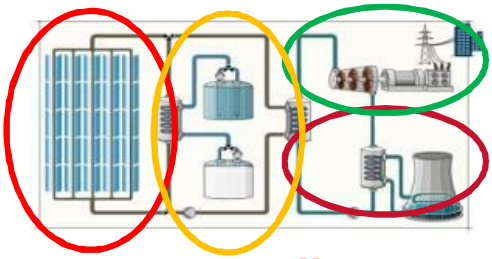
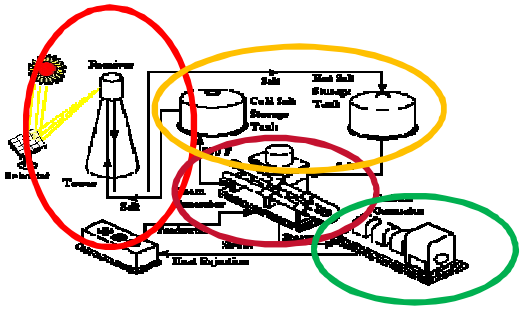
Different CSP Technologies
Automation: Focus on Common areas



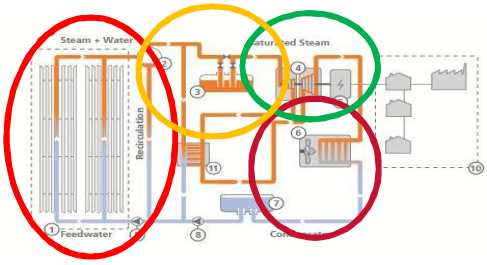


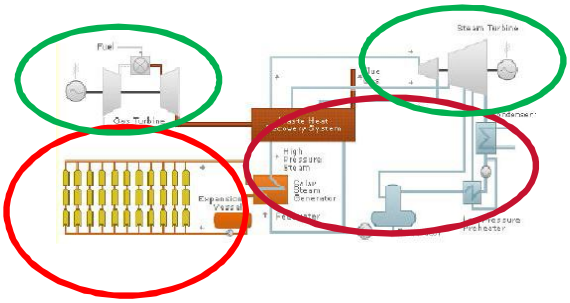
Boiler System – The Solar Field

BOP System – Power Plant Core

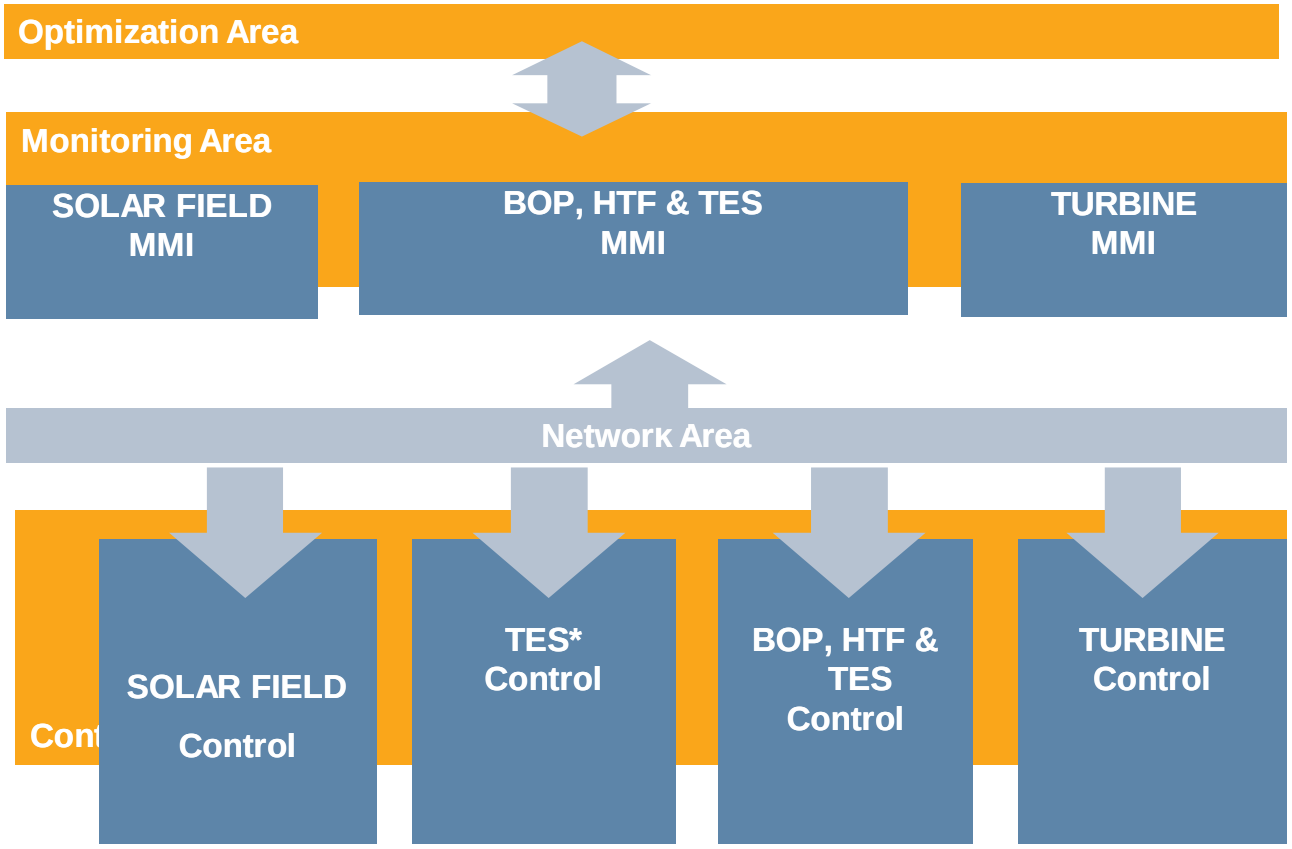
Turbine Control & Generator

Thermal Storage System -optional-

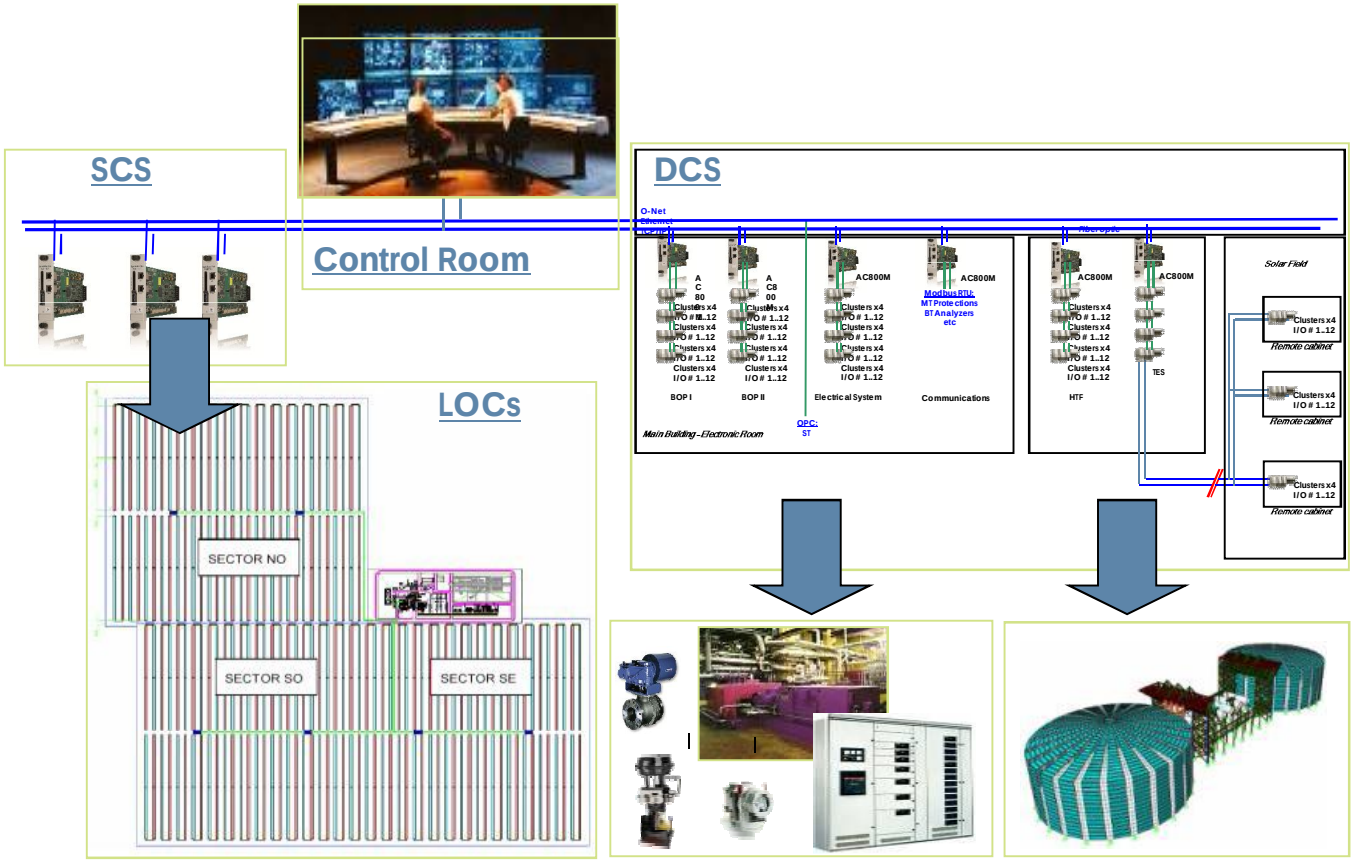




CSP Common Automation Areas



Automation Concept
Concentrated Solar Thermal Power Plant



Direct Control – Controlled Systems

- Heat Transfer Fluid Control

▶Balance of Plant Control:

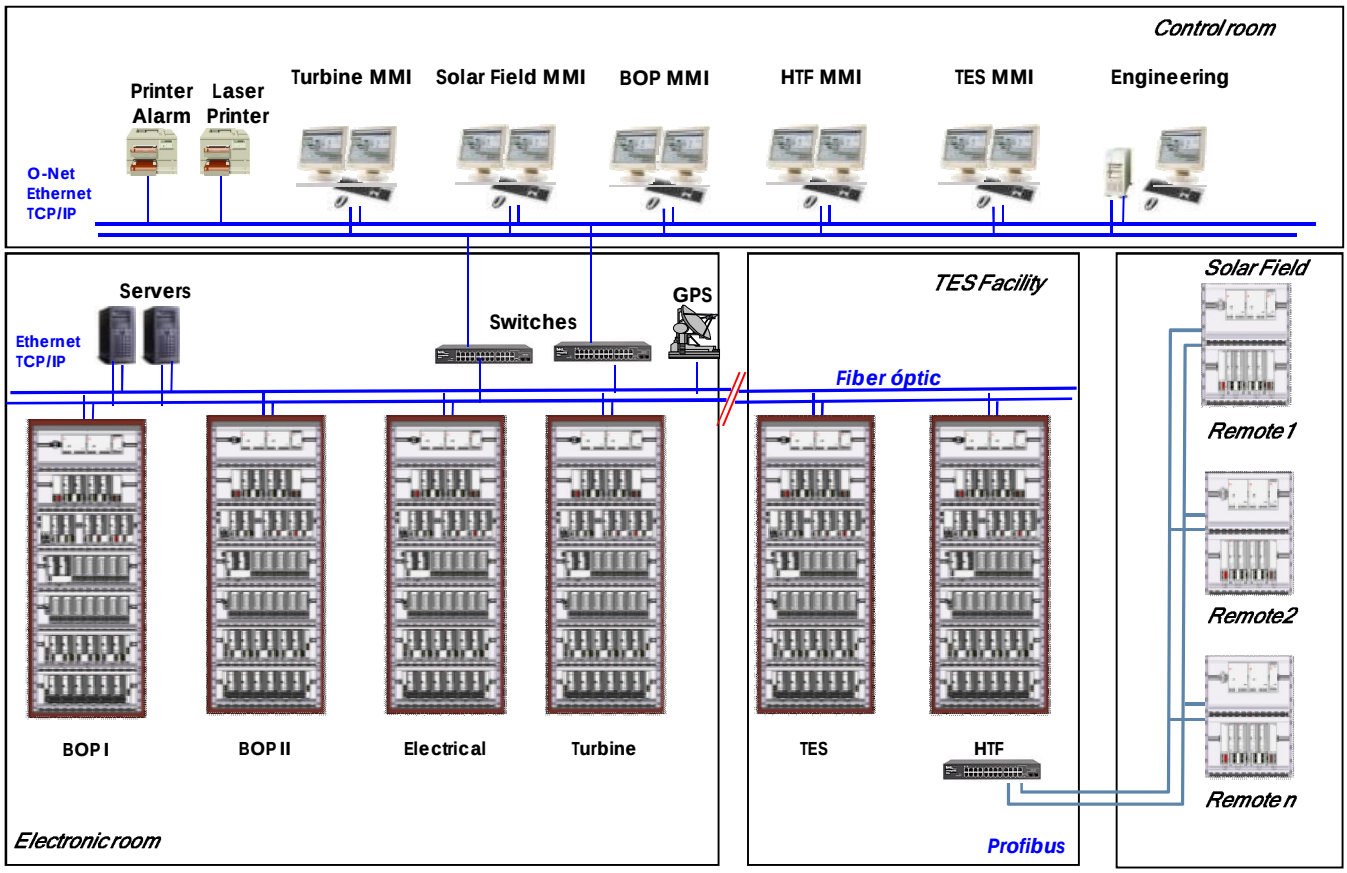
- Feedwater pumps & water auxiliaries
- Cooling systems
- Water & steam cycle control
- Condensate systems
- Electrical systems
- Auxiliary systems

▶Thermal Energy Storage -TES

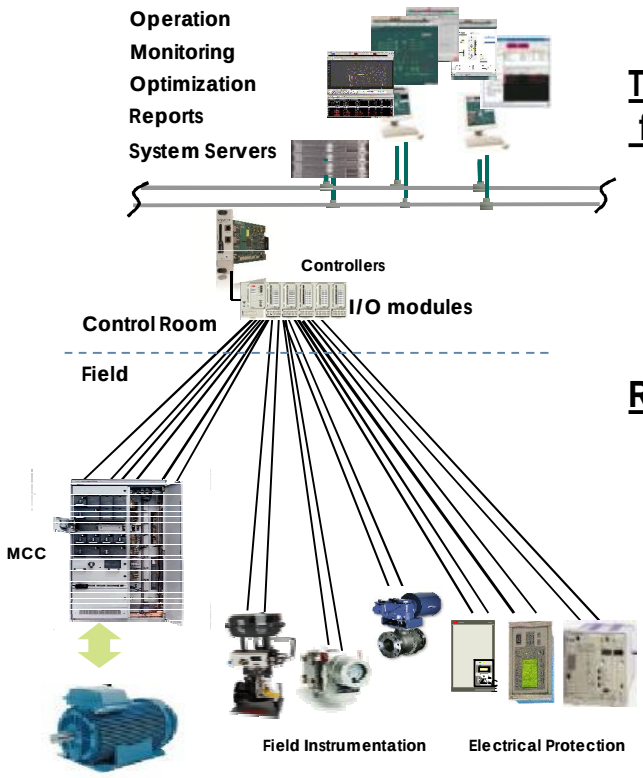
Indirect Control- Monitored systems

- Turbine control
- Water treatment systems
- Instrumentation compresed air systems
- Black start / Diesel Genset
- Auxiliary HTF boiler
- Electrical protection systems

DCS Network Architecture



DCS Field Intrumentation Interface
Hard Wired approach



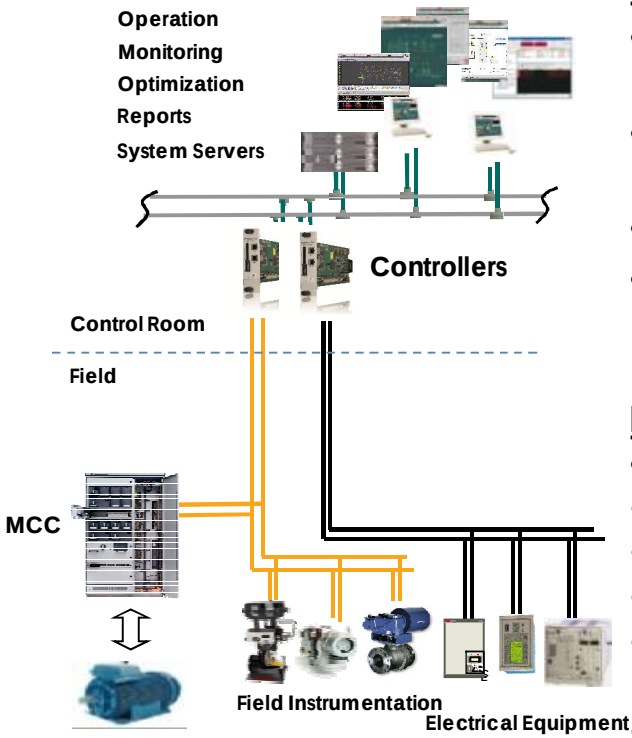
The interface between Instrumentation field and DCS is based upon:

- Traditional I/O cards
- Multicables
- Marshalling cabinets
- Distribution Panels

Relevant Points:

- High Reliability
- High Costs in DCS HW
- High Cost in Erection
- Medium Cost in Design Engineering
- High Cost in Documentation Engg.
- High Cost in Commissioning

DCS Field Intrumentation Interface
Full FieldBus approach



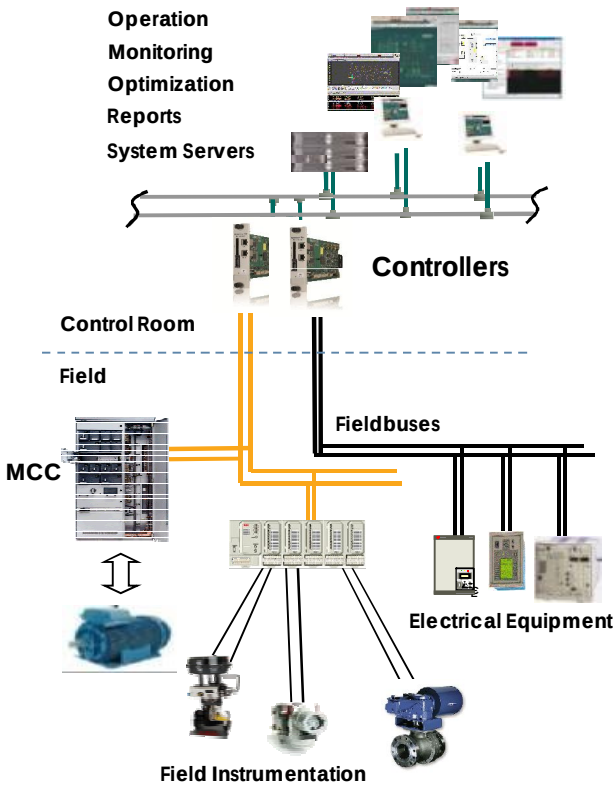
Interface between Instrumentation Field & DCS is based in fieldbus:

- Profibus / FieldBus Foundation cabling
- Full remote Instrumentation configuration
- Diagnostics
- Easy maintenance and Asset Management

Relevant Points:

- Medium Reliability
- Low Costs in DCS HW
- Low Cost in Erection
- High Cost in Design Engineering
- Low Cost in Documentation Engineering
- Low Cost in Commissioning

DCS Field Intrumentation Interface
Mixed Approach



Mixed Approach allows:

- Cabling Optimization
- Possibility of remote configuration
- Flexible Intrumentation Procurement

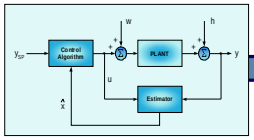
Relevant Points:

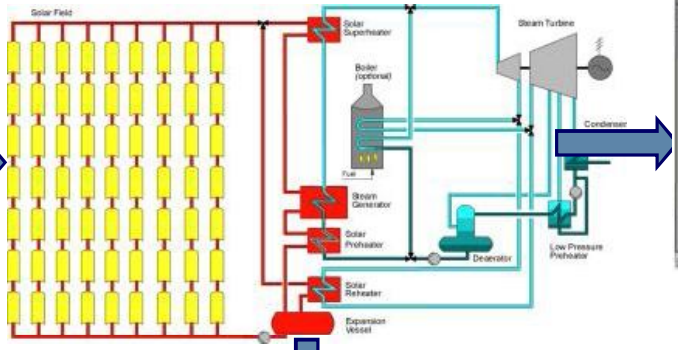
- High Reliability
- Medium Costs in DCS HW
- Medium Cost in Erection
- Medium Cost in Design Engineering
- Medium Cost in Documentation Engineering
- Medium Cost in Commissioning

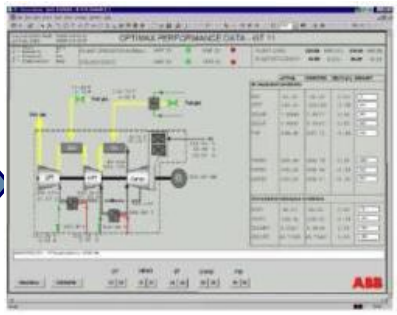
DCS Optimization Area
Real-Time Optimization

Solar Field Optimization
Advanced Temperature Control

Advanced
Process Control
(APC)





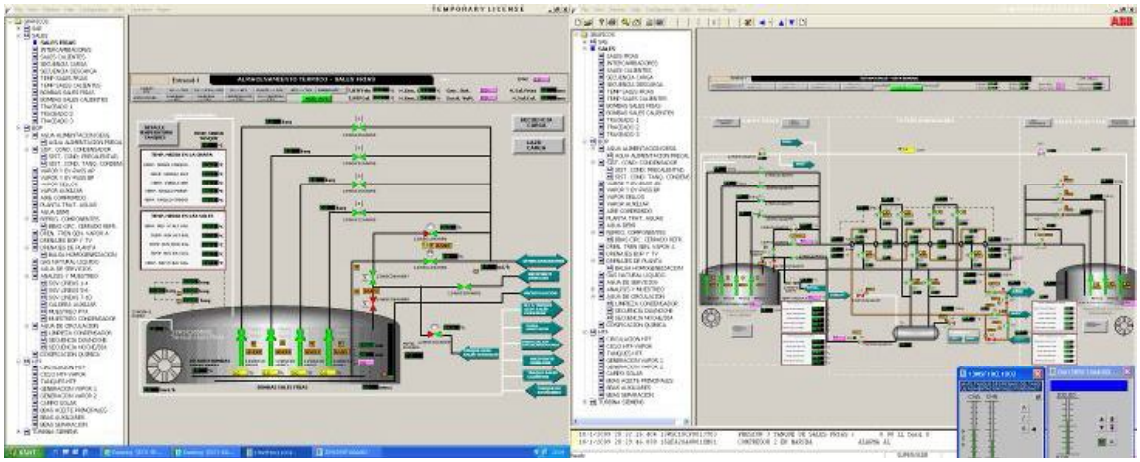


Asset Optimizacion
Stress Calculations
Life Remaining
What-If analysis

Improved Heat Rate
Faster Ramp Rates

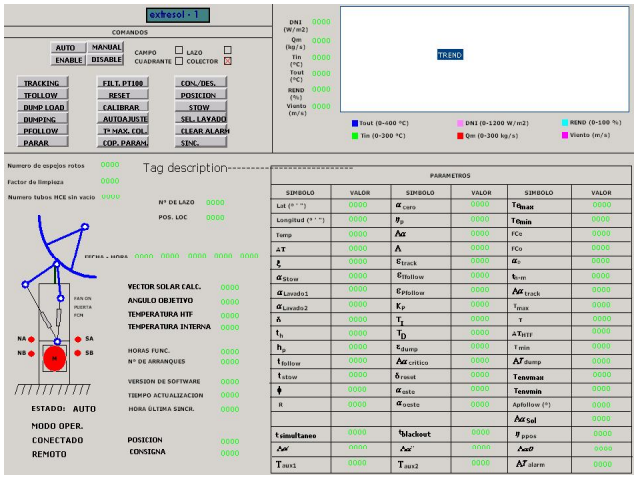
Concentrated Solar Power Plant (CSP)
Operator Workplace

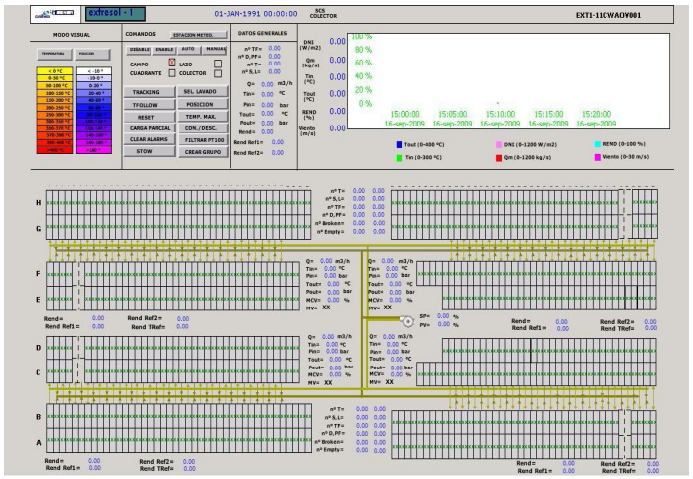
- Human Machine Interface
- Based on state of the art solutions
- Integration of engineering functions
- Integration of Process optimization tools



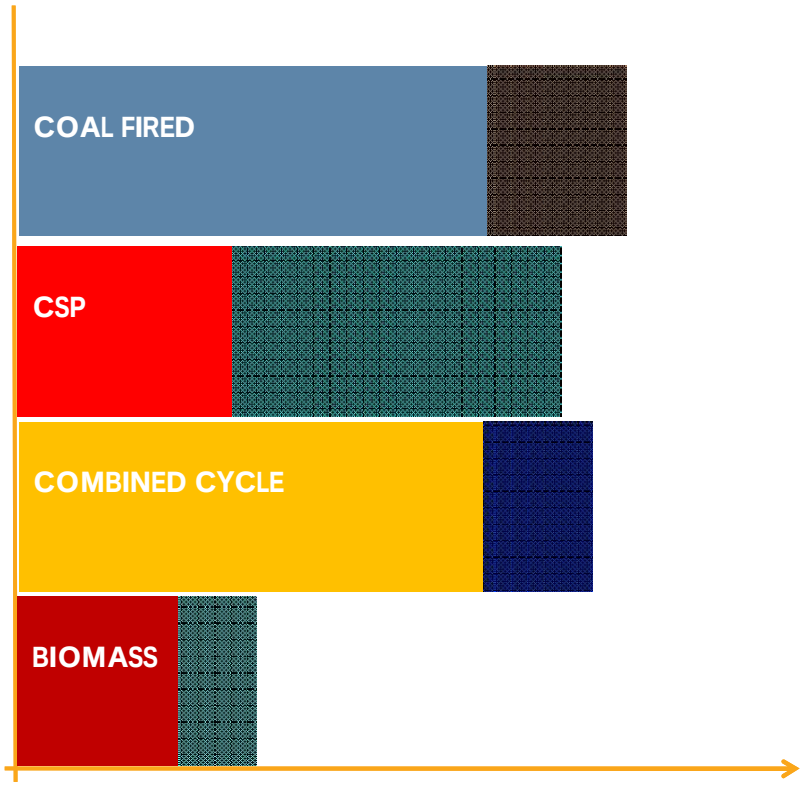
Concentrated Solar Power Plant
Operator Workplace

Operation displays for Solar Field

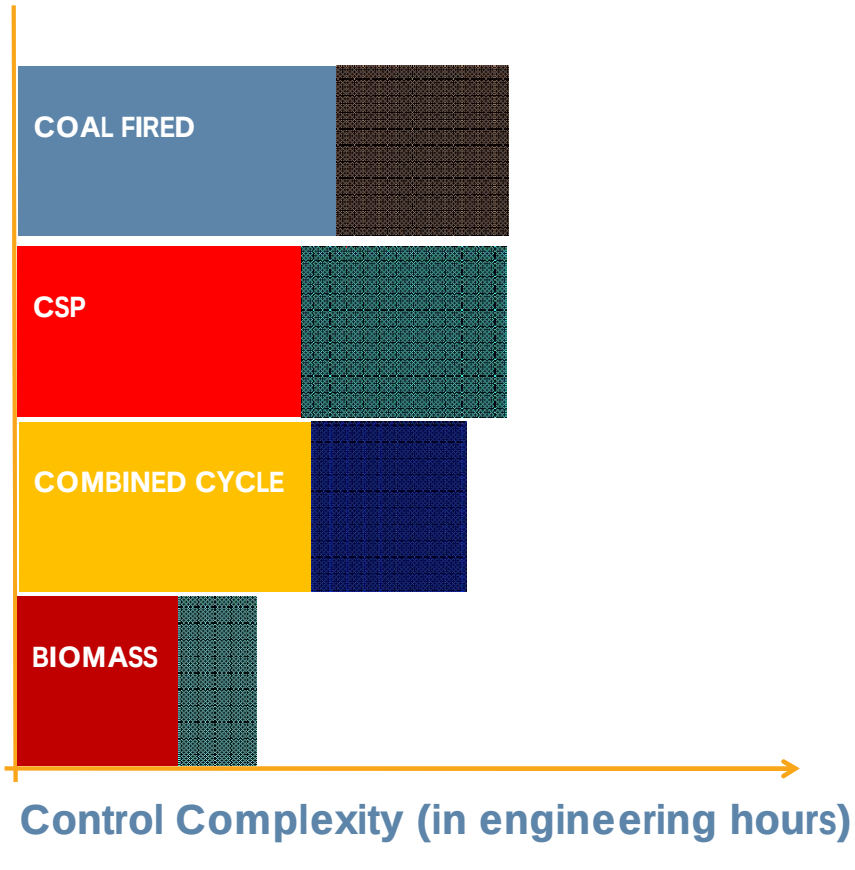




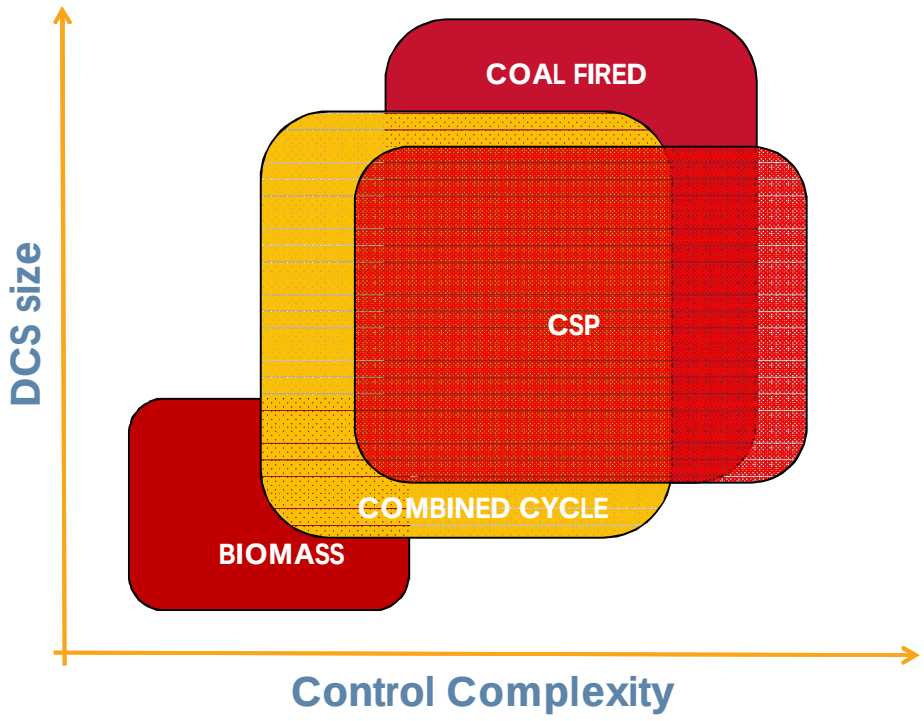
CSP Automation Control System
Plant Sizing



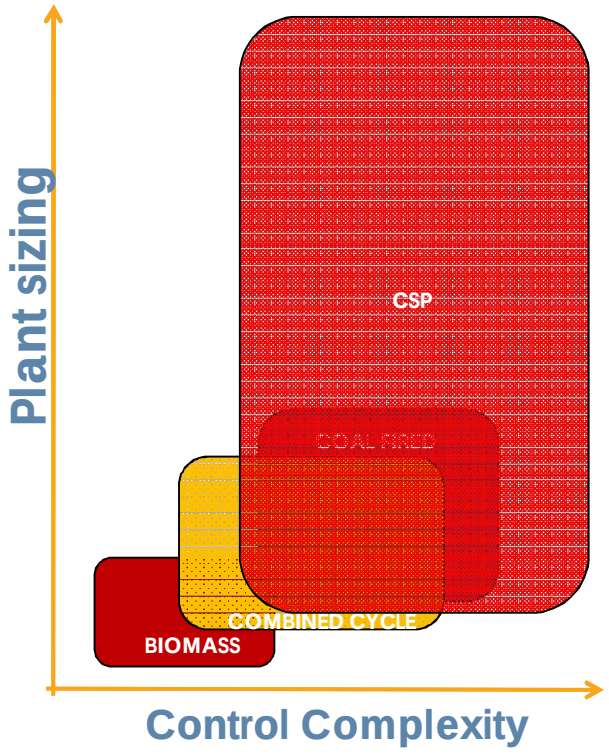
CSP Automation Control System
Control Complexity



CSP Automation Control System
DCS Size vs Control Complexity



CSP Automation Control System
Overall Control Size vs Complexity



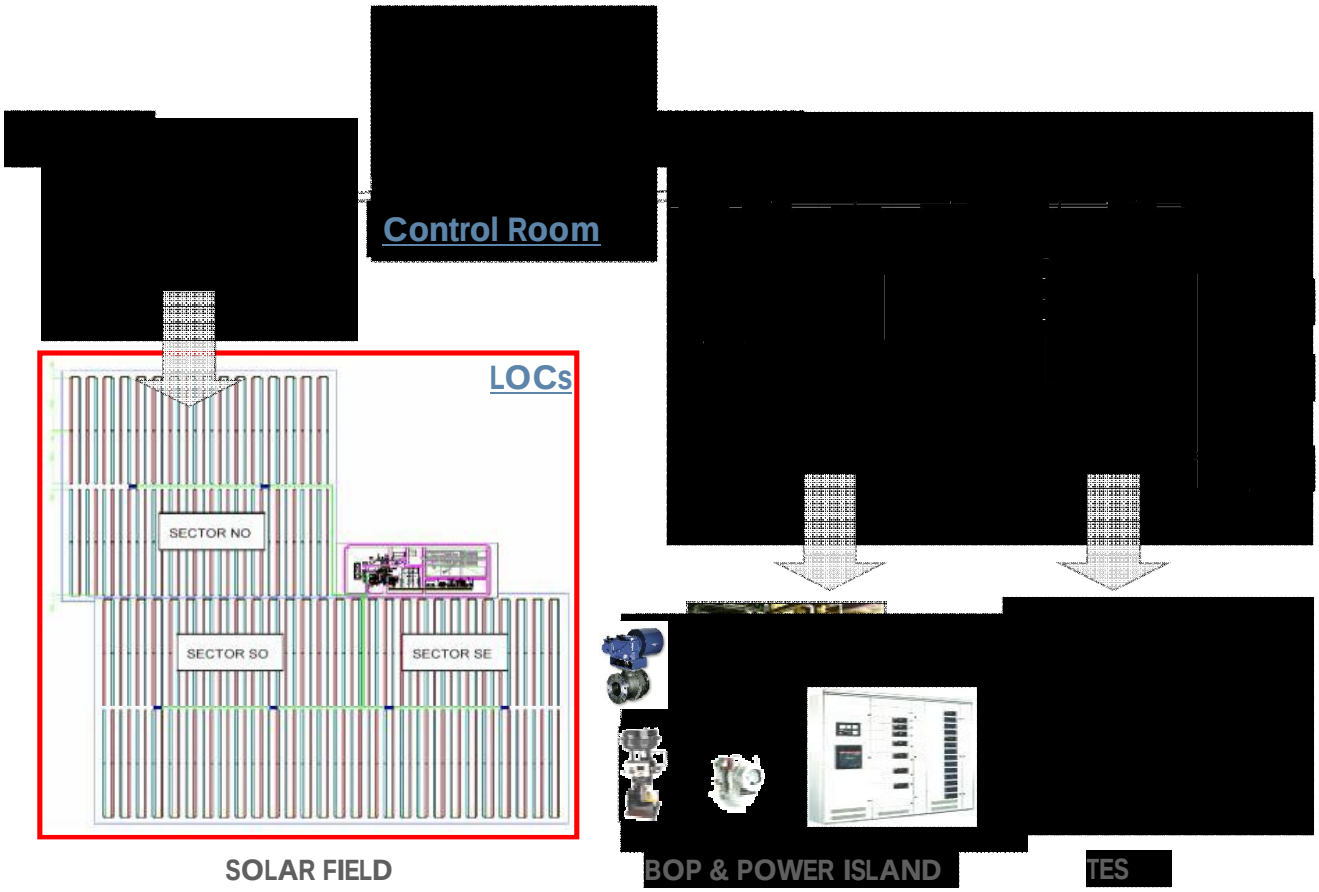
50MW Overall Plant Sizing

25.000 I/O signals – average

200.000 system tags – average

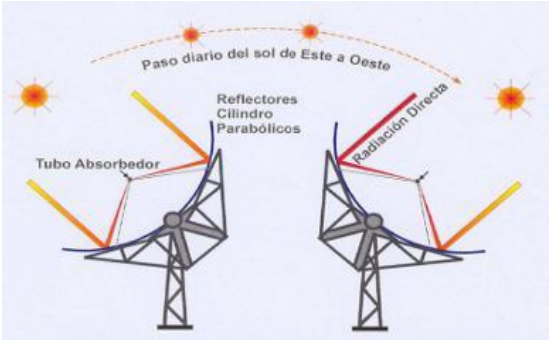
SOLAR FIELD CONTROL SYSTEM - LOC

LOC Automation Concept



Solar Field Control System
LOC Concept

Foto Andasol 1



Application Concept

- Positioning & Control of Solar Mirrors to concentrate sun radiation in a Collector and heat HTF

Design Parameters

- Keep the Functioning Mode on Autonomous mode
- Continuous Sun Tracking basis (maintaining the panels 90 deg to sun)
- Maximize the performance of Solar Field
- Keep operation & installation safe.

Key Factor

- Wide automation systems
- Extreme environmental conditions
- Time -Synchronization requirement
- Easy to reconfigure & maintain
- Proactive monitoring of stings and irradiance levels.
- Improved ROI

Solar Control System
LOC

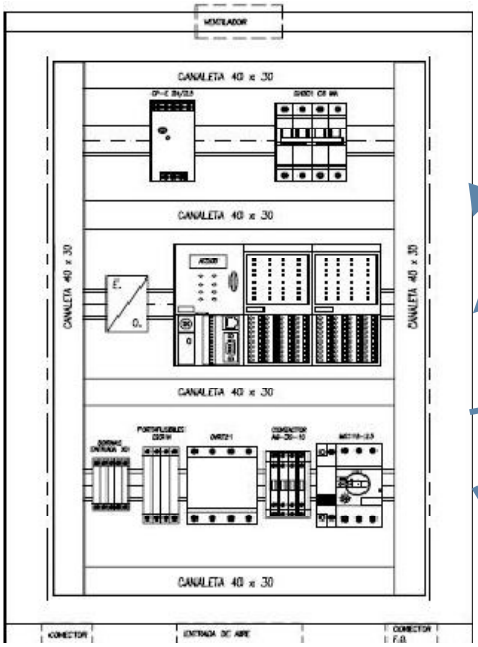
Solar Control System
LOC – Design validation

ENGINEERING DESIGN → PROTOTYPE TEST CERTIFICATION → FIELD IMPLEMENTATION



In order to check the relaibility of the design a laboratory test is performed in order to verify the response to the simulated weather conditions specially the thermal behaviour.

Solar Control System
LOC Control interfaces



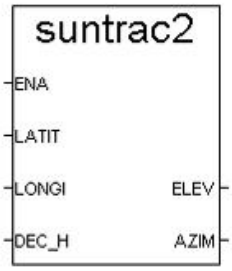
DCS interface :
Through SCS system
Monitoring & Control Collector Position
Monitoring Collector Temperature
Functioning modes execution

Temperature Collector Monitoring:
PT100 HTF acquisition

Positioning system:
Hydraulic Solenoid valves actuator
Inverter Positioning Control (1 & 2 axis)
Hydraulic pressure control

Collector Secure & Stow position:
Limit switches

Solar Control System
Solar Position Algorithm



National Renewable Energy Laboratory

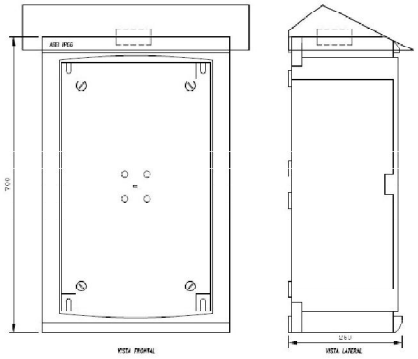
1617 Cole Boulevard
Golden, Colorado 80401-3393

NREL is a U.S. Department of Energy Laboratory
Operated by Midwest Research Institute • Battelle • Bechtel

Contract No. DE-AC36-99-GO10337

- **The SPA by NREL is a procedure to implement an algorithm to calculate**
  - The solar zenith and azimuth angles
  - In the period from the year – 2000 to 6000
  - Resolution of 0.0003 deg for calculation of solar vector

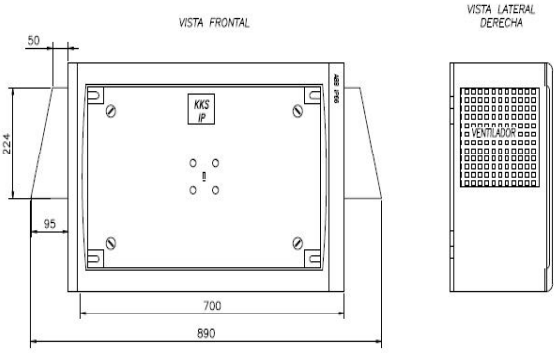
Solar Control System
Closed IP65 LOC



Vertical LOC Cabinet:

- **IP 65**
- **Dusty, High Humidity or harsh environment**
- **Resistant to direct exposure to the sun**
- **High resistance to chemical and environmental elements**

Solar Control System
Air Cooled LOC

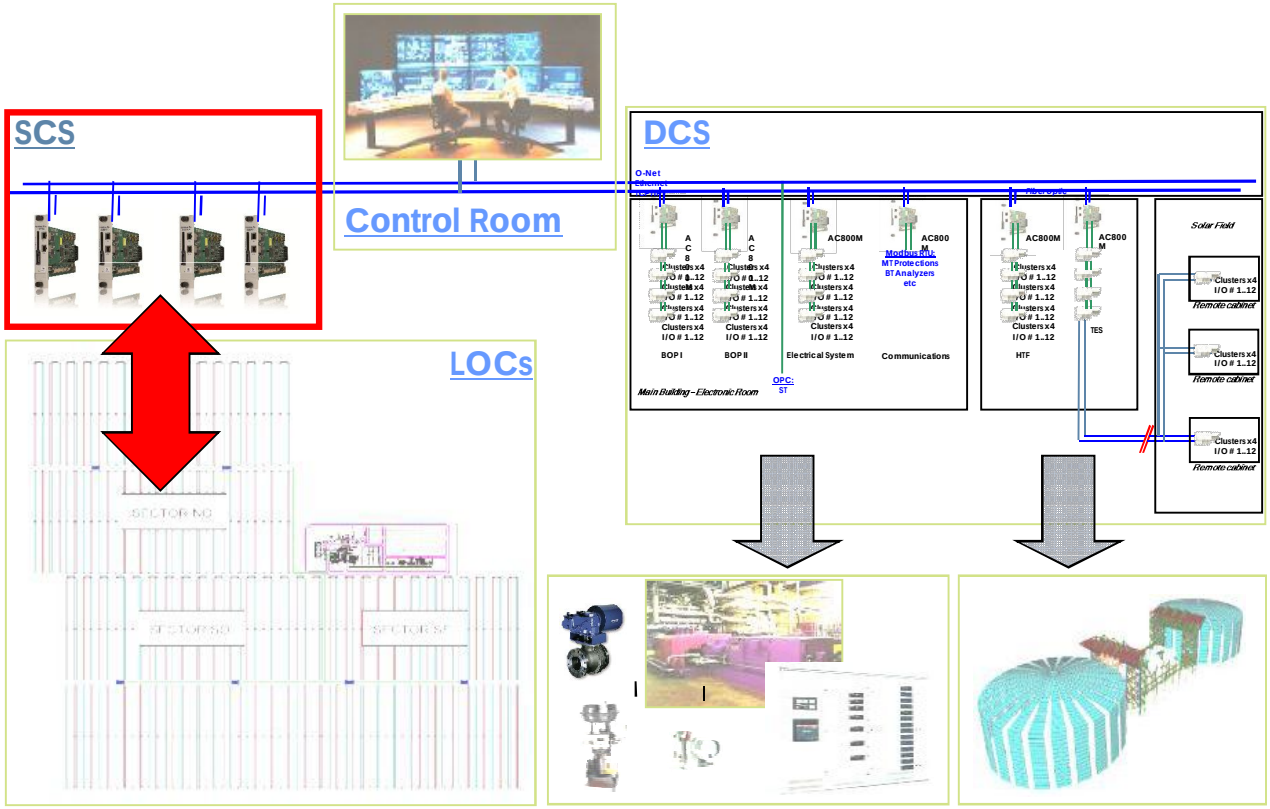


Horizontal LOC Cabinet:

- **Natural & Forced Air cooling**
- **Higher environtment design temperature**
- **Direct sun radiation exposure optimized design**

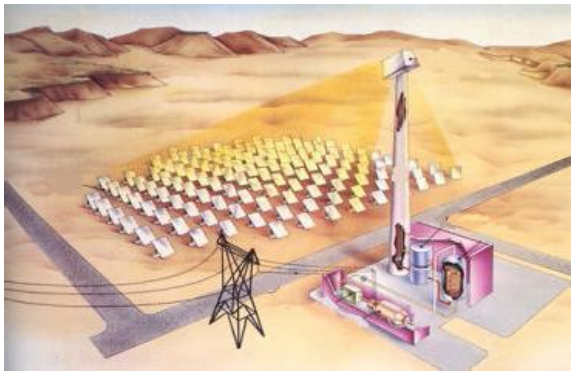
SOLAR FIELD COMMUNICATION - SCS

Automation Concept
SCS



SOLAR FIELD | BOP & POWER ISLAND | TES

Automation Control System
SCS Concept



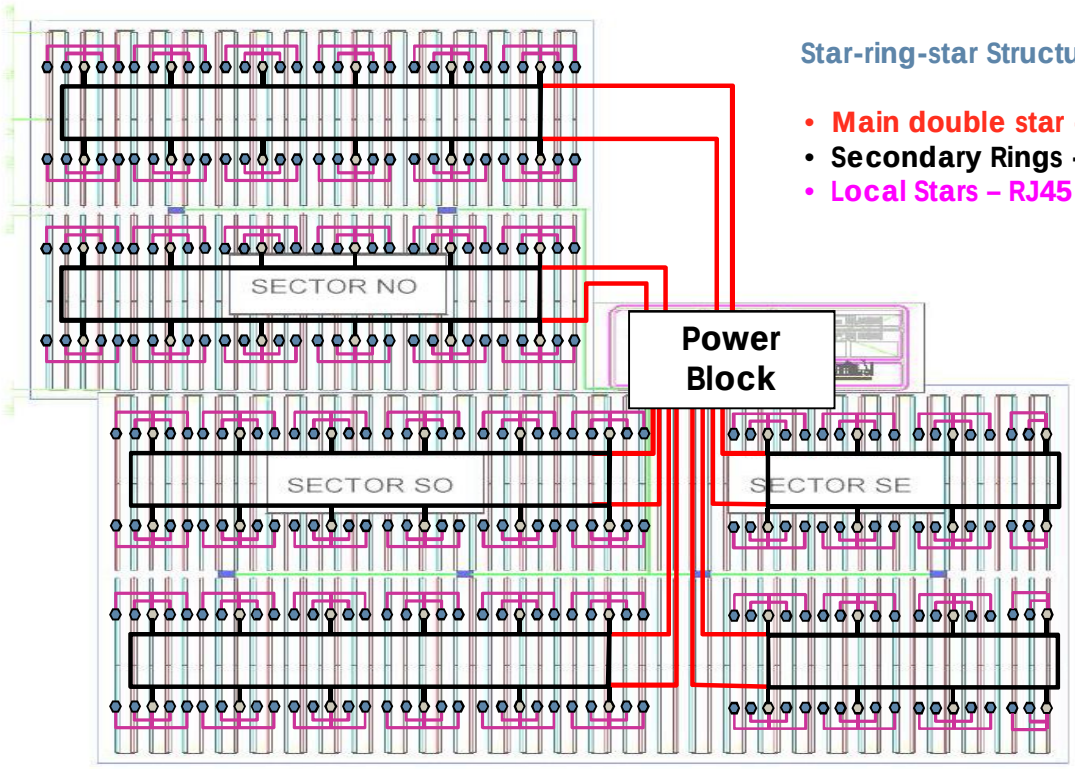
Application Concept

- **Seamless Integration of Massive data from Solar Field – LOC into DCS**

Key Factor

- **Industrial Automation solution**
- **Low refreshing time for complete Solar Field**
- **High Availability, Redundancy**
- **Optimization of Solar Field Cabling layout**

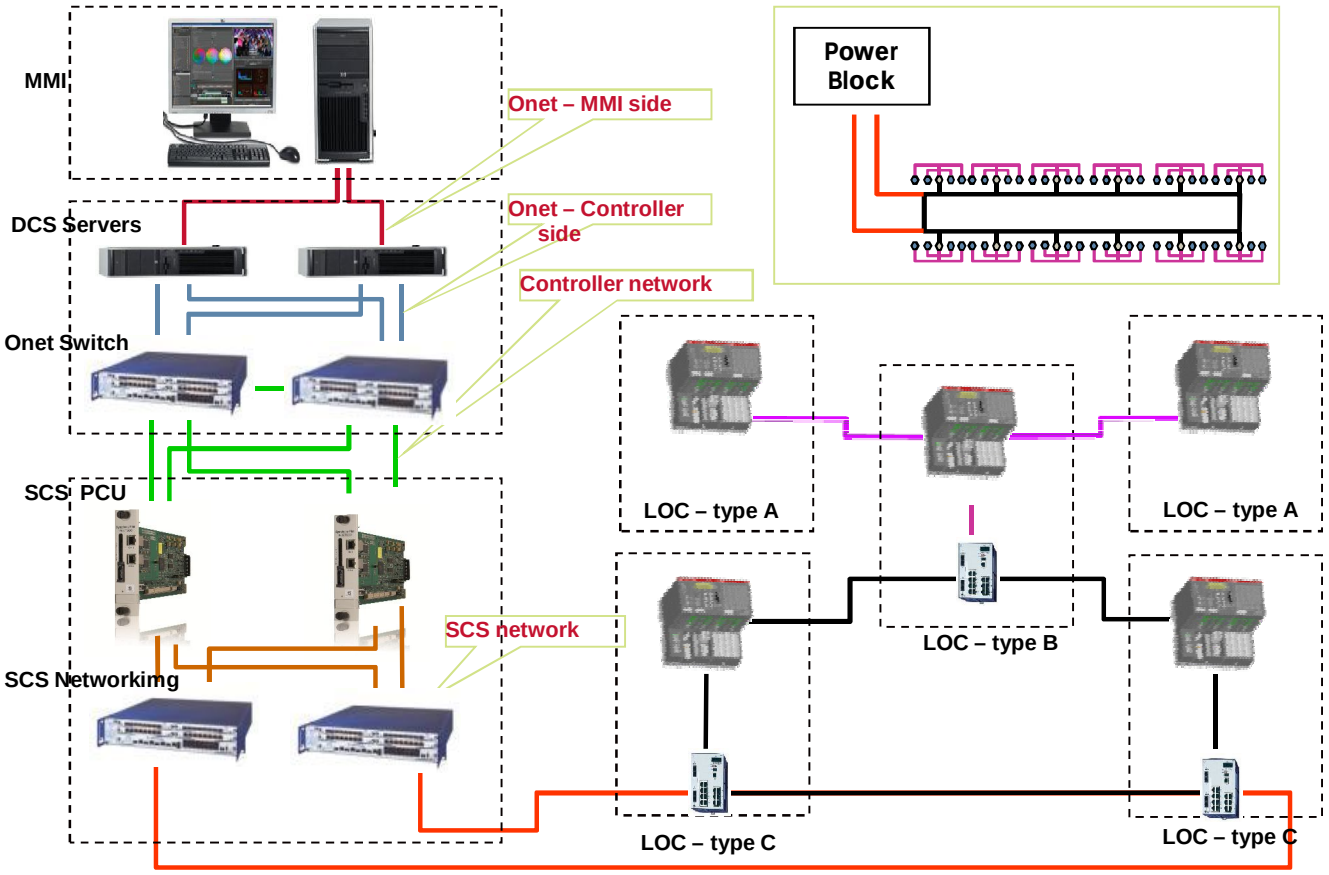
Automation Layout
Field Network Topology



Star-ring-star Structure

- Main double star - optics
- Secondary Rings - optics
- Local Stars – RJ45

Solar Control System
Field Network detailed structure



Solar Control System
Summary - Main Features

Control Design Criteria:

- **Seamless Integration of Automation: DCS+SCS+LOCs**
- **Modular & Expandable**
- **Robust for Hard environment**
- **Secure for Delicate Process**
- **Use of Standard communication protocols**

ISA Delhi Section

ABB

Thank You

A Presentation on

Two Axis Solar Tracking System

Presented by:
Vishal Singh
Engineer
NETRA

Flow of Presentation

1. Solar Energy Potential

2. Solar Energy capture Techniques & Solar Tracker requirement

3. Solar tracking-basics

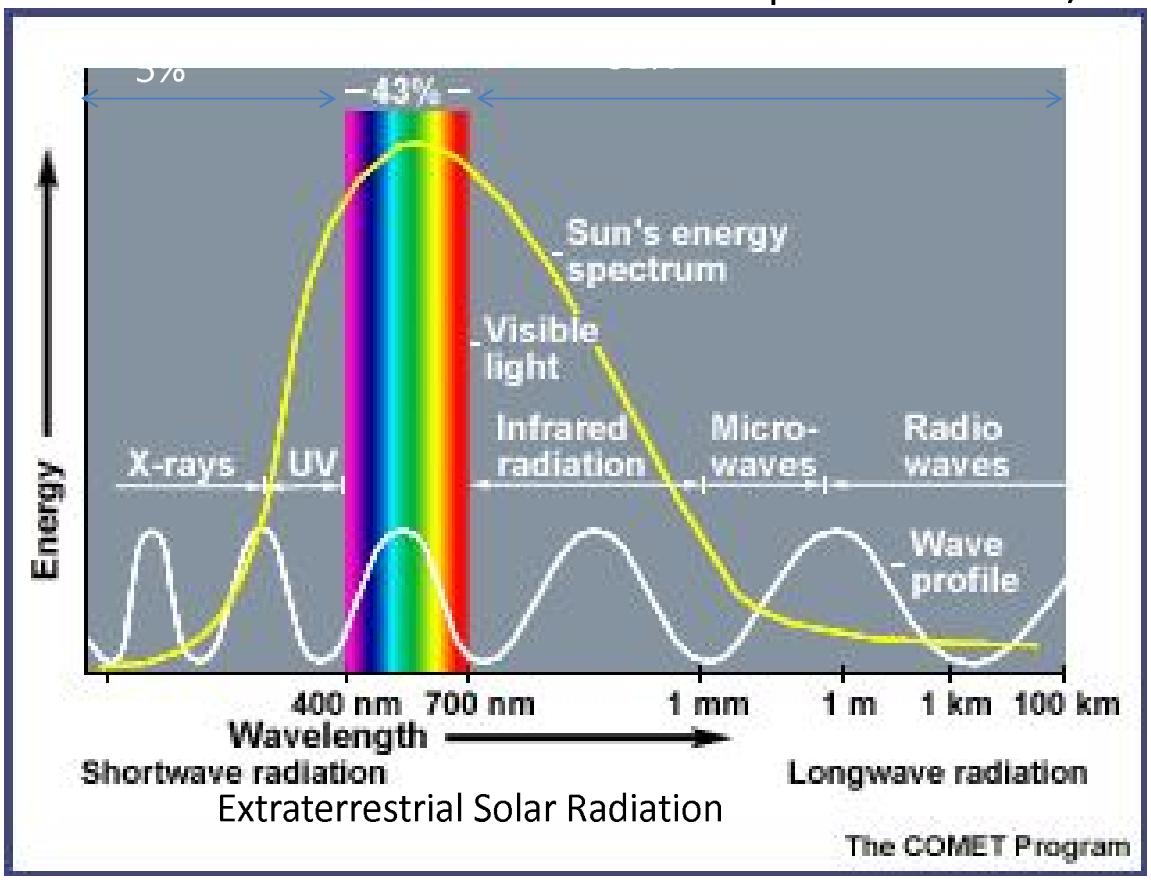
4. NETRA's Solar Tracker

5. Applications and Cost-Economics

Solar Energy Potential

Solar Radiation

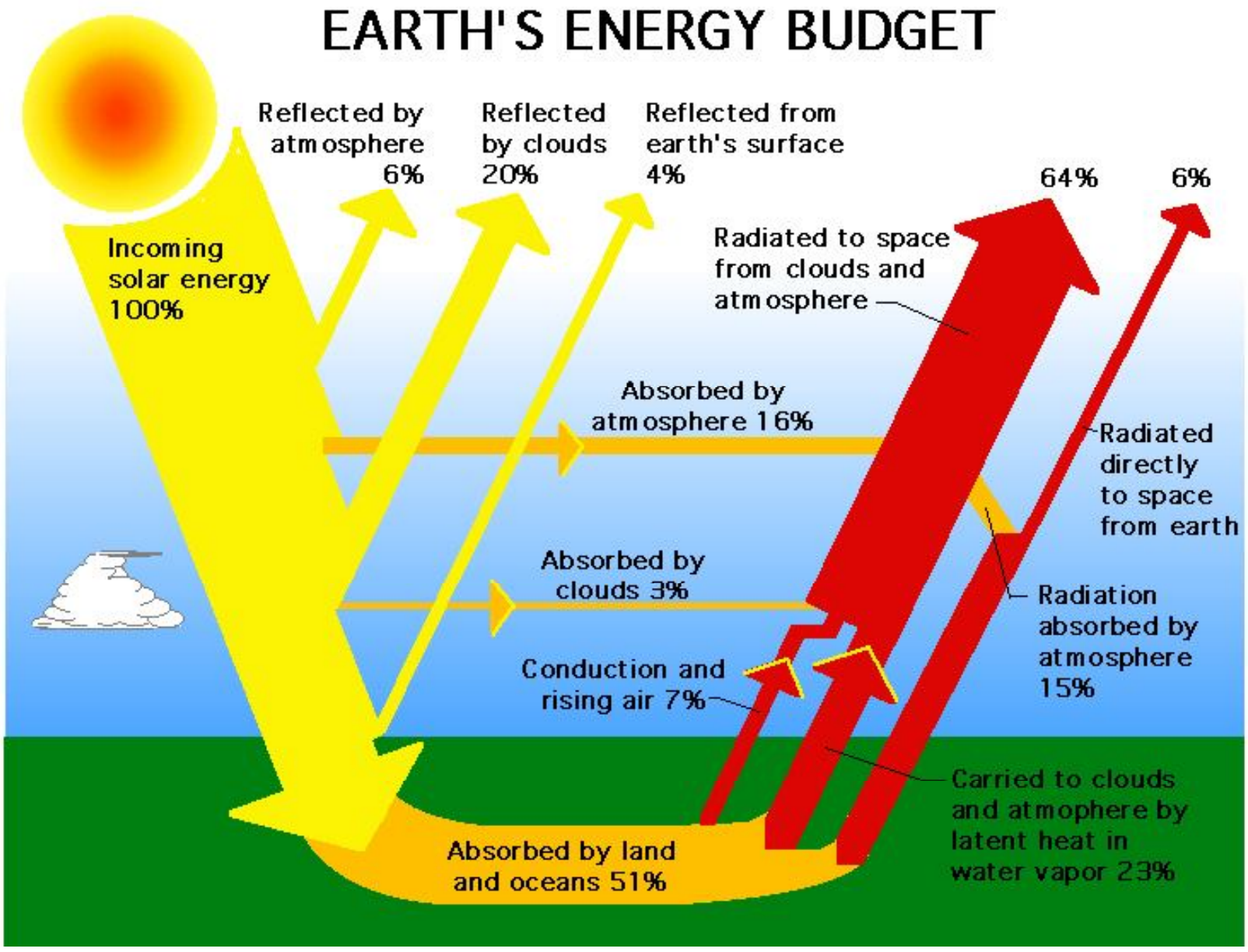
- The total solar energy flux intercepted by the earth : 4.2 X 10^9 MU of energy/Day
- This is equivalent to burning 360 billion tons of oil per day.
- Irradiance received above earth atmosphere is 1367 W/m2



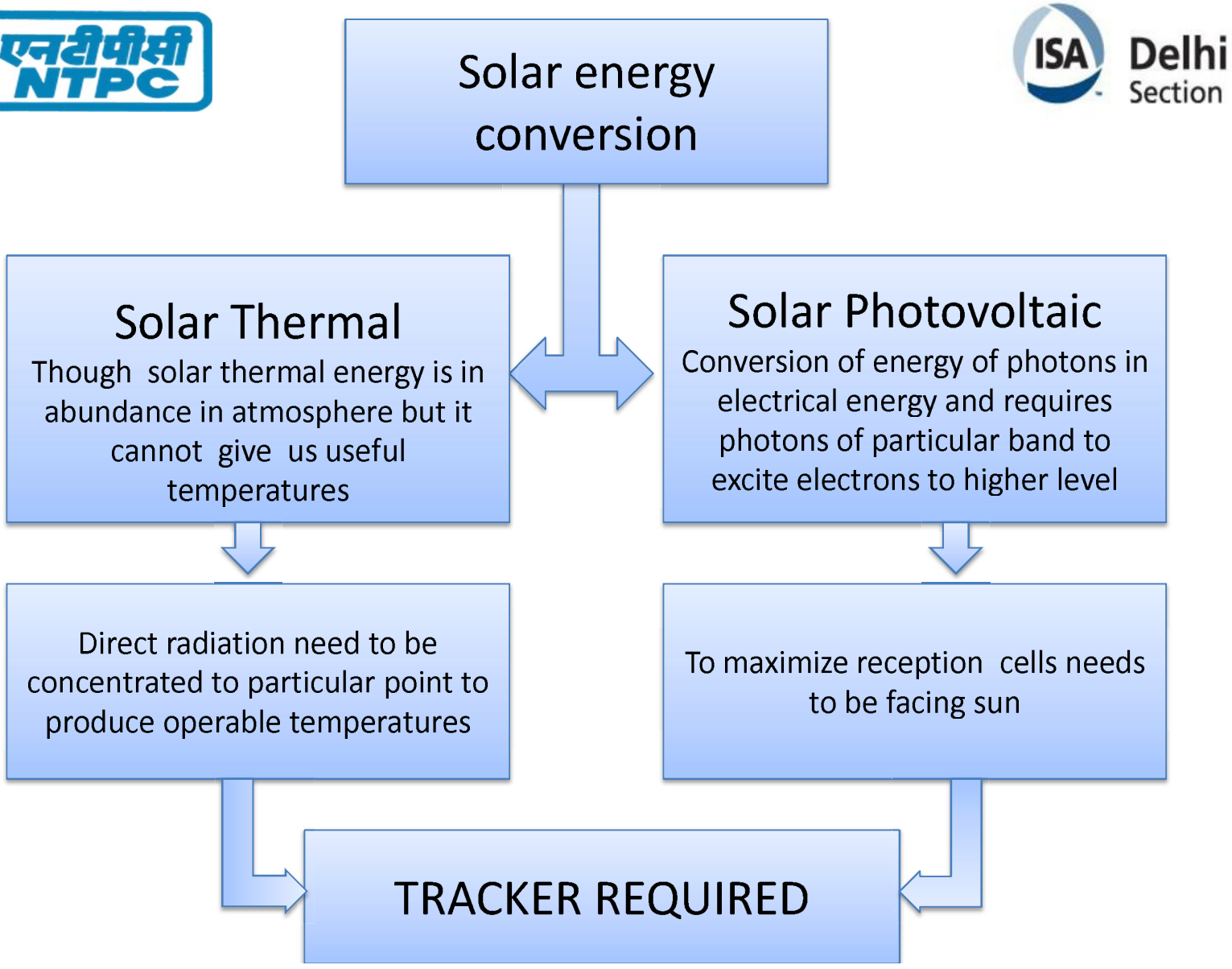
Extraterrestrial Solar Radiation

Terrestrial spectrum

- Terrestrial radiation available is from 290-2300 nm.
- Atmospheric gases absorbs the spectrum below 290 while water vapors above 2300 nm.


EARTH'S ENERGY BUDGET
Reflected by atmosphere 6%
Reflected by clouds 20%
Reflected from earth's surface 4%
64%
6%
Incoming solar energy 100%
Radiated to space from clouds and atmosphere
Absorbed by atmosphere 16%
Radiated directly to space from earth
Absorbed by clouds 3%
Radiation absorbed by atmosphere 15%
Conduction and rising air 7%
Carried to clouds and atmophere by latent heat in water vapor 23%
Absorbed by land and oceans 51%

Solar Energy Capture Techniques & Solar Tracker Requirement


Solar energy conversion
Solar Thermal
Though solar thermal energy is in abundance in atmosphere but it cannot give us useful temperatures
Solar Photovoltaic
Conversion of energy of photons in electrical energy and requires photons of particular band to excite electrons to higher level
Direct radiation need to be concentrated to particular point to produce operable temperatures
To maximize reception cells needs to be facing sun
TRACKER REQUIRED

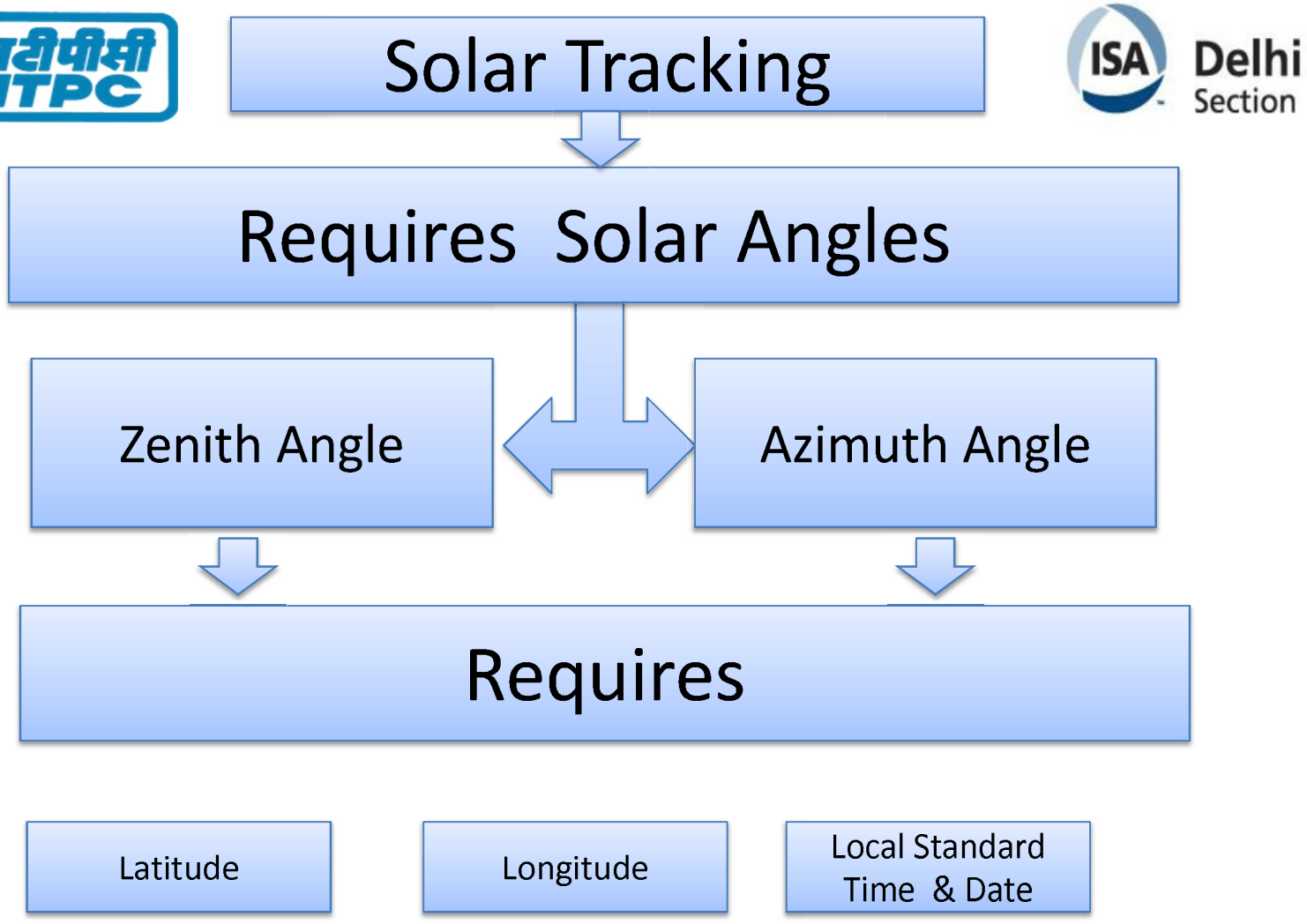
Single Axis and Dual Axis Tracking

- **Single axis**
  - Either Have A Horizontal Or A Vertical Axis.
  - Horizontal type is used in tropical regions (sun gets very high at noon, but the days are short.
  - The vertical type is used in high latitudes (sun does not get very high, but summer days can be very long.

- **Dual axis**

Have both a horizontal and a vertical axis and thus they can track the sun's apparent motion virtually anywhere in the world.

Solar Tracking-Basics


Solar Tracking
Requires Solar Angles
Zenith Angle
Azimuth Angle
Requires
Latitude
Longitude
Local Standard Time & Date

True Solar Time

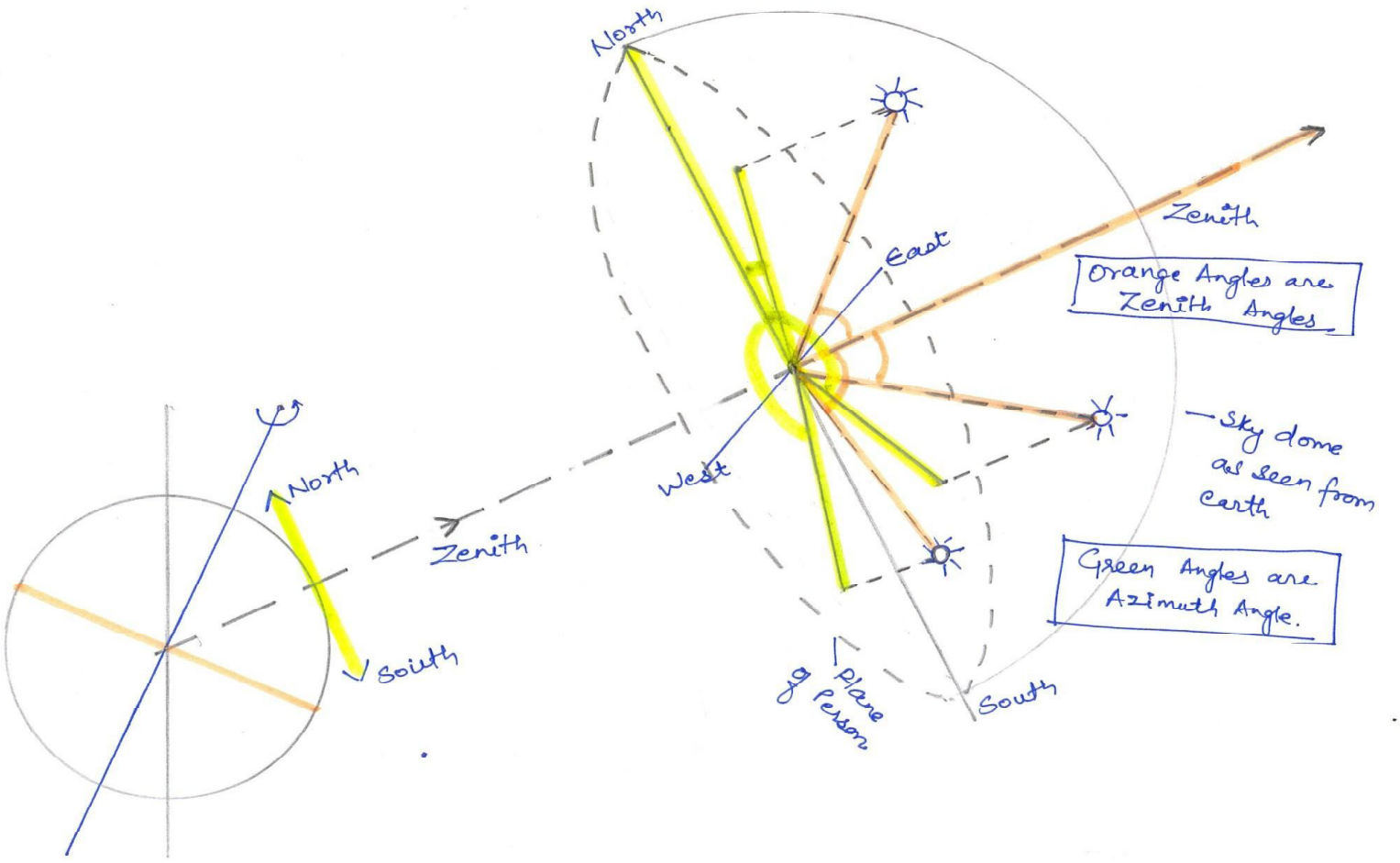
Local Time	=	Local standard time	-	LST difference from GMT	+	local longitude*24/360

TST	=	Local Time	+	Error b/w TST and LT

Error between TST and LT can be calculated by using Equation of Time

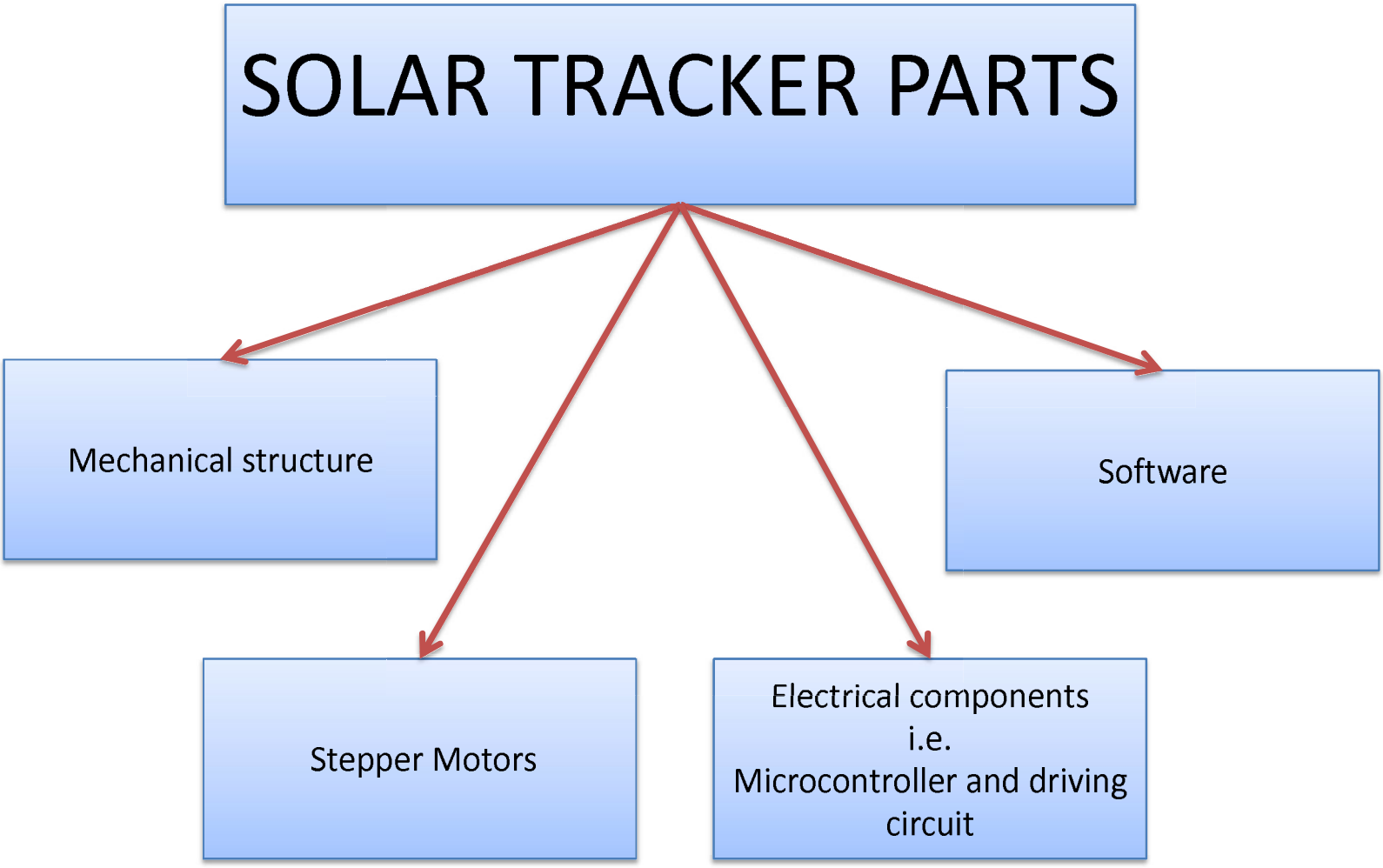
Azimuth and Zenith angles

Delhi Section



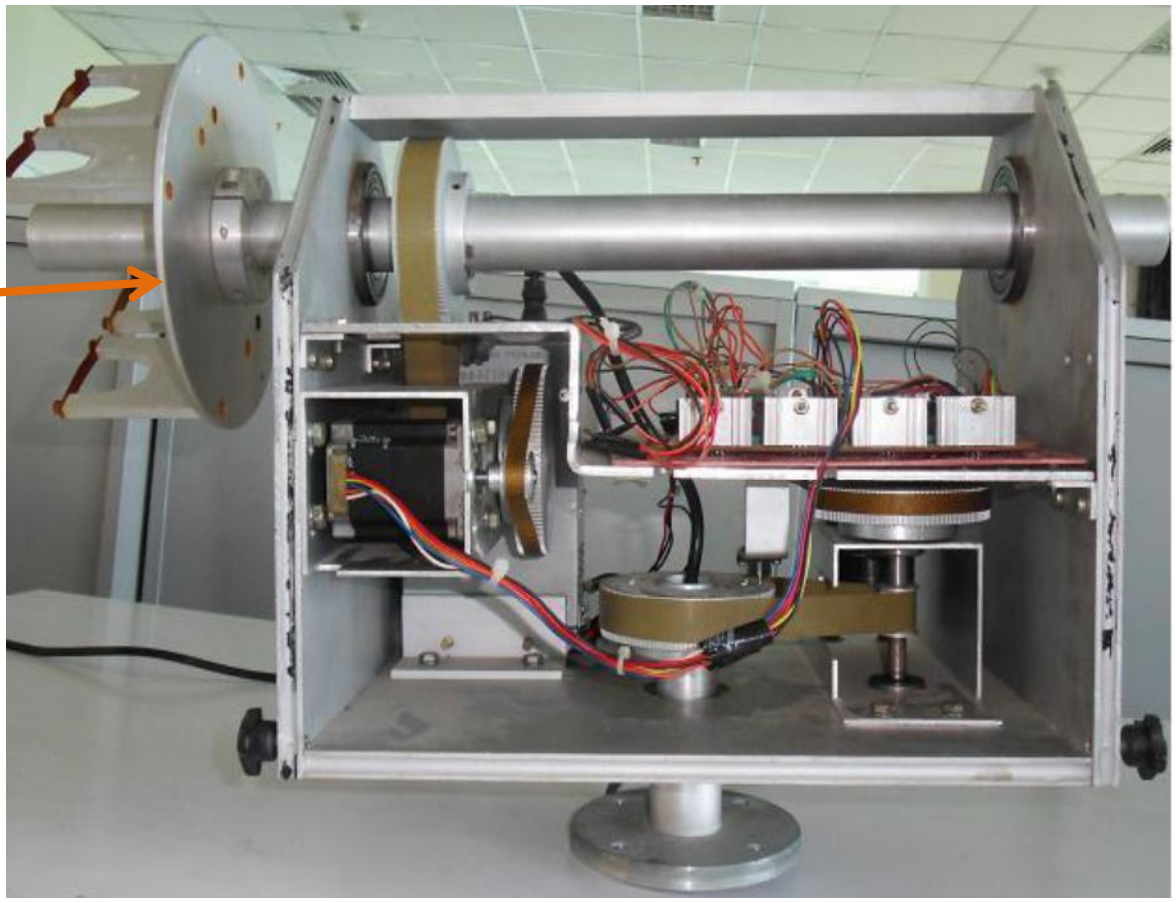
NETRA's Solar Tracker

SOLAR TRACKER PARTS

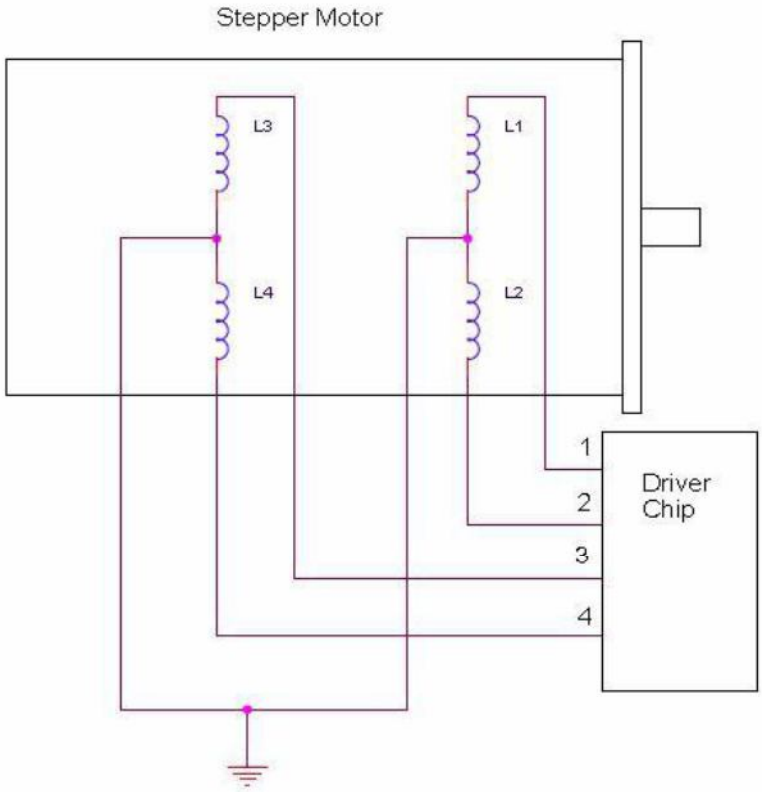


Mechanical Structure

Pyrheliometer can be place here as this part can traverse 360 degree in both horizontal and vertical plane



Stepper motors

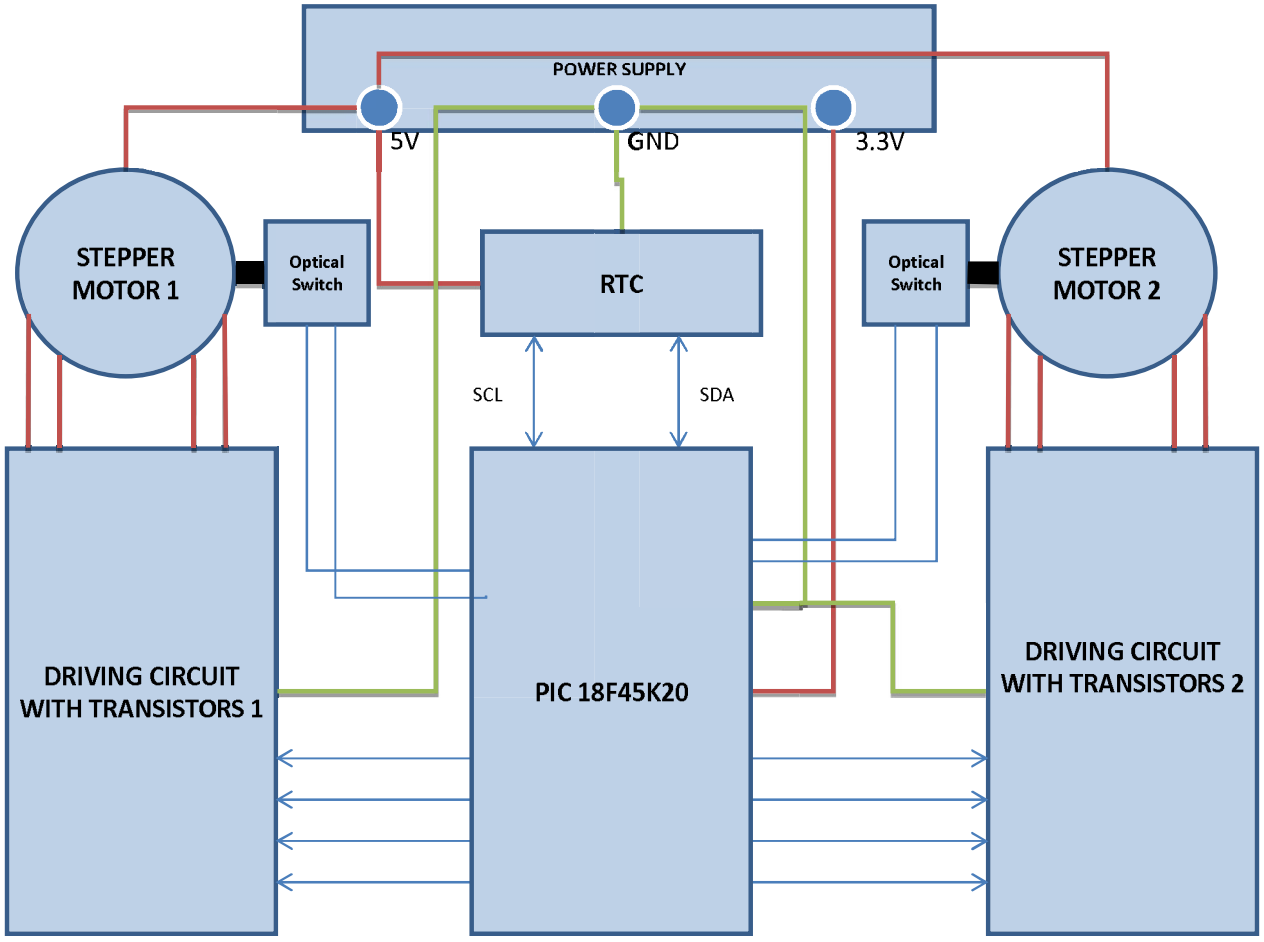


An electromechanical device which converts electrical pulses into discrete mechanical movements.

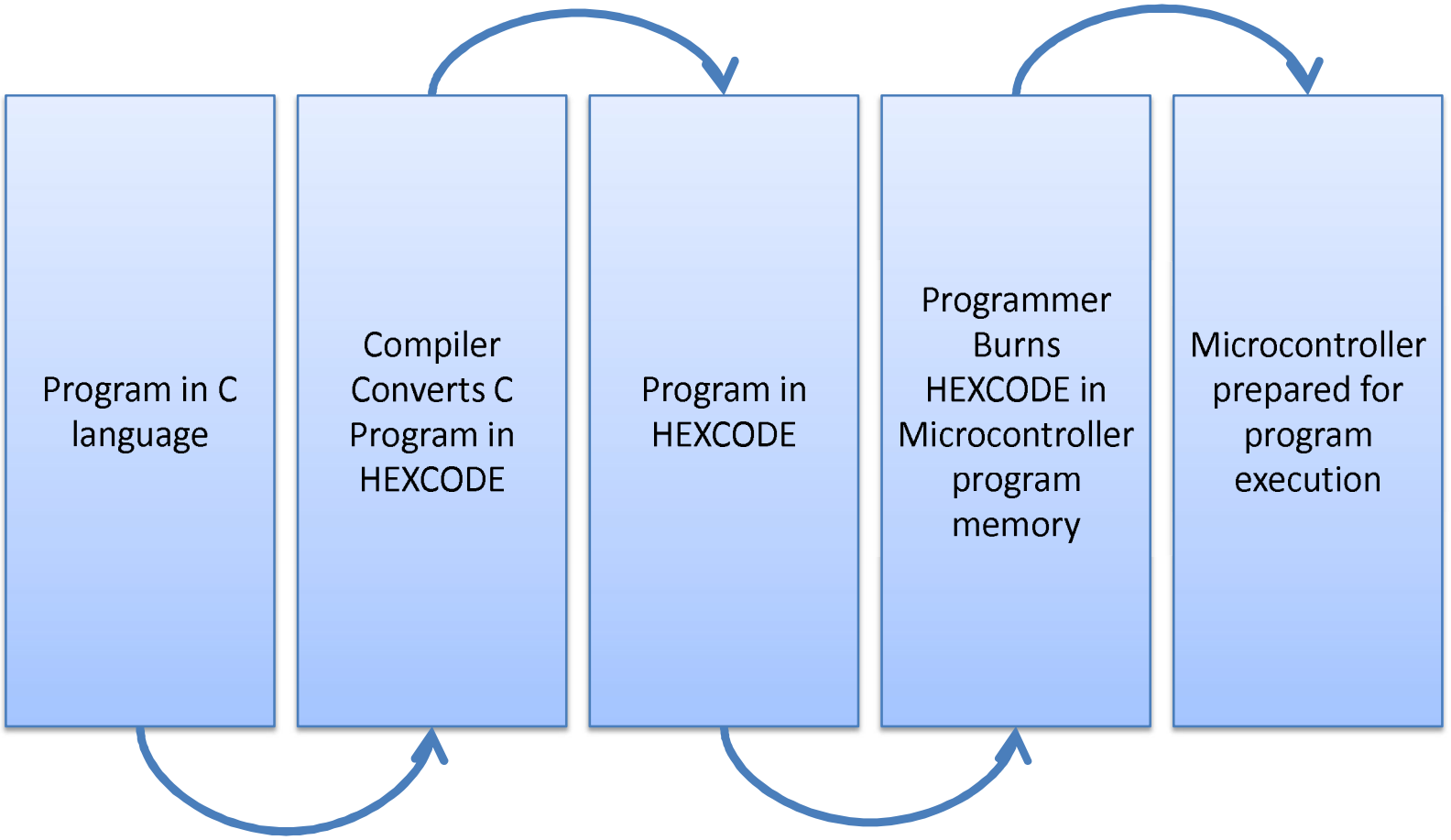
Advantage of stepper motor :

- Precise open loop control
- Presence of holding torque

Electrical Components



Software


Program in C language
Compiler Converts C Program in HEXCODE
Program in HEXCODE
Programmer Burns HEXCODE in Microcontroller program memory
Microcontroller prepared for program execution

Applications and Cost-Economics

Applications and Cost Economics

➢Developed tracker can be used for solar radiation data collection to estimation of solar energy potential ,Solar Natural lighting ,SPV,CPV etc.

➢There are many leading manufacturer of solar tracker around the world like Kipp & Zonen (The Netherlands), EPLAB (USA), WattSun Trackers (USA), Solon Mover (Germany) etc. There is no manufacturer of solar tracker in India as of now. The available trackers in Indian market costs more than 5 lacs as per its mechanical design and applications.

➢In-house developed solar tracker at NETRA costs approx. Rs 30,000/- is very less with compare to solar trackers available in the market.

THANK YOU
QUESTIONS???