

***First Summer School***  
***Part A: Line-focus Solar Thermal Technologies***  
*September 20-24, 2021*

**Lecture 11:**

**Lessons Learned in Spain with Solar Thermal Electric Plants**

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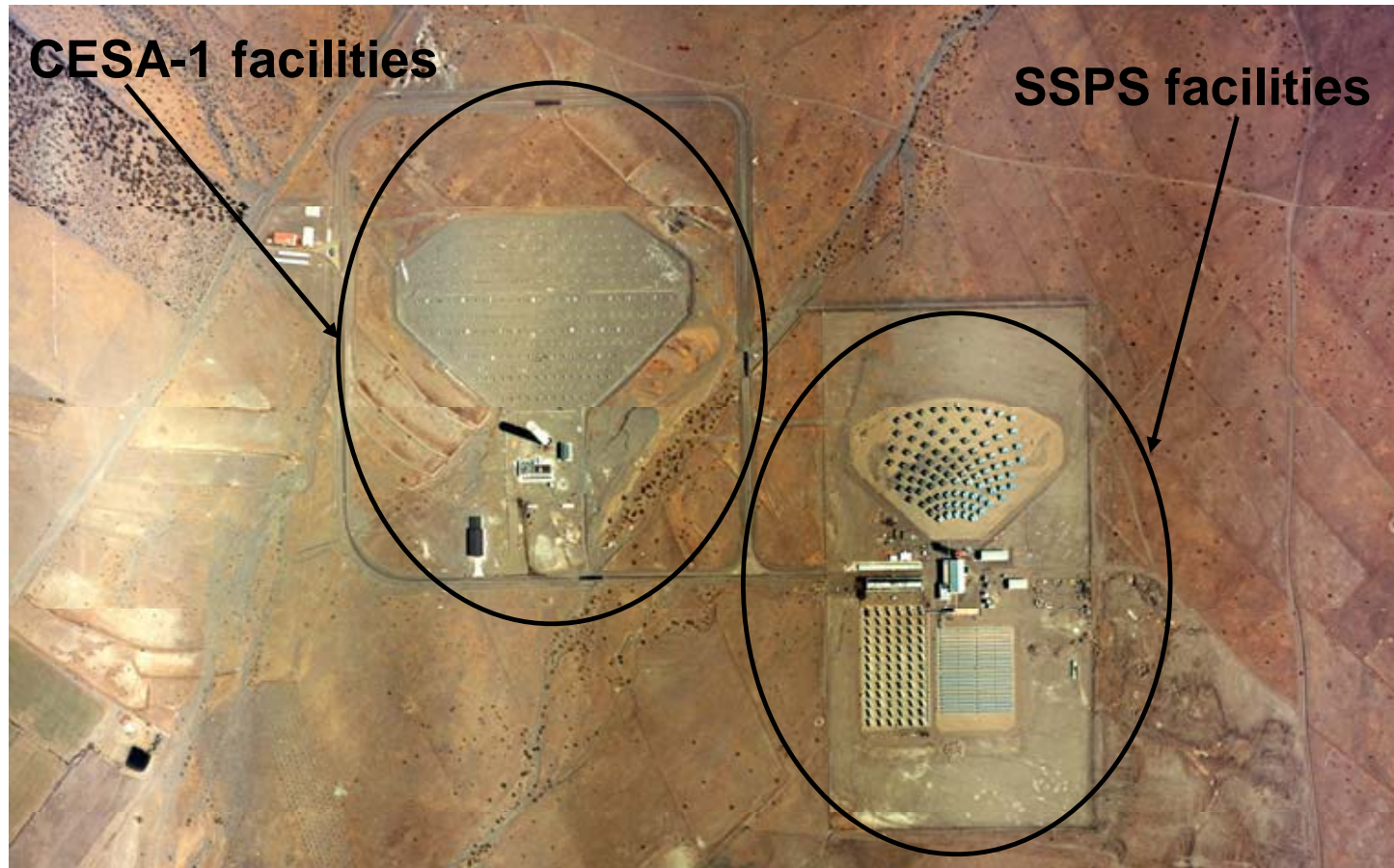
# Lessons learned in Spain with STE plants

## Content

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- First steps promoting STE plants**
- The commercial “Boom”**
- Current status**
- Conclusions**

# Background

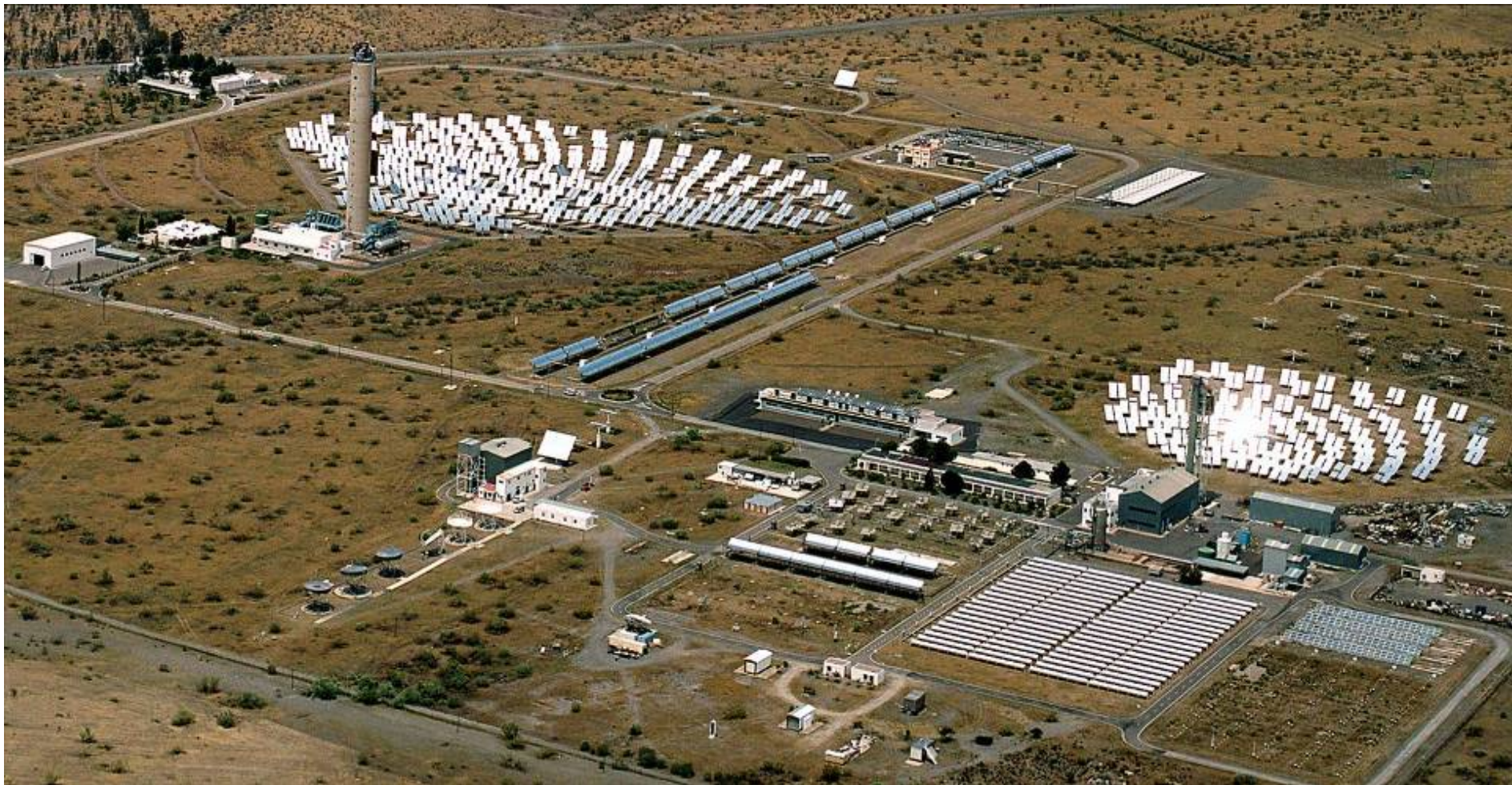
The Plataforma Solar the Almería (PSA) was born in 1986, by merging into a single legal entity the facilities of the former IEA *Small Solar Power Systems* Project with the CESA-1 central receiver plant





# Background

Many new facilities have been Implemented since 1986 at the PSA, so that it is nowadays the biggest public R+D centre devoted to CST technologies



# Background

- After the creation of PSA in 1986, the German DLR and the Spanish CIEMAT (owner of the PSA) signed a bilateral agreement in 1987 to jointly operate the PSA facilities and promote joint R+D projects.
- PSA started in 1988 to develop R+D projects related to concentrating solar thermal (CST) systems in collaboration with industrial Partners (Spanish and German partners mainly), and the number of Spanish and German companies with experience on CST technologies was thus growing more and more.

# Lessons learned in Spain with STE plants

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**Background**



**First steps promoting STE plants**

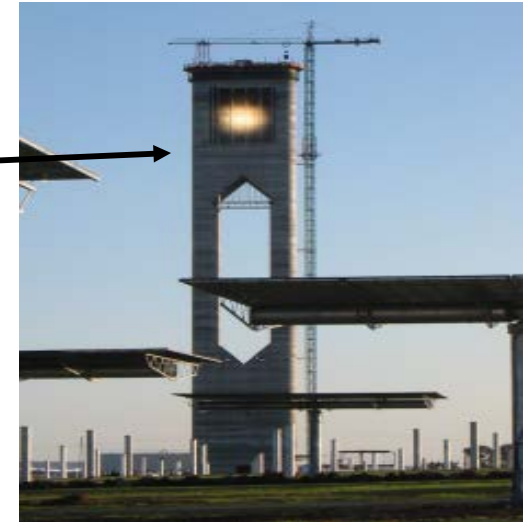
**The commercial “Boom”**

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# First steps promoting STE plants

After a first confusing attempt in 2002, the first feed-in tariff for STE was issued in Spain in 2004 (RD 436/2004). This feed-in tariff was 0.22€/kWh. This feed-in tariff made the first STE projects in Spain bankable (PS-10 and Andasol-I and II), although with a low profit margin



PS-10 tower and receiver

Aerial view of the 10 MWe PS-10 plant of ABENGOA (Seville)  
(The first commercial STE plant in the World with central receiver)

# First steps promoting STE plants

After a first confusing attempt in 2002, the first feed-in tariff for STE was issued in Spain in 2004 (RD 436/2004). This feed-in tariff was 0.22€/kWh. This feed-in tariff made the first STE projects in Spain bankable (PS-10 and Andasol-I and II), although with a low profit margin



Aerial view of the 50 MWe ANDASOL-I plant



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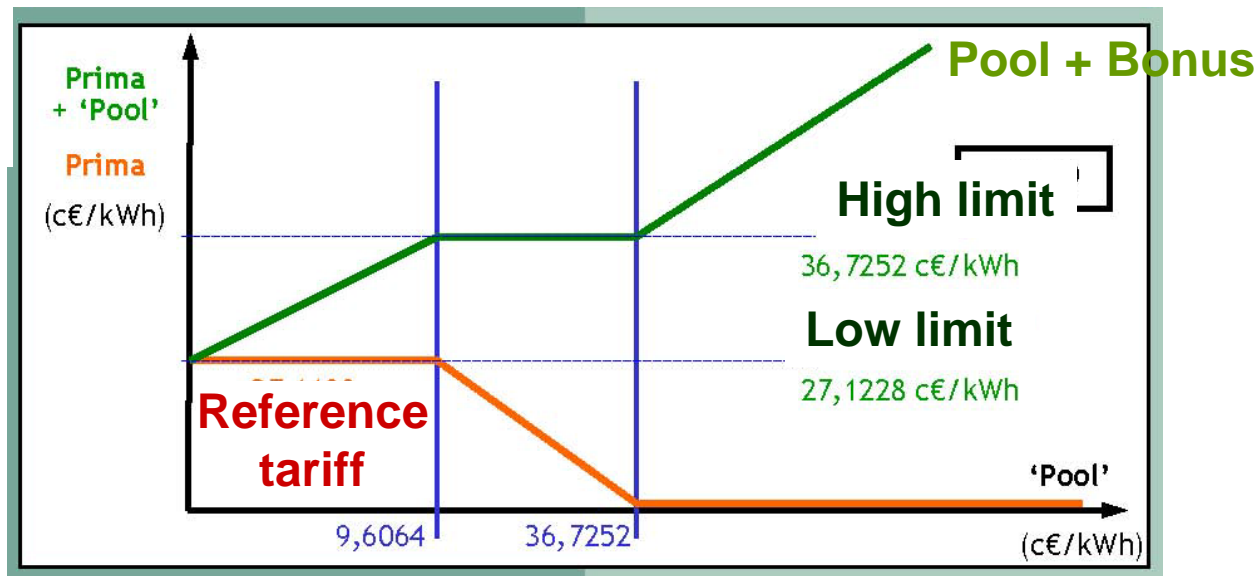


# The Spanish Experience in STE: the take-off

The real commercial take-off of STE plants in Spain took place in 2007 with the feed-in tariff implemented by the RD 661/2007, for plants with a maximum unit power of **50 MWe**, and up to a total installed STE power of **500 MWe**.

Two different tariffs for STE were implemented by RD661/2007:

- a) regulated tariff: 0,26€/kWh first 25 years, 0,23€/kWh thereafter
- b) variable feed-in tariff (Pool + Bonus) depending on the pool price, with a low and high limits: 0,27€/kWh and 0,36€/kWh, respectively



# The Spanish Experience in STE: the Correction

- Due to the generous feed-in tariff implemented in 2007, licenses for a high number of STE plants totaling more than 10 GWe were arranged in less than 1 year and the relevant bank deposits imposed by RD 661/2007 were given by promoters
- Since the procedure defined by the Government to not exceed a total STE installed power of 500 MWe showed to be ineffective, the Government issued in mid 2009 a law imposing certain conditions (e.g., legal permits, financing available, purchasing contracts for main equipments) to allow the project under development the access to the feed-in tariff defined by RD-661/2007.
- Only those STE project fulfilling the requirements defined in mid 2009 were included in the so-called *retribution pre-assignment register*. 51 STE plants were included in this register. 50 STE plants were finally implemented until the end of 2013, with a total installed power of 2332 MWe

# The Spanish Experience in STE: the Correction

- 50 STE plants (2332 MWe) are in operation since 2013. No STE plant has been built afterwards
- In June 2013, a new law issued by the Spanish Government replaced the feed-in tariff by a *Complementary Payment* to be added to the Pool price of the electricity to provide the investors with a “*reasonable profitability*” (7.5%).
- Procedure to calculate a Complementary Payment to Spanish STE plants was legally defined in June 2014 by two new laws.
- Changes made by the Spanish Government in the legal framework for STE plants have reduced their incomes by 37%, jeopardizing the confidence of investors in Spain and damaging the image of Spain abroad
- Since investors and promoters were in disagreement with the *Compensatory Payment* defined by the Government, more than 20 law suits against the Kingdom of Spain at CIADI (International Center for Settlement of International Investment Disputes) were presented.
- The Spanish Government is currently negotiating with the plants owners

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# Spanish STE Plants in Operation

➤ 50 STE plants (2332 MWe) are in operation since 2013. No STE plant is currently under construction or promotion

## - Parabolic trough technology:

45 PT plants (2222,5 MWe):

- ✓ Twenty six 50MWe-plants without TES
- ✓ Eighteen 50MWe-plants with 1GWht TES
- ✓ One 22.5MWe-plant hybridized with biomass

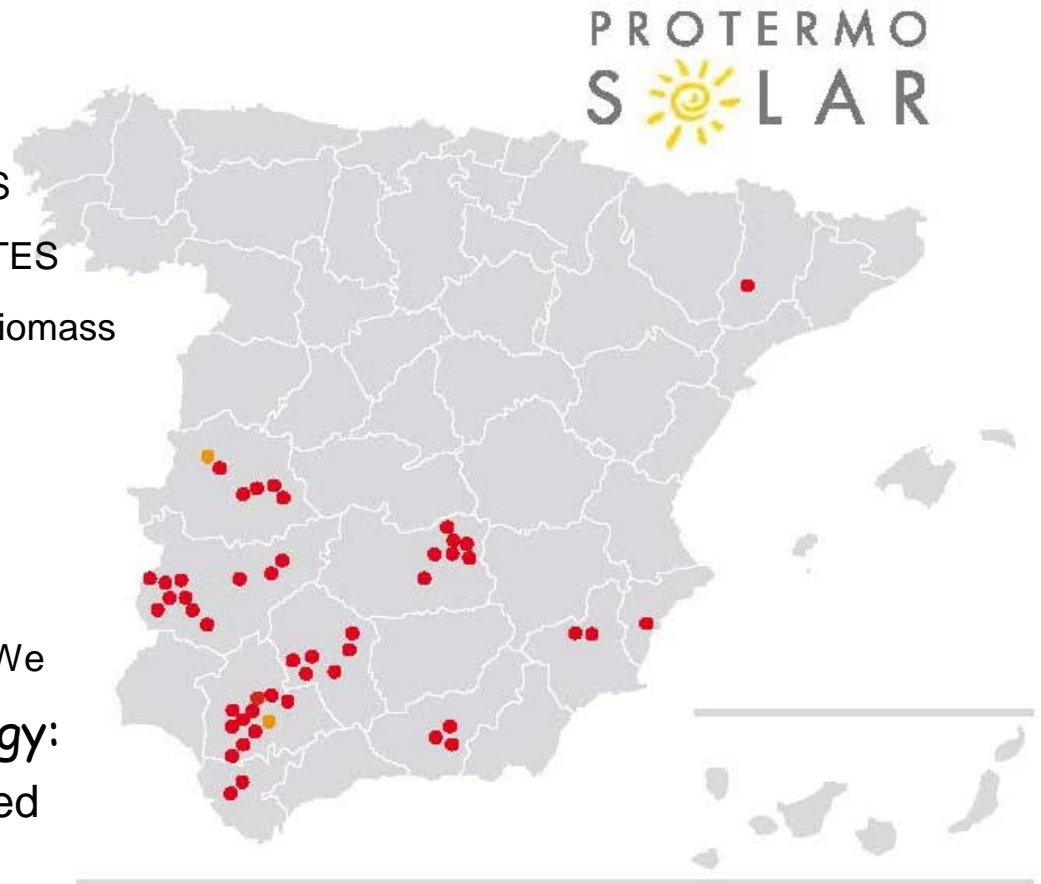
## - Central receiver technology:

3 CR plants (49,9 MWe)

- ✓ Two saturated steam receiver plants (10MWe and 20MWe)
- ✓ One molten salt receiver plant (19MWe)

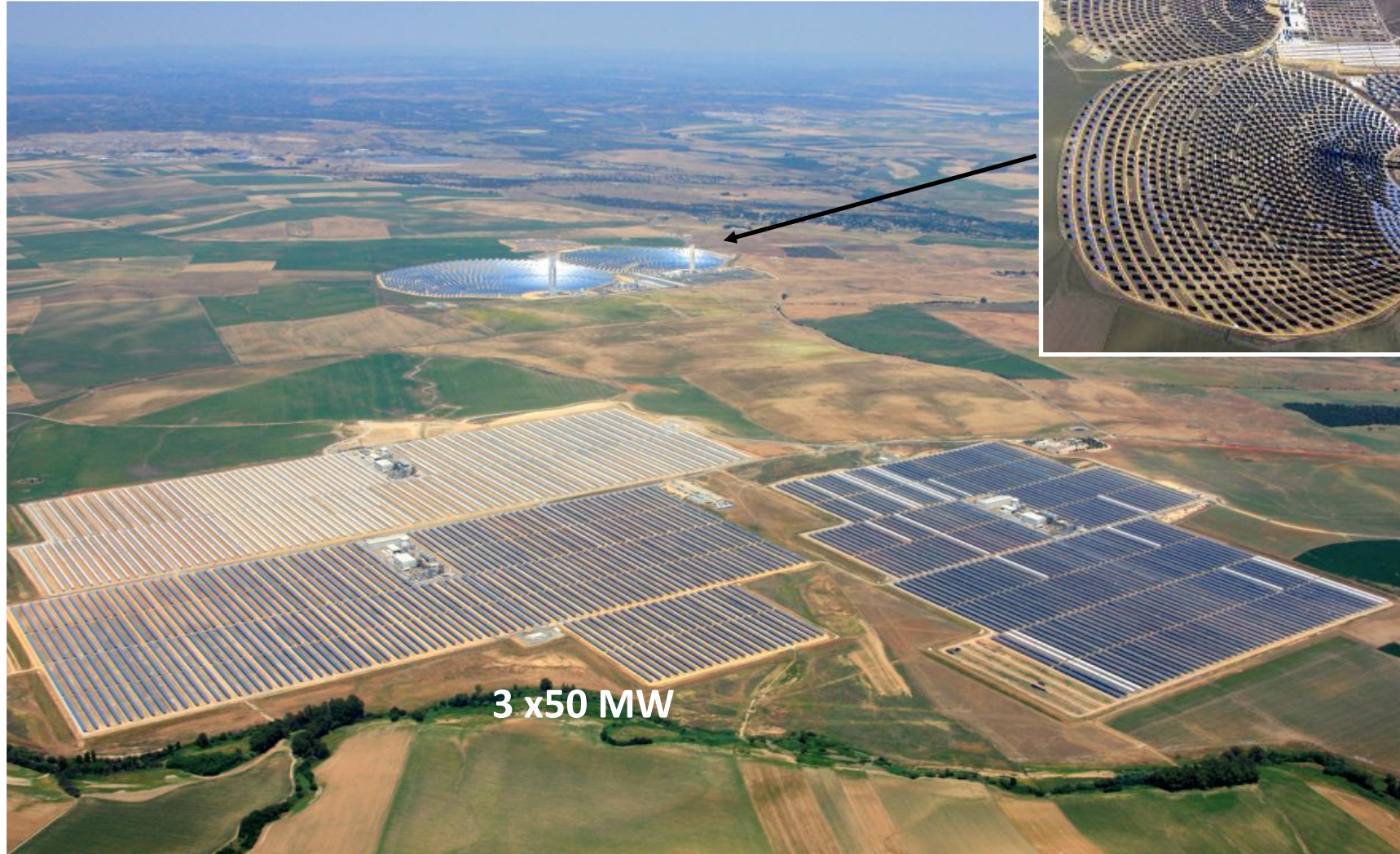
## - Compact Linear Fresnel technology:

2 LF plants (31,4 MWe), with saturated steam and no TES





# SOLNOVA 1, 3 & 4 / PS 10 & PS 20, (Seville, Spain)





# GEMASOLAR (Sevilla, Spain)

19,9 MW, (15 h Storage capacity)



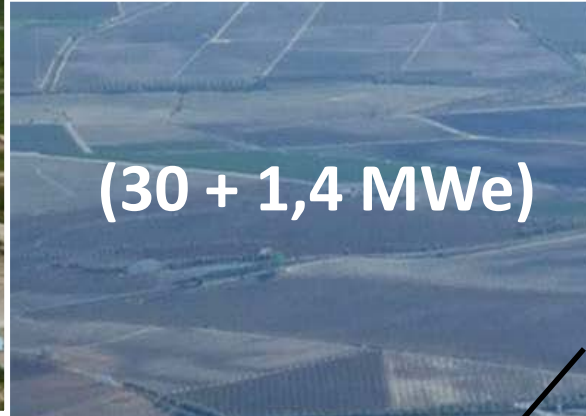


# ANDASOL 1, 2 & 3 (Granada, Spain)

3 x 50 MW, 7 h St.



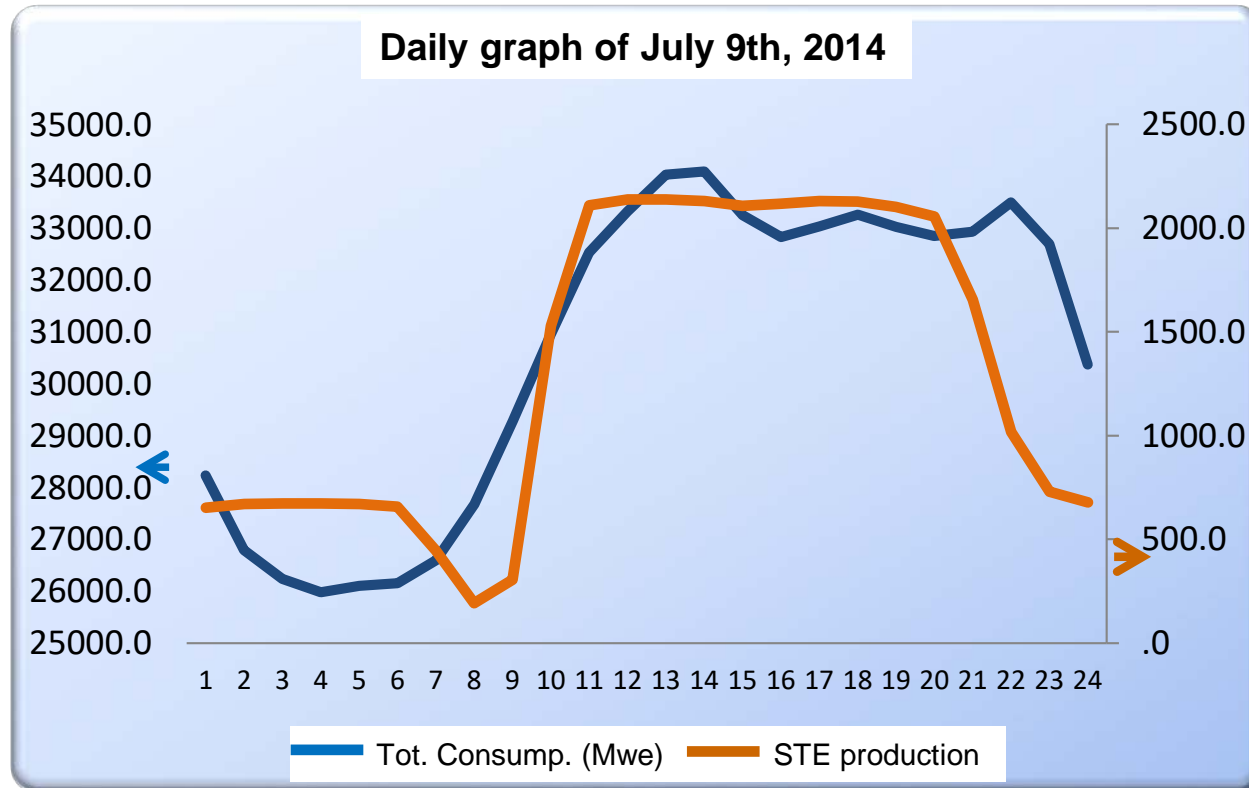
# Puerto Herrado I&II (Murcia, Spain)



# Data about STE generation in Spain

## Important milestones of STE in Spain:

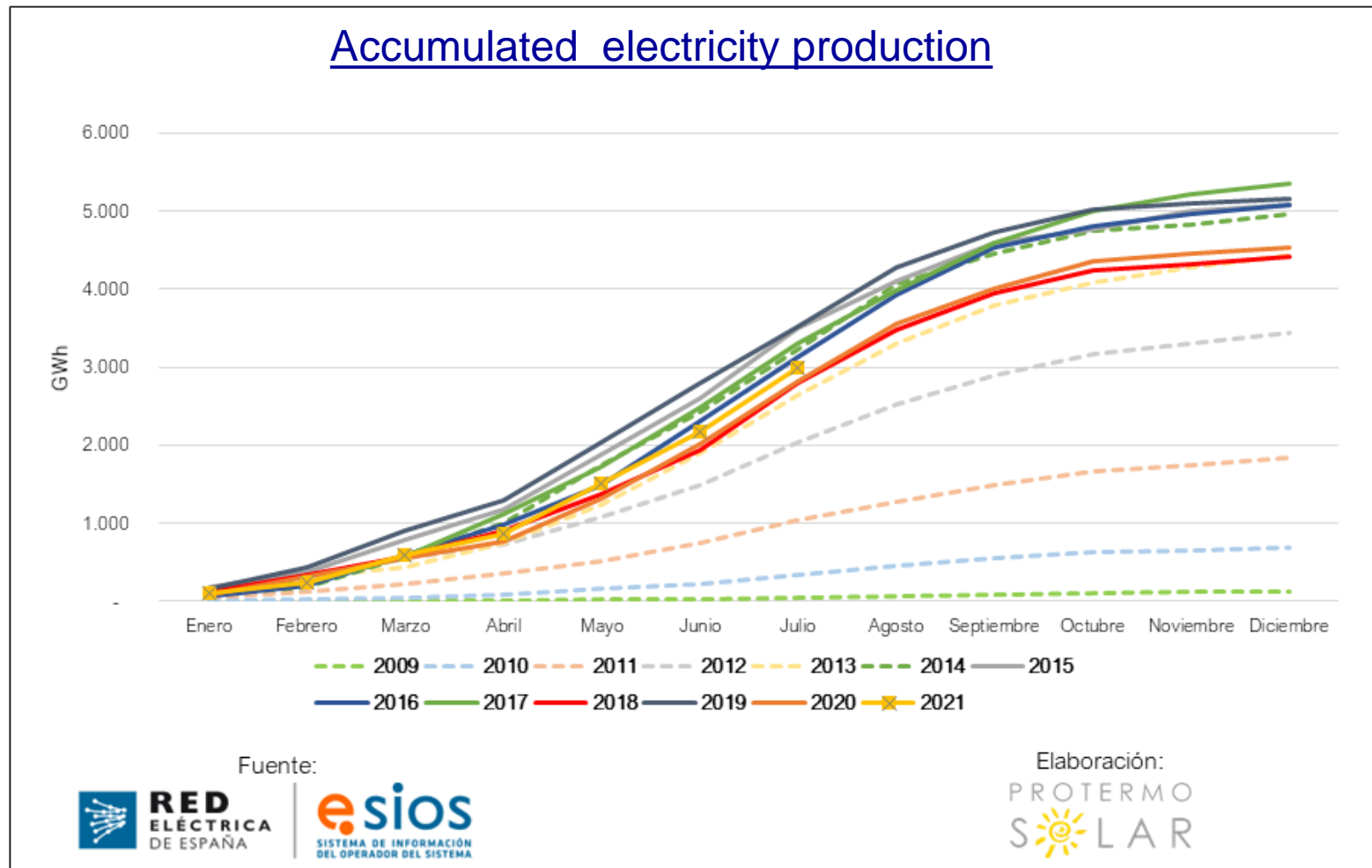
- ✓ Peak contribution to the Spanish market: 9.4 % (July 2016)
- ✓ Max. daily contribution 5% (July 2016)
- ✓ Monthly contribution is slightly higher than 4% in Summer months
- ✓ Yearly production of about 5100 GWh (2% of total electricity generation in Spain)



Source REE

# Reliability of Spanish STE plants

- Spanish STE plants are showing a great reliability. Lower production in 2018 and 2020 due to very bad weather conditions in those years



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# Achievements:

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- Spain is now the World leader in STE, with Spanish companies involved in most of the commercial projects developed in other countries.
- Spanish STE plants are showing a great reliability and ispatchchability
- The number of suppliers for STE key components has significantly increased and their cost has been reduced.
- Banks and other investors are now acquainted with STE technologies and project bankability is easier now.
- The Spanish experience will be very useful for other countries willing to promote STE plants.

# Drawbacks:

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- The legal framework initially implemented in Spain was not efficient and the total installed power exceeded by far the planned one
- The way how the Spanish Government has reduced the revenues of the STE plants has seriously damaged the confidence of investors in Spain and damaging the image of Spain abroad
- Most of the STE plants have a very similar design → little innovation
- Lack of dialogue between the Government and the STE industrial and R+D sectors

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- Thank you very much for your attention**
- Questions?**