CSP – technology options to lower costs

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Solar Research

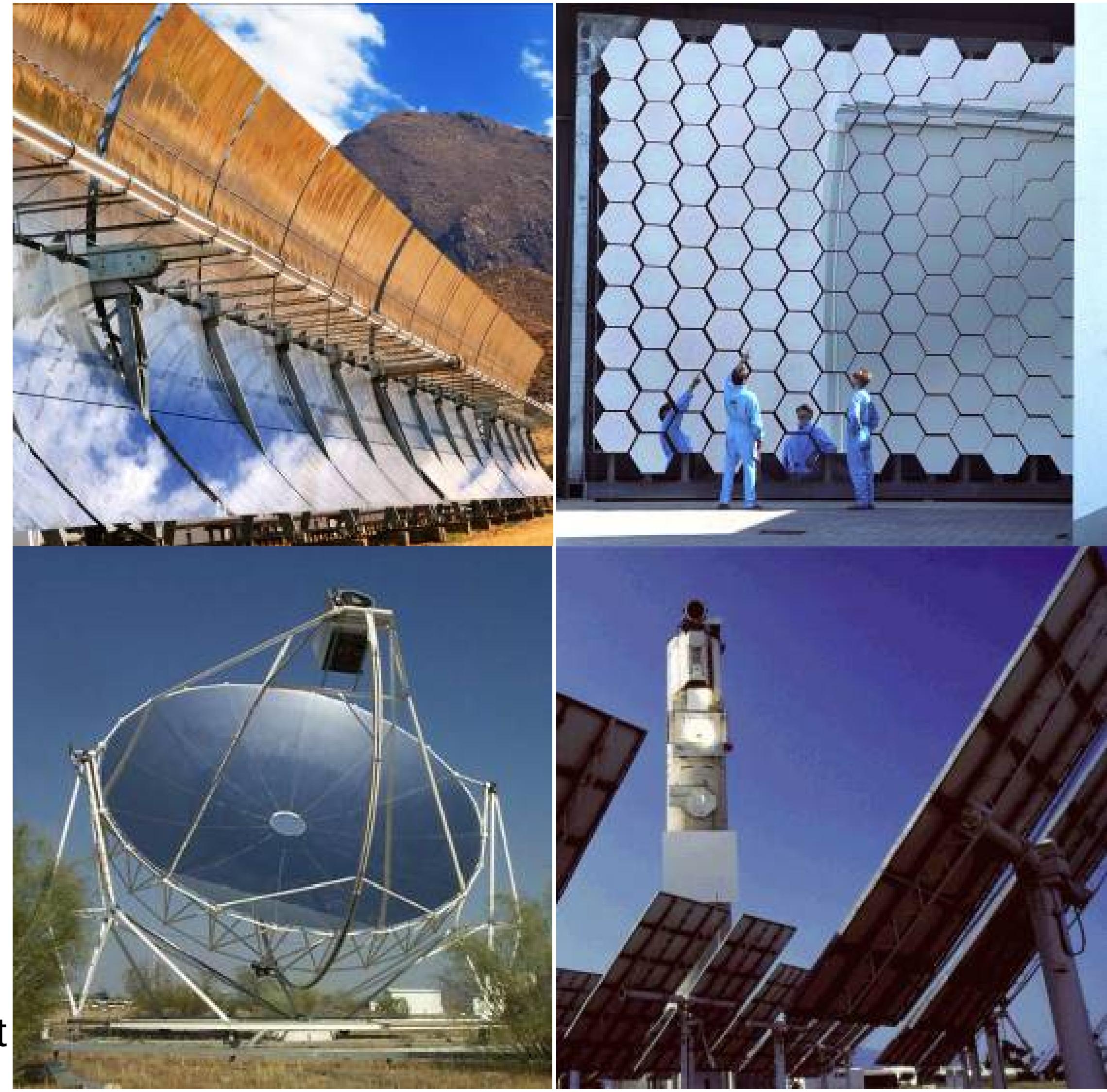
Concentrating solar systems for electricity-, heat- and fuel production

Mission:
Development of concentrating solar technologies for a sustainable energy supply

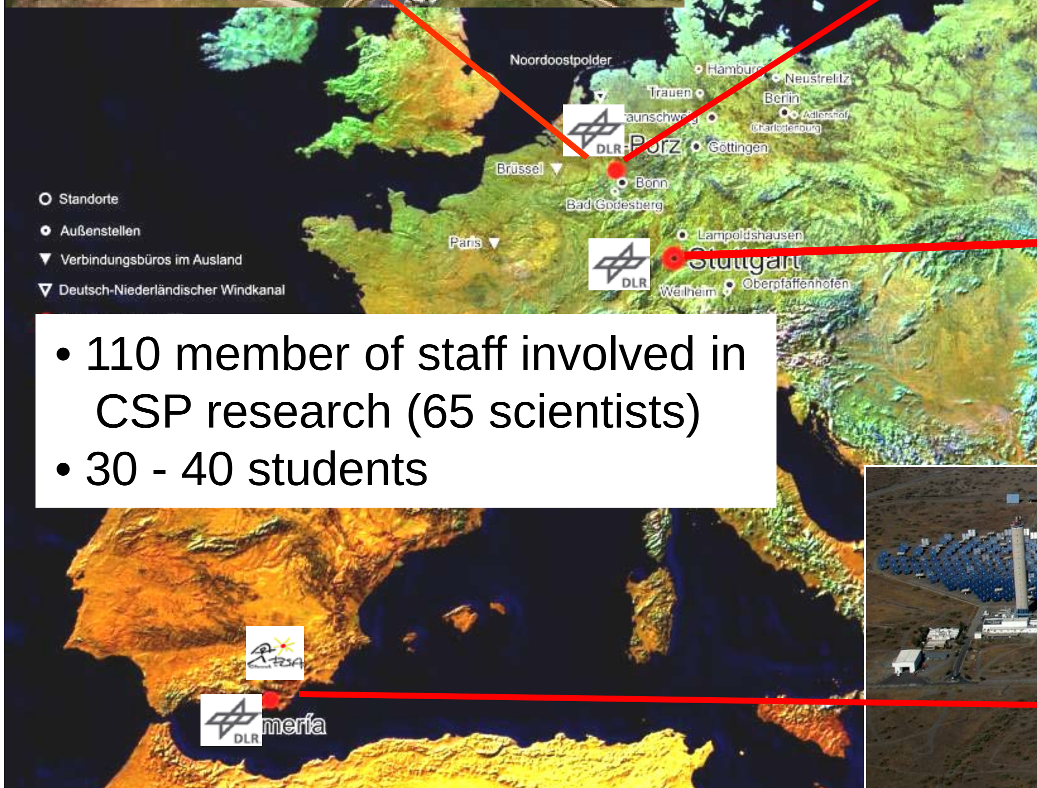
Goals:
Short term:
- R&D services for industry to support the market entry of concentrating solar technologies

Medium term:
- Technology development to achieve LEC reductions for sustainable market penetration

Long term:
- Exploitation of options for long term energy storage and transport by cost effective production of solar fuels



Institute of Solar Research



- 110 member of staff involved in CSP research (65 scientists)
- 30 - 40 students

Innovations are expected across all four CSP technologies and along the entire system value chain

RD&D AXIS AND IMPROVEMENT POTENTIAL BY CSP TECHNOLOGY ALONG THE CSP VALUE CHAIN

CSP plant maturity

	Solar collection	Thermal generation	Storage	Power block
Parabolic troughs	• Mirror materials, size and accuracy • Support structure design	• Receiver characteristics • Alternative working fluid • Higher operating temperature	• Alternative storage media • System design	• Turbine efficiency
Solar Towers	• Field configuration and heliostat size optimization • Optimized tracking system costs	• Alternative working fluid • Higher operating temperature • Improved cycle technology	• Alternative storage media • System design	• Turbine efficiency
Linear Fresnel Systems	• Automatic mirror assembly • Optimized mirrors	• Receiver characteristics • Higher operating temperature	• Storage development	• Turbine efficiency
Parabolic dishes	• Optimized support structure design • Optimized mirror sizes for various solar resources		• Storage development	• Engine reliability • New engines

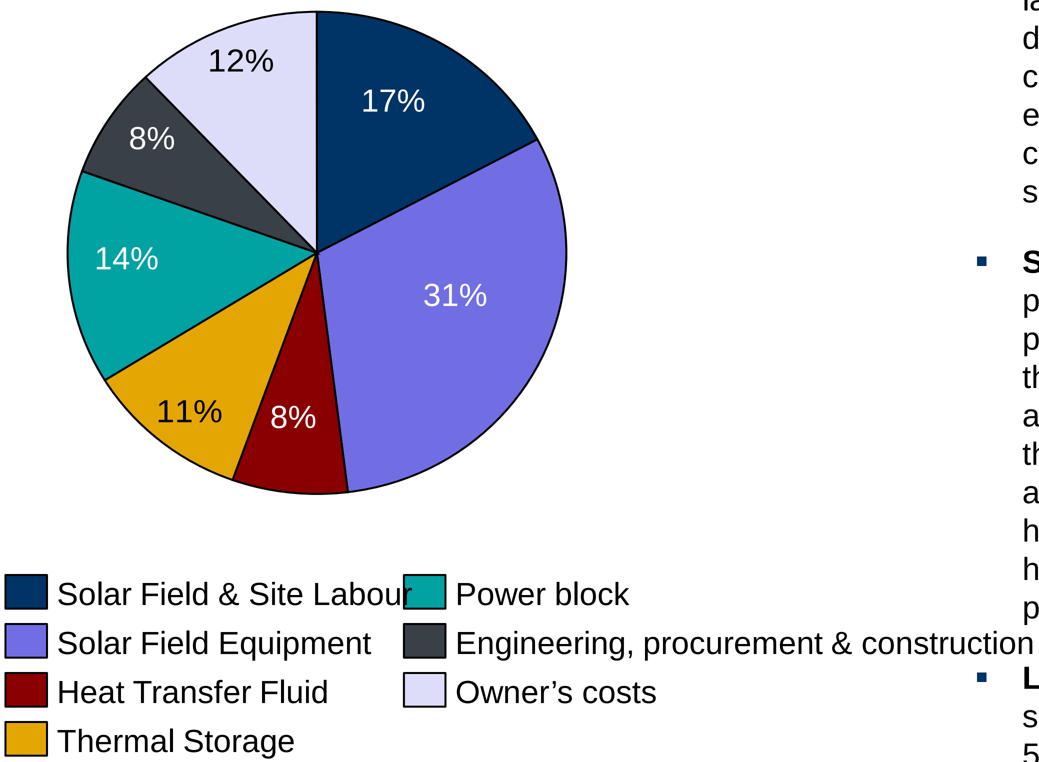
Improvement potential: High Medium Low

Source: EASAC (2011), "Concentrating Solar Power"; ESTLA (2011), "Solar Thermal Energy 2025"

Capital costs are dominated by solar fields equipment and labour for the plant construction

CAPITAL COSTS BREAKDOWN FOR A TROUGH PLANT WITH THERMAL STORAGE

% of total capital cost



- **Cost components** - Solar field accounts for the largest share of the investment cost of CSP, driven by mirrors, receivers and steel construction. Salt, storage tanks and heat exchangers are the main components of storage costs. The heat transfer fluid accounts also for a significant share of the initial capital cost
- **Solar Tower** - The capital cost of a solar tower plant is expected to be lower than that of a parabolic trough system in the future because of the higher efficiency of solar towers, less collector area (heliostats) needs to be installed. Also, thermal storage costs are relatively lower: according to IRENA, the absolute cost of nine hours of storage at a solar tower plant would be half the cost of the same period of storage at a parabolic trough plant.
- **Labour cost** - Labour costs account for a significant share of the initial investment, with a 50MW plant requiring a workforce of 500 people for 24 months This could be lowered if CSP were to be developed in emerging countries.

Note Capital costs are for a 50 MW parabolic trough with 7.5 hours of storage on the model of the Andasol plant in Spain
Source: IRENA (2012), "Renewable Energy Technologies: cost analysis series. Concentrating Solar Power"

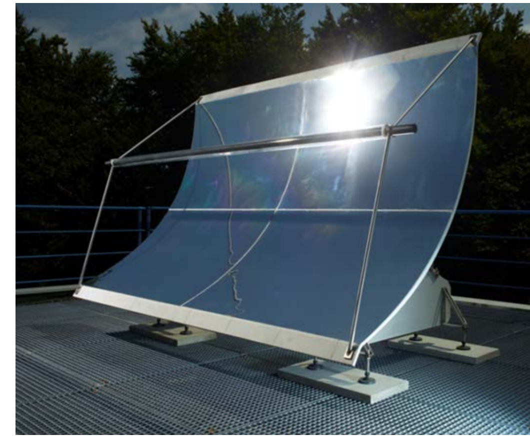
Collector Structure Development

	LS-1	LS-2	LS-3	Euro-trough	Helio-trough	Sener-trough 1	Sener-trough 2	Ultimate Trough
Start of development	1984	1985	1989	1998	2005	2005	2006	2009
Aperture width in m	2550	5000	5,77	5,77	6,78	5,77	6,87	7,51
Length per Module/SCE in m	6,3	8	12	12	19	12,27	13,23	24
SCA length in m	50,2	47,1	99	147,8	191	-	158,8	242,2
Focal length in m	0,68	1,40	1,71	1,71	1,71	1,71	2	-
Torsion force carried by	Torque tube	Torque tube	V-truss Frame-work	Torque box	Torque tube	Torque tube	Torque tube	Torque box

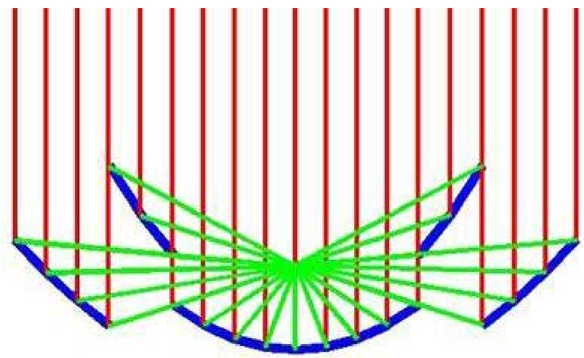


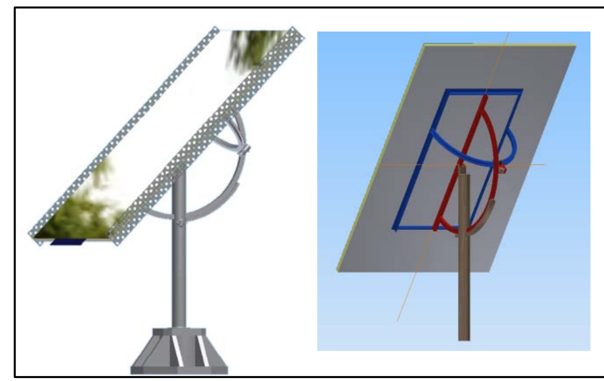

Collectors

- New materials



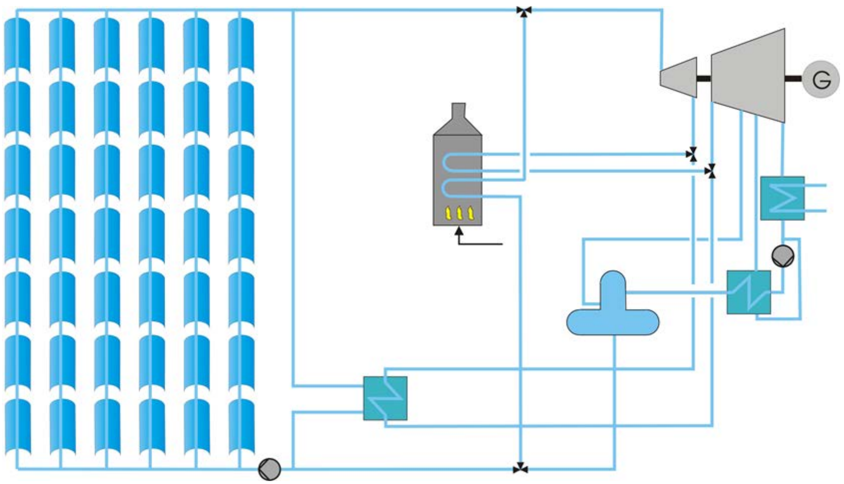
- New designs

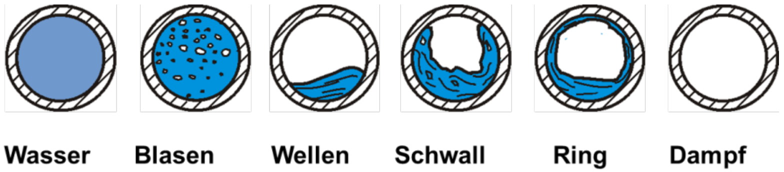




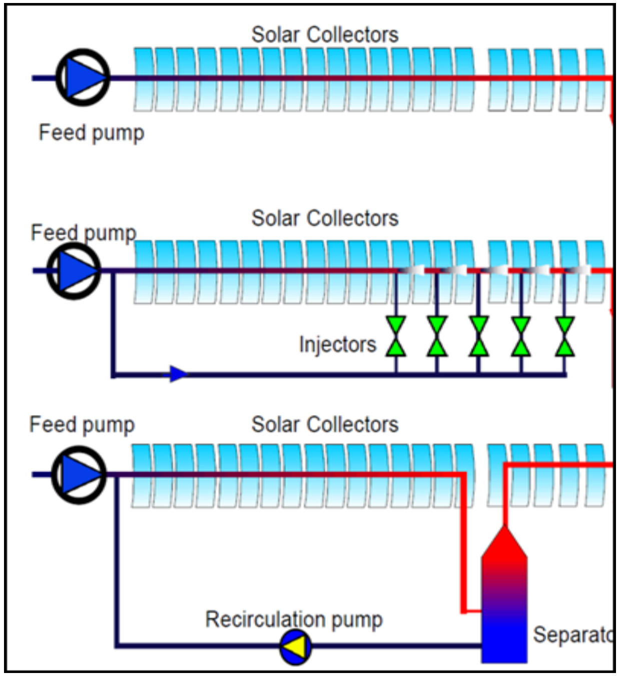
- Efficient performance verification

Direct Steam Generation in Parabolic Troughs



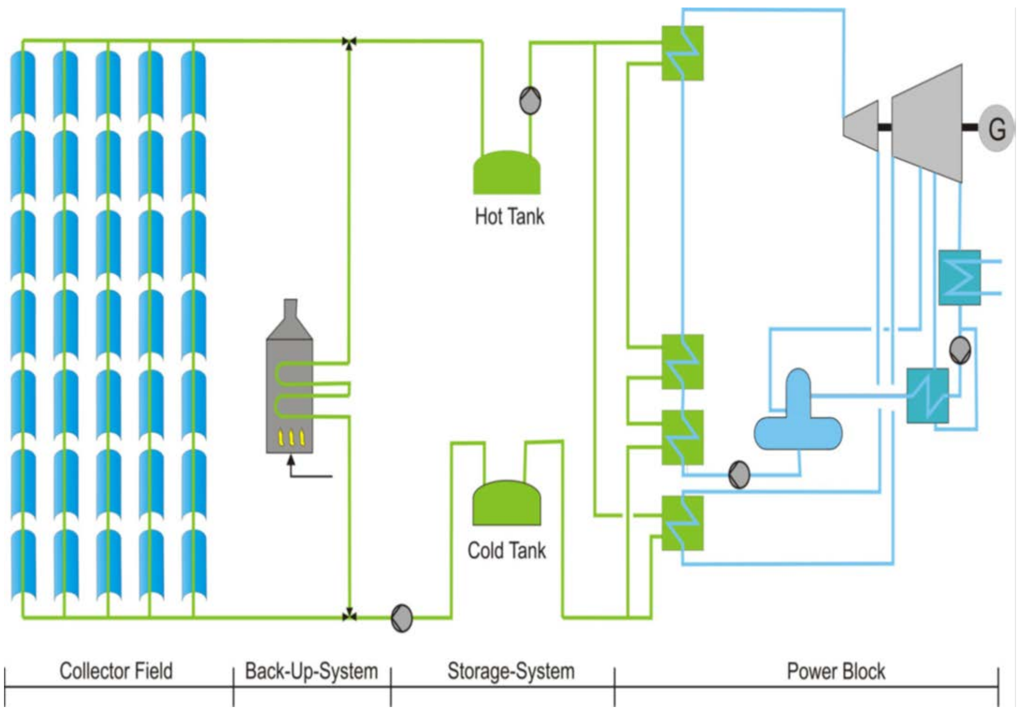


Two Phase Flow is a challenge



Several options exist to control the system

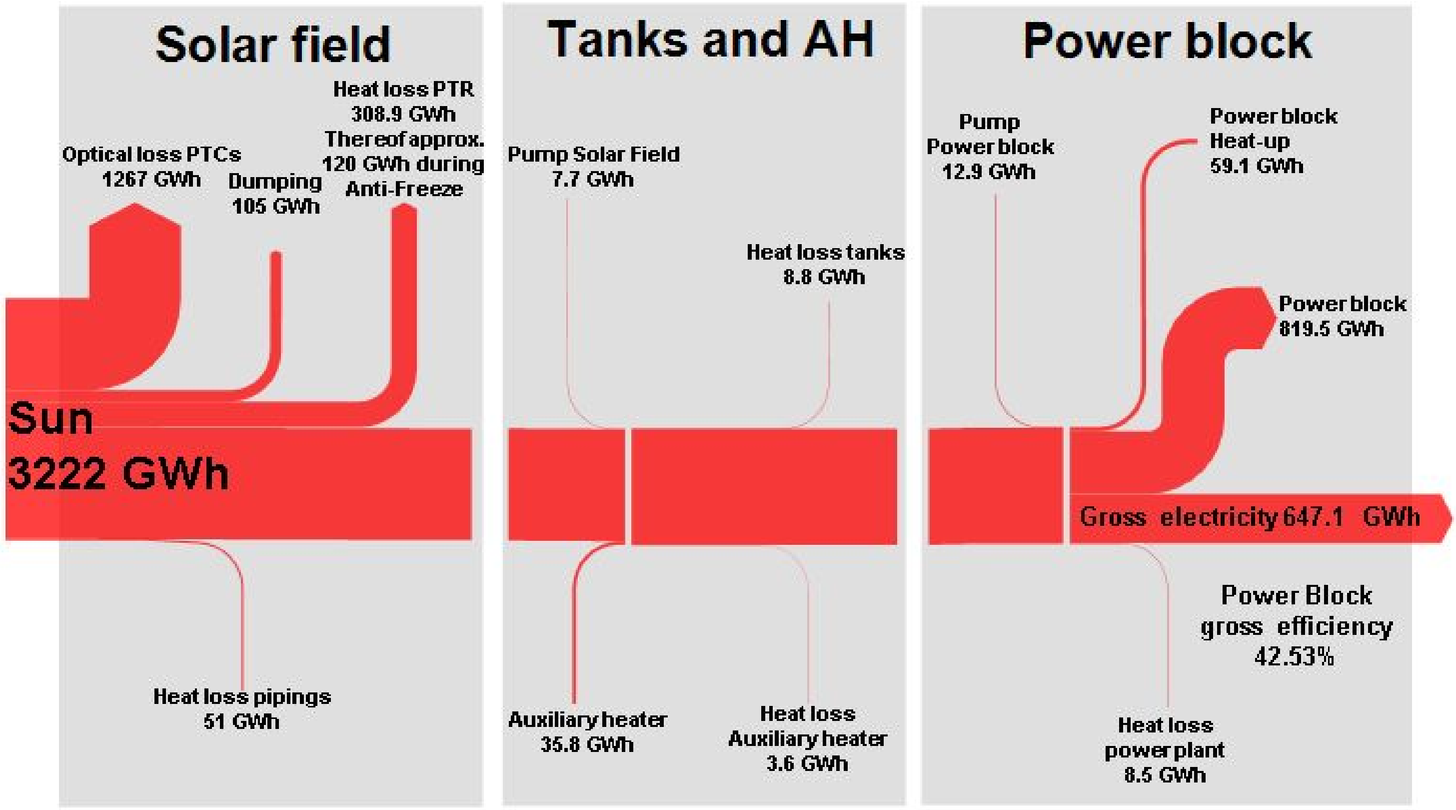
Molten Salt Heat Transfer Fluid in Parabolic Troughs



Challenges

- Freeze protection at 220° C in whole collector and piping system
- Overnight heat losses
- Corrosion / material selection
- Salt mixtures with low melting point

Molten Salt
Annual Heat Balance



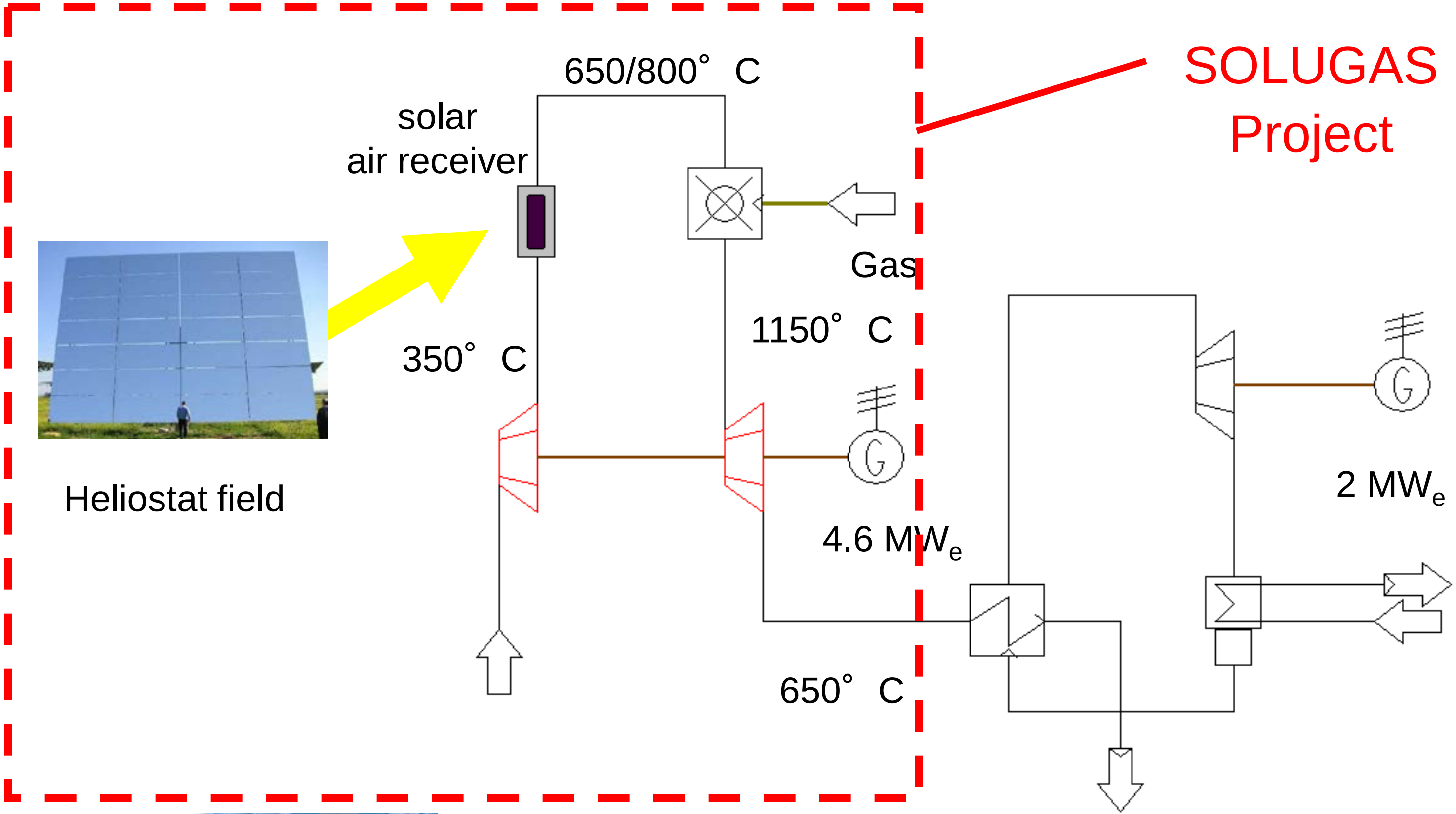
125 MW, 12 hr storage

DSG or Molten Salt / preferred applications

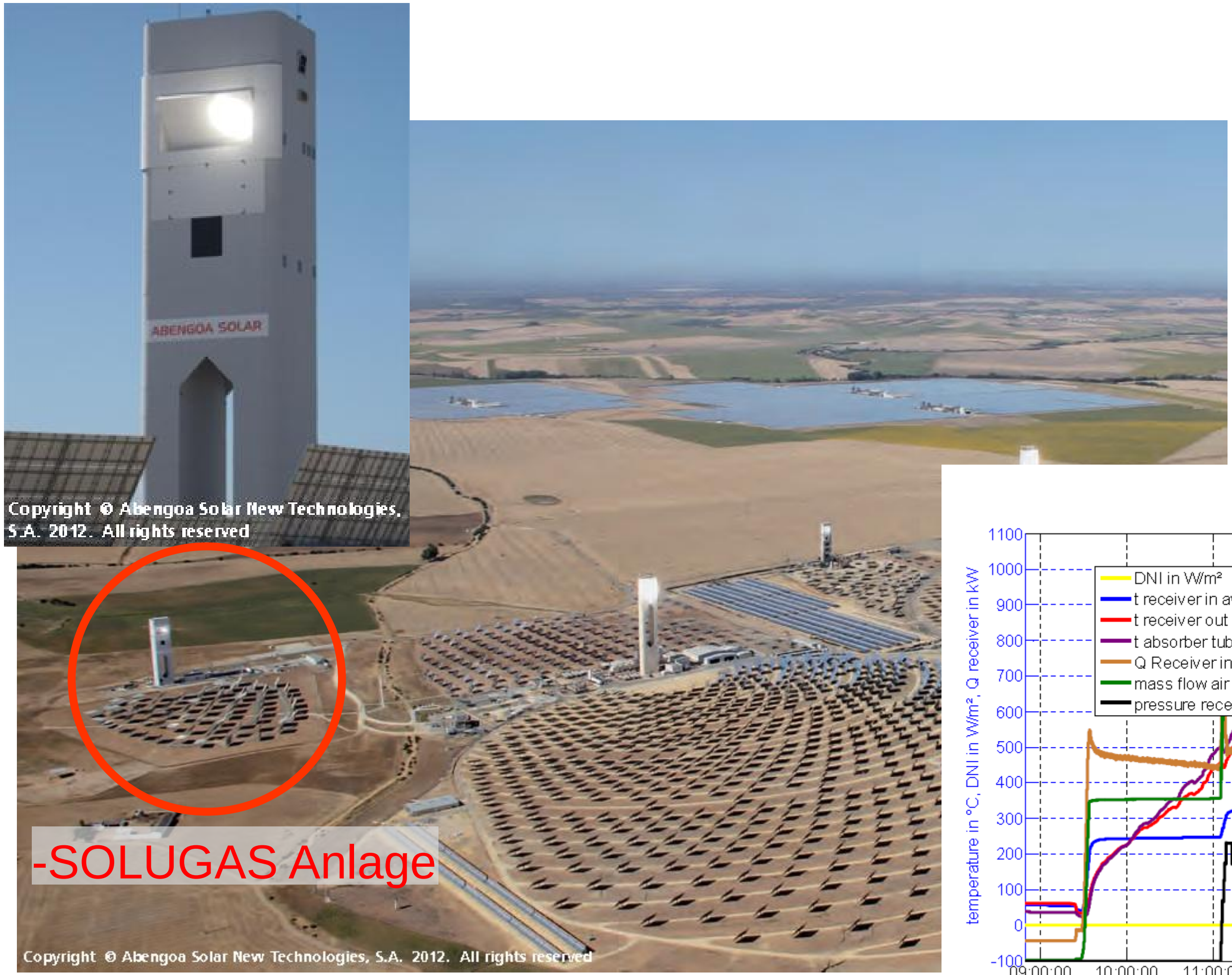
- DSG
  - Smaller plants / decentralized systems / co-generation
  - Hybrid systems
  - ISCCS
- Molten Salt
  - Large plants
  - High storage capacity
  - High DNI

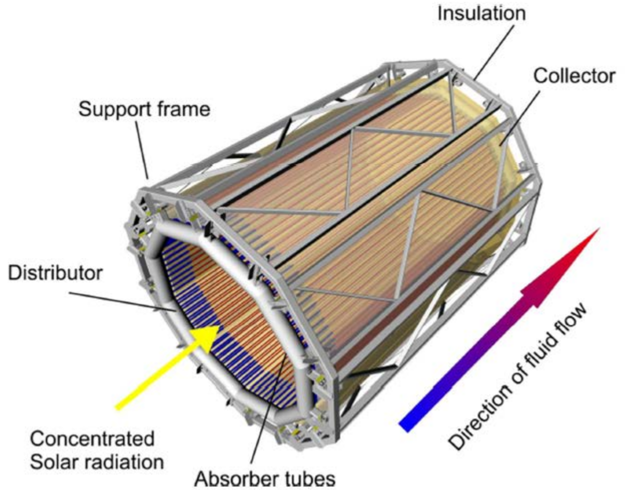
Solar-hybrid Gas Turbine Power Plant

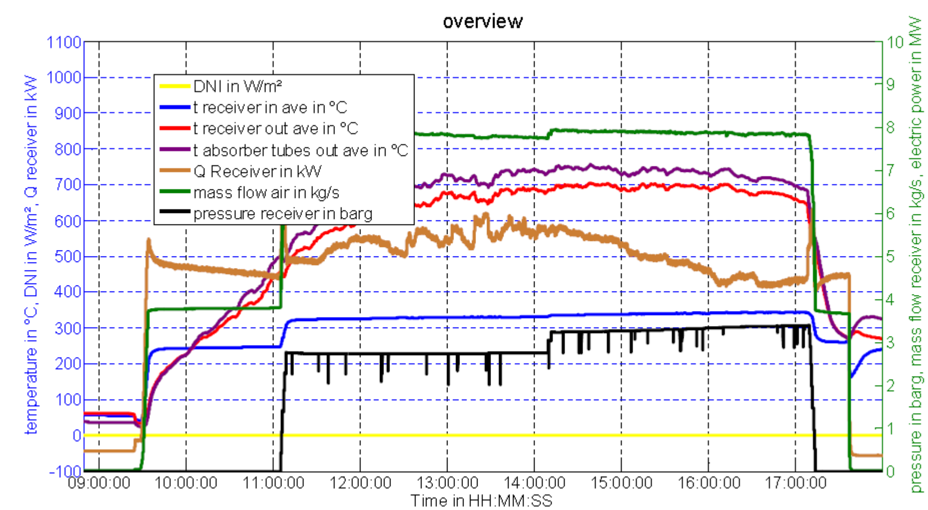
- Industry partner: ABENGOA
- Demonstration plant near Seville, Spain
- Solar heating of compressed air



Highlights 2012: SOLUGAS achived 700° C

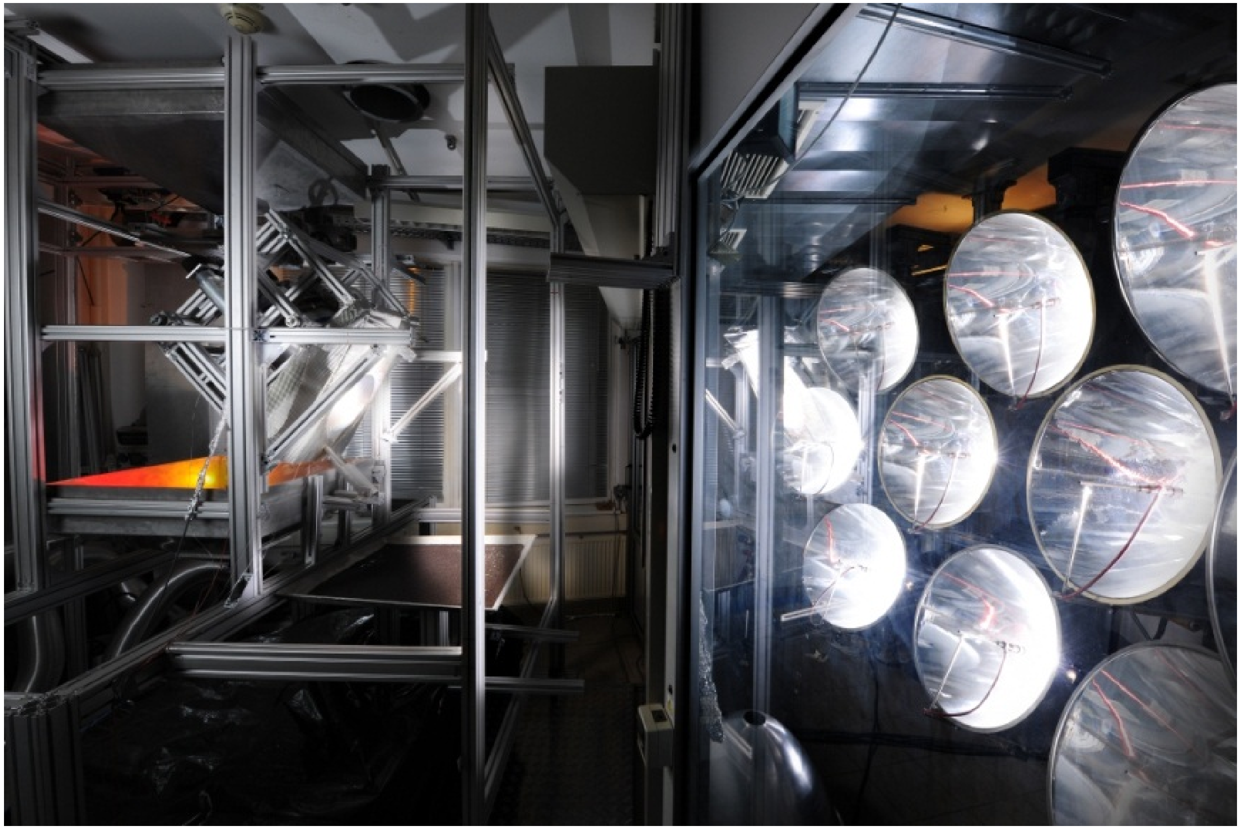






Future Option: Particle receiver

1st Test campaign: Up to 900° C demonstrated in DLR High Performance Solar Simulator

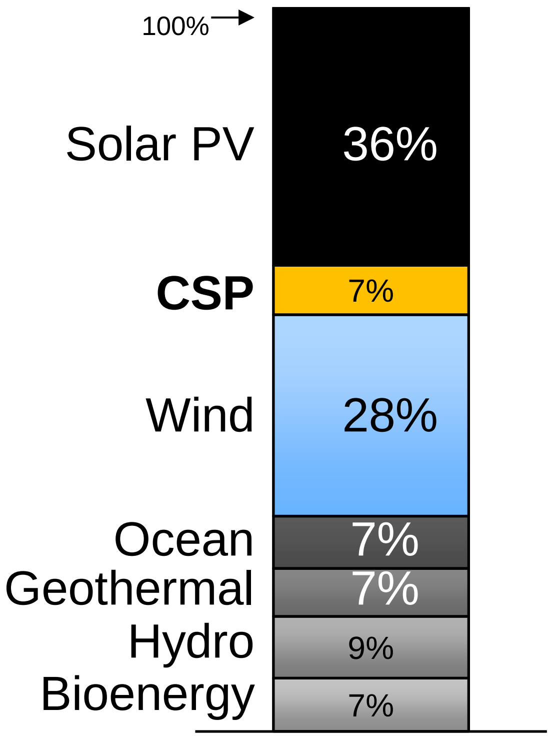


How to speed up innovation cycles?

In the OECD, CSP receives the smallest share of public R&D funding for renewables

OECD PUBLIC R&D FUNDING FOR RENEWABLES
2010

USD 1,500 million



PUBLIC OECD R&D FUNDING FOR CSP
2010

- Total public R&D funding for CSP in the OECD reached $104 million in 2010 versus $542 million for Solar PV and $424 million for Wind
- CSP is less mature than Solar PV and Wind. As a result, the IEA estimates that CSP requires continued government investment in R&D, coupled with support to foster early deployment
- The US, Europe and Australia account for most of public R&D funding, despite the recent interest of China, South Korea, Abu Dhabi (with Masdar) and Chile

- Increase public and private R&D funding

- Close co-operation between Industry and Researchers

- Support demonstration projects

Source: SBC Energy Institute Analysis (2012); IEA, Tracking Clean Energy Progress (2012)