



Flüssigsalzbasierte
Hochtemperaturwärmespeicher –
die Schlüsseltechnologie für solare
Stromerzeugung mit
planungssicherer
Leistungsverfügbarkeit



Martin Selig
03.03.15

Puerto Errado 1, Spain 2009



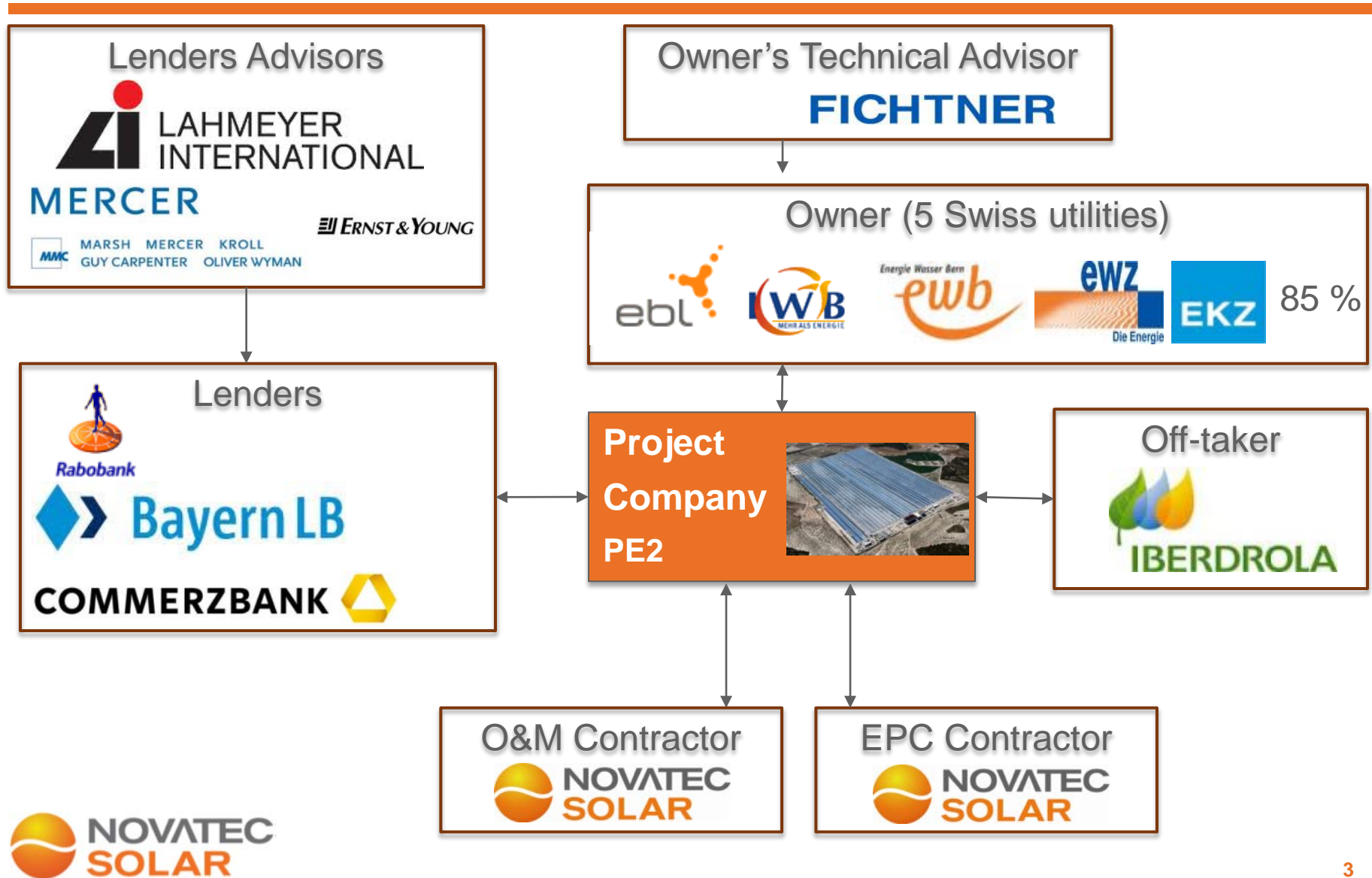
Liddell solar augmentation, Australia 2012



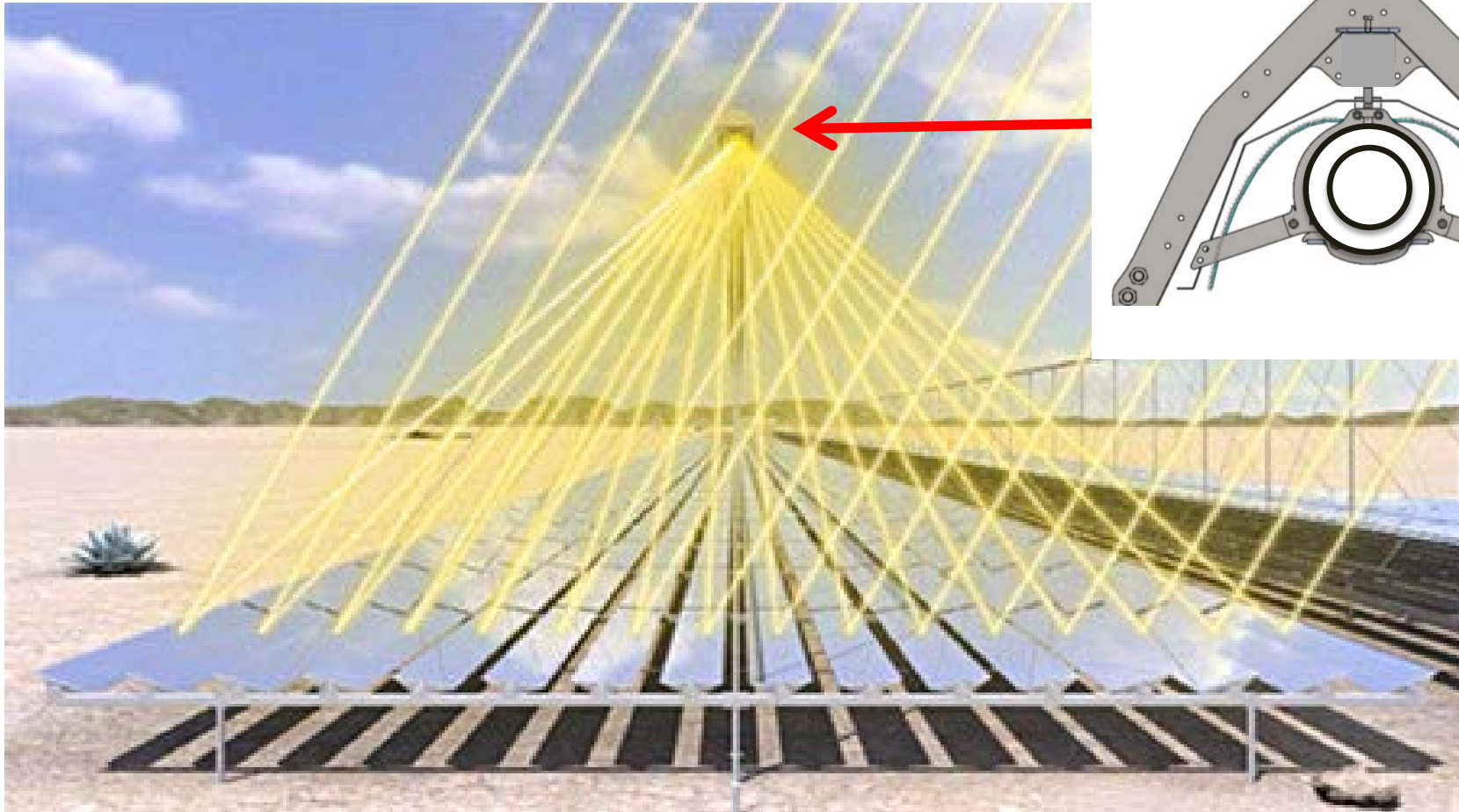
Puerto Errado 2, Spain 2012



Puerto Errado 2 - Project Stakeholders

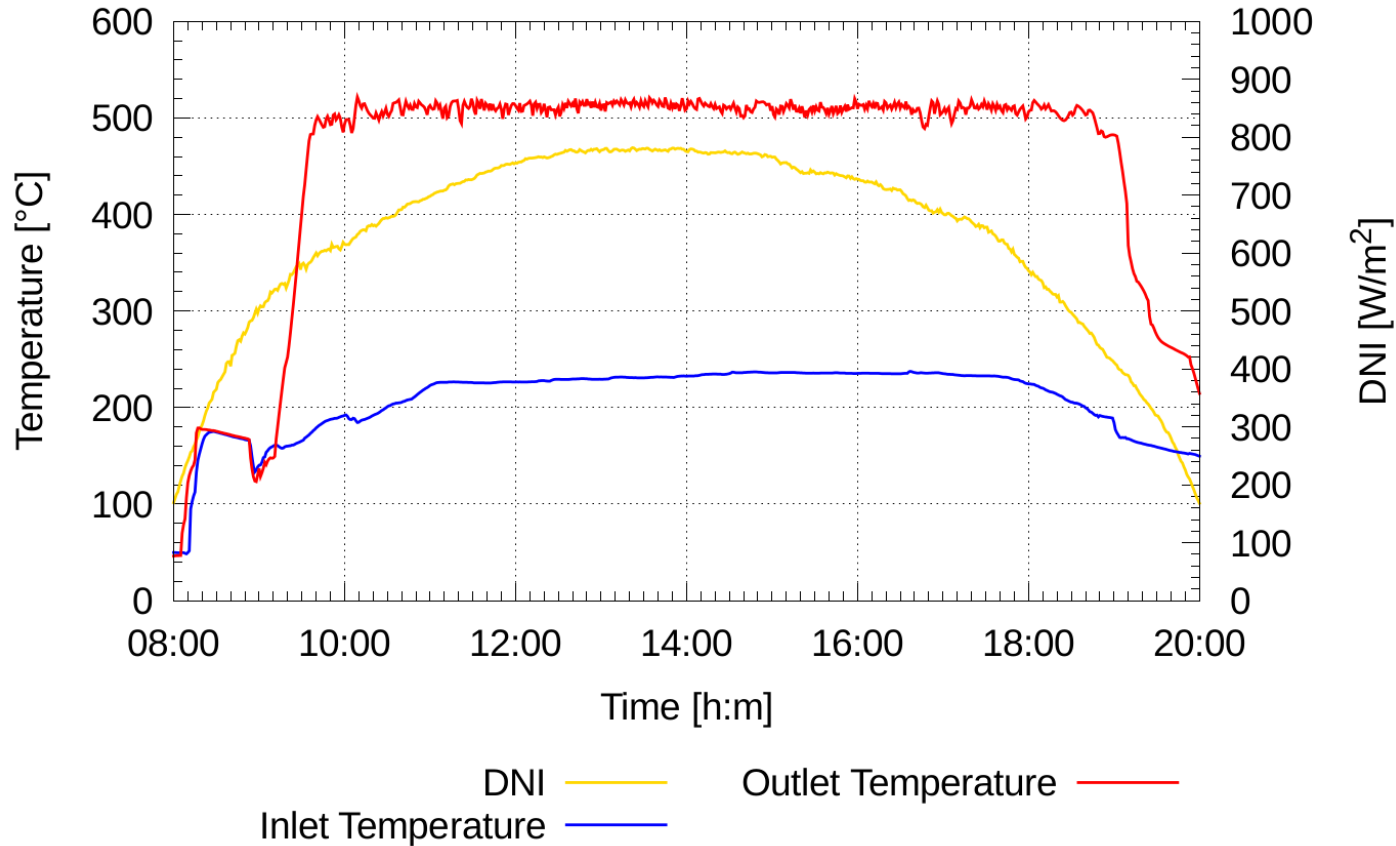


Novatec Solar's Linear Fresnel Collector Technology



>500°C Fresnel Collector

SuperNOVA 120816



More than 3 years
operational
experience with
Vacuum Tube
Receiver

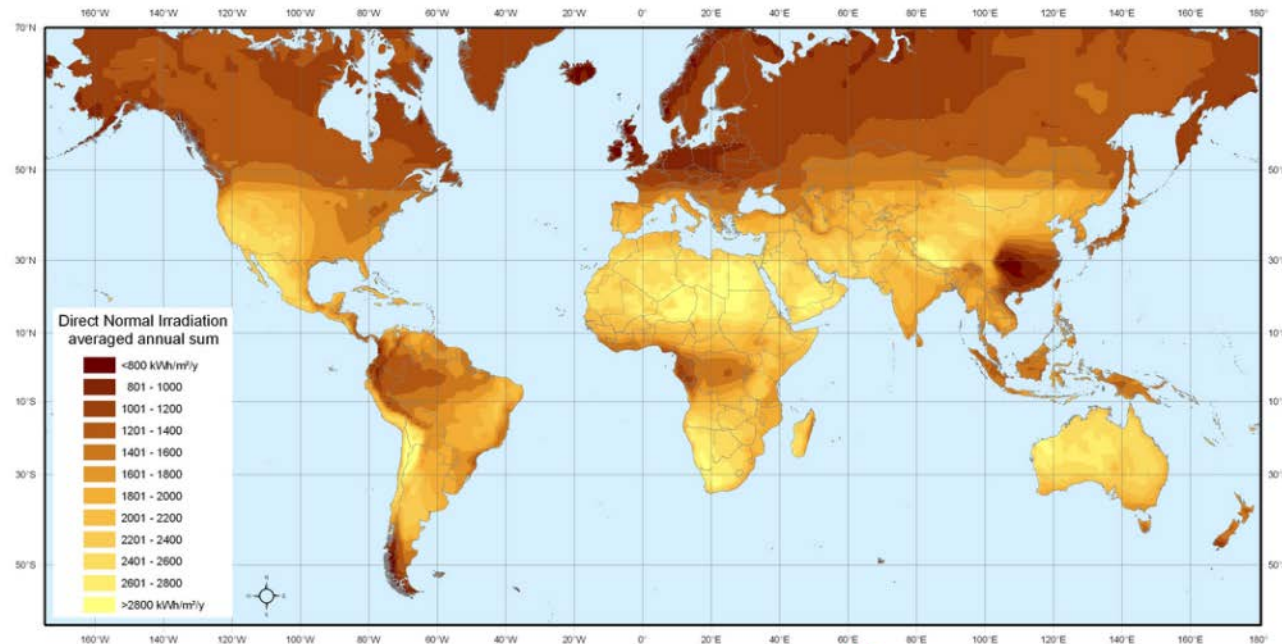
Fluid >500°C
limited by fluid or
vacuum tube
temperature
stability


Why Thermal Energy Storage?


Developing Countries in Desert Regions do not have Access to Pump Hydro stations or other conventional Storage Systems

Power Demand Curves show strong Peak in Evening Hours

Direct Normal Irradiation (DNI)



Data based on  SSE 6.0 dataset for a 22-year period (July 1983 - June 2005)
(<http://eosweb.larc.nasa.gov/sse/>)

Map created and map layout by  2008
(<http://www.dir.de>)

Why Thermal Energy Storage? Power Load curve Morocco

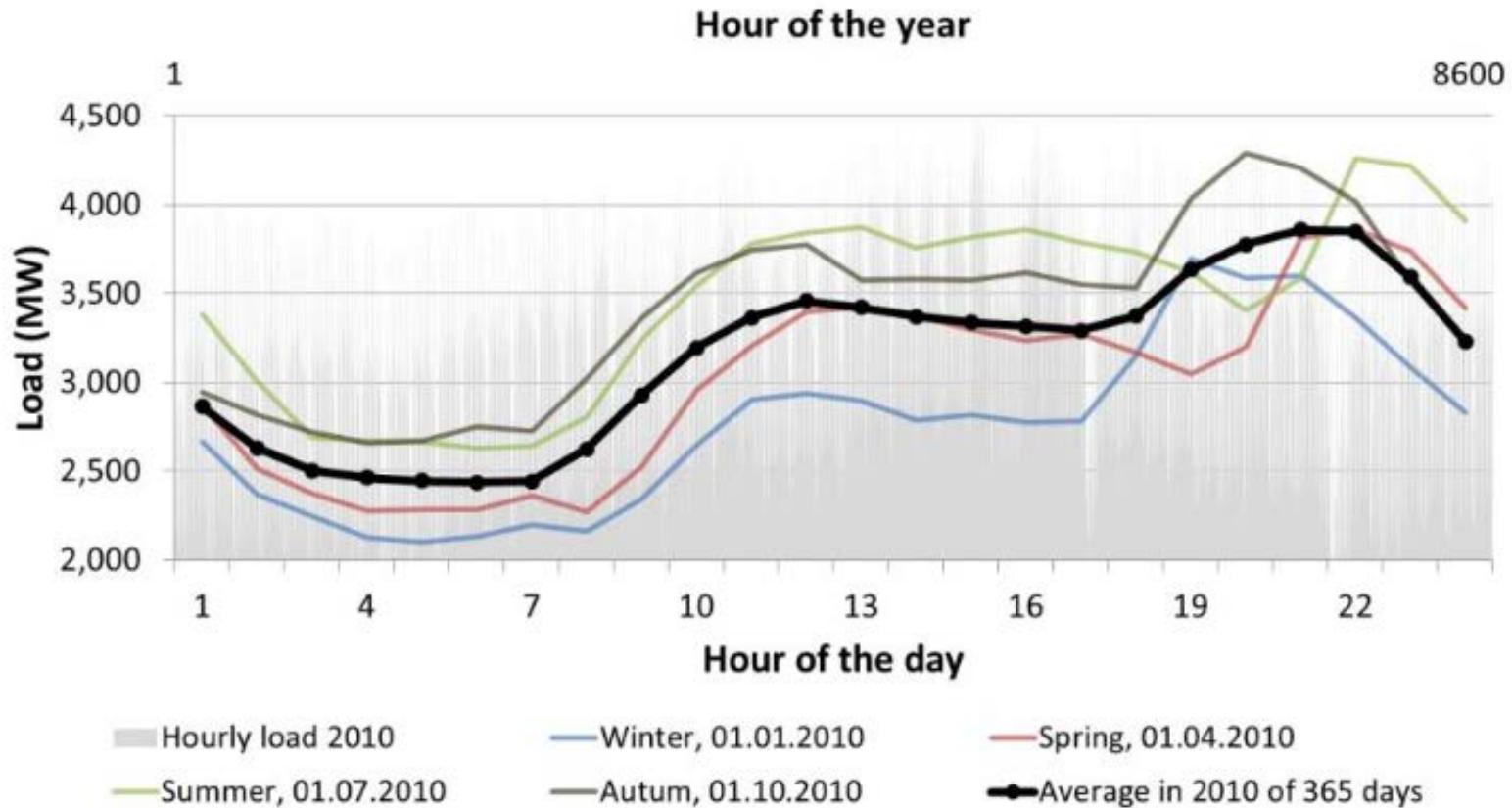
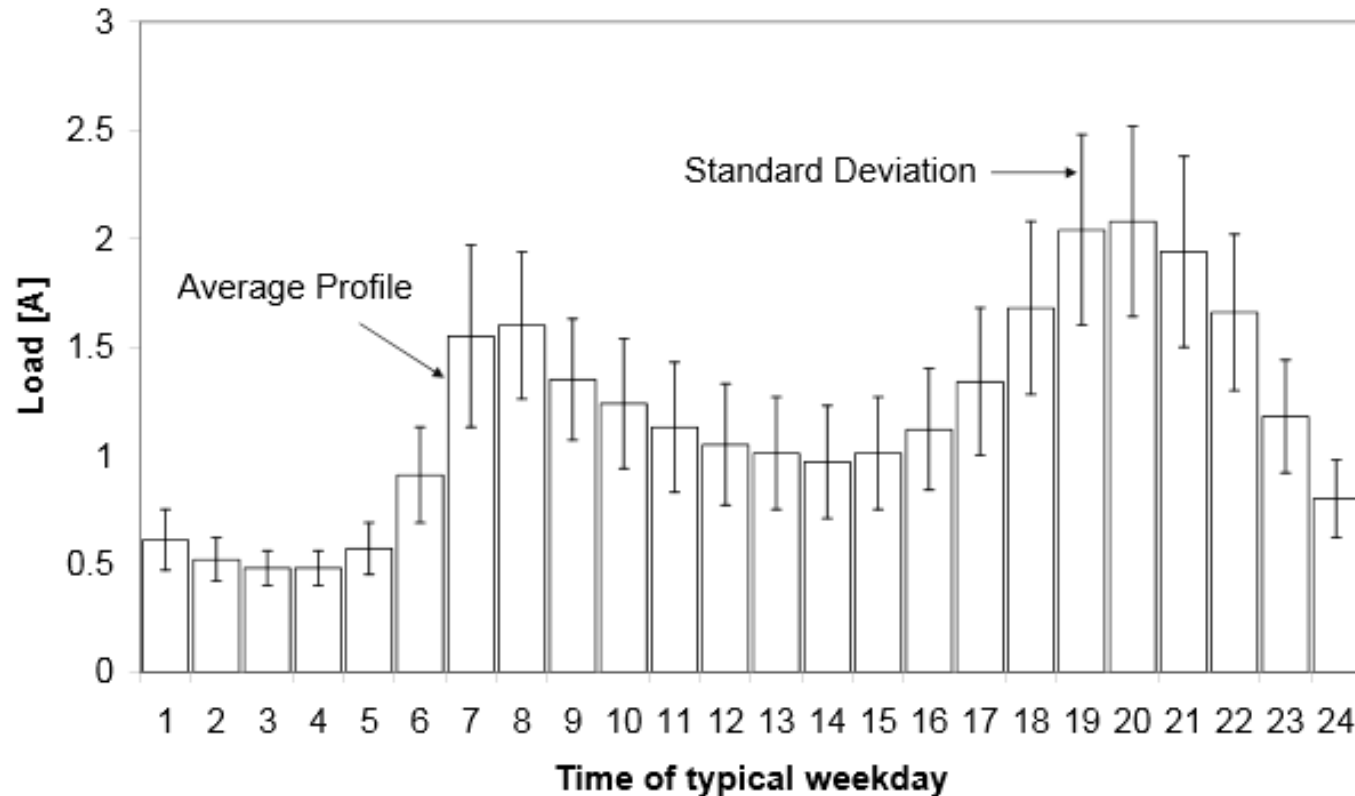


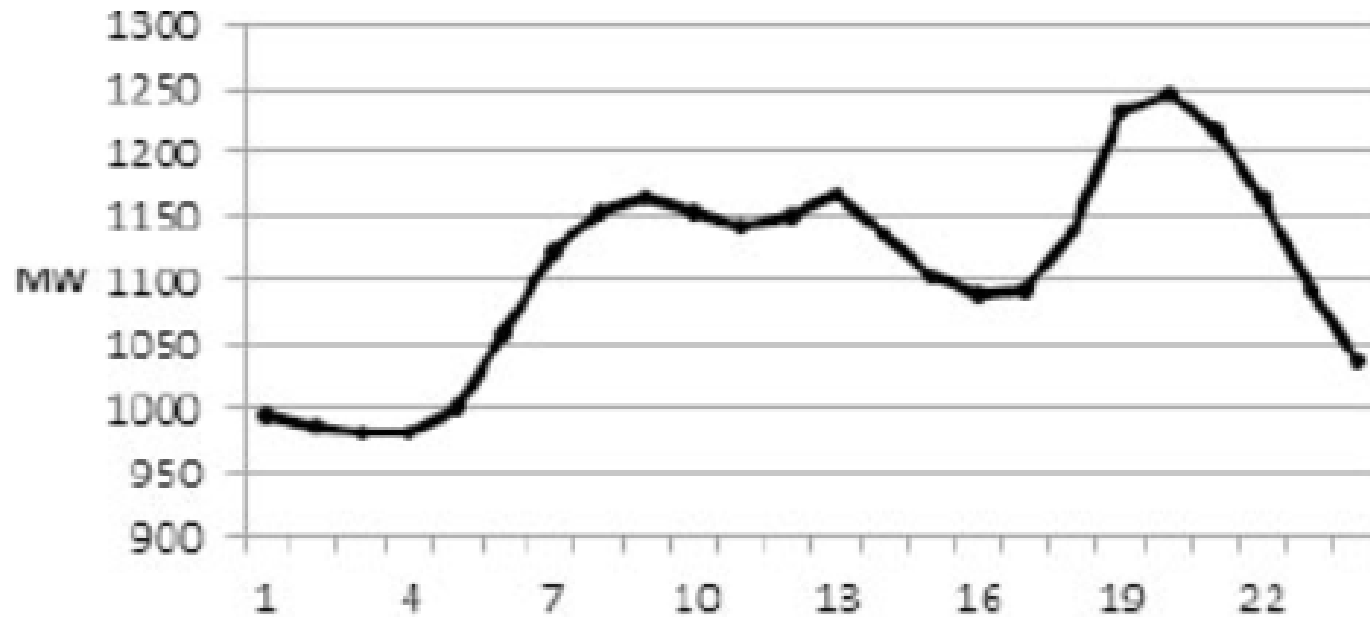
Figure 4: Characteristic load curves for Morocco in 2010

Source: own elaboration referring to (Mouchtakiri, 2011)

Why Thermal Energy Storage? Power Load curve South Africa

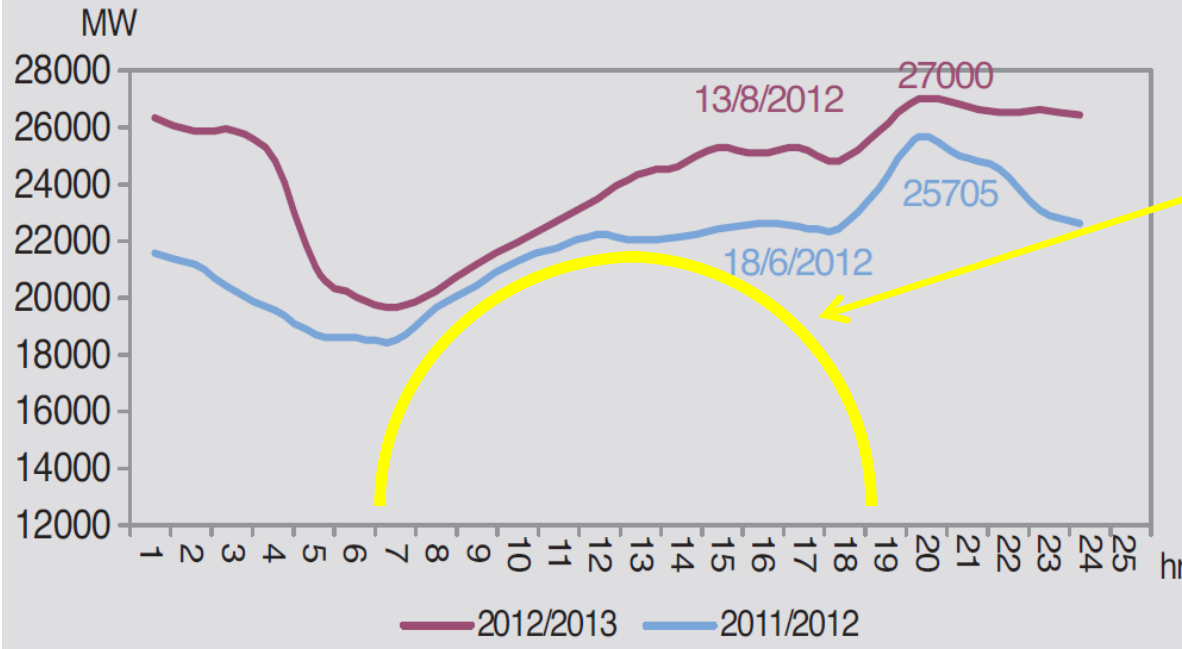


Why Thermal Energy Storage? Power Load curve Zambia



Why Thermal Energy Storage? Power Load curve Egypt

Peak Load Curve 2011/2012-2012/2013



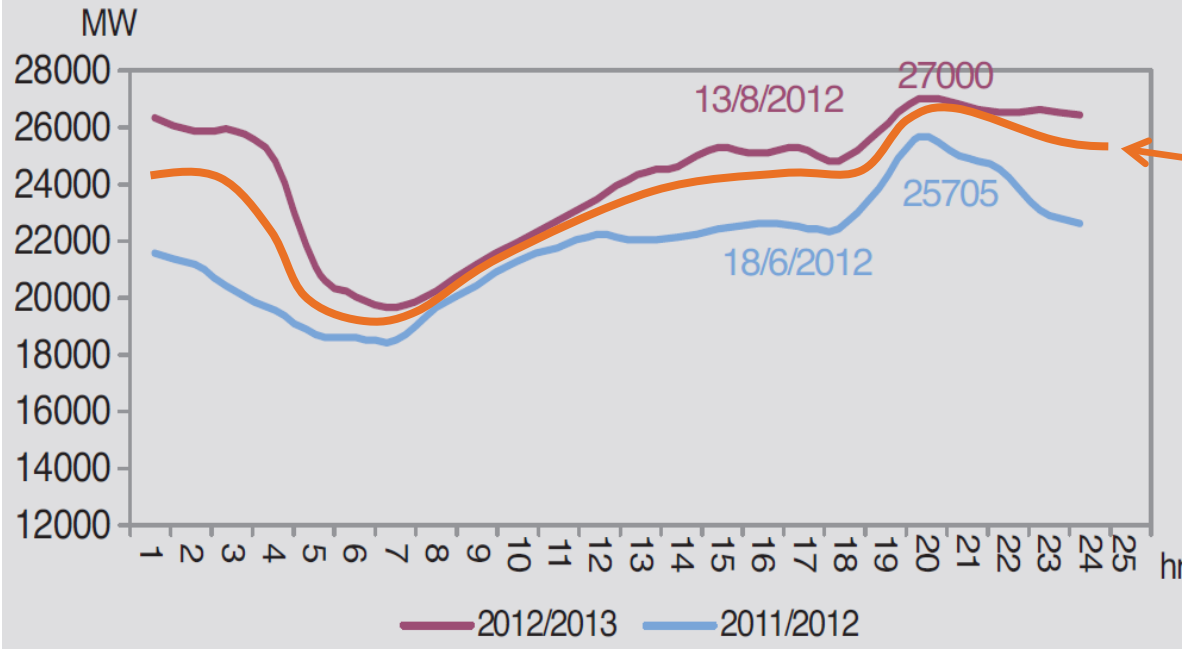
PV itself is a fairly cheap source of energy **but**:

does not match Egypt's demand curve

does not contribute to lower the growing need of installed power generation capacity.

Why Thermal Energy Storage? Power Load curve Egypt

Peak Load Curve 2011/2012-2012/2013

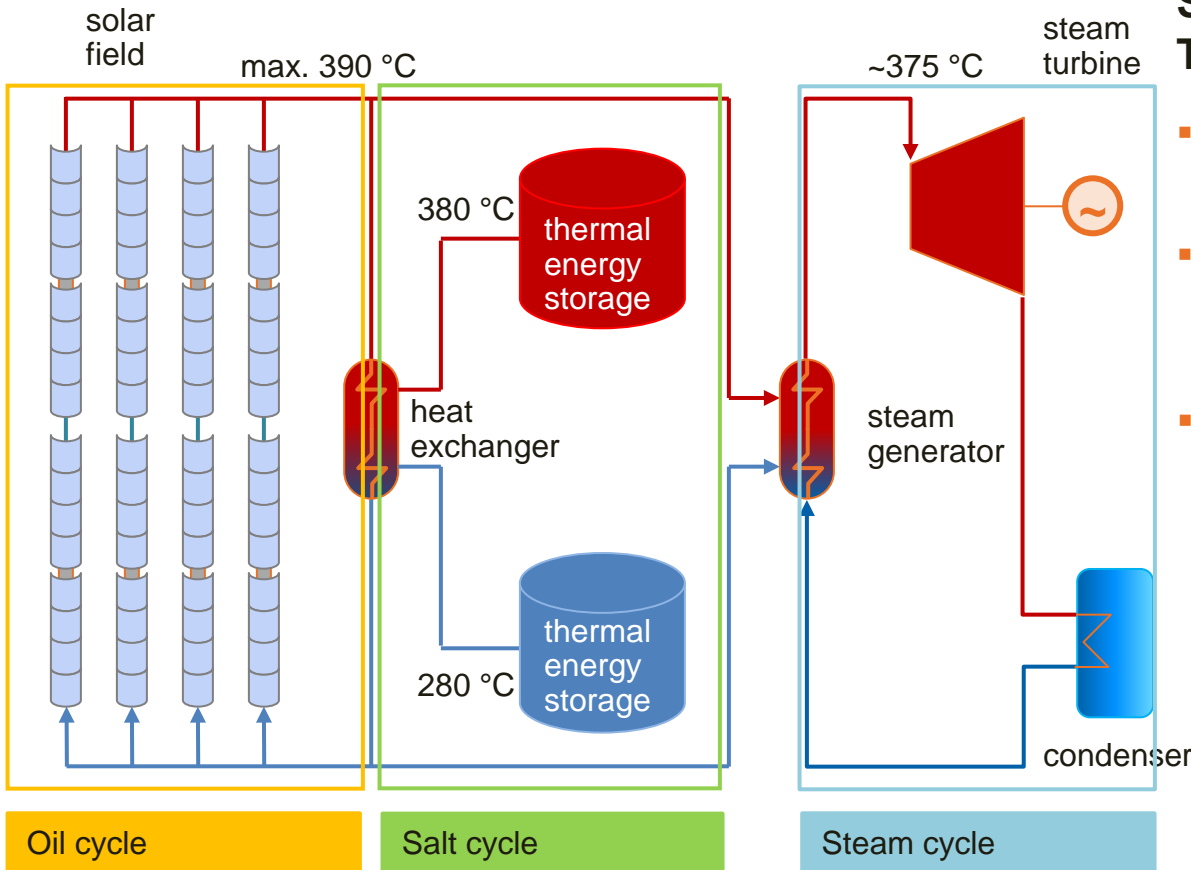


Novatec's CSP technology does match Egypt's PV Feed in Tariffs **and**:

Can match the demand curve 100% thanks to 16 h thermal storage

Every MW installed CSP will lower the need of conventional power generation capacity 1 by 1

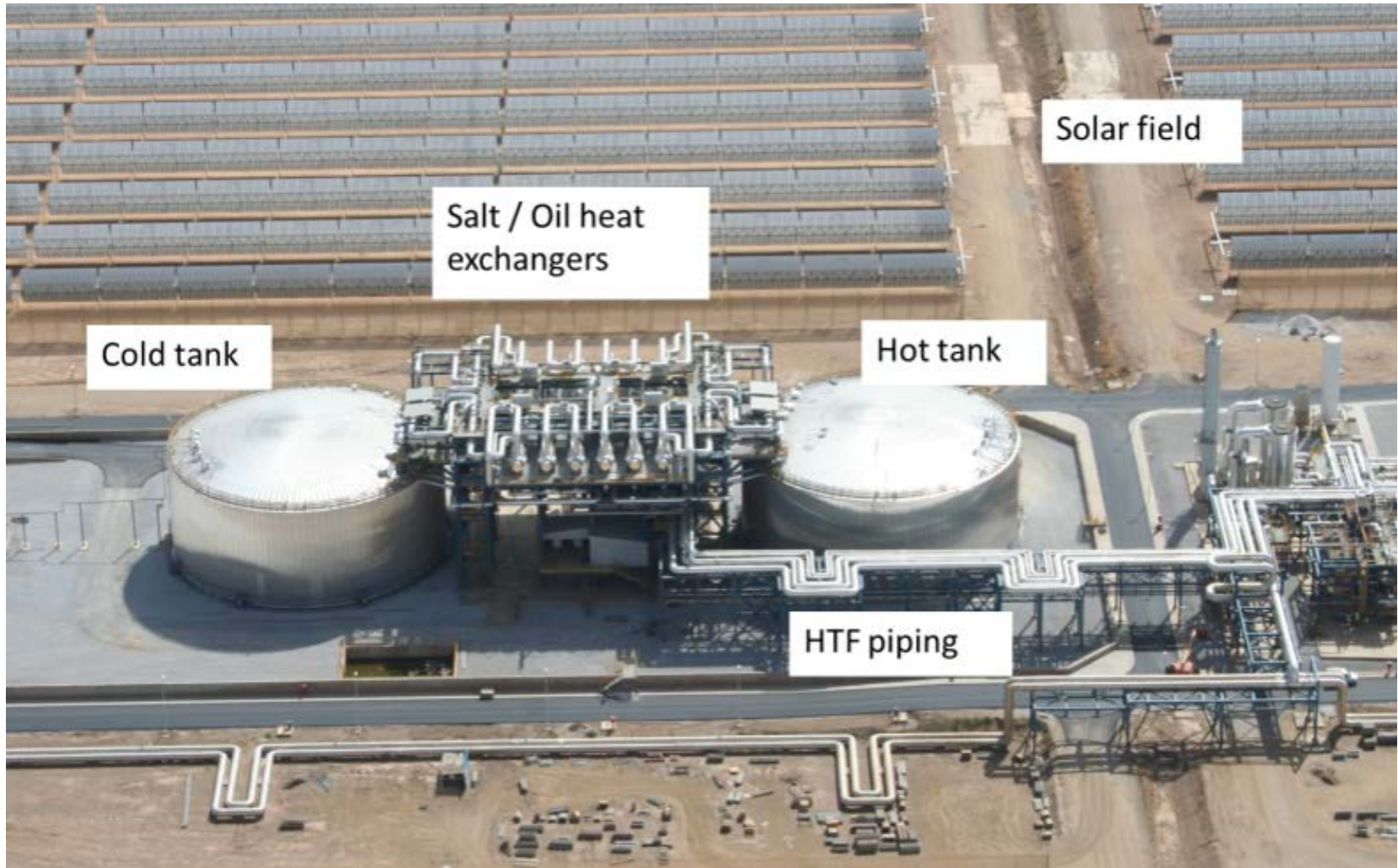
Conventional CSP Plant Layout based on Synthetic Oil as Heat Transfer Fluid



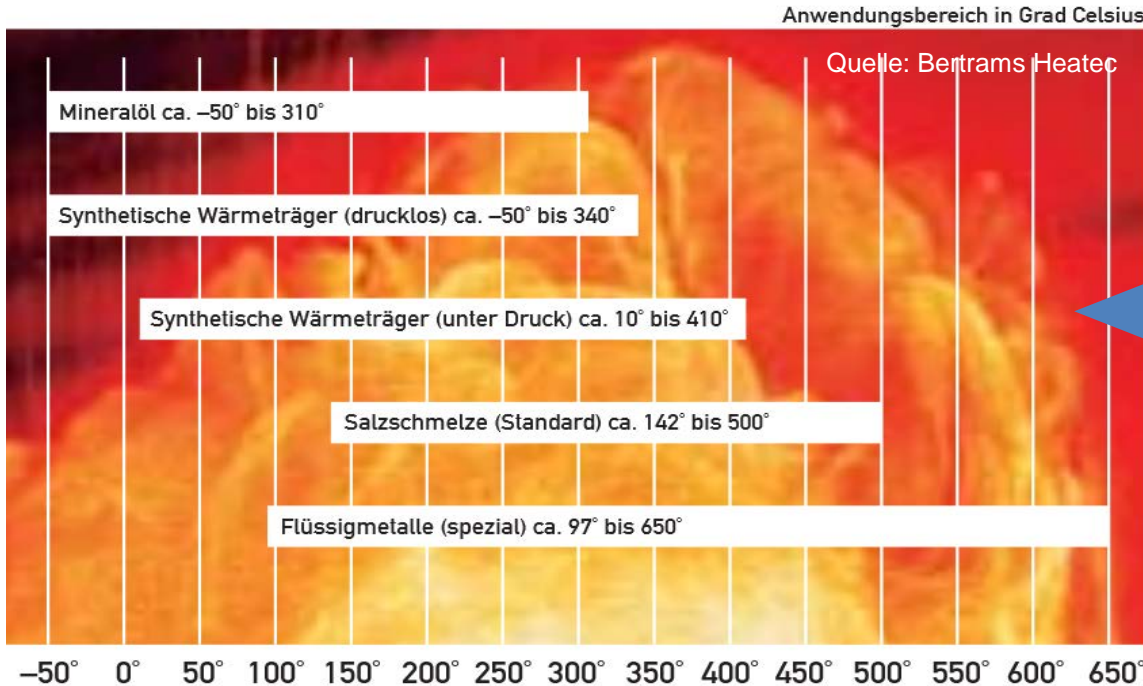
Standard Design of Parabolic Trough CSP with TES

- Temperature limitation of thermal oil of 390°C
- 2 heat exchanger required (from thermal oil to molten salt and from molten salt to steam)
- High storage volume required due to low temperature difference between cold and hot tank

Conventional Molten Salt Thermal Energy Storage



Heat Transfer & Storage Fluids



Standard Heat Transfer Fluids in Parabolic Trough Plants < 390°C

	Composition	m.p.	T _{max} (State of the art)
HITEC®	NaNO ₂ / KNO ₃ / NaNO ₃ (40:53:7 wt%)	140 °C	480 °C
Solar Salt	KNO ₃ / NaNO ₃ (40:60 wt%)	220 °C	565 °C

Novatec Transfer and Storage Fluid

Standard Storage Fluids in Parabolic Trough Plants

Direct Molten Salt (DMS[®]) CSP Technology

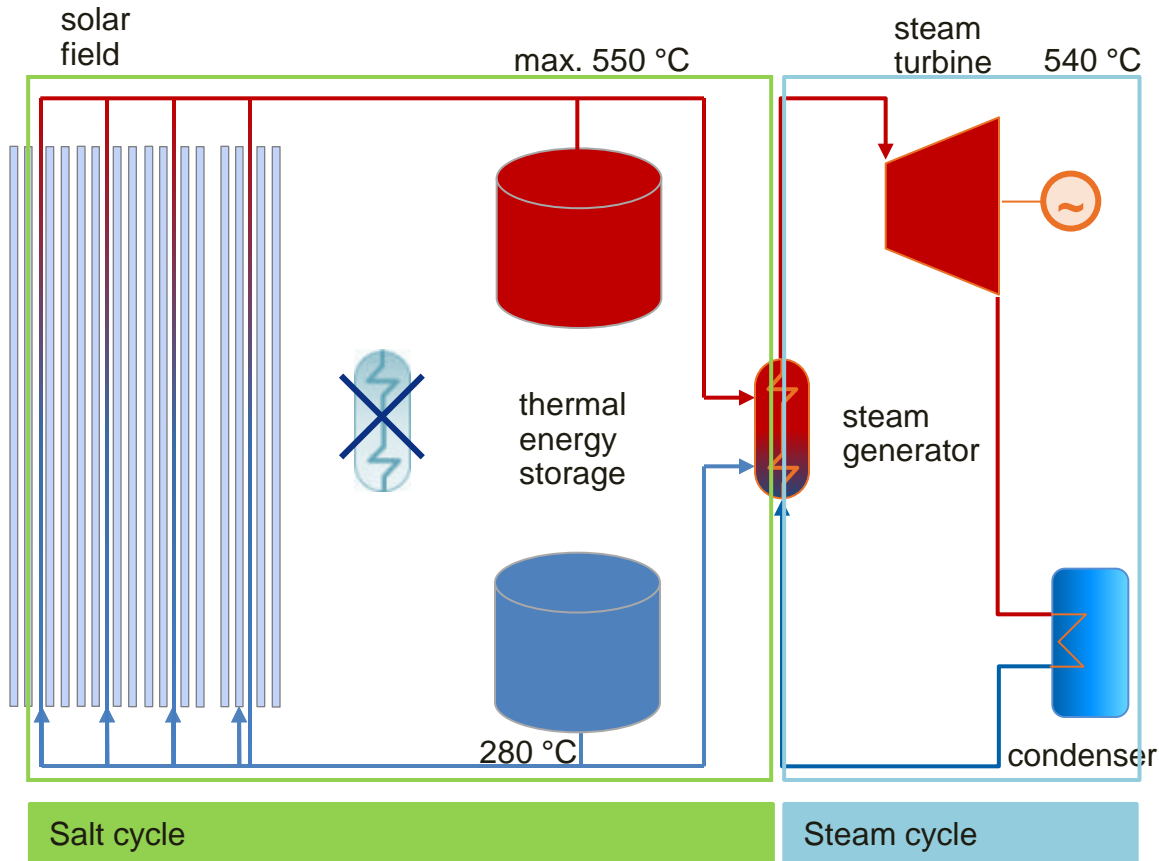
Novatec Solar's DMS Technology has been jointly developed with BASF.

BASF brought in more than 30 years experience in design & operation of molten salt systems.

DMS has been successfully tested and released for sales in 2014.



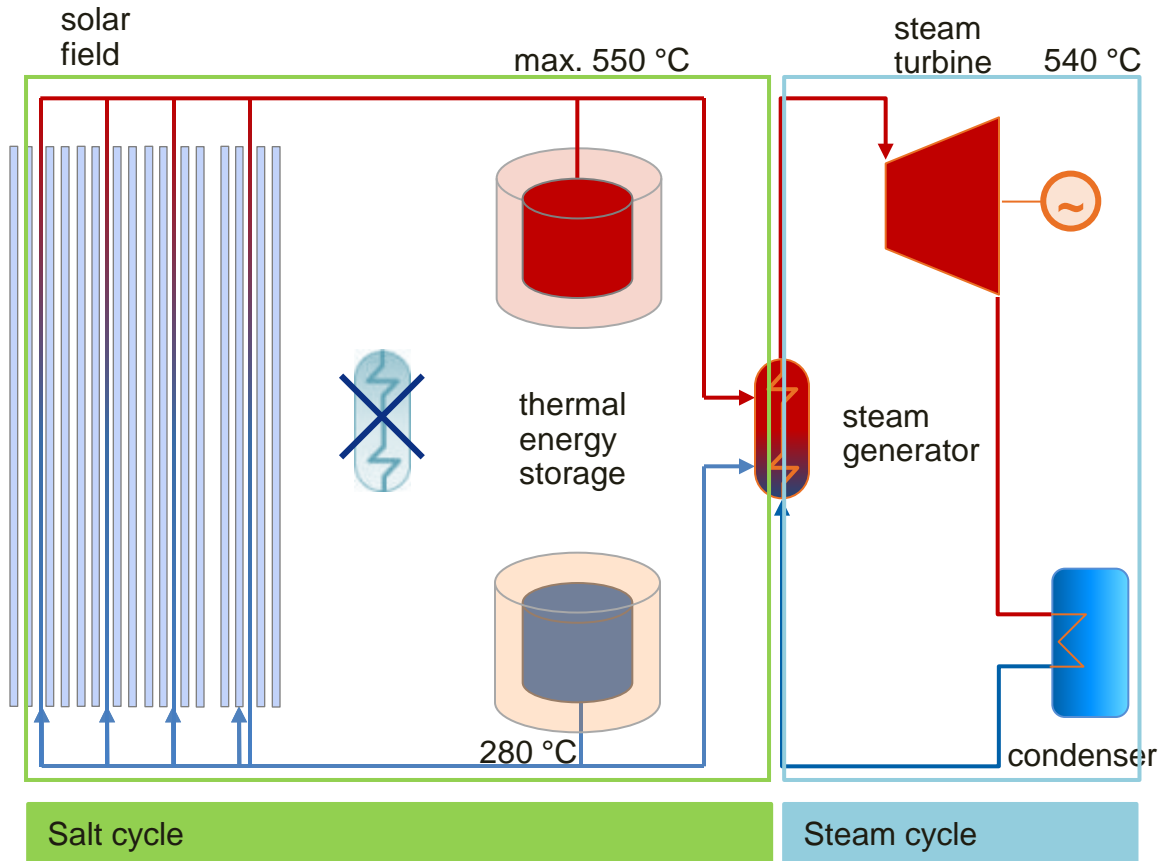
Novatec's Direct Molten Salt (DMS) CSP Plant Designs



Benefits of Direct Molten Salt

- Only one heat exchanger

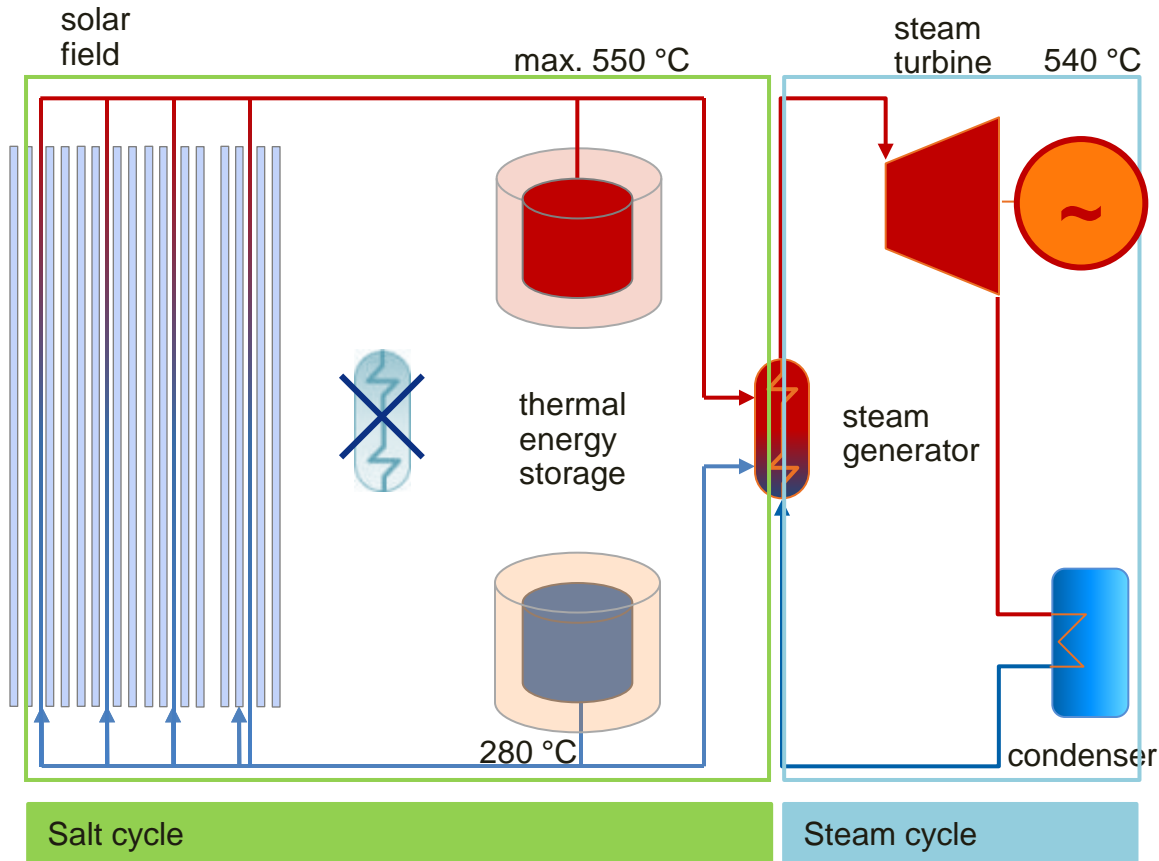
Novatec's Direct Molten Salt (DMS) CSP Plant Designs



Benefits of Direct Molten Salt

- Only one heat exchanger
- 2.5 times reduction of volume storage tanks

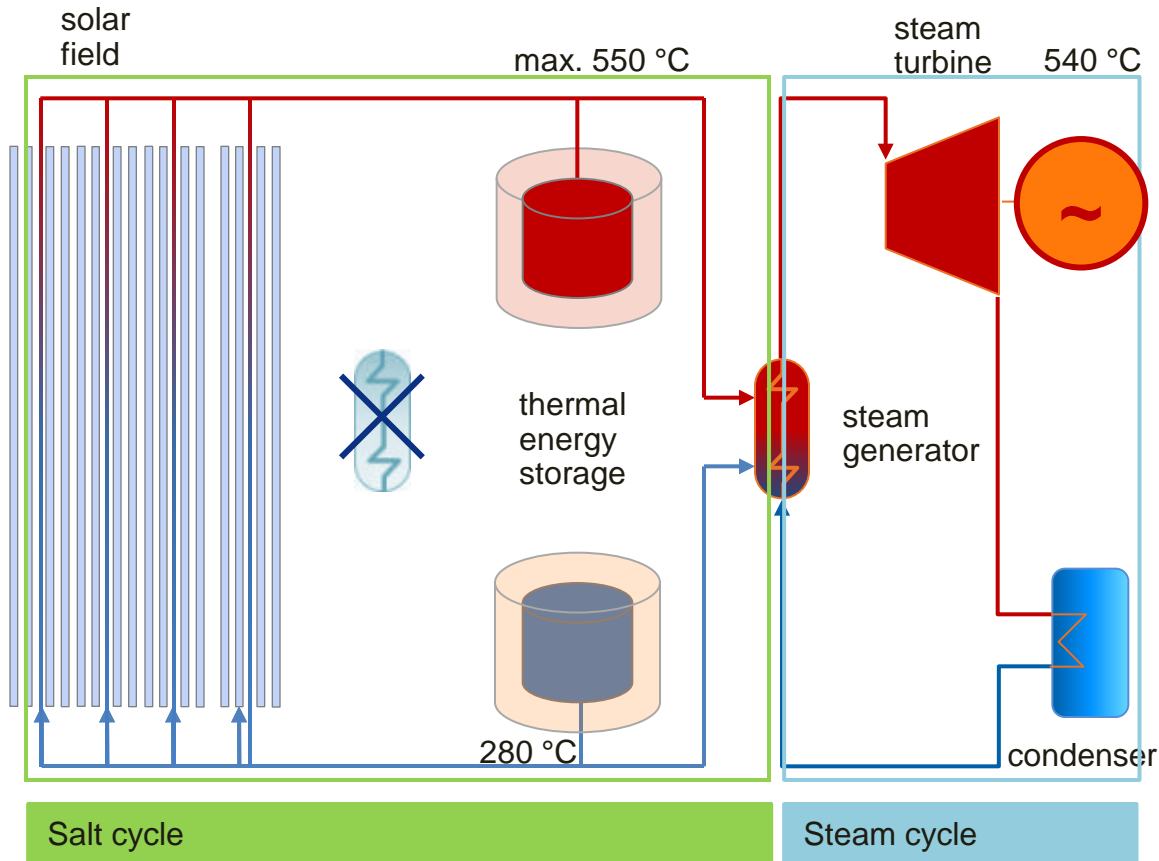
Novatec's Direct Molten Salt (DMS) CSP Plant Designs



Benefits of Direct Molten Salt

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- Higher thermal to electrical conversion efficiency due to increased heat transfer fluid (HTF) / steam temperature

Novatec's Direct Molten Salt (DMS) CSP Plant Designs

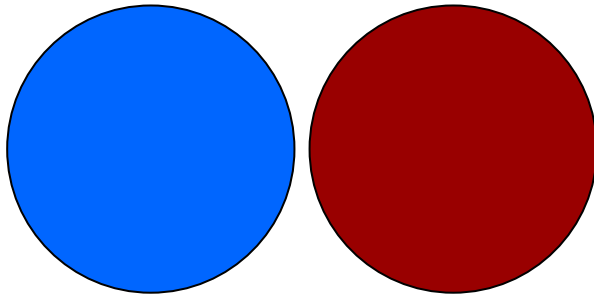


Benefits of Direct Molten Salt

- Only one heat exchanger
- 2.5 times reduction of volume storage tanks
- Higher thermal to electrical conversion efficiency due to increased heat transfer fluid (HTF) / steam temperature
- Nominal peak load achievable during charging and discharging mode

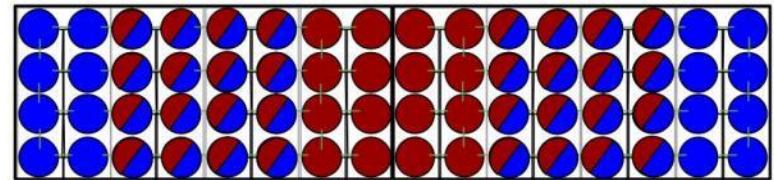
Solar Thermal Energy Storage (TES)

Conventional 2 Tank TES



0% standardisation and pre engineering
50% filled volume
100% at site assembly

Novatec multi Tank TES



100% standardisation and pre engineering
80% filled volume
10% at site assembly

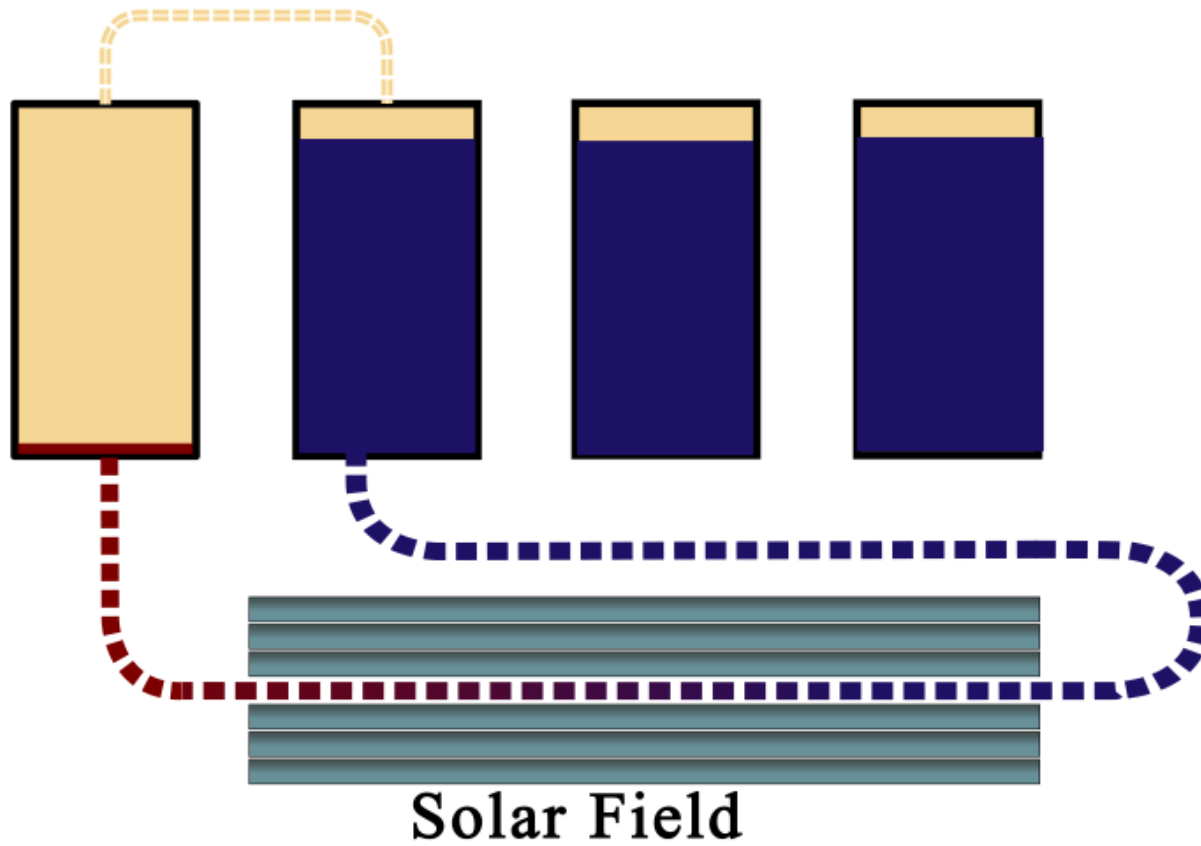
Multi Tank – Transport and Assembly



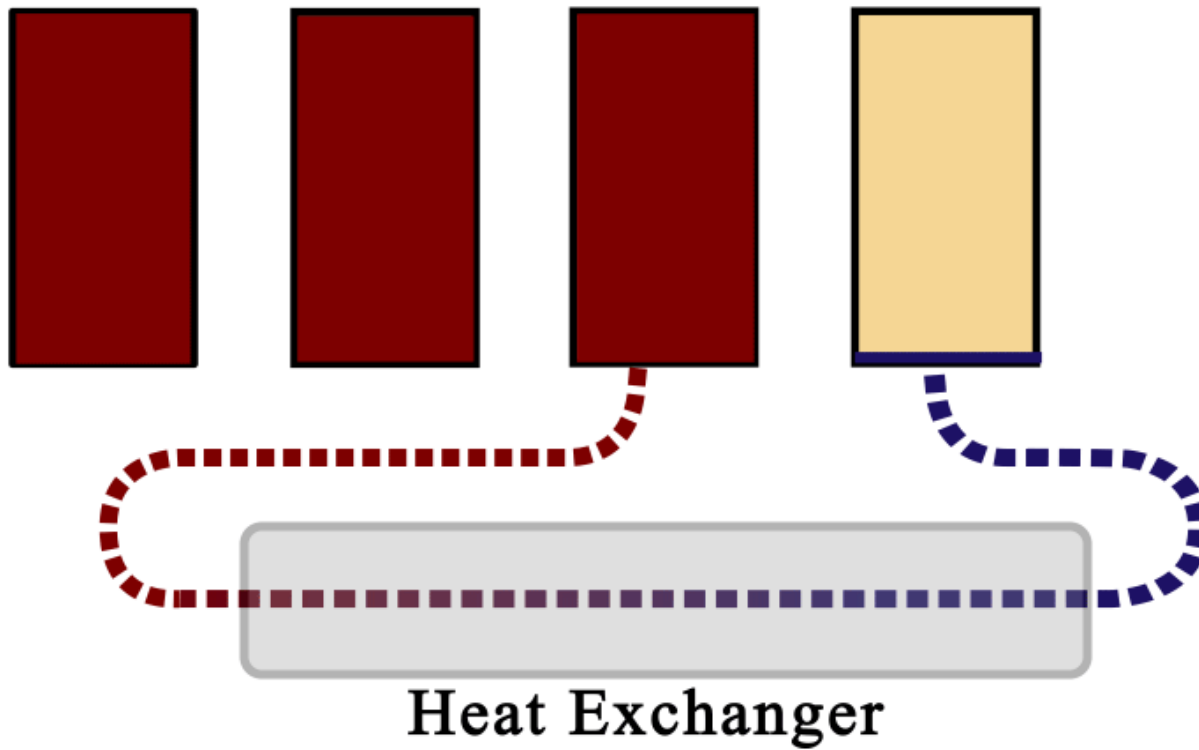
Dimension of one tank:
3.6 meter diameter 12 meter height



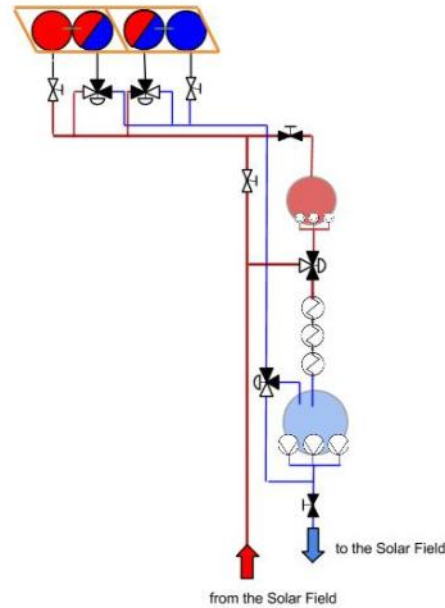
Animation Charging Day



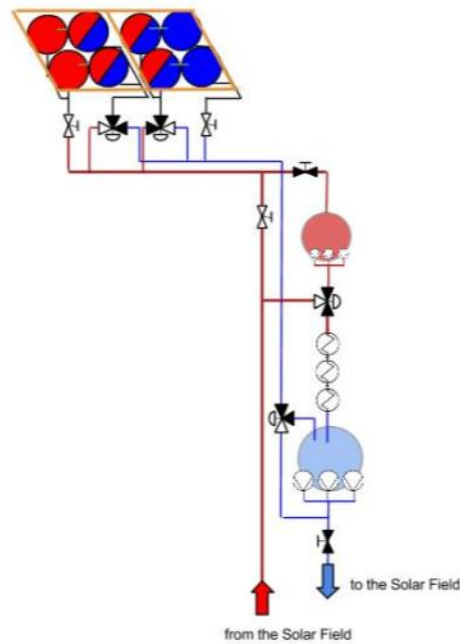
Animation Discharging Night



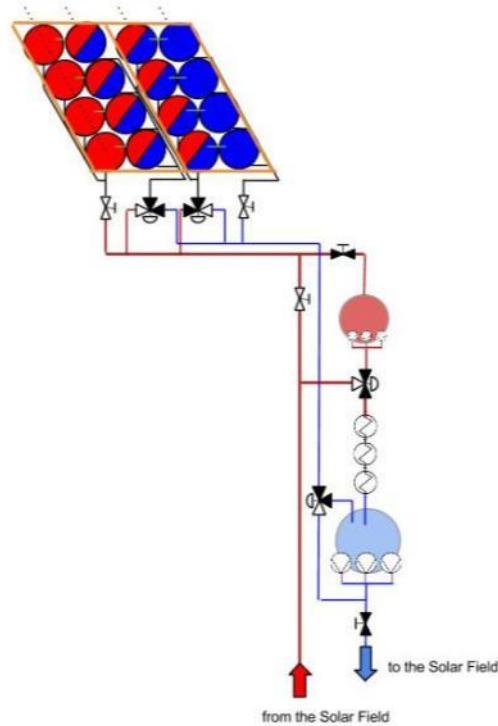
Arrangement for 75MWh_{thermal} – 4Tanks



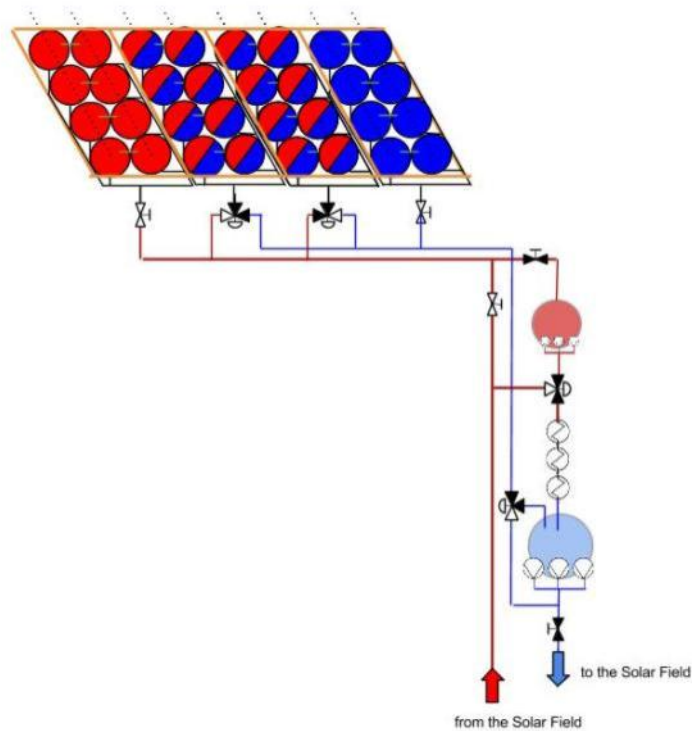
Arrangement for 150MWh_{thermal} – 8Tanks



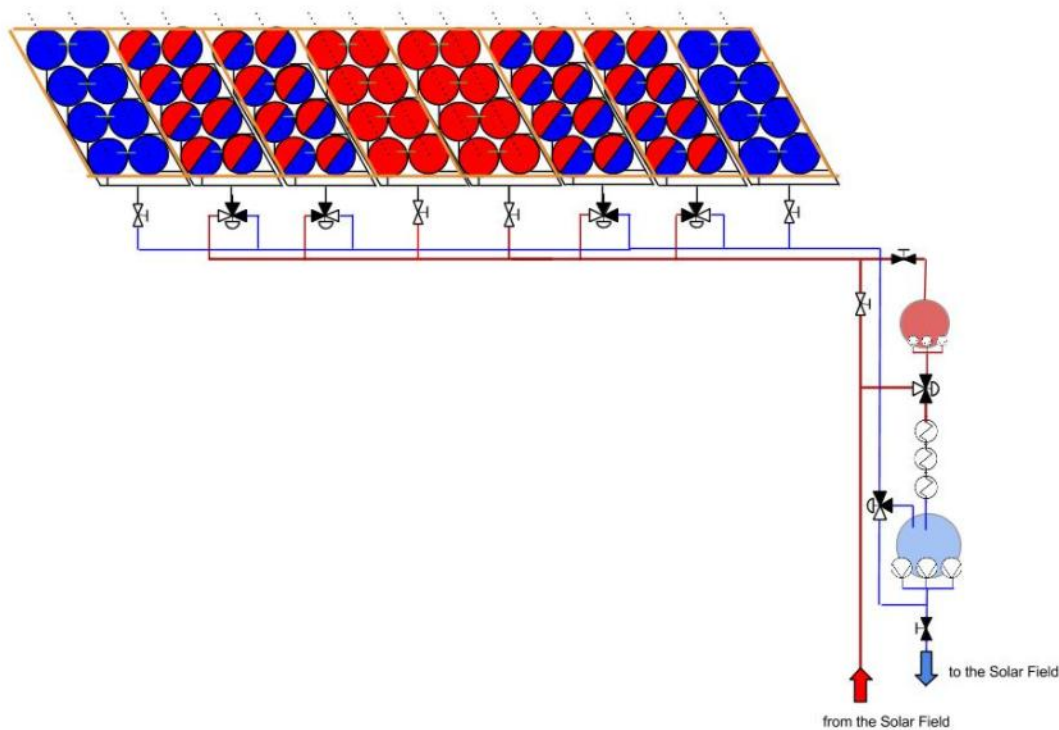
Arrangement for 300MWh_{thermal} – 16Tanks



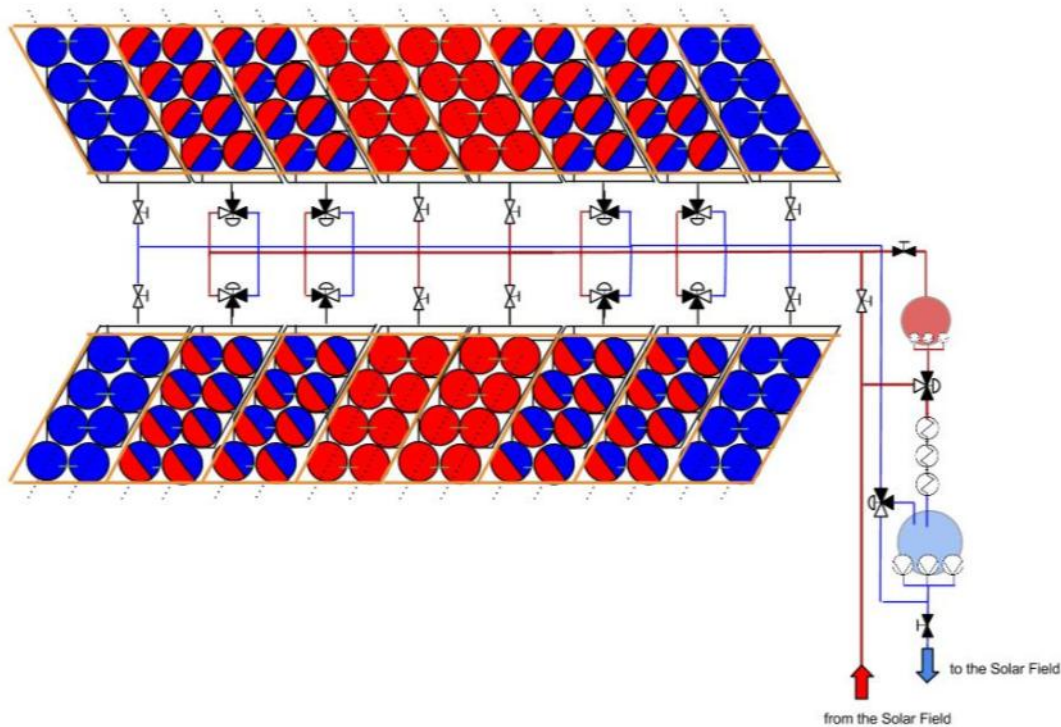
Arrangement for 600MWh_{thermal} – 32Tanks



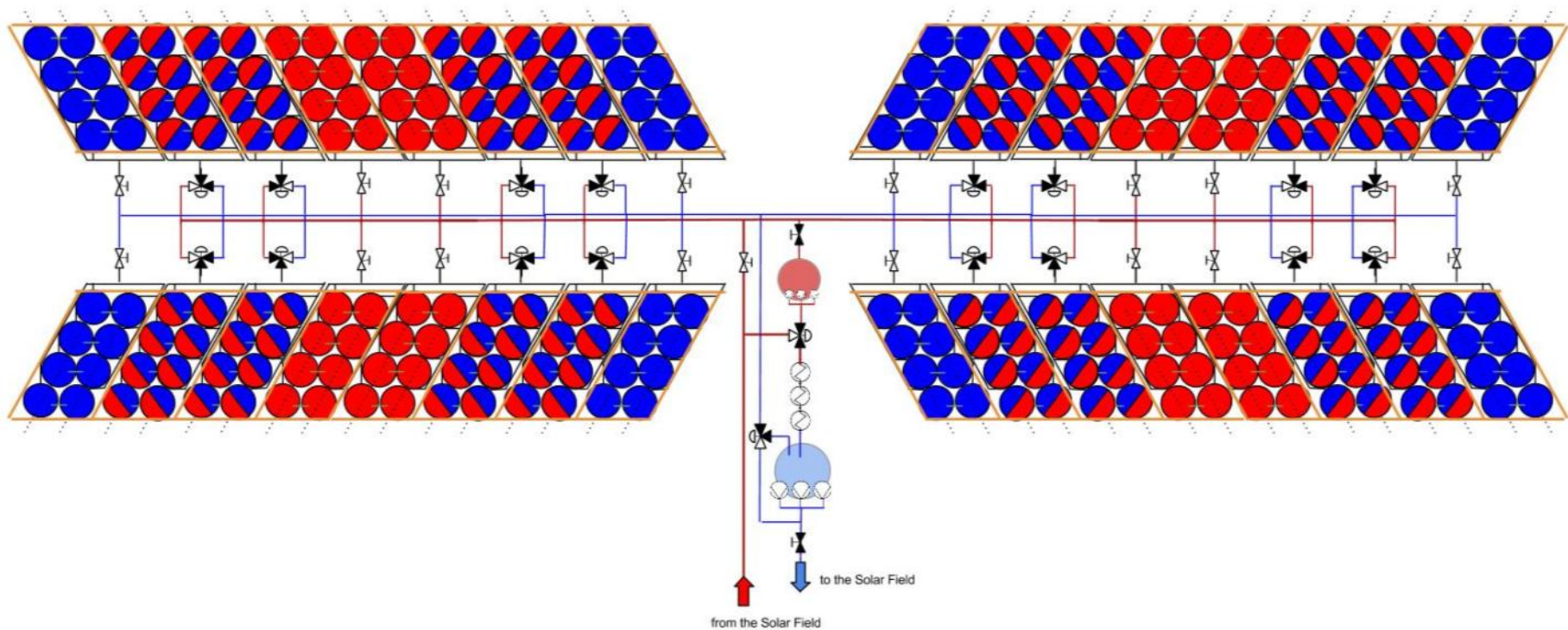
Arrangement for 1200MWh_{thermal} – 64Tanks



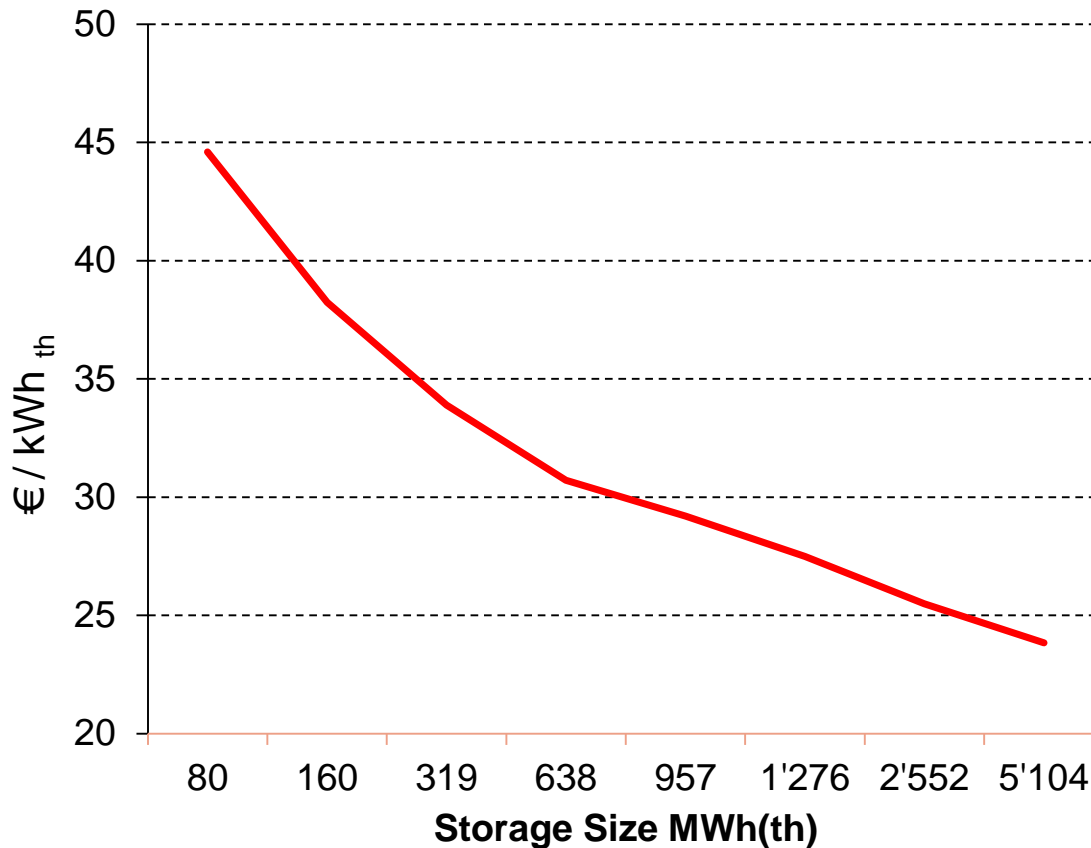
Arrangement for 2400MWh_{thermal} – 128Tanks



Arrangement for 4800MWh_{thermal} – 256Tanks



Cost of Multi Tank High Temperature Thermal Energy Storage



Modular system provides interesting cost even at small storage size

Electricity Cost from Storage can be derived by dividing specific thermal cost by turbine cycle efficiency

Zusammenfassung und Ausblick

- Die Kombination von DMS Fresnelsolarfeldern mit Multi-Tank-Systemen verspricht Stromerzeugungskosten im Bereich von 8 – 15 US Cent pro Kilowattstunde mit Kapazitätsfaktoren von bis zu 85%
- DMS basierte CSP Kraftwerke ermöglichen als ergänzende Grund- und Reservelastkraftwerke, die Anteile der günstigen aber volatilen Photovoltaik und Windkraft zu steigern.
- Dies erlaubt den Ländern im Wüstengürtel der Erde eine nachhaltige und von Energieimporten unabhängige Wohlstandsentwicklung
- Die Markteinführung beider Technologien bedarf keiner Grundlagenforschung, wohl aber eines sehr umsichtigen „Up-Scale Engineering“