# From Sunlight to Electricity

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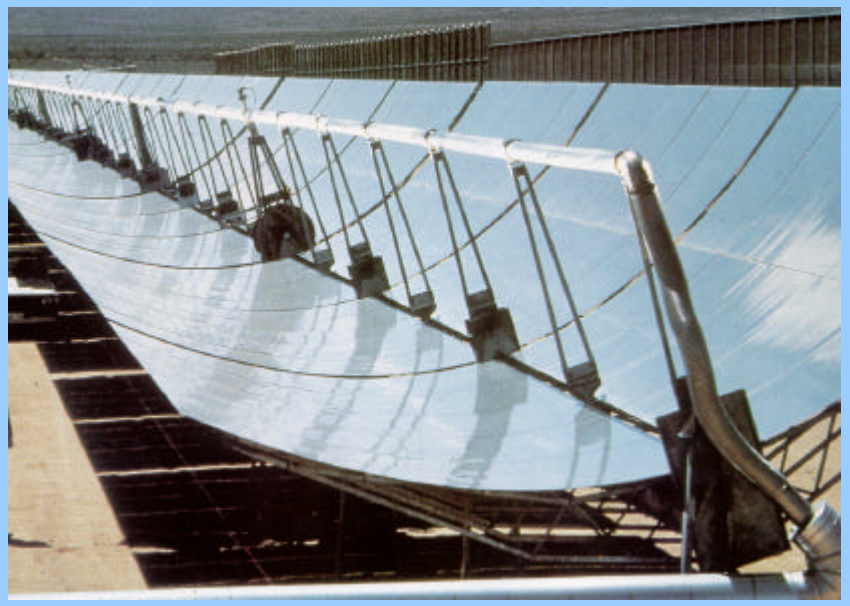
Stuttgart, Germany

http://www.dlr.de/tt

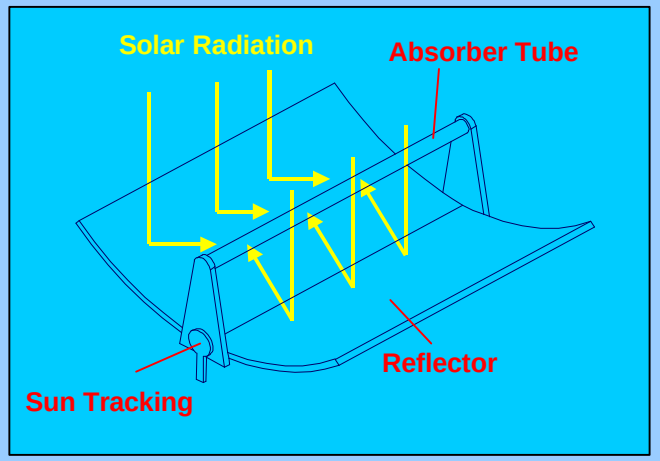
# From Sunlight to Electricity

Step 1:

Sunlight is Concentrated by Parabolic Mirrors that Continuously Follow the Sun‘s Position on the Sky



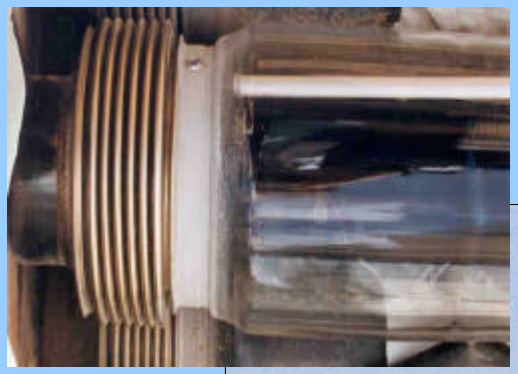
Parabolic Trough Concentrator



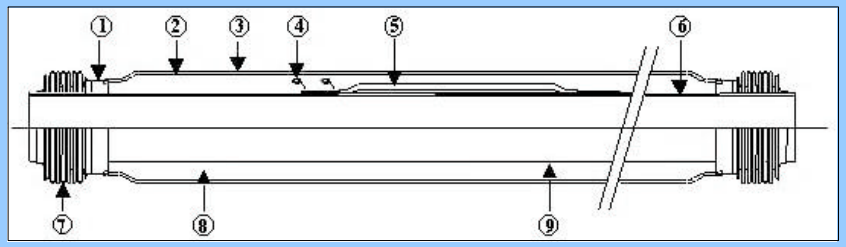
# From Sunlight to Electricity

Step 2:

The Concentrated Solar Heat is Absorbed by a Steel Tube and Transported away by a Fluid that is Circulated within the Tube



## Heat Collecting Element with Absorber Tube and Evacuated Glass Tube




1 Glass-Metal-Connection
2 Glass Envelope
3 Anti-Reflective Coating
4, 5 Getter
6 Steel Tube
7 Expansion Bellows
8 Evacuated Space
9 Solar Coating

# From Sunlight to Electricity

Step 3:

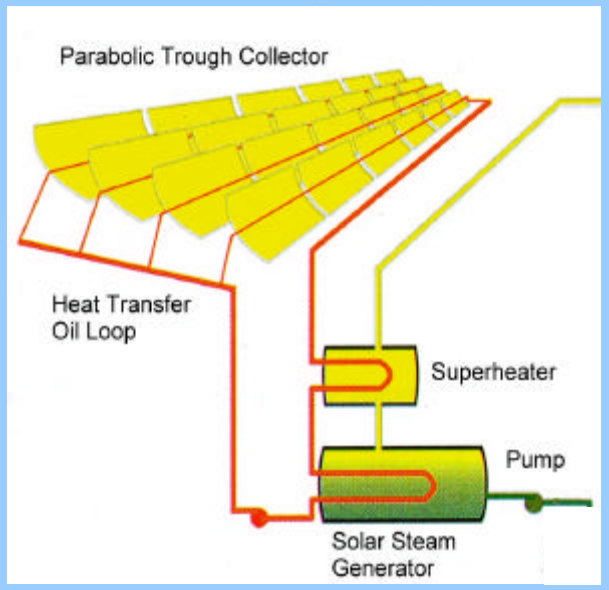
The Hot Fluid is Gathered from a Large Field of Solar Concentrating Collectors and then is Pumped to a Central Heat Exchanger

Parabolic Trough Collector Field

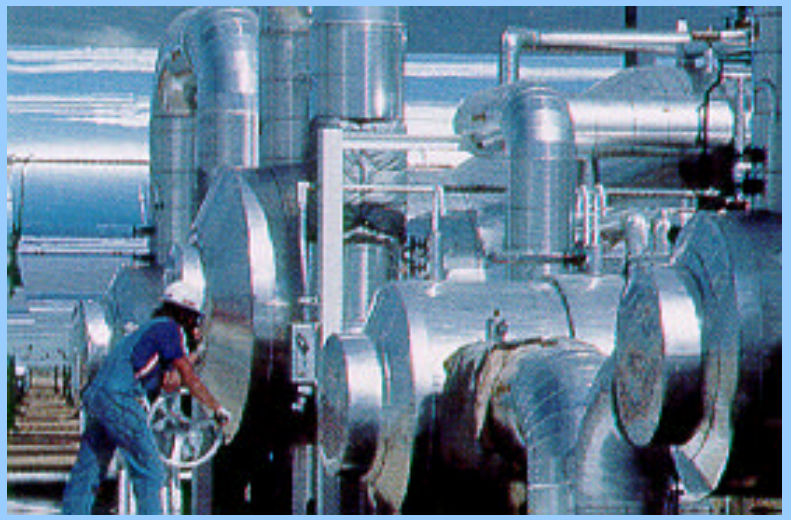
# From Sunlight to Electricity

Step 4:

Within the Heat Exchanger, the Hot Fluid Generates Superheated Steam with over 100 bar Pressure




Solar Steam Generator



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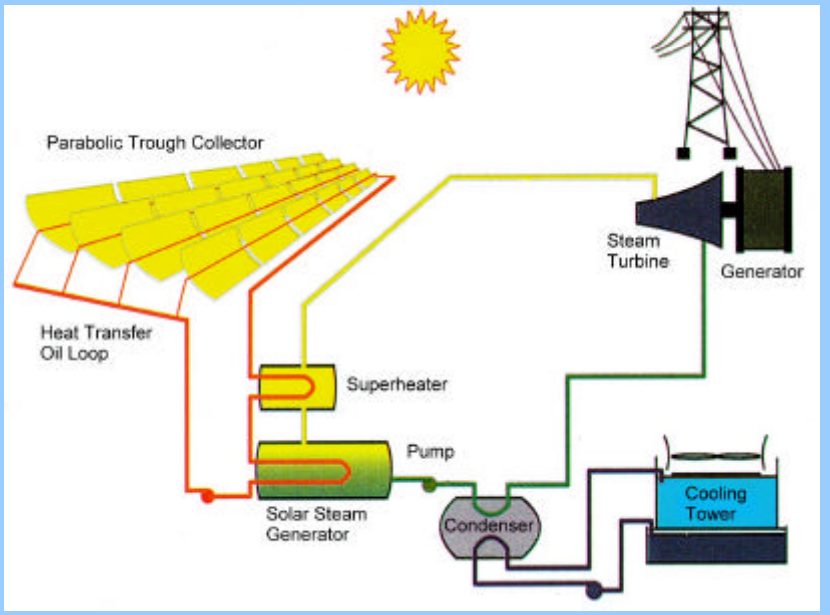
Step 5:

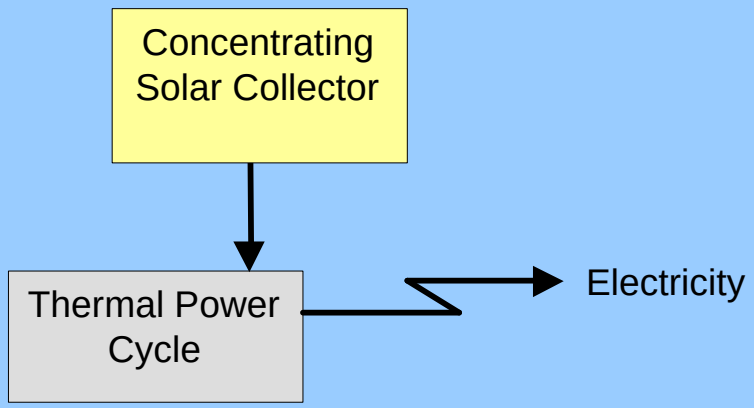
The Superheated Steam Activates the Turbine and the Electricity Generator of a Steam Cycle Power Plant



# From Sunlight to Electricity

Option 1:

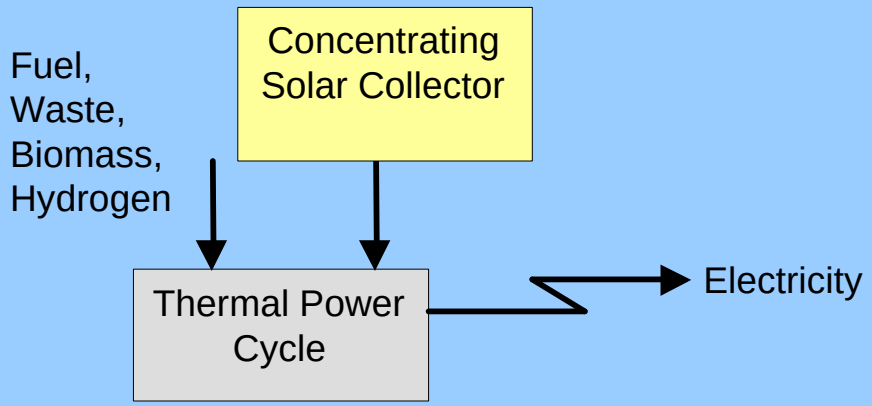
Solar (only) Electricity Generating System




# From Sunlight to Electricity

Option 2:

Hybrid (solar & fuel) Electricity Generating System

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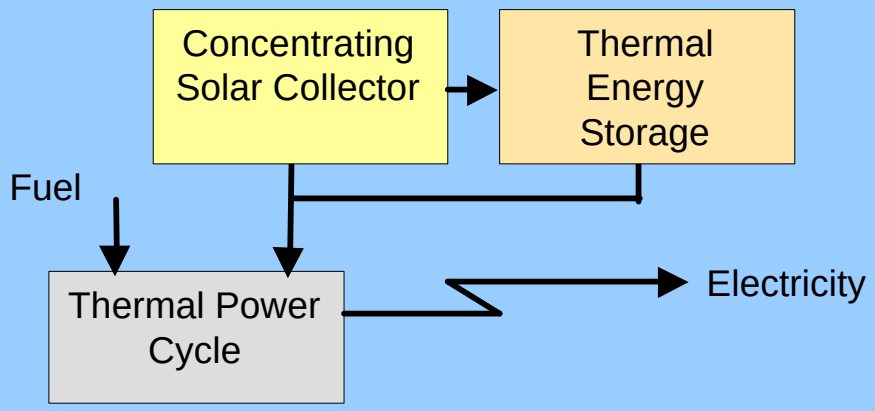
Option 3:

Solar/Hybrid Electricity Generating System
with Thermal Energy Storage

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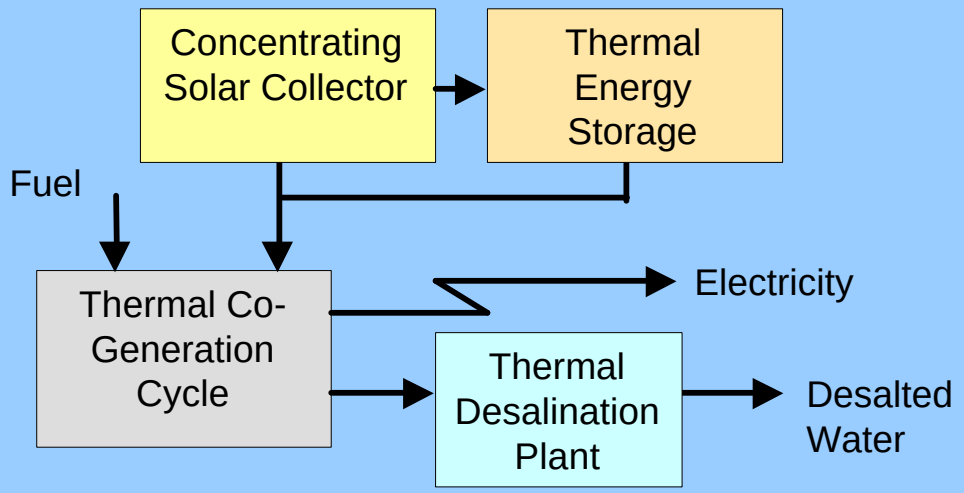
Option 4:

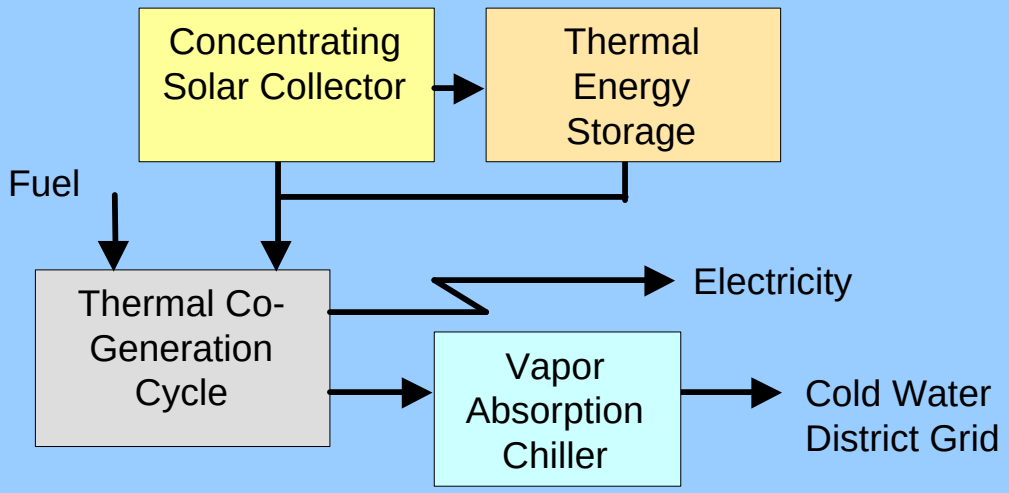
Solar/Hybrid Co-Generation of Electricity and Heat for Seawater Desalination

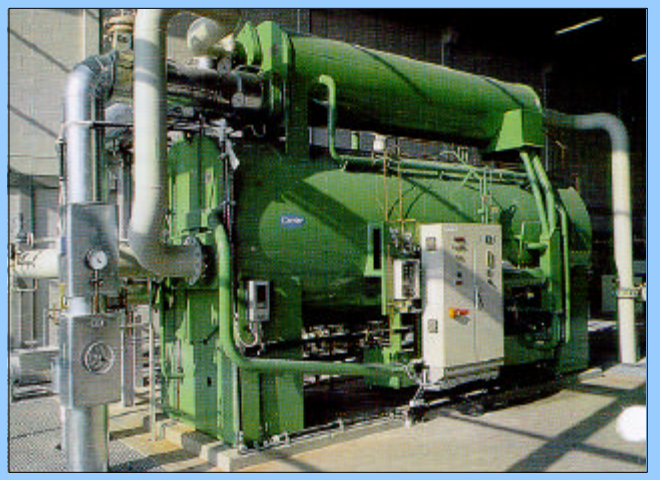



# From Sunlight to Electricity

Option 5:

Solar/Hybrid Co-Generation of Electricity and Heat for District Cooling



# From Sunlight to Electricity

Operating Experience:

Parabolic Trough Plants in Kramer Junction, Dagget and Harper Lake, California

354 $MW_e$ Installed Capacity

Commercial Operation since 1986

More than 1 Billion US$ Turnover

Steam at 390 °C, 100 bar

# From Sunlight to Electricity

Recent Highlights:

Direct Steam Parabolic Trough Demonstration
at Plataforma Solar de Almeria, Spain

Demonstration of Direct Superheated Steam Generation in Parabolic Trough Collectors

Steam at 400 °C, 100 bar
(550 °C, 120 bar projected)

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Recent Highlights:

Demonstration of Pressurized Air Receiver for Gas Turbine Operation at Plataforma Solar de Almeria, Spain

Demonstration of Pressurized Volumetric Air Receiver for Gas Turbines and Combined Cycles

Air at 850 °C, 15 bar
(1200 °C, 20 bar projected)

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Recent Highlights:

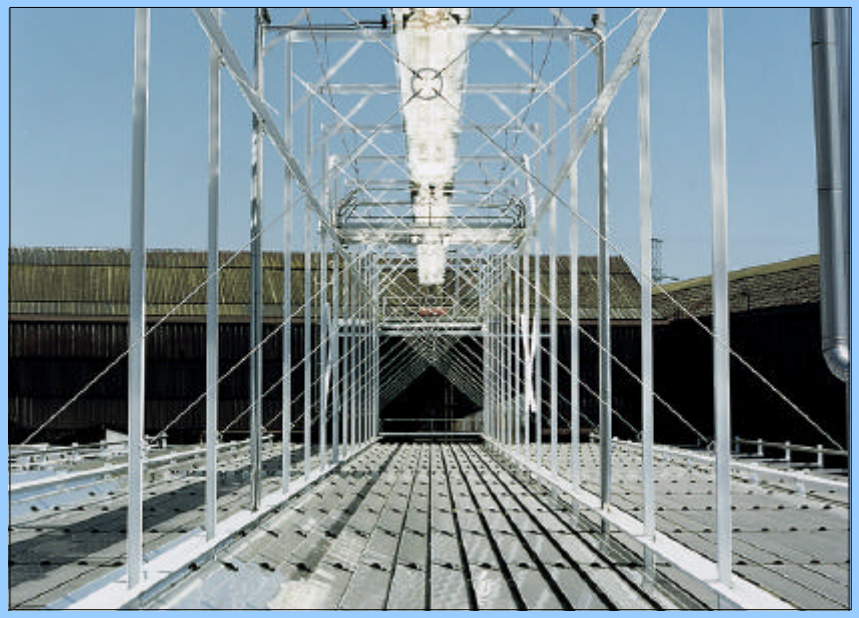
NEVAG‘s Foldable Parabolic Trough Collector „Synthesis Solar“

Less Wind Load, Automatic Washing and Water Recycling in Closed Position

# From Sunlight to Electricity

Recent Highlights:

Demonstration of Solarmundo‘s Advanced Solar Concentrating System at Liege, Belgium



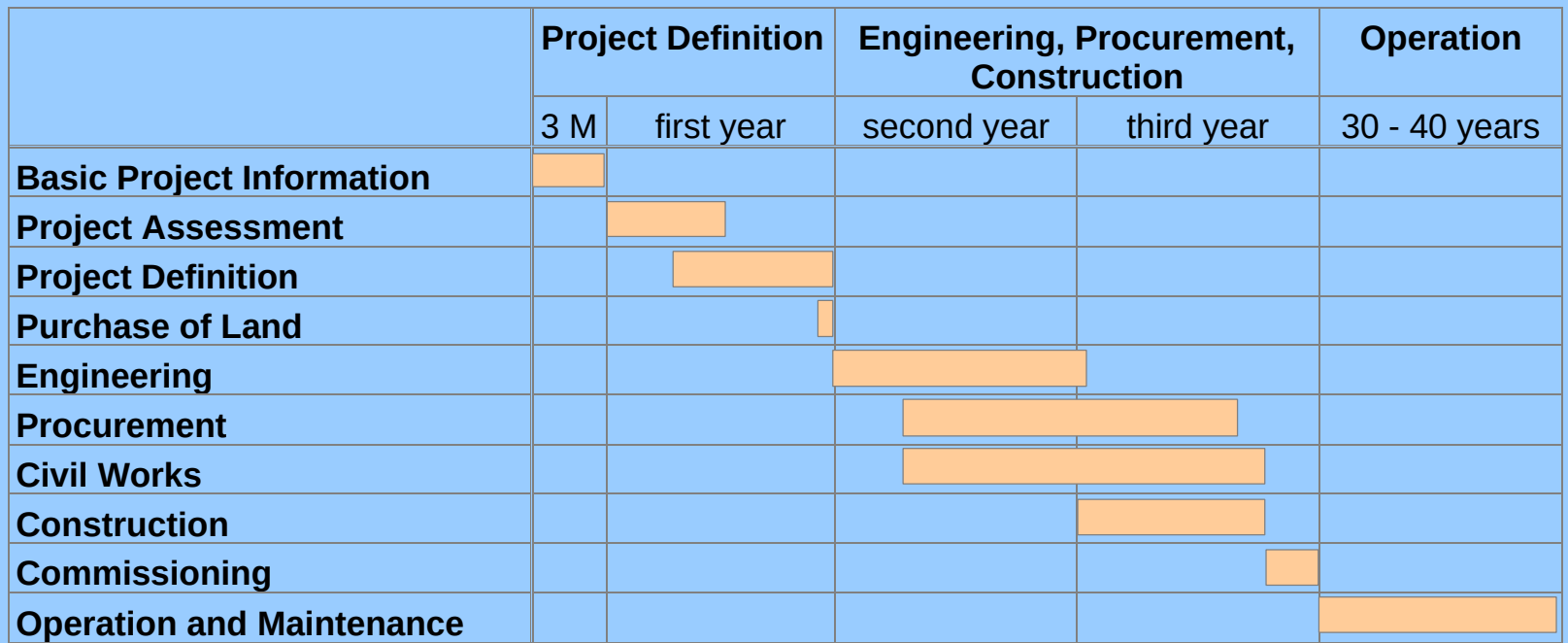
Demonstration of Direct Steam Generation in Fresnel Collector

Steam at 500 °C, 100 bar projected

# From Sunlight to Electricity

Solar Thermal Power Projects:

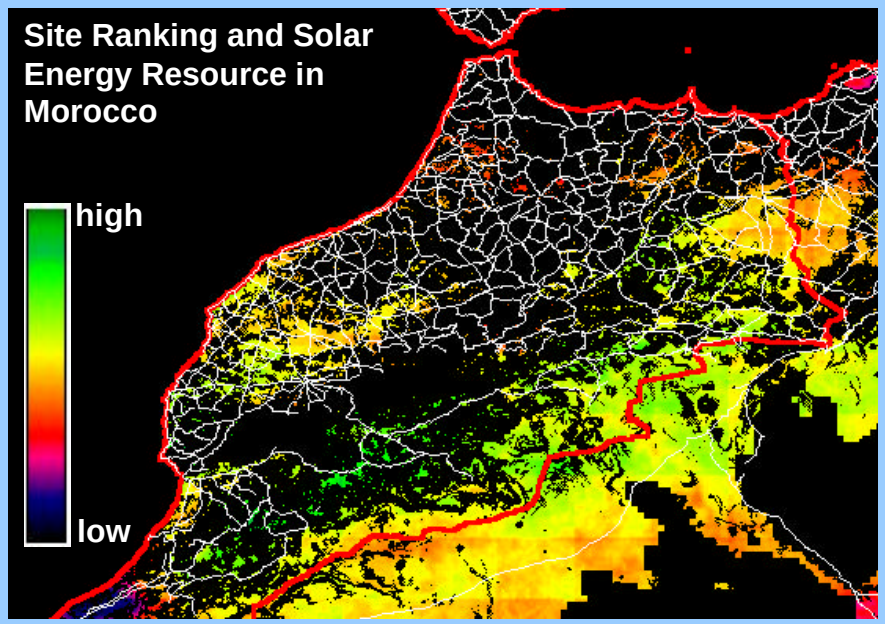
From Basic Information to Commissioning



# From Sunlight to Electricity

Project Assessment Phase

Gathering Basic Data and Comparing Investment Opportunities




- Basic Project Information
- Finance of Project Studies
- Solar Resource Assessment
- Site Ranking
- Comparison of Project Alternatives

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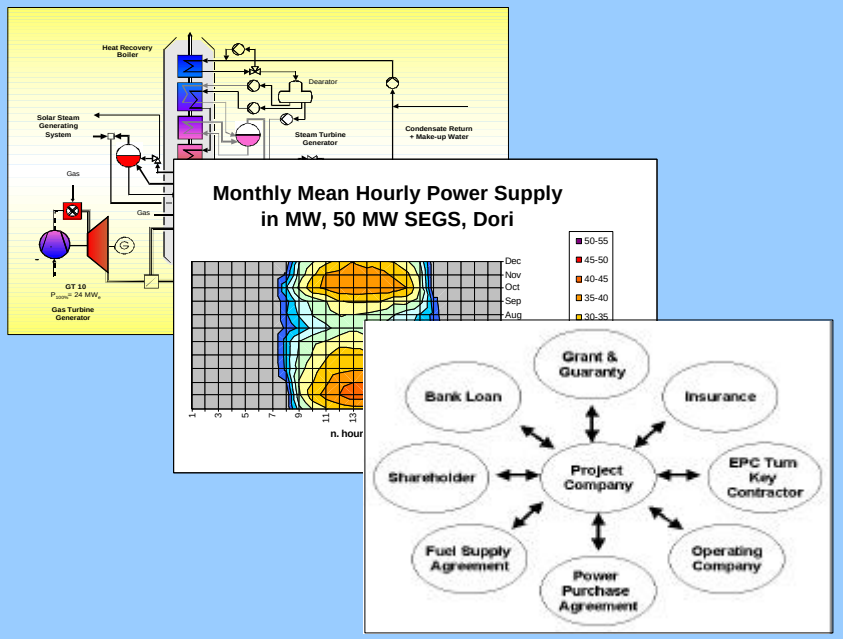
Project Definition Phase

In-Depth Studies and Decisions on Investment, Technology, Site, Project Consortium and Scheme of Finance




Project Company

Licencing Negotiations

Site Selection

Performance Model

EPC Contract

Project Consortium

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Engineering, Procurement & Construction Phase

Finance, Insurance and Realisation
of Power Plant Construction Phase

Construction Loan

Detailed Engineering

Procurement of Equipment

Civil Works & Construction

Commissioning & Grid Synchronisation

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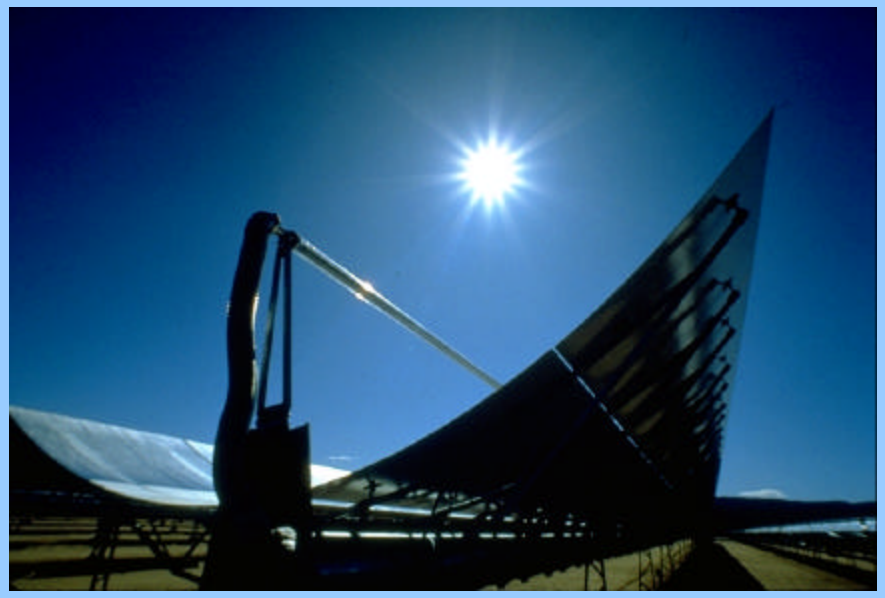
Operation Phase

Electricity, Desalted Water and District Cooling
from a Regional Resource with no Pollution or Cost Escalation



Public Utility

Independent Power Producer

Power Purchase Agreement

Acceptable Rate of Return

Build, Own, Operate, Transfer

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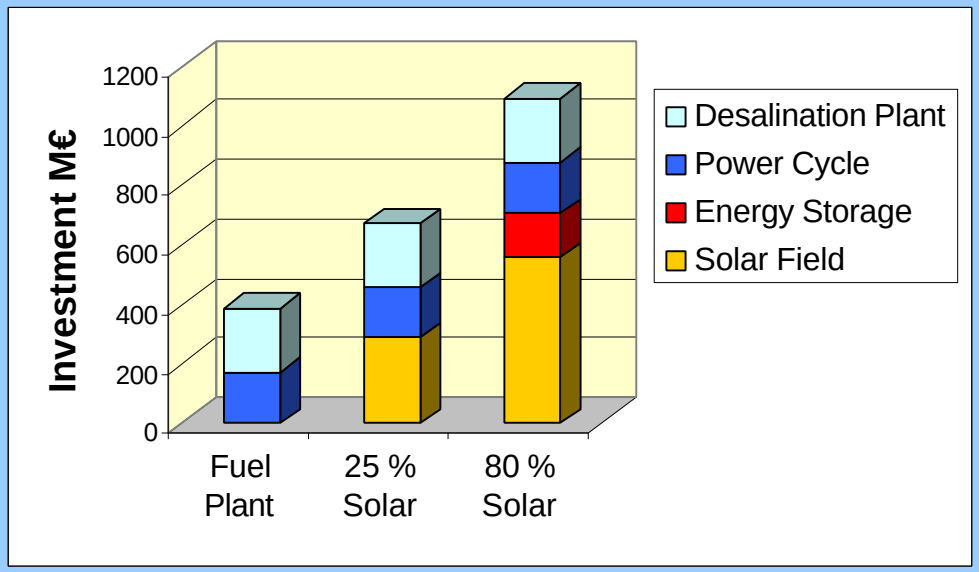
Economics:

Fuel Resources are replaced by Capital Goods.
This means higher Investment.

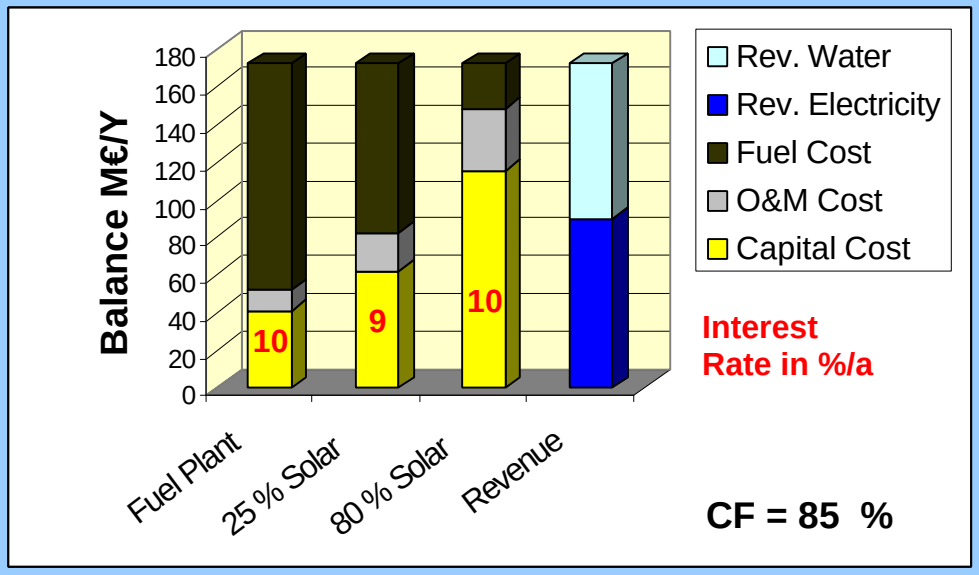



Investment Structure of Power Plants with 200 MW Capacity and 190,000 m³/d Seawater Desalination

# From Sunlight to Electricity

Economics:

Fuel Resources are replaced by Capital Goods.
This means higher Investment and Capital Cost,
but lower Fuel Cost and Cost Escalation




Annual Balance of
Power Plants with 200 MW
Capacity and 190,000 m³/d
Seawater Desalination

<u>Cost</u>:

| | |
|---|---|
| Electricity | 0.055 €/kWh |
| Water | 1.50 €/m³ |
| Fuel Oil | 0.80 €/gal |