

IEE-CAS

(Institute of Electrical Engineering
Chinese Academy of Sciences)



Presentation

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Outline

1

General information of IEE-CAS

2

Solar Thermal Group and main activities



Brief Introduction

- **Founded in 1958**
- **Focused on the basic knowledge and high-tech. R&D in the field of electrical engineering**
- **One of 104 research institutes in CAS**
- **431 employees (375 are scientists, engineers, research assistants)**
- **About 277 Post Doc., Ph.D. and Master students**
- **2 National Energy R&D Centers**
- **4 Key Labs of CAS, 4 Key Labs of Beijing**



Organizational Structure

Research Dept.

Research Group

IE
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C
A
S

1、 Lab. of Renewable Energy

- Wind &PV G.
- Solar Thermo G.
- Solar Cell
- Ocean Wave G.
- Testing center

2、 Lab. of New Power Equipment Technology

- Evaporative cooling tech.

3、 Lab. of Power Electronics & Energy Conversion

- EV Drives
- PE &LM Drives
- EV Energy M.
- HV Tech.

4、 Lab. of Superconductors and New Materials

- SP Power Tech.
- SP Magnetics Tech
- HT SP Materials
- Nano Tech.

5、 Lab. of Bioelectromagnetics and Electromagnetic Detection

- Bioelectromagnetic Theory
- EM Signal Detection Tech.
- EM Theory

6、 Laboratory of Smart Grid

- Smart Grid



Research Activity

Lab. of Renewable Energy

Solar Thermal Power Technology

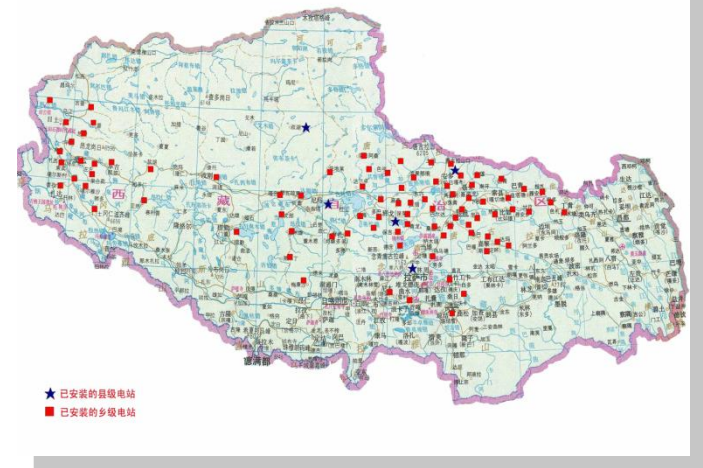
- 1st MW tower-type solar thermal power plant in China as well as in Asia
- 10MW tower-type thermal power plant are being developed



1 MW STE plant

Wind & PV Generation Technology

- Nearly 200 PV power stations in Tibet
- 2MW hydro and PV complementary power Plant in Qinghai
- 20MW PV plant in Golmud City of Qinghai



Research Activity

Lab. of Renewable Energy

Solar Cell Technology

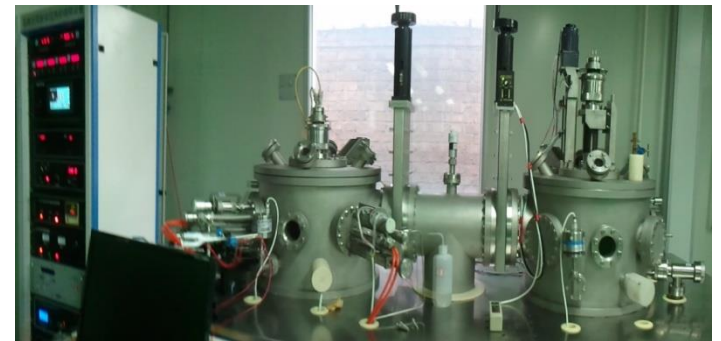
- New types of high- efficiency silicon solar cell
- Low-cost silicon thin film solar cell
- Low-cost CdTe thin film solar cell



MW level PV production

Ocean Wave Power Technology

- Demo of 5kW ocean wave generator with magnetic fluid
- Recovery technology of spilled oil of ocean with magnetic fluid



CdTe testing

PV & Wind Generation System Quality Test Center of CAS

Research Activity

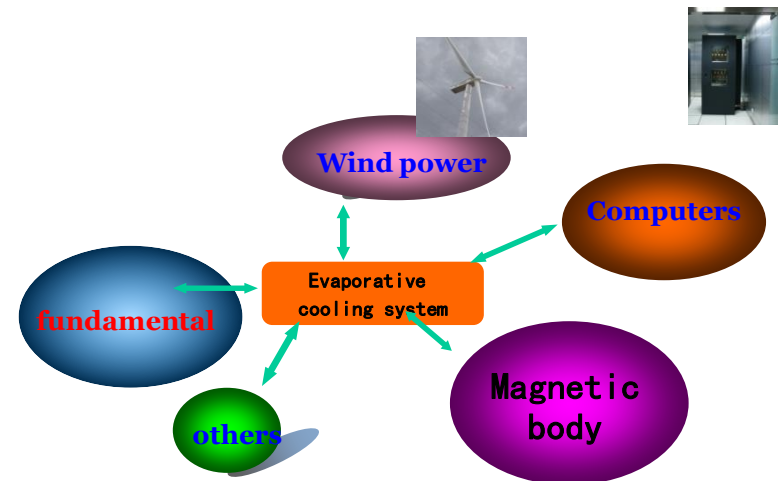
Lab. of New Power Equipment Technology

Evaporative cooling technology

- ❑ Evaporative cooling technology and Applications in hydro-generators, turbine generators, wind generators, transformer and some other power equipments
- ❑ The evaporative cooling system for 70MW hydro-generators in three Gorges power plant in 2012/2013
- ❑ 2.5MW and 5MW PM evaporative cooling Wind generators in 2012
- ❑ The evaporative cooling system for super-computers in 2013



Two 700MW water turbine generator



Research Activity Lab. of Superconductors and New Materials

Superconducting Power technology

- ❑ Superconducting power cable
- ❑ Fault current limiting technology
- ❑ Superconducting magnetic energy storage
- ❑ Other superconducting power equipments



Superconducting Magnet & Materials

- ❑ Superconducting magnets with complex structure & special cooled manner
- ❑ Space superconducting magnets & special electrical equipments
- ❑ New HT superconducting Materials



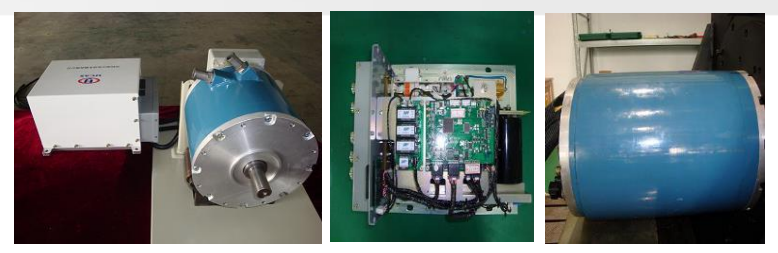
- 9.4T; diameter:54mm;
- 1Hz/h;
- 0.2ppm (50mm DSV)

Research Activity

Lab. of Power Electronics & Energy Conversion

Electric Drive Technology for EV

- ❑ R & D of motor drive system for EV
- ❑ R & D of electrical system for EV
- ❑ Multiple phase motor drive
- ❑ Package technology of power modules



Drive system



High Power Drive Technology

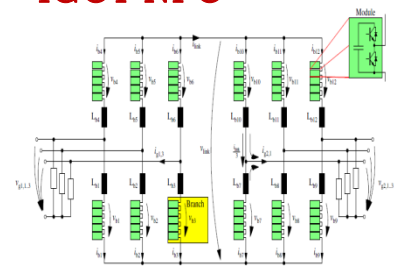
- ❑ Topology and Control of High Power Converters
- ❑ Analysis and Control of Large Linear Motors
- ❑ Large Electric Drive Technology
- ❑ New Power Converters and Applications in Transportation and Power System



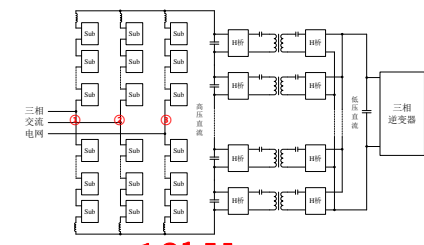
IGCT NPC



500kVA



MMC



10kV



Research Activity

Laboratory of Smart Grid

- ❑ Basic Research of Smart grid and DC grid
- ❑ System architecture design, energy management, control and relay protection technology of DG based on Micro-grid structure
- ❑ Energy storage technology for DG and power quality improvement with Ultra-capacitor, flywheel and battery

基于多种可再生能源综合利用的分布式智能电网研究示范基地



绿色电源
塔式太阳能热发电
槽式太阳能热发电
多种类型光伏电池
多种类型风力发电机

储能装置
先进储能电池
超级电容器
飞轮阵列
先进压缩空气储能
电动汽车充电/储能站

研究平台
光伏发电技术研究平台
风力发电技术研究平台
太阳能发电技术研究平台
分布式直流电网技术研究平台
分布式智能电网动模实验系统
含大规模可再生能源电力的区域电网数模混合仿真平台

绿色 智能 安全 高效

中国科学院电工研究所
IEECAS



PV+wind



Power electronic transformer



Power electronic fault current limiter



Battery energy storage unit



Flywheel ESP station



Super capacitor energy storage unit



Electric vehicle charging pile



Data acquisition and information management system



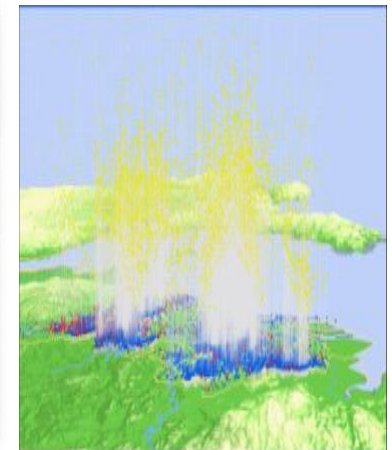
Research Activity

Lab. of Bioelectromagnetics & Electromagnetic Detection

- ❑ Biological effects of electromagnetic field and their mechanism
- ❑ Detection of biological spontaneous electromagnetic characteristics and its application
- ❑ Bioartificial organ
- ❑ Electromagnetic technique intersected with nano-technique and bio-technique.



Long time observation base of low frequency electromagnetic field on the dynamic and plant ecological effect



Three dimensional lightning detector

Solar Thermal Group

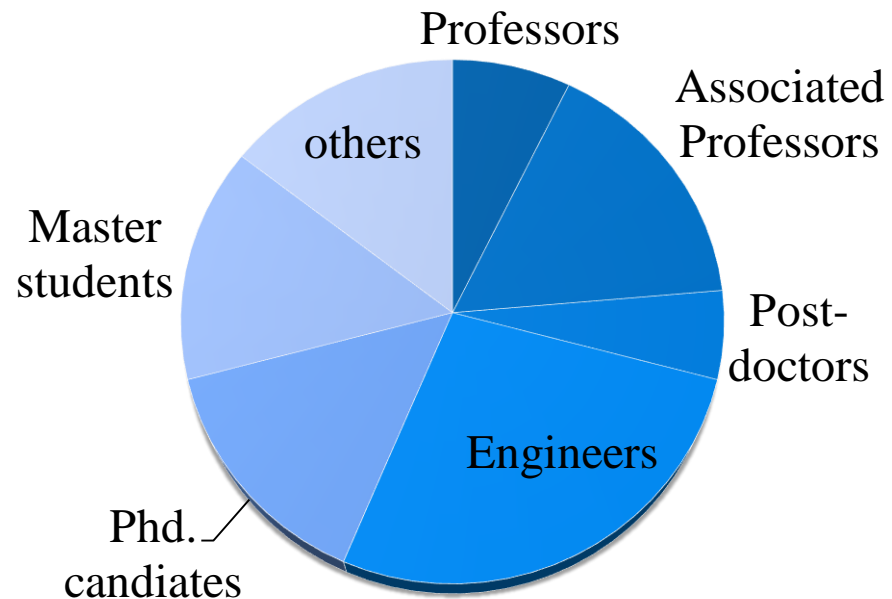
Established in 2001

Now, 36 staffs including 4 professors, 9 associated professors, 15 engineers and others.

3 Post-doctors

9 Phd. Candidates

8 Master students



www.chsel.com

Solar Thermal Group

Research Interests

- ✓ **Solar thermal power technology (solar tower power、 solar parabolic trough power、 solar dish Stirling power) :**
 - **System optimization of CSP plant,**
 - **Solar concentrator,**
 - **Receiver,**
 - **Thermal energy storage,**
 - **Solar thermal power materials,**
 - **Control technology**
- ✓ **Solar desalination**
- ✓ **Solar integrated building**
- ✓ **Solar collector/heater thermal performance testing technology**

1MWe solar tower pilot plant

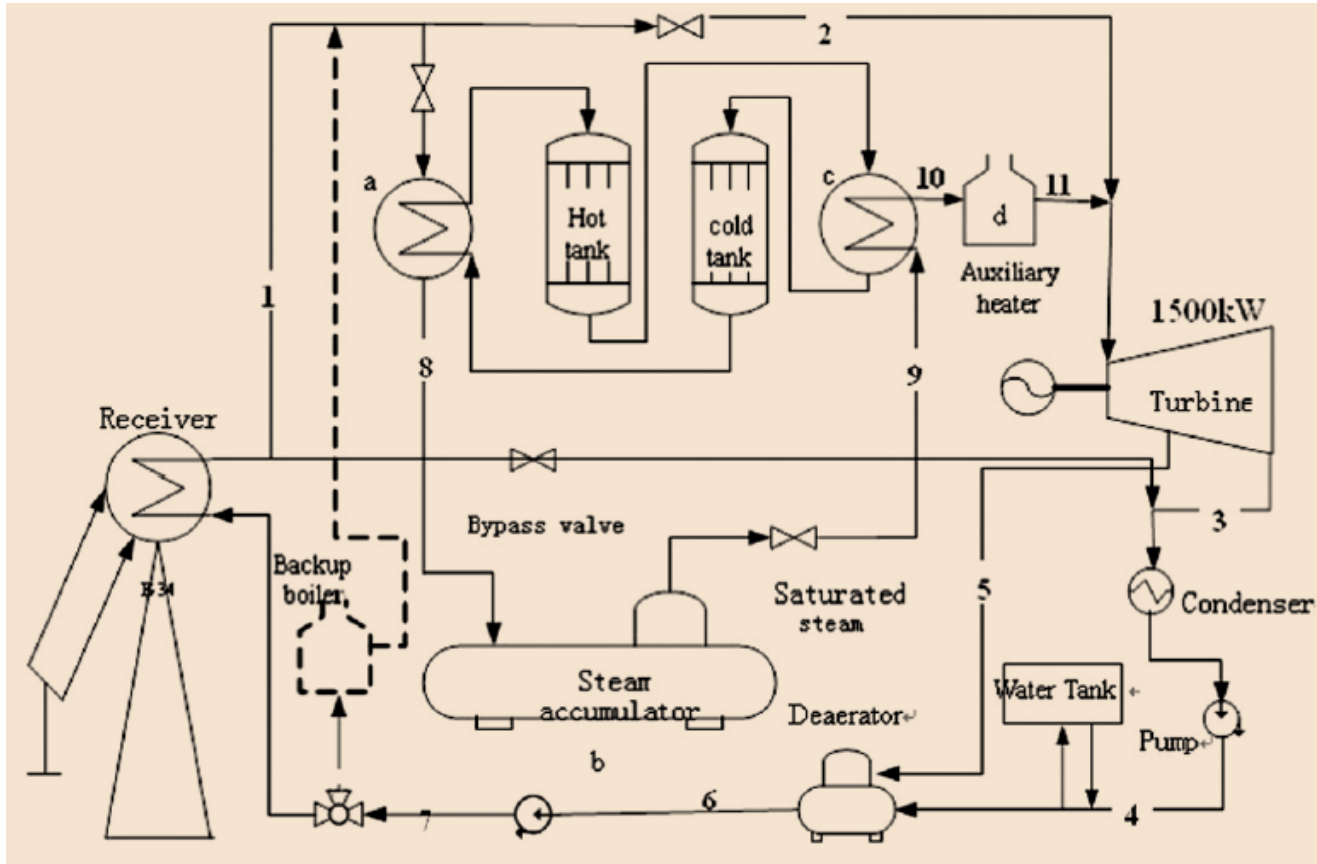
Tower: 119m, three apertures, HTF: water/steam, SF:10000m², Turbine: 1.5MW



1MWe solar tower pilot plant in winter, 2011



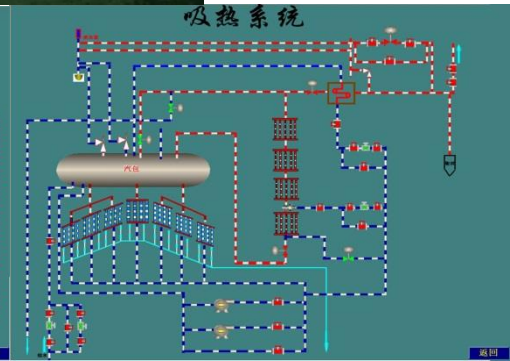
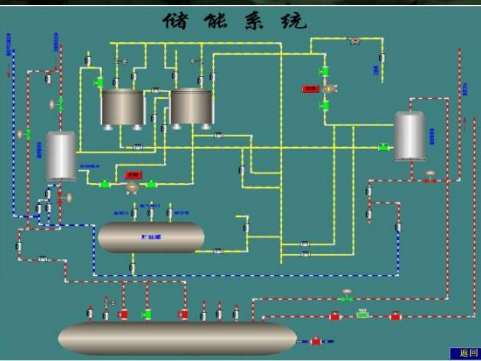
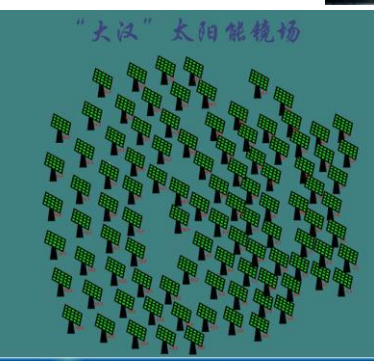
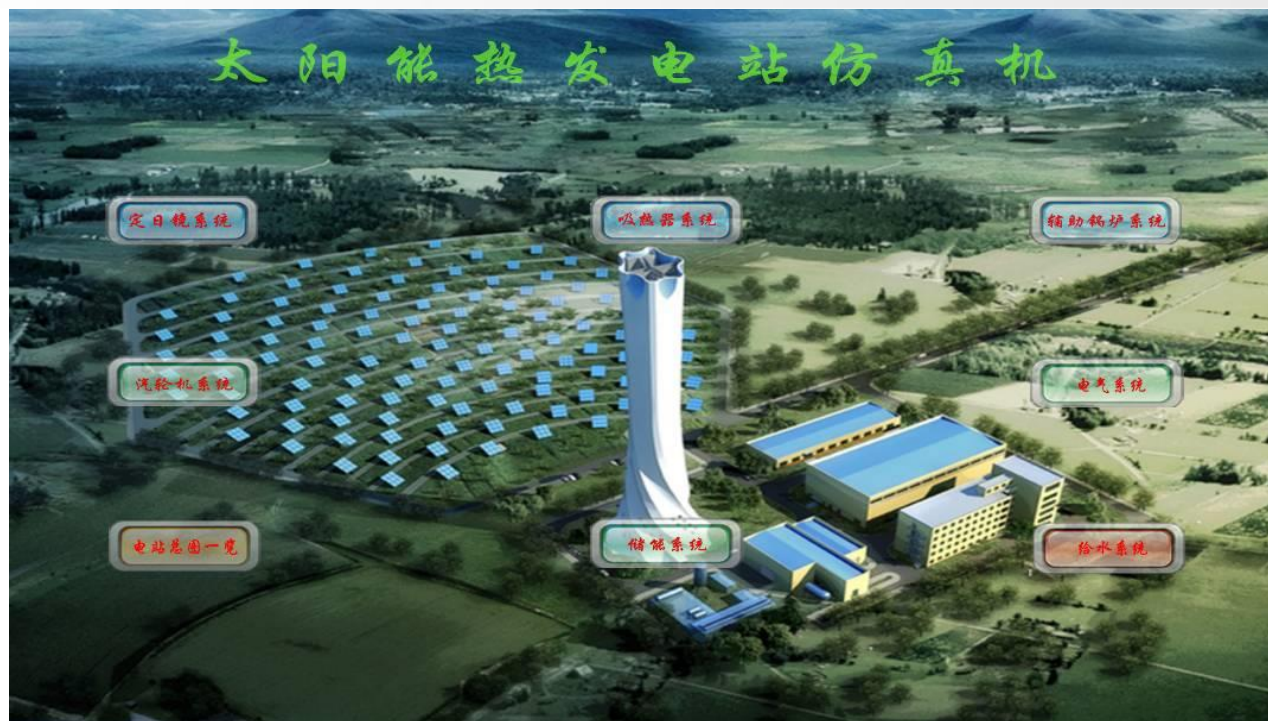
Schematic flow chart of the 1MWe solar tower pilot plant



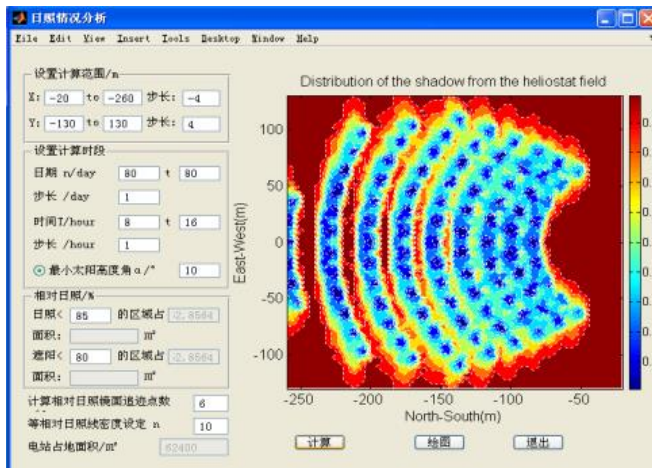
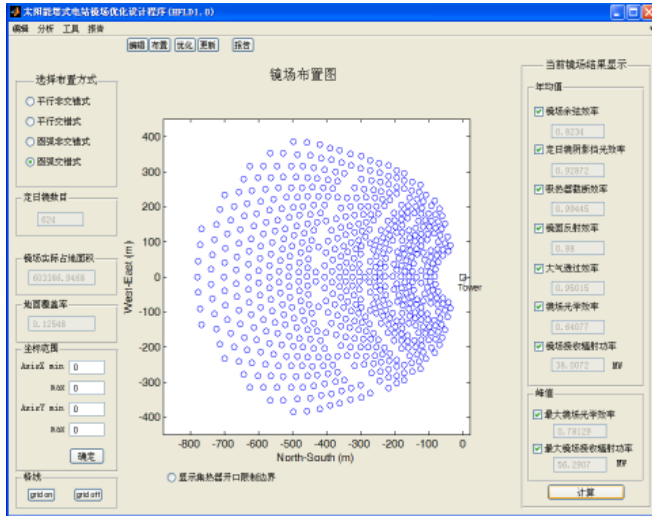
Two oil tanks
steam accumulator
100m³
2.5MPa



Simulator of the 1MWe solar tower pilot plant



Heliostat field layout design software



PS10 solar tower plant	reported	Calculated by HFLD	errors
nominal optical efficiency	77%	76.5%	-0.5%
Nominal received peak power	55.0MW	56.3MW	+1.3MW
Annual optical efficiency	64.0%	64.08%	+0.08%
Annual cosine efficiency	>81%	82.3%	+1.3%
Annual shading and blocking efficiency	>95.5%	92.9%	-2.6%



considering the land utilization



Heliostats



120m²



125m²



108m²



High order surface heliostat

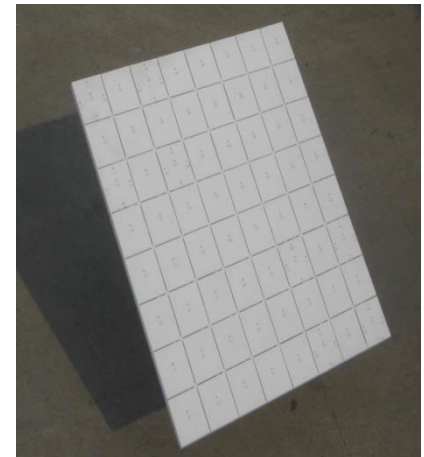


Heliostat used in Dahan plant



Focal plane

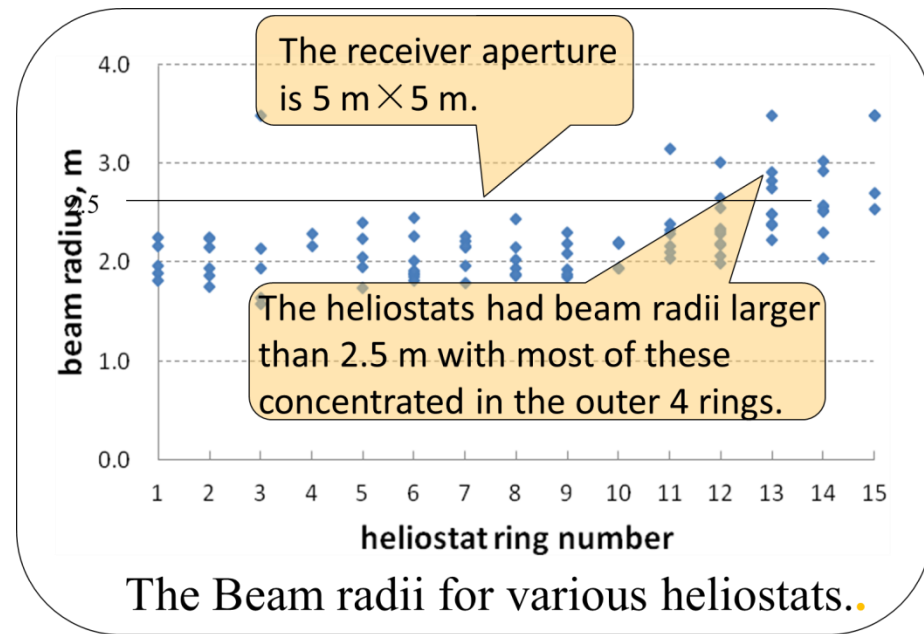
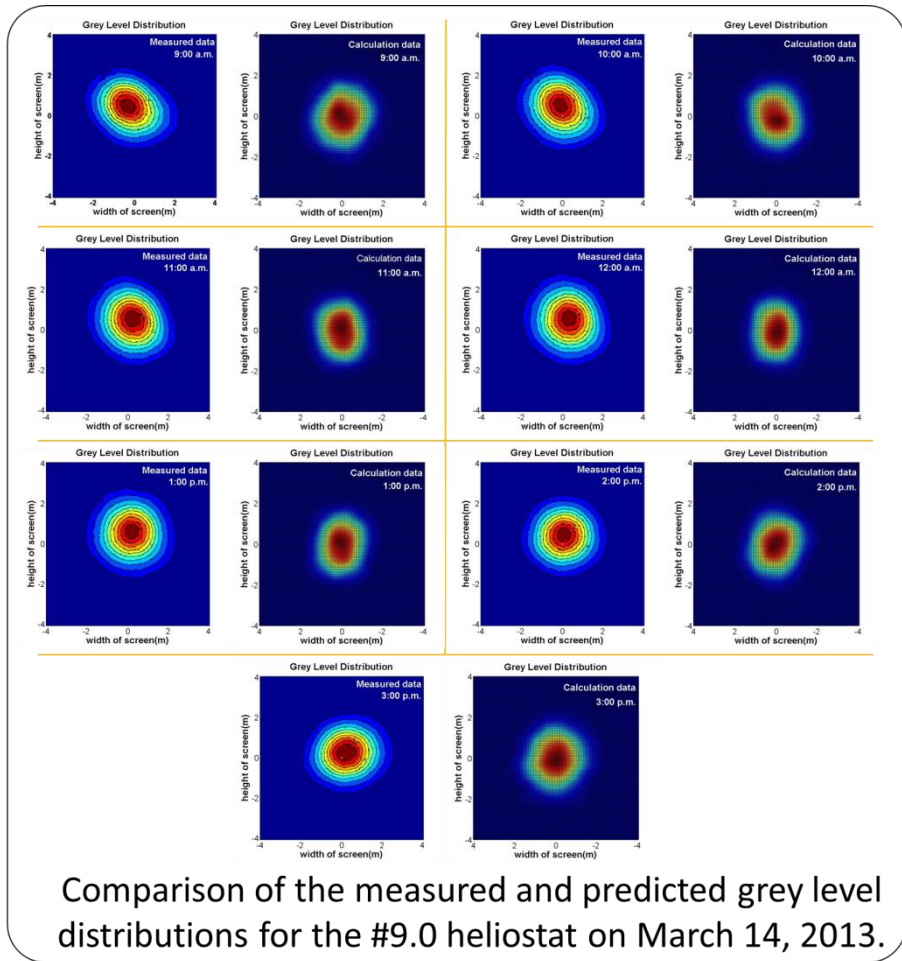
Wind load on concentrators testing



Wind tunnel : testing section 2.5m × 3m, Speed:0-30m/s



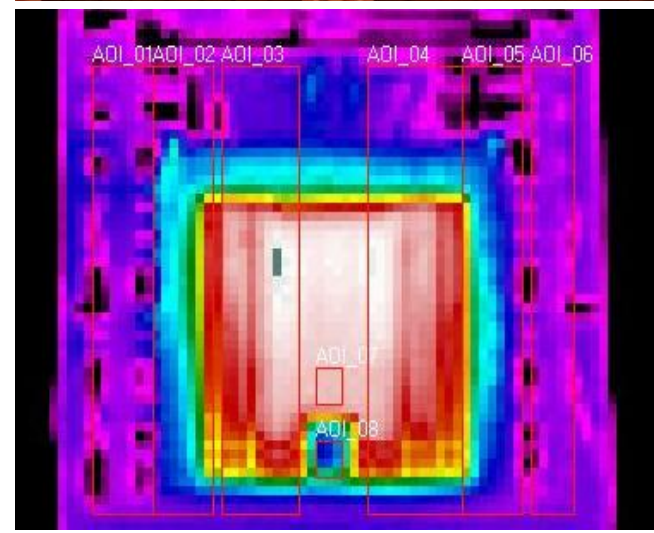
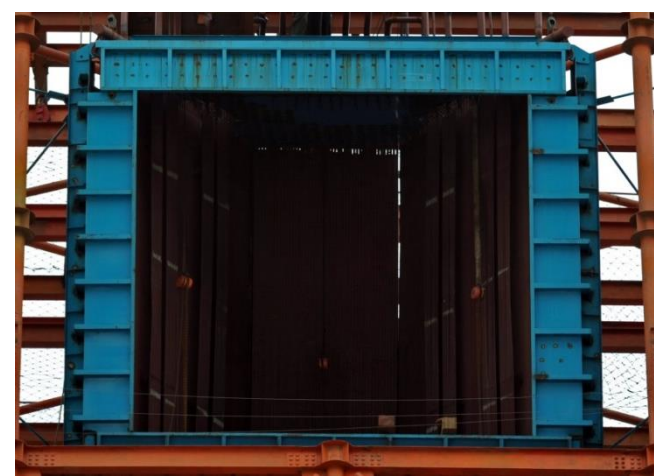
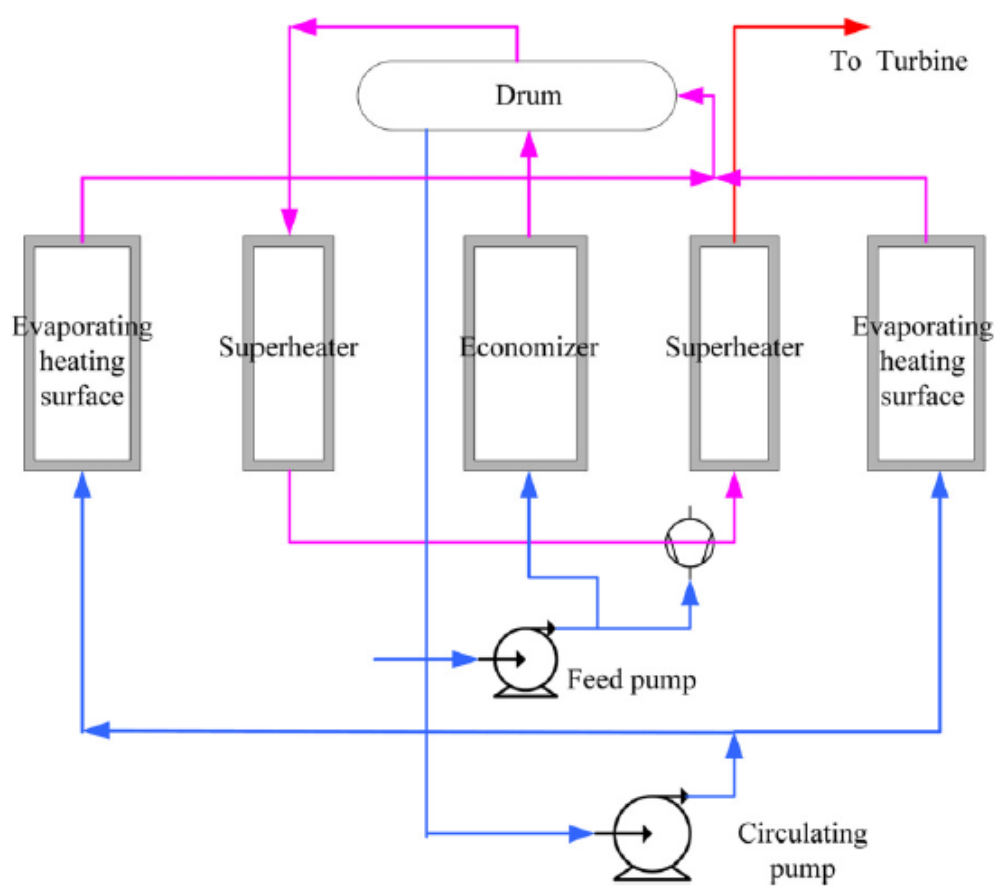
Optical performance of a heliostat



26% of the measured heliostats radii were more than 2.5 m, so additional alignment was needed.



Water/steam cavity receiver



TES system



Steam accumulator



Two oil tanks

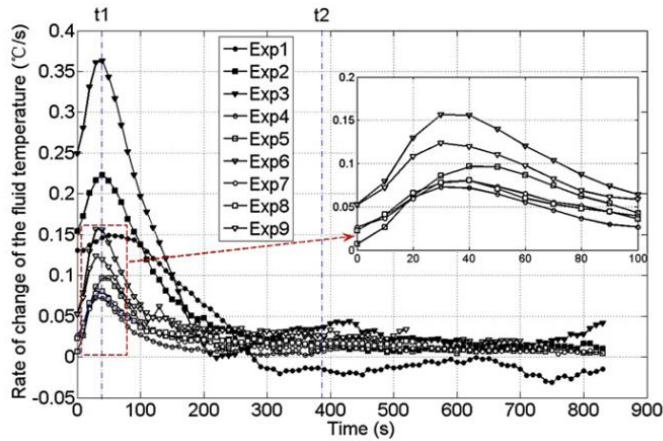
DCS control room



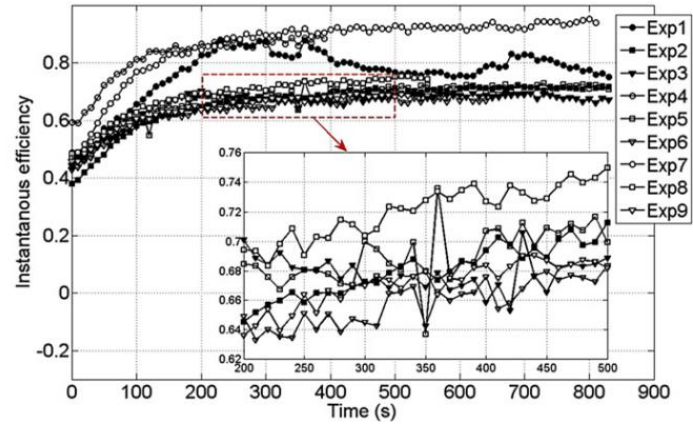
Molten salt test platform



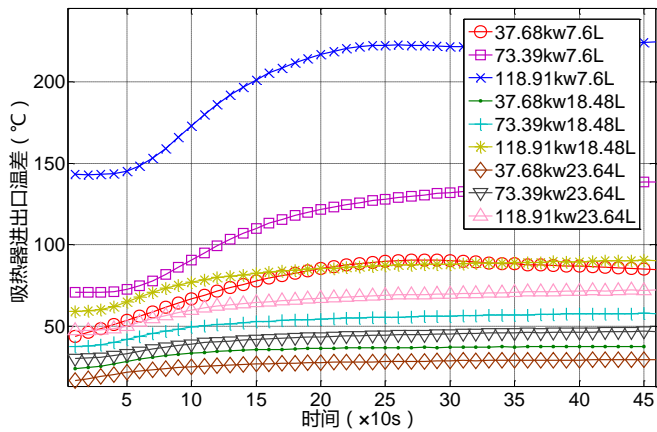
Thermal performance test



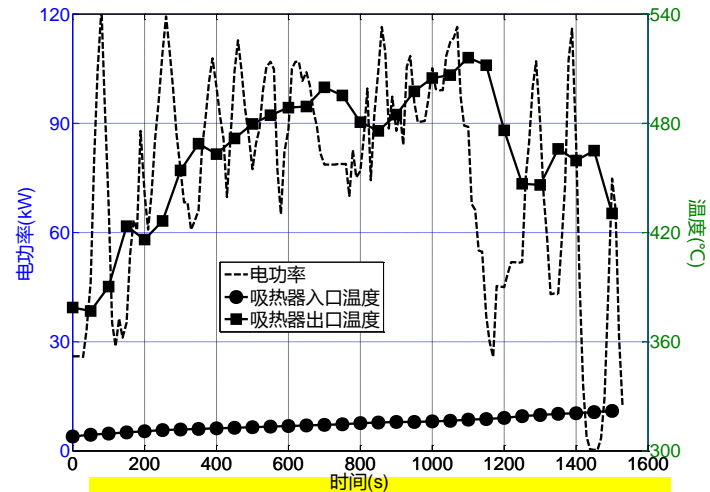
Time derivative of fluid temperature



Instantaneous efficiency vs.time



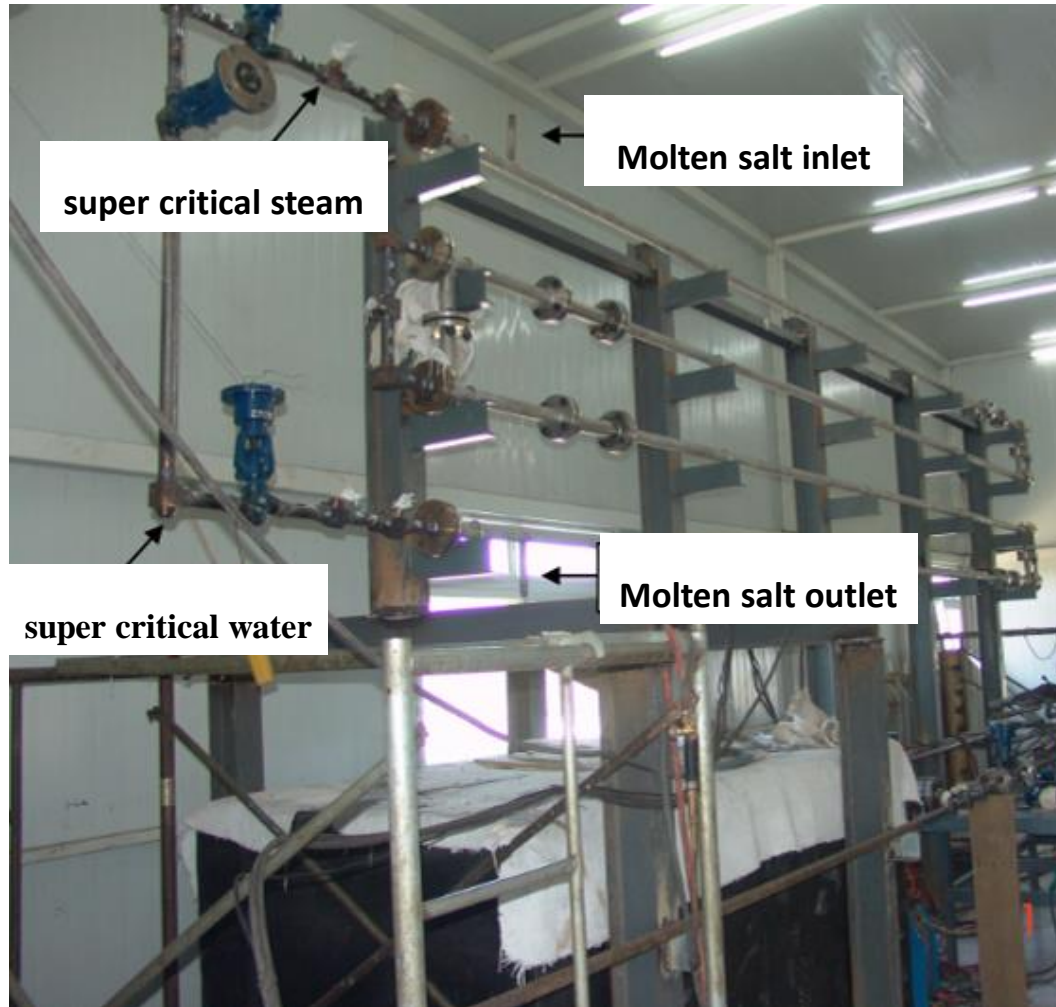
Δt vs. input power and flowrate



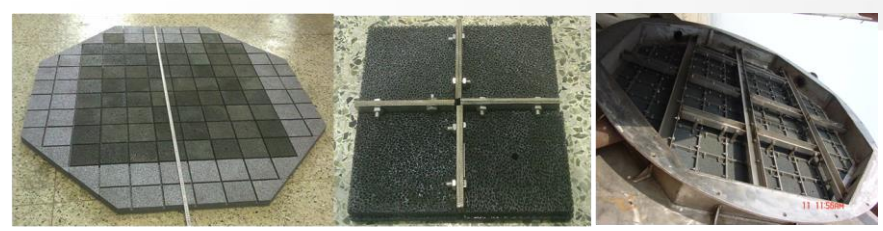
Outlet temperature vs. input power



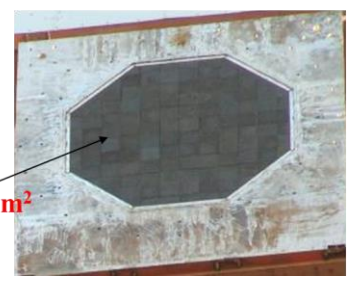
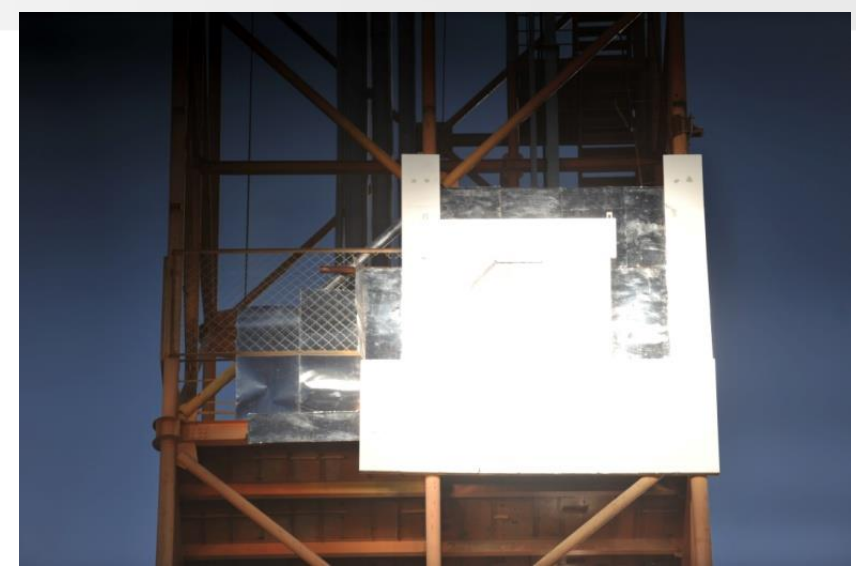
Molten salt super critical steam generator test platform



1MWth air receiver



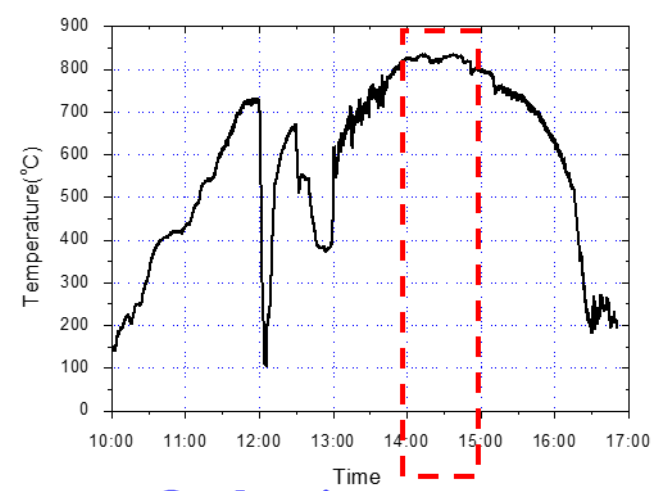
160mm × 160mm



2.167 m²



- The maximum power is 845 kW
- The maximum of incoming solar thermal power is 1076 kW
- The maximum of outlet air temperature is 835 °C
- Average efficiency at 14:00-15:00 is 0.77



Outlet air temperature



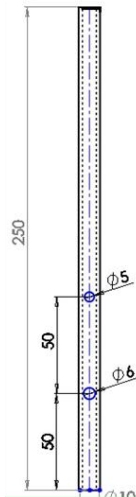
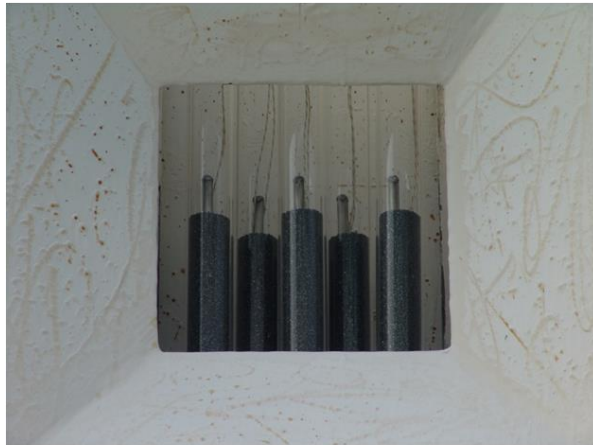
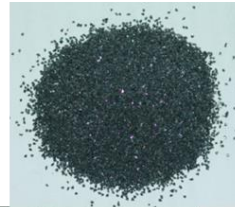
Quartz tube solid particle air receiver

Quartz tube

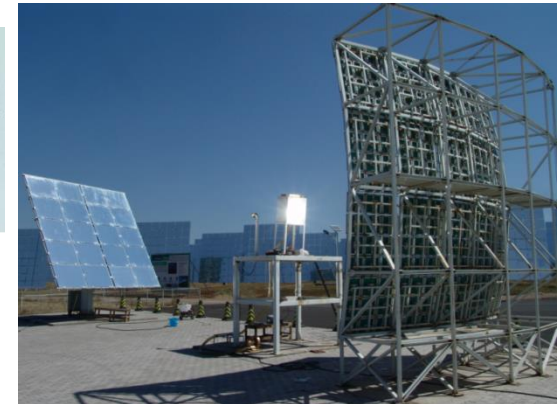
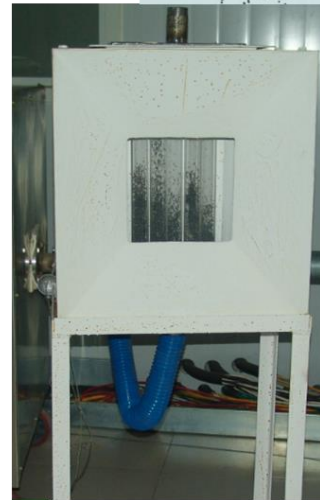
- ✓ Inner diameter: 40mm
- ✓ Thickness: 3mm
- ✓ Length: 500mm

Solid particles

- silicon carbide
- Diameter: 1mm



Stainless steel entrance duct



- ❑ Outlet air temperature of five tubes: **624.1°C**
- ❑ Outlet air temperature of single tubes: **866.6°C**



Dish concentrator



10m dish concentrator in Dezhou



5m dish concentrator



5m dish concentrator

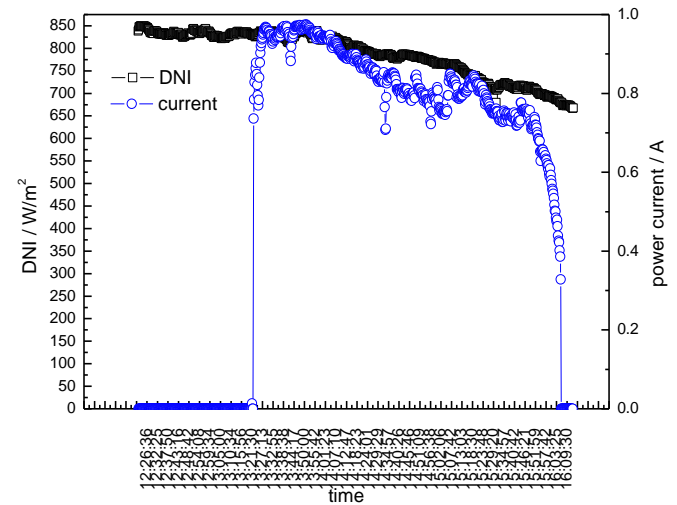
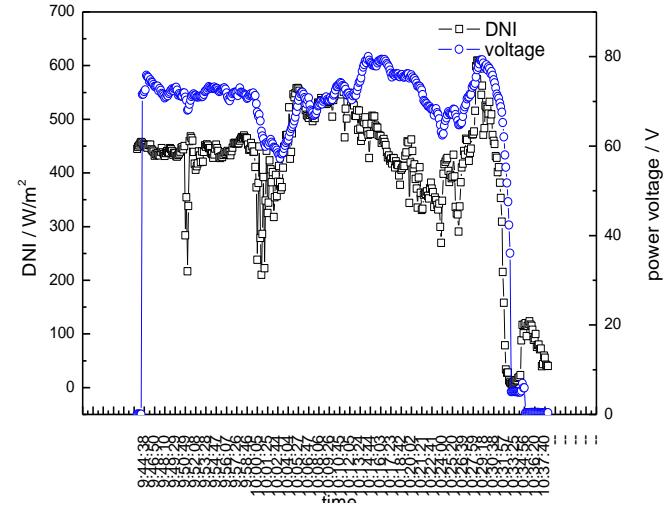


Membrane stretched dish concentrator

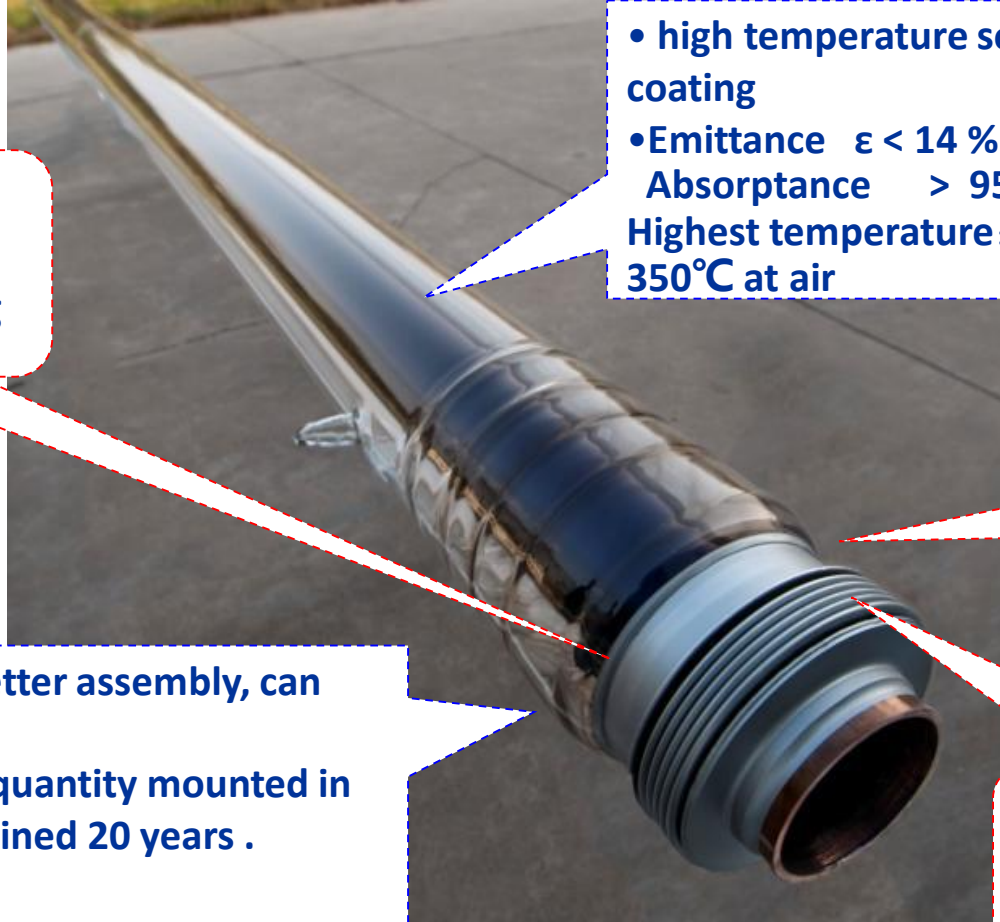


55 m² dish concentrator in Guangzhou

Dish Stirling system(1kWe)



Himin-PTR



- Matched glass-to-metal seals
- Automatic sealing

- high temperature solar-selective absorber coating
- Emittance $\epsilon < 14\%$ at 400°C
- Absorptance $> 95\%$
- Highest temperature: 550°C at vacuum, 350°C at air

Low profile radiation shield.

- New designed getter assembly, can absorb Hydrogen.
- Increased getter quantity mounted in cool place, maintained 20 years .
- Pressure $< 10^{-2}$ Pa

Design with reduced bellow length, active length $> 96\%$



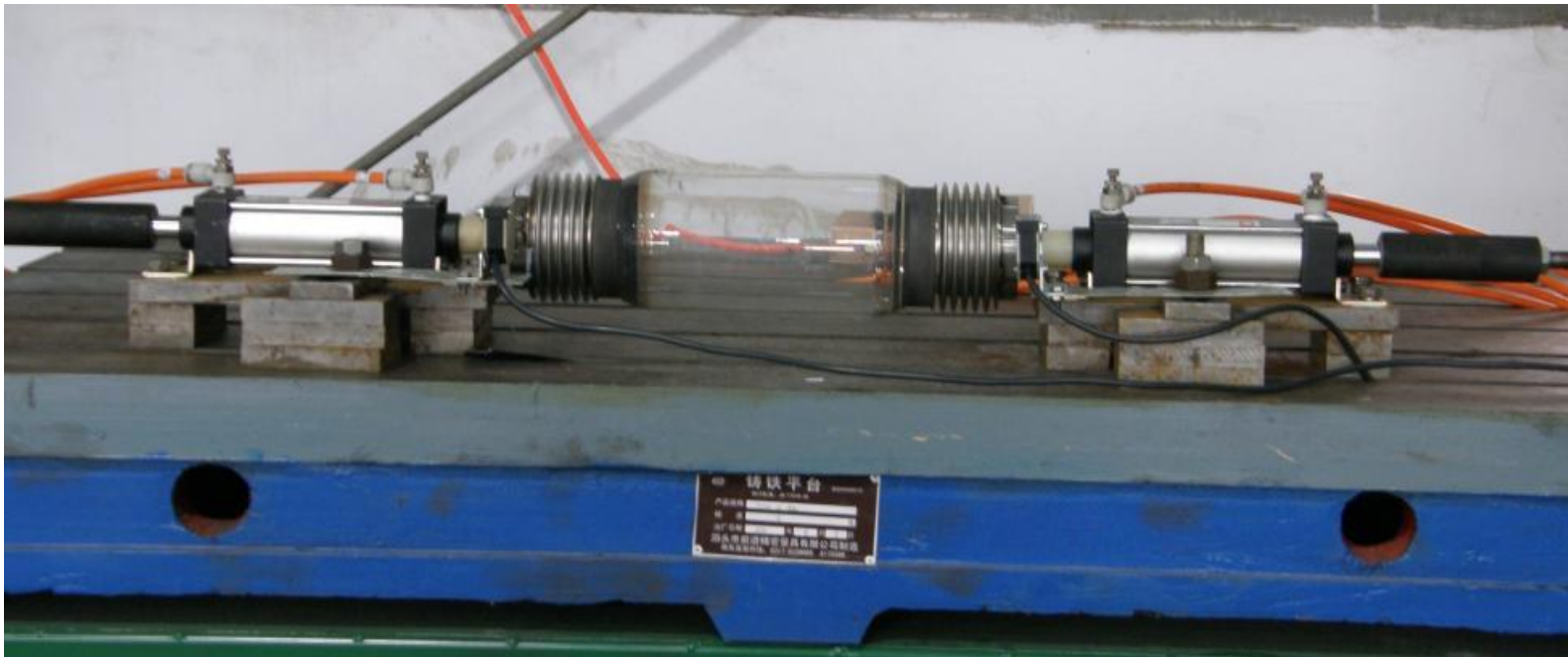
Vacuum performance

- leaking rate $< 1 \times 10^{-11} \text{Pa m}^3/\text{s}$
- Max Vacuum $= 3 \times 10^{-4} \text{Pa}$,
- Vacuum in long time using $> 10^{-2} \text{Pa}$



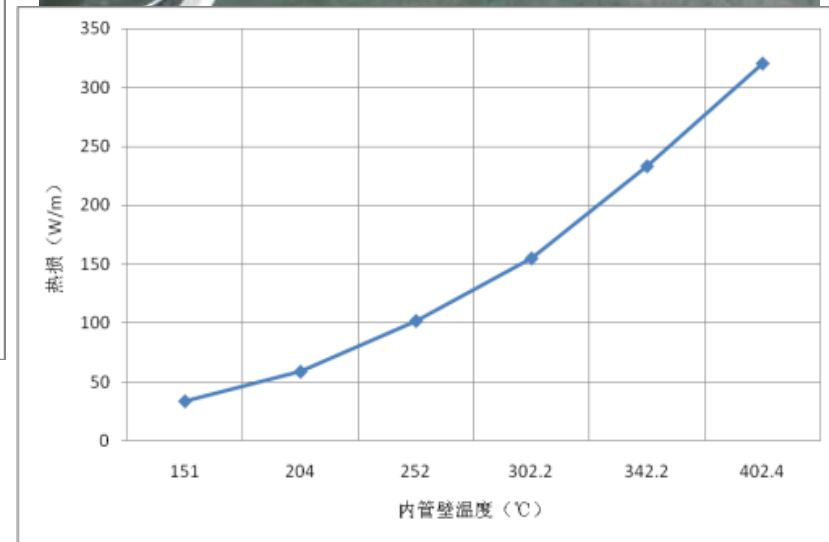
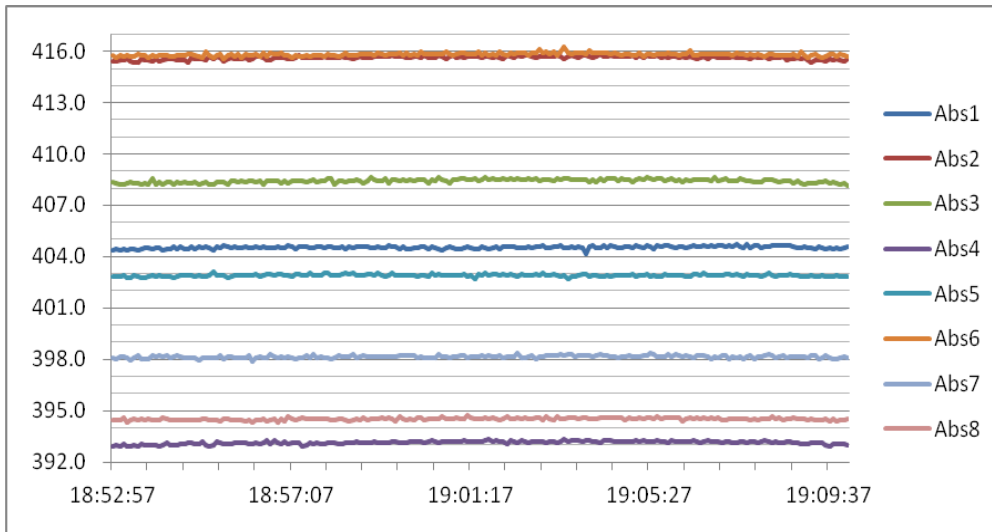
Fatigue life test

- Fatigue cycle: 20times/min
- Positive displacement: 12mm;
- Negative displacement: 10mm;
- results: >40000times , life >25 years



Thermal performance test

➤ Heat loss test: heat loss in 150-400°C operation temperature



100m parabolic trough testing loop



300kW_{th} solar furnace



Solar desalination demonstration

- PT: 200m², steam pressure :2.35MPa
- Testing results of water: 0.35ton/hour



Solar water heating system testing system



Thanks for your attention!

On going projects

- 1MWe parabolic trough power plant (comparison with tower, same power block) , will be finished in 2016
- 1MW_{th} molten salt receiver and 2MW_{th} molten salt thermal energy storage testing loop (two-tank and thermocline) , will be finished in 2015

