IEA CSP Workshop:

Frank Lenzen, 03.03.2014

Different CSP Technologies

Parabolic trough collector	Linear Fresnel collector
	
Solar tower	Dish Sterling
	

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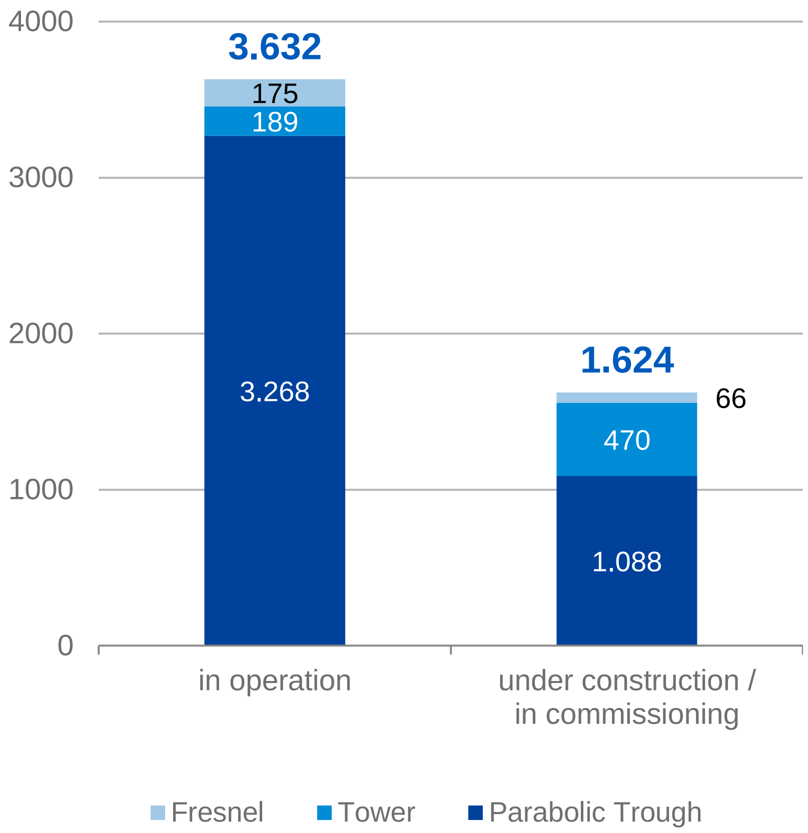
Until end of 2013, a cumulated capacity of more than 3,6 GW has been installed

Cumulated CSP installations and technology share (MW)



- Approx. 90% of the installed capacity is Parabolic Trough
- 5% is Fresnel
- 5% Tower…

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Overview of possible collector systems, heat transfer media and storage media for CSP power plants

Collector system	Heat transfer fluid	Storage medium
Parabolic trough collector	Oil	Sensible molten: Solar salt
Fresnel collector	Molten salt	Sensible solid: Concrete, sand
Solar tower	Water (for DSG)	Phase Change Material (PCM): Salt
	Air	Water / Steam
		Compressed Air

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Overview of potential future CSP combinations consisting of collector, heat transfer fluid and storage medium

Validation of performance and costs drops
→ Increasing uncertainties

Collector system	Heat Transfer Fluid	Storage medium
Parabolic trough collector	Thermal oil Molten solar salt Water (for Direct Steam Generation - DSG)	Sensible: Molten solar salt • Sensible solid combined with Phase Change Material-PCM: Concrete & salt • Water / Steam
Linear Fresnel collector	Oil Molten solar salt Water (for DSG)	Sensible: Molten solar salt • Sensible solid combined with PCM: Concrete & salt • Water / Steam
Power tower	Molten salt Water (for DSG) Air	Sensible: Molten solar salt • Sensible solid combined with PCM: Concrete & salt • Water / Steam • Sensible solid: Sand • Compressed Air

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CSP Technology will move to Molten Salt or DSG as HTF in future if storage up to 3 hours and more is required → Molten Salt

Advantage / Disadvantage	Salts	Water (DSG)
Advantages	• High evaporation point and hence high HTF temperatures possible • Same material used for heat storage and as heat transfer fluid, thus saving of heat exchanger • Lower specific costs compared to oil	• Reliable HTF, non toxic • Direct admission of the steam turbine with steam provided by the solar field, hence saving of heat exchanger • Very low specific costs compared to oil and salt
Disadvantages	• Advanced freeze protection system required • No long term experience regarding corrosion risk	• Sophisticated handling of the DSG-process in the solar field • Elaborate design of a heat storage for DSG required

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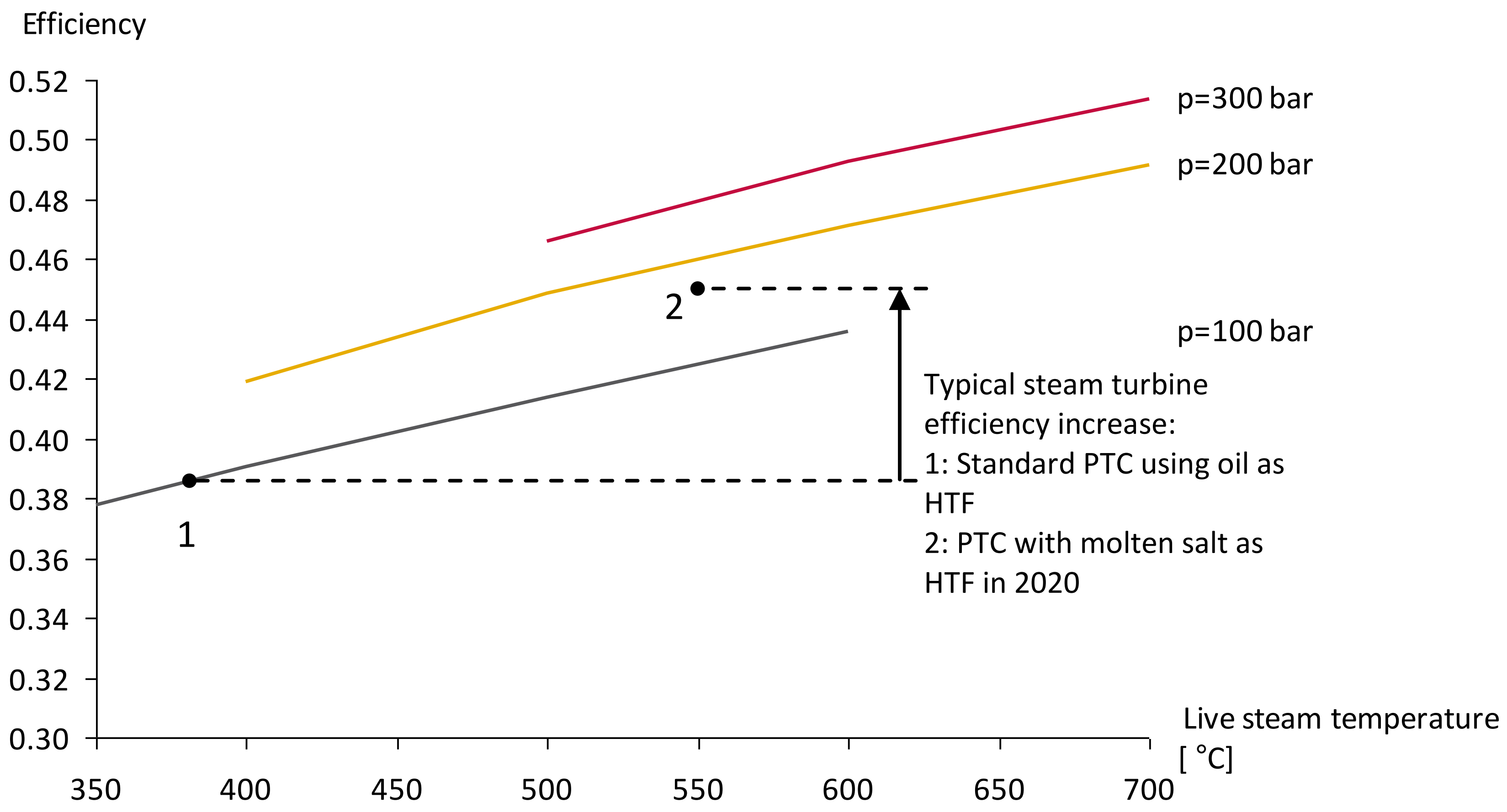
Higher Temperatures will lead to higher Effiziencies in the Power Block



Source DII CSP 2020

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LCOE reduction of 30 % expected for Molten Salt compared to oil as HTF

1. Efficiency improvement of the Power Block performance
   - 380 °C / 100 bar 39 %
   - 550 °C / 150 bar 45 % → 16 % rel. performance improvement

2. Reduced parasitic loads

3. Increased process temperature leads to reduced salt quantities and improved Cost for thermal heat storage

Andasol – Typ	100 %
Molten Salt design	36 %

→ Cost efficiency for heat storage significantly better
→ No need for heat exchanger between oil and salt
→ Equipment for the permanent quality stabilisation of HTF/oil is expensive and can be avoided
→ Corrosion of Molten Salt and increased process temperatures require selected materials
→ Anti freezing protection necessary

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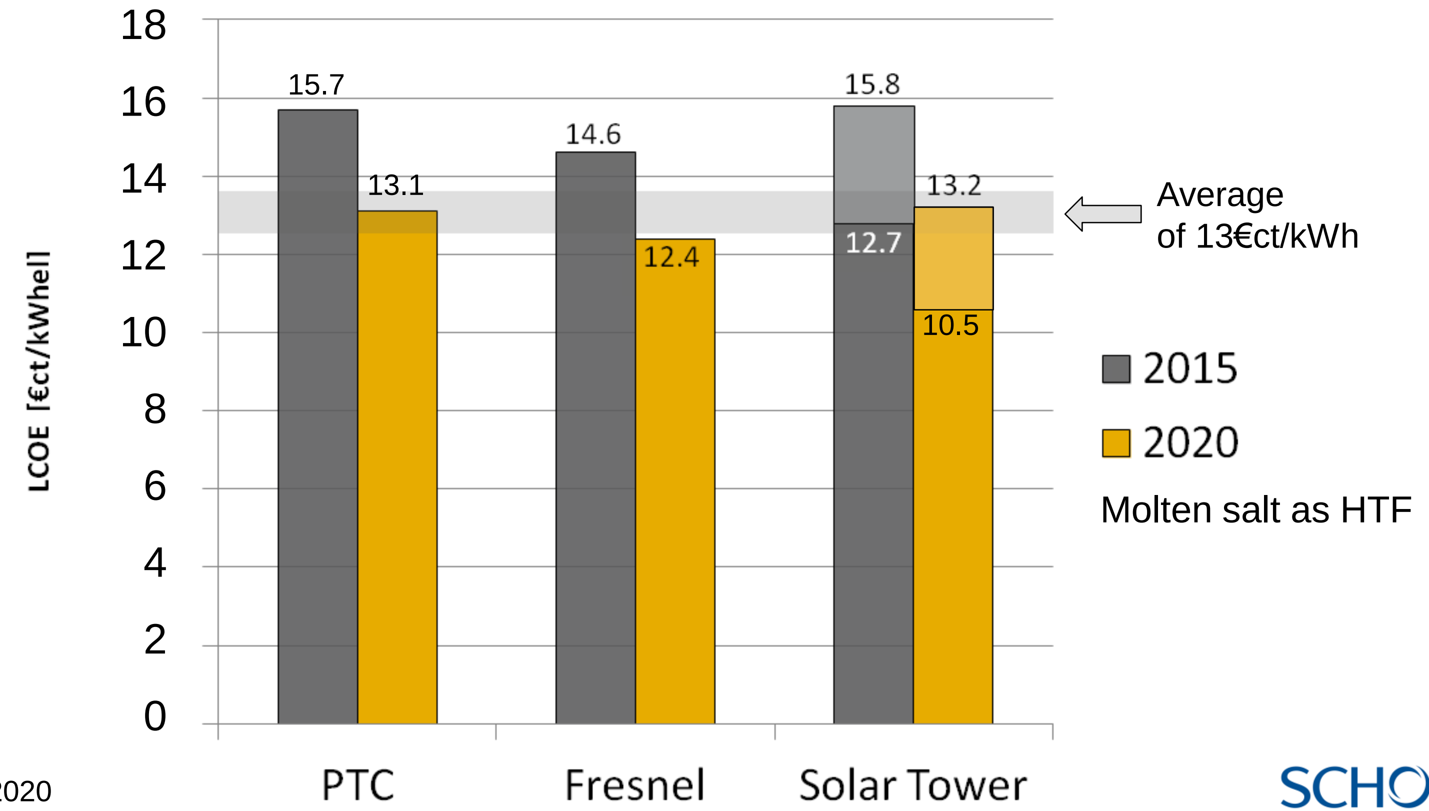
Design Aspects for the Study

- Solar only power plants
- Large scale power plants beyond 100 MW_{el} output for utility applications
- **CSP systems capable of installation of large storage capacities, > 3h**
- Heat transfer fluid interaction with the solar field, power cycle and storage system shall not cause any major technical or commercial problems
- Optimization of the power plant design regarding lowest levelized cost of electricity

LCOEs of Investigated CSP Technologies

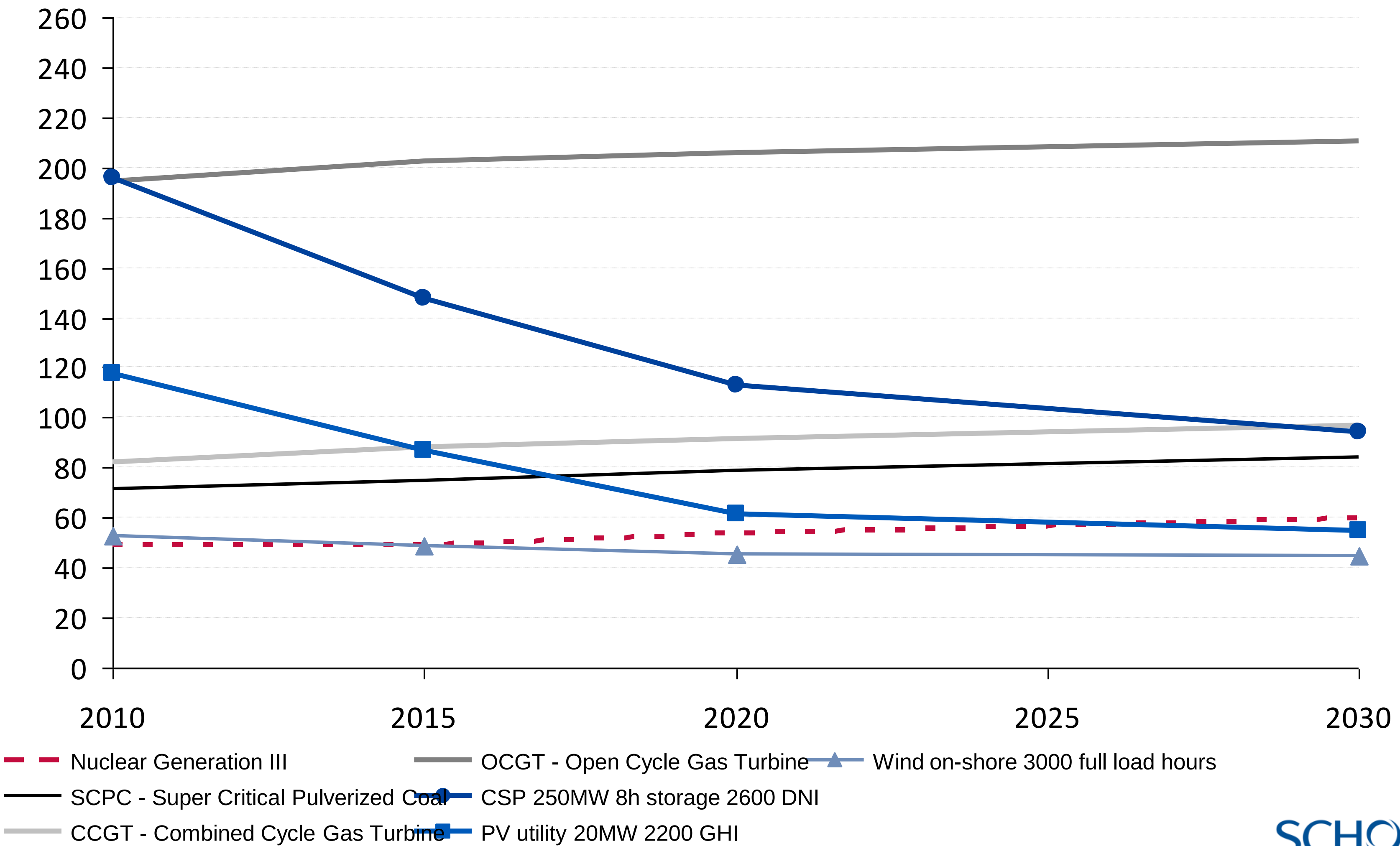
- Significant cost reduction by 2020 for CSP possible
- Average values of **13€ct/kWh** can be reached
- Differentiation of CSP technologies not possible at this stage; highly depending on site criteria required storage capacity and other boundary conditions



Source DII CSP 2020

Between 2020-2030 all renewable technology will be competitive to all fossil technologies

LCOE, medium fuel prices [€/MWh]



Source: Dii

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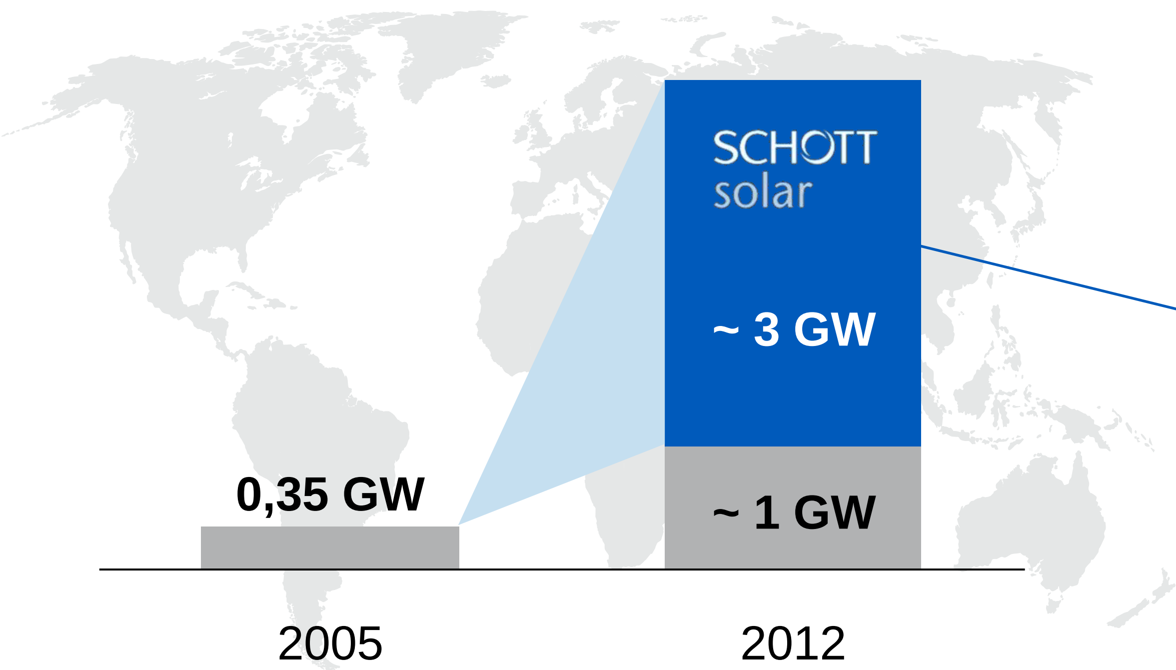
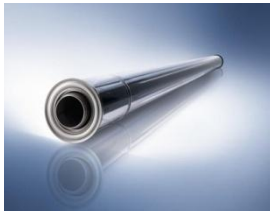
Since the market entry in 2005, SCHOTT Solar CSP has achieved a leading market position

CSP capacity installed or under construction



More than 3 Gigawatts capacity equipped with SCHOTT PTR®70 receivers



More than 1 Million receivers supplied to over 50 CSP projects worldwide

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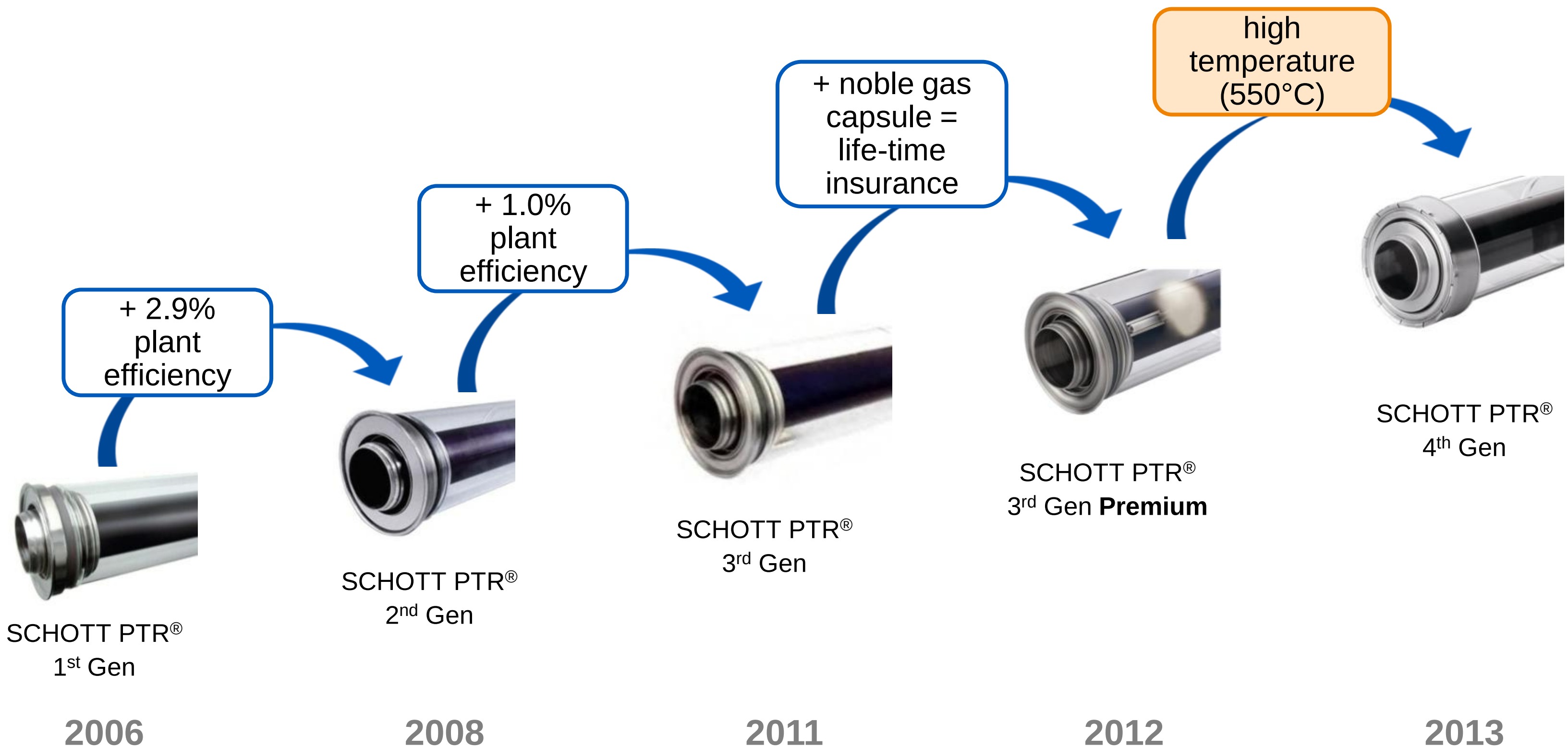
SCHOTT pursues a continuous improvement of its PTR® receiver

SCHOTT PTR®70 Receiver Development



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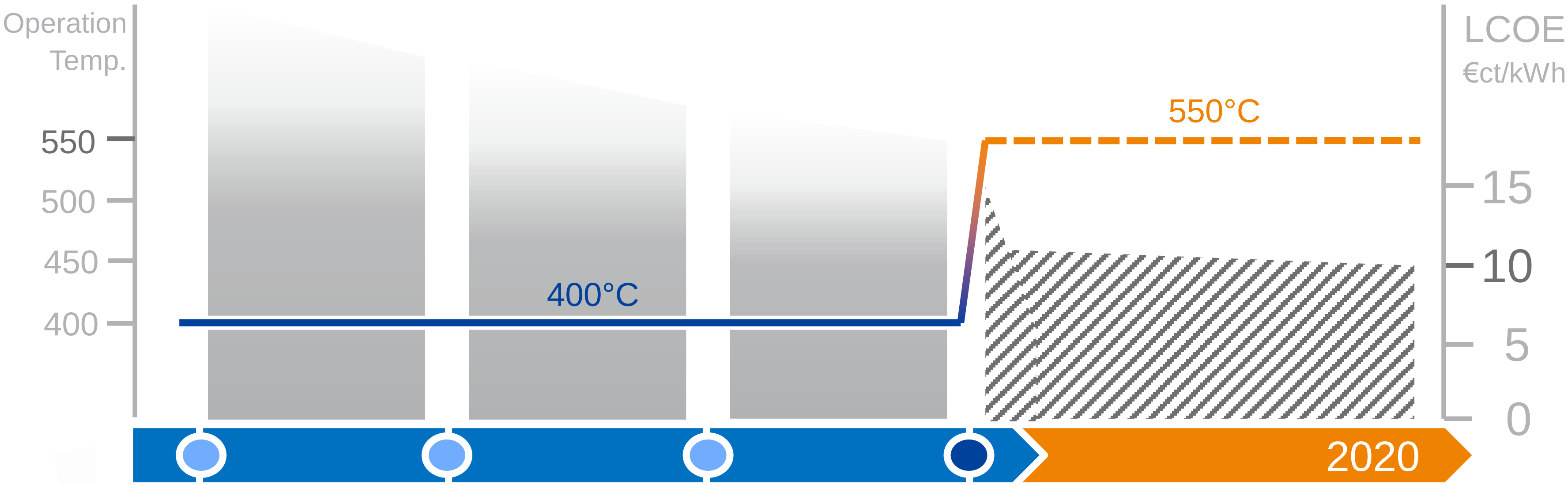
The 4th generation receiver of SCHOTT Solar paves the way to competiveness of CSP technology



SCHOTT PTR® 1st Gen

SCHOTT PTR® 2nd Gen

SCHOTT PTR® 3rd Gen

SCHOTT PTR® 4th Gen

- Operation temperatures up to 550°C
- Usable with Molten Salts as heat transfer fluids
- Optimized robustness for easy handling

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Based on a new receiver platform, SCHOTT issues three receiver products

SCHOTT PTR® 4th generation receiver platform

SCHOTT PTR®70 Advance

- New steel grade for 550°C
- Novel absorber coating

Molten Salt

SCHOTT PTR®70 Premium

- Integrated Noble Gas Capsule as lifetime extender

Oil

SCHOTT PTR®70

Oil

- New bellow design, suitable for high-temperature operation
- Glass-to-metal seal with matching coefficients of thermal expansions
- Protection cap for improved product robustness and easy handling

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Conclusion

- Investigated parabolic trough, linear Fresnel and solar tower systems are feasible CSP concepts to lower LCOEs by 2020. 13Cent/KWh seems to be a possible target (2020)

- Storage is a crucial feature for all CSP power plants in terms of lowering the LCOEs and enabling power dispatchability, especially when considering high grid penetration of renewable energy sources such as PV and Wind

- Technology leap compared to existing systems is necessary to reach defined targets

- Molten salt is considered by all players in the CSP branch to be one of the preferred HTFs for all investigated systems which will enable the necessary technology leap by 2020

- System optimization shows a trend toward high storage capacities for all technologies by 2020 leading to high full load hours

→ First test installations will show the prove of concept short term

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