



***First Summer School***  
***Part A: Line-focus Solar Thermal Technologies***  
*September 20-24, 2021*

**Lecture 3:**  
**Parabolic Trough Collectors: Main Components**

Lecturer: Eduardo Zarza Moya

Plataforma Solar de Almería – CIEMAT

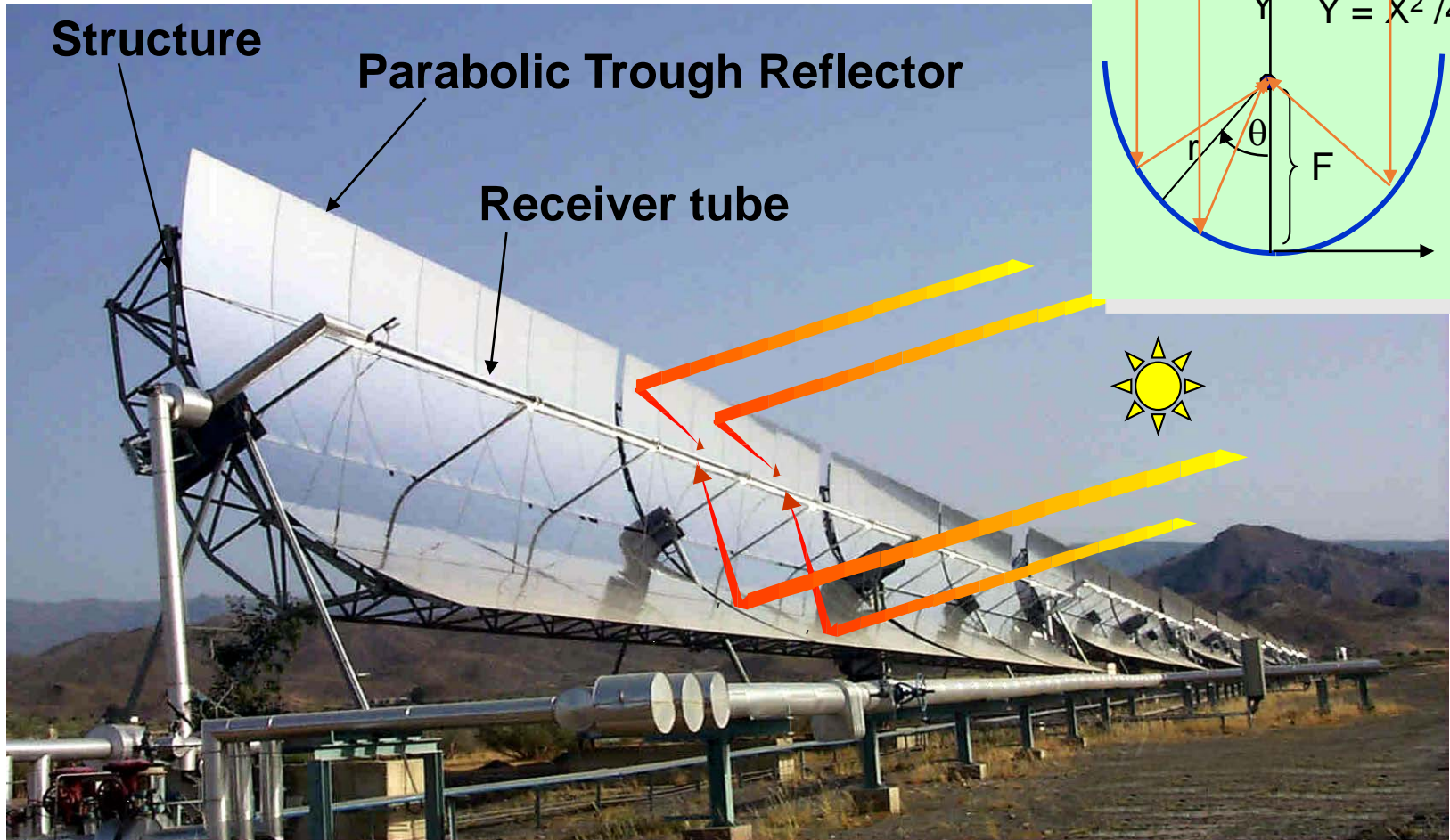
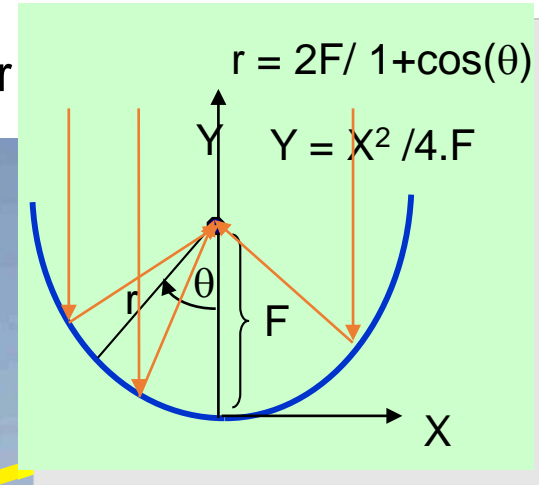
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# Parabolic Trough Collectors: Main Components

- ☞ Introduction
- ☞ Components

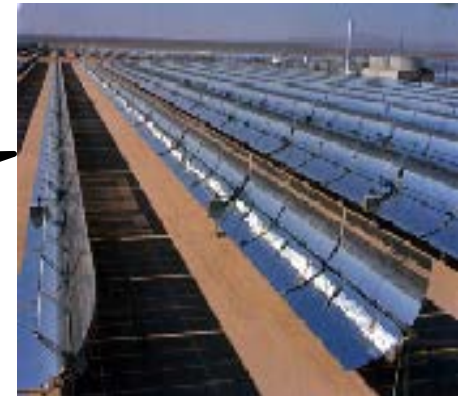
# Parabolic Trough Collector (PTC)

A PTC collects and concentrates the direct solar radiation onto a linear receiver, where the concentrated solar radiation is converted into useful heat in a working fluid circulating inside the receiver



# Introduction

## Parabolic Trough Collector: example of plant



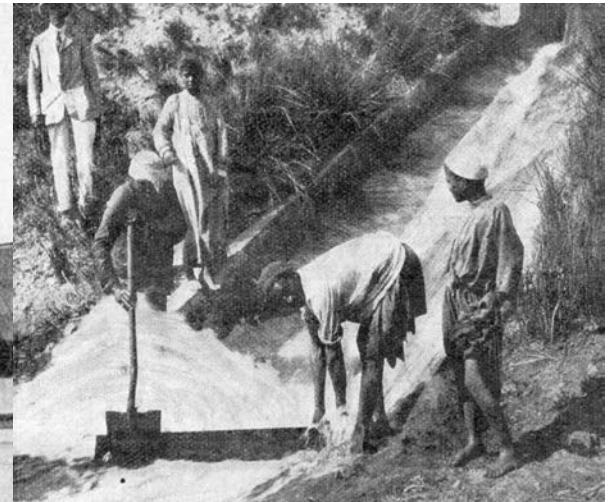
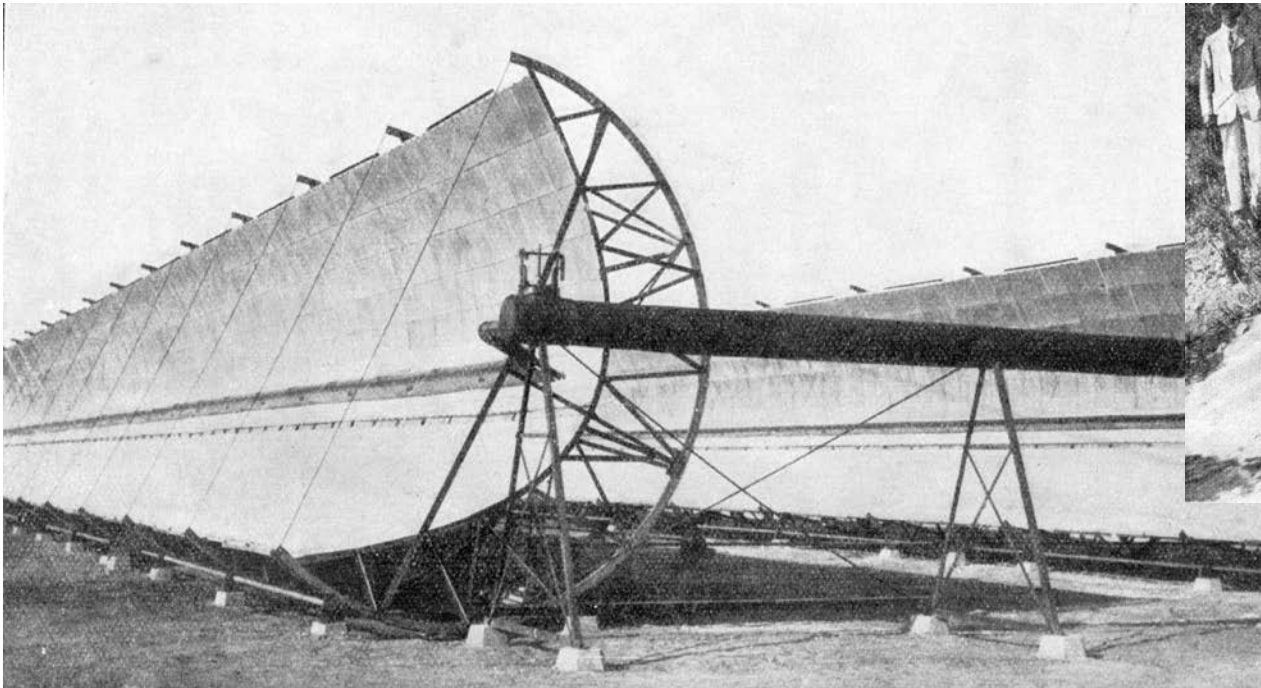


# Introduction

## The beginning (PTC)

– Frank Shuman (USA)

- Pumping irrigation water
- 1913: the first real operating plant, Meadi (El Cairo, Egypt)



# Introduction

## Collector types (PTC)



Big collector for solar thermal electricity plants

Small collector for process heat, with flat glass cover



Small collector for process heat

# Contents

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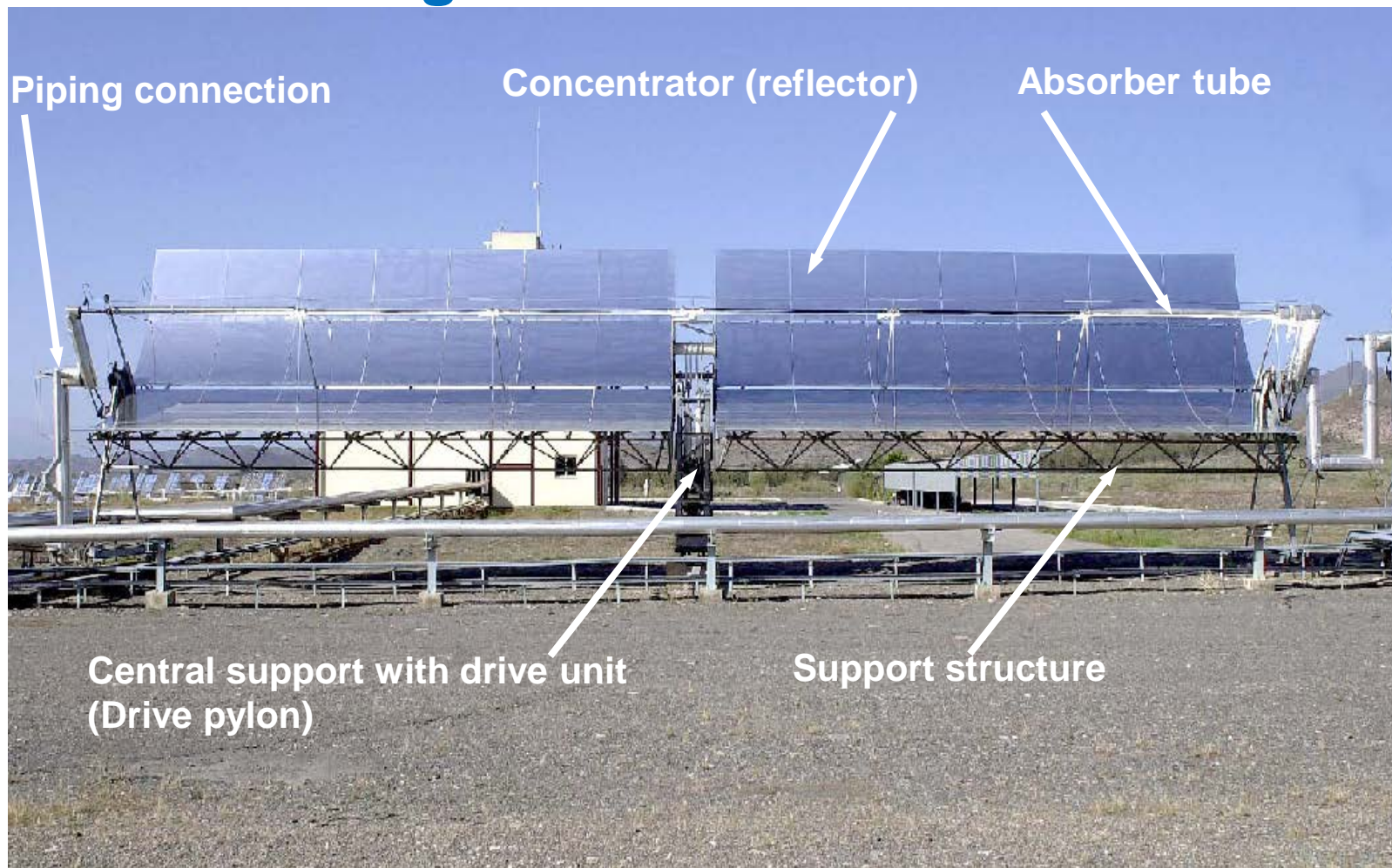
➤ Introduction

👉 ➤ Components



# Components

## Parabolic Trough Collector







# Components: reflectors

- Silvered thick-glass reflectors

Low-iron glass (<0.015 %). 3-7 mm thickness
Reflective layer : Silver (0.7-1.2 g/m <sup>2</sup> )
Back layer : Copper (> 0.3 g/m <sup>2</sup> )
Paint layer (20-2.5% Pb). Pb free: 0.15 %
Paint layer (10-1% Pb). Pb free: 0.15 %

Manufacturers:

- Rioglass
- AGC
- Guardian

- ✓ Reflectance
- ✓ Durability
- ✓ Cost
- ✓ Shape



# Components: reflectors

- Silvered thin-glass reflectors

Low-iron glass (<0.015 %). < 0.4-1.2 mm thickness

Reflective layer : Silver (0.8-1.2 g/m<sup>2</sup>)

Back layer : Cooper

Paint layer (20-2.5% Pb). Pb free: 0.15 %

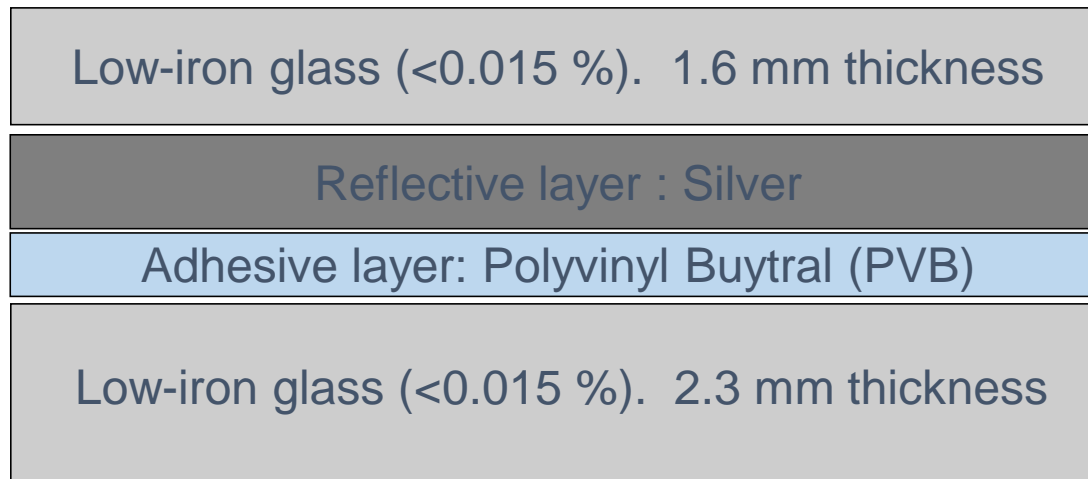
Paint layer (10-1% Pb). Pb free: 0.15 %

- ✓ Reflectance
- ✓ Durability
- ✗ Cost
- ✗ Shape (back)
- ✗ Fragile



# Components: reflectors

- Laminated silvered glass reflectors

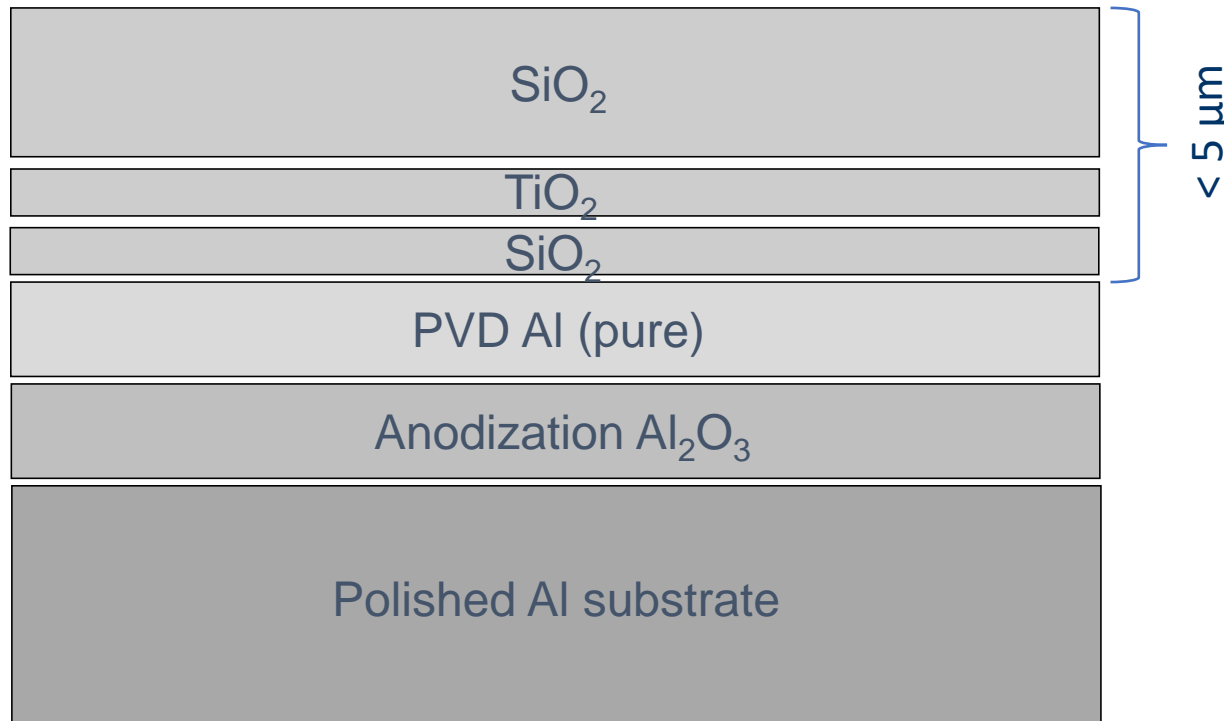


Manufacturers:  
- Guardian

- ✓ Reflectance
- ✓ Durability
- ✓ Shape
- ✗ Cost

# Components: reflectors

- Aluminum reflectors ( $\approx 0.3\text{-}0.5$  mm thickness)



Manufacturers:

- Alanod
- Alcan (Constelium)
- Almeco

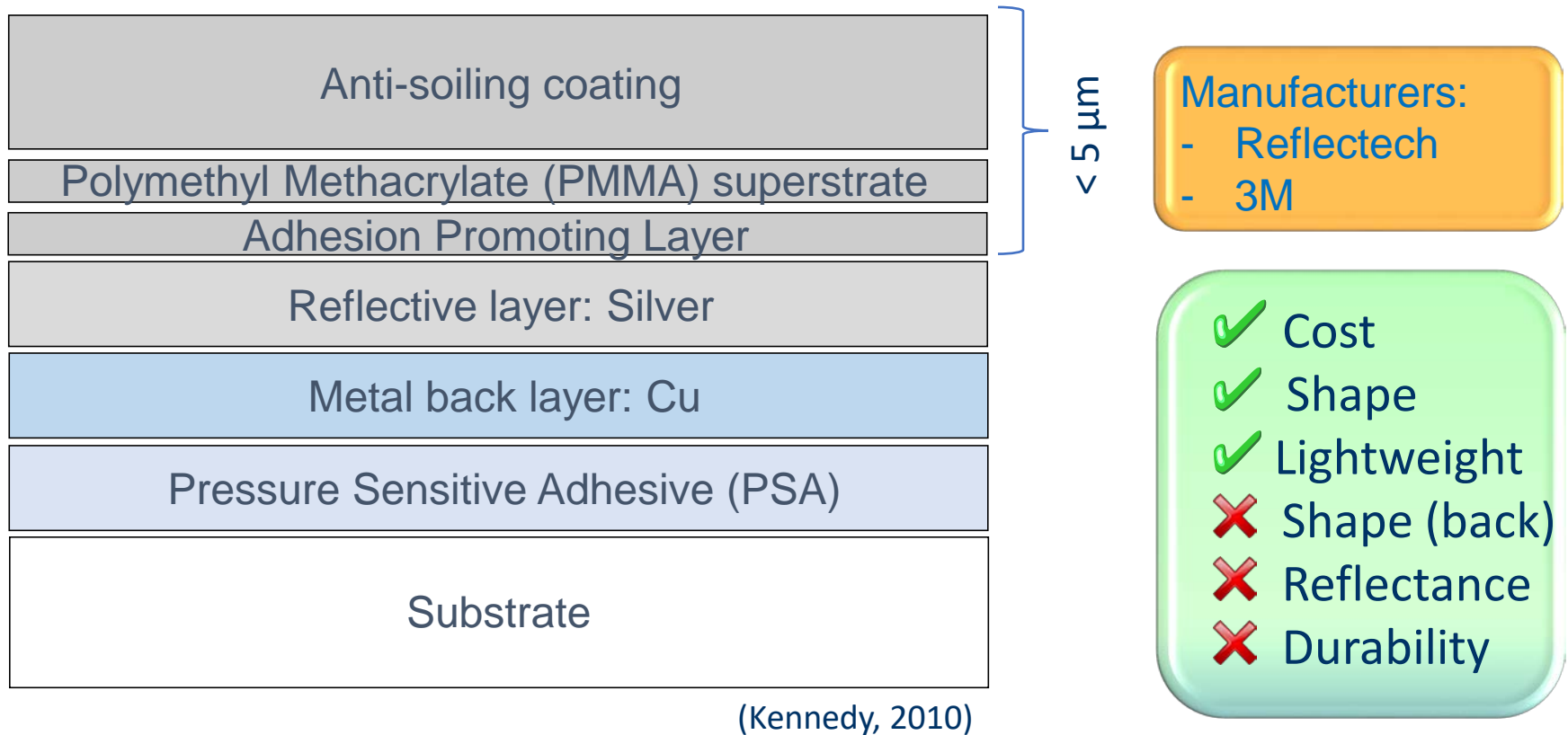
- ✓ Cost
- ✓ Lightweight
- ✗ Shape (back)
- ✗ Reflectance
- ✗ Durability





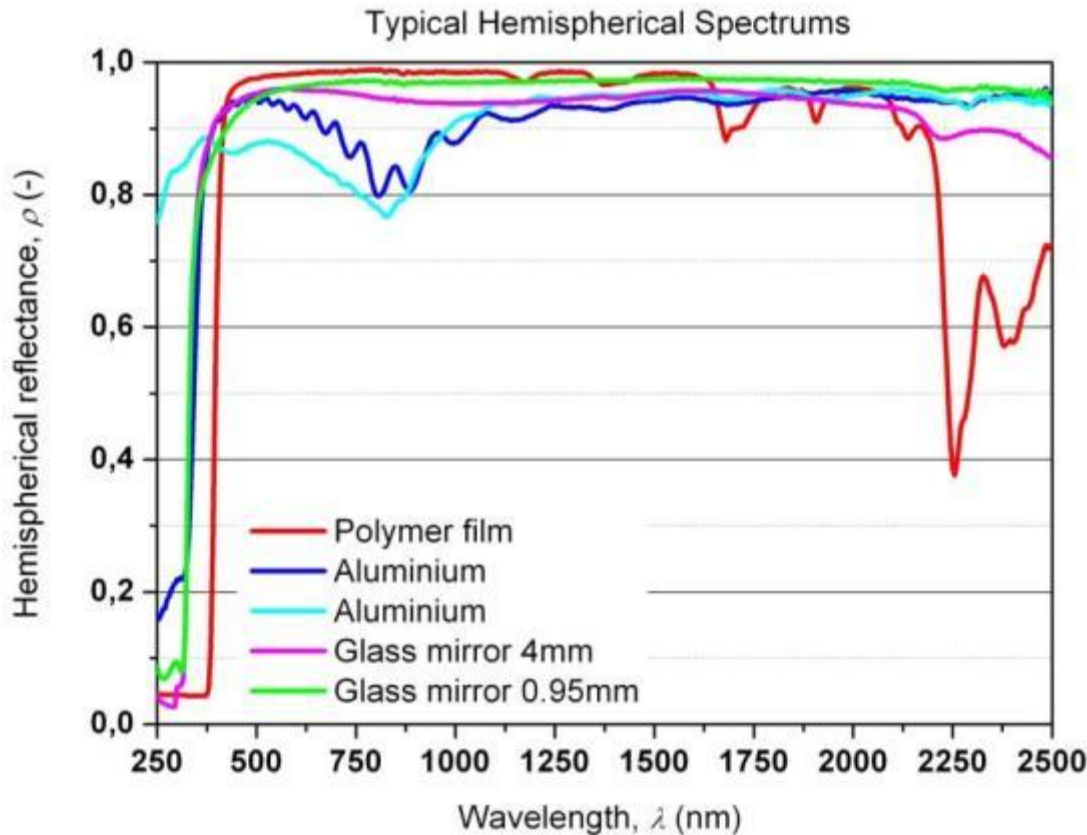
# Components: reflectors

- Silvered polymer films (<0.2 mm thickness)



# Components: reflectors

- Reflectance of different solar reflectors



Type of reflector	Reflectance
Silvered Thin Glass	0.95
Silvered Thick Glass	0.93—0.94
Laminated silvered glass	0.90-0.93
Silvered Polymer Film	0.83-0.87
Aluminum	0.83-0.87



# Components: reflectors

- Cost of different solar reflectors (approx.)

Type of reflector	Cost (€/m <sup>2</sup> )
Silvered Thick Glass	11-15
Silvered Thin Glass	16-43
Silvered Polymer Film	15-25
Aluminum	15-22



# Components: receiver tubes

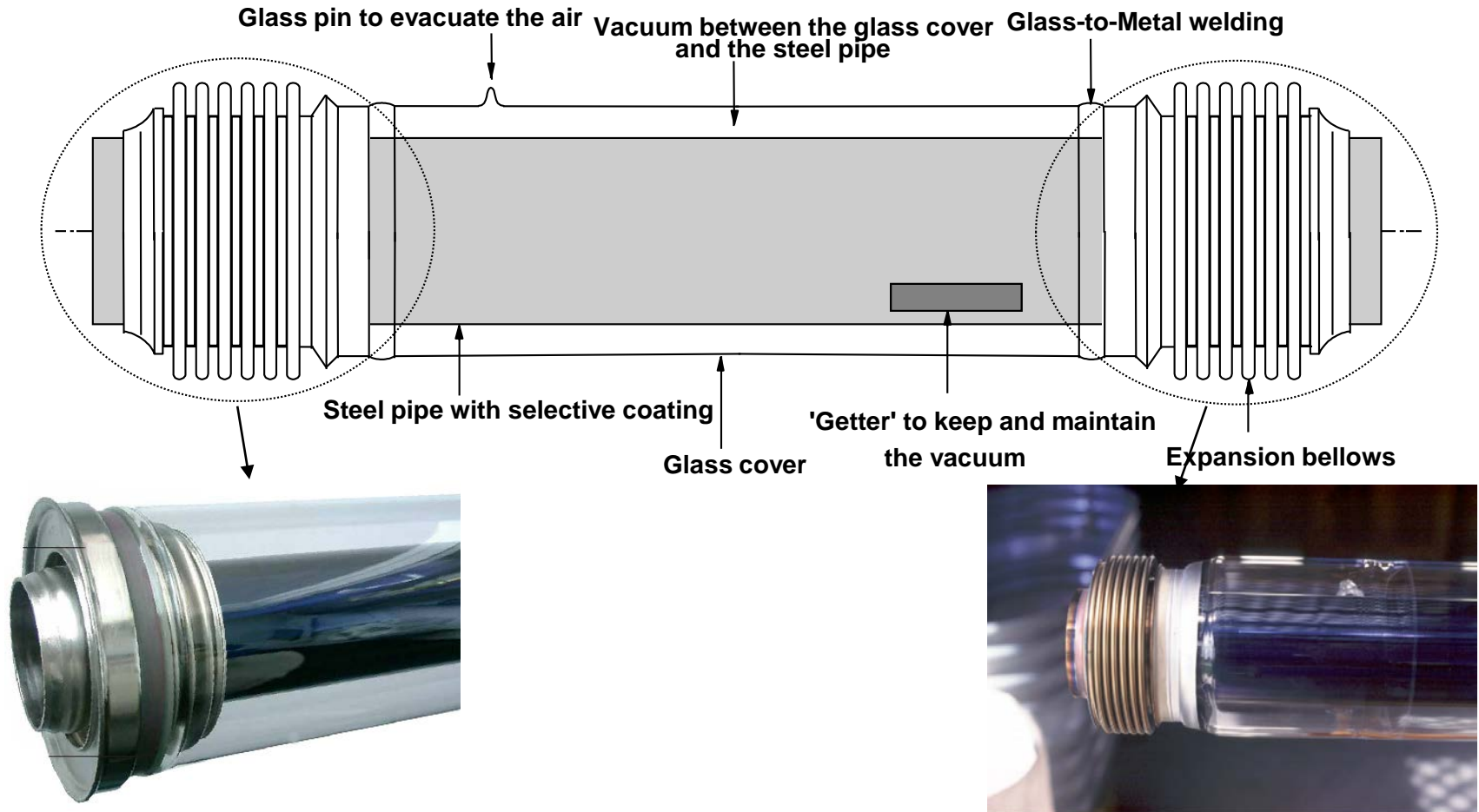
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- Receiver tubes for parabolic-trough collectors
  - ✓ Evacuated tubes
  - ✓ Non-evacuated tubes



# Components: receiver tubes

## Typical Evacuated Receiver Tube



# Components: receiver tubes

## a) Evacuated tubes ( $10^{-4}$ mbar)

- absorptance= 0.94 - 0.96; transmittance=0.96-0.97
- emittance: 0.095 (400°C)
- cost (4m)  $\approx$  700 €/unit
- durability: yearly breackages  $<$  1%
- stainless steel metal tube
- maximum operating temperature: 400°C
- suppliers: Rioglass, Archimedes Solar, .....

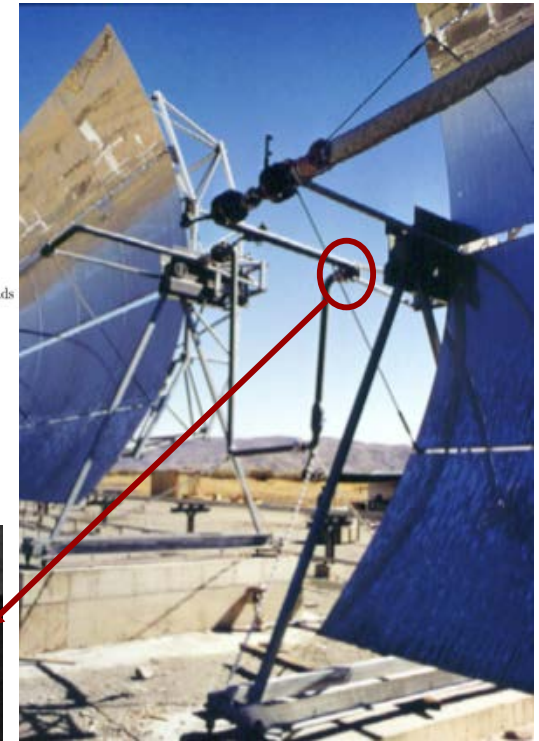
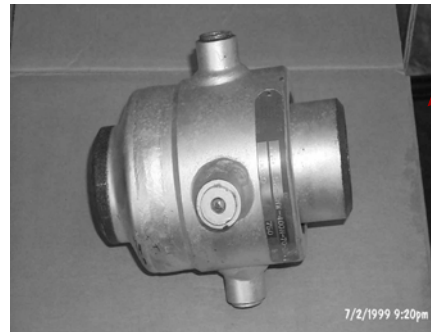
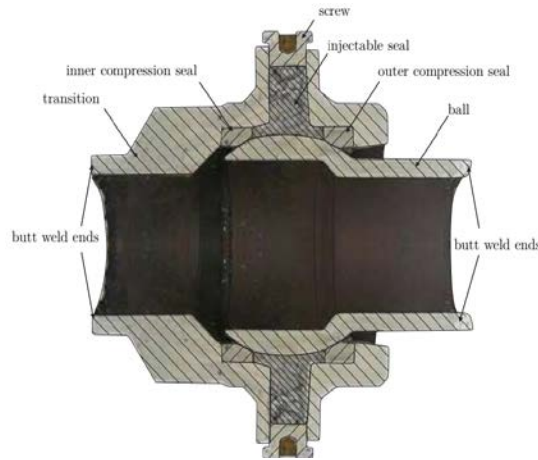
## b) Non-evacuated tubes

- must be assembled by the user
- emittance: 0.25 - 0.9 (300°C)
- absorptance  $\approx$  0.92 - 0.95
- cost  $\approx$  75 - 150 €/m
- durability: yearly breackages  $\ll$  1%
- carbon steel metal tube
- maximum operating temperature: 290°C
- suppliers: Energie Solaire, IST , Tempil, Solec

# Components: connecting elements



a) Flexible hose



b) Ball-joint



# Components: support structure

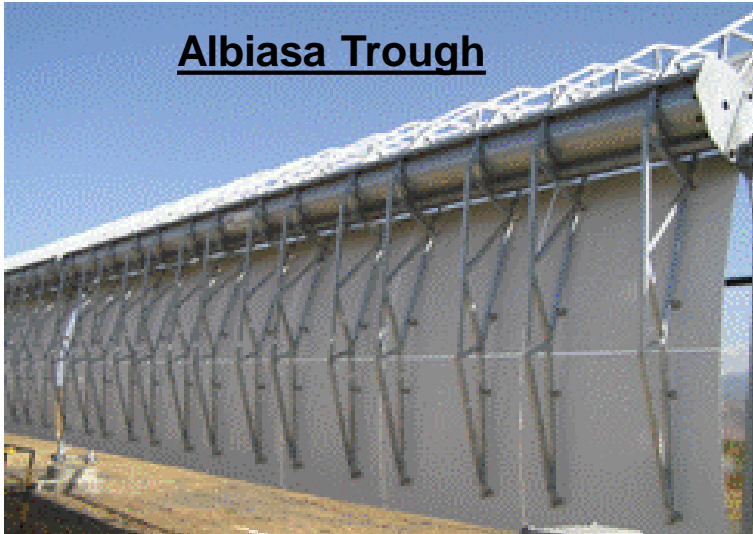
EuroTrough



SolarGenix



Albisa Trough



SenerTrough



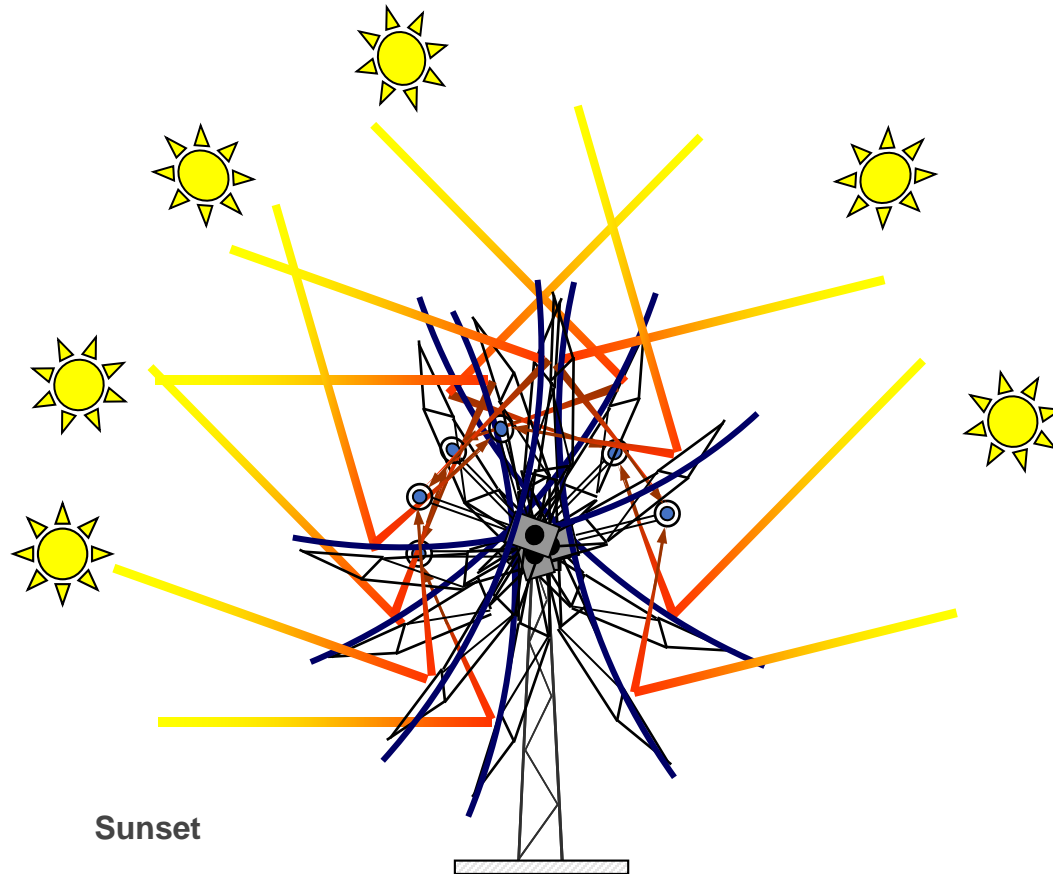


# Components: support structure

## Small-sized collectors

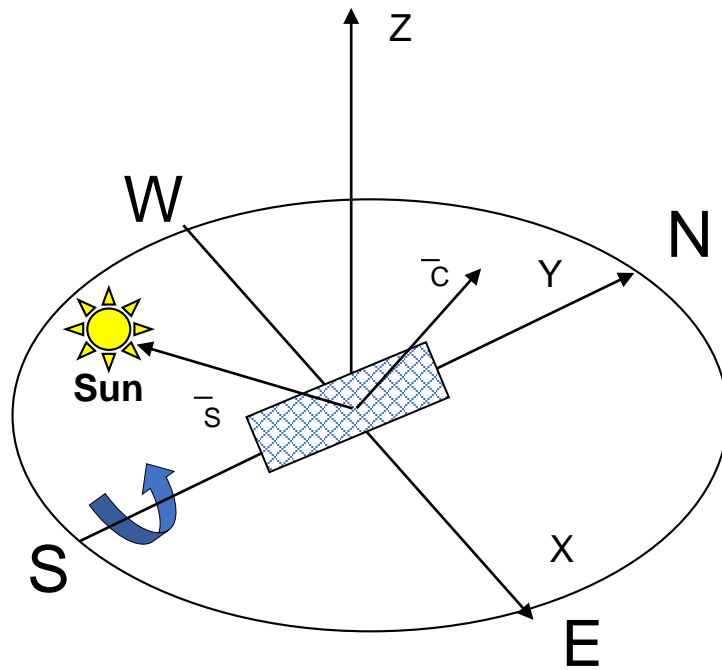


# Components: tracking system

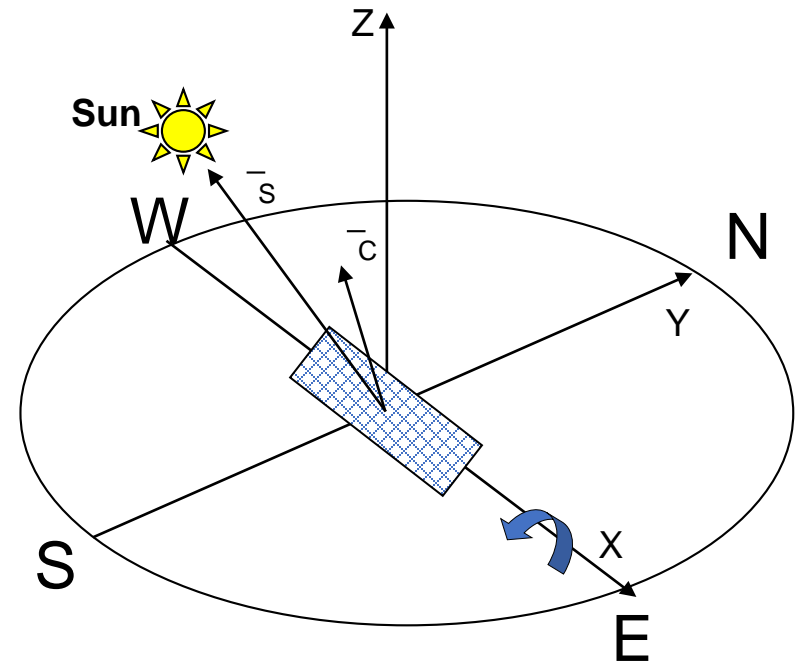


# Components: tracking system

## Main orientations of the tracking axis



a) North-South



b) East-West



# Components: tracking system


## Components:

- Drive unit
  - Hydraulic system
  - Electric motor with a speed-reducing gear
- Local control
  - In close loop (with solar sensors)
  - In open loop (with a computer code to calculate the Sun position + sensor to measure the angular position of the rotation axis)



# Components: tracking system

## Components:

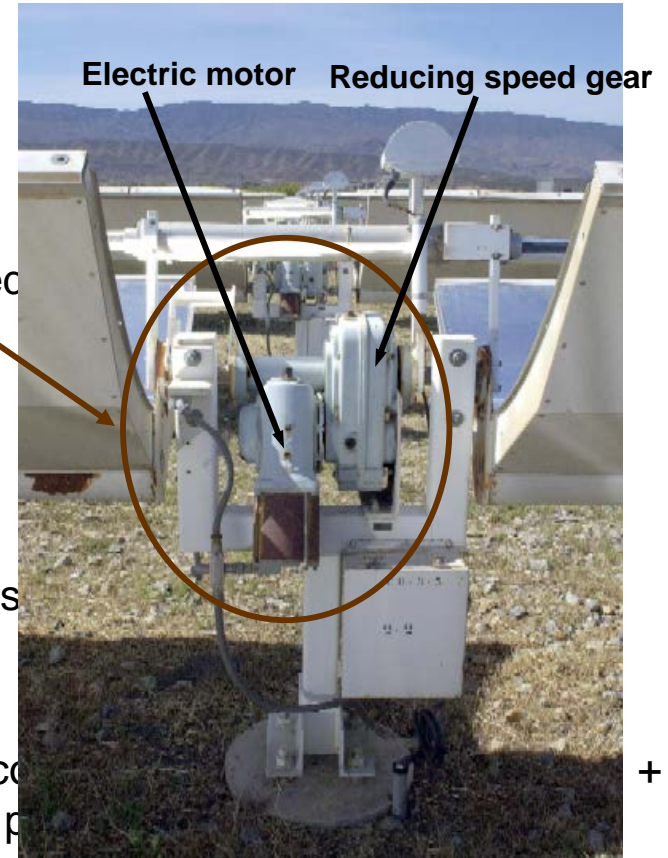
- Drive unit
    - Hydraulic system
    - Electric motor with a speed-reducer
  - Local control
    - In close loop (with solar sensor)
    - In open loop (with a computer controller and a sensor to measure the angular position of the receiver tube)
- 

# Components: tracking system

## Components:

- Drive unit
  - Hydraulic system
  - Electric motor with a speed-reducer

- Local control
  - In close loop (with solar sensors)
  - In open loop (with a computer controller and a position sensor to measure the angular position)





# Components: tracking system

## Components:

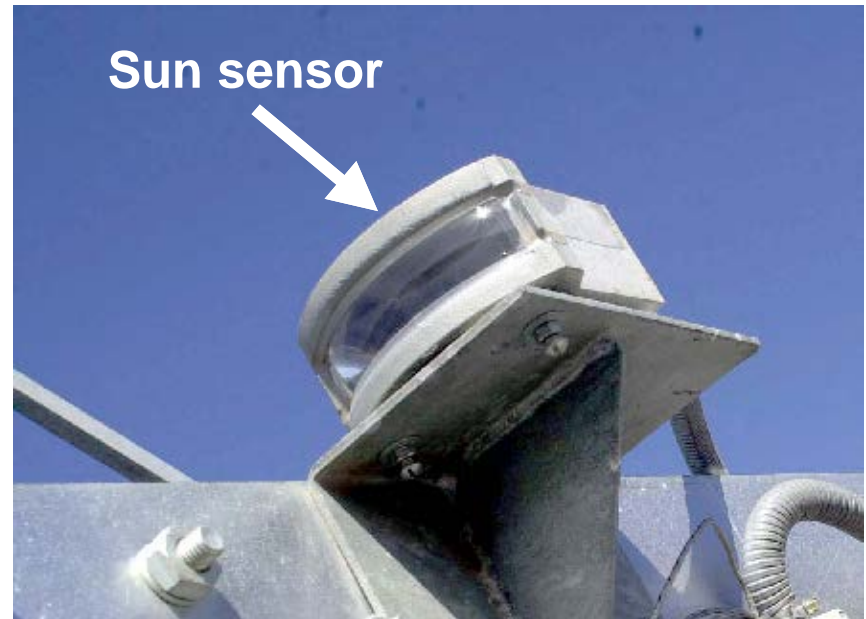
- Drive unit
  - Hydraulic system
  - Electric motor with a speed-reducing gear
- Local control
  - In close loop (with solar sensors)
  - In open loop (with a computer code to calculate the Sun position + sensor to measure the angular position of the rotation axis)

# Components: tracking system

## Different Sun Sensors for Parabolic Trough Collectors



Sun sensor made of two photovoltaic cells  
(developed by FLAGSOL)



Sun sensor with a lens and two photo-sensors  
(developed by LUZ Industries)

# Components: tracking system

Typical Angular Encoder used to measure the angular position of rotation axes



# Working Fluid in the Receiver

➤ The main heat transfer fluid (HTF) used in IPH plants is the pressurized water and in solar thermal power plants is thermal oil

## Advantages of thermal oil:

- No phase change
- Low operating pressure

## Disadvantages of thermal oil:

- Operating temperature under 400 °C
- Expensive auxiliary components
- High freezing temperatures (sometimes)
- Replacement cost (3%)
- Thermal losses linked to the heat exchanger
- Environmental risk (and fire risk)
- High pumping power





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### **Lecture 3:**

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- **Thank you very much for your attention**
- **Questions?**

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