

II WORKSHOP “RENEWABLE ENERGIES AND SPACE”

Solar Thermal Electricity and Space

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General-Secretary of Protermosolar*



Madrid, 09/ Oct/2012



ESTELA and PROTERMOSOLAR are respectively the European and Spanish Solar Thermal Electricity Associations



Protermosolar, founded in 2004, has now 100 associated members and **covers the whole value chain of the Solar Thermal Electric projects**, from research centers to plant constructors along with engineering companies, component manufacturers, promoters, etc.



ESTELA, founded in 2007, has now 65 associated members and **covers as well the whole value chain of the Solar Thermal Electric projects**.

In addition to the European full members, ESTELA has also associated members from the Union for the Mediterranean countries.



All the operating plants in Spain as well as those others which are under construction or in an advanced planning stage in Spain (more than 2500 MW in total) belong to **Protermosolar** members. **The largest operating plants in USA** (SEGS, Nevada Solar 1 & Martin) as well as the **ISCC in Morocco, Algeria and Egypt** and most of the on going projects around the world have the participation of **ESTELA** and **Protermosolar** members.



The world STE association federation has been recently constituted by SASTELA, AUSTELA and ESTELA



Solar Thermal Electricity technologies were first developed in Space companies

At the end of the 70's Space companies received orders to develop STE components (Heliostats, parabolic troughs, receivers, control systems, ...)

Good examples were:

In USA: Martin Marietta, Boeing,
McDonnell Douglas

In Europe: MBB, Dornier, CASA, ...

Today -for instance- the advanced molten salt receiver for the Tonopah power plant is being designed and manufactured by Rocketdyne/P&W applying rocket technology and materials for the design of the panel headers



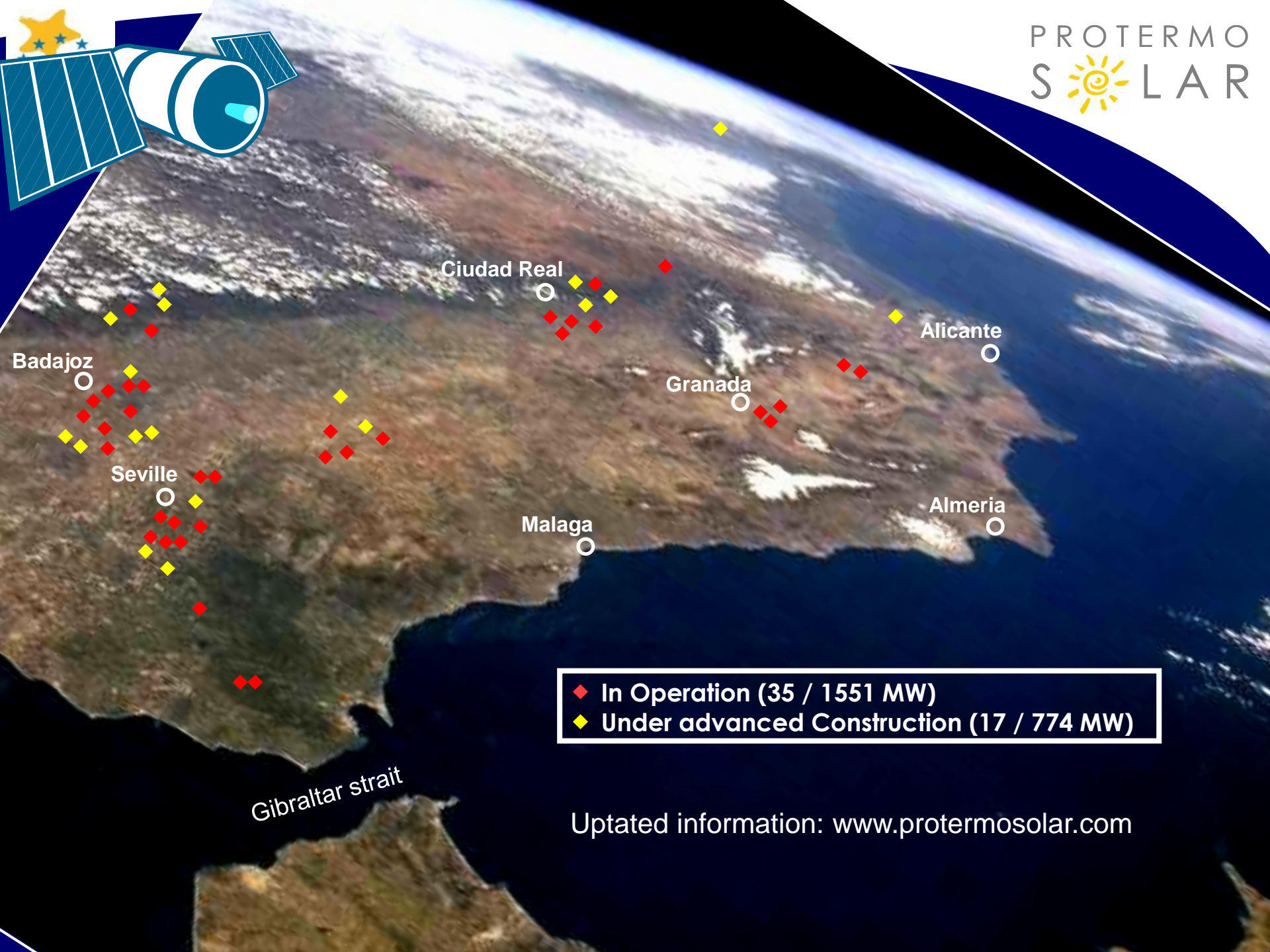
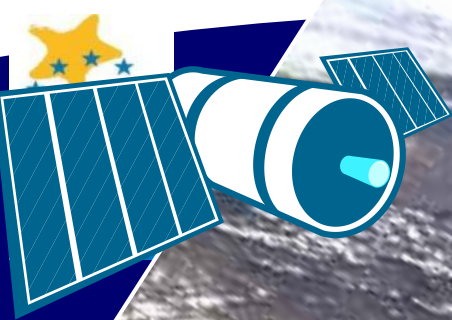
The reasons for a **brilliant** STE future

1. STE is the only dispatchable renewable technology with potential enough to meet the electricity needs worldwide and to achieve a carbon free generation system

Intermittent RE technologies -which has been largely developed until now- could cover only a part of the supply as they will always require back up from conventional fossil plants



2. Local content of STE plants will be one of the main drivers behind the support policies in many countries of the sun belt
3. The cost of STE plants will show important reductions when approaching from the current 3 GW installed to the similar values of Wind (250 GW) and PV (80 GW)



- ◆ In Operation (35 / 1551 MW)
- ◆ Under advanced Construction (17 / 774 MW)

Uptated information: www.protermosolar.com



Situation of approved STE plants in Spain

In operation:
35 / 1551 MW

By Dec-2012
43 / 1925 MW

Under
construction
17/ 774 MW

Propietario	Nombre	Población	Provincia	Tecnología	Potencia (MW)	Almacenamiento (horas a cargo nominal)	Producción estimada* (GWh/año)	Emisiones evitadas (t/año de CO2e)	Fase pre registro	Fecha 1ª conexión a red** (mes-año)	Superficie de terreno ocupada (Ha.)	Área de captación solar (m2)
Abengoa Solar	PS10	Sanlúcar la Mayor	Sevilla	TMS	10	1	34	15.458	n/a	nov-00	65	75.000
REEP/ANTIN/COBRA	Andasol-1	Adáfrica	Granada	CCP	50	7,5	370	109.480	n/a	nov-08	280	510.120
Abengoa Solar	PS20	Sanlúcar la Mayor	Sevilla	TMS	20	1	44	26.938	n/a	abr-08	90	150.000
Navarra	Puerto Errada I	Calasparrá	Murcia	Fixedtil	3,4	8,5	3	1.388	1	abr-09	1	18.000
Andasol-2	Andasol-2	Adáfrica y La Calahorra	Granada	CCP	50	7,5	370	109.480	1	jun-09	280	510.120
Iberdrola Energía Solar de Puertollano	Ibersol Puertollano	Puertollano	Ciudad Real	CCP	50	n/a	300	64.400	n/a	jun-09	150	390.000
Acciona/ Mitsubishi Corp.	La Alisa	Alvarado	Badajoz	CCP	50	n/a	300	64.400	1	sep-09	190	390.000
COBRA	Estresol-1	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	370	109.480	1	sep-09	280	510.120
COBRA	Estresol-2	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	370	109.480	2	abr-10	280	510.120
Abengoa Solar	Salasca 1	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	300	64.400	1	may-10	115	350.000
Abengoa Solar	Salasca 3	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	300	64.400	1	jun-10	115	350.000
Renovables SAMCA, S.A.	La Florida	Badajoz	Badajoz	CCP	50	7,5	370	109.480	1	jul-10	220	550.000
Abengoa Solar	Salasca 4	Sanlúcar la Mayor	Sevilla	CCP	50	n/a	300	64.400	1	ago-10	115	350.000
Acciona/ Mitsubishi Corp.	Majadas	Majadas	Cáceres	CCP	50	n/a	300	64.400	1	oct-10	110	380.000
Renovables SAMCA, S.A.	La Odrada	La Garrovilla	Badajoz	CCP	50	7,5	370	109.480	1	oct-10	320	550.000
Acciona/ Mitsubishi Corp.	Palma del Río I	Palma del Río	Córdoba	CCP	50	n/a	300	64.400	1	dic-10	135	380.000
COBRA	Marchosil-1	Alcalá de San Juan	Ciudad Real	CCP	50	7,5	370	109.480	2	dic-10	280	510.120
COBRA	Marchosil-2	Alcalá de San Juan	Ciudad Real	CCP	50	7,5	370	109.480	3	abr-11	280	510.120
Ternisol	González	Fuente de Andalucía	Sevilla	TS	20	18	300	64.400	2	abr-11	385	804.750
Acciona/ Mitsubishi Corp.	Palma del Río I	Palma del Río	Córdoba	CCP	50	n/a	300	64.400	1	jul-11	135	380.000
Valorka/Siemens	Labría 1	Labría	Sevilla	CCP	50	n/a	300	64.400	2	jul-11	188	423.000
S. Millares/Luz/Ternisol/REEP/Enel/ENEL	Andasol-3	Adáfrica/la Calahorra	Granada	CCP	50	7,5	370	109.480	1	ago-11	220	510.000
Abengoa Solar/ENEL	Helioenergy 1	Écija	Sevilla	CCP	50	n/a	300	64.400	2	sep-11	180	500.000
Enel/Enel/Enel	Andasol 4	Badajoz	Badajoz	CCP	50	7,5	370	109.480	3	nov-11	190	510.120
Ternisol	Arcoval-58	San José del Valle	Cádiz	CCP	50	7,5	370	109.480	3	nov-11	180	510.000
Ternisol	Arcoval-58	San José del Valle	Cádiz	CCP	50	7,5	370	109.480	3	dic-11	180	510.000
Enel/Enel/Enel	Aste 1A	Alcalá de San Juan	Ciudad Real	CCP	50	8	370	109.480	2	ene-12	180	510.120
Enel/Enel/Enel	Aste 1B	Alcalá de San Juan	Ciudad Real	CCP	50	8	370	109.480	2	ene-12	180	510.120
Abengoa Solar/ENEL	Helioenergy 2	Écija	Sevilla	CCP	50	n/a	300	64.400	2	ene-12	180	500.000
Navarra, ERL, IWB, IWB, ERL y ERL	Puerto Errada II	Calasparrá	Murcia	Fixedtil	30	8,5	54	12.200	2	ene-12	50	802.000
Abengoa Solar/IGC Corporation	Salasca 1	El Cargilo	Córdoba	CCP	50	n/a	300	64.400	2	feb-12	115	350.000
Abengoa Solar/IGC Corporation	Salasca 2	El Cargilo	Córdoba	CCP	50	n/a	300	64.400	2	mar-12	180	500.000
Iberdrola	Morán	Morán de la Frontera	Sevilla	CCP	50	n/a	300	64.400	2	may-12	181	580.000
Abengoa Solar	Hellas 1	Puerto Lapice	Ciudad Real	CCP	50	n/a	300	64.400	1	may-12	180	500.000
Abengoa Solar/TOCHU	Salasca 3	Laguarda	Cáceres	CCP	50	n/a	300	64.400	3	jun-12	280	500.000
SUB TOTAL CONECTADAS					35		1.581	4.280	2.704.988		5.540	14.504.836
Renovables	Casa de las Pintas	Casa de las Pintas	Cuenca	SP	8	n/a	3,23	1.489	4	mar-13	5,4	5.380
REC/MINRA	Guadán	Palma del Río	Córdoba	CCP	50	n/a	300	64.400	3	jun-13	280	510.400
Grupo ENEL - Grupo TSE - Alagor	La Alfranca	Pozoblanco	Córdoba	CCP	50	7,5	370	109.480	1	jun-13	190	540.360
Renovables	Oliveros 1	Oliveros	Badajoz	CCP	50	n/a	300	64.400	1	jun-13	188	403.000
Abengoa Solar	Hellas 2	Puerto Lapice	Ciudad Real	CCP	50	n/a	300	64.400	1	ago-13	180	500.000
Acciona	Ortella	Ortella	Badajoz	CCP	50	n/a	300	64.400	1	ago-13	180	409.480
COBRA	Estresol-3	Torre de Miguel Sesmero	Badajoz	CCP	50	7,5	370	109.480	3	ago-13	280	510.120
Abengoa Solar/TOCHU	Salasca 1	Laguarda	Cáceres	CCP	50	n/a	300	64.400	3	oct-13	112	350.000
Abengoa / Unión EMTE	Bongos Blancos	Bongos Blancos	Lleida	CCP + HIL	22,5	n/a	98	33.313	3	dic-13	70	181.000
Acciona-PP	Ternisol 3	Navalvillar de Páez	Badajoz	CCP	50	8	370	109.480	4	mar-14	285	523.280
Abengoa Solar	Salasca 1	Laguarda	Cáceres	CCP	50	n/a	300	64.400	4	mar-14	180	500.000
COBRA	Cáceres	Salasca y Valdehuelga	Cáceres	CCP	50	7,5	370	109.480	4	mar-14	320	510.000
COBRA	Cataluña	Cataluña	Cáceres	CCP	50	7,5	370	109.480	3	jun-14	280	510.120
REC	Ortella	Ortella	Alcázar	CCP	50	n/a	300	64.400	4	jun-14	214	323.000
Acciona-PP	Ternisol 2	Navalvillar de Páez	Badajoz	CCP	50	8	370	109.480	4	jun-14	212	523.280
Abengoa Solar	Salasca 6	Laguarda	Cáceres	CCP	50	n/a	300	64.400	4	ago-14	113	390.000
Abengoa / Unión EMTE	Arroba	Morán de la Frontera	Sevilla	CCP	50	8	370	109.480	4	oct-14	220	510.000
SUB TOTAL EN CONSTRUCCIÓN					17		774	2.096	1.585.121		2.893	7.087.166
Renovables	Puertollano 1	Puertollano	Ciudad Real	SP	8	n/a	38,3	11.654	3	mar-12	370	44.794
Renovables	Puertollano 2	Puertollano	Ciudad Real	SP	10	n/a	22,8	14.554	3	mar-12	390	54.898
Renovables	Puertollano 3	Puertollano	Ciudad Real	SP	10	n/a	22,8	14.554	3	mar-12	390	54.898
Renovables	Puertollano 4	Puertollano	Ciudad Real	SP	10	n/a	22,8	14.554	3	mar-12	390	54.898
Renovables	Puertollano 5	Puertollano	Ciudad Real	CCP	10	n/a	22,8	14.554	4	mar-13	390	54.898
Renovables	Puertollano 6	Puertollano	Ciudad Real	CCP	10	n/a	22,8	14.554	4	mar-13	390	54.898
Renovables	Puertollano 7	Puertollano	Ciudad Real	CCP	12,4	n/a	27,9	17.958	4	mar-13	410	68.708
Ternisol Alázar S.L. Personal y Solar Reservo					Central Solar Ternisol Alázar de San Juan		TS	80				
SUB TOTAL PREASIGNADAS					8		79	109	102.396		2.338	383.872
TOTAL					60		2.425	6.449	4.153.317		10.772	21.975.066

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

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



3 x50 MW

ANDASOL 1, 2 & 3, Granada

3 x50 MW, 7 h St.





GEMASOLAR, Seville

19 MW, 15 h St.



PUERTO ERRADO 1 y 2, Murcia

1,4 MW

30 MW



Lebrija 1, Seville

50 MW

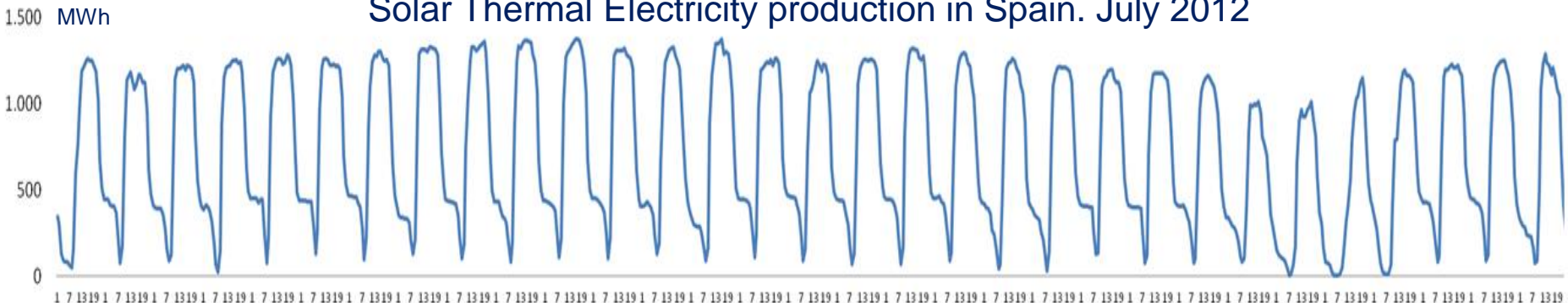


**A good signal:
Big energy industrial companies entered recently
in the STE sector (Siemens, Areva, GE, Alstom, ABB, ...)**



Important milestones in July 2012:

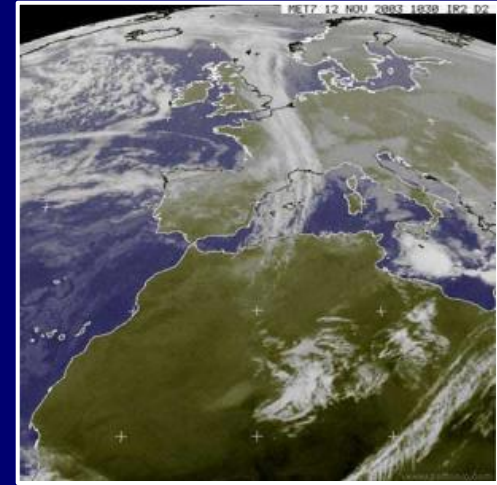
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- SPAIN: July the 11th, 2012**
- | Hour | Global Demand MWh (left) | STE Production MWh (right) |
|------|--------------------------|----------------------------|
| 0 | 29500 | 400 |
| 1 | 28500 | 400 |
| 2 | 25500 | 400 |
| 3 | 24500 | 400 |
| 4 | 24000 | 400 |
| 5 | 23800 | 400 |
| 6 | 24500 | 200 |
| 7 | 26500 | 100 |
| 8 | 28500 | 200 |
| 9 | 31500 | 1000 |
| 10 | 33000 | 1200 |
| 11 | 34000 | 1300 |
| 12 | 35000 | 1350 |
| 13 | 35500 | 1400 |
| 14 | 34000 | 1400 |
| 15 | 33500 | 1400 |
| 16 | 33200 | 1400 |
| 17 | 33200 | 1400 |
| 18 | 33000 | 1350 |
| 19 | 32500 | 1200 |
| 20 | 32000 | 800 |
| 21 | 31500 | 400 |
| 22 | 32500 | 300 |
| 23 | 31000 | 250 |



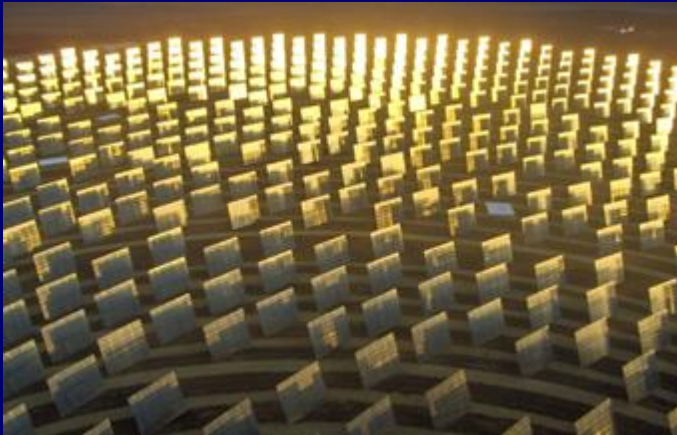
Data in the Earth from the Space

- ❑ Reliable large series of data are necessary for a proper design of the of the plants as well as for reliable business plan

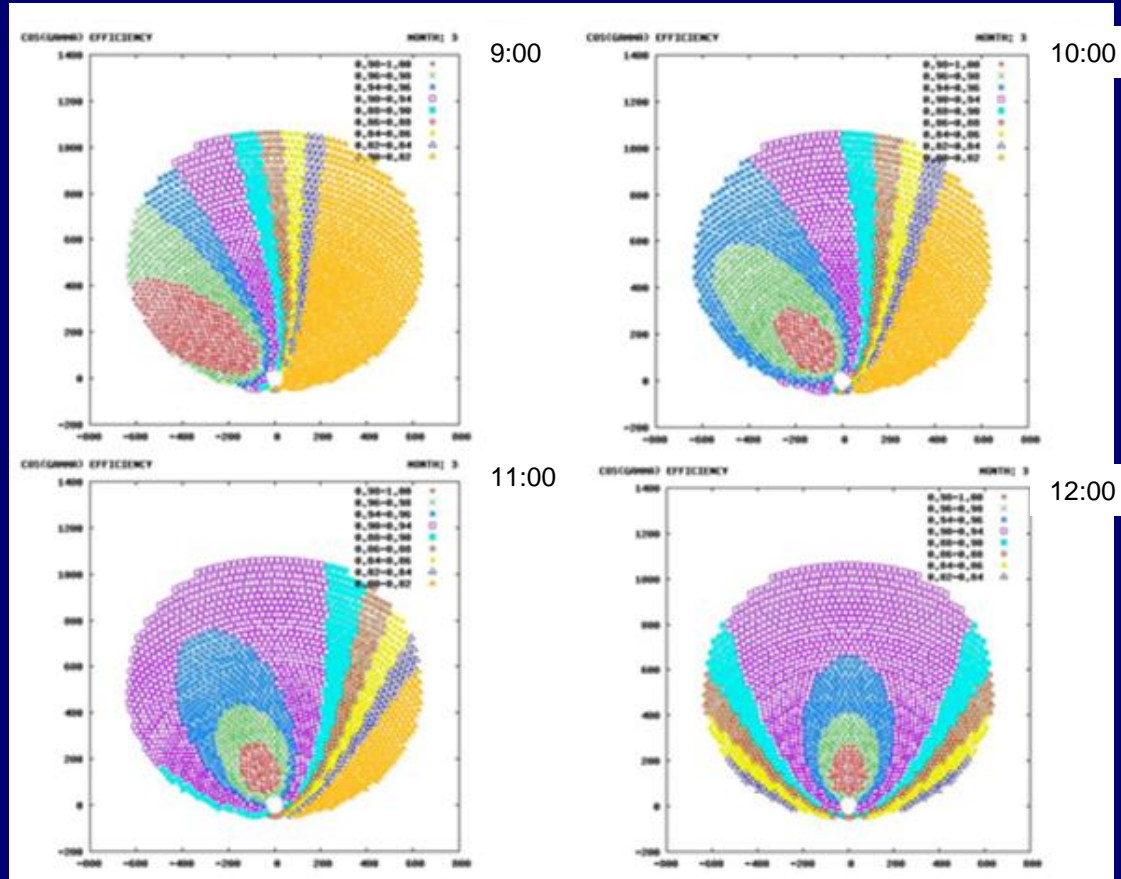
Historical satellite image data correlated with piroheliometer measurements are being widely used



- ❑ Accurate weather forecast could help improving the yield of the plants and the O&M activities

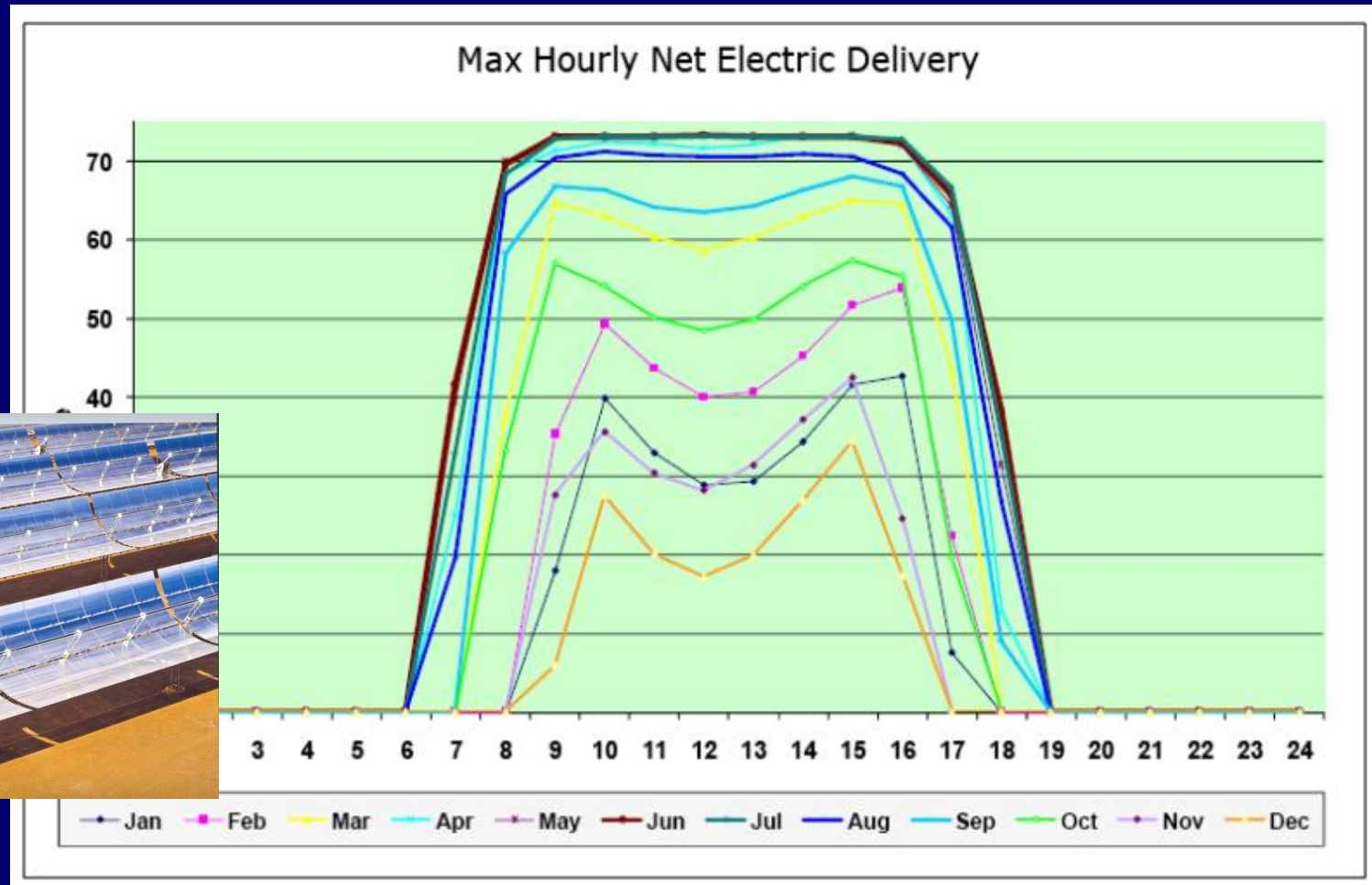


Towers

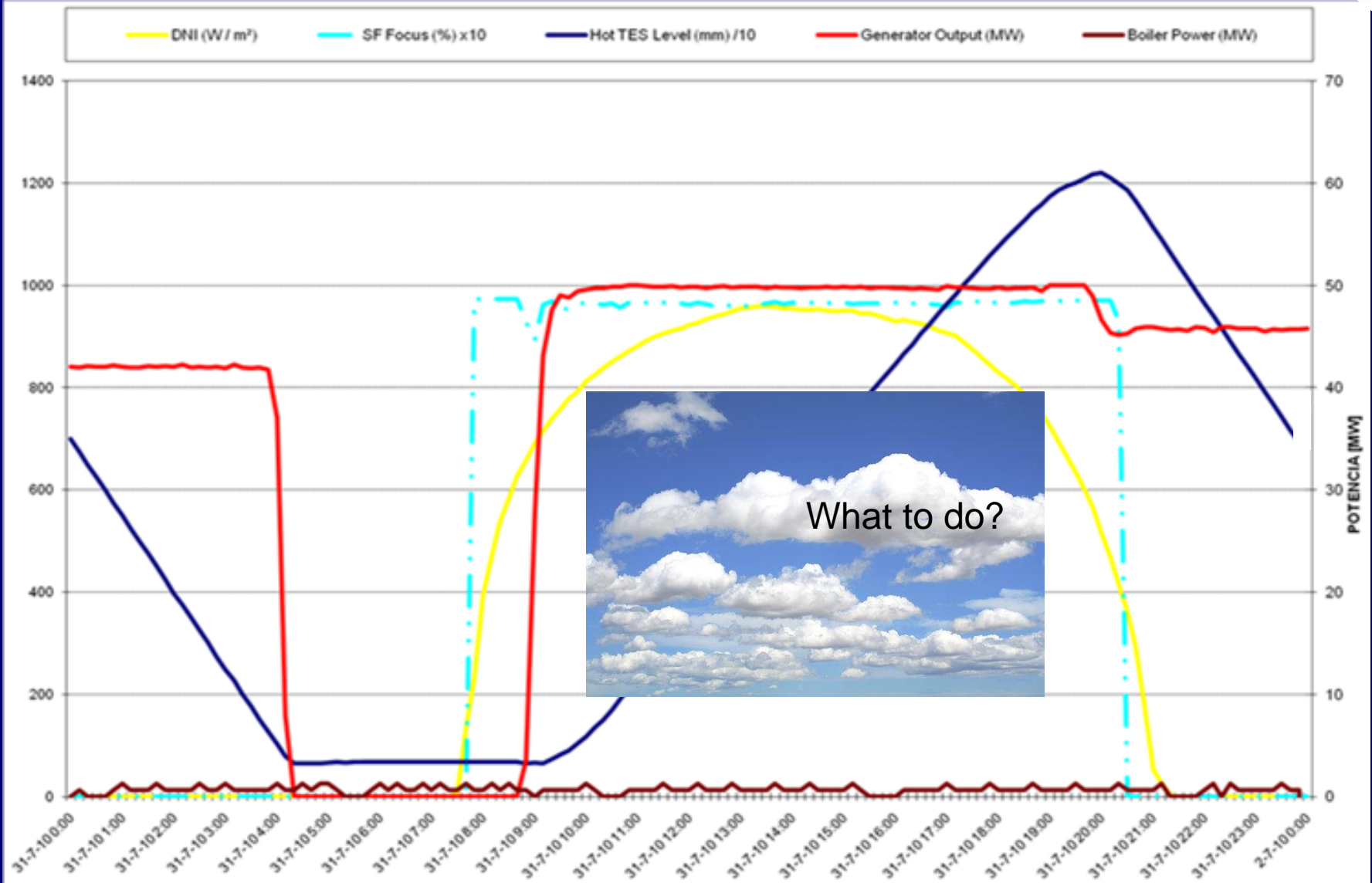


Impact of the radiation data on the design and performance of STE plants

Parabolic
trough



Impact of the radiation data on the operation of STE plants





Thank you for your attention!

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