Basic principles of solar radiation and STE plants

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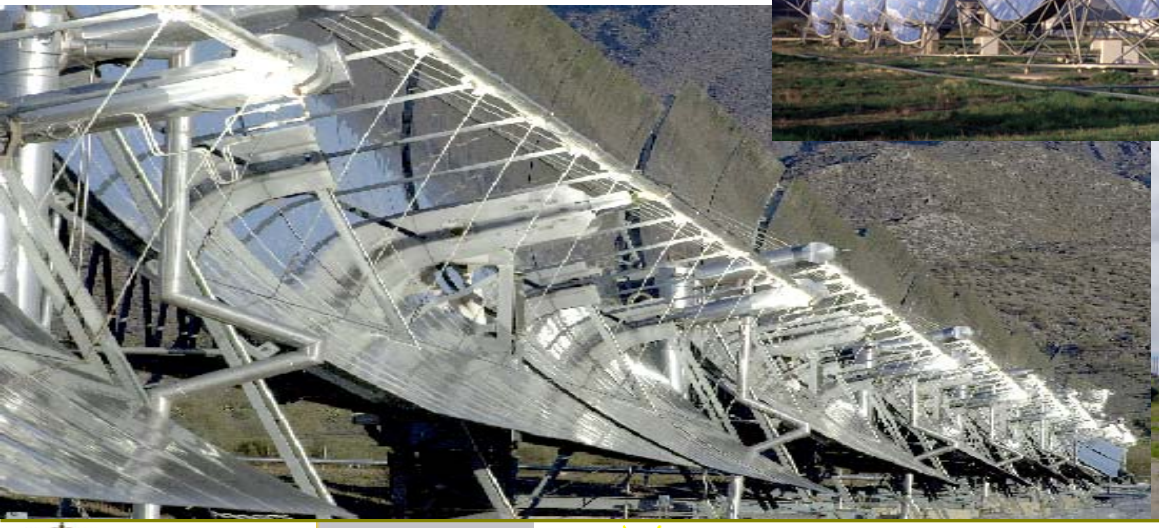

Índice de la Presentación

- The Sun and the solar radiation
- Solar Concentrating Systems
- Solar Thermal Electricity (STE) Plants
- STE technologies comparison

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- **The Sun and the solar radiation**
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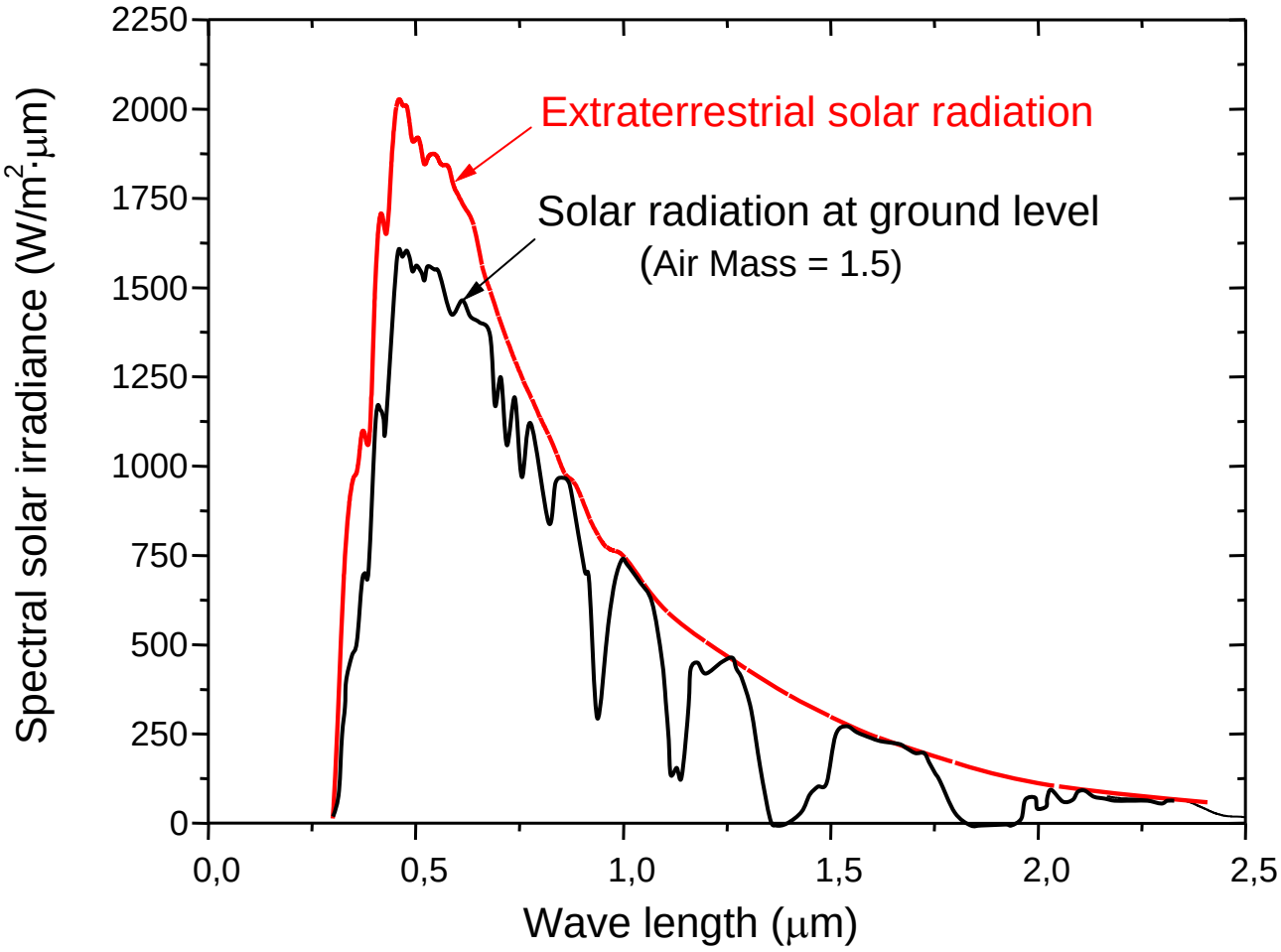
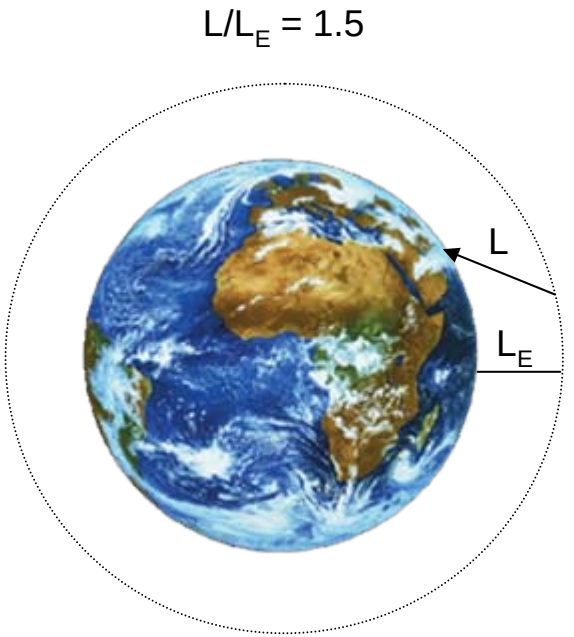
The Sun and the Solar radiation

- Sun is a huge nuclear reactor ($7x10^5$ km radius) emitting a great amount of radiant energy ($3,8x10^{23}$ kW, 5800°K), which can be easily converted into thermal energy

Spectral Solar Irradiance





The Sun and the Solar radiation

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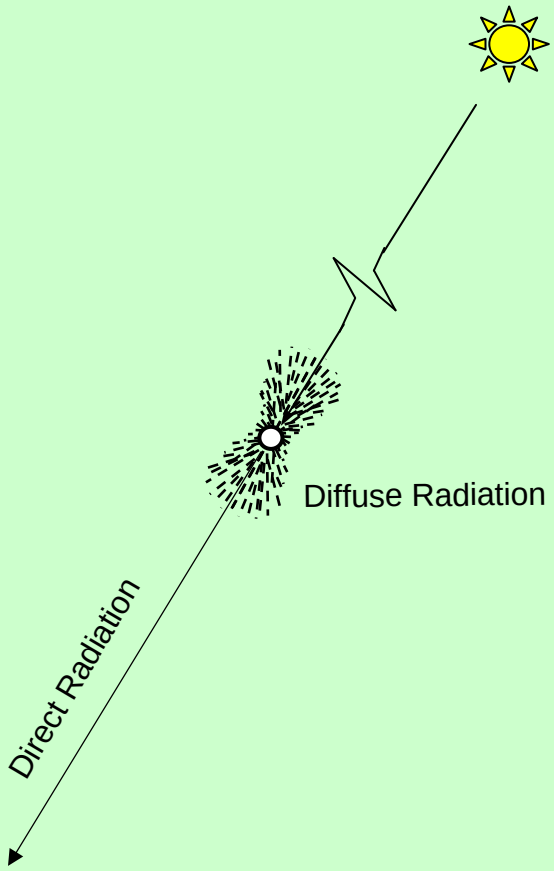
- The Earth intercepts only $1,7x10^{14}$ kW of solar radiation (10 days ≅ known fossil fuels resources)

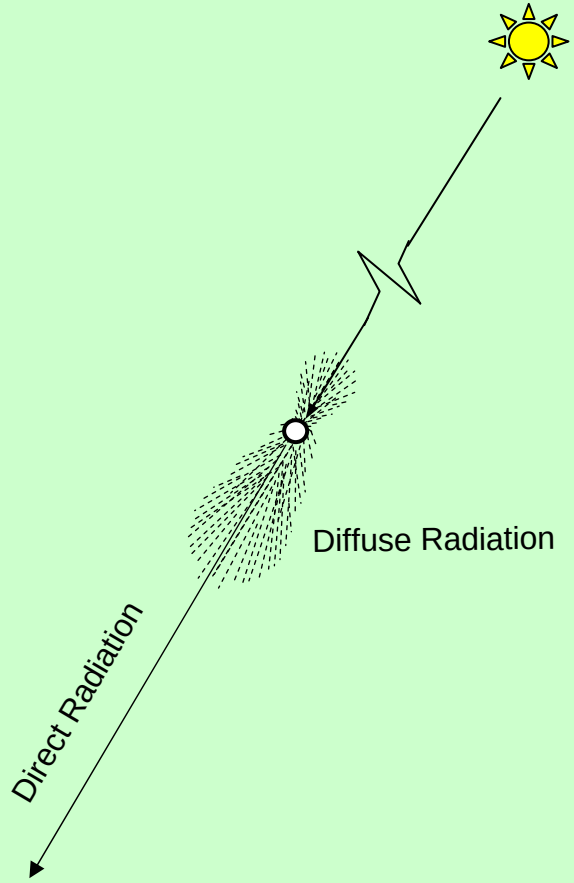
- The solar irradiance outside the atmosphere is almost constant (its value is called "Solar Constant", 1367 W/m^2)

- Solar radiation at ground level has two components: *Direct Radiation* and *Difuse Radiation*.

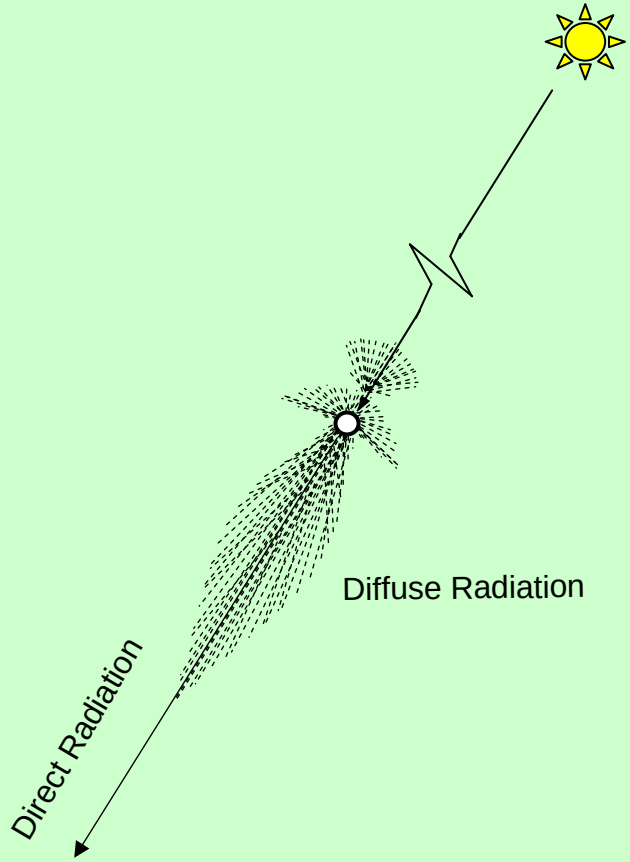
Direct and Difuse Solar Radiation



a) d < λ/10



b) d ≈ λ/4

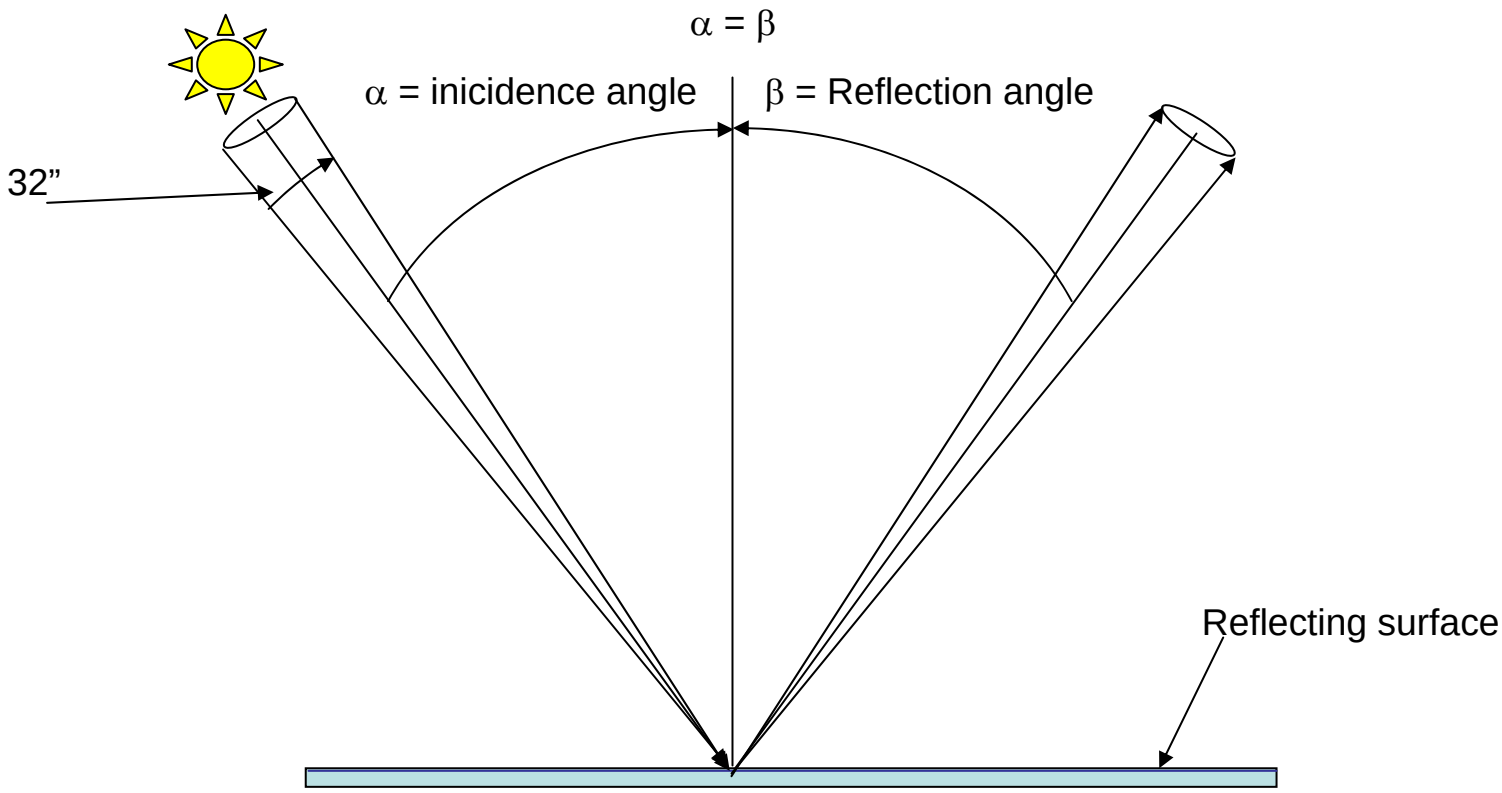


c) d > λ

The Sun and the Solar radiation

- Sun is a huge nuclear reactor ($7x10^5$ km radius) emitting a great amount of radiant energy ($3,8x10^{23}$ kW, 5800°K), which can be easily converted into thermal energy
- The Earth intercepts only $1,7x10^{14}$ kW of solar radiation (10 days ≅ known fossil fuels resources)
- The solar irradiance outside the atmosphere is almost constant (its value is called "Solar Constant", 1367 W/m^2)
- Solar radiation at ground level has two components: *Direct Radiation* and *Difuse Radiation*.
- Only *Direct Solar Radiation* can be concentrated.
- Solar radiation reaching any point is not composed of a single ray, but of a cone of rays within a solid angle of 32" (approx.).

The Sun and the Solar radiation



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- The Sun and the solar radiation
- **Solar Concentrating Systems**
- Centrales Termosolares y Crecimiento Sostenible
- Situación actual
- Conclusiones

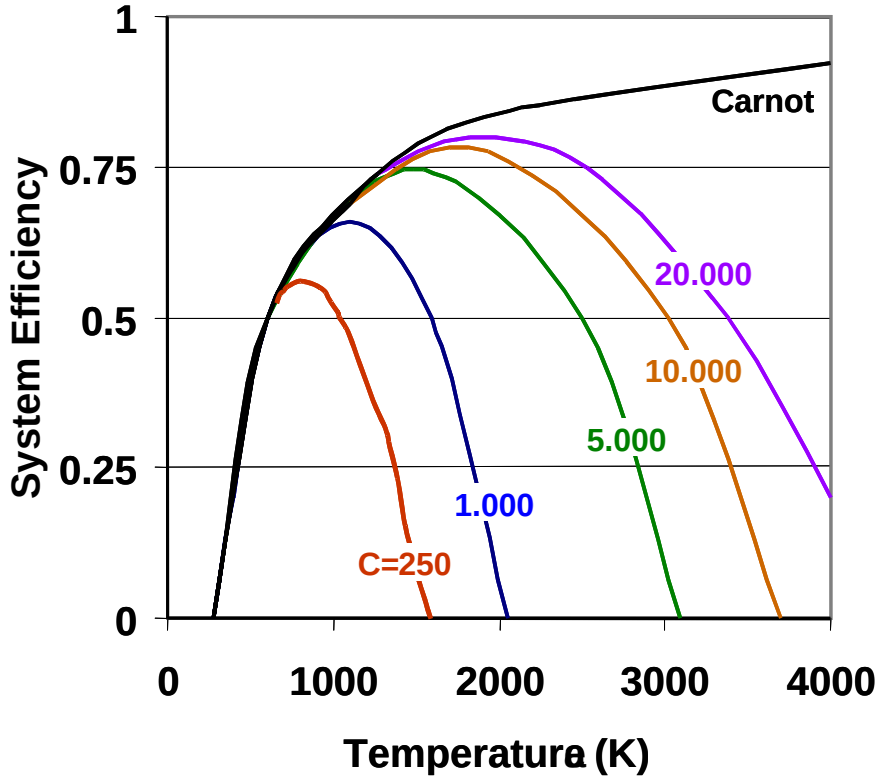
Solar Radiation and its Concentration

- Solar Concentration: Why?

  Since solar radiation suffers a significant attenuation in its way to the Earth (from 63,2 MW/m^2 to 1 kW/m^2) we have to concentrate solar radiation in order to compensate for its low flux density at the Earth surface and thus achieve higher temperatures and efficiencies.

Efficiency versus concentration factor

$\eta = f(C, T)$



Dependence of the *Efficiency* and the *Optimum Working Temperature* on the *Solar Radiation Concentration Factor*

Solar Radiation and its Concentration

- **Solar Concentration: Why?**

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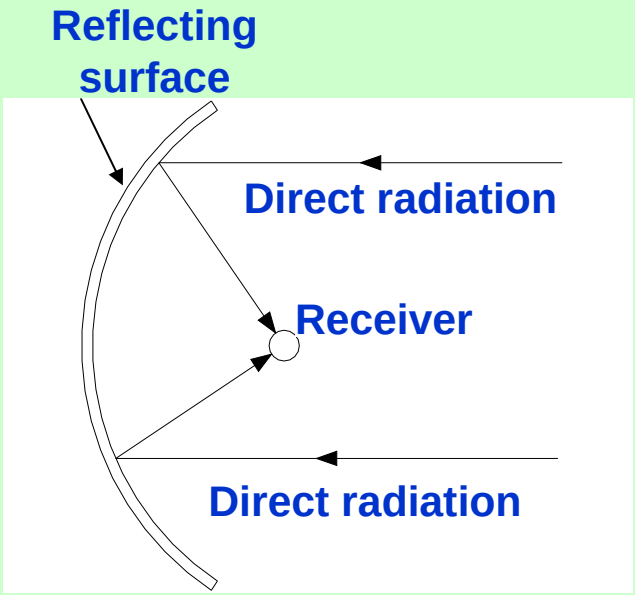
- **Ways to concentrate the direct solar radiation**

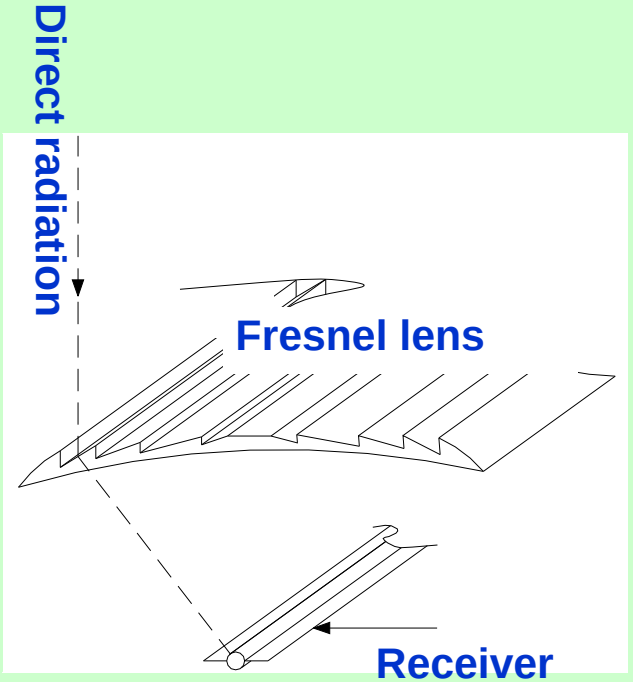
  a) by Reflection b) by Refraction

Solar Radiation and its Concentration

Direct Solar Radiation can be concentrated by Reflection and by Refraction:



a) by Reflection



b) by Refraction

Solar Radiation and its Concentration

➢ Solar Concentration: Why?

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➢ Ways to concentrate the direct solar radiation

a) by Reflection b) by Refraction

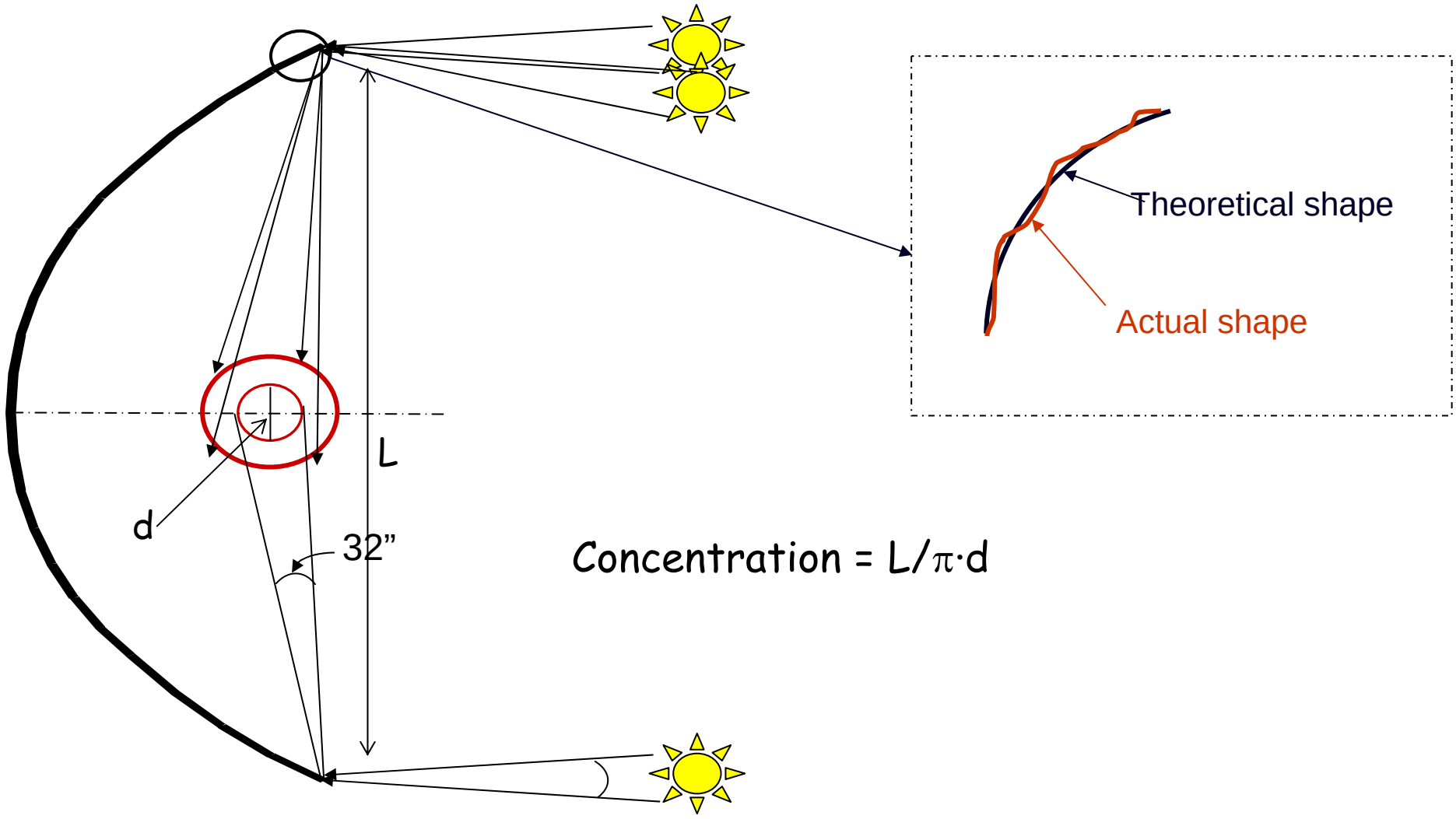
➢ Theoretical and practical limits for solar concentration

- Point focus concentrators: 46200 (theoretical); 5000 y 10000 (practical)
- Linear focus concentrators: 220, (theoretical); 20 – 80 (practical)

➢ Limiting factors for solar concentration

a) The apparent size of solar sphere is 32´ as seen from the Earth
b) Inaccuracies and optical errors of solar concentrators

Concentration limit due to the Sun disk size



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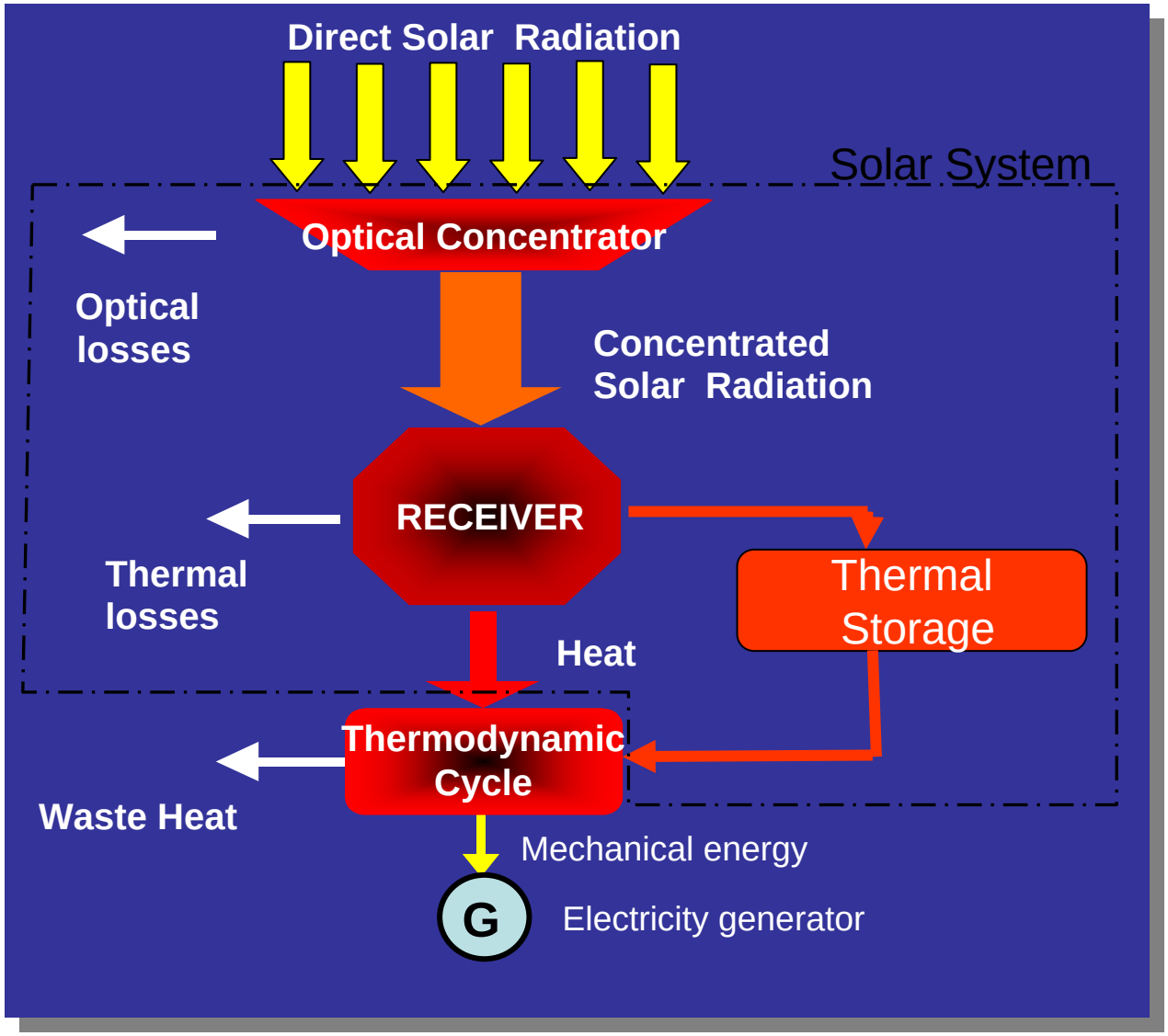
Solar Thermal Electricity Plants

What is a Solar Thermal Electricity (STE) plant ?

A STE plant is a system where solar radiation is concentrated and then converted into thermal energy at medium/high temperature (300°C – 800°C). This thermal energy is then used in a thermodynamic cycle to produce electricity.

Simplified Scheme of a typical STE Plant



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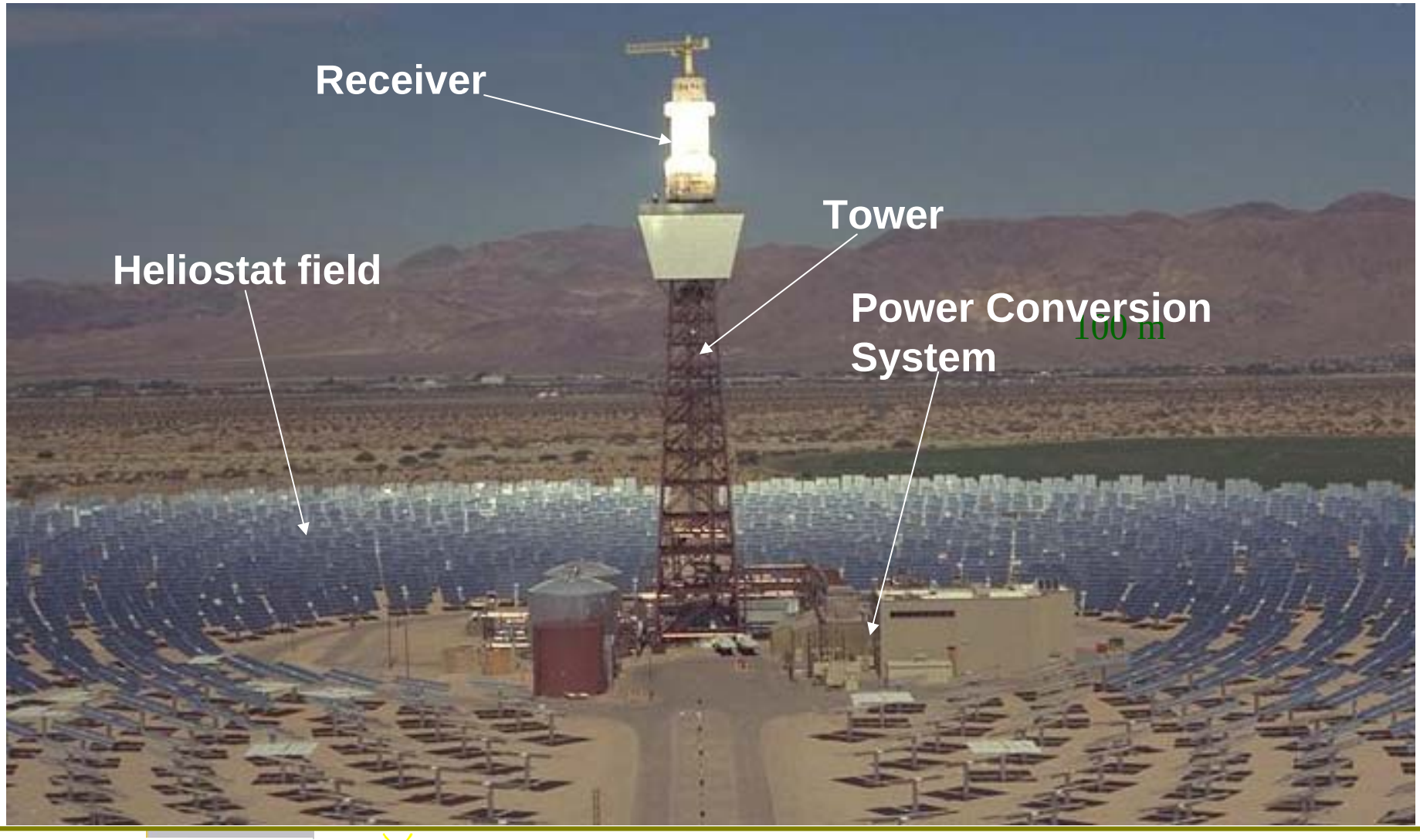
Why are Solar Thermal Power plants interesting nowadays ?

- ✓ It is already profitable in some Countries due to public subsidies or incentives
- ✓ There is a huge market worldwide for these solar plants
- ✓ There are many Countries with good solar radiation level
- ✓ The technology is mature enough for commercial deployment
- ✓ These plants demand a lot of manpower for construction, as well as for O&M
- ✓ These plants do not increase the emissions of CO_2 :
  - A STP plant saves 2000 Tons of CO_2 per year and MW_e installed
  - Every GWh of electricity produced by a STP plant saves 800 tons of CO2

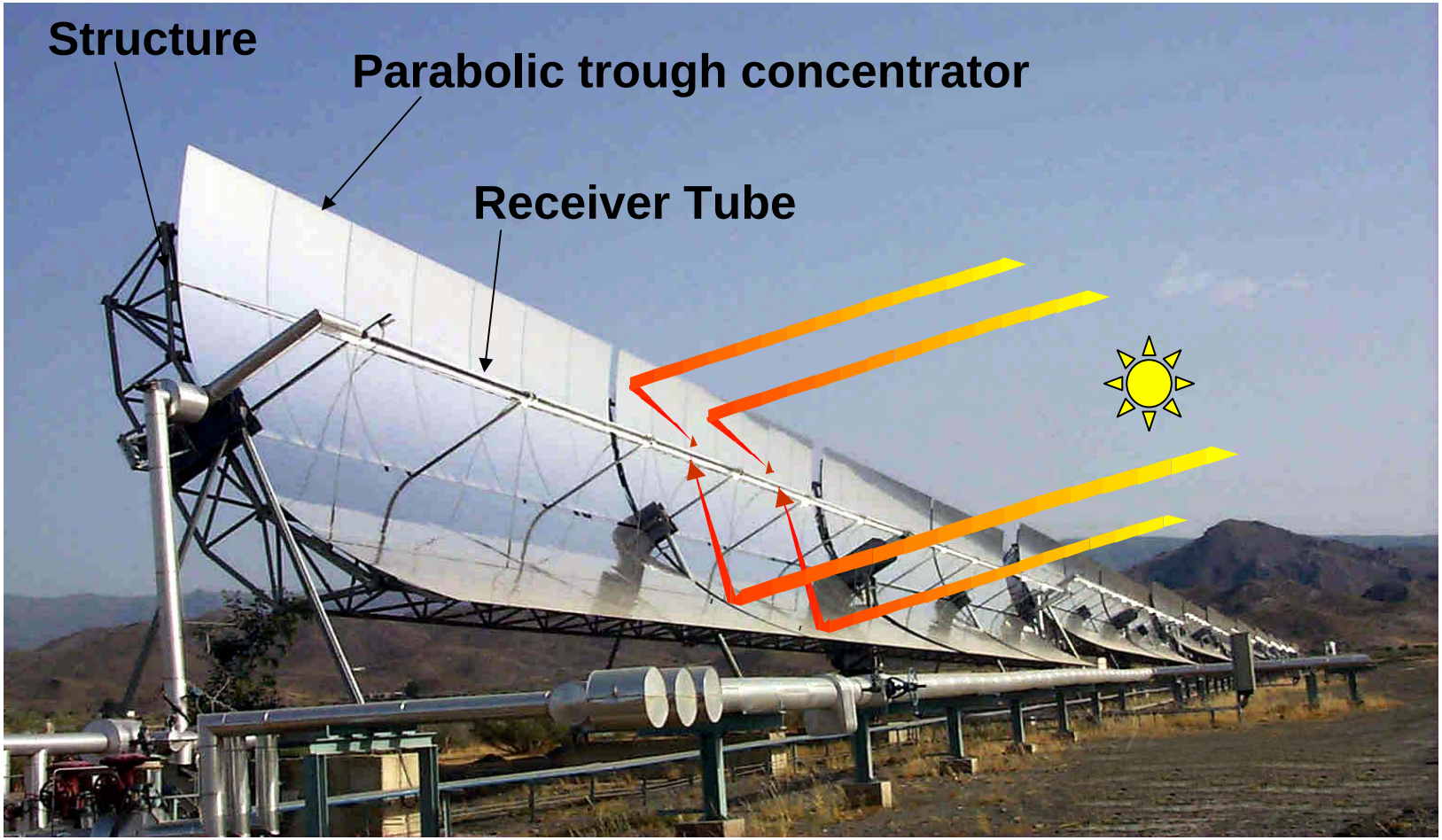
Current Technologies for STE plants (I)

Central Receiver Technology



Current Technologies for STE plants (II)

Parabolic Trough Collectors

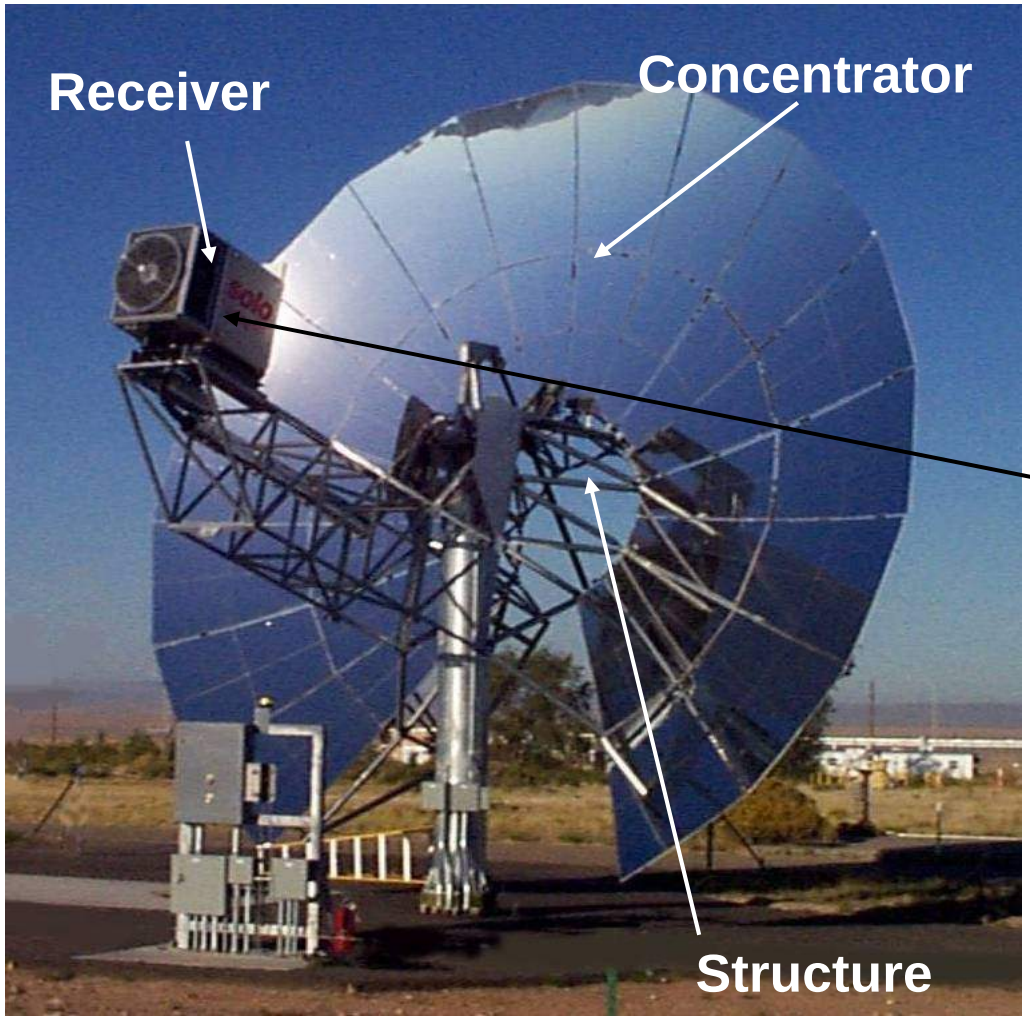


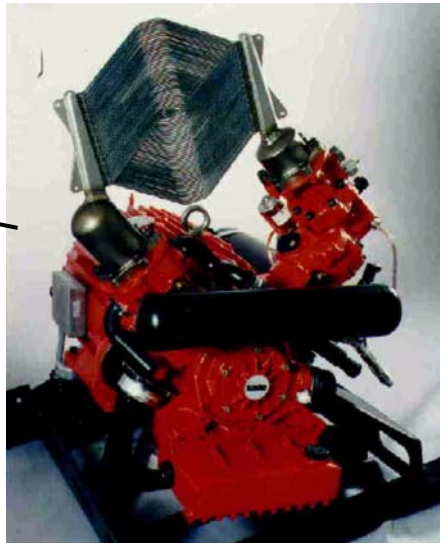
Current Technologies for STE plants (II)

STE Plant with Parabolic Trough Collectors

Current Technologies for STE plants (III)

Stirling Dishes

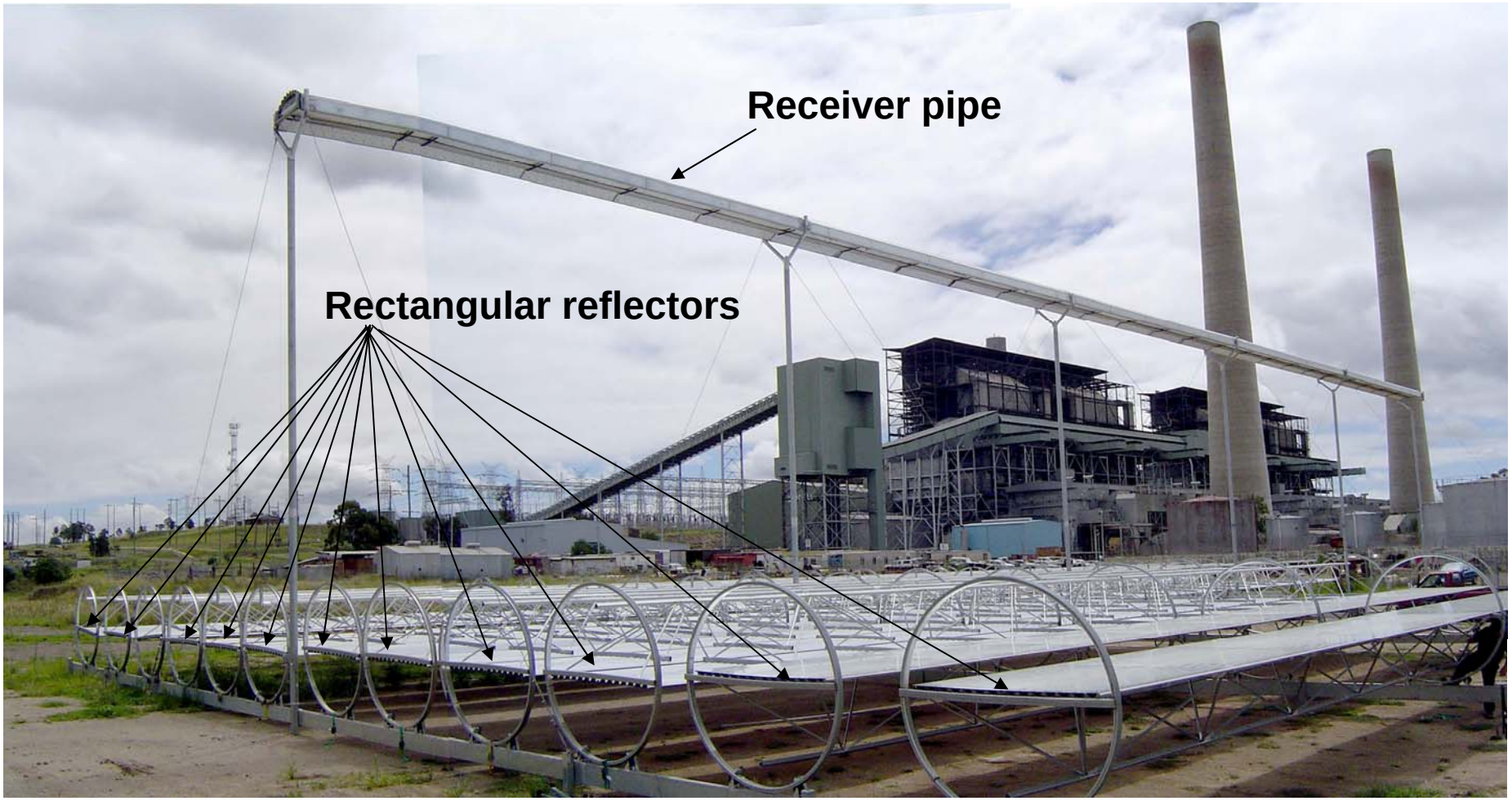




Solar Stirling engine

Current Technologies for STE plants (and IV)

Linear Fresnel Concentrator



Solar Thermal Electricity Plants

Technologies comparison

	PTC	Central Receiver	Parabolic Dishes	LFC
Unit plant power	15-200 MW	15-100 MW	9-25 kW	15-200 MW
Working temperature	390 °C	575 °C	750 °C	390°C
Peak efficiency (solar-electric)	20 %	23 %	30 %	18
Yearly net Efficiency	11-16 %	7-20 %	12-25 %	13
Current status	Available	Available	Prototypes-Demonstration	Available
Technological risk	Low	Low	Low	High-Medium
Storage availability	Si	Si	Si	Si
Hybrid designs	Si	Si	Si	Si

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! Thank you for your attention !