

ABENGOA

Cost reduction in CSP
all factors needed in a
winner CSP case

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Current challenges on CSP Industry

Costs reduction

- Cost reduction in CSP is **mandatory**, otherwise it won't be a competitive solution against other technologies.
- **Noor Energy I Project** in UAE has reached the best goal ever achieved for CSP in terms of \$/kWh, but **still not enough**.
- **Main cost reduction will potentially happen in CT** (lower MW installed, less LL and more Financial constrains).

Reliability on CSP Technology

- Ramp-up periods and **learning curves are taking longer than expected** in CSP Plants. Lower Plant Performances lack of confidence.
- Many lessons learned must be applied in coming Projects to get **more confidence**.
- CSP Technology needs to evolve to a more **cost-effective solution**.
- This strategy will lead Lenders to be more confident. **Project de-risking**.

New Developments on key components

- **Critical components** (SF and MS components) shall be adapted to new market necessities.
 - Innovation
 - Chain supplies.
 - Higher performances.
 - Local manufacturing.

Enhance CSP capabilities against others

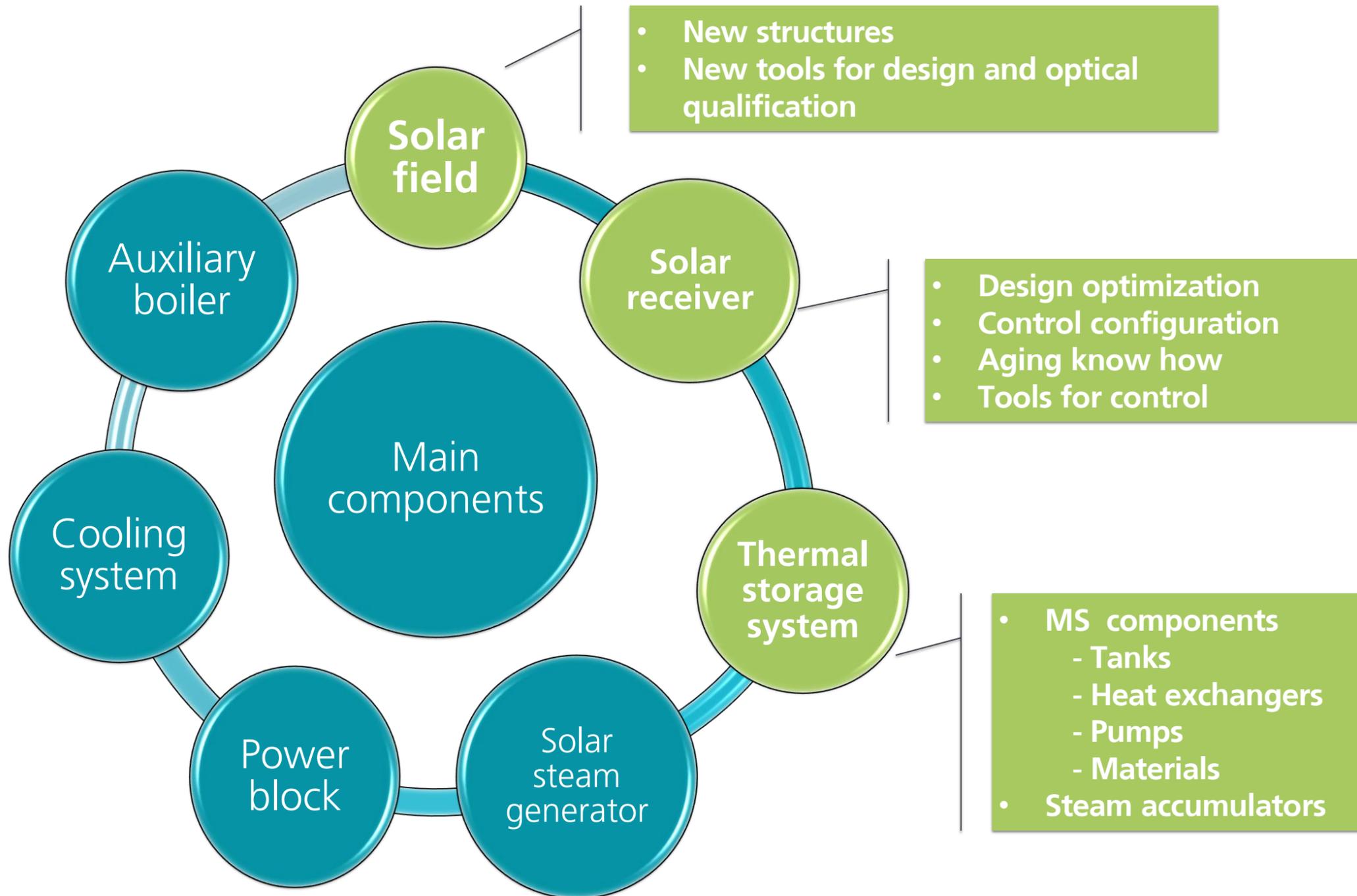
- CSP technology allows efficient and flexible dispatching strategies. **Profit increasing due to larger TES**.
- Develop **Hybrid solutions** to achieve better performances. Deployment of **Smart Solar Plant Concept**.
- **Solar Heat for Industrial Processes**. CSP owns a broad range of heat conditions to accommodate any industrial request.

1

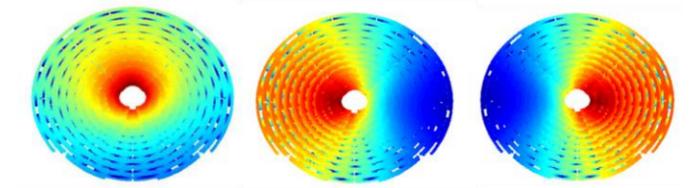
Innovation



Continuous R&D on main systems and components



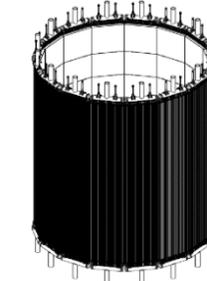
Solar Field Efficiency



Summer 12 p.m.

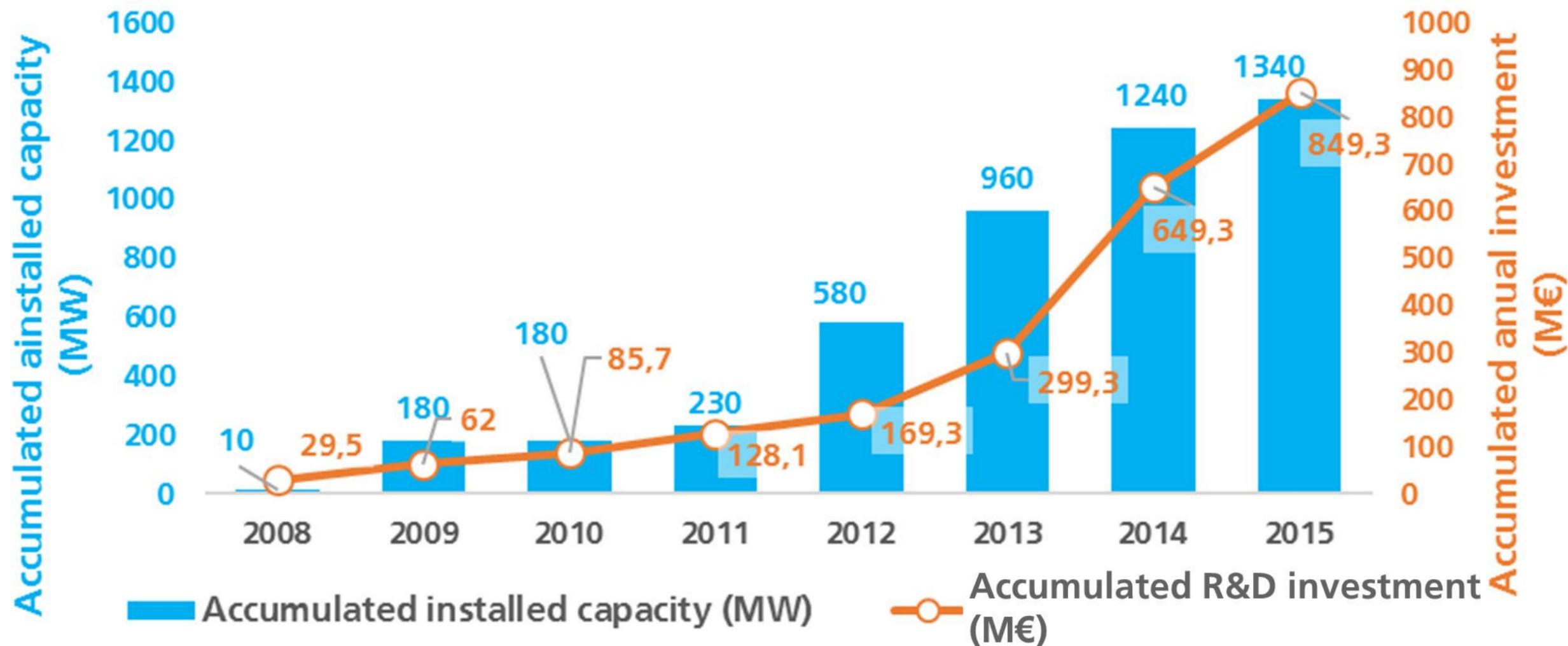
Summer 9 a.m.

Summer 16 9.m.



Innovation in CSP: Public funding "mandatory"

R&D investment vs installed CSP capacity



2

Key factors



Key factors

Abengoa's in-house performance model

Guarantee production

- Allows Abengoa to present bids and guarantee energy productions
- A proprietary PM allows integration vendors data instead of extrapolating characterization of commercial software (SAM)
- Completely customizable in-house.
- Lifetime simulations with a wide range of outputs (financial model inputs)

	A	B	C	D	E	F	G	H	I	J
31										
32		GrossPw (ST Gross power output MWe)								
33		Solar Thermal Power (kWh) // Dry Bulb Temperature (°C)	-2	1	4	7	10	13	16	19
34		26,884	5.30	5.31	5.31	5.31	5.31	5.31	5.31	5.31
35		35,000	8.07	8.07	8.07	8.07	8.07	8.07	8.07	8.13
36		50,000	12.92	12.92	12.92	12.92	12.92	12.92	12.92	13.07
37		65,000	17.69	17.69	17.69	17.69	17.69	17.69	17.69	17.81
38		80,000	23.26	23.26	23.26	23.26	23.26	23.26	23.26	23.24
39		95,000	28.94	28.94	28.94	28.94	28.94	28.94	28.94	28.94
40		110,000	36.16	36.16	36.16	36.16	36.16	36.16	36.16	36.14
41		125,000	42.22	42.22	42.22	42.22	42.22	42.22	42.22	42.21
42		140,000	48.25	48.25	48.25	48.25	48.25	48.25	48.25	48.21
43		155,000	54.25	54.25	54.25	54.26	54.26	54.26	54.26	54.21
44		170,000	60.20	60.20	60.20	60.20	60.20	60.20	60.20	60.21
45		185,000	66.04	66.04	66.04	66.03	66.04	66.04	66.04	66.00
46		200,000	71.82	71.82	71.82	71.82	71.82	71.82	71.82	71.81
47		215,000	77.59	77.59	77.59	77.59	77.59	77.59	77.59	77.61
48		230,000	83.35	83.35	83.35	83.35	83.35	83.35	83.35	83.31
49		245,000	89.07	89.07	89.07	89.07	89.07	89.07	89.07	89.00
50		268,844	100.68	100.68	100.68	100.68	100.68	100.68	100.68	100.60
51		275,000	102.10	102.10	102.10	102.10	102.10	102.10	102.10	102.00
52		290,000	106.92	106.91	106.91	106.92	106.92	106.92	106.92	106.80
53		298,417	110.23	110.23	110.23	110.23	110.23	110.23	110.23	110.10
54		302,900	111.67	111.68	111.68	111.68	111.68	111.68	111.68	111.60
55		318,680	115.66	115.66	115.66	115.66	115.66	115.66	115.66	115.60
56		318,680	112.66	112.66	112.66	112.66	112.66	112.66	112.66	112.60
57		305,800	111.61	111.61	111.61	111.61	111.61	111.61	111.61	111.60
58		298,417	110.23	110.23	110.23	110.23	110.23	110.23	110.23	110.10
59		290,000	106.92	106.91	106.91	106.92	106.92	106.92	106.92	106.80
60		268,844	100.68	100.68	100.68	100.68	100.68	100.68	100.68	100.60

Time of day:	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1	274	0	0	0	0	0	0	0	8	4	4	4	4	4	4	4	5	6	6	6	0	0	0	0
2	275	0	0	0	0	0	0	0	8	4	4	4	4	4	4	4	5	6	6	6	0	0	0	0
3	276	0	0	0	0	0	0	0	8	4	4	4	4	4	4	4	5	6	6	6	0	0	0	0
4	277	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
5	278	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
6	279	0	0	0	0	0	0	0	8	4	4	4	4	4	4	4	5	6	6	6	0	0	0	0
7	280	0	0	0	0	0	0	0	8	7	7	7	7	7	7	7	6	6	6	6	0	0	0	0
8	281	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
9	282	0	0	0	0	0	0	0	7	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
10	283	0	0	0	0	0	0	0	8	8	8	8	8	7	0	4	6	6	6	6	0	0	0	0
11	284	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
12	285	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
13	286	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
14	287	0	0	0	0	0	0	0	8	4	4	4	4	4	4	4	5	6	6	6	0	0	0	0
15	288	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
16	289	0	0	0	0	0	0	0	8	8	8	8	7	7	7	7	6	6	6	6	0	0	0	0
17	290	0	0	0	0	0	0	0	8	7	7	7	7	7	7	7	6	6	6	6	0	0	0	0
18	291	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
19	292	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
20	293	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
21	294	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
22	295	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
23	296	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
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25	298	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
26	299	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
27	300	0	0	0	0	0	0	0	8	7	7	7	7	7	7	7	6	6	6	6	0	0	0	0
28	301	0	0	0	0	0	0	0	8	7	4	4	4	4	4	4	5	6	6	6	0	0	0	0
29	302	0	0	0	0	0	0	0	8	7	7	7	7	7	7	7	6	6	6	6	0	0	0	0
30	303	0	0	0	0	0	0	0	8	7	7	7	7	7	7	7	6	6	6	6	0	0	0	0
31	304	0	0	0	0	0	0	0	8	3	3	3	3	3	3	3	4	4	4	4	0	0	0	0
32	305	0	0	0	0	0	0	0	8	3	3	3	3	3	3	3	4	4	4	4	0	0	0	0
33	306	0	0	0	0	0	0	0	8	3	3	3	3	3	3	3	4	4	4	4	0	0	0	0
34	307	0	0	0	0	0	0	0	8	3	3	3	3	3	3	3	4	4	4	4	0	0	0	0
35	308	0	0	0	0	0	0	0	8	3	3	3	3	3	3	3	4	4	4	4	0	0	0	0

Key factors

Economy of scale has been one of the most important key factors in order to optimize the costs....

- Due to the size of the Project the costs are optimized
- Suppliers are able to invest in order to improve their fabrication procedures
- The construction of identical plants simultaneously produces engineering savings (same equipment x3)



Key factors

Agreements with OEMs and local contractors to improve the costs

- Collaboration agreements with OEMs
- Dealing with local contractors and know-how of the local market
- Chinese market essential to lower costs
- Validation of new manufacturers



Key factors

Power purchase agreement extended to 35 years

- Allows the facility energy production for an extended period beyond 25 years
- Improvement in the financial model
- Design life of equipment for 35 years (confirmation by vendors required)



Shared facilities

- If you have several plants close to each other, shared facilities are going to be implemented
- Total costs of the Project are optimized

Main challenges

Logistics

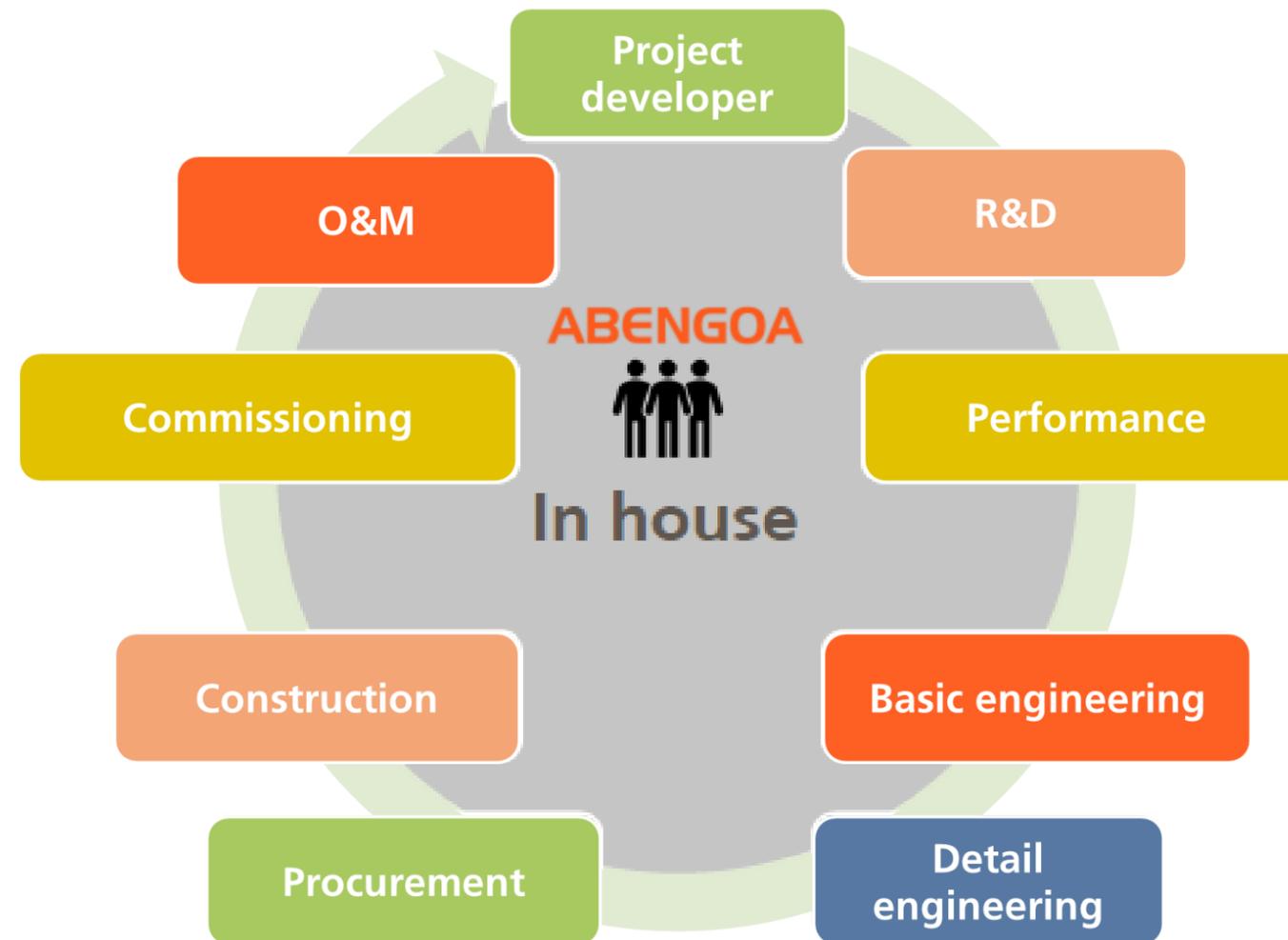
- Only for the solar field you will have more than 30 big trucks arriving at our plant on a daily basis
- Stock area has to be monitored
- Solar component manufacturing process has to be carefully controlled
- Traffic control has to be dealt with Roads & Transport Authority



Main challenges

Many stakeholders in one project....

....working at the same time in the same place...



Leading with many contractors and many interfaces is critical to comply with time Schedule and plant performance

Abengoa: Full integration in the CSP value chain

3

Hybridization



Hybridization Challenge in the Energy Industry

Reducing CO₂ Emissions

- In the current situation of the market, the Energy Industry must **strictly comply with the applicable regulatory framework**.
- Conventional solutions cannot accommodate such tight regulatory frameworks keeping the same LCOE.

Dispatchability

- **Generation profiles shall meet, at the minimum cost**, the final consumer profiles. Those request are quite different depending on the geographies.
- PPA are being developed for a longer period of time with a very tight structure in terms of generation, increasing flexibility and reducing time response.

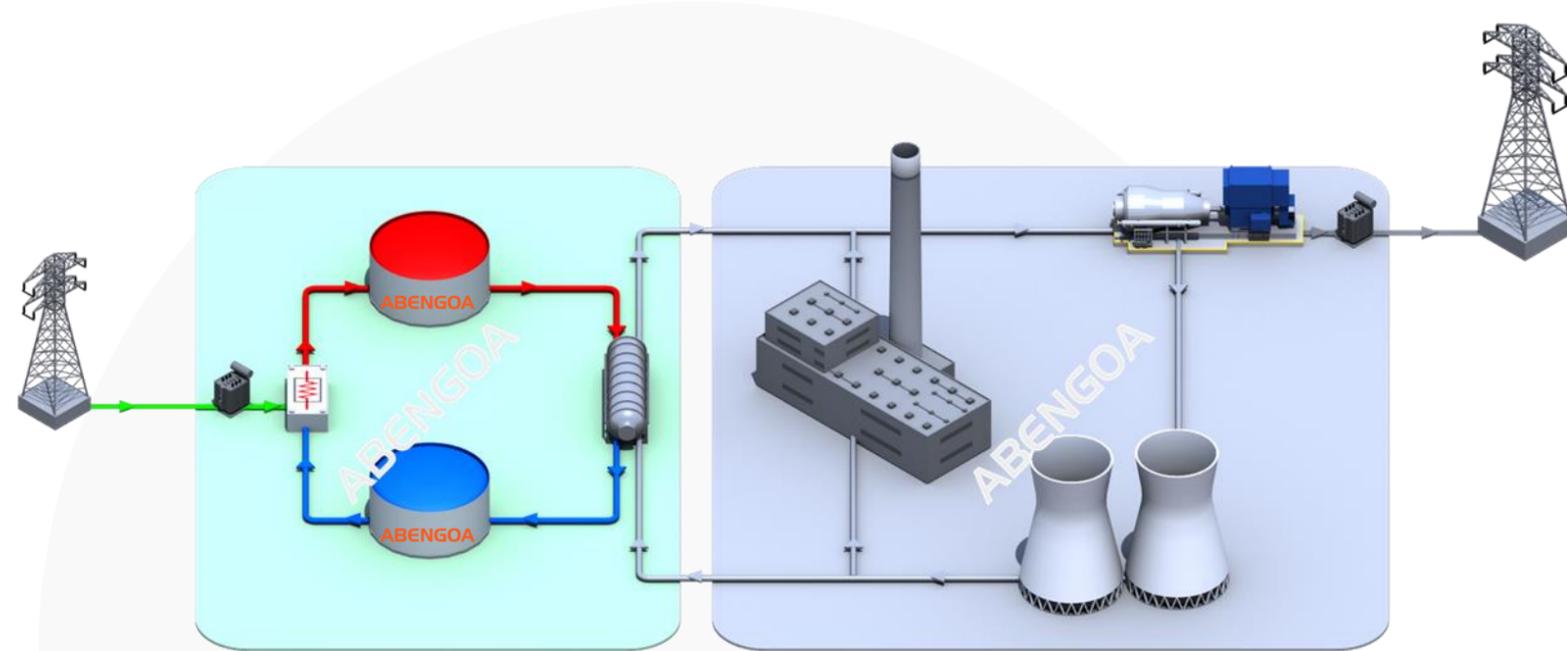
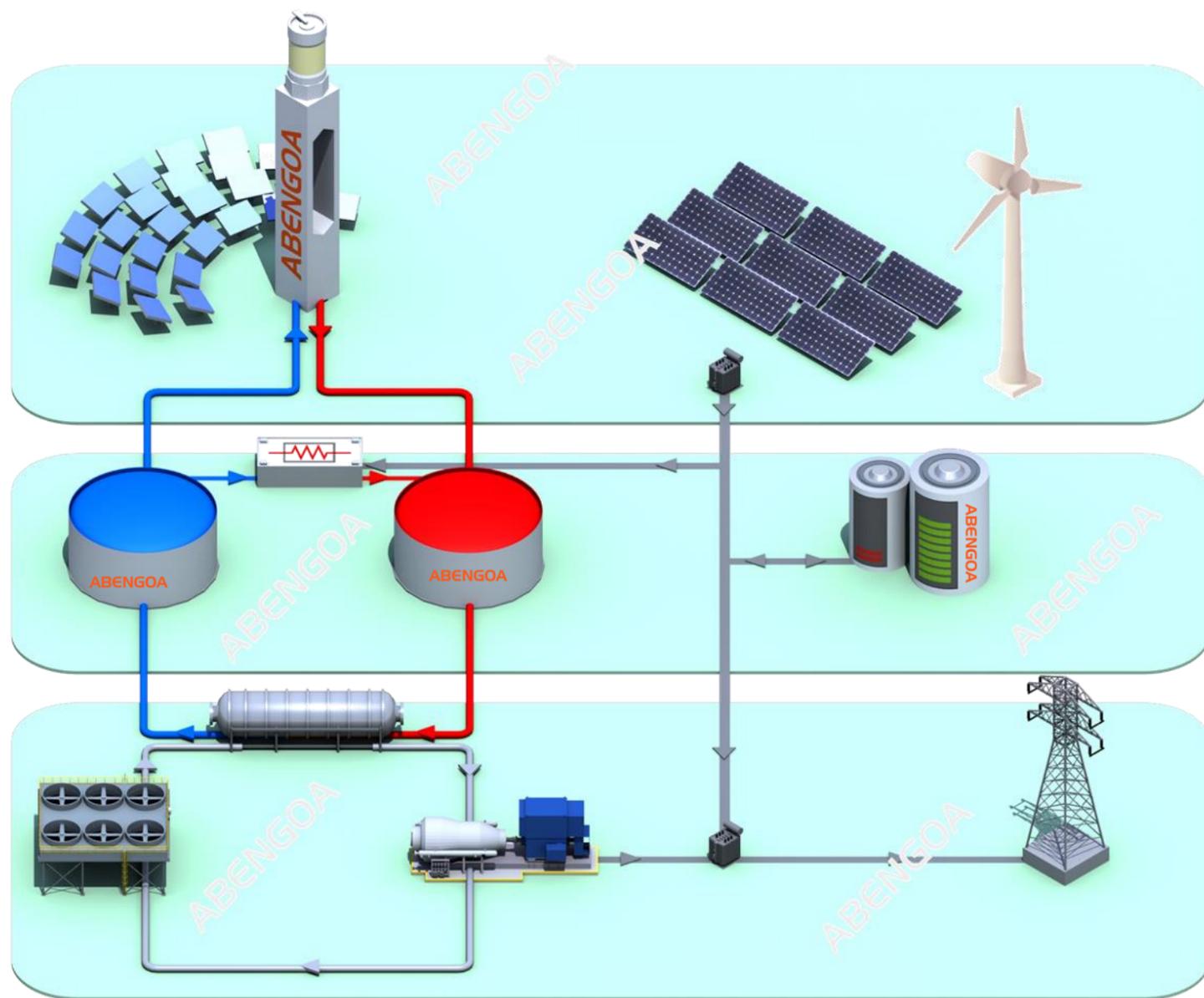
Lowering LCOE

- today it is not only "LCOE" but "flexibility"
- in past year, the **Market has dramatically reduced the costs of the Main Components for all technologies** (CSP, PV, BESS and MS).
- A certain proportion of CSP with a high storage capacity allows a maximum penetration of REs at a more than acceptable cost and with less curtailments.

Development of Hybrid Performance Models

- To **provide an accurate and reliable hybrid solution**, is required a theoretical model able to define an appropriate design at the lowest cost.
- **Abengoa has its own technology to develop specific theoretical models to provide innovative, credible and accurate solutions** for any generation profile for any specific Industry.

Energy solutions currently provided by CSP Technology

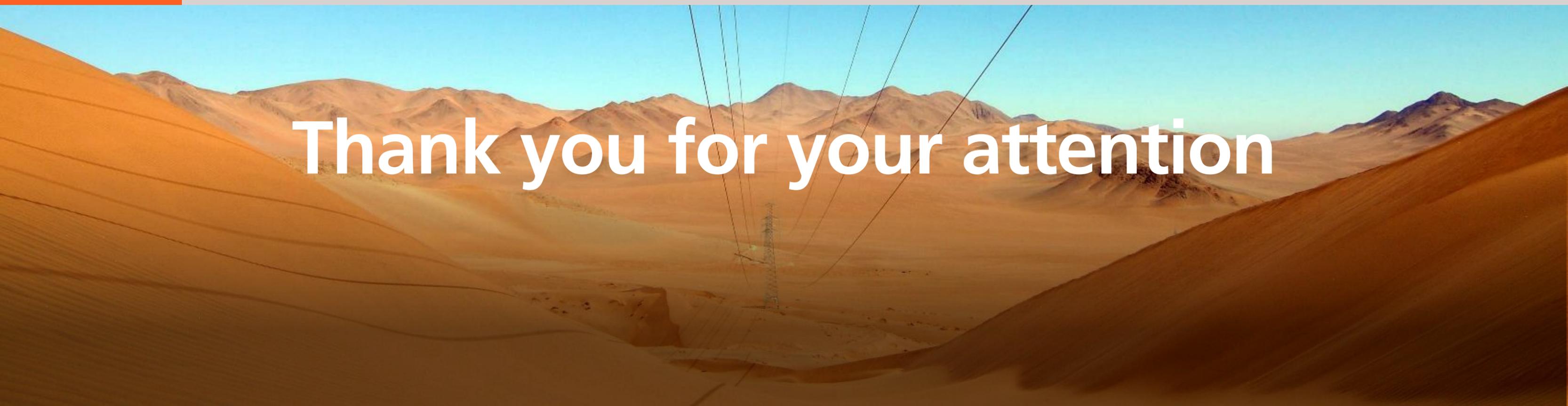


Hybrid Solution CSP+PV+TES+BESS
75 % Capacity Factor
Takes Advantage of PV/Wind low cost
TES guarantees constant power output
Electrical Heaters to use the PV/wind dumping. Reserve solutions
Coal Power Plant. Reuse the thermal cycle with molten salts to increase grid dispatchability

ABENGOA

Innovative technology solutions for **sustainability**

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A wide-angle photograph of a desert landscape featuring rolling sand dunes in shades of orange and brown. In the distance, a power line tower stands on a ridge, with several power lines stretching across the sky. The sky is a clear, pale blue. The text "Thank you for your attention" is overlaid in white, bold, sans-serif font across the center of the image.

Thank you for your attention