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
Business Sectors

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 million
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

Online RTUVR receivers with Siemens
0 breakage
0 complaint
Puerto Errado 1 project in Spain
Molten salt receivers

40 pcs of RTUVR Molten Salt Receivers since 2014

0 breakage
0 complaint
Cooperation with FRENNEL/NOVATEC

Molten salt receiver
40 pcs trial order

2014

Field Tests

Molten salt receiver

2 years co-development

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

Not installed at hot end

Reference letter

Customized vacuum receiver

DSG

Supervision

1,000 pcs

2016

NTPC Dadri ISCC Project
First in Asia.

Comment:

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 are 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
EU Horizon 2020

Innovated by Heliovis

30pcs of RTUVR receivers have been installed for the solar steam project.
Industrial Solar GmbH

Modularized CSP Fresnel Solar Thermal Solutions for Process Heat

Typical Project References

- 2010 Doha Qatar World Cup Stadium Cooling
- 2014 South Africa MTN Cooling
- 2015 Jordan Pharmaceutical Factory Heat
CSP Trough Power Plant Developing

- **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
| **Capacity** | 100MWe |
| **Location** | Inner Mongolia |
| **DNI** | Around 2,000 |
| **Technology** | Parabolic Trough |
| **HTF type** | Thermal oil |
| **Solar Field Aperture area** | 1,226,250m² |
| **Number of loops** | 375 |
| **Storage capacity** | 10 hours |
| **Storage medium** | Molten salt |
# World’s 1st Commercial Project to use Wacker HELISOL® 5A Silicone Oil

<table>
<thead>
<tr>
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<th>Yumen 50MW CSP projec</th>
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</thead>
<tbody>
<tr>
<td><strong>Capacity</strong></td>
<td>50MWe</td>
</tr>
<tr>
<td><strong>Location</strong></td>
<td>Gansu</td>
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<tr>
<td><strong>DNI</strong></td>
<td>Around 1,900</td>
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<tr>
<td><strong>Technology</strong></td>
<td>Parabolic Trough</td>
</tr>
<tr>
<td><strong>HTF type</strong></td>
<td>Helisol®5A</td>
</tr>
<tr>
<td><strong>Solar Field Aperture area</strong></td>
<td>627,840m²</td>
</tr>
<tr>
<td><strong>Number of loops</strong></td>
<td>200</td>
</tr>
<tr>
<td><strong>Storage capacity</strong></td>
<td>9 hours</td>
</tr>
<tr>
<td><strong>Storage medium</strong></td>
<td>Molten salt</td>
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</tbody>
</table>
WHY HELISOL®?

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

**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

\[
\text{LCOE} = \frac{\text{CRF} \times \sum \text{CAPEX} + \sum \frac{\text{OPEX}}{\text{Year}}}{\text{Revenue} \div \text{Year}}
\]

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

PSA: PROMETEO Loop

by courtesy of CIEMAT
PSA: Plataforma Solar de Almeria

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

Royal Tech (CN)

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)

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag
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
Globally Present – Sales, Production and R&D

Burghausen, Germany
- 8,000 Employees
- €150 mn Investment per Year

Zhangjiagang, China
- Silicons Since 1998

Nünchritz, Germany
- Silicons
- PV Silicon

Tennessee, USA
- PV Silicon
- Investment > €2 bn, since 2016
15 Months of successful operation in “Urat”

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

Key Points:
- Ambient Temp: <-30°C in Winter
- Outlet Temp: 425°C
- No System Failure at all
- All KPIs Targeted Achieved

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

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°C in “Yumen”
For a prosperous CSP industry & better world