LCOE reduction potential of parabolic trough and solar tower CSP technology until 2025

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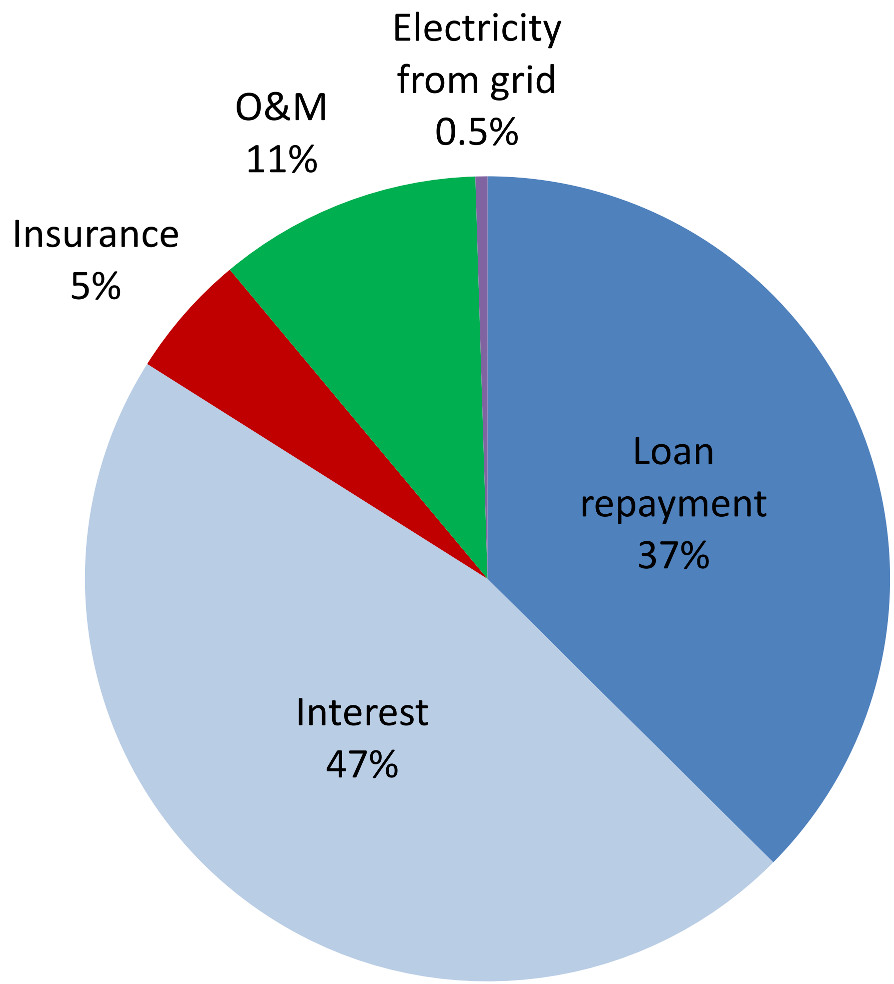
Content

Source: noorouarzazate.com

1. Introduction – Contributing Cost Factors for LCOE

- Example based on annuity loan over 25 years at 7.5%
- Main Impact factors:
  - Investment cost (CAPEX)
  - Financing conditions
- → **LCOE estimation is mainly CAPEX estimation**

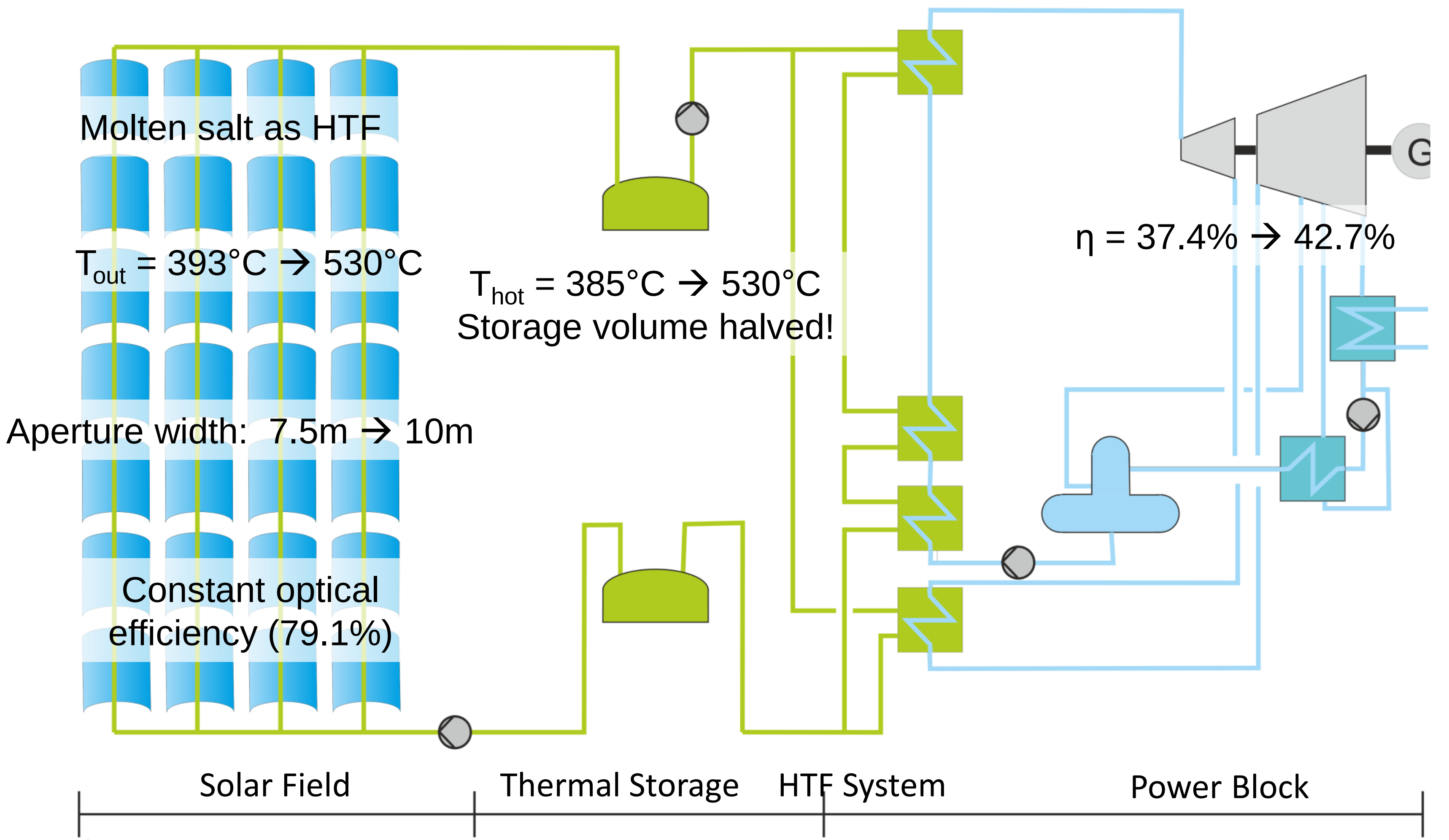


1. Introduction – Methodology and Boundary Conditions

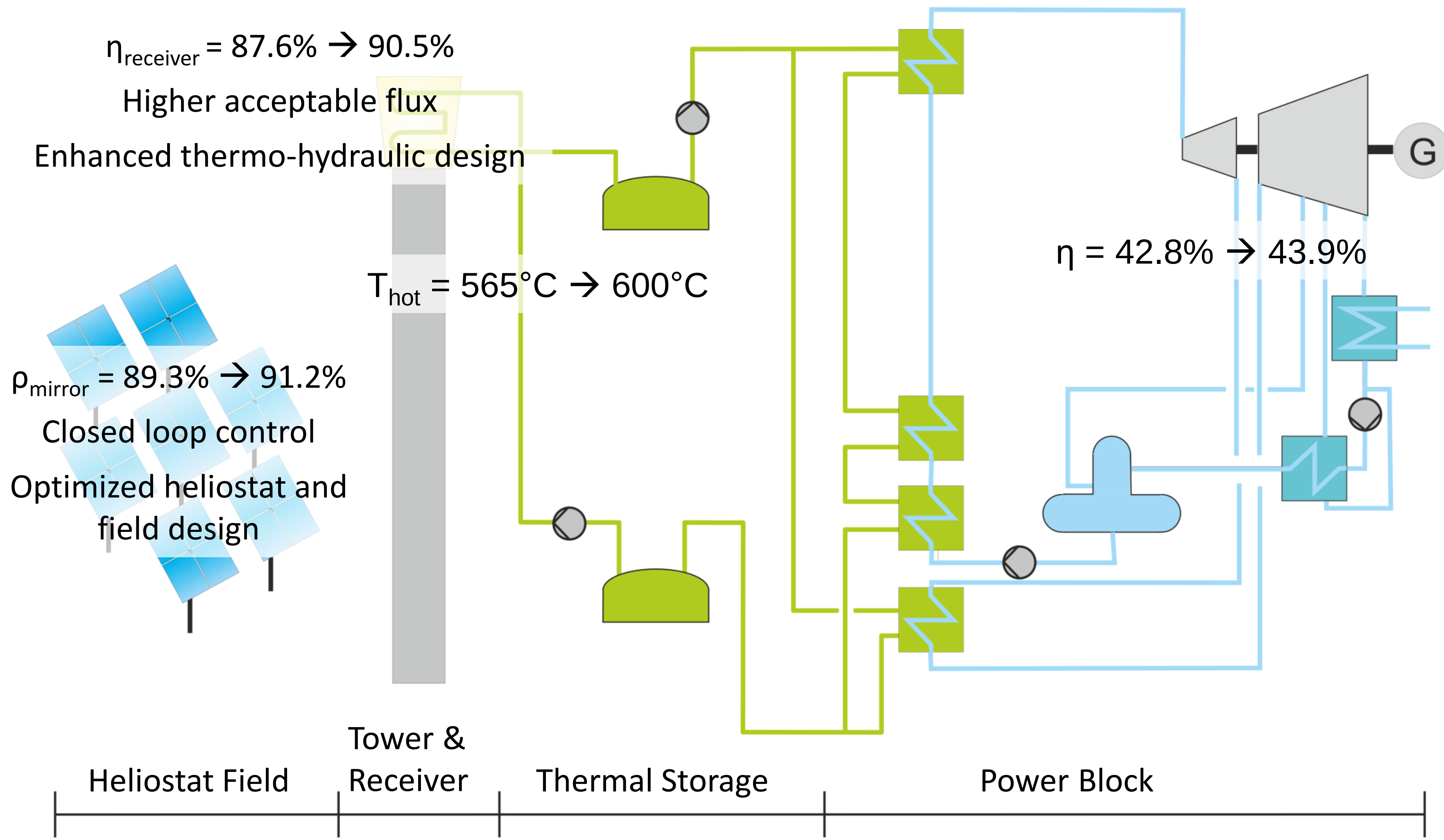
- Technology-based bottom-up approach relying on inhouse expertise as well as external data sources
- Contrasted with published Power Purchase Agreements (NOOR II + III)
- Ouarzazate, Morocco, DNI: 2017 / 2558 / 2935 kWh/(m²·a)
- Currency: US-$$_{2015}$
- CSP capacity growth to about 20GW in 2025

	Parabolic Trough	Solar Tower
Nominal Electric Net Output	160 MW	150 MW
Thermal Storage Capacity	7.5 h	9 h

2. System Overview – Parabolic Trough 2015 → 2025



2. System Overview – Solar Tower 2015 → 2025



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3.1 Cost and Performance – Parabolic Trough Field

	2015	2025
Collector	UltimateTrough™	Future Trough
Turnkey Cost*	231 $/m²	177 $/m²

*: includes site preparation, collectors, piping, cabling, HTF, HTF system, assembly & construction

- Total cost reduction: 23%
- Cost reduction equally distributed over sub-components
- 25% less collectors, foundations, pylons, drives and receivers
- Collector structure: -14 $/m²
  - (Sub-)supplier standards and standardized designs
  - Automatization in manufacturing
- HTF cost: -18$/m²

Source: sbp.de

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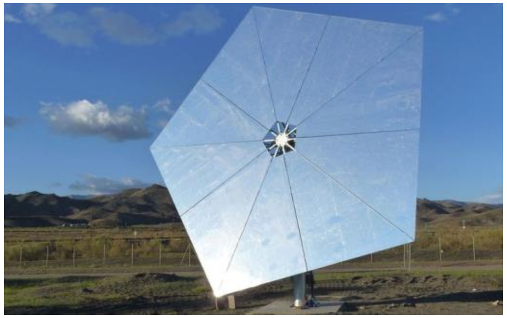
3.2 Cost and Performance – Solar Tower System

	2015	2025
Heliostat	Stellio™	Future Heliostat
Heliostat Field Cost*	143 \$/m²	103 \$/m²
Tower Cost	90,000 \$/m	72,000 \$/m
Receiver Cost	125 $\$/kW_{th}$	100 $\$/kW_{th}$

*: includes site preparation, heliostat field, cabling, assembly & construction

- Total heliostat cost reduction: -28%
- Mirrors: -9 \$/m²
  - Reach parabolic trough mirror cost
- Drives: -11 \$/m²
  - Replace costly slewing drives
  - Closed loop control
- Structure & foundations: - 10 \$/m²
  - Bigger market volume, standardized designs
  - Idustrialized assembly procedures

- Total receiver cost reduction: -20%
  - Improved material concepts
  - Optimized absorber surface utilization
  - Higher average solar flux



Source: sbp.de

3.3 Cost and Performance – Thermal Storage

	Parabolic Trough		Solar Tower		
	2015	2025	2015	2025	
Cost	42	26	26	22	$/kWh
Hot tank temperature	385	530	565	600	°C

- Both technologies:
  - Adapted storage materials
  - Innovative storage concepts (e.g. Single-tank thermocline storage)
- Tower Storage Costs: -4 $/kWh (-17%)
- Trough Storage Costs: -16 $/kWh (-38%)
  - -12.5 $/kWh for storage medium
    - halved storage fluid mass thanks to higher temperature
  - -3 $/kWh for HXs and pumps

Source: www.renewableenergyfocus.com

3.4 Cost and Performance – Power Block

	Parabolic Trough		Solar Tower		
	2015	2025	2015	2025	
Cost	1220	1100	1270	1100	$/kW
Live Steam Temperature	383	520	555	590	°C
Thermal Efficiency	38.4	42.7	42.8	43.9	%

- Minor cost reduction potential
- Dry cooling predominant
- Efficiency gain thanks to increased live steam temperatures

Source: The Energy Blog – energy.org.za

3. Cost and Performance – Overview and Indirect Cost

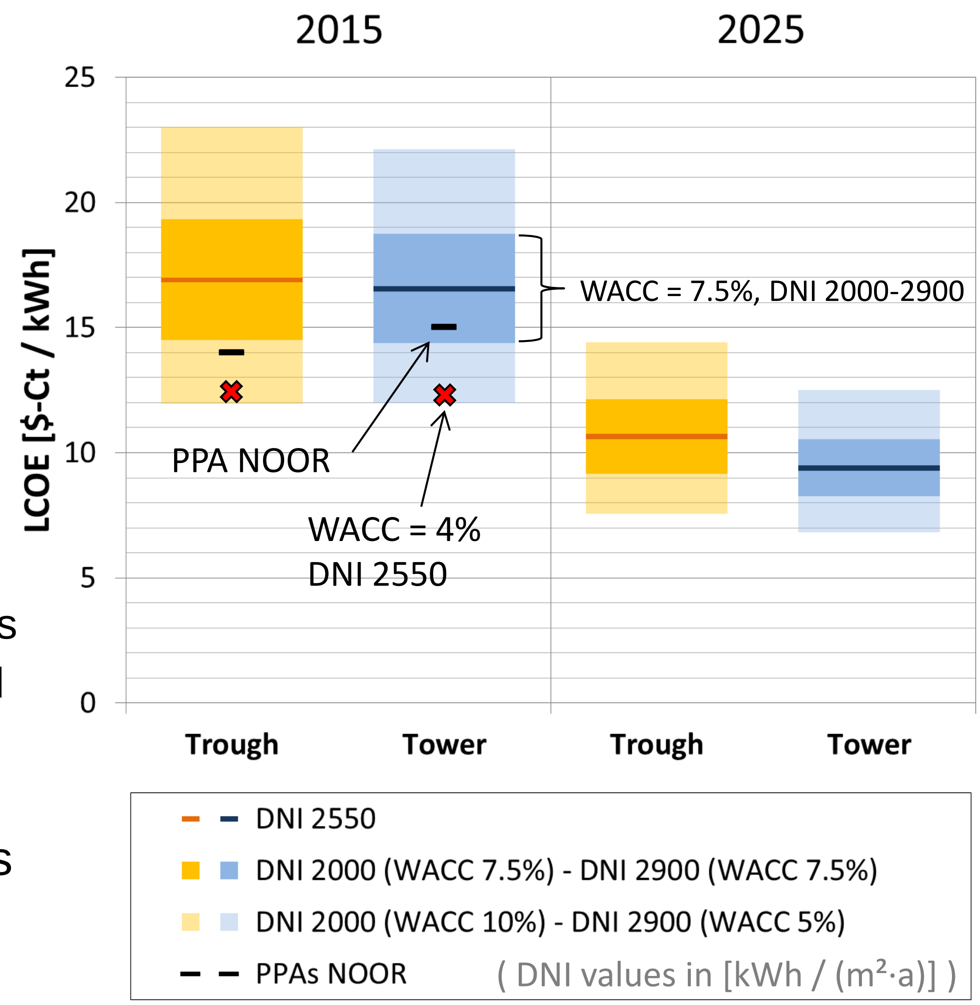
	Unit	2015		Cost variation [%]		2025	
		Trough	Tower	Trough	Tower	Trough	Tower
Direct EPC costs	**Mio. $**	**675**	**598**	**-24**	**-23**	**508**	**459**
Engineering, management, add. EPC services	% on direct EPC	5				2	
Profit margin and contingencies	% on direct EPC	10	19			6	
Indirect EPC cost	**Mio. $**	**101**	**144**	**-60**	**-74**	**41**	**37**
Project development	% on dir.+indir. EPC	10				4	
Land cost	$ / m² land	1				1	
Infrastructure	Mio. $	6				6	
Additional owner's cost	% on dir.+indir. EPC	3				2	
Owner's cost	**Mio. $**	**112**	**113**	**-61**	**-60**	**44**	**46**
CAPEX	**Mio. $**	**888**	**854**	**-33**	**-37**	**593**	**541**
OPEX	% of CAPEX	2.2	2.3			2.1	1.9

4. Results – Plant Output and LCOE

Parabolic Trough	2015	2025
Annual el. output	576 GWh	625 GWh
Overall efficiency	15.1%	17.0%

Solar Tower	2015	2025
Annual el. output	598 GWh	644 GWh
Overall efficiency	15.5%	18.3%

- Until 2025 LCOEs decrease to
  - 10 $-ct/kWh for medium DNI levels
  - 7 $-ct/kWh for high DNI levels and favourable financing conditions
- PPAs ≈ LCOE + 1…1.5 $-ct/kWh
- Assuming 4% WACC, LCOE values match well to published PPAs from NOOR



5. Conclusion

- CAPEX: 5600 → 3600 $/kW (-35%) for both technologies (7.5/9h storage)
- LCOEs can reach 7 $-ct/kWh (high DNI, favourable financing)
- Major cost drivers Trough:
  - Molten salt as HTF
  - Trough collector CAPEX
- Major cost drivers Tower
  - Steep learning curve, reduction of contingencies, overcoming of teething troubles
  - Heliostat field CAPEX
- Financing conditions are a massive cost driver:
  - For each 1%-point WACC reduction LCOEs decrease by 1.1 $-ct/kWh

→ IRENA publication (2016): „*The power to change – Solar and Wind Cost Reduction Potential to 2025*"

MANY THANKS

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IRENA
International Renewable Energy Agency

THANK YOU

for your attention!

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