



Ultimate Trough®: The new parabolic trough collector for CSP

Marrakech, 15th May 2012

LEADING GLASS TECHNOLOGY

Solar



Sales 2010/11: 97 m €

- Large parabolic mirrors for solar thermal power plants
- Mirrors for Fresnel, Dishes and Power Tower applications
- Mirrors for CPV Applications
- Solar Engineering

Automotive



Sales 2010/11: 70 m €

- Calottes
- Interior and exterior mirror glass
- Mirror glass sub-systems

Technical Glass



Sales 2010/11: 17 m €

- Special coatings for technical applications
- Anti-reflex coated glass for consol applications

Group Overview Global Presence

Production facilities: Solar



Business Unit Solar

Solar Mirrors

Solar Engineering



 DESERTEC

PARTNER



Dii
Renewable energy
bridging continents

ASSOCIATED PARTNER

Solar: Products

FLABEG SOLAR MIRRORS

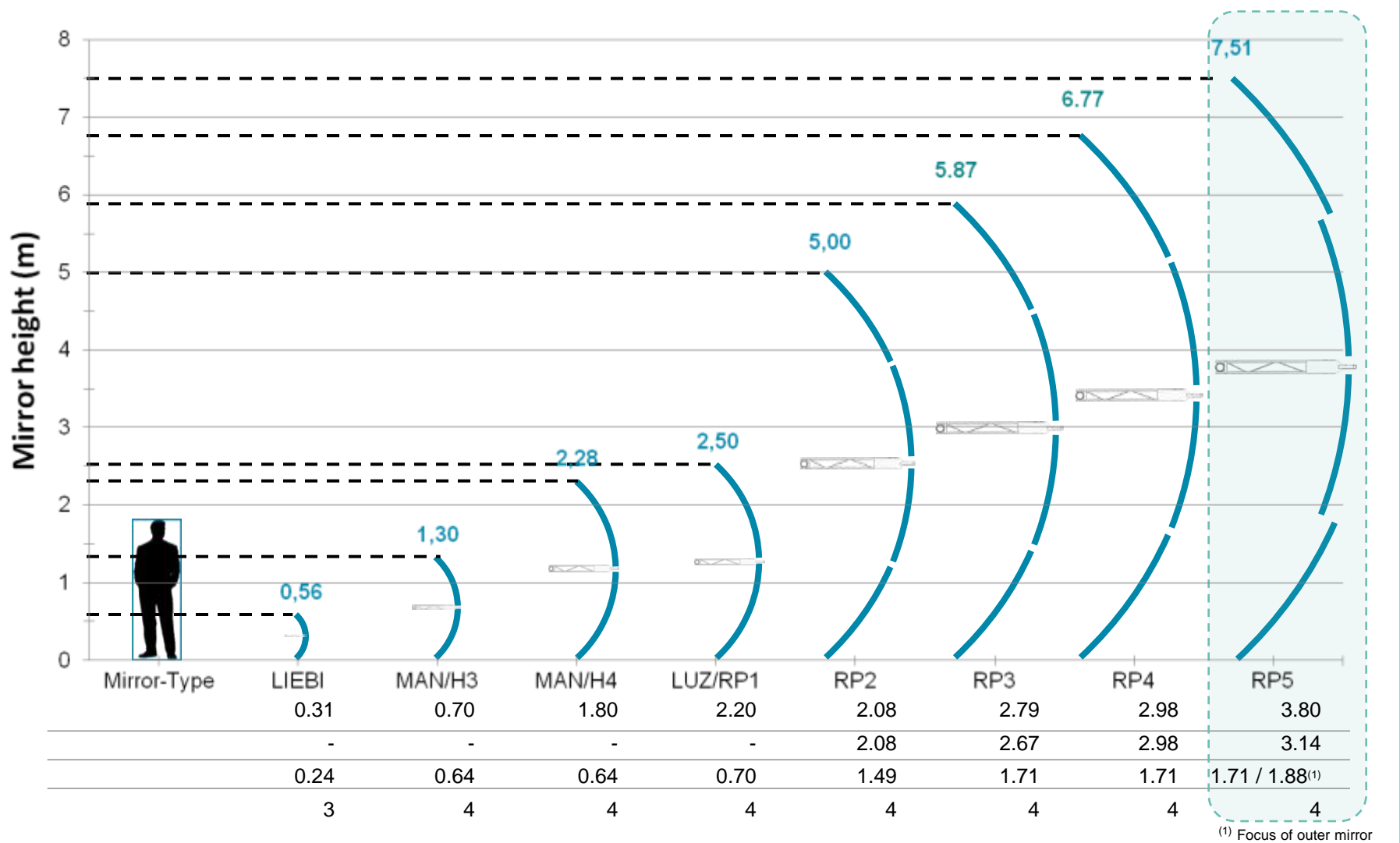
1. Best and independent global sourcing
2. Latest coating technology
3. Continuous improvement of production processes



**HIGHEST
EFFICIENCY**
for your
Solar Application



Development in Solar Mirror Sizes (1970 – 2011)



FLABEG's extended Scope of Supply

Next step: FLABEG's engineering team is developing
the most cost effective and highest efficient Parabolic Trough Collector

➔ **The Ultimate Trough®**



Prototype available as of Q1/ 2011

UltimateTrough Development – Design goals

Design goal for the Ultimate Trough:

Cost reduction of about 25% compared to the EuroTrough by

- decreasing specific cost [€/m²] by “going large” (- 20% specific cost savings)
- increase of optical performance (8%) by tension free mirror attachment



UltimateTrough – Conceptual design overview

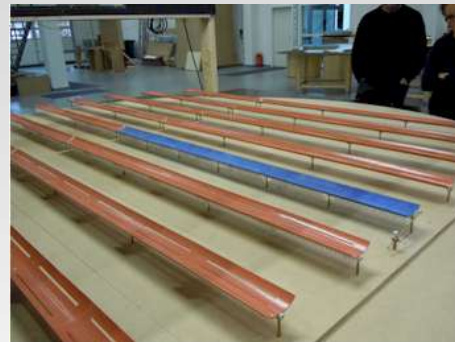
Going large:

- One Solar Collector Element (SCE):
7.5 m x 24 m, 169 m² aperture area
- 10 SCEs/SCA (1,689 m² aperture area)



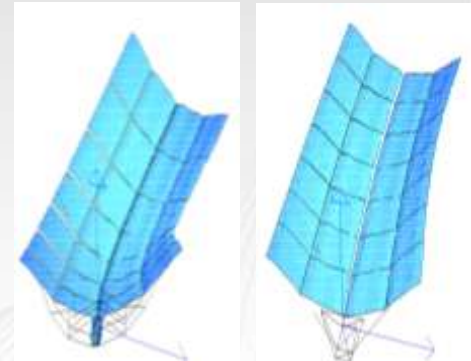
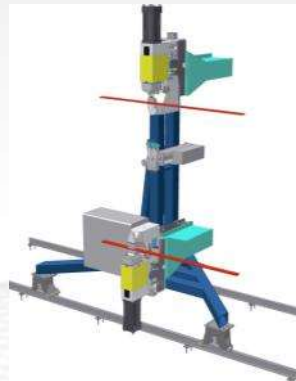
Intensive wind tunnel tests:

- Torque box vs. torque tube
- Wind release gap between inner/outer mirror
- Stow position east and west



FEM Analysis:

- Steel mass optimized: Lowest possible steel mass to fulfill bending/torsion criteria



Advanced joining technique:

- Clinching of torque box

Ultimate Trough – Key figures



Solar Collector Assembly SCA key figures

- 10 SCE/SCA
- Length: 243 m
- Aperture area: 1,689 m²
- Hydraulic drive system
- Thermal output two times higher than a 150 m EuroTrough

(EuroTrough is the current reference design on the market)

Solar Collection Element SCE key figures

- Length: 24 m
- Aperture width (gross): 7.5 m
- Aperture area (net): 169 m²
- Torque box design
- 5 HCE/SCE
- 12 x 4 = 48 refl. Panels

Cost reduction of about 25% compared to the EuroTrough

- decreasing specific cost [€/m²] by “going large”
- increase of optical performance

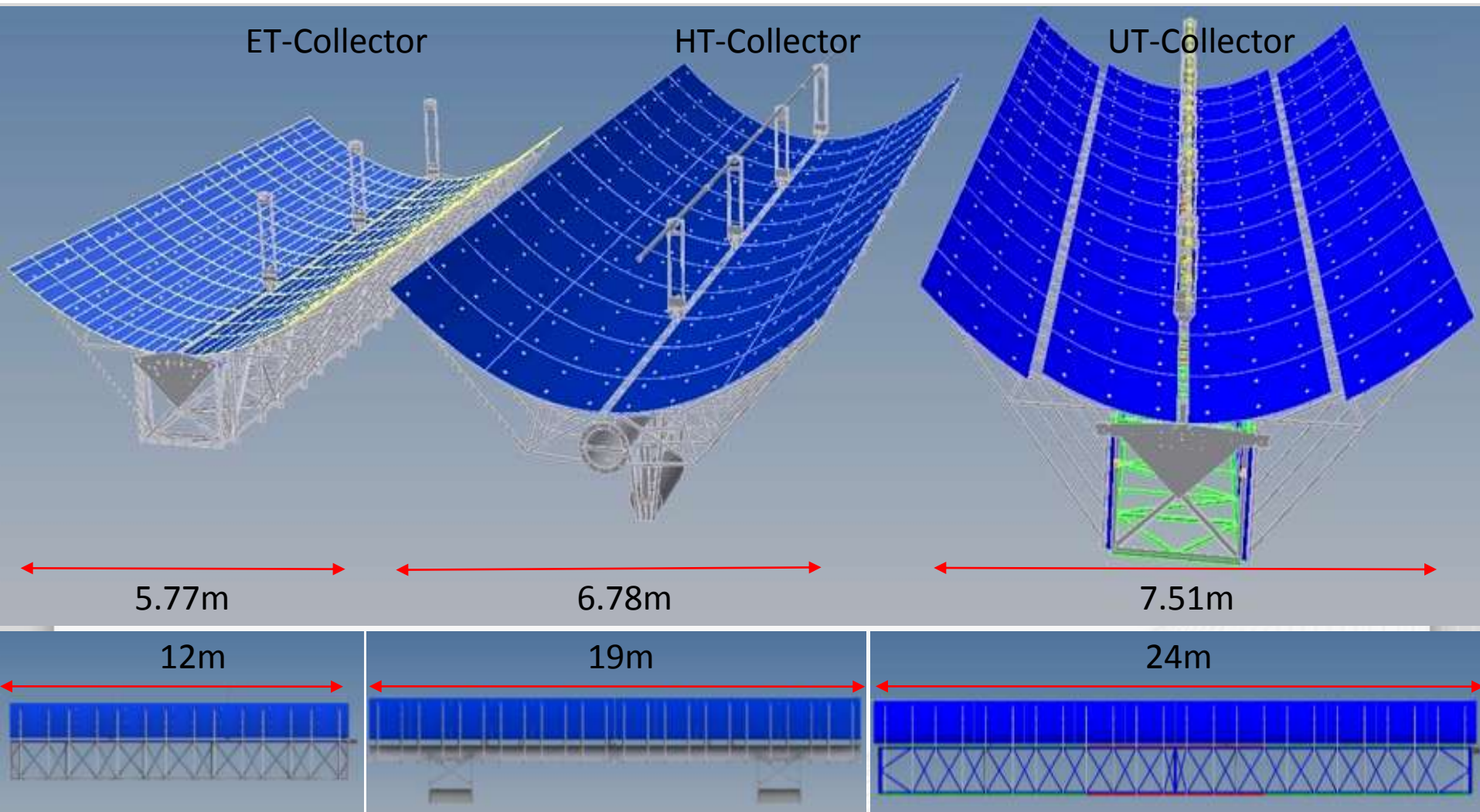
Metal parts with large tolerances

- lots of sourcing opportunities / high local content possible
- Low labor skill requirements for assembly tasks

High accuracy by intelligent jig based assembly concept

- Intercept factor with consideration of the sun shape: 99.2%
- Allows high concentration ratio in molten salt systems with significantly reduced heat losses

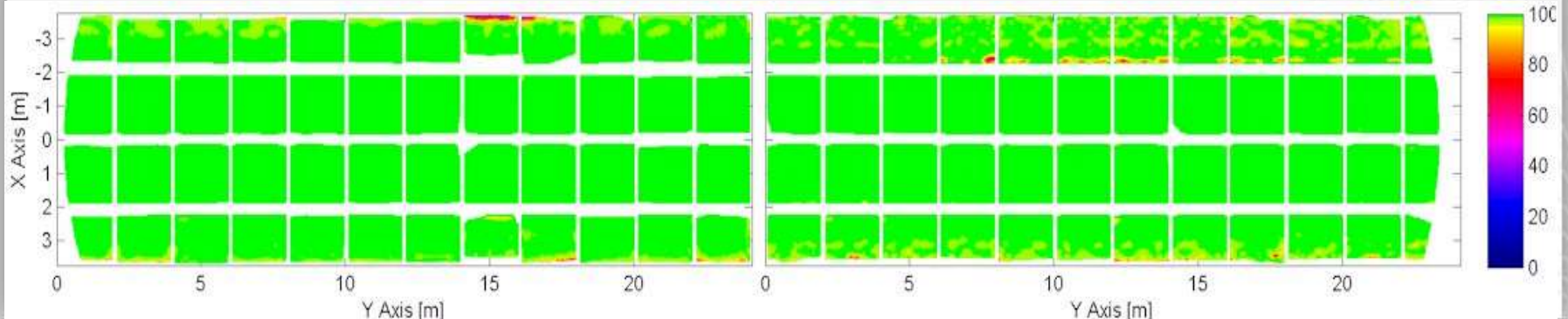
Comparison to existing designs



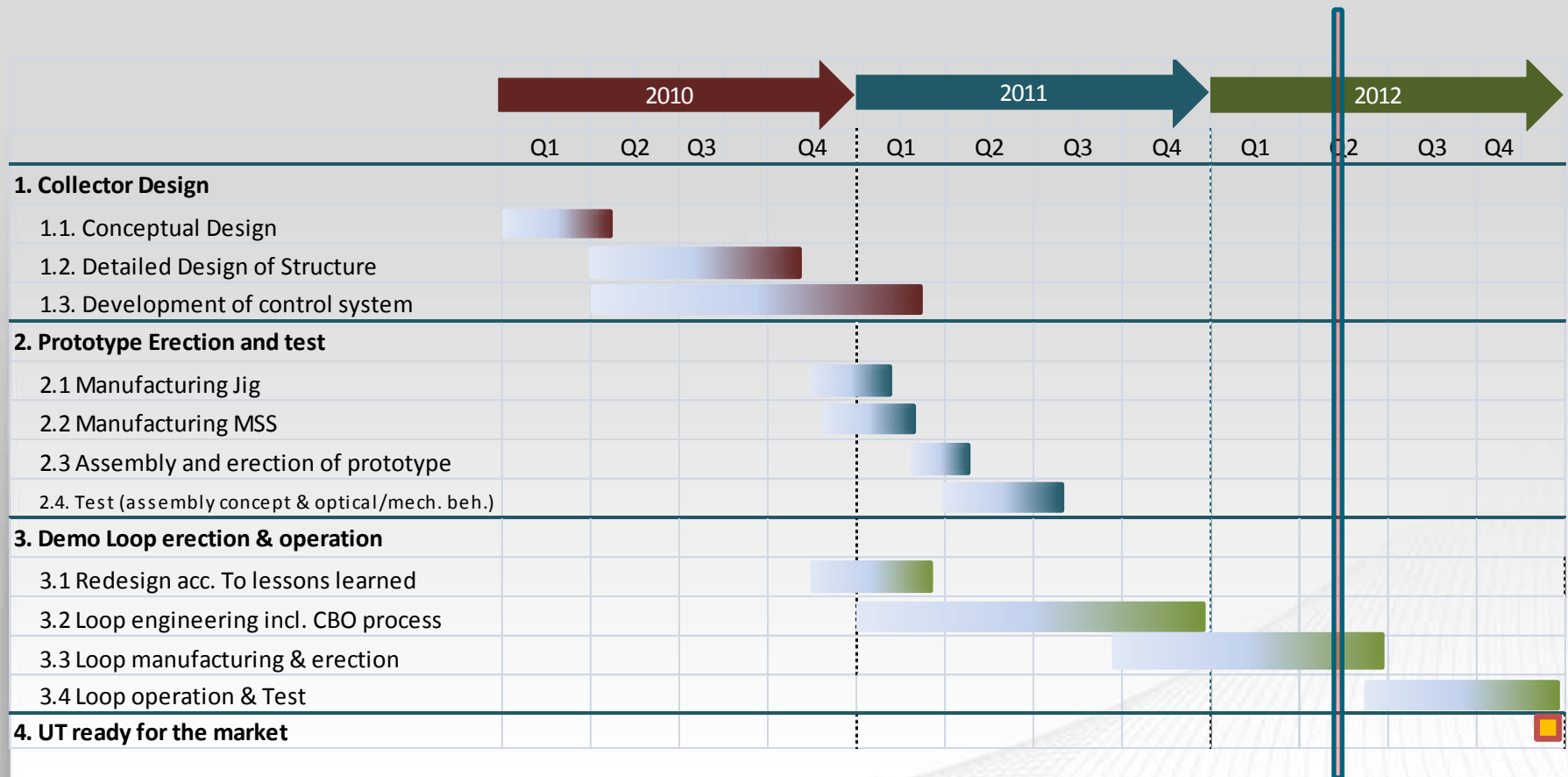
Indoor Prototype – Two SCEs mounted



- Two SCEs assembled and mounted
- ✓ Assembly procedure validated
- ✓ Bending, torsion very close to design
- ✓ Optical performance reached, intercept factor > 99 % (incl. sun shape, tracking inaccuracy, misalignment of HCEs, SCEs...)



Time Schedule – UT Collector

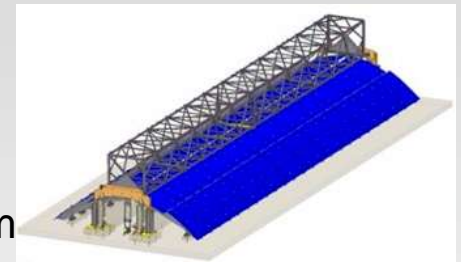


UT ready for the market

FLABEG offers:

- ***UT Technology Know-How package***

- Generic set of engineering documents (tender documents) required for collector procurement and erection
- All engineering documents (tender documents) required for collector procurement and erection for a specific project
- All support services for technology implementation
 - Investment and O&M cost estimate
 - Performance estimates
 - Collector and solar field related engineering and procurement
 - Supervision and training for assembly, erection, and commissioning



- **Mirror panels**

- RP3 (Eurotrough, LS3, SENERtrough, SAMCAtrough,...)
- RP4 (HelioTrough)
- RP5 (Ultimate Trough)
- and other geometries on request



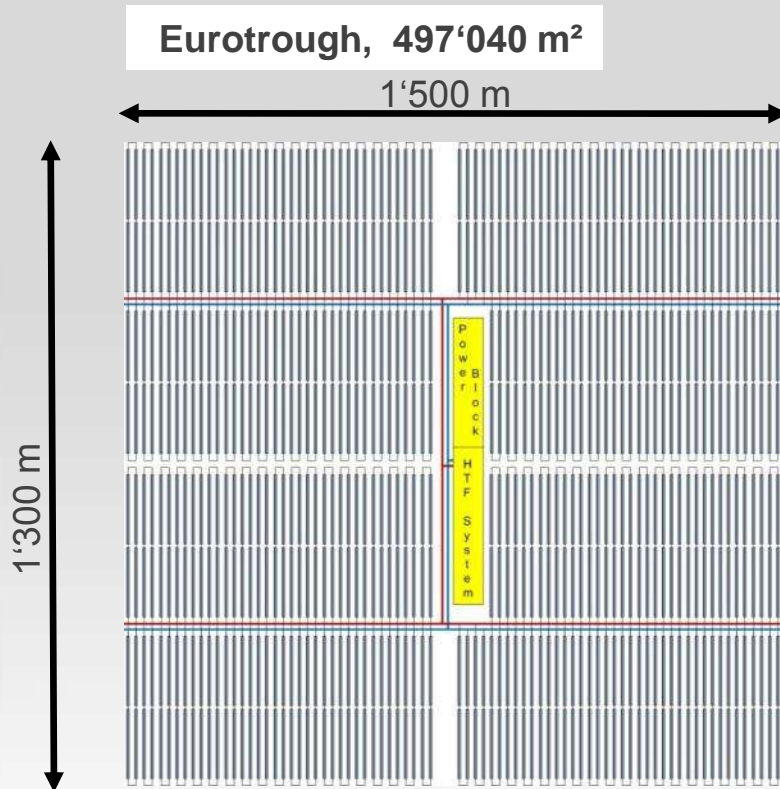
Technology comparison: UT/ET solar field cost ratio

Example: Power Plant, 50 MW with 8 h storage (or: 90 MW w/o storage)

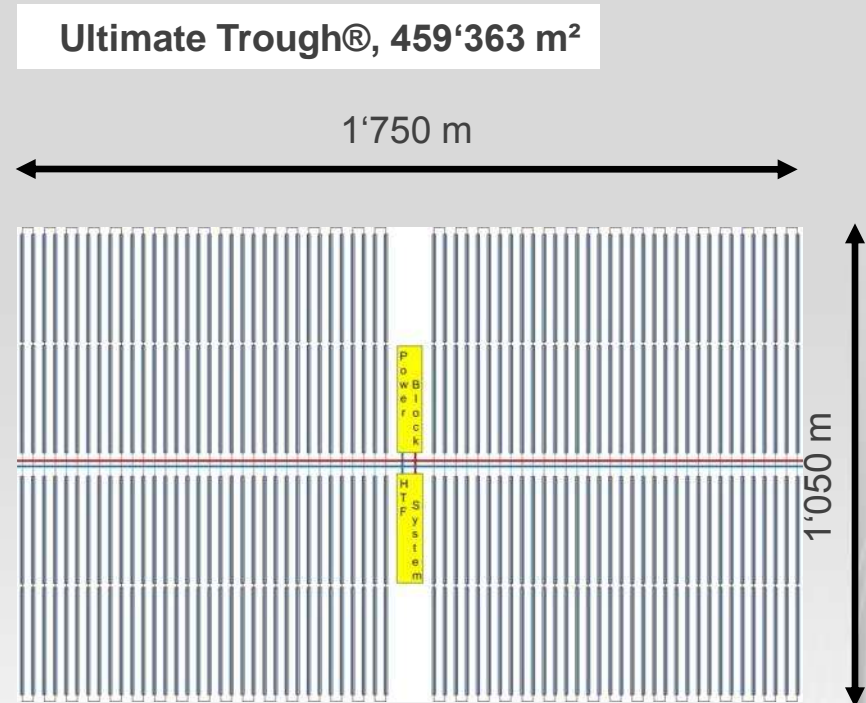
Collector Technology	50 MW with 8h storage
Solar field size [m ²]:	ET: 497'040 UT: 459'354
Solar Field	82.9%
Metal Support Structure	94.3%
SCA Foundations	57.4%
Mirrors	88.2%
HCE	88.5%
Swivel Joints	69.0%
Drive Units	45.1%
LOC, FSC & Meteo Station	95.6%
Sensors & Pylon Cabling	93.1%
SF Cabling (Supply & Installation)	92.4%
SCE Assembly Line incl. Photogr	122.8%
SF Assembly & Erection	58.4%
Piping (Material & Installation)	63.1%
Instrumentation	94.3%
HTF Fluid	74.5%
License (Collector Drawings)	71.0%

- Based on budgetary quotes from the same vendors (MSS, Mirrors, HCE, Drive units...) and Engineering / Cost models

Technology comparison: ET / UT – Solar field Layout




Header piping		ET	UT	Ratio
north-south	m	1'678	n/a	
east-west	m	6'840	3'757	55%
total m		8'518	3'757	44%
HTF Volume	m ³	1'813	1'353	75%

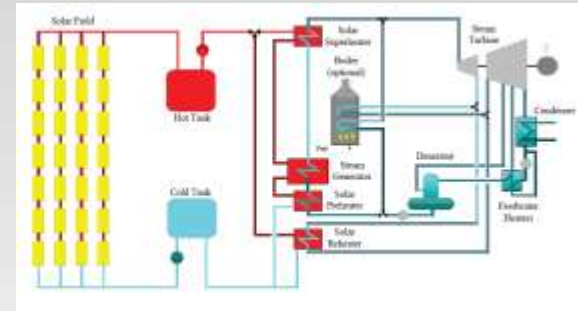


Significant cost reduction due to

- **Less piping (material, supports, insulation & installation works)**
- **Less heat transfer fluid**

Outlook – CSP technology in 2012 – 2015 - 2020

- Trough specific component costs decrease due to mass production, more competitors
 - Further R&D activities necessary, most promising step: **molten salt** as HTF?
 - 10 % **higher efficiency of power cycle**
 - **Direct storage** decreases cost for storage & facilitates significantly plant operation
 - Turbine can be driven in full load as long as the storage tank is filled
 - almost no “dumping” losses
 - Risk: freeze event due to high melting point
- 



- Ultimate Trough® collector is ready for MS operation!
 - Higher concentration factor using 70 mm HCE, still high intercept factor: 97.5%
 - Electrical isolation of HCE for impedance heating
 - HCE supports suitable for higher expansion length due to elevated temperatures

Configurations		ET 2012	UT 2012	UT 2015	UT 2020
Power Cycle gross	MW	270	270	270	270
Collector	ET/UT	ET	UT	UT	UT
HTF	Oil/Salt	Oil	Oil	Solar Salt	Solar Salt
Solar field size	Mio. m²	2.68	2.47	2.13	2.03
Storage capacity	MWht	4'800	4'800	6'480	6'480
LCOE (DNI: 2780 kWh/m²a)	€/kWh	14.7	12.7	8.1	6.7

Ultimate Trough Development Partners



FLABEG Holding GmbH



sbp sonne GmbH



Fraunhofer FhG



German Aerospace Center (DLR)



Co-funded by BMU



- Solar mirror
- Solar field design



- Structural engineering
- Supervision

Thank you for your attention!



Flabeg GmbH
Im Zollhafen 18
50678 Köln
Germany
klaus-juergen.riffelmann@flabeg.com