

Solar Thermal Power Generation

System

J.K. Nayak

Dept. of Energy Science and Engineering

IIT Bombay



System

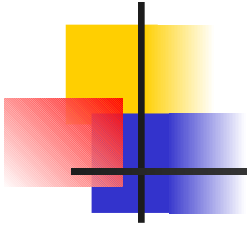
- **Introduction**
- **Types and Components of System**
- **Challenges and Issues**
- **Summary**



Power Generation: key application

**Concentrating Solar radiation for
generating Power (CSP)**

**Attractive method: Utilisation of
solar energy**

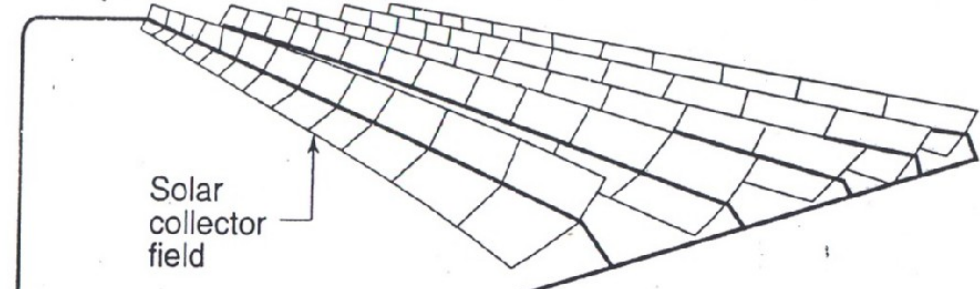


Cylindrical Parabolic Concentrator (Trough Concentrator)

Paraboloid Dish

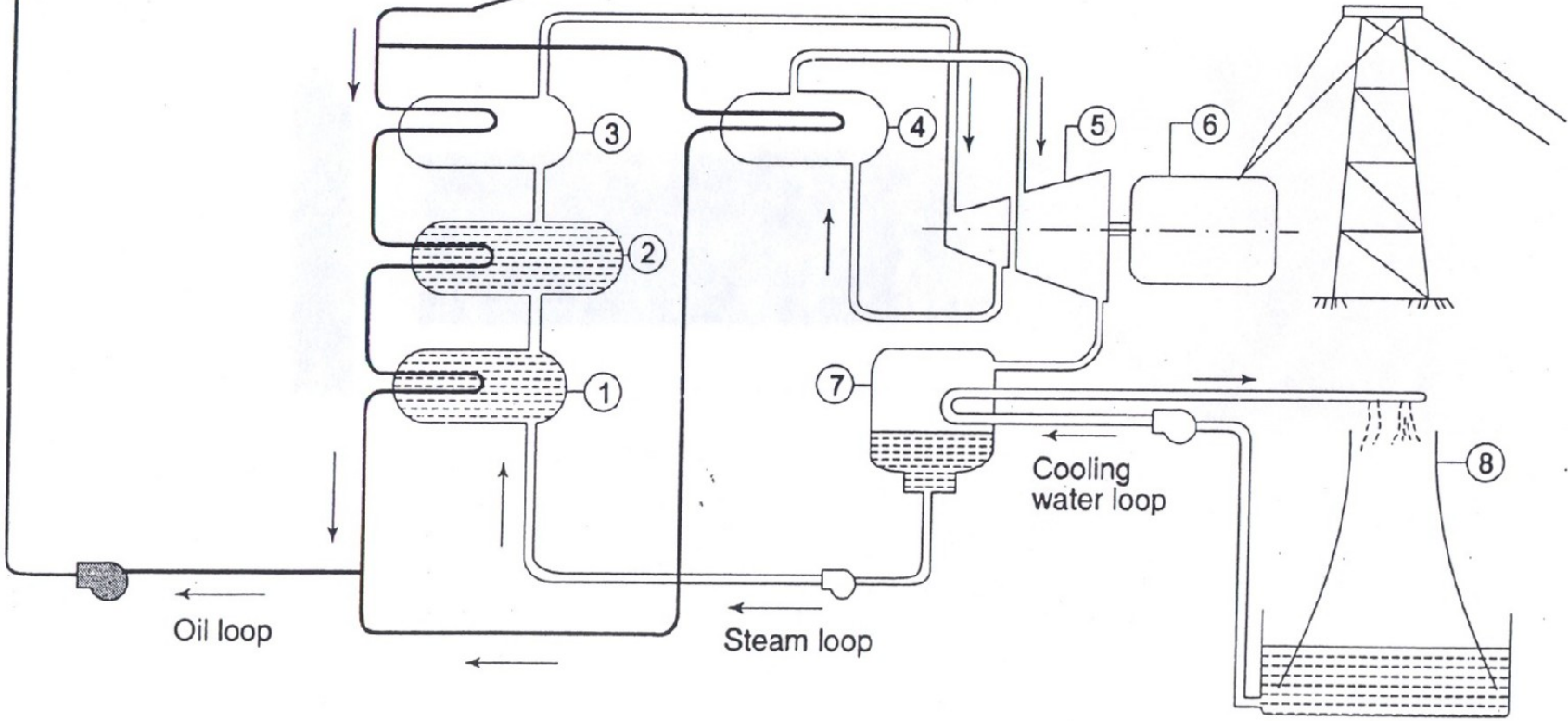
Central Tower

Trough



Solar collector field

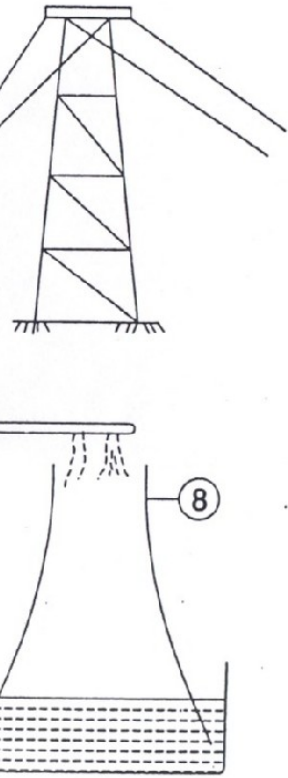
- 1 Preheater
- 2 Steam generator
- 3 Super heater
- 4 Reheater
- 5 Turbine
- 6 Generator
- 7 Condenser
- 8 Cooling tower



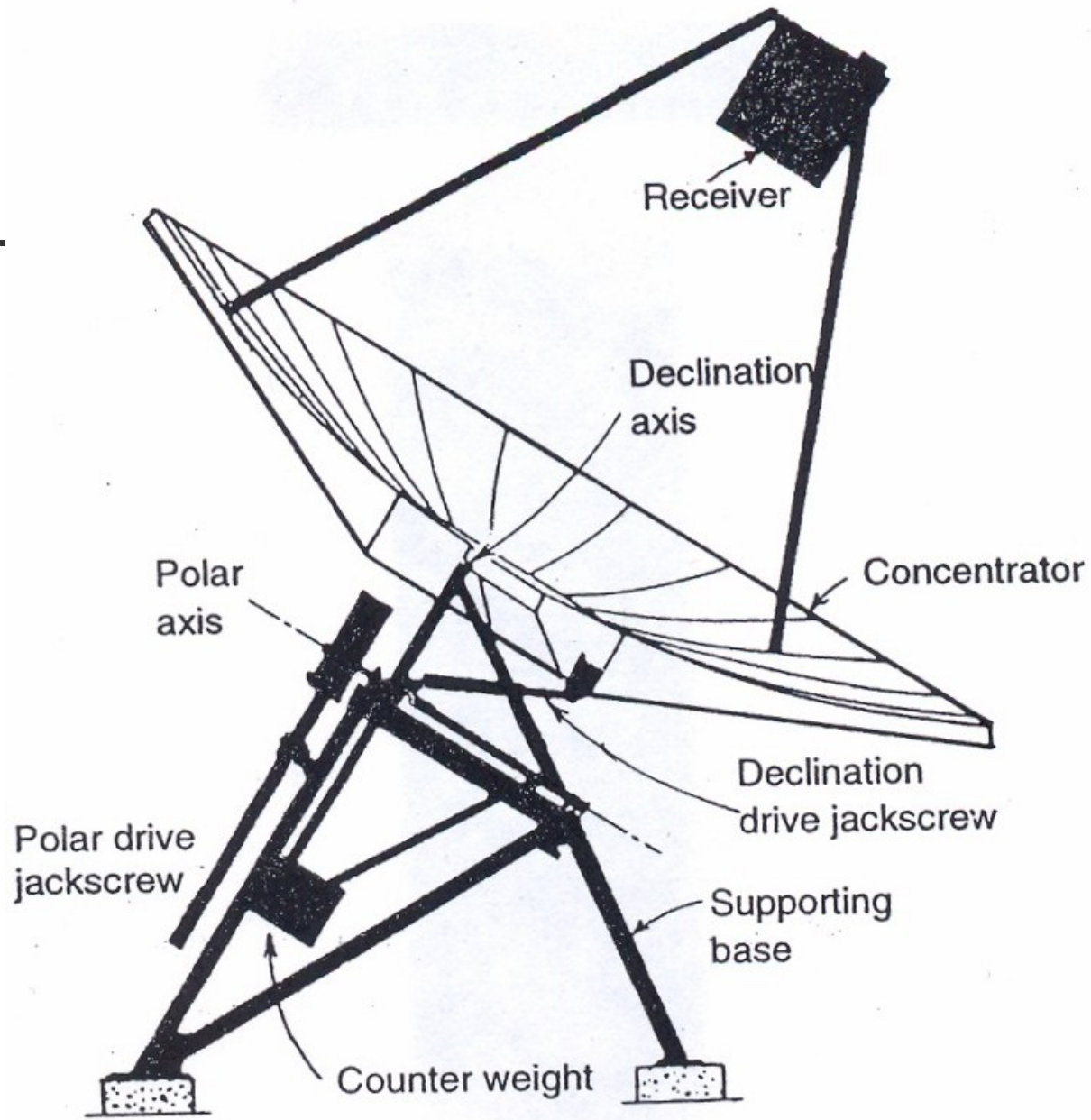
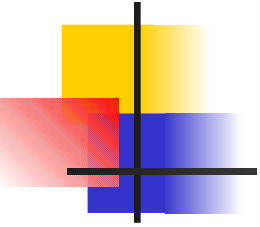
Oil loop

Steam loop

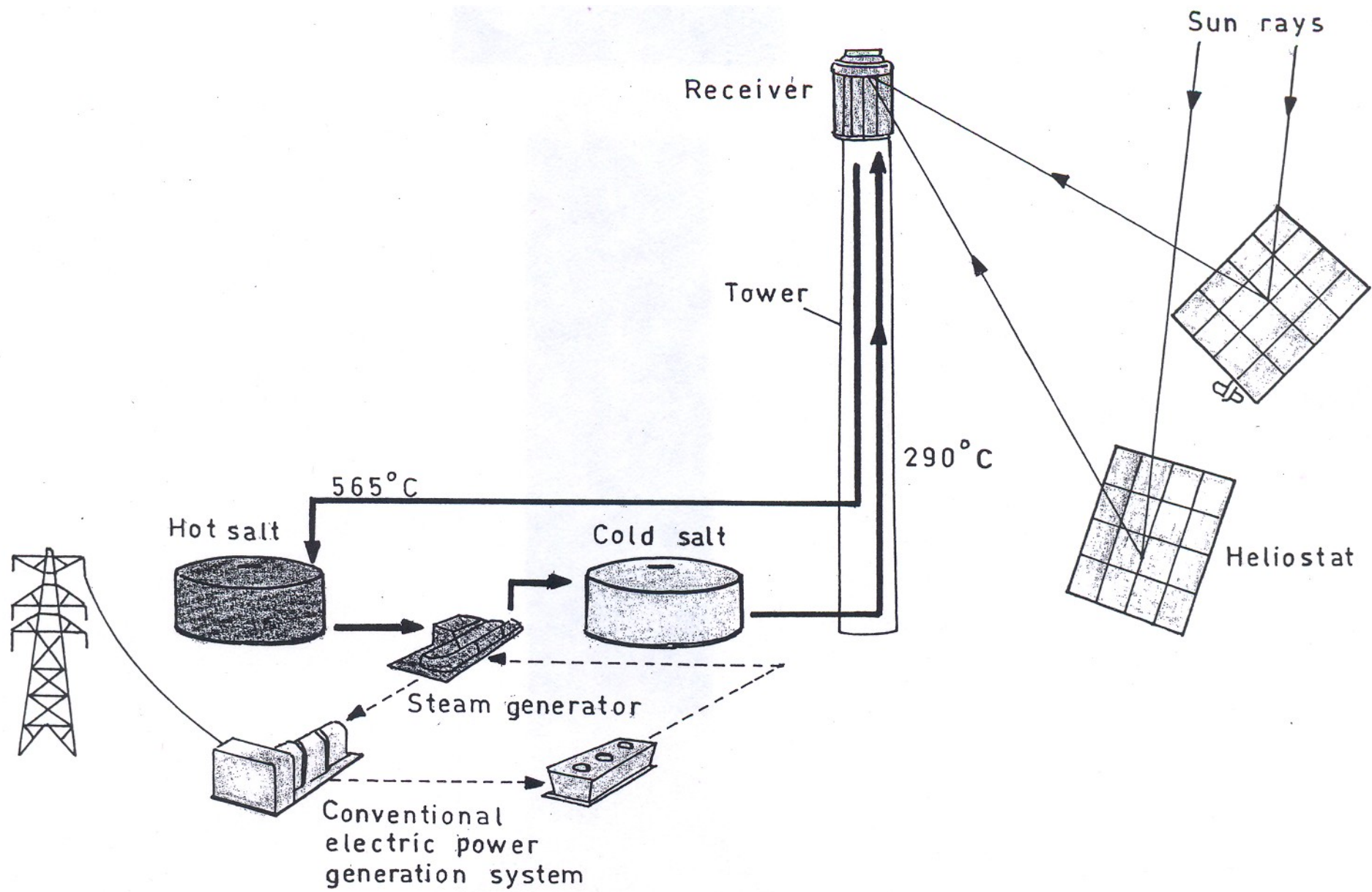
Cooling water loop



Dish



Central Tower





Cylindrical Parabolic Concentrator (Trough Concentrator)

- **Medium Temperature**

Paraboloid Dish

- **High Temperature**

Central Tower

- **High Temperature**

Components



1. Parabolic Trough Concentrators

- single-axis-tracking
- axis: north-south horizontal

Reflector, Frame, Receiver

Thin/ Thick glass, Front/Back surface mirror

Components



2. Heat transfer fluid/Steam generation unit

- Synthetic oil (Therminol, Dowtherm)
- Mineral oil
- Pressurised water
- Water/steam
- Silicon oil
- Nitrate salt

Components



3. Power cycle unit

4. Thermal Storage

- **optional**
- **Fossil-fired back up**



Operating Plants

- **California : 354 MWe**
- **Arizona : 1 MWe**
- **Nevada : 64 MWe**

No.	Net output (MWe)	Solar Field outlet Temperature (°C)	Dispatchability due to
I	13.8	307	3 h thermal storage
II	30	316	Gas-fired boiler
III/ IV	30	349	Gas-fired boiler
V	30	349	Gas-fired boiler
VI	30	390	Gas-fired boiler
VII	30	390	Gas-fired boiler
VIII	80	390	Gas-fired HTF heater
IX	80	390	Gas-fired HTF heater



Arizona plant: Commissioned 2006

- **Area of Trough collectors : 10 346 m²**
- **Collector fluid : Thermic fluid**
300°C
- **Organic Rankine cycle**
n-pentane : working fluid
Vapour : 22.3 bar, 204°C
- **Cycle efficiency : 20.7 per cent**
- **Annual generation : 2000 MWh**

Nevada plant: Commissioned 2007



Area of Trough collectors : 300 acres

Collector fluid : Thermic fluid

Dowtherm(TM)

390°C

Generates steam to run conventional Rankine cycle

Annual generation : 134 million units



Challenges

- **High marketing and engineering effort**
- **Decision-making process**
(be it private sector or public sector)
- **Reliable energy supply**
- **Demonstration**
- **Operating experience**



Issues

- **Define a road map**
- **Build and run a plant**
(demonstration, operating experience, research-cum-testing facility)
- **Appropriate component design**
- **Heat transfer fluid**
- **Storage: yes/no, type**



Issues

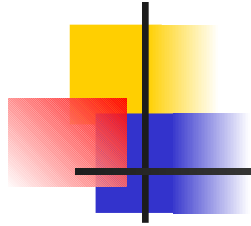
- **Integrated Solar Combined Cycle System (hybrid)**
- **Direct Steam generation (serious safety and maintenance concerns, two-phase flow instabilities)**
- **Organic Rankine Cycle (geothermal power plant technology, up to 10 MWe)**



Summary

**Component design, integration and
performance optimisation:
System approach**

Simulation



Build and run a plant

- . demonstration**
- . operating experience**
- . research-cum-testing facility**



Thank you