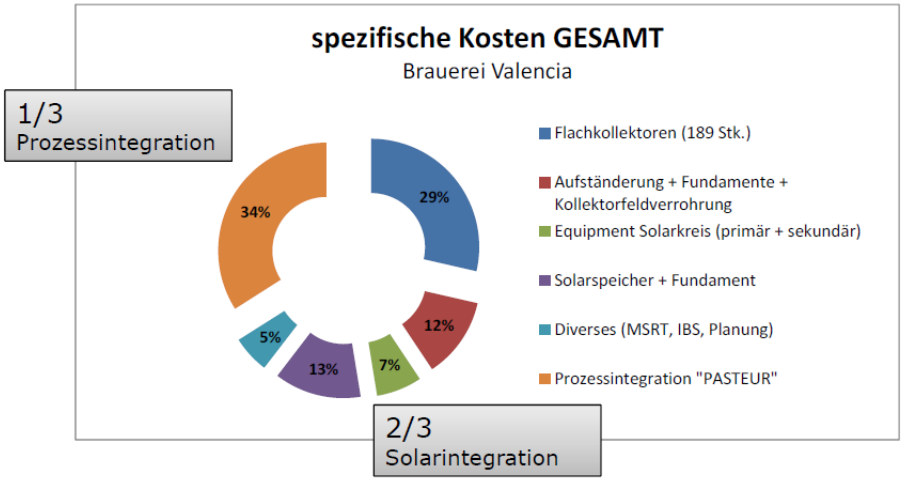
- 20 – 27 Sude/Woche
  - min. 400 hl/Sud
  - ca. 75 – 90 min/Sud
- Nachrüstung von „dimple plates"



Example: Heineken Brewery in Spain

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

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TRADE MARK Heineken®

Example: Heineken Brewery in Spain

Gleisdorf Solar 2012 - 13.09.2012

Brauerei Valencia - Spanien

Why SHIP in SA is good

- We have significantly higher solar resources
- We have more clear-sky days
- We generally have higher ambient temperatures
- We can manufacture the components locally
- We should have cheaper installation costs
- We have the right industries for integration

Thank you

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Stellenbosch University

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