

World's First Commercial Application for “HELISOL[®] 5A” new silicone based HTF

— Royal Tech 50 MW Trough project
in Yumen, Gansu, China

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SolarPACES 2017 — Technology Innovation Award

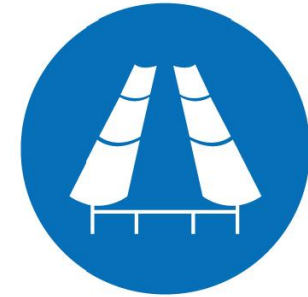
George Dou, Dr. Fridolin Stary, Erich Schaffer



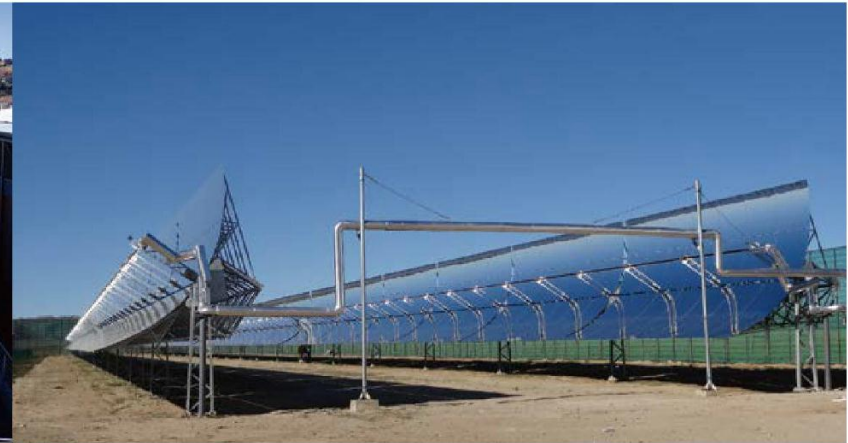
Vaccum Receivers



Solar Process Heat & Cooling



Trough CSP Projects Developing



“Phase 1” Factory
with **80,000** Pcs / yr



“Phase 2” factory with **240,000** Pcs / yr in construction



Land area 54,000m²

Building area 24,000m²

Total Investment \$28 milion

120,000pcs/yr/line x 2

In total 300,000+ pcs/yr max.

Able to supply around **600MW** linear CSP Projects



50MW Trough Power Plant
5,000 Pcs supplied since 2014



Puerto Errado 1 project in Spain Molten salt receivers

40 pcs of RTUVR Molten Salt Receivers since 2014

0 breakage
0 complaint



Cooperation with FRENELL/NOVATEC

Molten salt receiver
40 pcs trial order

2014

Field Tests

Molten salt receiver

2 years co-development

Reference letter



Customized
DSG vacuum receiver 1,000pcs

Supervision

2016

Not installed at hot end

Optimization of MT coating for 550°C
7,000+ hrs Ageing Test

Comment:

NTPC Dadri ISCC Project
First in Asia.



We are absolutely convinced that Royal Tech is capable to compete and even beat its competitors from technological as well as commercial point of view. Considering the progress Royal Tech made in these regards within the last two years and the outlook for 2017 with new manufacturing facility, we see Royal Tech future development very optimistic and extremely confident.

To conclude, I would also like to express my conviction that we cooperation as we are looking forward to future joint projects.

Yours sincerely,
Dr. Max Mertins

Registered Office:
FRENELL GmbH

Tel.:

USt-IdNr.: DE25



Dadri

Site for Solar Thermal Hybrid Plant



EU Horizon 2020

30pcs of RTUVR receivers
have been installed for the solar steam project

Innovated by Heliovis



Industrial Solar GmbH



Typical Project References



2010 Doha Qatar World Cup Stadium Cooling



2014 South Africa MTN Cooling



2015 Jordan Pharmaceutical Factory Heat

- 
- 20 projects selected into Chinese 1st Round of National Demonstration Projects
 - Total capacity 1.35 GW, FIT price at 1.15 RMB/Kwh
 - Royal Tech won 250 MW in total, 100 + 50 MW, 2 project as the developer & another 100MW as the technology provider

	Urat 100MW thermal oil parabolic trough CSP project
Capacity	100MWe
Location	Inner Mongolia
DNI	Around 2,000
Technology	Parabolic Trough
HTF type	Thermal oil
Solar Field Aperture area	1,226,250m ²
Number of loops	375
Storage capacity	10 hours
Storage medium	Molten salt



World's 1st Commercial Project to use Wacker HELISOL[®] 5A Silicone Oil

	Yumen 50MW CSP projec
Capacity	50MWe
Location	Gansu
DNI	Around 1,900
Technology	Parabolic Trough
HTF type	Helisol [®] 5A
Solar Field Aperture area	627,840m ²
Number of loops	200
Storage capacity	9 hours
Storage medium	Molten salt



Up to 5 % LCOE Reduction Potential

CAPEX

- + Reduced TES cost
- + No freeze protection
- + Filling at any time (temperature independent)
- + No Ullage needed for viscosity control
- Higher vapor pressure to be considered

Revenue (electricity sold)

- + Working temperature: - 40°C to 425°C

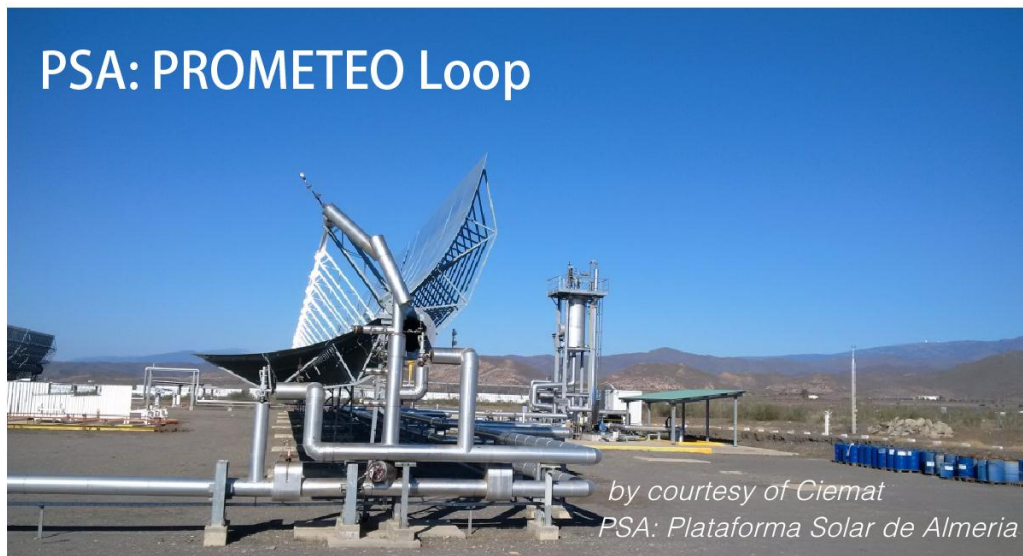
OPEX

- + No recirculation for freeze protection
- + Maintenance at any time
- + Less pump energy (low viscosity)
- + Shorter start up period
- + Lower degradation/exchange rate at same temperature
- + Lower H₂ generation
- + No fouling

$$\text{LCOE} = \frac{\text{CRF} * \sum \text{CAPEX} + \sum \frac{\text{OPEX}}{\text{Year}}}{\frac{\text{Revenue}}{\text{Year}}}$$

LCOE: Levelized cost of electricity, CRF: Capital recovery factor

PSA: PROMETEO Loop



Royal Tech (CN)



SITEF: A public funded project (2016–2017)

- ▶ Cooperation partners : CIEMAT, DLR, TSK-Flagsol, TÜV-Nord, Senior Flexonics, Innogy
- ▶ Early operation @ 400°C
- ▶ Proof of Concept at 425°C

Supported by:



Federal Ministry
for Economic Affairs
and Energy

on the basis of a decision
by the German Bundestag

Royal Tech

- ▶ Loop configuration similar to Spain's CSP plants
- ▶ Operating temperature up to 430°C
- ▶ Royal Tech will realize a 50 MW plant in YUMEN (China)

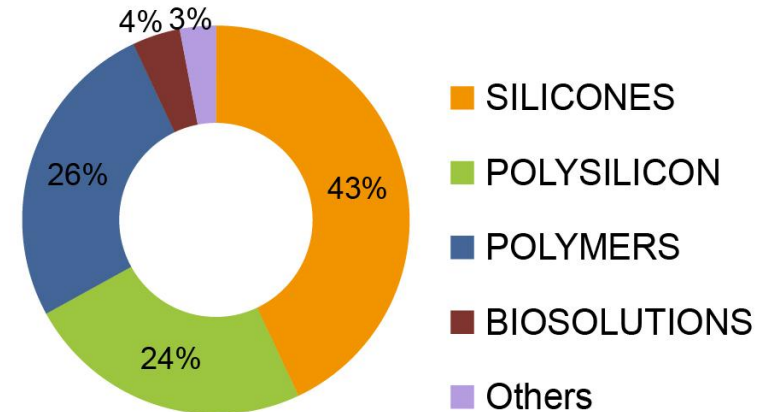
Wacker Chemie AG

- ▶ Founded in 1914 by Dr. Alexander Wac
- ▶ Headquartered in Munich

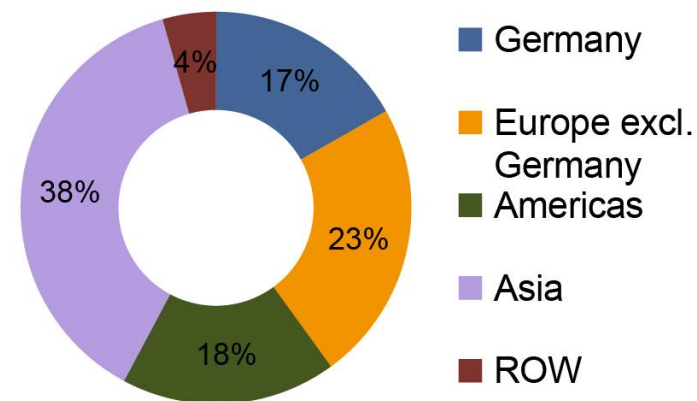
WACKER Group (2016)*

- ▶ Sales: €4.63 billion
- ▶ EBITDA: €956 million
- ▶ R&D: €150 million
- ▶ Investments: €338 million
- ▶ Employees: 13,448

Business 67% Si-based



60% of Sales Outside Europe



Burghausen, Germany



Zhangjiagang, China



Nünchritz, Germany



Tennessee, USA



15 Months of successful operation in "Urat"

Start to operate with HELISOL[®] 5A at high temperature in April, 2016

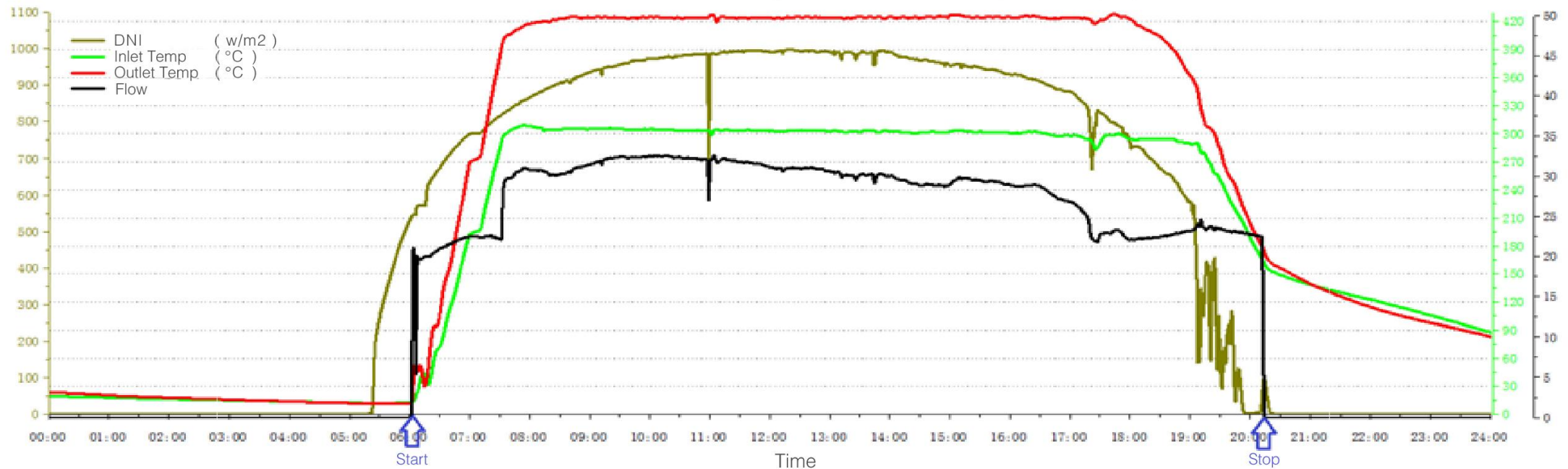
The Demo Loop (built & operated since 2013) finished adaption and started Silicone application from 4, 2016



Key Points:

- ▶ Ambient Temp: $< -30^{\circ}\text{C}$ in Winter
- ▶ Outlet Temp: 425°C
- ▶ No System Failure at all
- ▶ All KPIs Targeted Achieved

the run data of Silicone Oil system in Demo Loop – 2017/06/07



2019

World's 1st PT Commercial Power Plant (50MW)

With Operation Temp $>400^{\circ}\text{C}$ in "Yumen"



For a prosperous CSP industry & better world