SOLAR sCO2OL

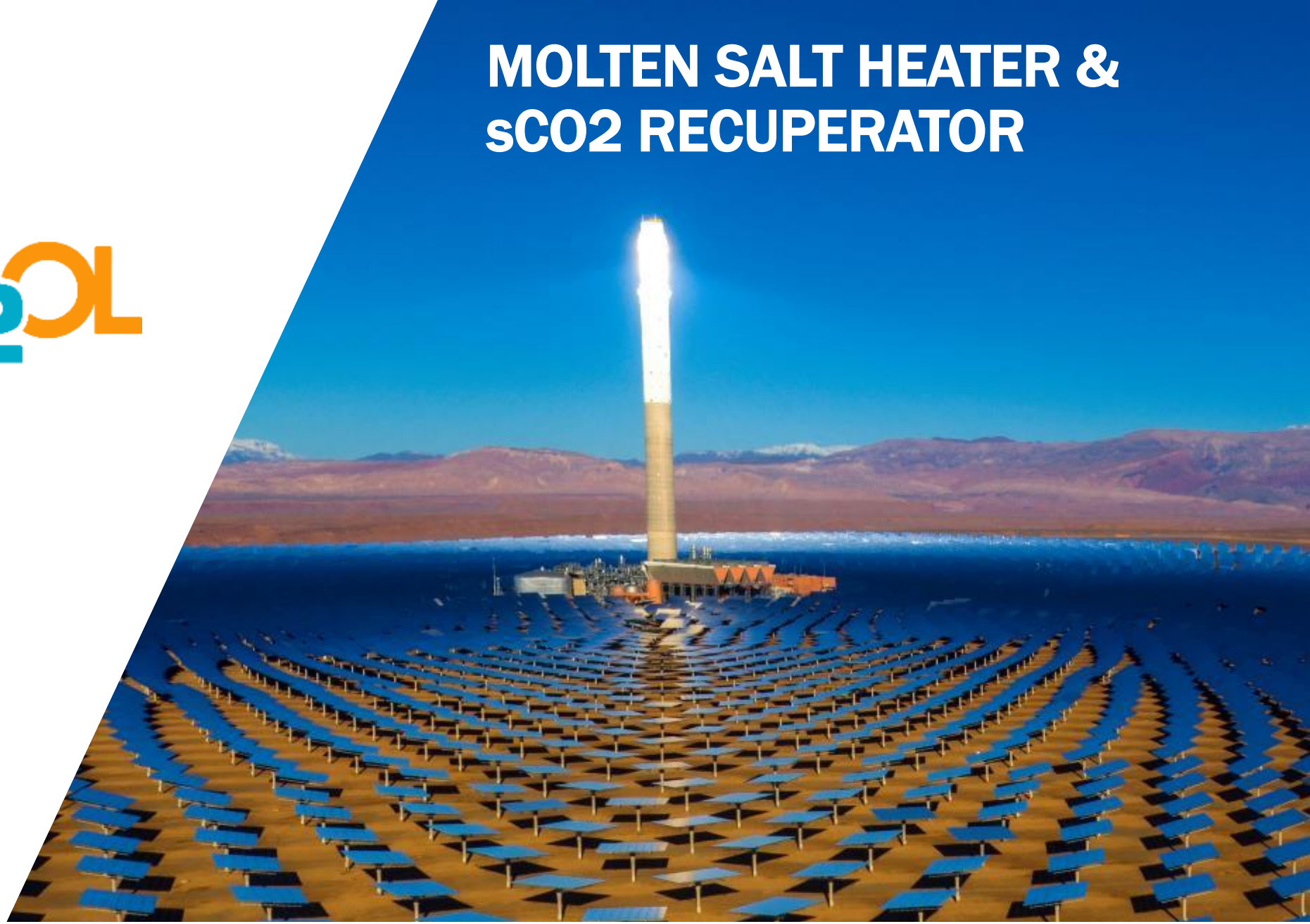
HEAT EXCHANGERS

lointek

EX HEAT SEICO AN EXHEAT GROUP COMPANY

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.952953

MOLTEN SALT HEATER & sCO2 RECUPERATOR



ÁLVARO BILBAO
(LOINTEK)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.952953

LOINTEK: Our Company Profile (I)

Business Units

Oil & Gas, Petrochemical & Power

- *Reactors*
- *Condensers*
- *Columns*
- *Heat Exchangers*
- *FWH*

Industrial Boilers

- *Watertube*
- *Firetube*
- *HRSG*
- *Biomass*
- *WHB*

CSP Division

- *Steam Generation Systems*
- *Thermal Energy Storage* (Oil-to-Salt HEX)
- *Turn-Key Solutions*

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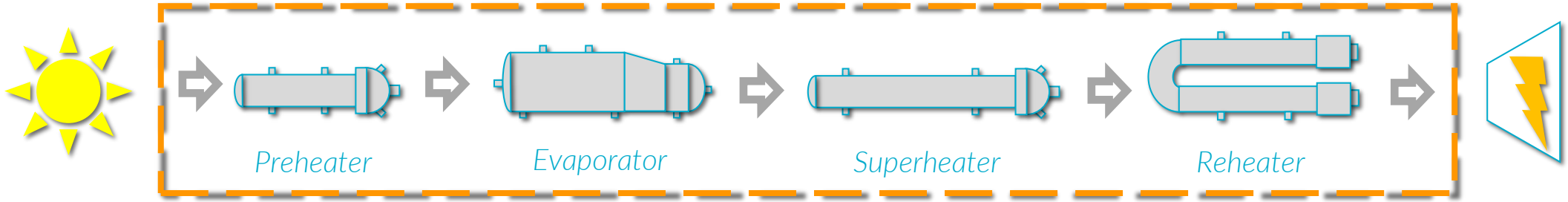
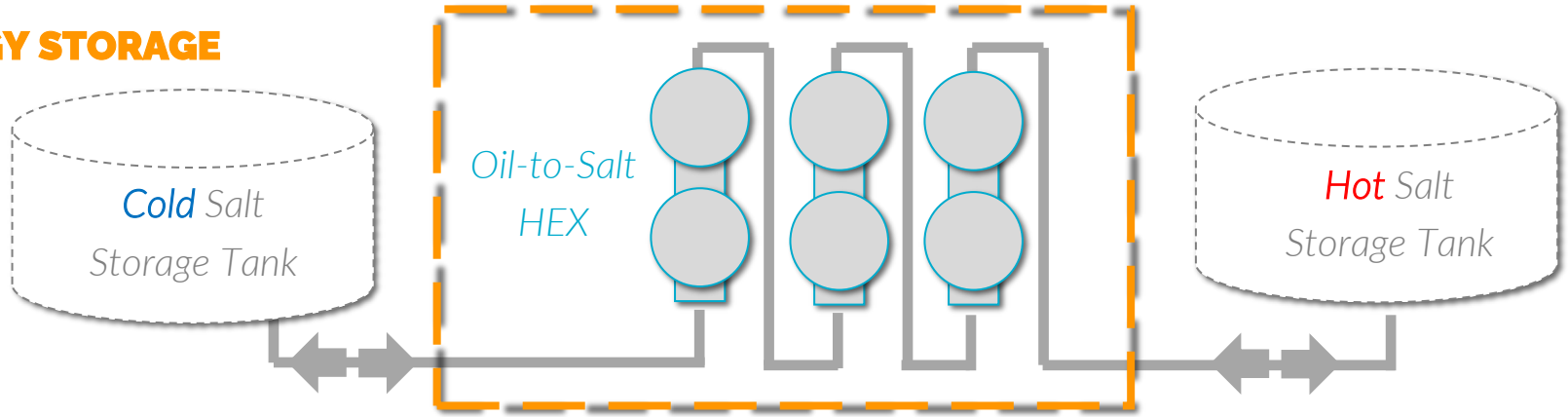
LOINTEK: Our Company Profile (II)

Turn-Key supply for CSP

STEAM GENERATION SYSTEM



THERMAL ENERGY STORAGE



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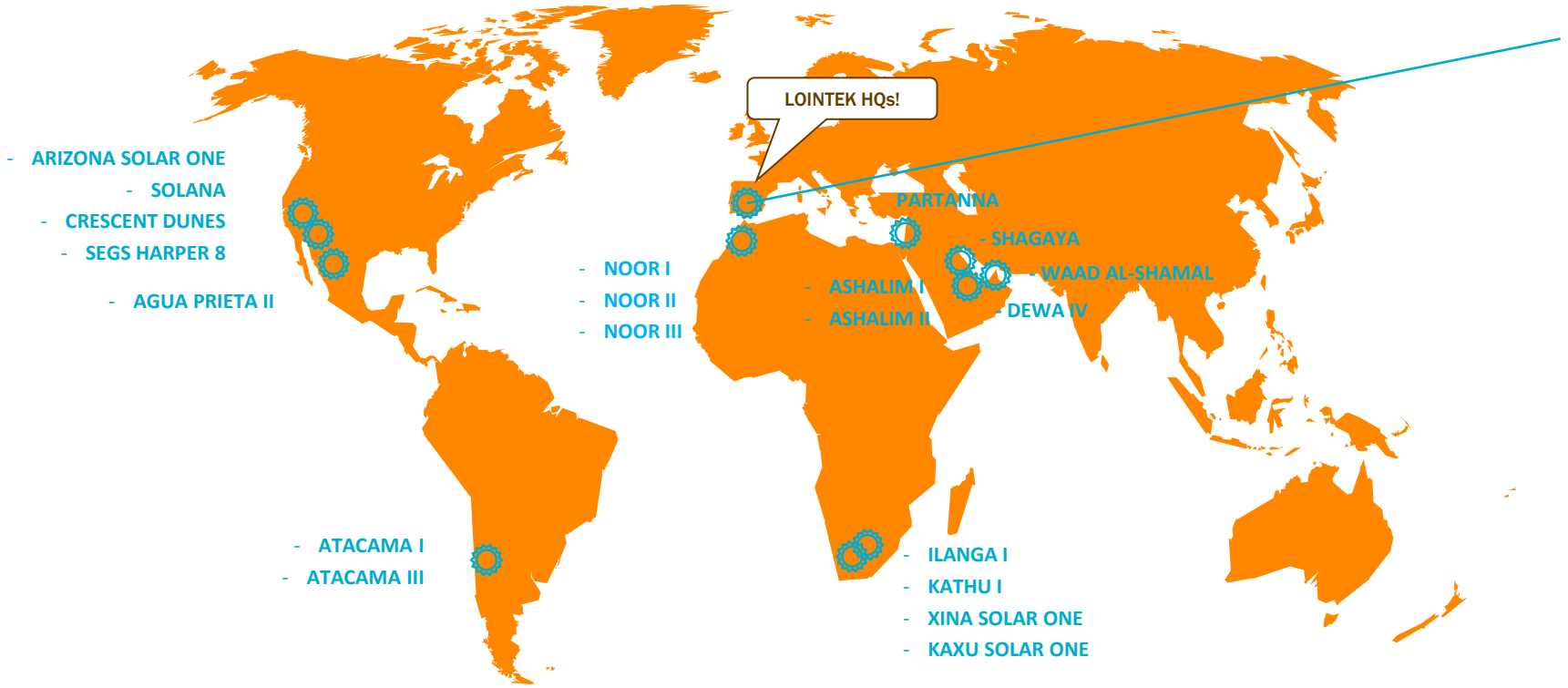
LOINTEK: Our Company Profile (III)

LOINTEK provided +800 shell&tube HEX for 50 CSP plants



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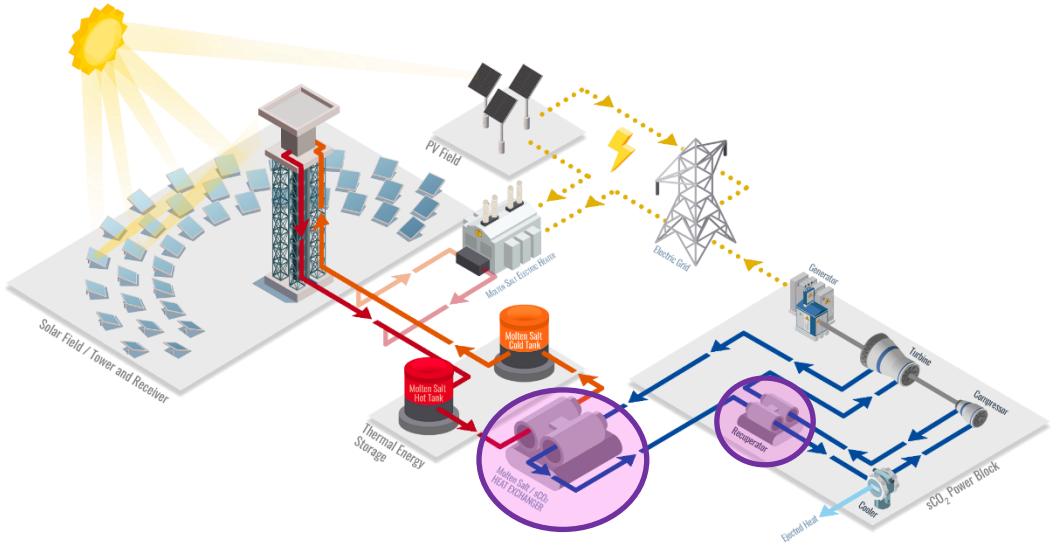
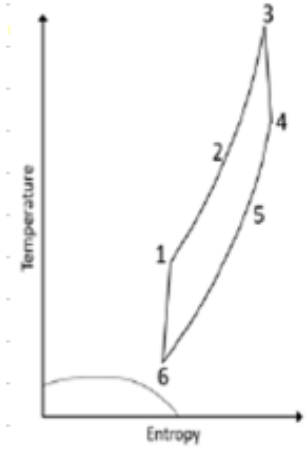
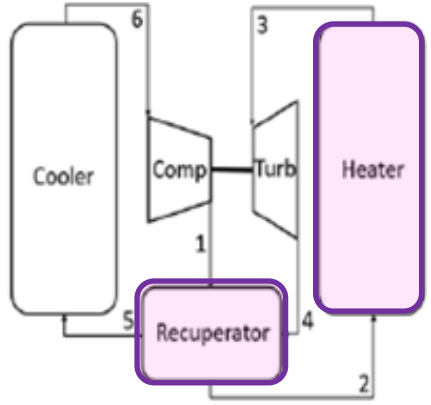
LOINTEK: Our Role in SOLARsCO_2OL (I)

- WP4 package leader: HEX design, prototyping and integration
- ***sCO_2/sCO_2 Recuperator*** for heat recovery
- ***MS/sCO_2 Heater*** for molten salts heat extraction







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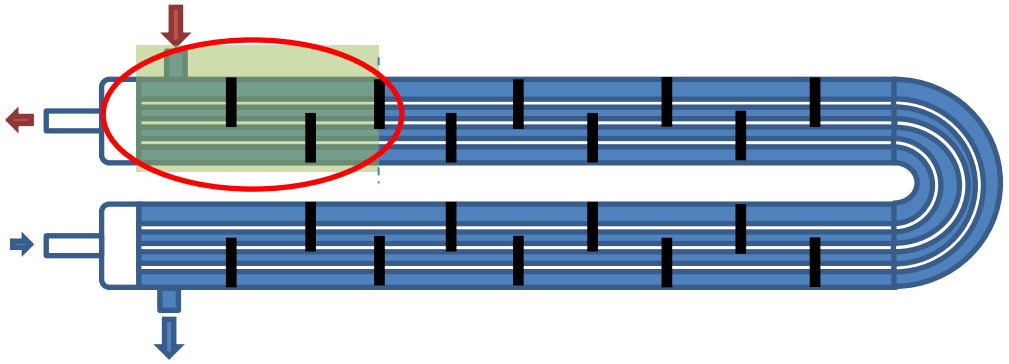
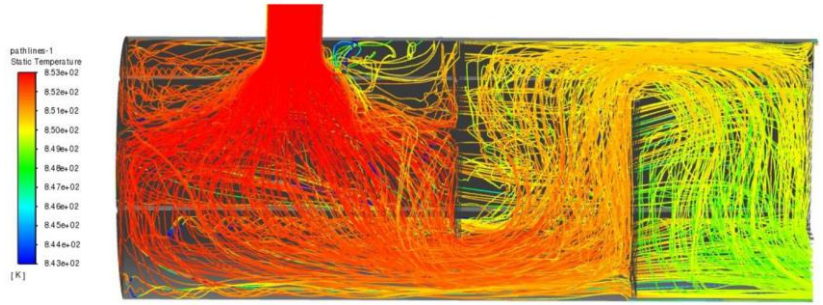
LOINTEK: Our Role in SOLARsCO$_2$OL (II)

- Numerically and experimentally study shell&tube heat exchangers and electrical heater implemented at molten salts level





- The ultimate goal is to upscale proven prototypes for both solar and even non-power contexts

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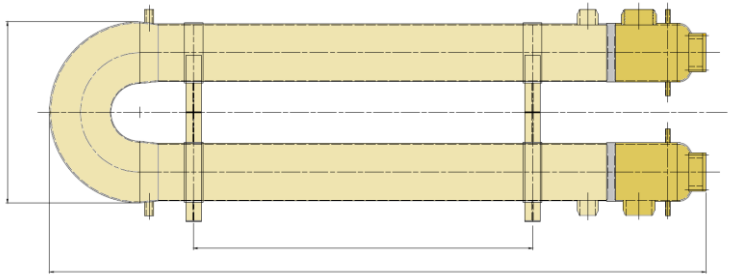
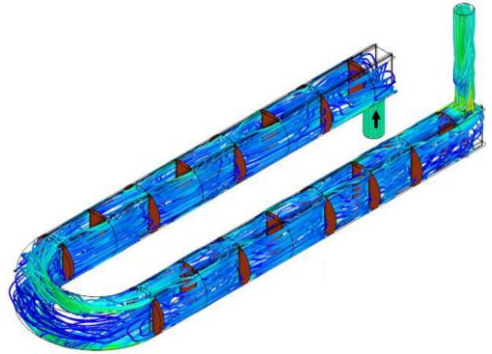
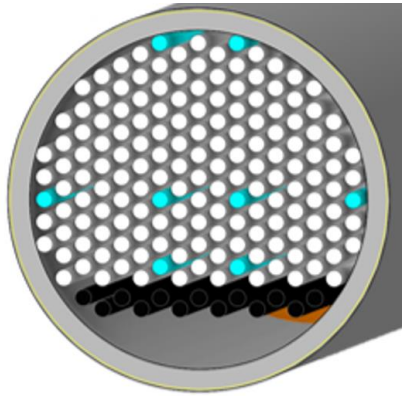
LOINTEK: HAIRPIN Design Features

- ***MS/sCO2 Heater*** & ***sCO2/sCO2 Recuperator*** employ the HAIRPIN design





- Most versatile design for high temperature difference fluid conditions
- Pure counter-current heat exchange
- Easy channel access for maintenance & reparations



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LOINTEK: Heat Exchanger Design

- LOINTEK combines both widely spread commercial software for heat exchanger thermal design (HTRI) with in-house tools

Process Conditions

Process Conditions

Flow rate	Hot Shell	21	Cold Tube	21	kg/s
Inlet/outlet Y		/		/	Weight fraction vapor
Inlet/outlet T	481	/	57	/ 301,5	C
Inlet P/allow dP	88,1	/ 4,5	188	/ 1,5	bar / bar

Shell Geometry

OD / ID	435 / 405	mm
Orientation	Horizontal	
Hot fluid	Shellside	

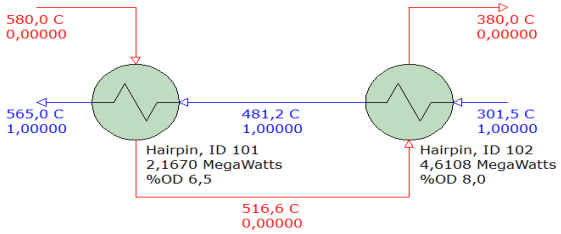
Baffle Geometry

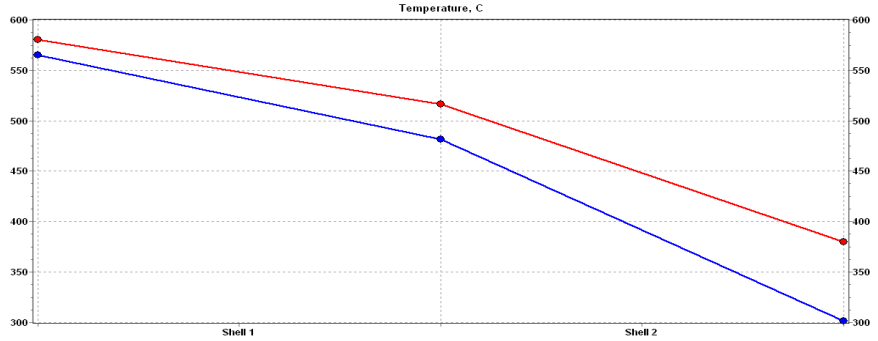
Type	Single segmental	
Orientation	Parallel	
Cut		% ID
Spacing		mm

Tube Geometry

Type	Plain	Wall thickness	2,108	mm
Nom. len	4655 mm	Layout angle	30	degrees
Tube OD	15,875 mm	Tubecount	164	
Pitch	22,225 mm			

Temperature distribution





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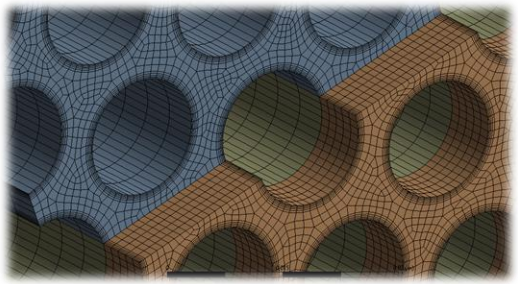
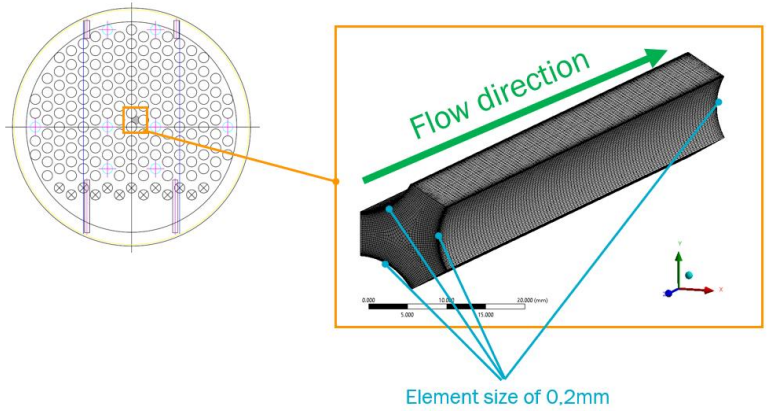
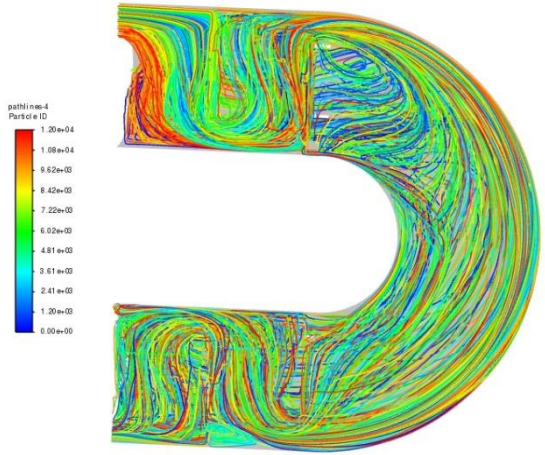
LOINTEK: Upcoming R&D activities

- Preliminary design of the shell-and-tube heat exchangers is finalized
- CFD studies shall confirm the expected behavior of the fluids inside the heat exchangers while seeking optimization of internal parts







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Thank you for your time!

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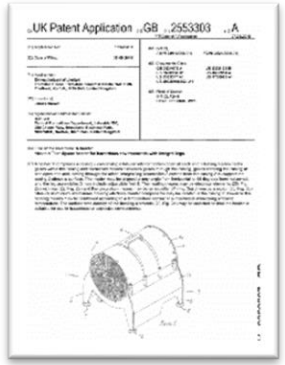
ELECTRIC HEATERS FOR MOLTEN SALT SERVICE

JAMES BROWN
(SEICO)

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No.952953

SEICO - An EXHEAT Group Company

- SEICO Gmbh: one of eight companies within the EXHEAT Group
- Over 80 years experience designing heating and cooling solutions up to 1000°C
- 2020: 311 Staff based in 5 countries
- 2020: €34.8m Group Turnover, with heaters & control panels in 147 countries
- James Brown – Technical R&D Manager



EX HEAT SEICO AN EXHEAT GROUP COMPANY

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WHY SOLARSCO2OL?

Seico / Exheat are working within the SOLARSCO2OL Project in order to

- Develop our understanding of molten salts
- Work at the forefront of long term energy storage
- Develop bespoke electric heaters for this service

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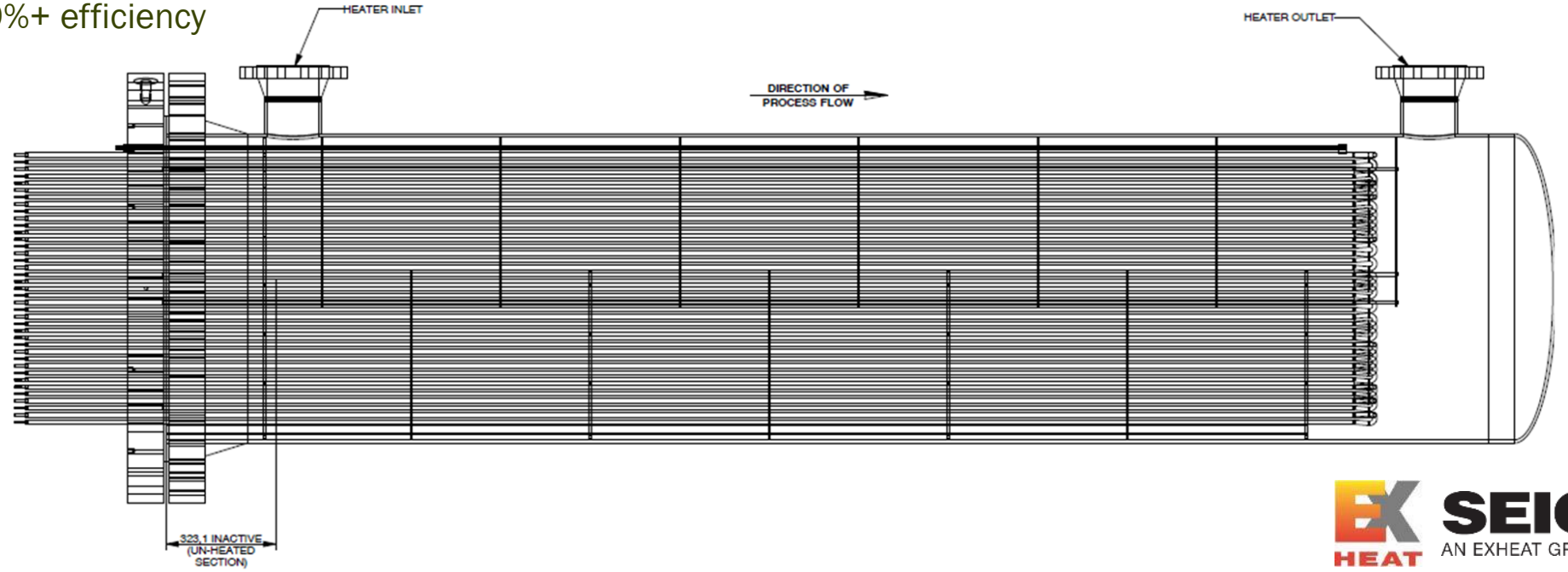
Electric Heater Specification – SOLARSCO2OL

- 7MW installed power @ 690V
  - 546 Active heating elements @ 12.82kW each
  - 14 Equal stages (0.5MW each) compliant with EN 61439 – Max Fault Current
  - 99.9%+ efficiency



HEAT SEICO AN EXHEAT GROUP COMPANY

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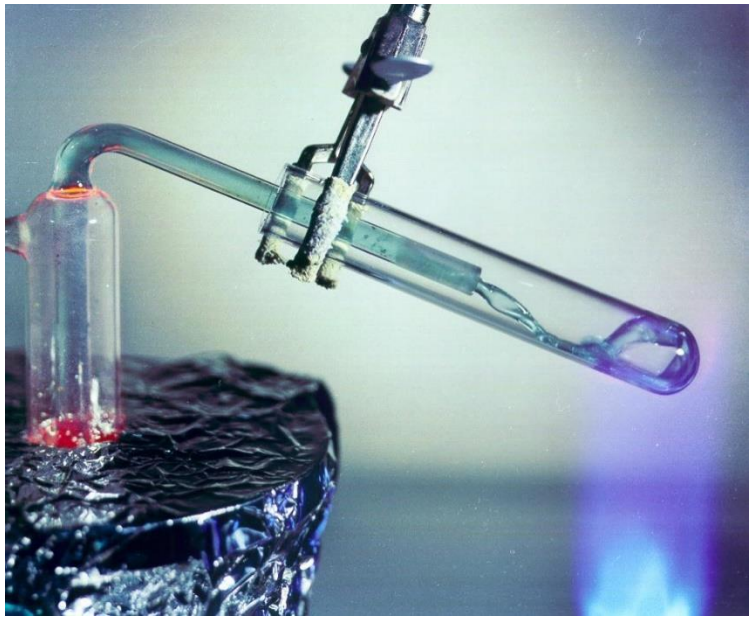
Molten Salt Challenges

- Closed loop system
- Degradation of the salts
- Corrosion to the heater elements
- Solidification if allowed to cool



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EH Control

One of the key elements of Electric Heater design for this service is temperature control, for which the following design features can be employed.

- Element sensors bonded directly to the heating element
  - Location based on CFD results to monitor the hottest areas.
  - Propose Duplex Thermocouple Type K
- Each heater stage is individually controlled
  - Thyristor controlled, fully scalable power from 0-100%
  - Stage split to be decided based on CFD
  - Managed either by commercial PLC or proprietary Exheat controller TBC

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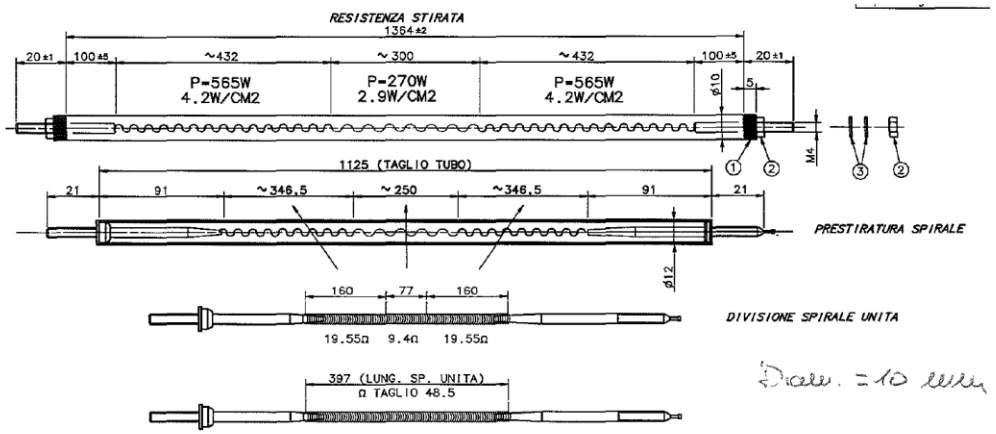
EH Design - Elements

There are also some options available to us to move the heat around inside the heater.

- SEICO are working with element suppliers to accurately manufacture multi-flux heating elements.
- SEICO have previously looked at elements with two or three different heat fluxes.
- And Considered a fully scaled heat flux to attempt a constant element surface temperature



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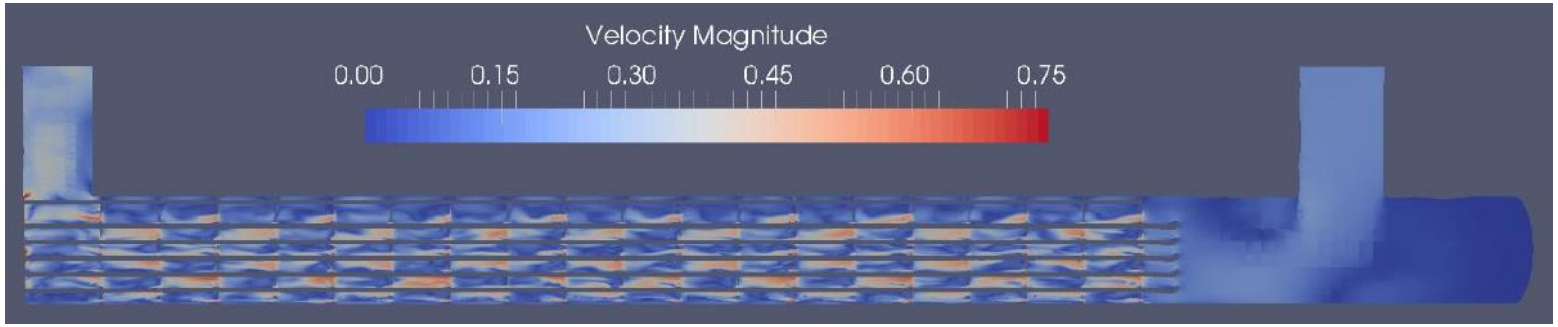
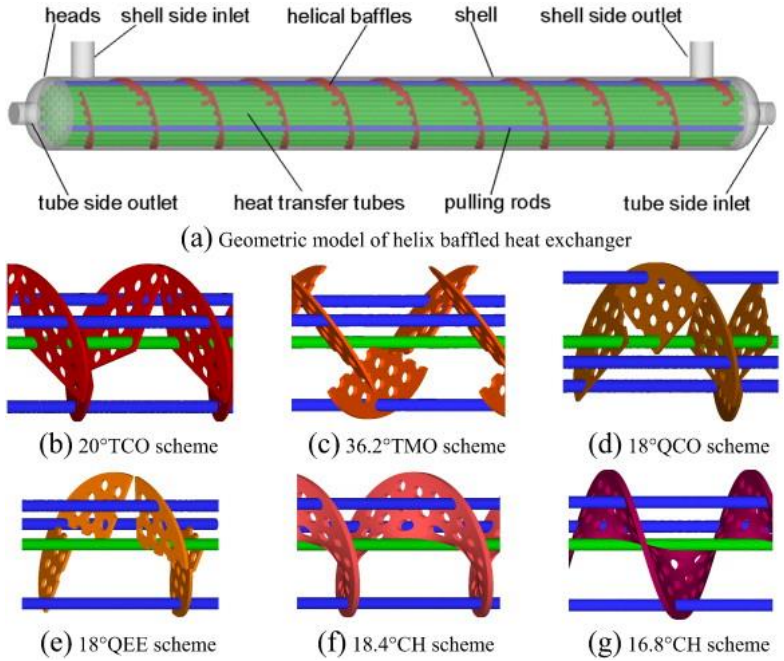
Electric Heater Design – Baffle Configuration

The Fluid Flow regime can also be optimised through careful selection of baffle design.

- Standard 45% cut or 25% cut baffles
- Unbaffled,
- Double/triple segmental.
- Spiral baffles.



Velocity profile of unbaffled baffles.



Comparison of heat transfer performances of helix baffled heat exchangers with different baffle configurations. 2014

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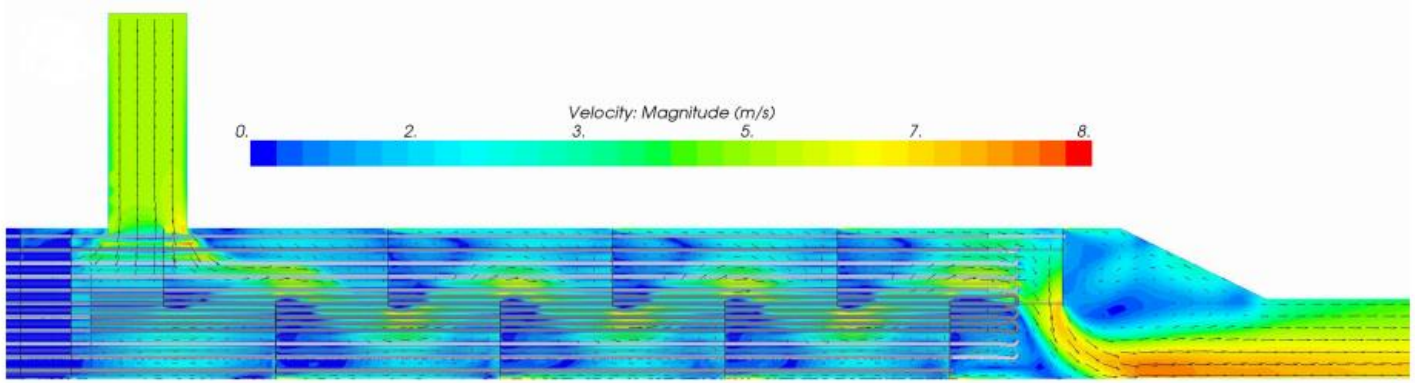
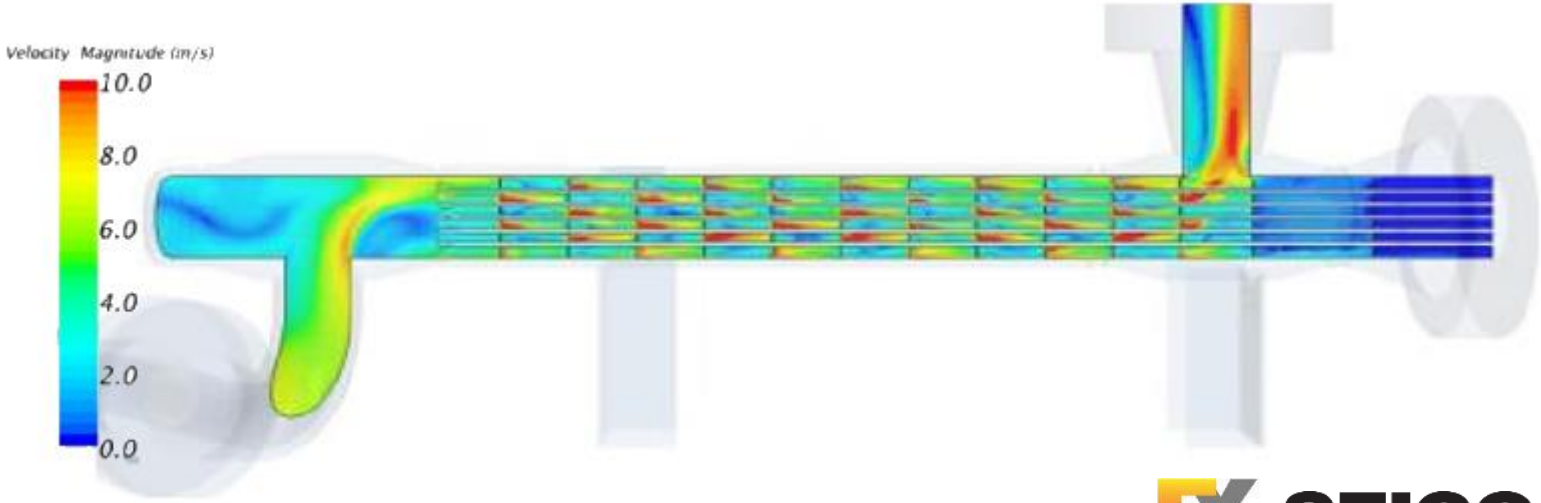
Electric Heater Challenges

Any baffle design can though result in:

- Low flow areas
- Localised hot spots
- Increased pressure drop
- Variable flow rates and temperatures



Velocity profiles within a segmental baffled (above), and an unbaffled (below) electric heaters



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Electrical Heater Design

In conclusion there are methods of optimising the design of the

- Temperature control
- Heat flux from the elements
- Flow regime with the baffle configuration

The intent is to find the best combination for the Molten Salt service, eliminating hot spots within the fluid and thus preventing salt degradation and corrosion of the heater shell and internals.

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Thank you for your time!

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