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EuroTrough - Design Issues and Prototype Testing at PSA

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German Aerospace Center (DLR), PSA, Spain

Wolfgang Schiel

Schlaich Bergermann und Partner, Stuttgart, Germany

Antonio Esteban, Rafael Osuna

INABENSA, Sevilla, Spain

Eduardo Zarza

CIEMAT-PSA, Almería, Spain

Paul Nava

FLABEG Solar International, Köln, Germany

EuroTrough initial remarks

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- Concentrating Parabolic Trough Collector for solar...
  - electricity generation
  - desalination
  - process heat
- Outlet temperature 400°C (752°F)
- Collector size 545 m^2 - 817 m^2

  up to 650 kW thermal output per collector
- Electricity price ranges 15 cts/kWh
- Technology under commercial operation in California (Mojave Desert, 354 MW_{el})

Schematic of a solar thermal power plant

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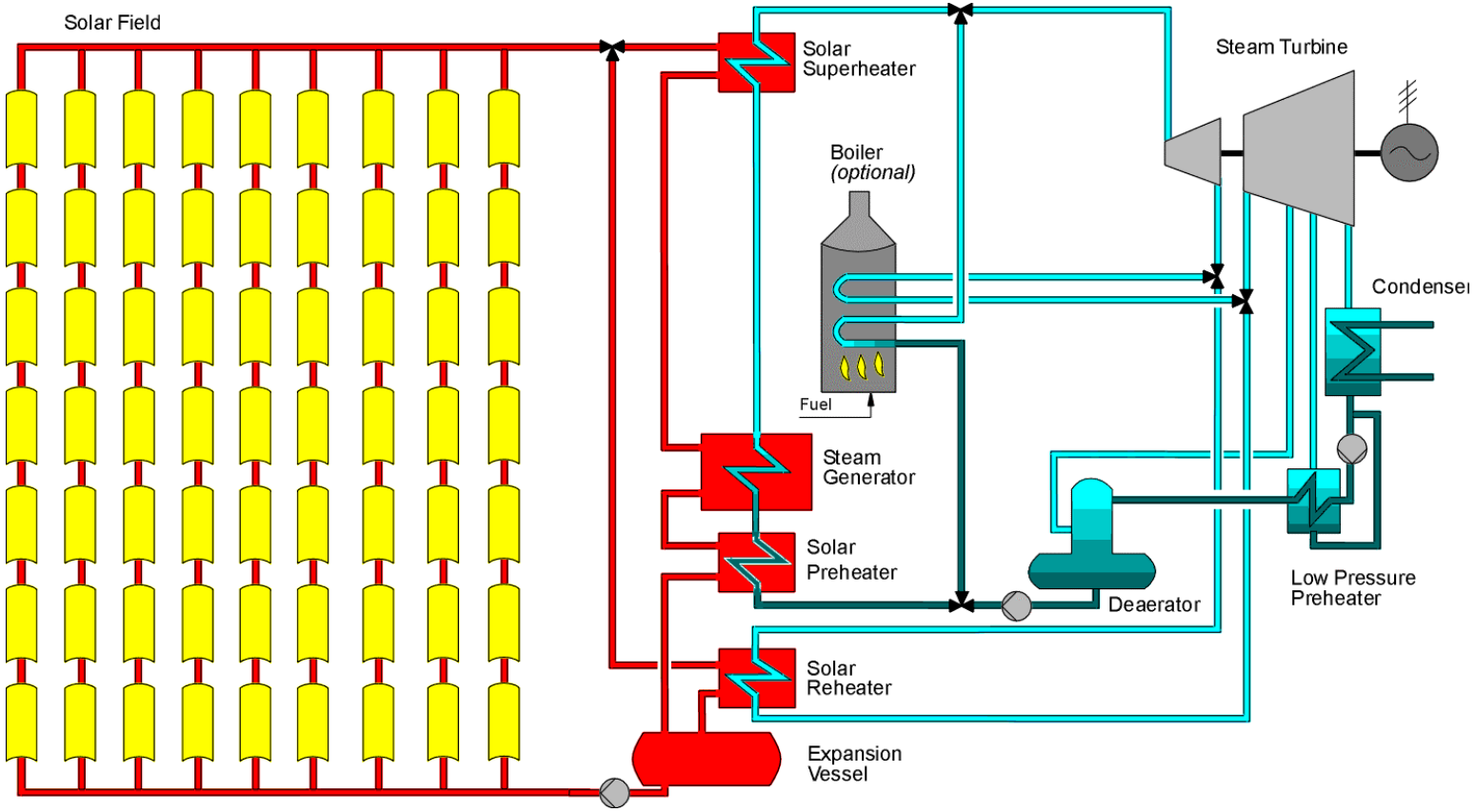

Trough Collector Performance (Egypt)

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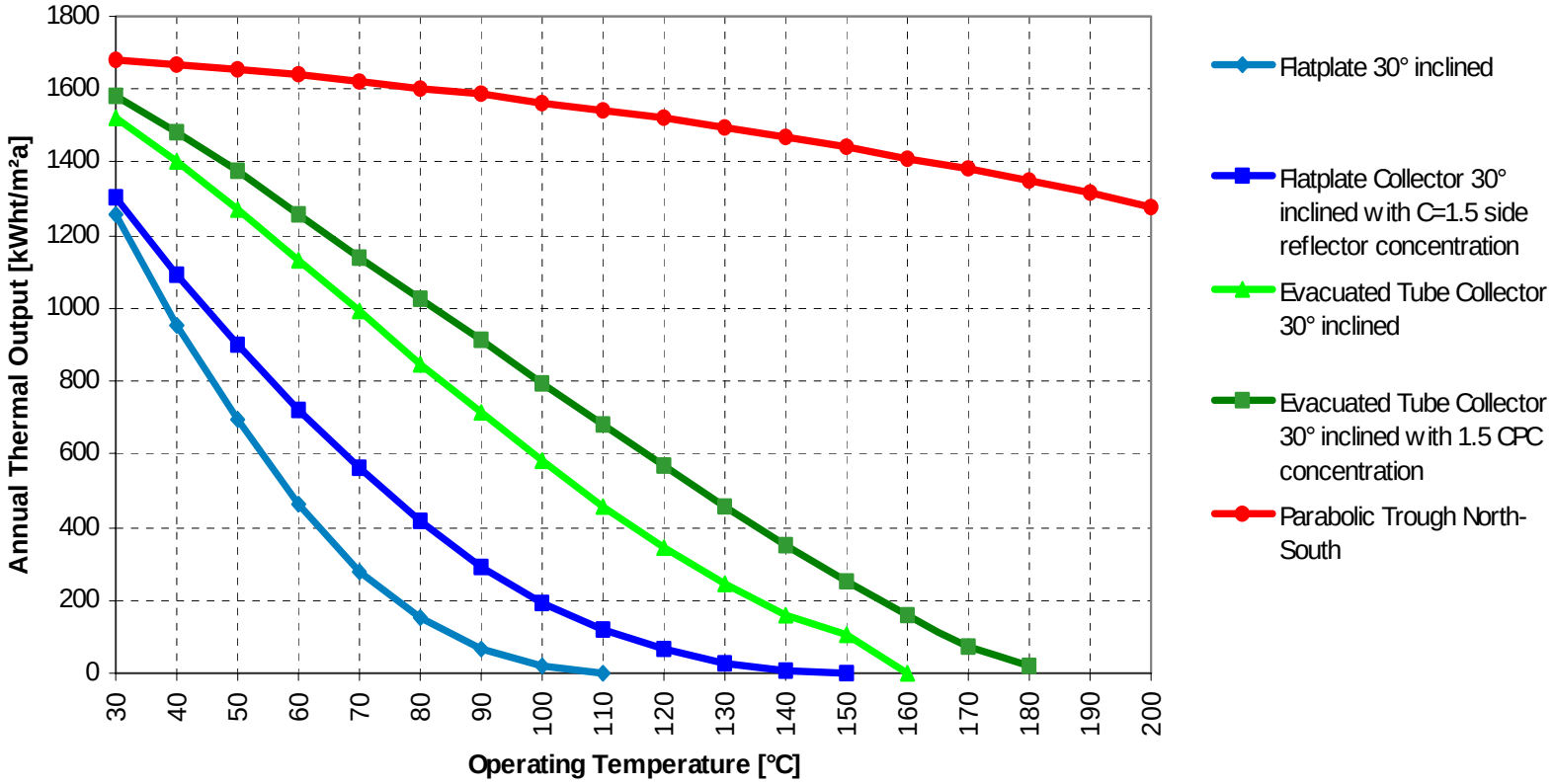

The EuroTrough Prototype

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EuroTrough Project Start

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in the nineties:

- a vision
- a group of visionaries

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EUROTrough

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Schlaich Bergermann und Partner

DLR Deutsches Zentrum für Luft- und Raumfahrt e.V.

Ciemat Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

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The European Commission

bmb+f

EuroTrough Project Starting point

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- an international platform
- a test loop on PSA
- a reference (California)

EuroTrough Characteristics

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Layout	parabolic trough collector
support structure	steel frame work, pre-galvanized, three variants; light weight, low torsion
collector length	12 m per element; 100 - 150 m collector length
drive	hydraulic drive
max. wind speed	operation: 14 m/s, stow: 40 m/s
Tracking control	clock + sun sensor, <2 mrad
parabola	$y = x^2/4f$ with f = 1.71 m
aperture width	5.8 m
Reflector	4 glass facets
optical efficiency	0.80 (design)
absorber tube	evacuated glass envelope, UVAC® or other, application dependent
Fluid	oil, steam, application dependent
cost	< 200 Euro/m^2

so what is new?

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Wind-tunnel results

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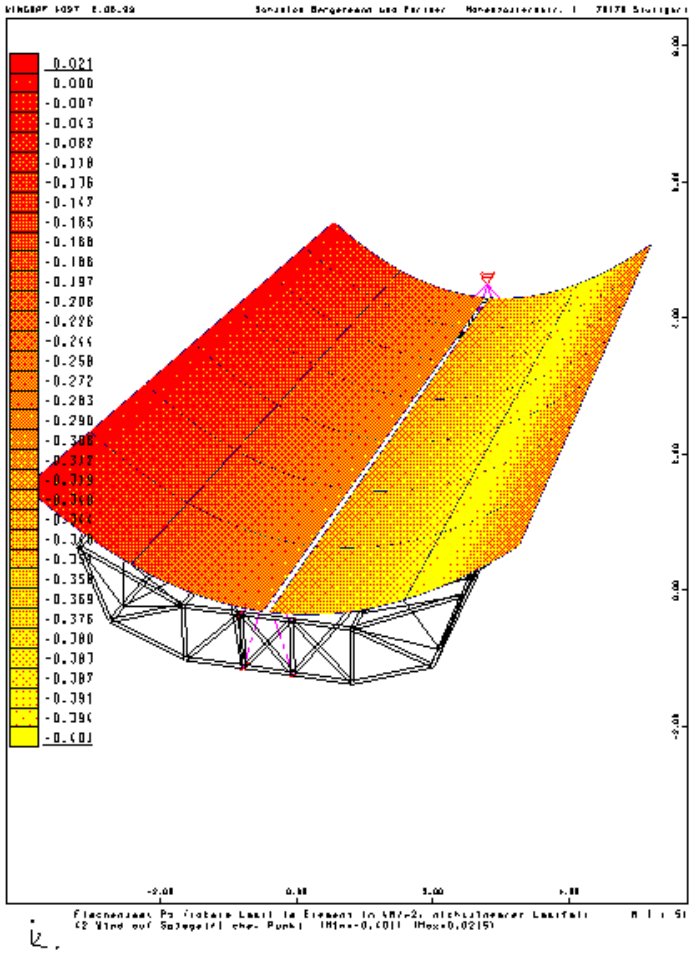

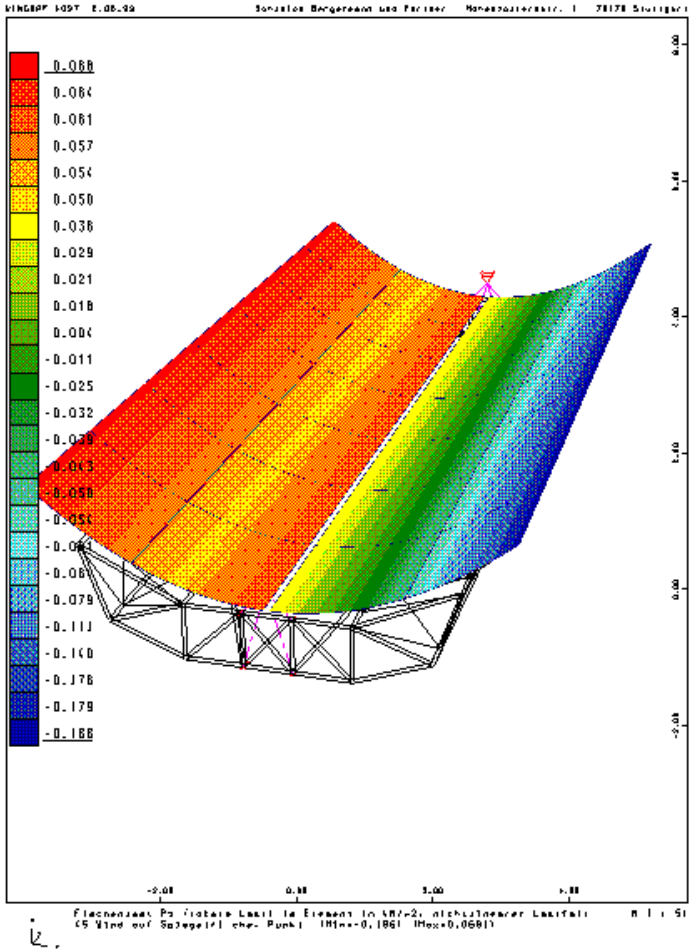

pressures in kN/m^2 for max. bending (left), max torsion (right)

Wind tunnel testing
+ finite elements structural analyses

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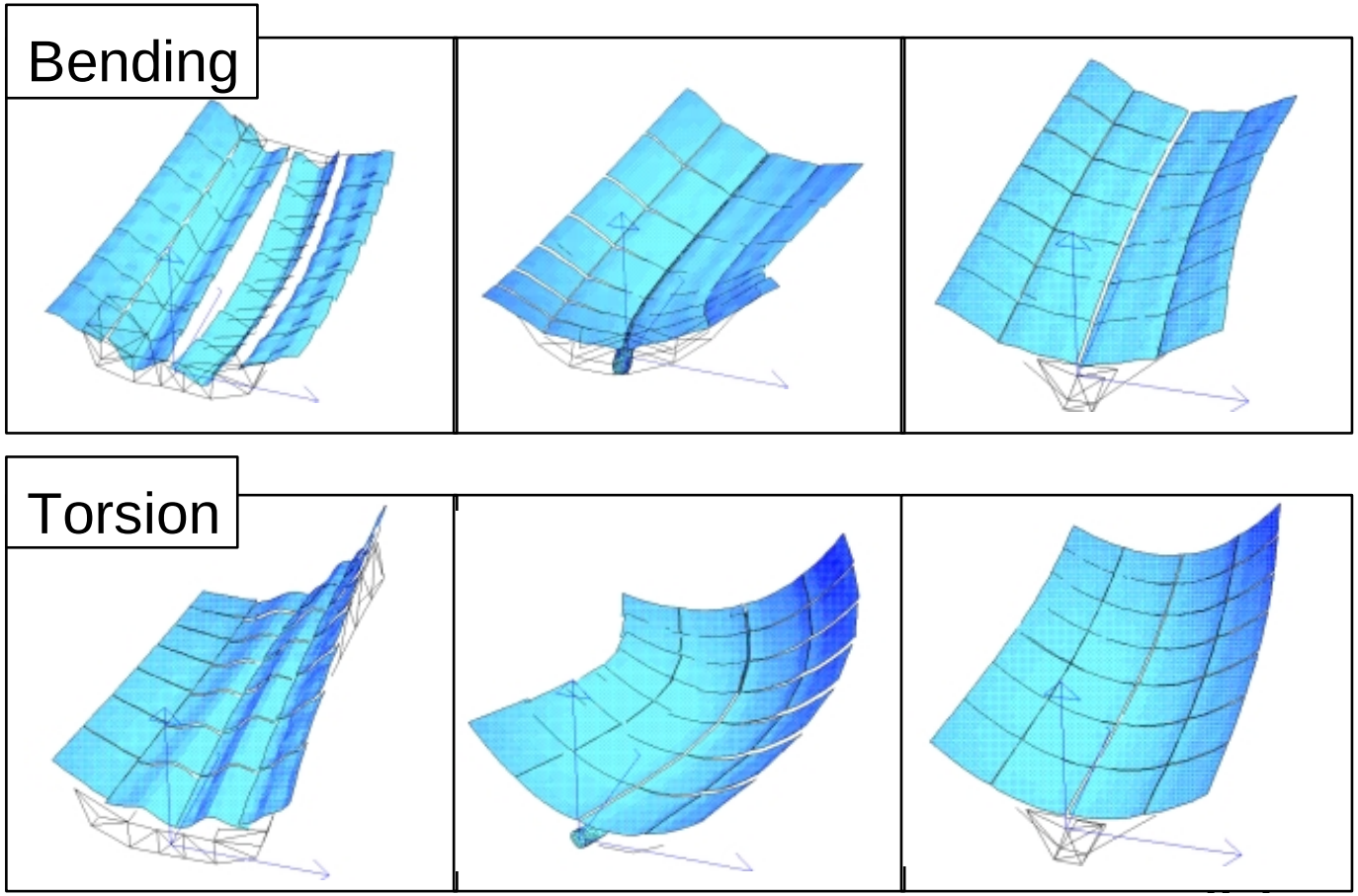

EuroTrough support structure

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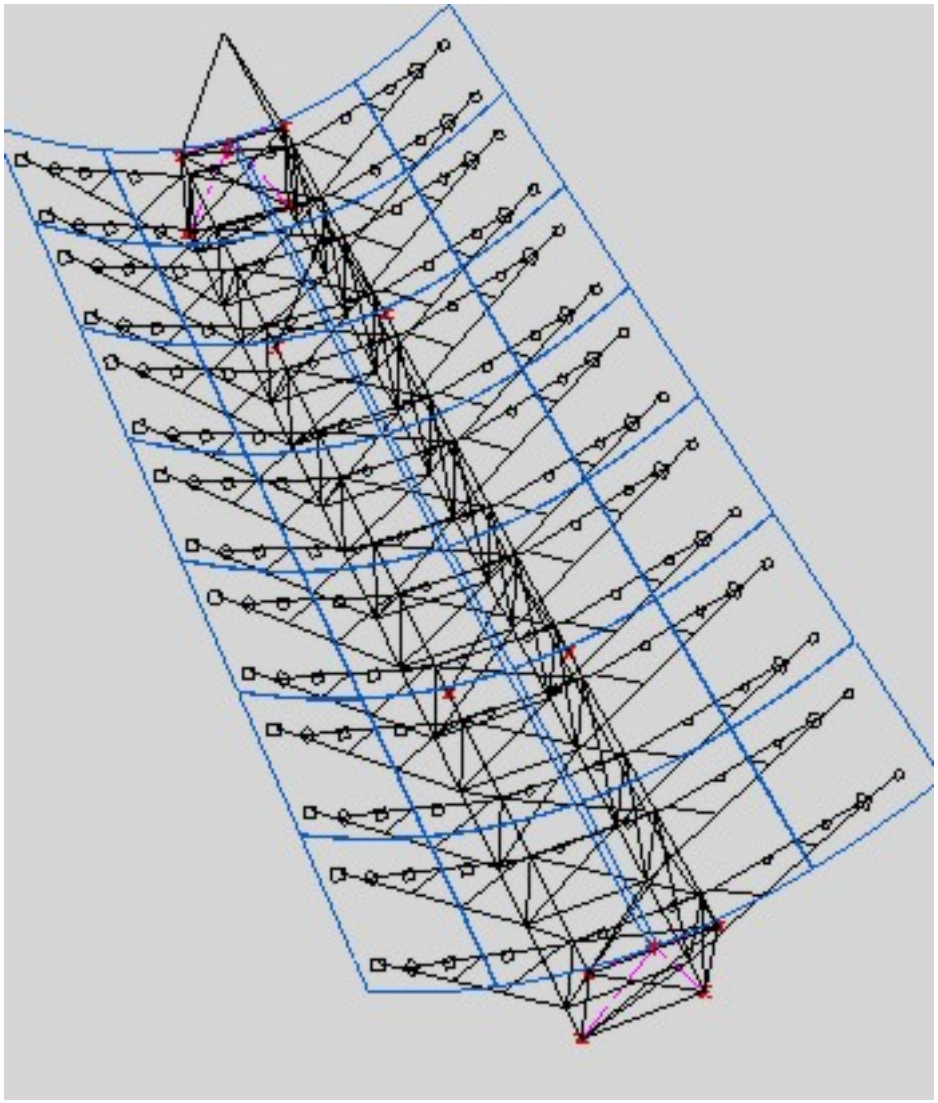

Optical Performance under Wind Loads

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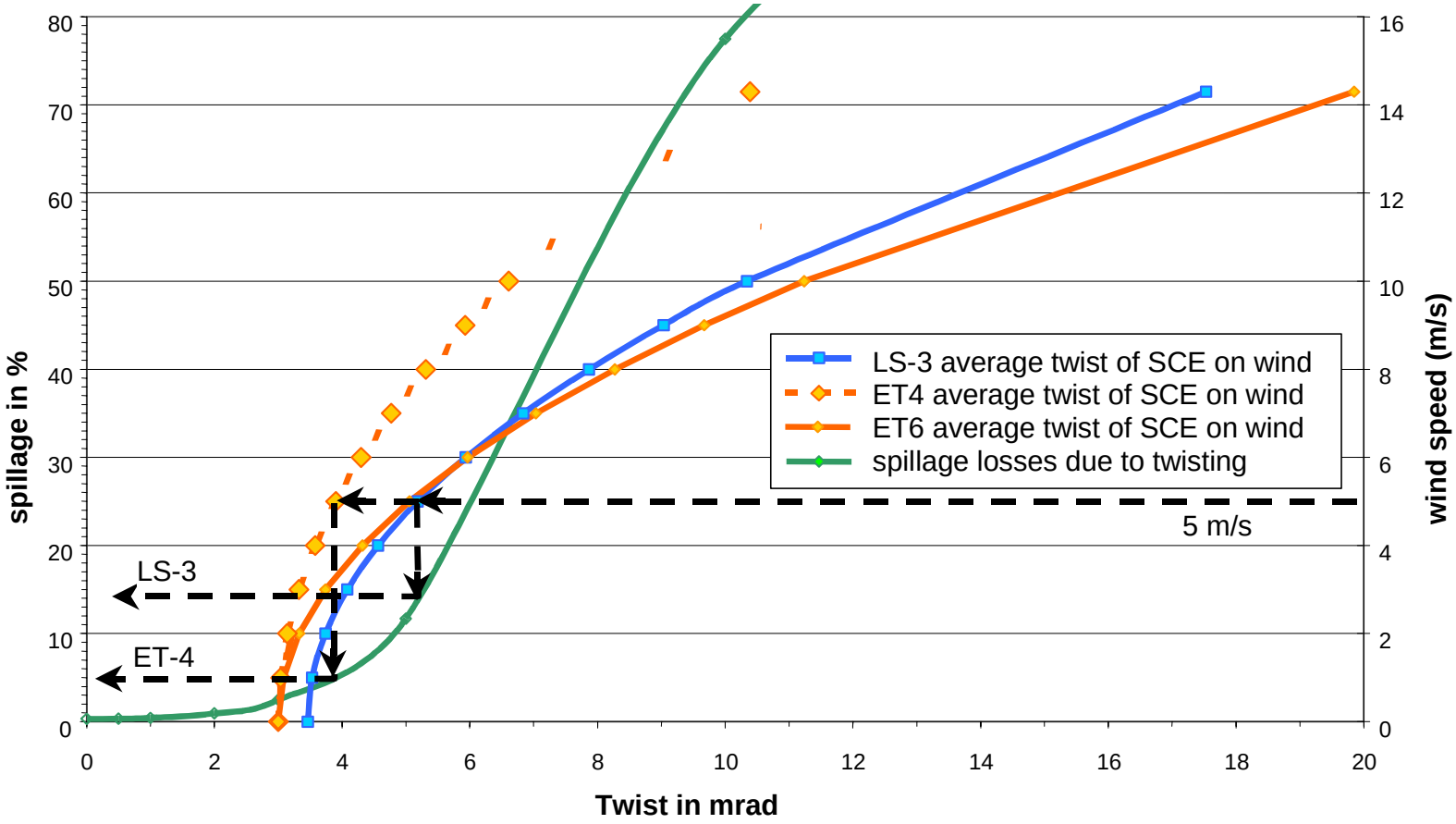

EuroTrough Structural Elements

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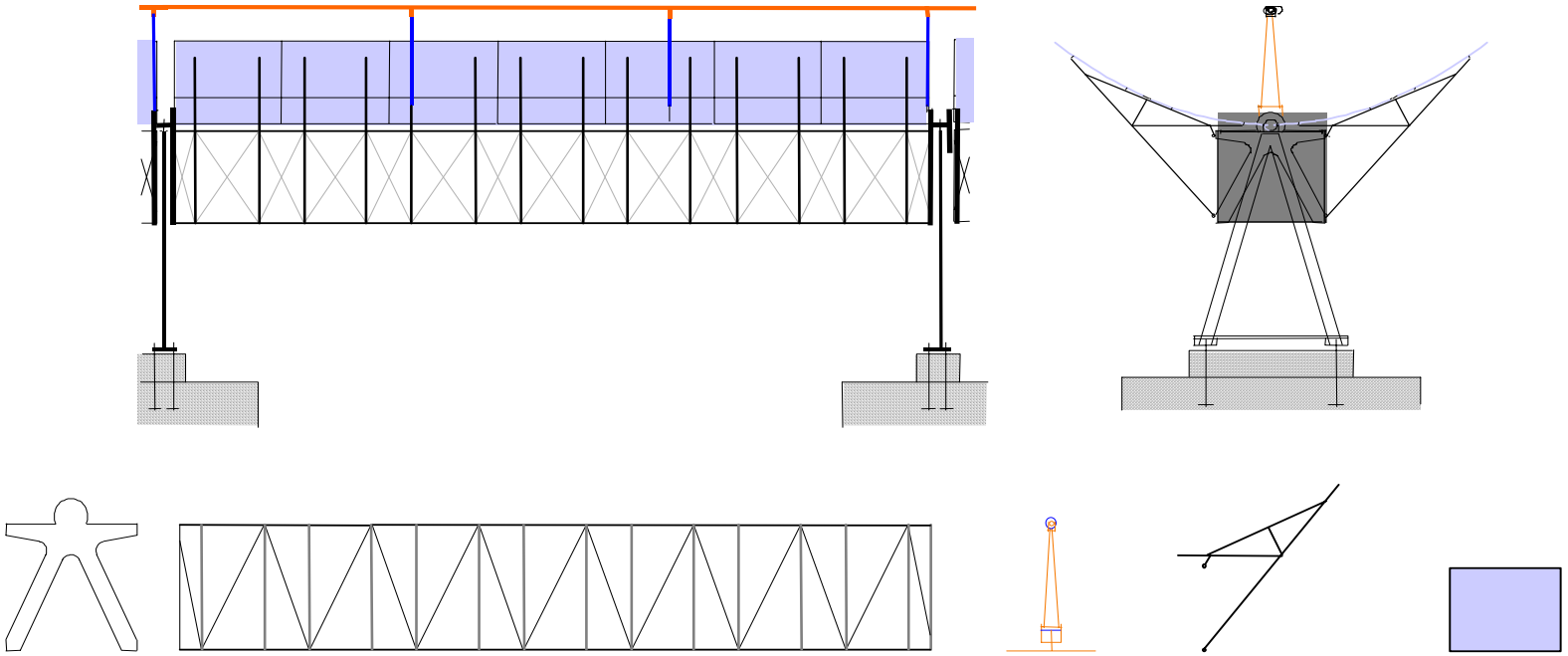

a b c d e

EuroTrough collector element consisting out of

(a) 2 endplates
(b) 4 simple steel frames screwed to a torque box
(c) 3 HCE supports
(d) 14 cantilever arms and
(e) 28 mirror facets.

EuroTrough Prototype

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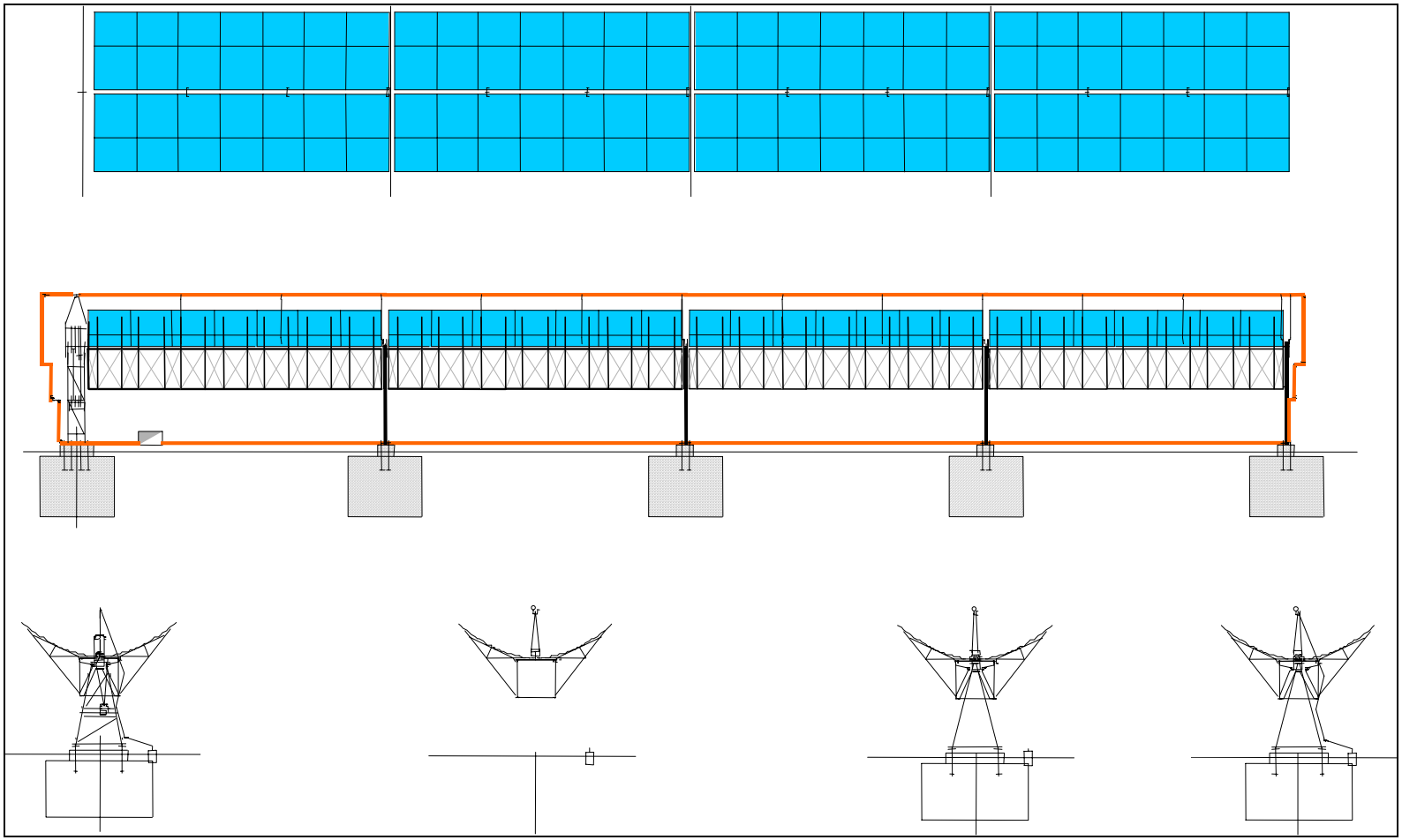

EuroTrough
Solar Collector Element - weights

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EuroTrough Collector Component		*strong SCE*	*"field" SCE*
Glass mirrors	kg	747	747
HCE (incl. oil)	kg	73	73
Torque box	kg	597	597
End Plates	kg	186	130
Cantilever Arms	kg	384	231
HCE supports	kg	113	90
Torque Transfer	kg	32	32
Total weight steel structure only	kg	1,312	1,080
Specific weight steel only	kg/m²	19.0	15.6
Total weight incl. mirrors and HCE	kg	2,132	1,900
Specific weight kg/m²	kg/m²	30.9	27.5

EuroTrough Collector Assembly

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Assembly Jig

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EuroTrough project results

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- various design studies
- many design details addressed
- collector drawings available
- prototype collector started up
- cost estimations for series production
- performance models
- market analyses
- design review and continuation
- world-wide exploitation opportunities
- project consortium established

EuroTrough results cost reduction aspects

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- following cost reduction potentials have been identified:
  - cost reduction by improvement of the optical performance of the collector
    - rigid support structure --> frame work torque box
    - manufacturing
    - assembly accuracy
  - cost reduction by simplification of the design
    - less different profiles, parts
    - better transportation
    - assembly concept
  - cost reduction by weight reduction of the structure
    - frame work structure, closed profiles
    - finite element method for structural design calculations
    - wind analyses for proper definition of the load cases
  - Further cost reduction achieved in additional steps towards inclination of the collector and extension of collector length per drive unit (EuroTrough II).

EuroTrough performance

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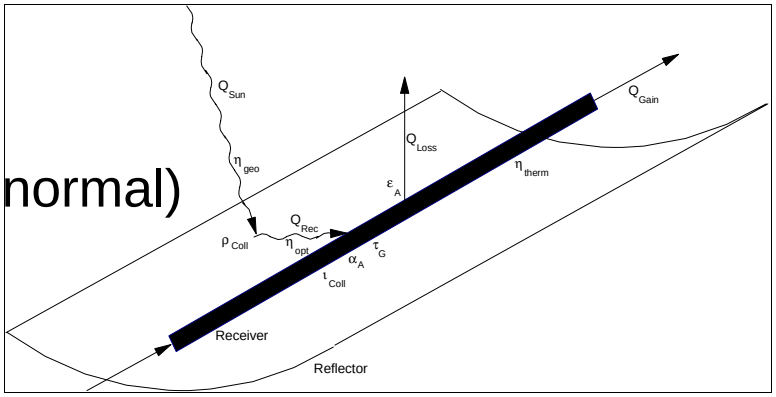
thermal testing at PSA

- with oil loop up to 390°C
- in east-west orientation

  (normal incident radiation once a day)

- influence of
  - fluid temperature
  - solar radiation (direct normal)
  - incidence angle
- photogrammetry
- mechanical analyses



Photogrammetric Analysis

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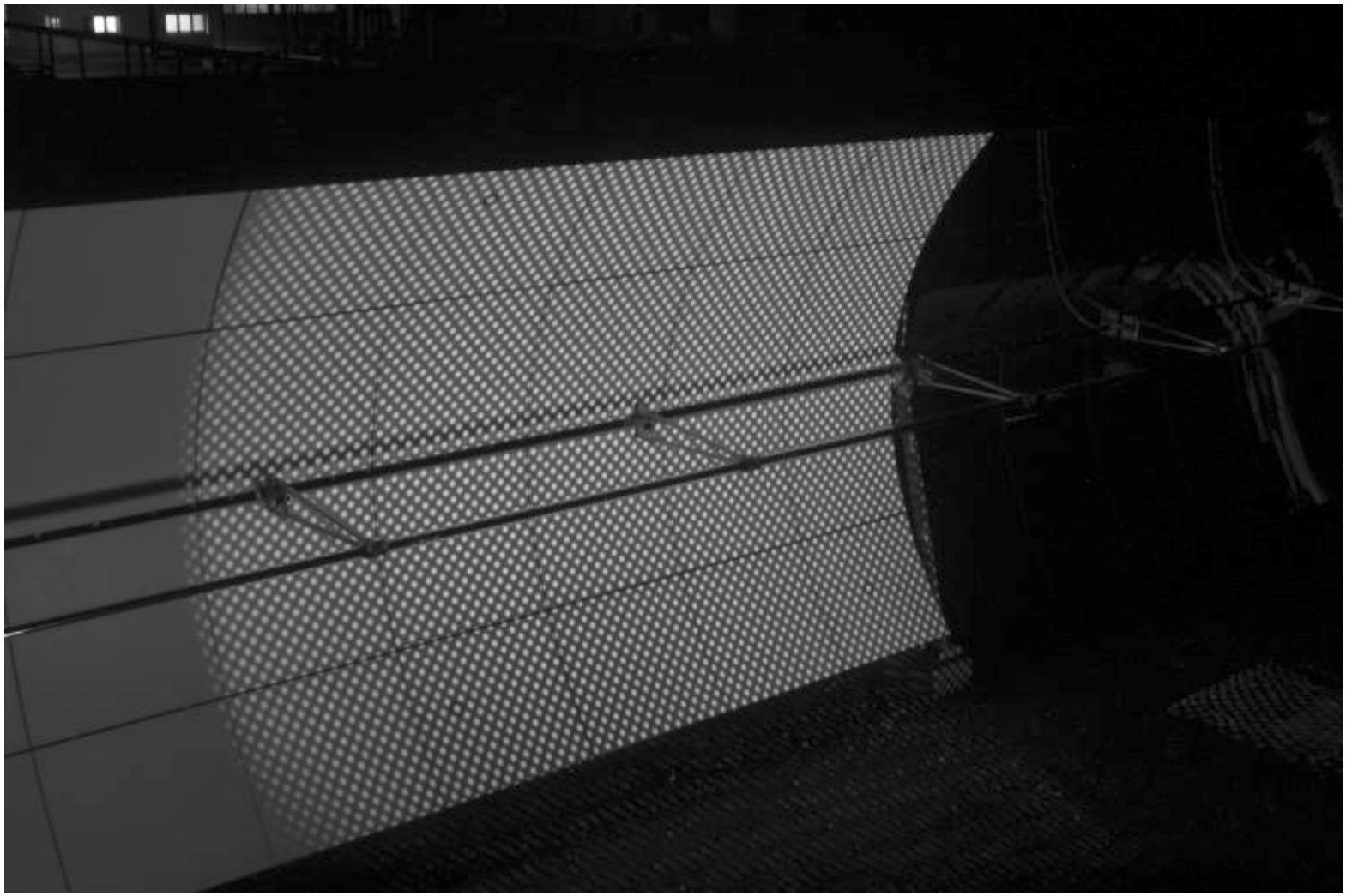

3D-Analysis of Reflector Geometry

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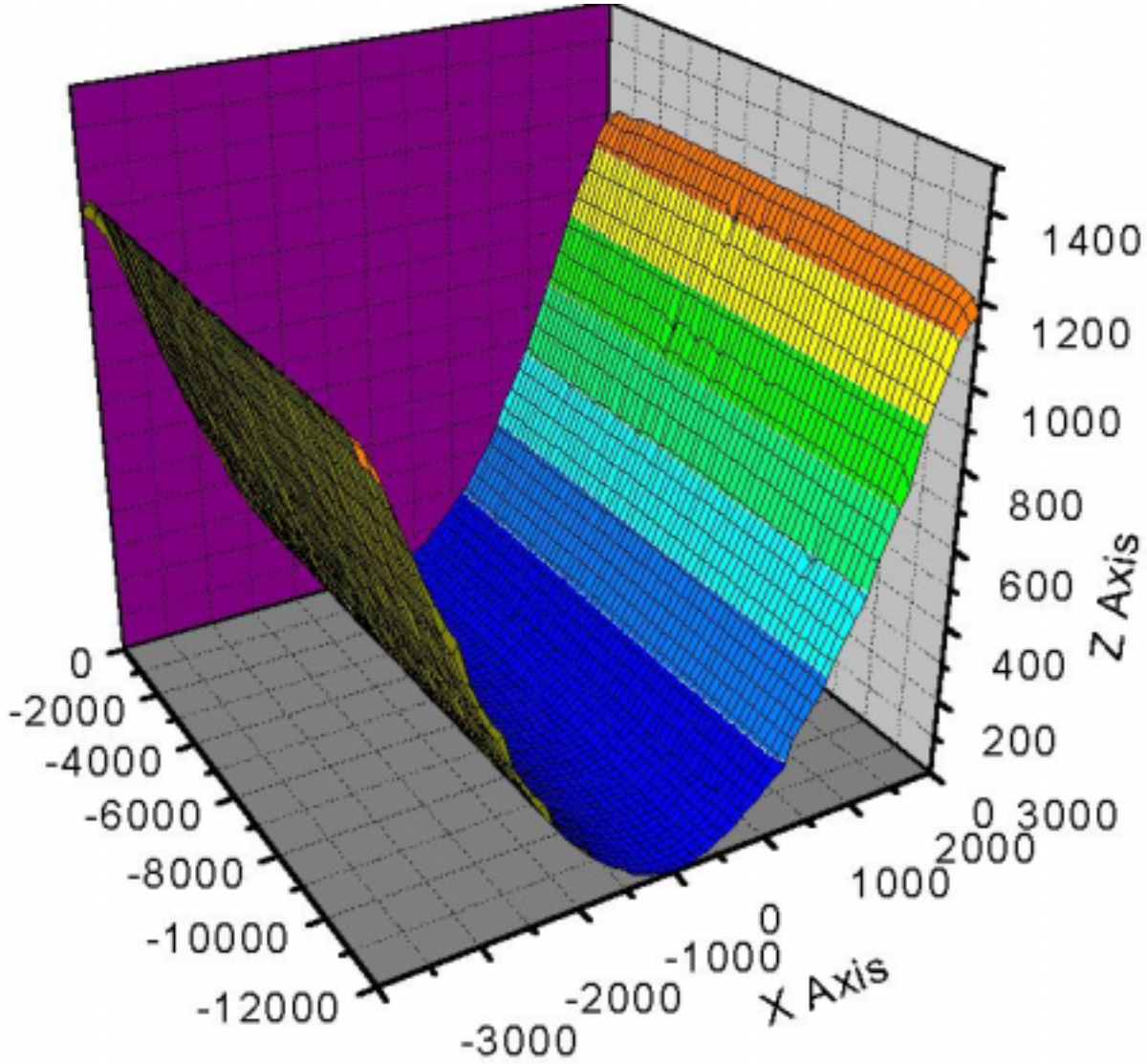

EuroTrough Project Prospects

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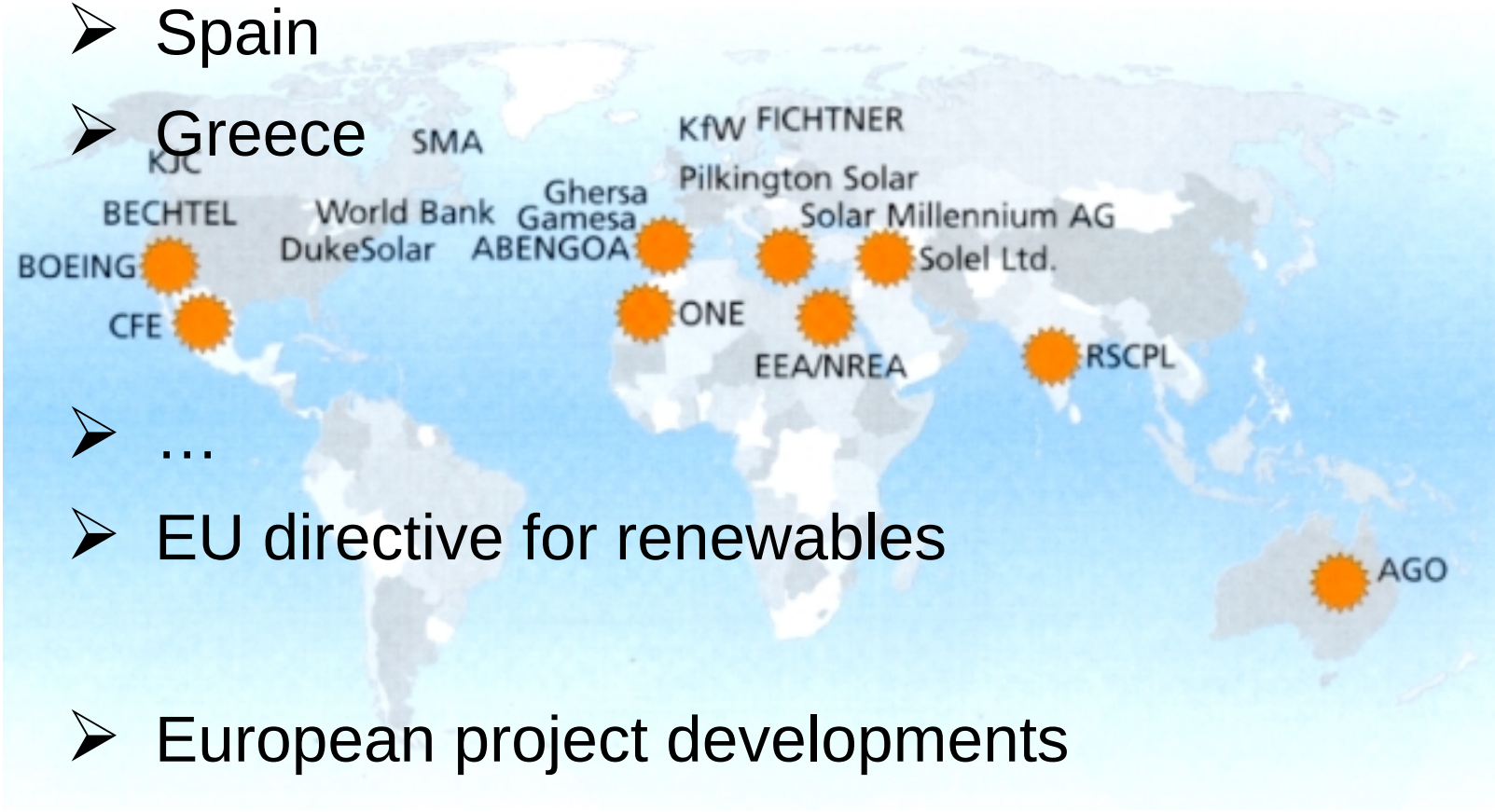
SOLEL

- world wide GEF projects
- Spain
- Greece
- …
- EU directive for renewables
- European project developments



Summary

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- European solar parabolic trough collector
- known geometry
- wind loads analysed
- improved support structure
- cost reduction achieved
- prototype testing at Plataforma Solar