

Status of STE Industry and Markets and ESTELA's Solar European Industry Initiative

Dr. Luis Crespo

President of ESTELA

Secretary General of Protermosolar





ONCE UPON
A TIME

There were well intentioned policy makers in some few industrialized countries who wanted to have some contribution of Renewable Energies on their electricity generation mix

Two technologies - which were conceptually modular - profited from their easy installation and from the virtuous circle “volume - cost reduction”



They were widely deployed and reached affordable cost figures per kWh. It looked so nice that people started dreaming with an emission free generation system

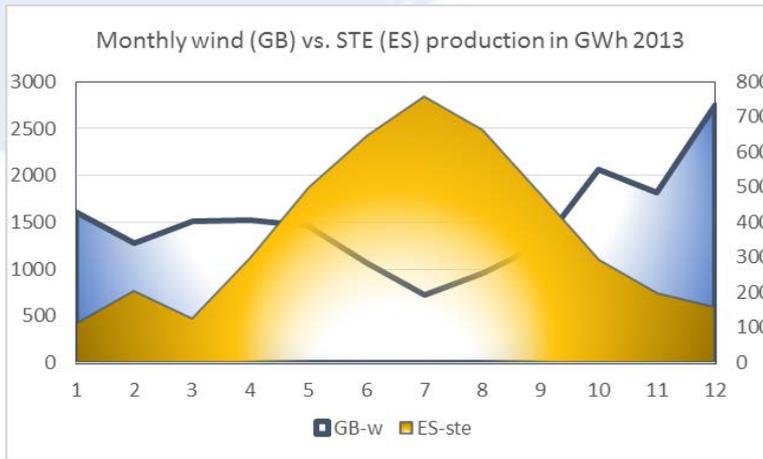
But these technologies couldn't satisfy the demand at all times of day and more and more conventional power plants needed to be built. Therefore people woke up from their dreams and started to consider **Solar Thermal Electricity plants** as key for the future

The vicious circle of “variable” generation technologies



The essential role of STE

STE is the necessary piece for the “nearly 0 emissions” generation mix, which will be a must in 30 years or sooner



Good complementarity with wind at local and at wide regional level

Although PV has still room for new power plants -and even for hybrid STE-PV plants- PV panels will be mainly deployed in a decentralized way in the future



Biomass, Geothermal and big Hydro will complement Solar and Wind depending on the country

The value of STE with Storage

The value of STE plant with storage has to be contemplated from two different perspectives

From the system operator point of view:

- Dispatchability
- Grid stability
- Ancillary services

Recent studies in the USA provided an estimation of c\$ 3-4 / kWh differential value compared with non-dispatchable generation systems

From the owner point of view

- Electricity can be dispatched when the pool price is higher
- Then the necessary gap to be filled up can be considerably reduce when promoting Projects and asking for some public support

The issues for a quicker STE deployment

- ❑ Current costs
- ❑ Limited project pipe line at world level
- ❑ Long development and construction times

But ...

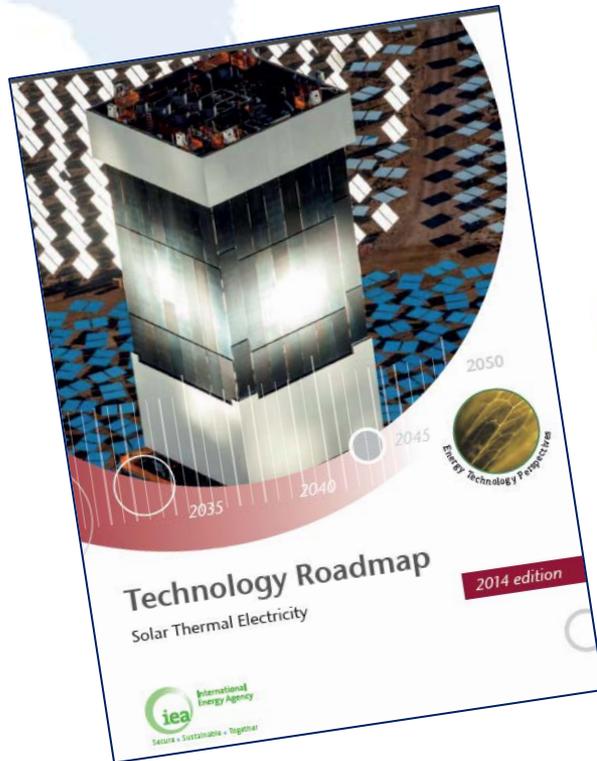
There is light at the end of the tunnel

Expected rump up in 5 years

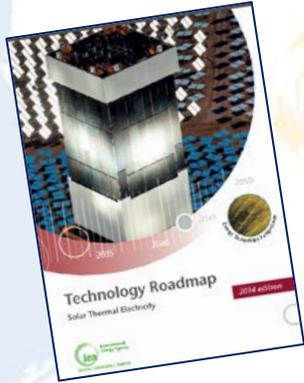




- ✓ The requested PPAs for the two new STE plants in Morocco (200 MW PT & 150 MW T) were \$c 16 / kWh

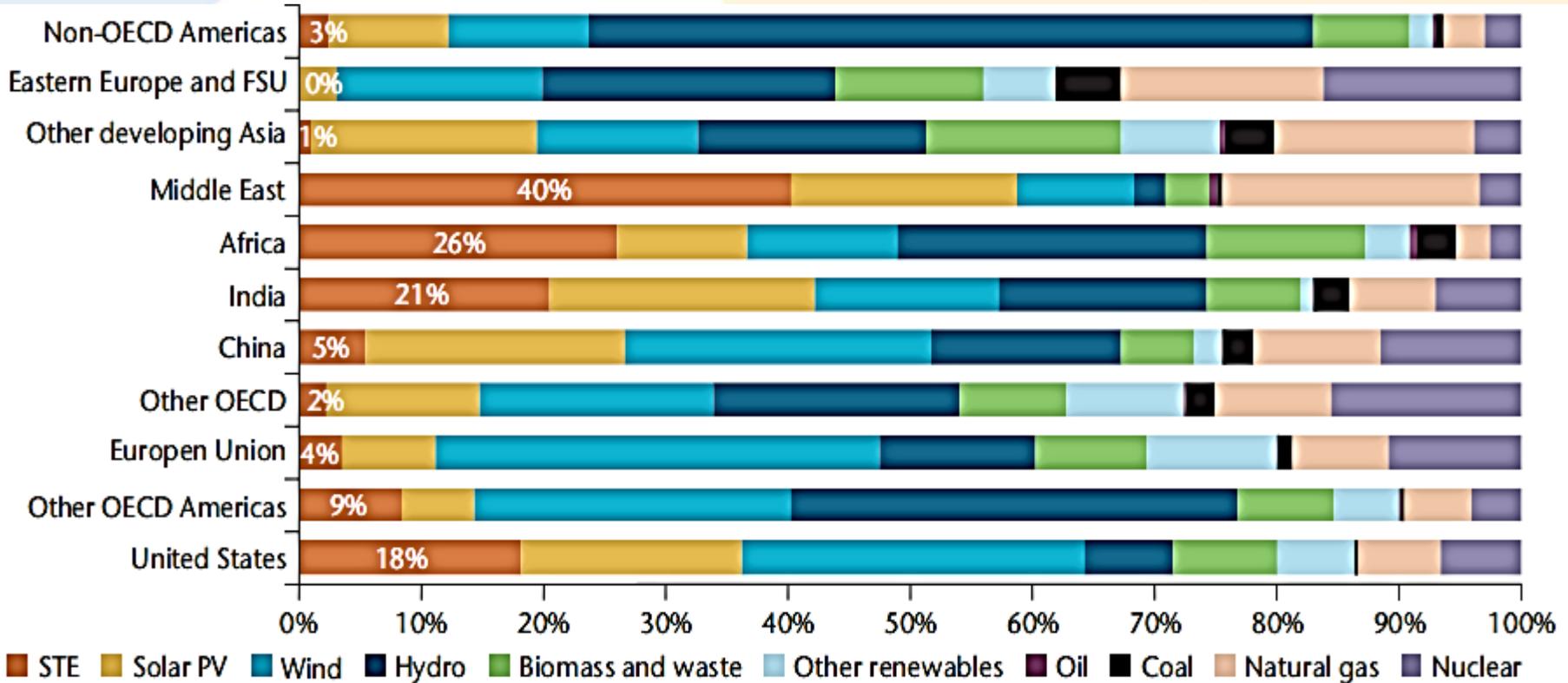


- ✓ The IEA foresees 11% of STE contribution to the world electricity generation by 2050
- ✓ In the Middle East and Africa STE will be the dominant technology by 2050 while in the USA STE and PV will play a similar role.
- ✓ The STE installed power by 2050 would be around 1.000 GW.



IEA STE Roadmap

STE plants will be the dominant technology in the future for Middle East and African countries and they will play a significant role in other regions



Debunking the myth on the “always lower” STE deployment level



❑ Industrialized countries

Intermittent technologies (Wind, PV) contribute to savings on fossil fuels without longer-term considerations. Overcapacity in the system lead to curtailments of R.E. installations or restrictions for conventional plants

STE will become essential when phasing out pollutant conventional plants

❑ Quick emerging countries

Substantial additional generation capacity (2 or 3 times over the next 10-20 years) will be required. This can't be firmly supplied by intermittent R.E. technologies alone and new backup power plants have to be considered when planning the investments of the whole electrical system.

In this context STE plants - with storage and/or hybridization - will provide major advantages besides their macroeconomic impact

STE could be considered as the best choice today

1. Technical

STE is the only dispatch-able and grid-friendly renewable technology with potential enough to firmly meet the electricity needs worldwide in order to achieve an almost carbon free generation system.

A wise mix with other R.E. technologies will be the right choice.

2. Local Economic Development

Local content of STE plants - and conversely its GDP contribution - should be one of the main drivers behind the coming supporting policies in most countries of the Sunbelt.

3. Affordable cost

STE plants are currently a cost competitive choice to supply the increasing power demand of emerging countries compared with “investing twice” as it would be the case regarding other fluent R.E. technologies + CC backup. Furthermore STE plants will show important reductions when approaching similar values of Wind (400 GW) and PV(200 GW) from their current 4 GW

Situation of commercial STE in EUROPE



NREAP forecast in 2010



SPAIN

Facts and Figures

- Completion of the last 7 previously approved plants (350 MW) in 2013
- Total power in operation **2300 MW** (mainly parabolic trough, 40% with storage and 60% without storage).
- Proven operational experience. Positive reference for other countries

Investor's Concerns

In the last two year several retroactive measures have been approved including the recent substitution of the FiT by a return on the investment payment

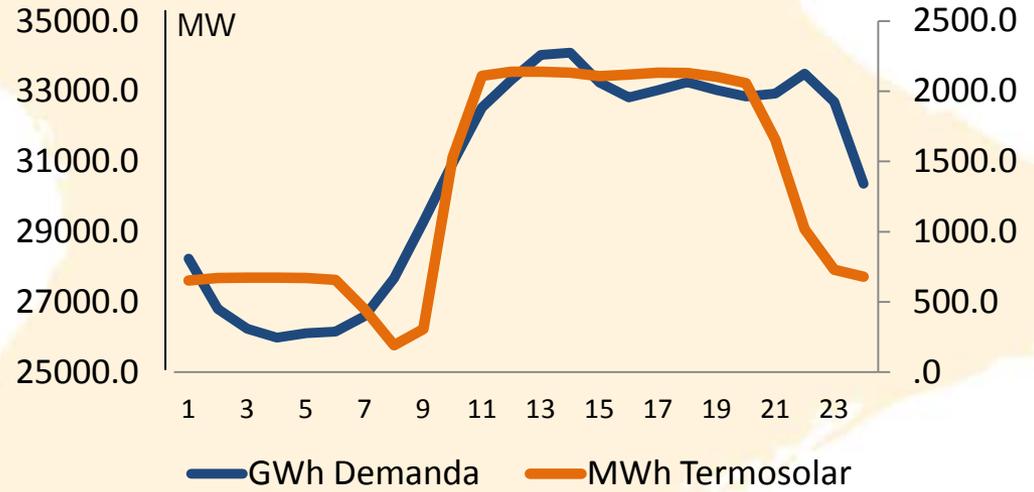
Regarding prospects, no more plants envisaged in the short term (Overcapacity + Moratorium).

Further deployment could be based on the Cooperation Mechanisms of the RES Directive.

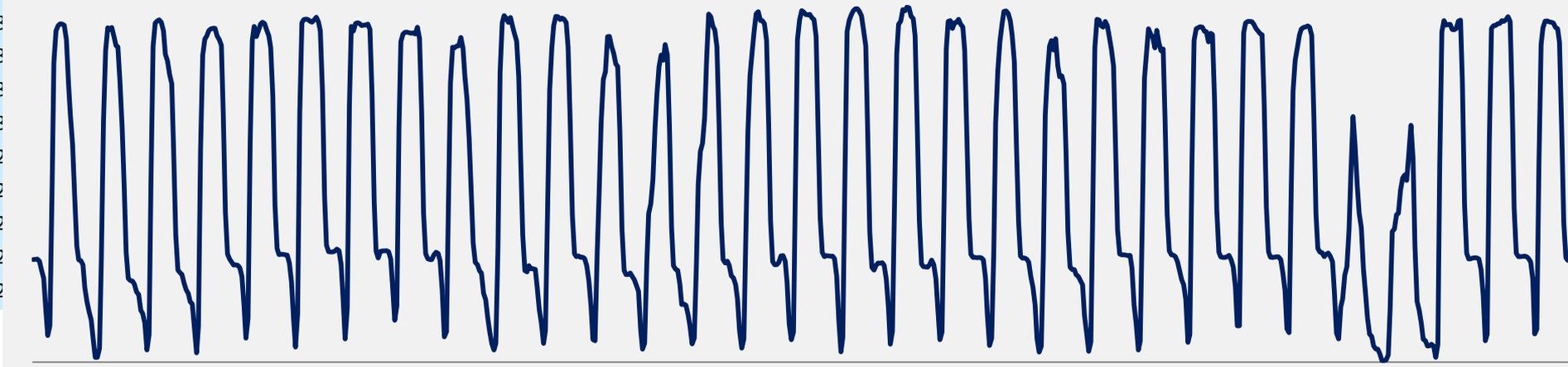
Important milestones in 2014

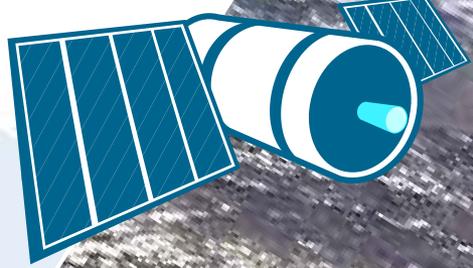
- ✓ Installed Power 2300 MW
- ✓ Max. contribution 8,5 %
(August the 3th at 18:00)
- ✓ Max. daily contribution around 5%
(many days in July and August)
- ✓ Monthly production 4,2%
(860 GWh in August)

July the 9th 2014



July





◆ In Operation (50 plants / 2300 MW)

Lérida

Ciudad Real

Cáceres

Badajoz

Córdoba

Granada

Murcia

Alicante

Sevilla

Málaga

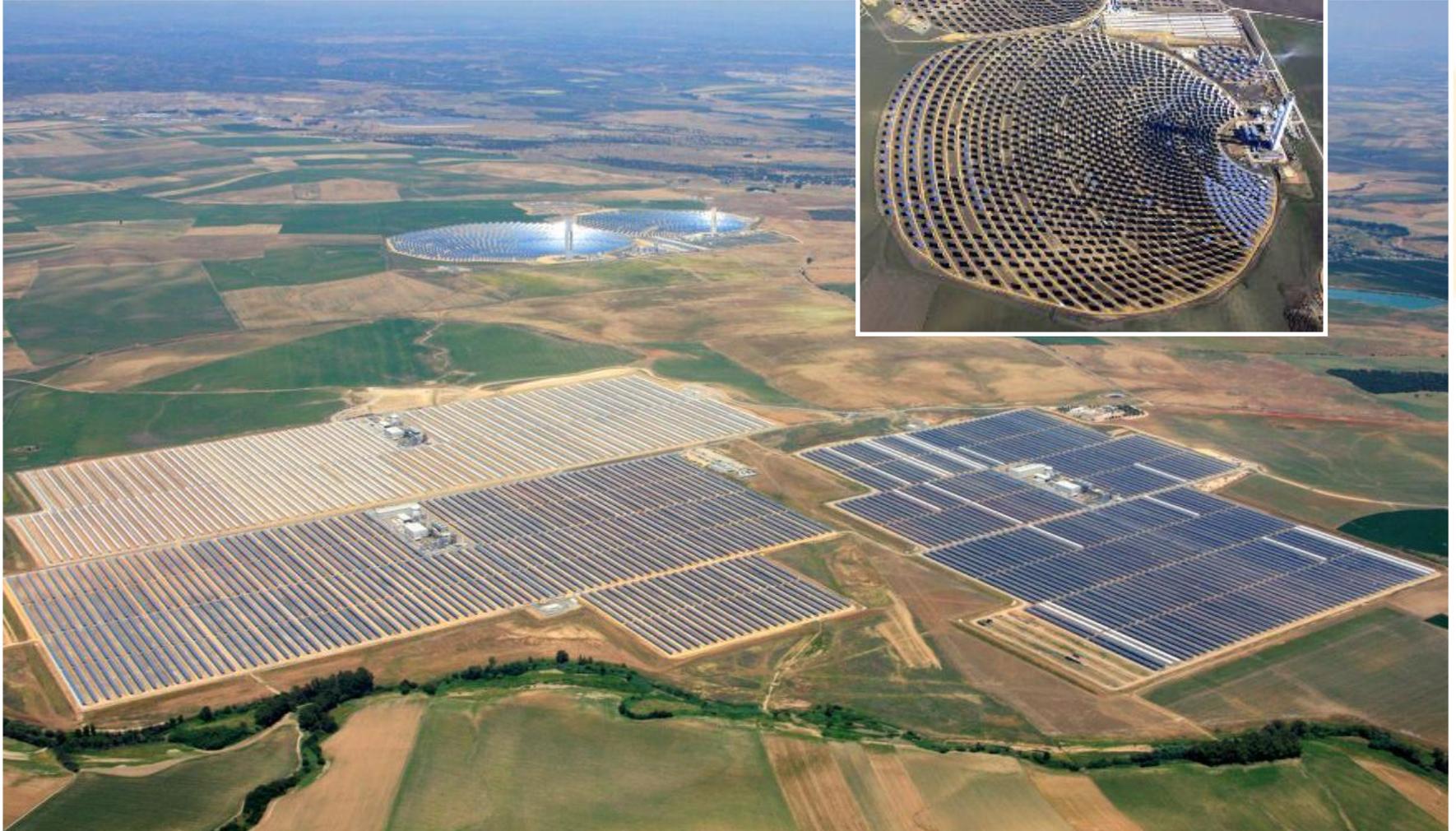
Almería

Cádiz

SOLNOVA 1, 3 & 4 / PS 10 & PS 20, Seville

3 x50 MW

11MW, 1h St
20 MW, 1h St



MANCHASOL 1 & 2 Ciudad Real

2 x50 MW, 7 h St.



GEMASOLAR, Seville

20 MW, 15 h St.



PUERTO ERRADO 1 y 2, Murcia

1,4 MW



30 MW



Borges Blanques, Lérida

22 MW Hybric Plant (Solar/Biomass)



Comparison between premiums received and returns to the Spanish economy in 2012

- + Leadership of the Spanish industry
- + Attraction of foreigner investment
- + Reduction of electricity pool price
- + Regional economical convergence



Unemployment subsidies avoided: 132 M€

Savings in CO2 rights: 17 M€

Savings from replacing imported fossil fuels: 131 M€

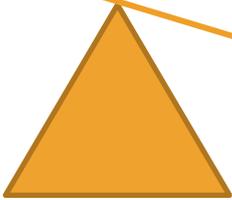
Fiscal contribution (Social Security, Corporate, Personal and Local Taxes,) 772 M€

Contribution to GDP: 1835 M€

Premiums: 927 M€



Supporting STE was a wise decision for Spain





FRANCE (FiT)

Current projects:

- ALBA NOVA 1 located at Corsica Island of France, a 12 MW Fresnel CSP technology started construction in April 2014. Commissioning and startup is expected to happen by 4Q2015.
- LLO located at the French Pyrenees, a 9 MW Fresnel CSP technology shall get all permit by 4Q2014, and construction is expected to start by 1Q2015 for a Commissioning and start up by mid 2017.



ITALY (FiT)

Projects in advanced promotion stage

Sicily

- 50 MW tower plant in Mazzara
- 12 MW parabolic trough with molten salts in Gela

Sardinia

- 55 MW parabolic trough with molten salts in Villasor
- 55 MW parabolic trough with molten salts in Gonnosfanadiga

Main land

- 50 MW parabolic trough with oil in Banzi (Basilicata)

There are other initiatives on solar concentrating projects smaller than 5 MW based on Fresnel technology for both electricity production and heat applications.

Pilot ISCC 5 MWe





CYPRUS (FiT pending)

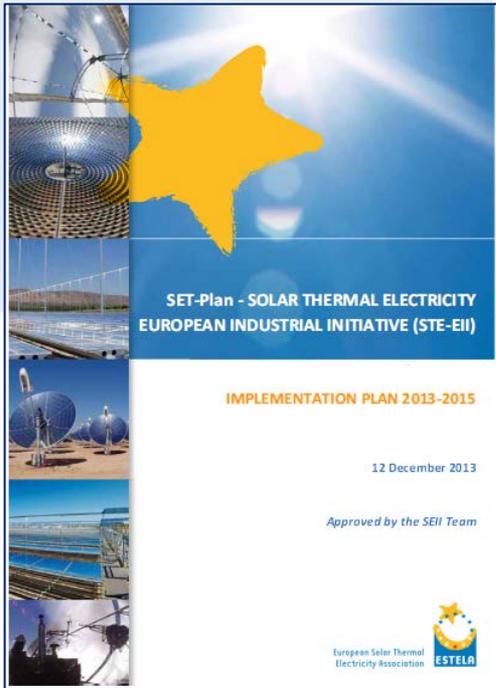
Current Projects

- EOS project, 25 MW consisting in a array of small towers with Australian innovative graphite storage system. It has received support from the NER 300 initiative. Civil works started already.



Greece (FiT)

There were two projects approved under the NER 300 initiative - MINUS tower in Crete and MAXIMUS dish in main land – although no promotional advances can be referred but doubts regarding the current political situation



Under the SET PLAN / HORIZON 2020 umbrella
The overarching selected KPI is PPA instead LCOE

1. R&D Projects (Strategic Research Agenda)

- Increase efficiency and reduce costs
- Increase dispatchability
- Improve environmental profile

2. Innovation in STE Plants in Southern Europe

- “First of its kind” commercial project under Cooperation Mechanisms of the RES Directive

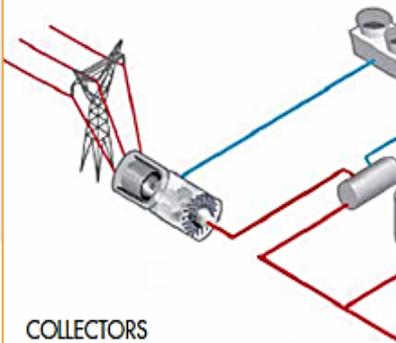
Another supporting European programs

- ERANET
- STAGE STE
- SFERA II
- EU-Solaris

Companies are doing lot on their own applying for resources at European, National or Regional levels

PARABOLIC TROUGH COLLECTORS

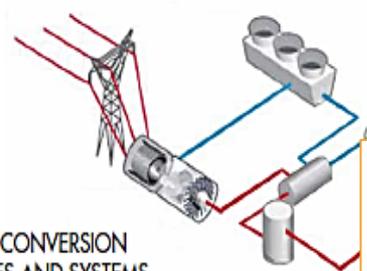
Research topics to be investigated to reach objective 1 for parabolic trough collectors



- COLLECTORS**
- Scale-up effect
 - Better collector design and manufacture
 - Better solar field control
 - Autonomous drive units and local controls

CENTRAL RECEIVERS

Research topics to be investigated to reach objective 1 for central receivers



- NEW CONVERSION CYCLES AND SYSTEMS**
- Brayton cycles
 - Combined cycles and supercritical steam cycles
 - Hybridisation with biomass
 - Secondary concentrators

RECEIVER

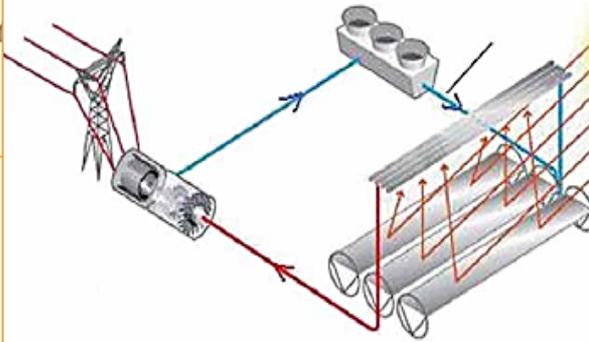
- Advanced high temperature receiver (direct absorption)
- New engineered materials (ceramic tubes)

HEAT TRANSFER FLUID

- Molten salt for supercritical steam cycles
- Air and CO₂ as primary fluids
- Direct superheated steam
- Particle receiver systems

LINEAR FRESNEL REFLECTORS

Research topics to be investigated to reach objective 1 for linear Fresnel reflectors



CONTROL AND DESIGN

- Better tracking options
- Hybridisation of tower and Fresnel technologies

RECEIVERS

- Evacuated tubular receivers
- New generation of non-evacuated tubular receivers

MIRRORS

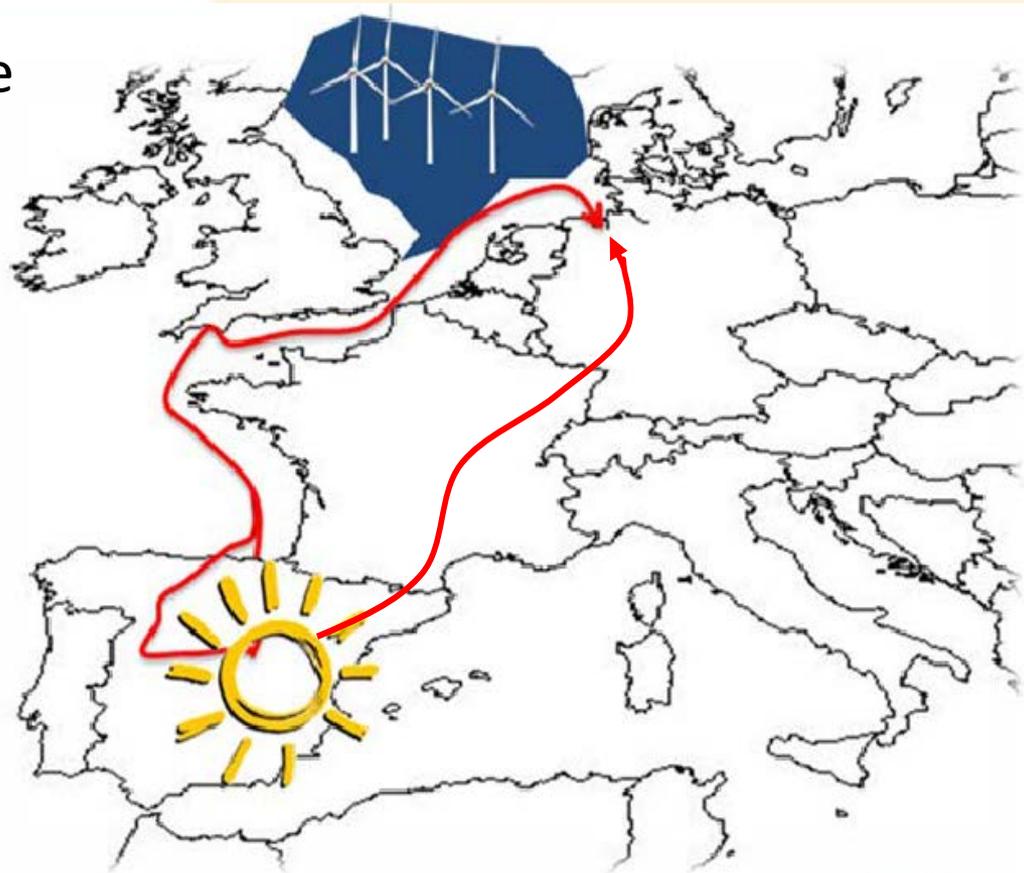
- Second stage concentration
- Thin films on curved support surfaces

HEAT TRANSFER FLUID

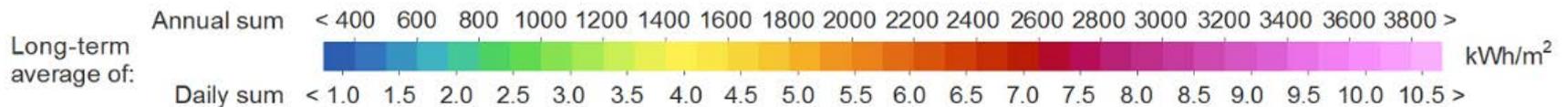
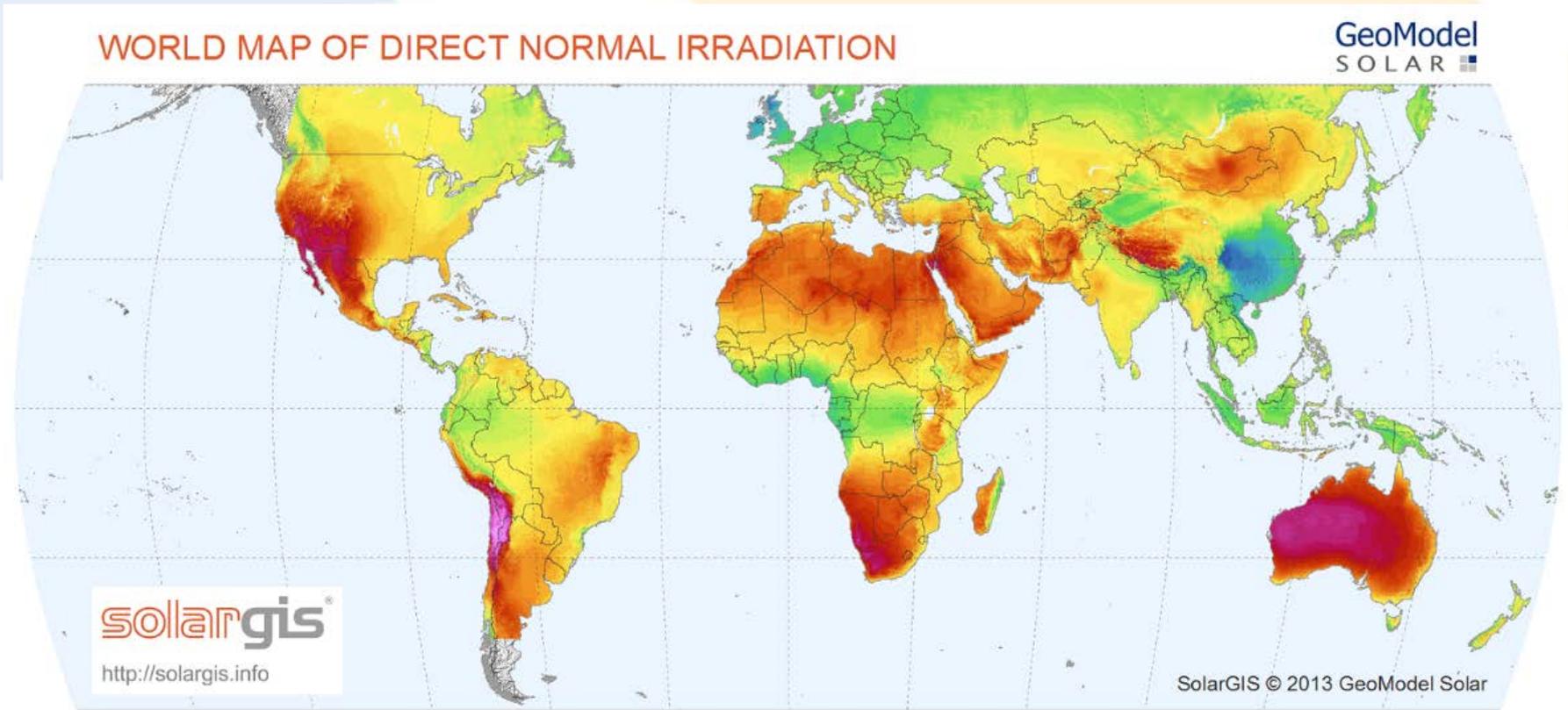
- Super-heated direct steam generation
- Molten salts only
- Pressurised CO₂ or air in non-evacuated receivers

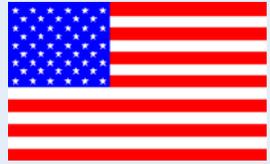
ESTELA is promoting the “First of its kind” commercial project under the Cooperation Mechanisms (articles 6, 7 and 8 of the RES Directive)

Our vision for the future



Situation of commercial STE in the Rest of the World





USA

Last developments

Completion of Solana (280 MW, PT), Ivanpah (390 MW, T), Genesis (250 MW, PT) and Mojave (280 MW PT)

Total power in operation

1730 MW in operation

Plants in advanced construction stages

Crescent Dunes (110 MW, T)

There are some other large projects in promotion or early development stages but only few of them have chances to be built in the next future.

Prospects

Strong competition with PV at the short term

Future STE plants will depend on the position of the utilities regarding dispatchability.

Rising of Portfolio Standards in some states will help.



Solana 280 MW



Ivanpah 390 MW



MENA Region (Arab countries)

Completion of Shams 1 (100 MW, PT) in 2013

Total STE power in operation: 165 MW (considering equivalent power of the ISCCs)

Noor I (160 MW PT) is under advance construction in Ouarzazate (Morocco)

Noor II (200 MW PT) and Noor III (150 MW T) recently awarded

Al Shagaya (50 MW PT) with big storage and dry cooling to be awarded in Kuwait

Stop of ambitious plans in Saudi Arabia?



South Africa

200 MW (150 PT / 50 T) under construction Rounds 1 & 2

100 MW (50 PT / 50 T) MW under construction Round 3

200 MW (100 PT / 100 T) Awarded recently in Round 3.5

ESKOM plant (100 MW) in RfP. to be announced

Interesting FiT approach with hourly discrimination (Time Of Day tariff +270%)

Increased interest in the dispatchability features and local content of STE plants.

Clear possibilities to increase the 2020 goal from 1100 MW to 3300 MW

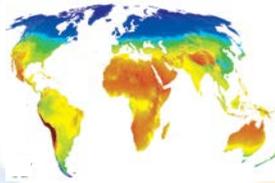


India

Completion of Godawari (50 MW PT) Reliance (100 MW F) & Megha (50 MW PT)

The other 4 plants of the JNNSM will most likely not be completed (unrealistic FiT)

Two new plants (50 MW PT & 50 MW T) could be announced soon for bidder PQ



Other countries

China

Apart from some demo plants the only real project is the completed first phase (10 MW, T) and the 50 MW PT under construction in Delingha. There are many projects in promotion but still uncertain FiT conditions. Ambitious plans for 2015 (1000 MW, unrealistic) and for 2020 (3000 MW ?)



Israel

2 plants (110 MW PT & T) under early construction phases. Another few hundred MW in promotion stage.

Australia

The ISCoalPlant in Kogan Creek (44 MW F) is near to completion.

Chile

The first plant (110 MW T / base load) has started construction

Mexico

A 14 MWe ISCC is completed



Thank you for your attention

luis.crespo@estelasolar.org

www.estelasolar.eu

www.protermosolar.com

