Next Generation Receivers

Workshop NREL
March 8-9

Nikolaus Benz

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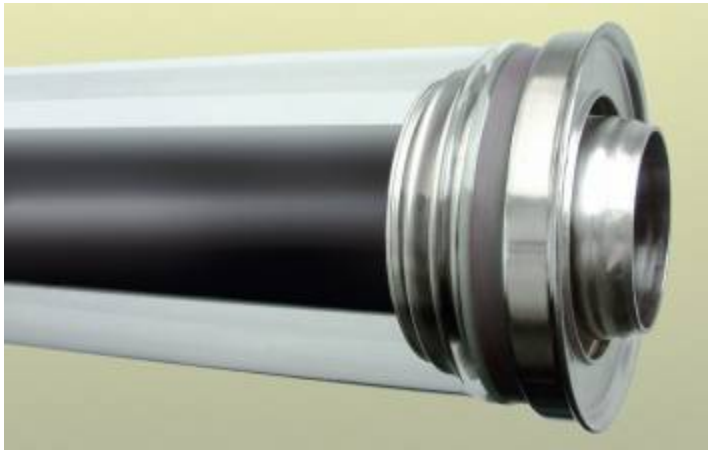
SCHOTT PTR 70 - Receiver for Parabolic Troughs

- Development 2002 - 2005
- techology leader, best performance
- Market introduction in 2006

AR-coated cover tube with high transmittance
solar transmittance ≥ 96%
high abrasion resistance

Fail-save glass-to-metal seal
new material combination with matched coefficients of thermal expansion



Steel tube absorber with highly selective coating
solar absorptance ≥ 95%
emittance ≤ 14% @400°C
High durability

Design with reduced bellow length
active length > 96%

Vacuum insulation
pressure < 10^{-3} mbar
maintained by new getter assemby

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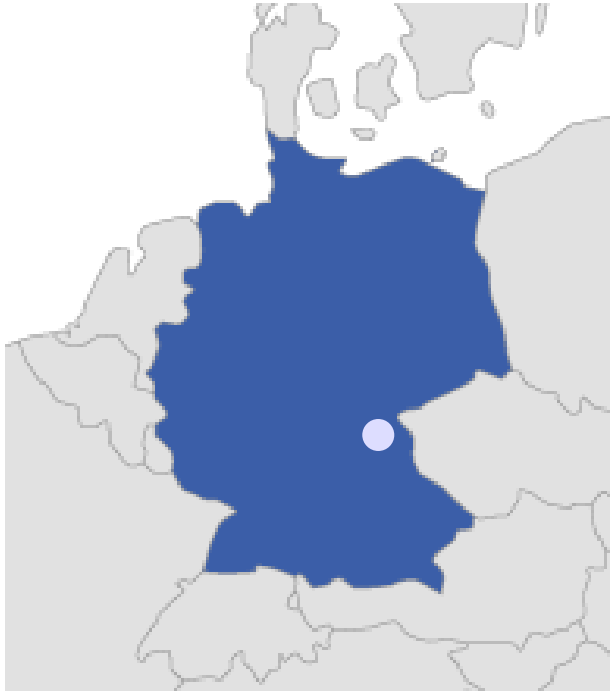
Production Line for Receivers in Germany

- Production Line in Mitterteich, Germany
- Start: August 2006
- Invest: 15 Mio € in E&M
- 80 new jobs in production
- annual capacity about 110 -160 MW



Schott blickt in sonnige Zukunft

15 Millionen Euro in neue Produktionsstraße investiert und damit 80 neue Arbeitsplätze geschaffen

Mitterteich. (upl) Spitzentechnologie für einen Zukunftsmarkt: Seit Anfang August stellt Schott am laufenden Band so genannte „Solarreceiver" für eines der größten Sonnenkraftwerke der Welt her. Am Dienstag hatte die Firmenleitung zur offiziellen Inbetriebnahme der Produktionsstraße geladen.

International besetzt war der Festakt in Mitterteich, zu dem neben Regierungspräsident Dr. Wolfgang Kunert auch Landrat Karl Haberkorn und Bürgermeister Roland Grillmeier gekommen waren, ebenso wie Gäste aus Spanien und den USA. In beiden Ländern kommen die „Solarreceiver" aus der Oberpfalz in den nächsten Jahren zum Einsatz.

Die „Solarreceiver" aus dem Hause Schott gelten derzeit mit als leistungsfähigste Absorbermedien für Sonnenenergie. Sie werden über parabolisch gekrümmten Spiegeln aufgehängt und sammeln große Mengen der aufgefangenen Sonnenenergie ein. Schott-Vorstandsvorsitzender Dr.

Sie tragen die Neuentwicklung aus dem Hause Schott auf Händen (von links): Landrat Karl Haberkorn und Geschäftsführer Dr. Gerrit Sames. In der Mitte Francisco Bas, Generaldirektor der Andalusischen Energieagentur, rechts neben ihm Schott-Vorstandsvorsitzender Dr. Udo Ungeheuer, Regierungspräsident Dr. Wolfgang Kunert und Ralf Christmann vom Bundesumweltministerium. Bild: upl

Lul 12, 2006
SHE/Bz

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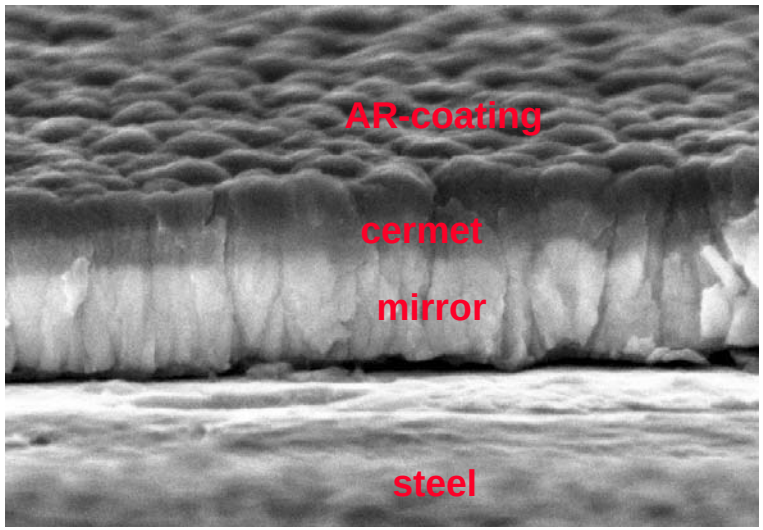
Selective Absorber with Multilayer Cermet for High Temperatures

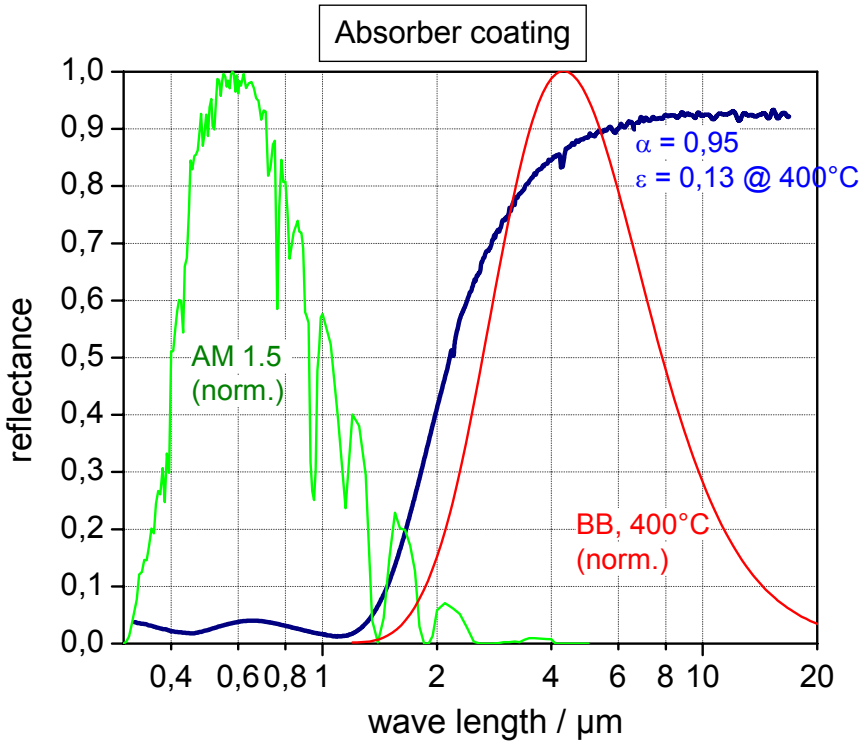
Performance data:

- temperature stable up to 500 °C (short term)
- solar absorptance >= 95 %
- thermal emittance <= 14% at 400°C

Material:

- polished low-carbon steel as substrate material
- Multilayer Cermet coating





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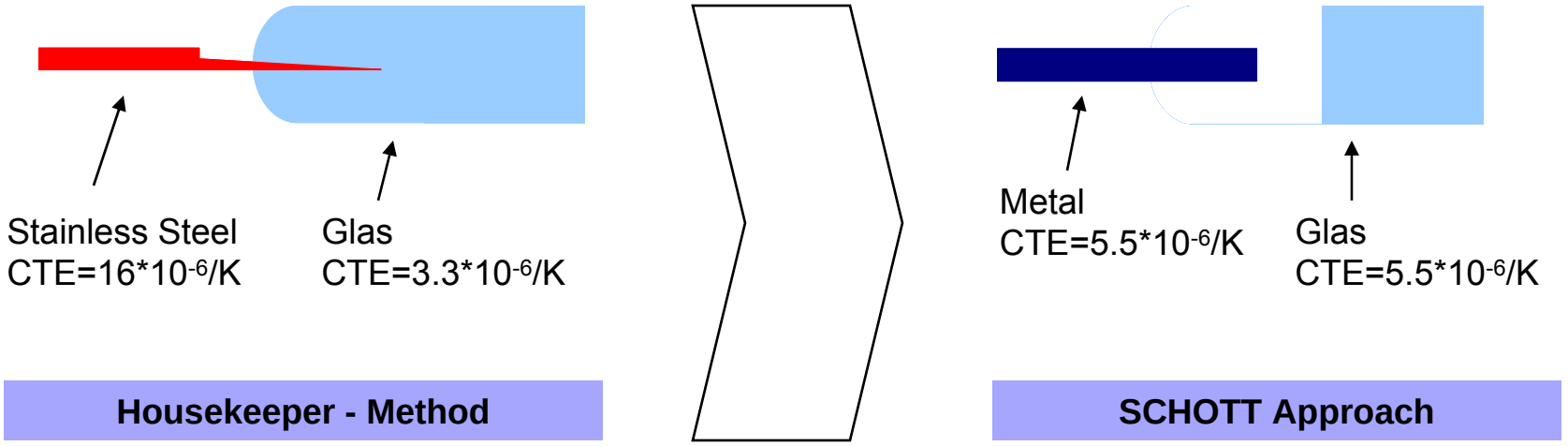
New Glass-to-Metal Seal Improves Strength Properties

- Breakage of glass-to-metal sealing (Housekeeper) is main cause for damages of receivers in existing power plants
- New approach with adapted CTE yields a sealing with low stress
- Only one glass type necessary
- Automated production process



Housekeeper - Method | **SCHOTT Approach**

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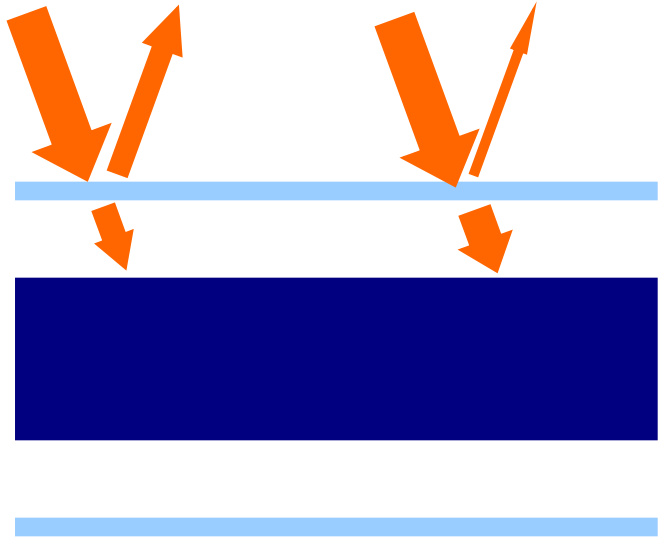
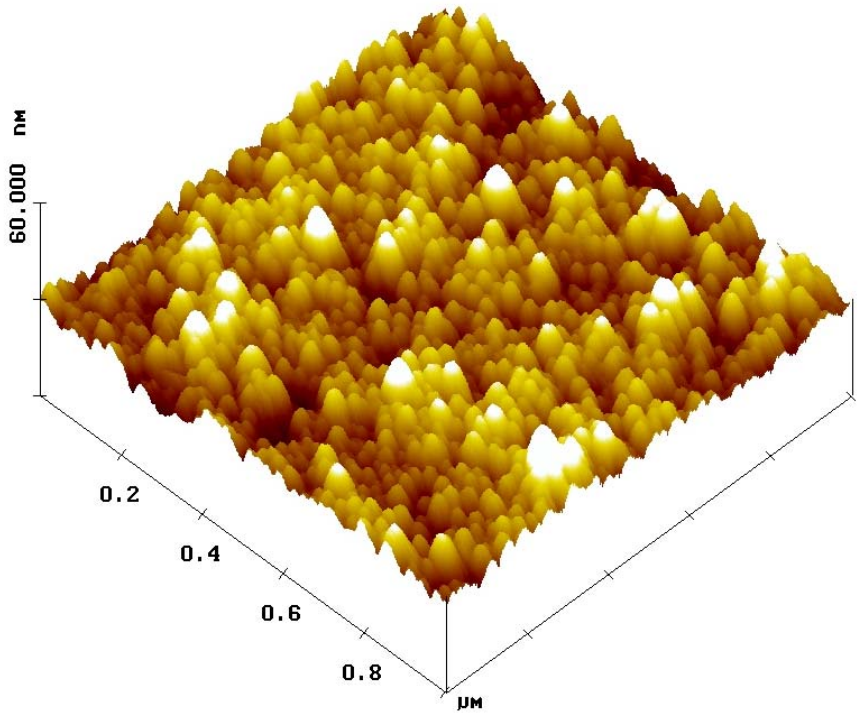
AR Coating with High Solar Transmittance

- Sol-Gel coating based on alcoholic dilutions with SiO_2 nano particles
- high abrasion resistance

Only glass:
τ = 92%

With AR-coating :
τ > 96%





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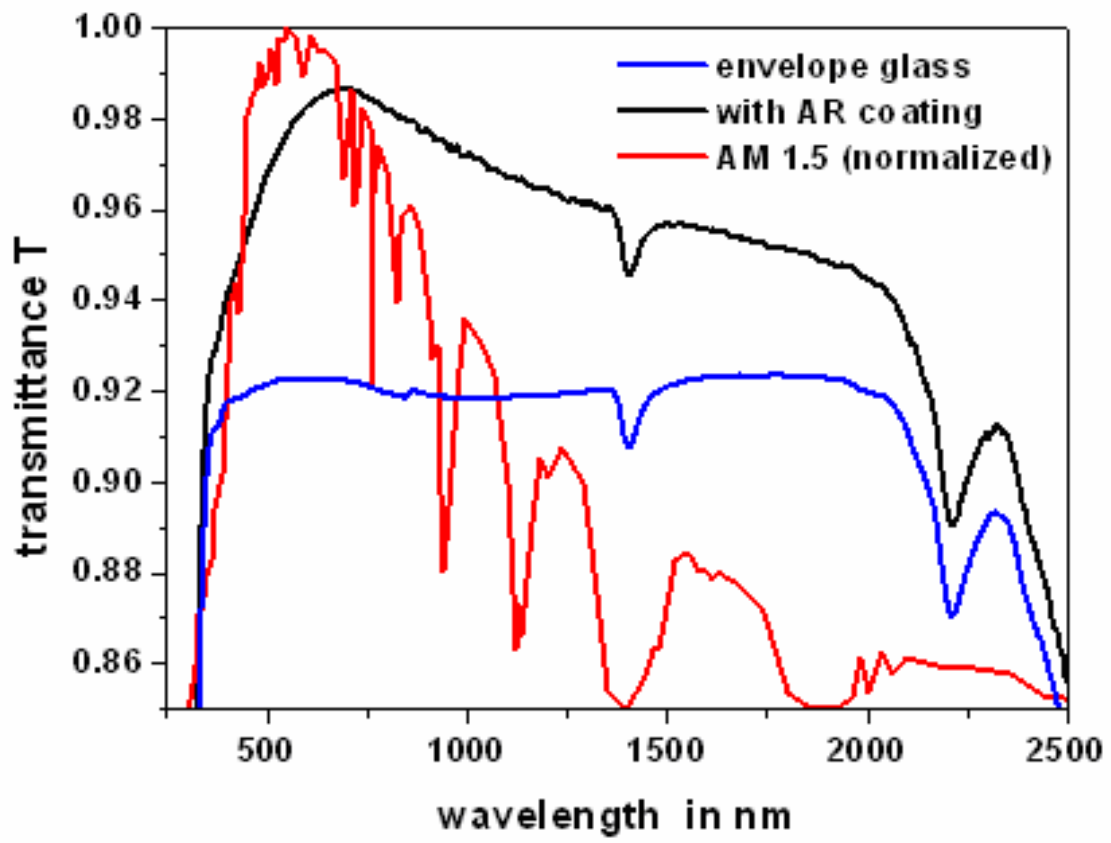
AR Coating with High Solar Transmittance

- transmittance of uncoated glass: 0.92
- transmittance of AR-coated glass: 97%



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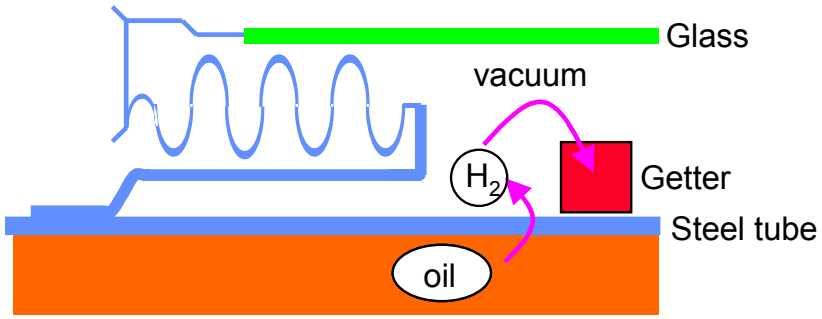
Solutions for Hydrogen Problem

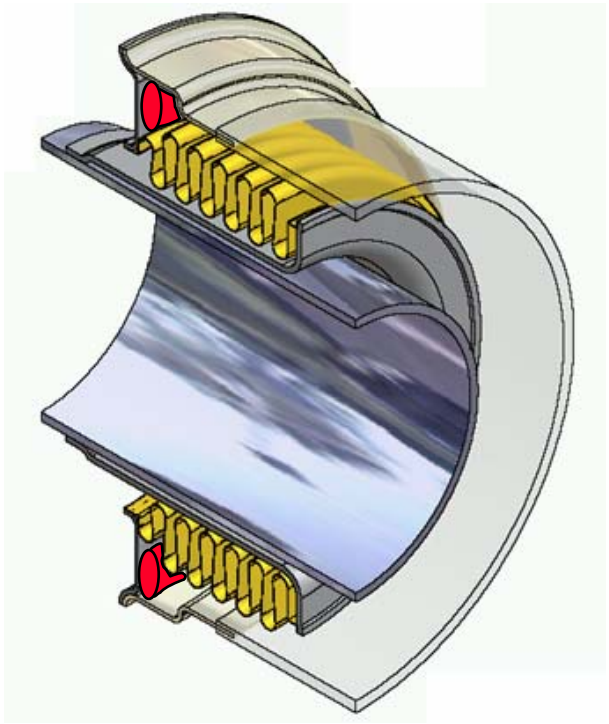
Problem:

- ➔ Thermo oil decomposes during operation, hydrogen is generated.
- ➔ Hydogen permeation through steel absorber tube leads to vacuum loss and increased heat loss (factor 2-3)

Solution:

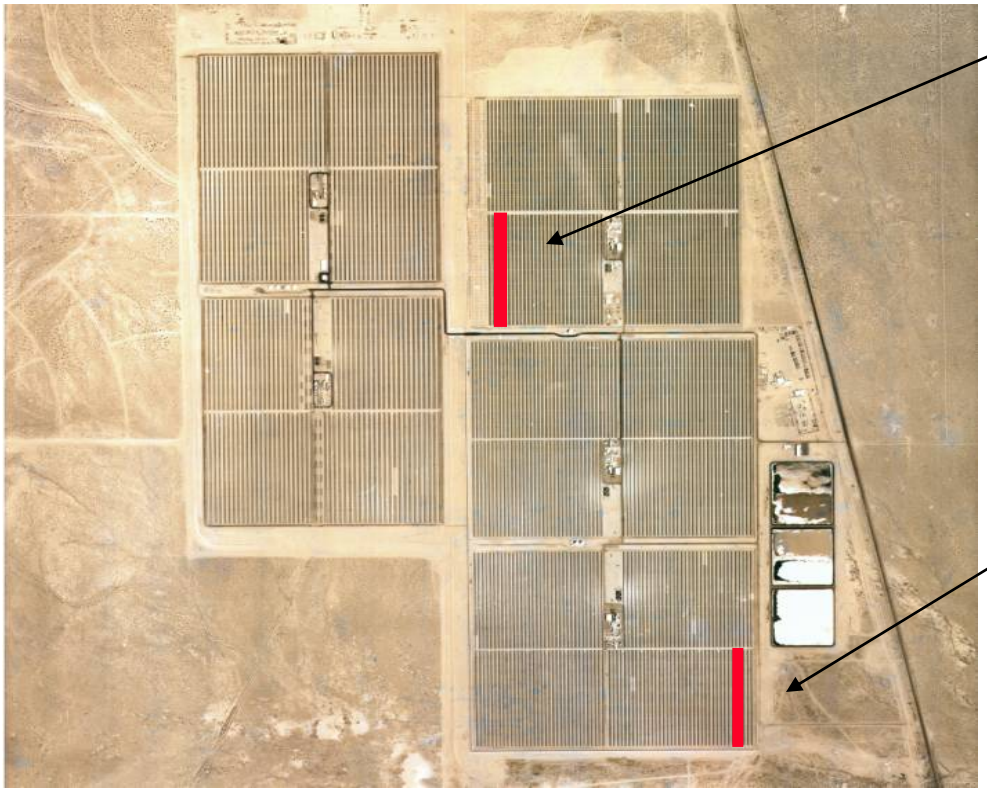
- ➔ Barrier to reduce permeation rate
- ➔ increased getter quantity mounted in „cool“ place





Field Test in Power Plant

- Successful field test with 300 receivers since October 03
- 2 % increase in preformance compared to previously installed tubes of competitor



SKAL-ET test loop

Durability test for GMS

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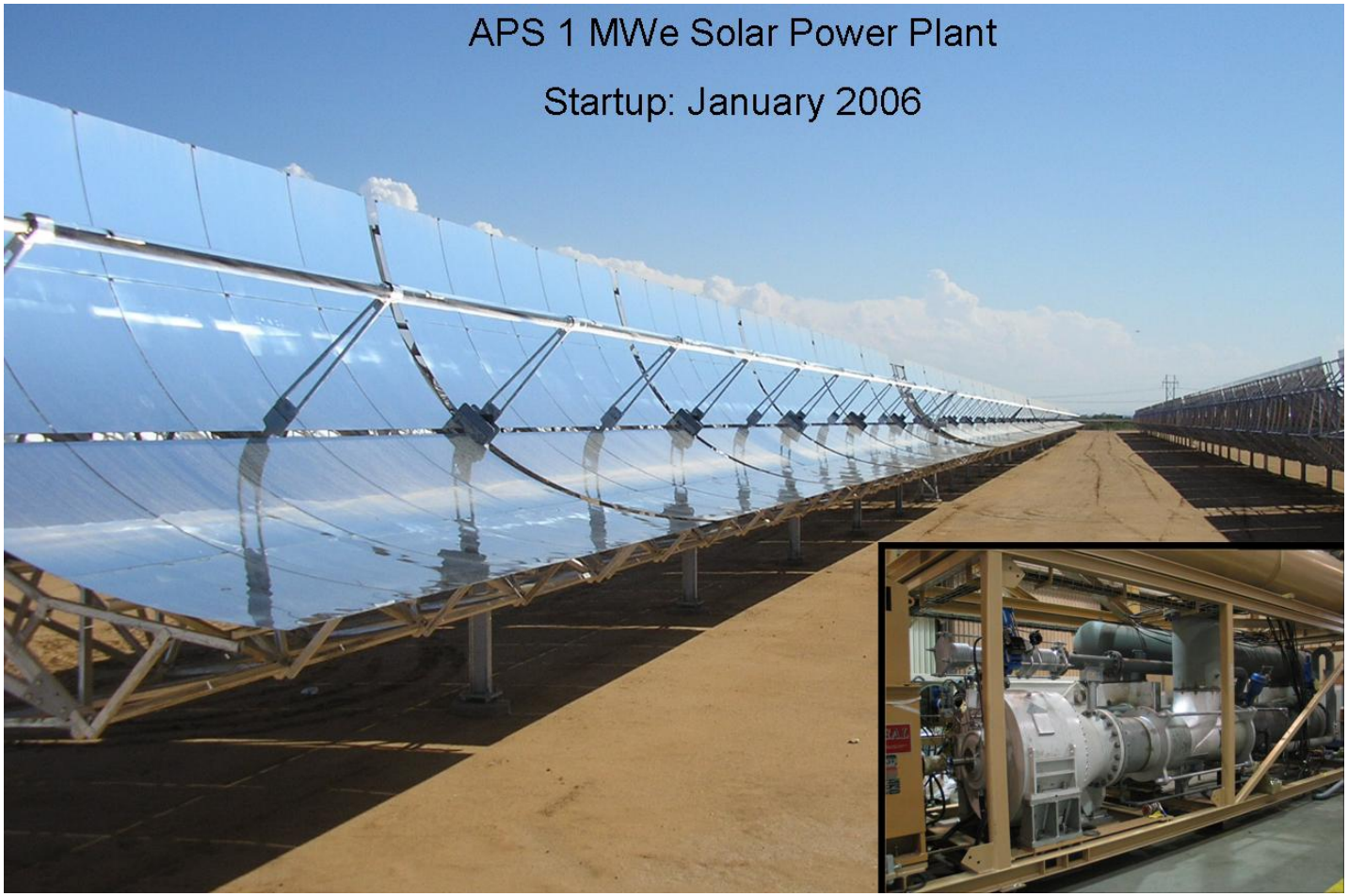
APS 1 MW Solar Power Plant

First parabolic trough plant since 1990



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Nevada Solar One Power Plant

- Size: 64 MW solar only
- annual capacity: 130 GWh
- mirror area: 357,200 m²
- Project developed by SolarGenix Energy since March 2003
- Under construction since February 2006, on grid in spring 2007
- 20 years PPA with Nevada Power Company and Sierra Pacific Power Company

(Coutesy of Acciona Solar Power Inc)

Boulder City, NV

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Production Line for Receivers in Spain

- 2nd production line in Spain (region Seville)
- production start: spring 2008
- capital expenditure: 22 Mio €
- annual capacity about 110 - 160 MW

Schott stärkt Solar-Geschäft

Glasspezialist investiert weitere 22 Millionen Euro in Receiver-Produktion

Von
Ralf Heidenreich

MAINZ Die Mainzer Schott AG stärkt ihren Solarbereich mit einer weiteren Großinvestition. Wie der Hightech-Glas-Hersteller gestern mitteilte, baut Schott in Spanien ein zweites Werk für so genannte Solarreceiver (siehe Kasten). Das Investitionsvolumen beträgt 22 Millionen Euro. Damit steigen die in diesem Jahr von Schott angestoßenen Investitionen in das Solargeschäft auf knapp 100 Millionen Euro. Erst im August hatte das Unternehmen eine Produktionslinie

dulen zur Stromerzeugung. Hier belaufen sich die Investitionen auf 60 Millionen Euro. „Solar ist ein wichtiges Zukunftsgeschäft für Schott. Parabolrinnenkraftwerke bieten ein enormes Potenzial für die Energieversorgung der Zukunft", sagte Vorstandschef Udo Ungeheuer. Schott sei bei Receivern weltweit Technologieführer. „Unser Ziel ist es, auch Marktführer zu werden." Die zweite Fertigungslinie werde in Spanien aufgebaut, „weil dort unsere europäischen Kunden sitzen und der Mittelmeerraum ein viel versprechender

Solarreceiver

Solarreceiver sind eine Schlüsselkomponente für solarthermische Parabolrinnenkraftwerke. Diese Kraftwerke bestehen aus parabolisch gewölbten Spiegeln, die das Sonnenlicht auf Receiver (Absorberrohre) bündeln. In den Receivern wird die Sonnenstrahlung in Wärme umgesetzt und an ein zirkulierendes Spezialöl abgegeben. Das Öl erhitzt sich auf bis zu 400 Grad, wird dann zum Kraftwerksblock gepumpt, durch-

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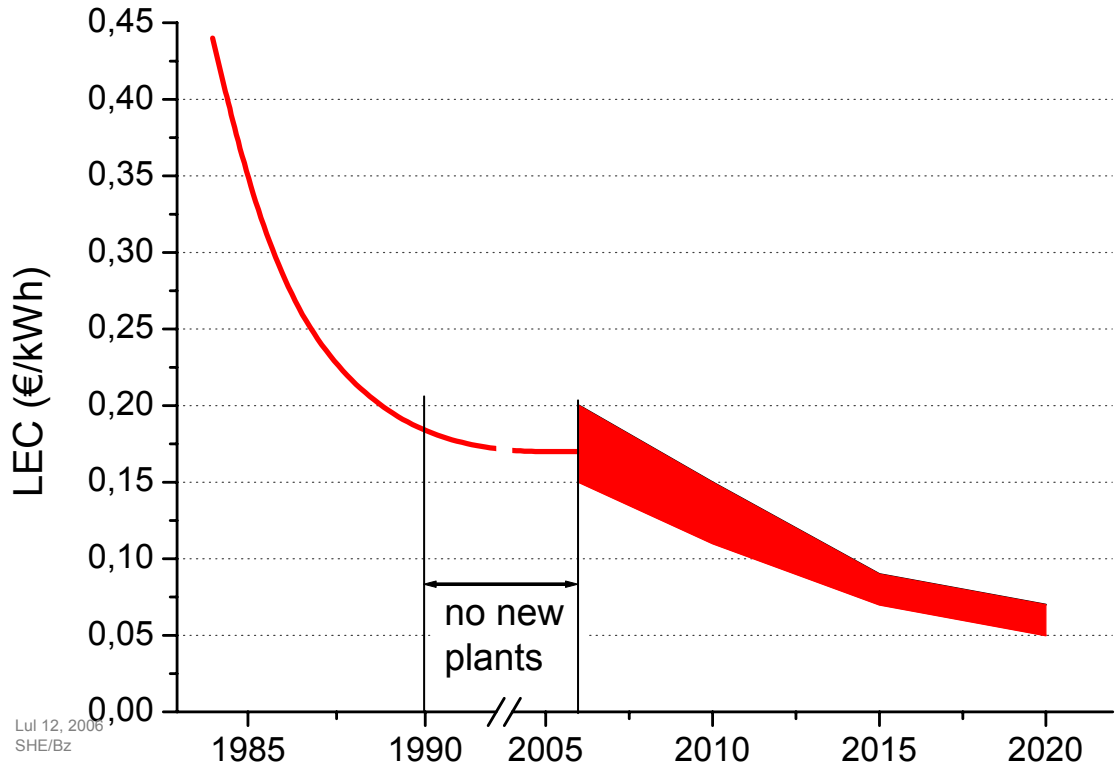
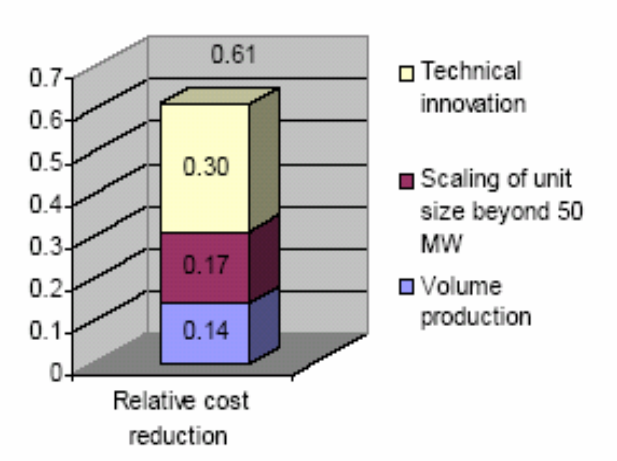
Roadmap for Parabolic Trough Plants

What brings the cost down?

- better design of components and system, improved production technology
- improving the overall efficiency
- increasing the full load hours by using thermal storage
- bigger power blocks (economy of scale)
- reducing the O&M costs





Relative reduction of LEC by innovations, scaling and series production through 2020 for the parabolic trough/HTF system compared to today's LEC (ECOSTAR, 2005)

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Technical innovations for Receiver to achieve cost reduction goal

Today:

Thermo-Oil / LS3-design

- 😐 Operation up to 400°C with with steam generator
- ☺ prooven technology
- 😐 Heat storage possible (indirect)
- 😐 over all efficiency 16-17%
- ☹ hydrogen problem

New Heat Transfer Fluid
- higher temperatures
- higher efficiency
- no hydrogen problem

?

Direct steam generation
- temperatures > 500°C
- efficiency >20%
- cheaper HTF

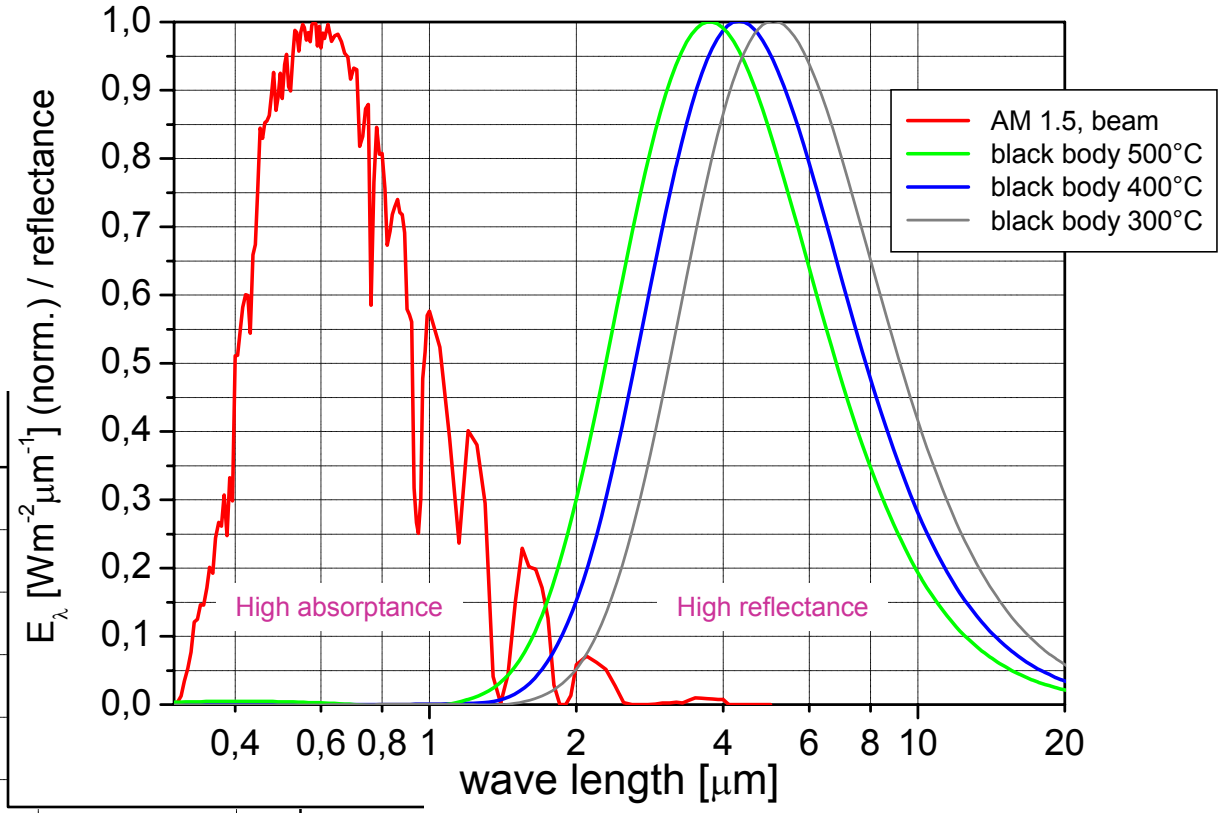
Molten salt
- temperatures > 500°C
- efficiency >20%
- Storage

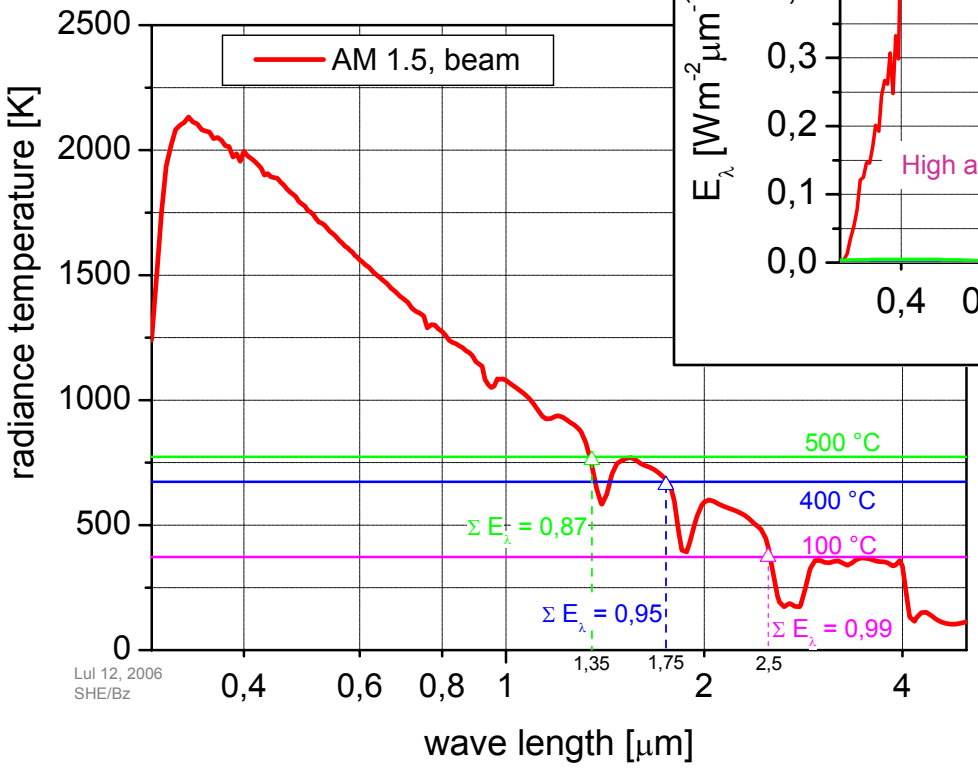
New Dimensions/Design
- lower system cost
- higher concentration
- higher efficiency

Design of Absorber Coatings

Requirements:

- emittance <0.12 @ 500°C
- absorptance > 0.94
- Stable up to 550-600°C
- stable production process





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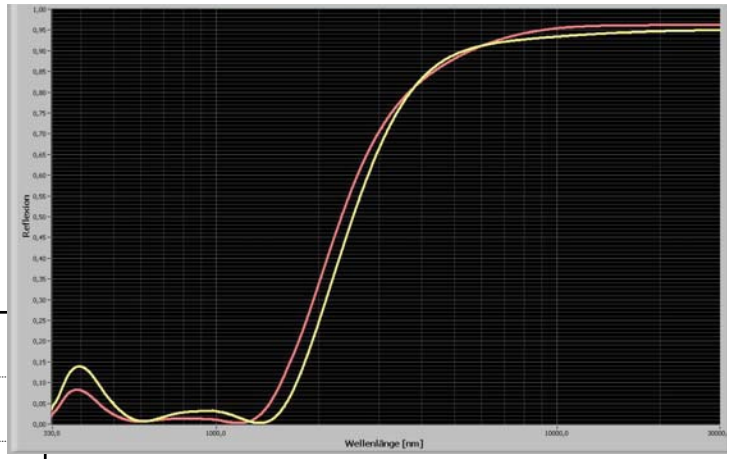
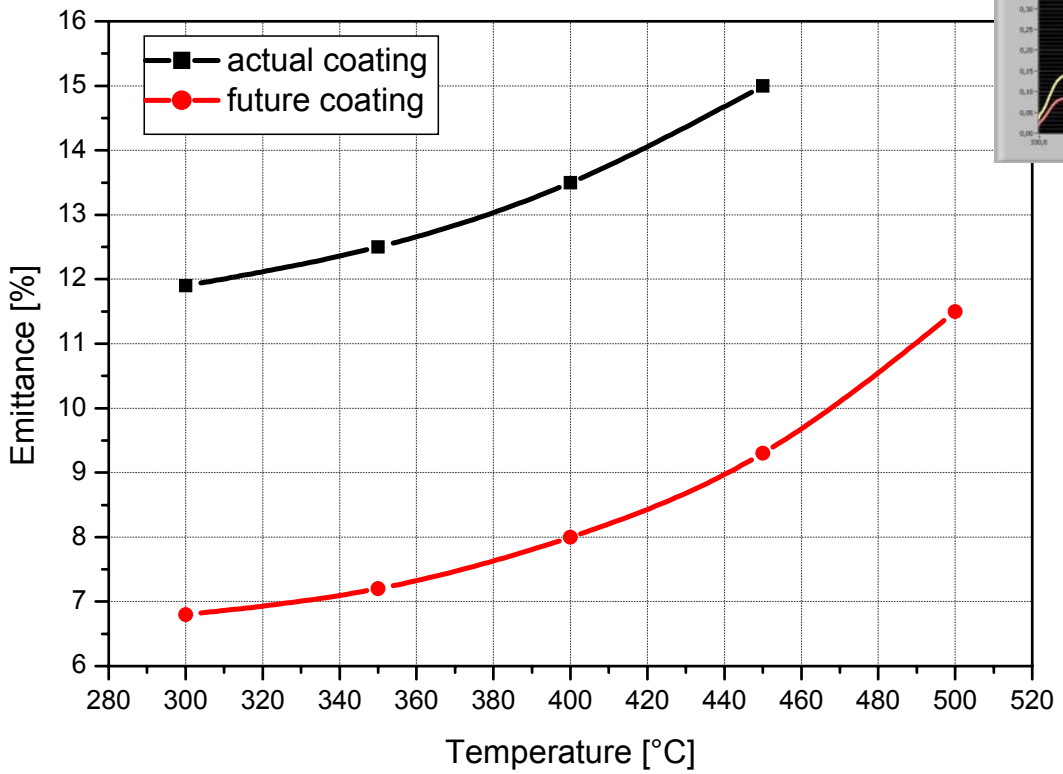
New absorber coating under development

- Coating with lower emittance
- benefit for oil-systems : ~ 2% better system efficiency
- temperature limit expected above 500°C but not yet determined





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Receivers for Molten Salt Technology

- SCHOTT tubes installed in 100m test loop at ENEA/Italy
- goal: 500-550°C operating temperature

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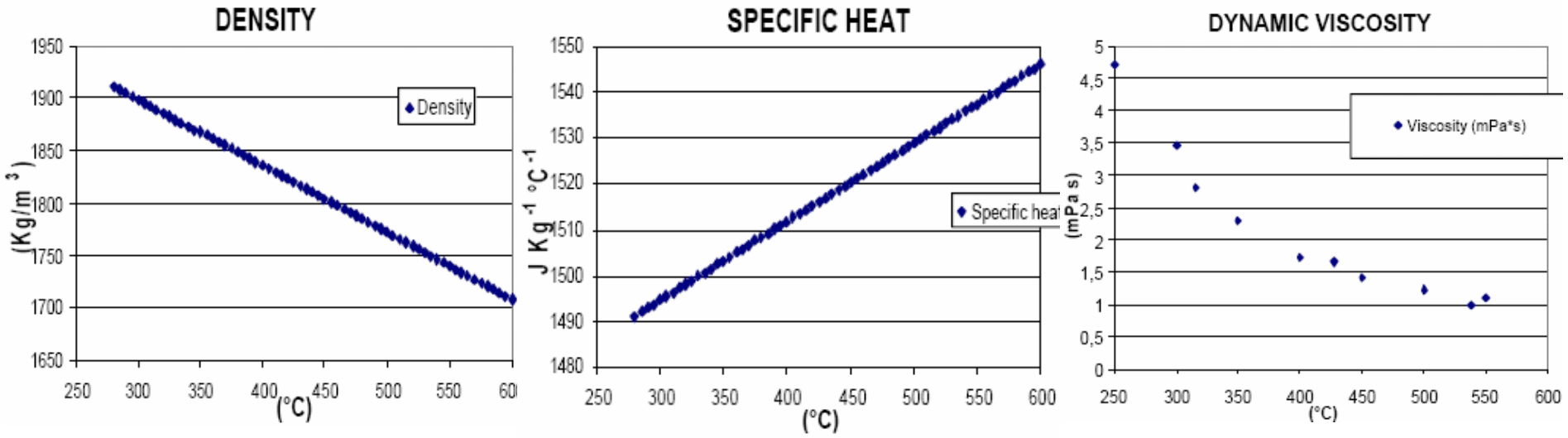
HTF: Molten Salt

- Molten salt 60% $NaNO_3$, 40%KNO_3
- high density leads to 50% higher specific heat capacity compared to oil
- + doubling the ΔT in a loop reduces flow rate to 1/3
- Low system pressure enables absorber tubes with low wall thickness
- Potential problems: freezing, corrosion



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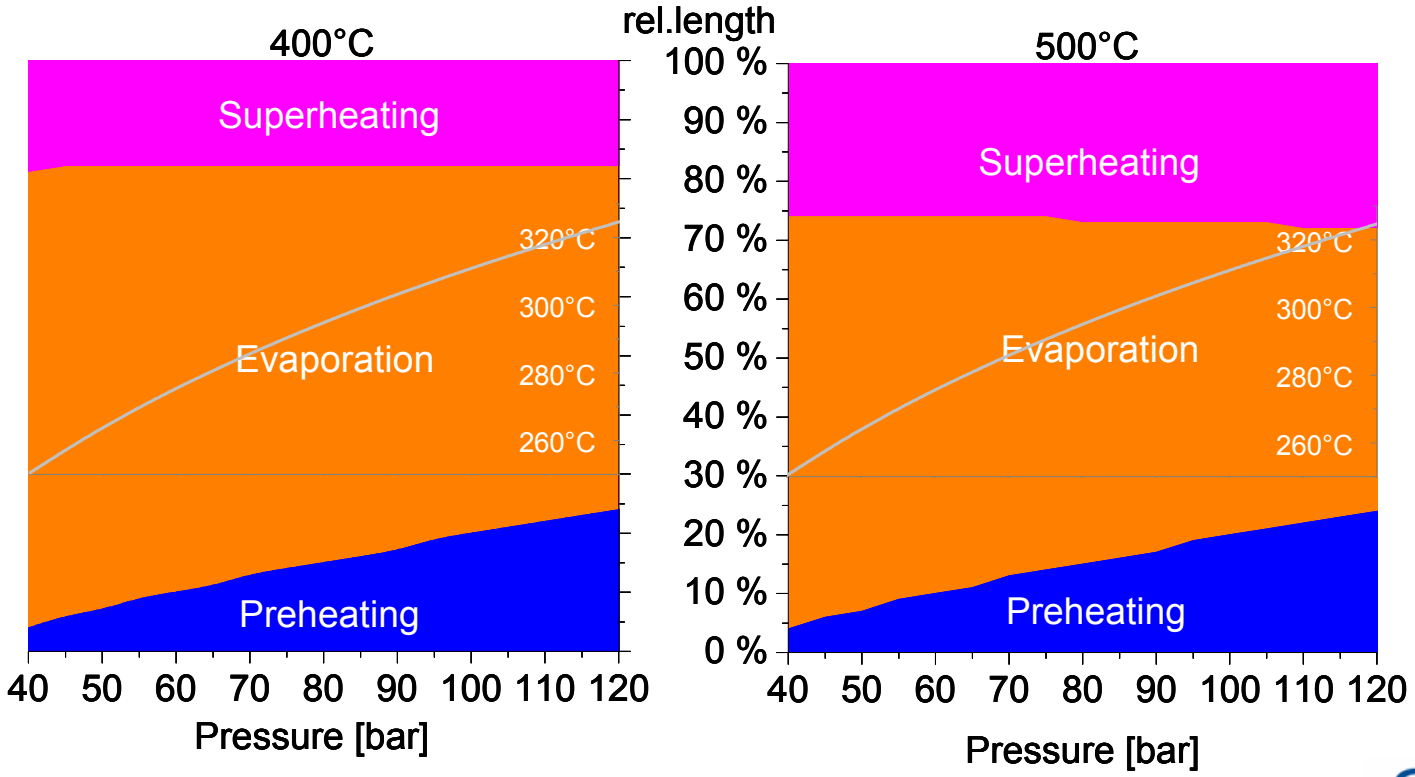
Direct Steam Generation

- Average absorber temperature 50-70 K lower than at single phase operation between 300 and 500°C (reduces heat losses)
- Absorber tubes with thick walls are required due to high system pressure
- increased temperature difference between absorber and HTF due to thicker walls and poor heat transfer coefficient in superheated region



(data: courtesy of M.Eck, DLR)

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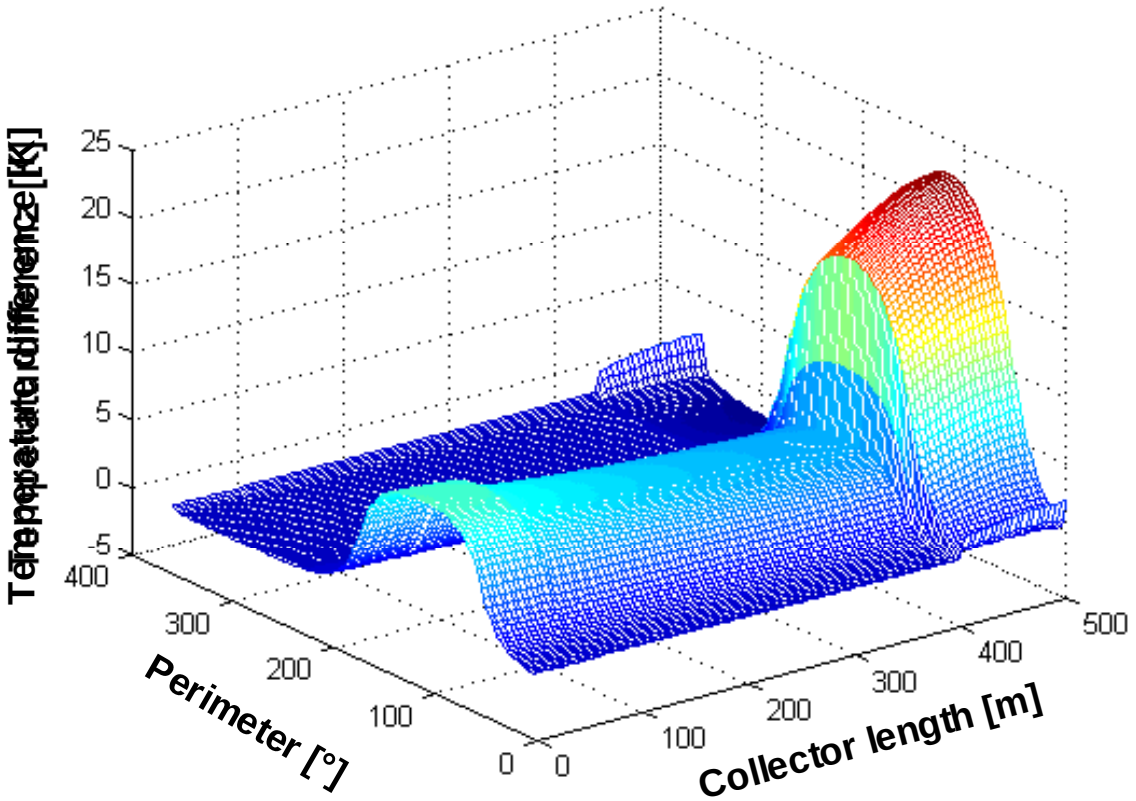
Direct Steam Generation

➔ high temperature difference between absorber surface and superheated steam reduces maximum operating temperature due to safety distance to stability limit of absorber coating.



(courtesy of M.Eck, DLR)

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Comparison of HTFs

	Synthetic Oil	Molten Salt	Direct Steam Generation
Maximum operating temperature	400°C	500-520°C	480-500°C
System pressure	30-40 bar	10 bar	60-100 bar
Corrosion of absorber tubes	no	?	no
Hyrogen problem	yes	unlikely	?
Cost reduction		Getter Steel	Getter
Cost increase			Steel
Main problem	Decomposing fluid	Freezing	High pressure weight

Conclusions

- Molten salt and direct steam generation are the most promising options to increase the system performance
- The operating temperature is limited by the properties of the absorber coating (emittance and long term stability)
- An operating temperature of 500°C seems to be feasable
- Cost for the receiver component will significantly increase for direct steam production (Steel)
- demonstration plants have to be built to investigate and improve the components, to optimize the whole system, to justify the economics and to make the new technology bankable.