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Renewable energy
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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

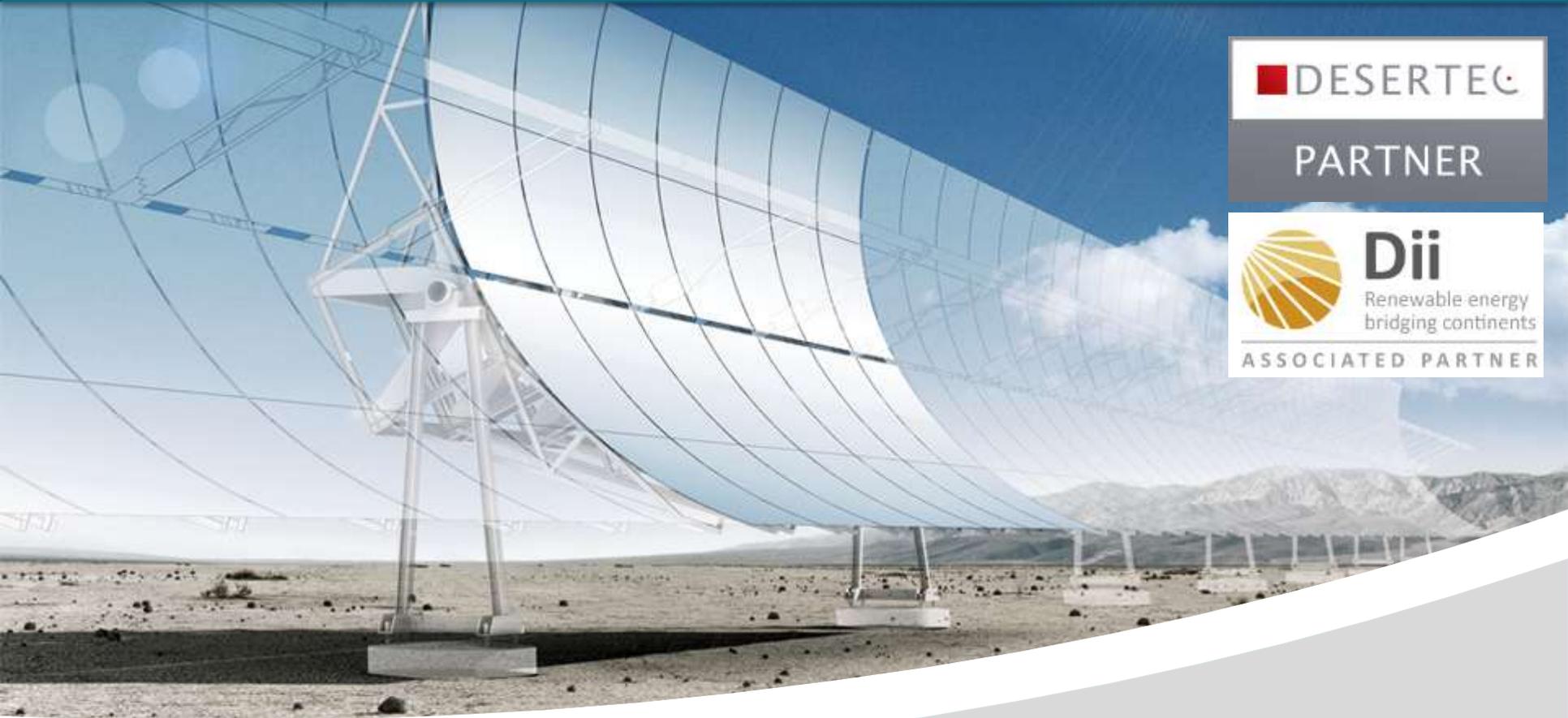
Group Overview Global Presence

Production facilities: Solar



Solar Mirrors

Solar Engineering



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Solar: Products

FLABEG SOLAR MIRRORS

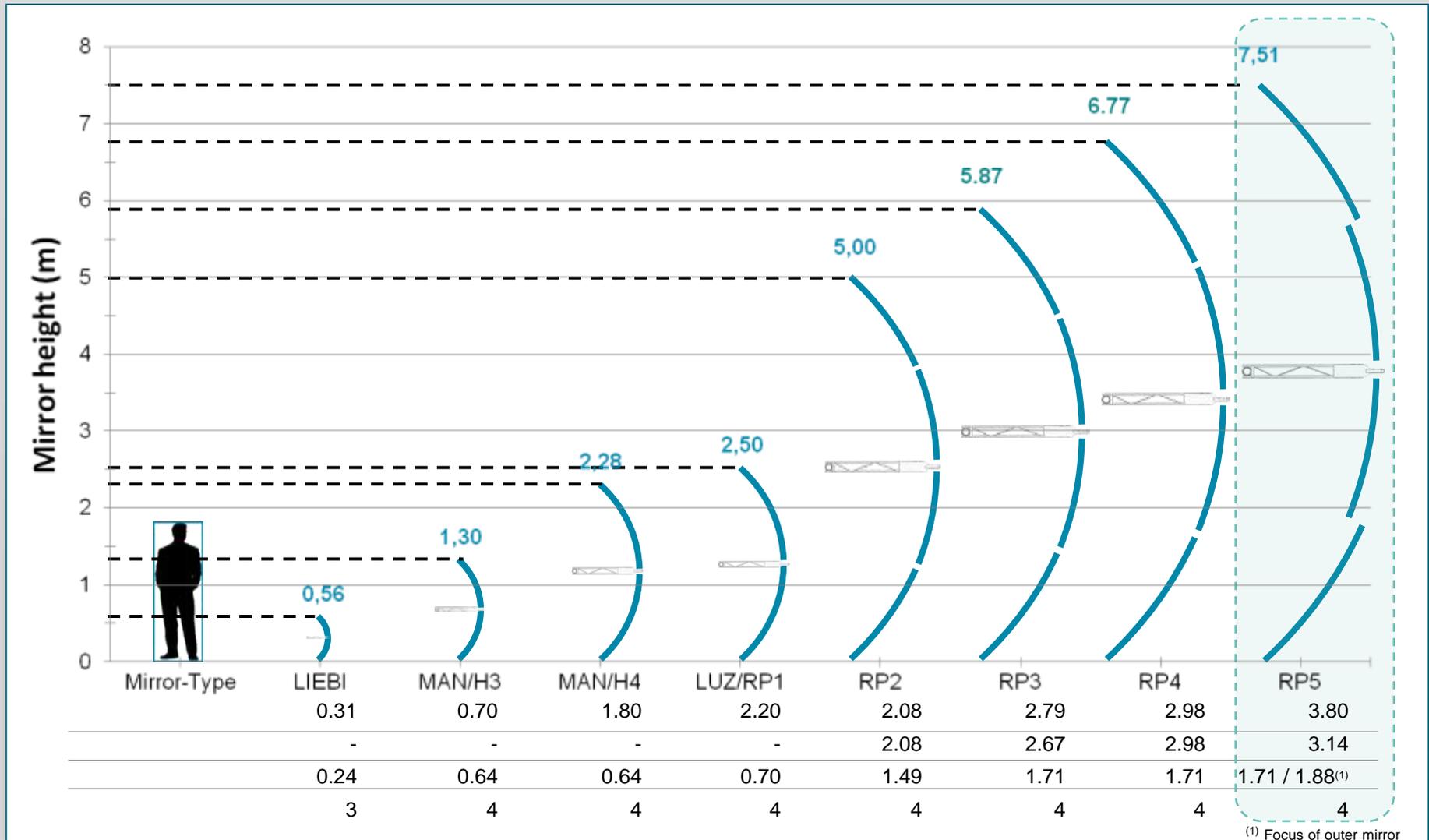
1. Best and independent global sourcing
2. Latest coating technology
3. Continuous improvement of production processes



**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

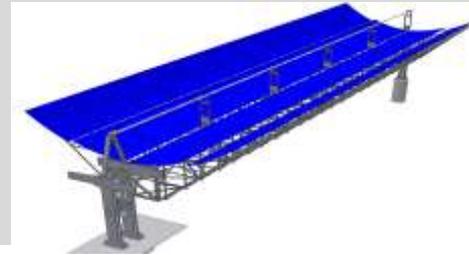
- decreasing specific cost [€/m²] by “going large” (- 20% specific cost savings)
- increase of optical performance (8%) by tension free mirror attachment



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)



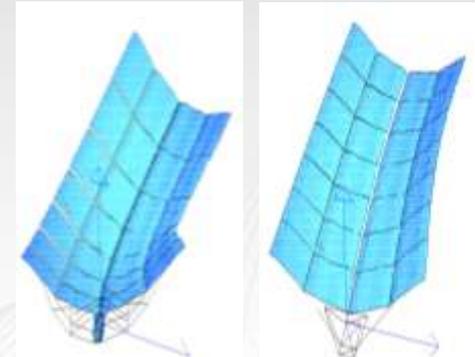
Intensive wind tunnel tests:

- 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

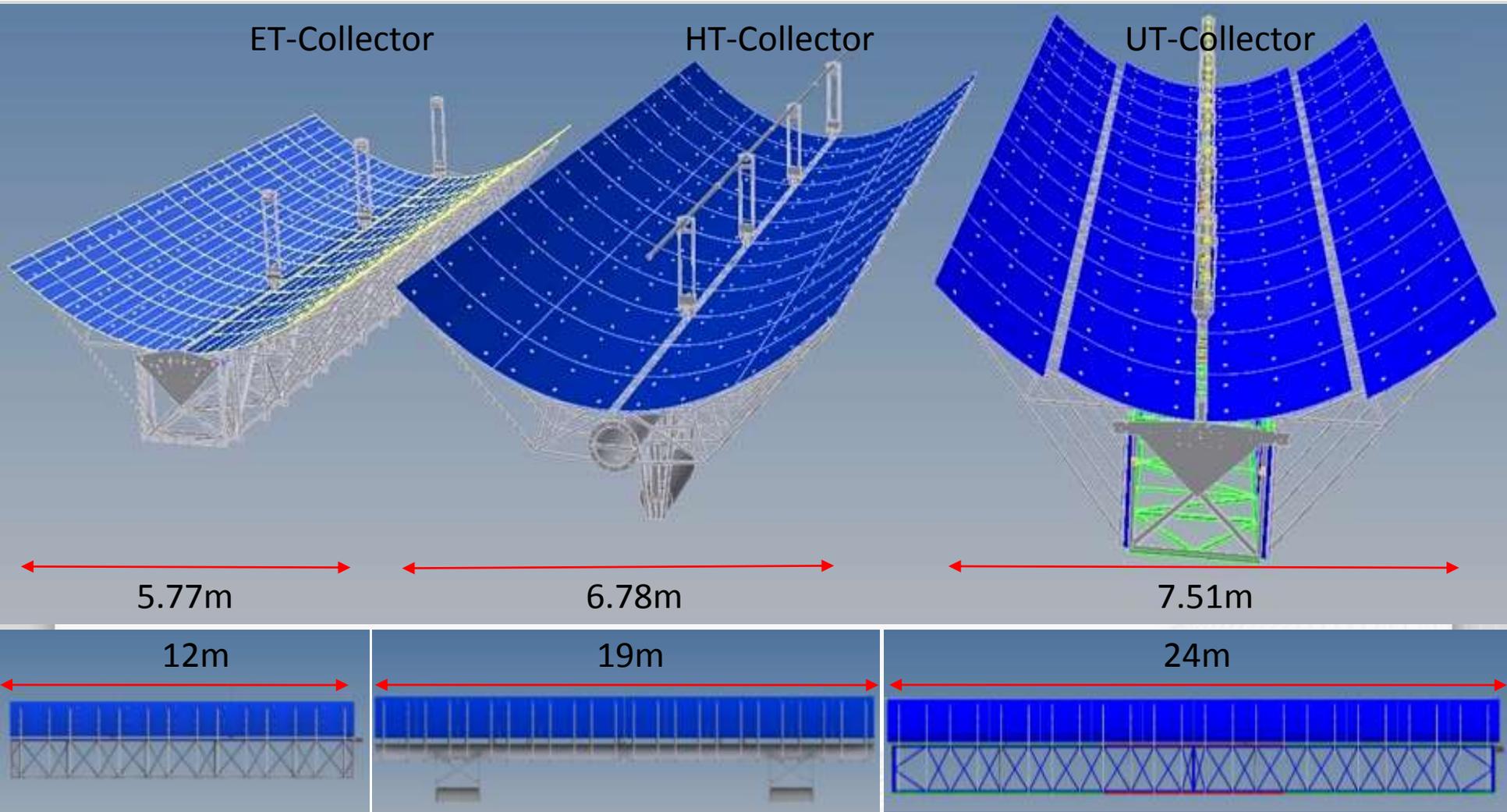
Metal parts with large tolerances

- 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

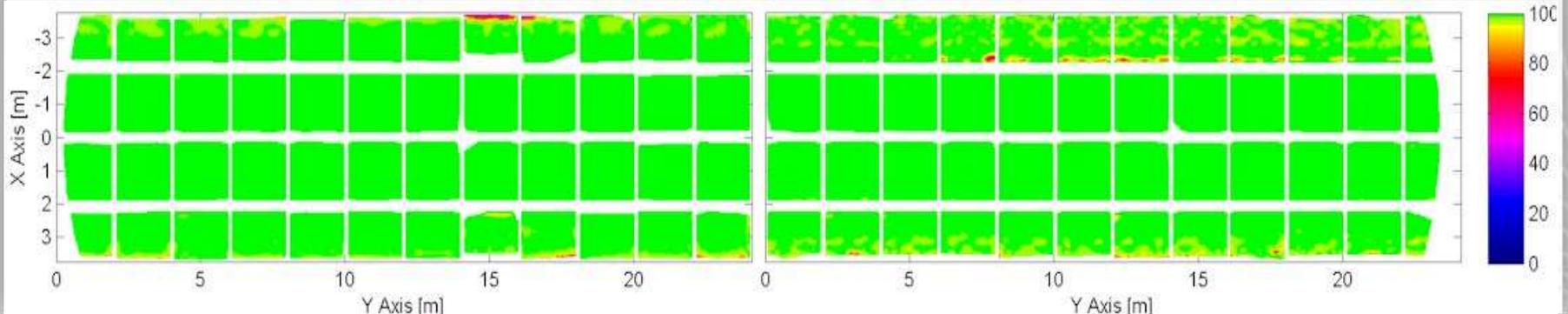
Comparison to existing designs



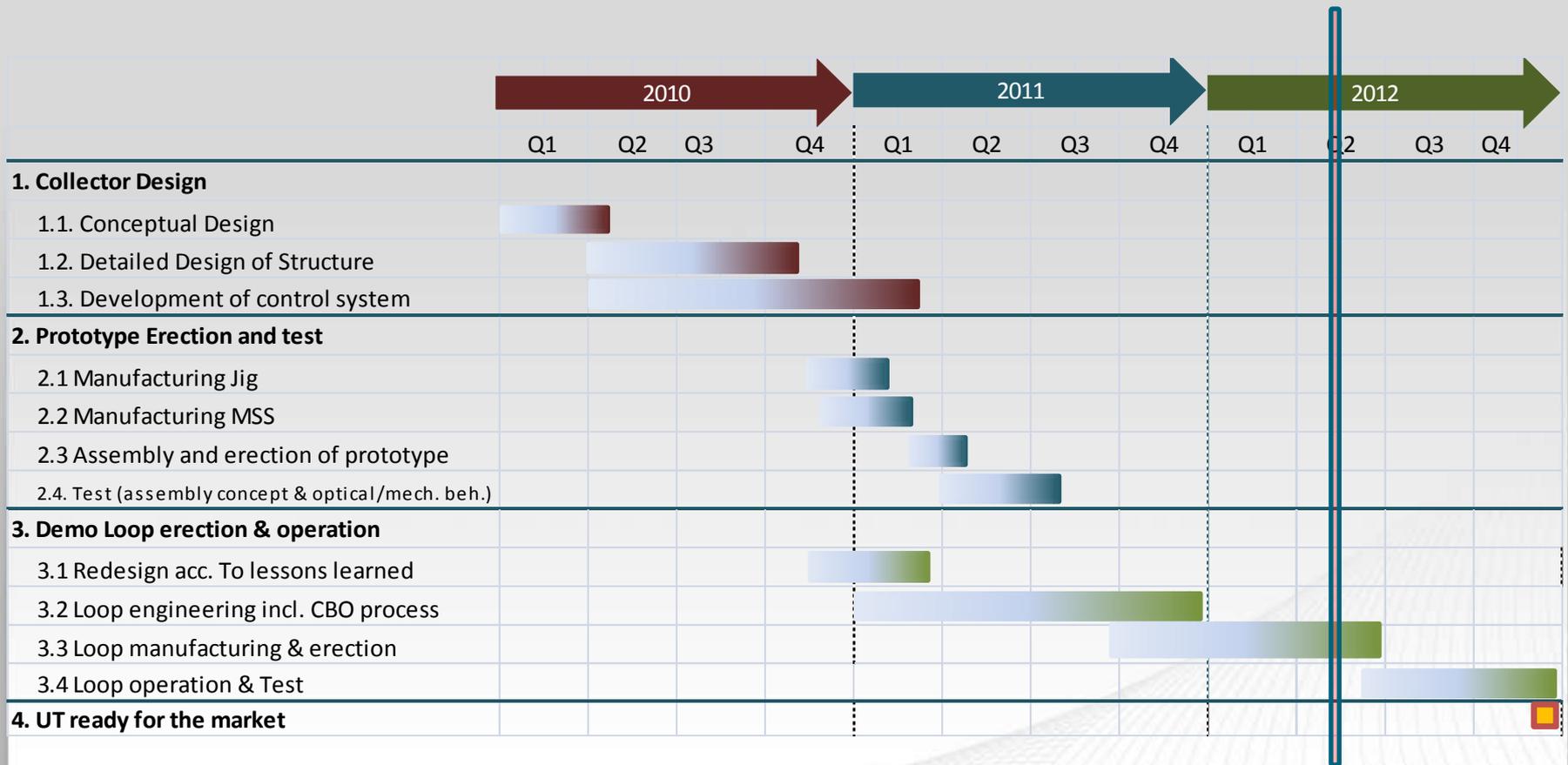
Indoor Prototype – Two SCEs mounted



- 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

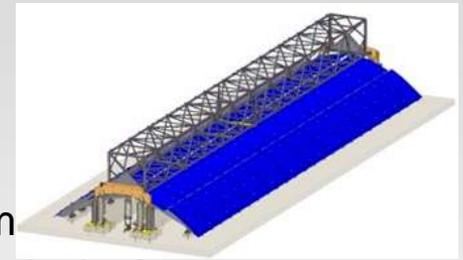


UT ready for the market

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

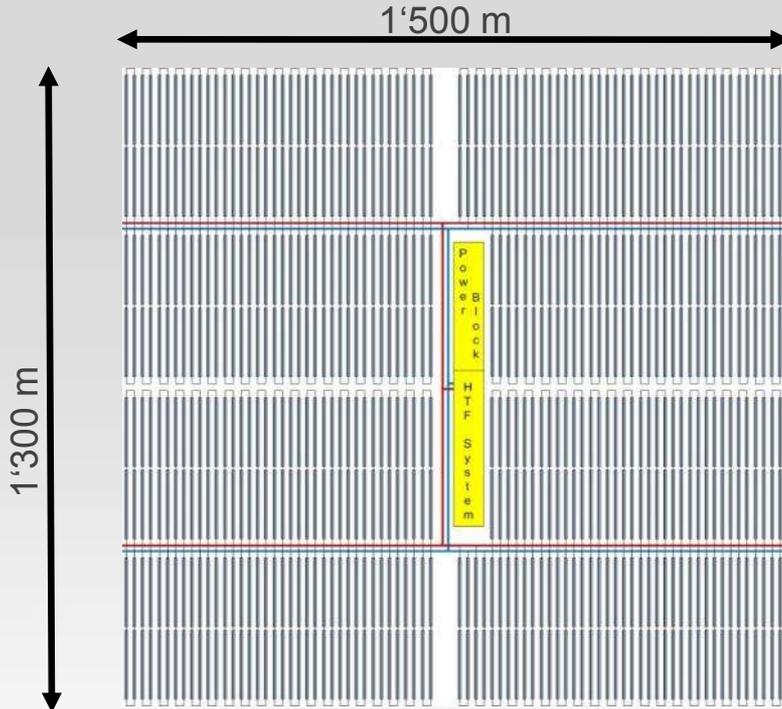
Example: Power Plant, 50 MW with 8 h storage (or: 90 MW w/o storage)

| 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% |

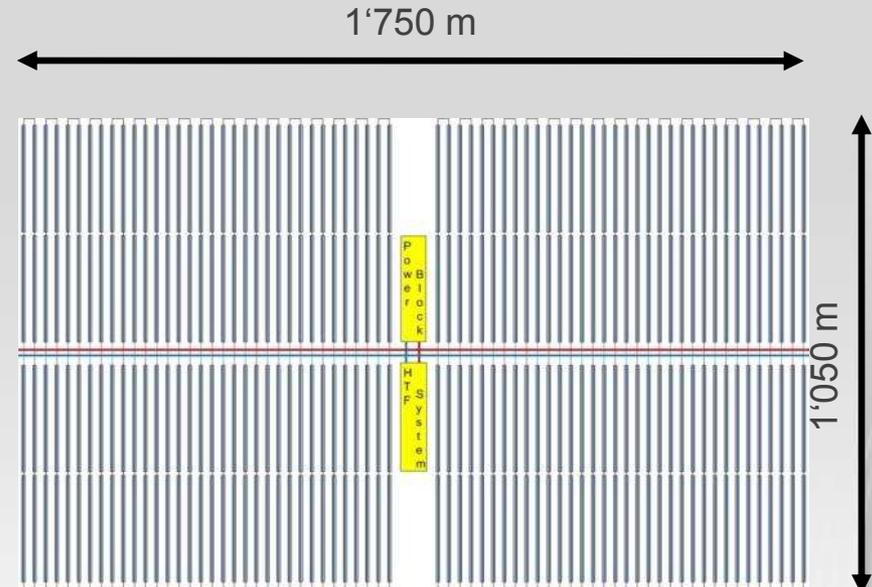
- Based on budgetary quotes from the same vendors (MSS, Mirrors, HCE, Drive units...) and Engineering / Cost models

Technology comparison: ET / UT – Solar field Layout

Eurotrough, 497'040 m²



Ultimate Trough®, 459'363 m²



| 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**

Ultimate Trough Development Partners

FLABEG Holding GmbH



sbp sonne GmbH



Fraunhofer FhG



- Solar mirror
- Solar field design



- Structural engineering
- Supervision

German Aerospace Center (DLR)



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Thank you for your attention!



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