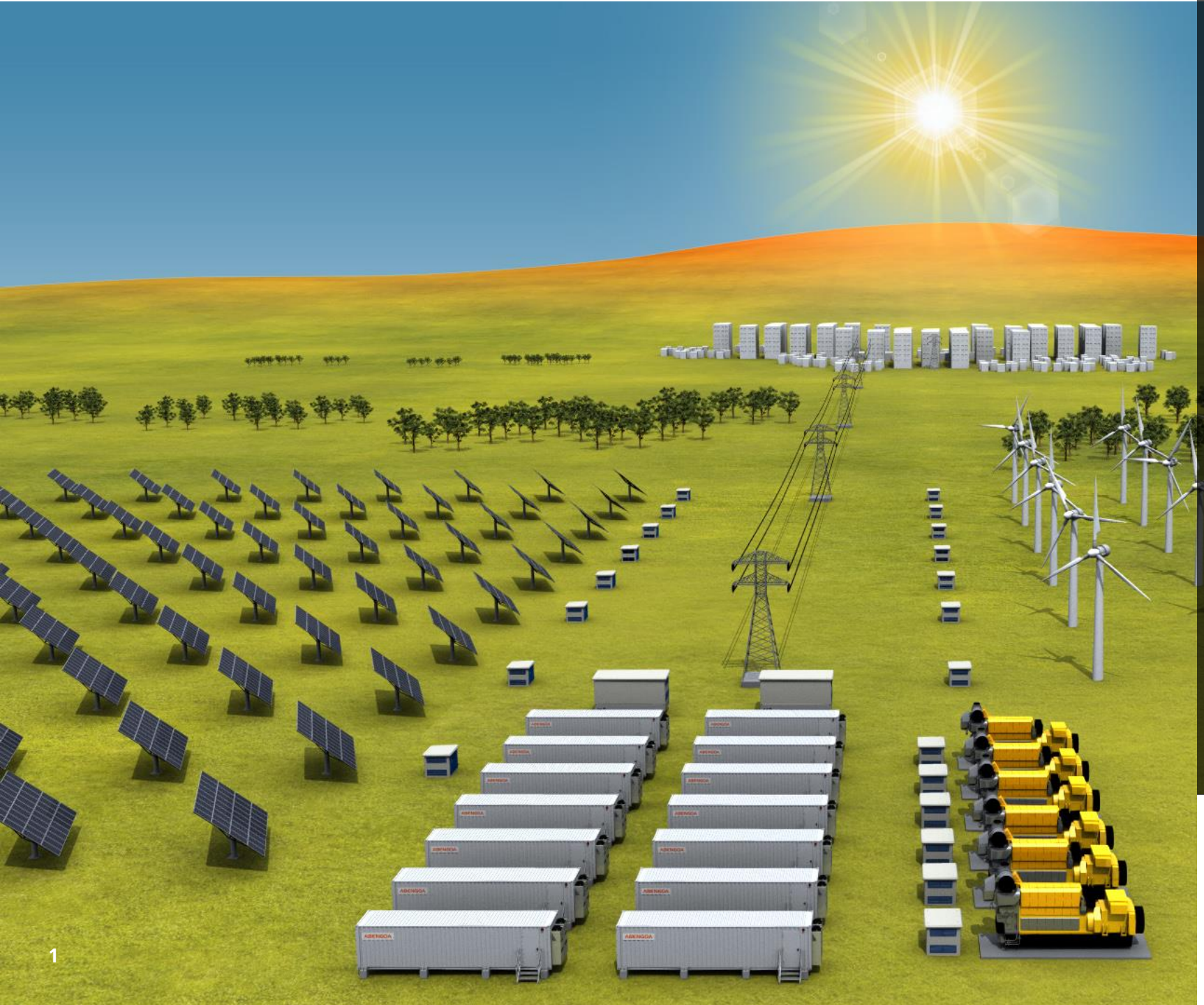

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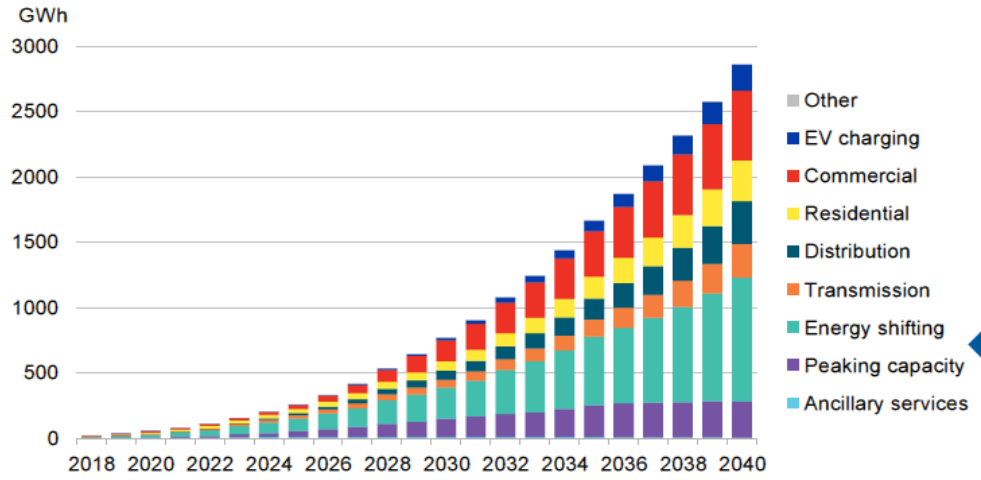
The role of the CSP in the new energy market

Miguel Méndez
Director of CSP Technology
Sacramento, 2020-18-02

Energy transition is not possible without the role of Solar Thermal Electricity

- Decarbonization of human activities is the main and urgent challenge that we face today
- Electricity is the easiest energy vector to be decarbonized, as renewable technologies are currently cheaper than fossil fuel plants
- The large majority of new capacity to be added – as result of demand increase and/or decommissioning of conventional plants – will be **renewable**
- But, non dispatchable renewables (PV / Wind) can't meet the demand at any time
- **More renewables = energy storage needed**

Stationary energy storage market by application through 2040



Source: Long-Term Energy Storage Outlook, Bloomberg, 2019

- *Energy shifting,* **energy from intermittent renewables is stored at times of low prices and surplus energy, and discharged tomeet demand at later:**
  83 GWh by 2025
  948 GWh by 2040
- *Peaking capacity,* **providing firm dispatchable capacity to meet peak grid demands**
  77 GWh by 2025
  276 GWh by 2040

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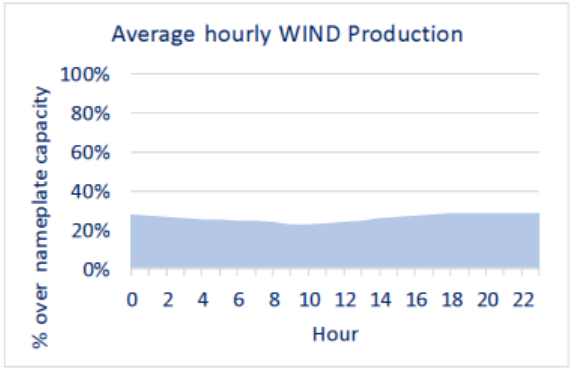
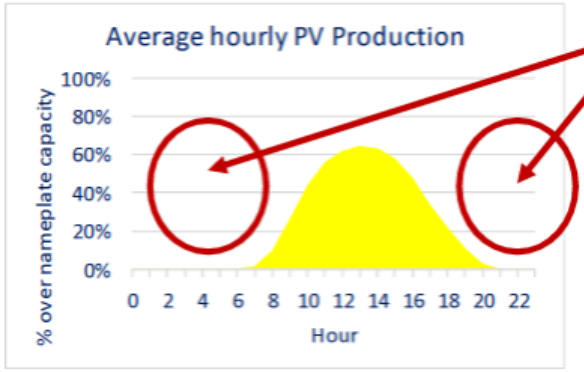
More renewables = energy storage needed

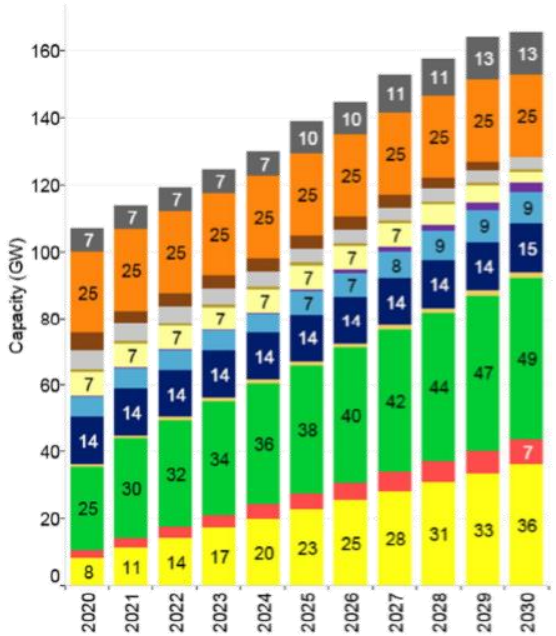




There are no utility scale 12 h batteries as of today. The experts don't expect them on the next decade

CSP plants can provide synchronous and absolutely firm supply, with no deviations for the day ahead program from sunset till sun rise next

National Energy Climate Plan in Spain: CSP/TES key for a full dispatchable system



1) 77% RES-E over generation by 2030 (100% by 2050)
- Including 40TWh net exports (vs.~11TWh Pöyry)
- 268TWh demand (vs.~292 TWh Pöyry incl. 5mEV)
- +5.9GW/y (2.8GW PV, 0.5GW CSP, 2.6GW Wind)
- +0.7GW/y Wind repowering

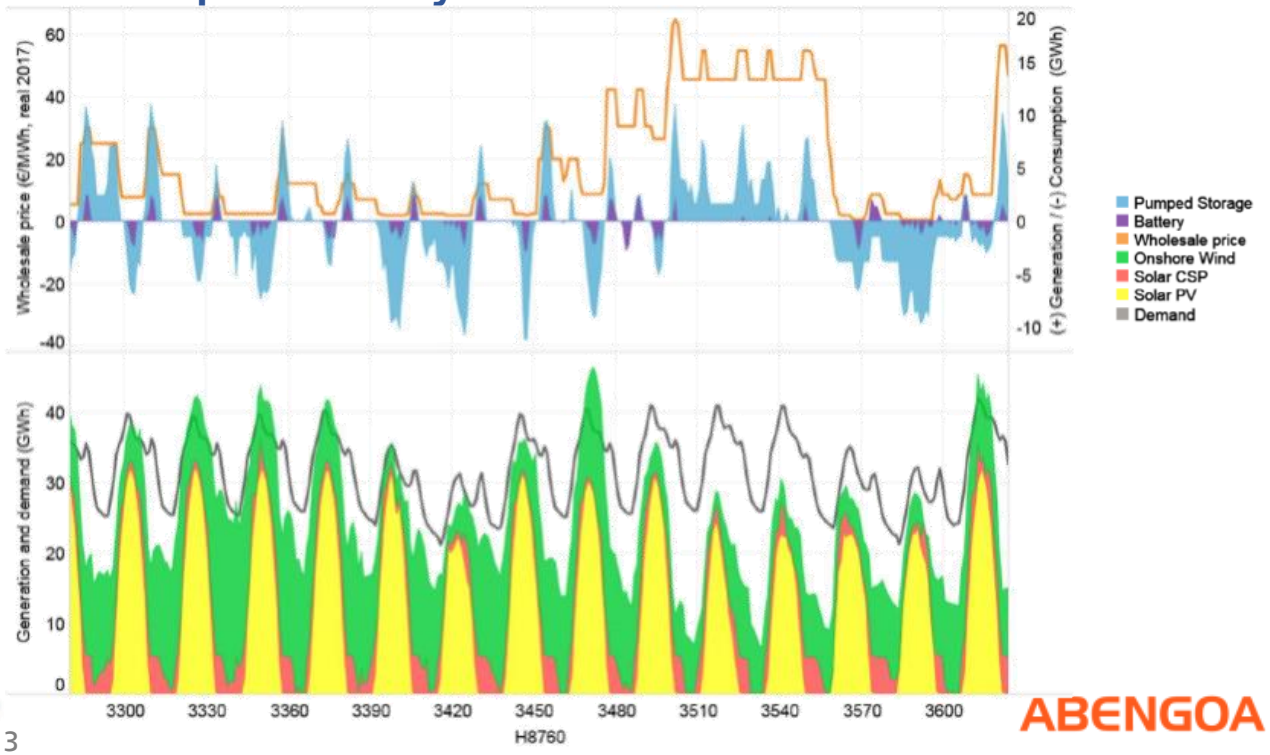
2) Additional storage
- +3.5GW pumped storage hydro
- +2.5GW batteries (2 hours storage)
- CSP with 9 hours storage

2) Thermal capacity
- Decommissioning of all coal plants by 2030
- Gradual phase-out of nuclear capacity (3GW by 2030)

3) Interconnections Spain-France
- ~3GW in 2019
- ~5GW in 2025
- ~8GW in 2030

Interconnector, CCGT, Coal, CHP, Waste, Nuclear, Battery, Pumped Storage, Hydro, Biomass, Onshore Wind, Solar CSP, Solar PV

PÖYRY



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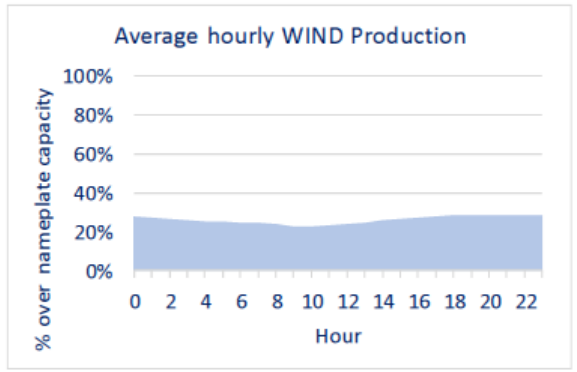
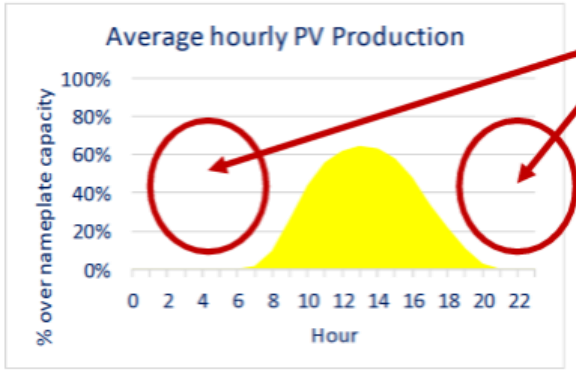
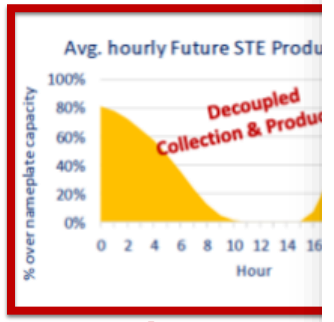
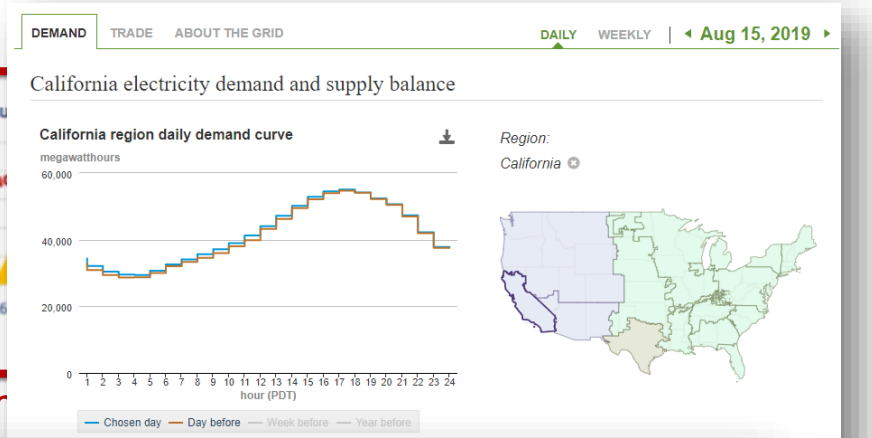
More renewables = energy storage needed

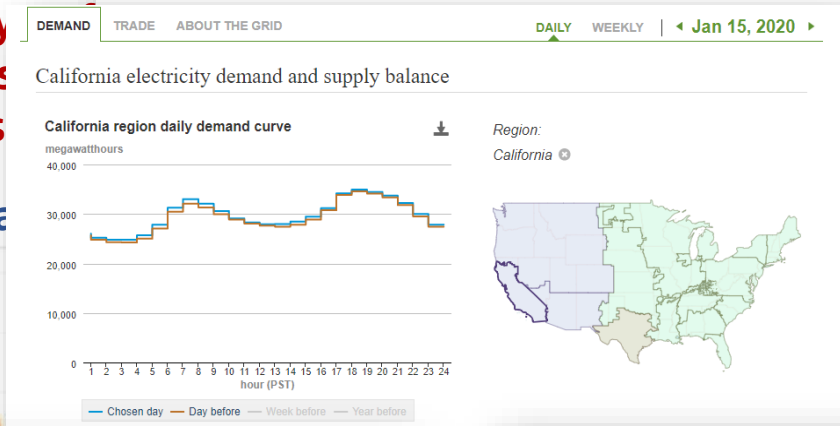




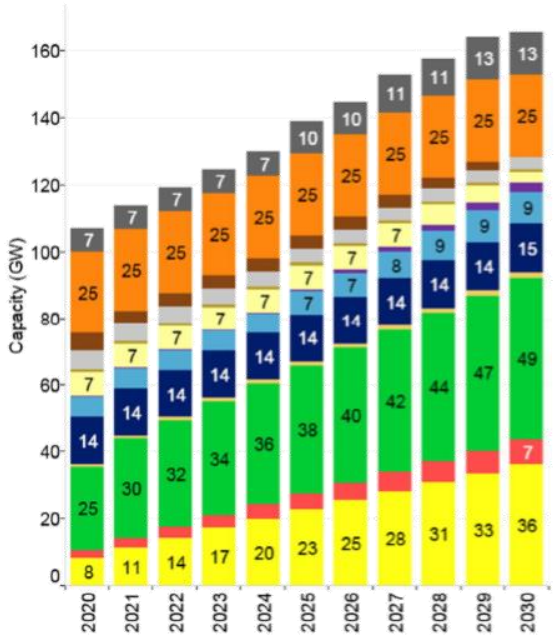




CSP plants car
absolutely
deviations
from suns



National Energy Climate Plan in Spain: CSP/TES key for a full dispatcha



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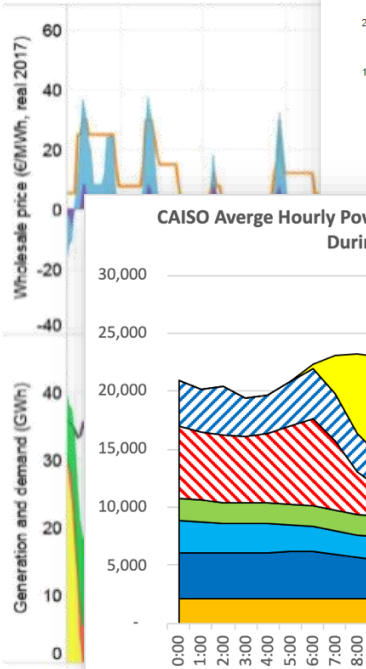
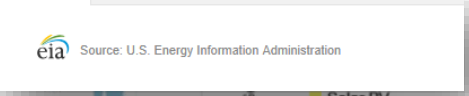
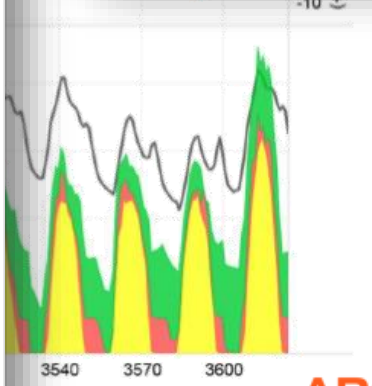
Interconnector
CCGT
Coal
CHP
Waste
Nuclear
Battery
Pumped Storage
Hydro
Biomass
Onshore Wind
Solar CSP
Solar PV

PÖYRY







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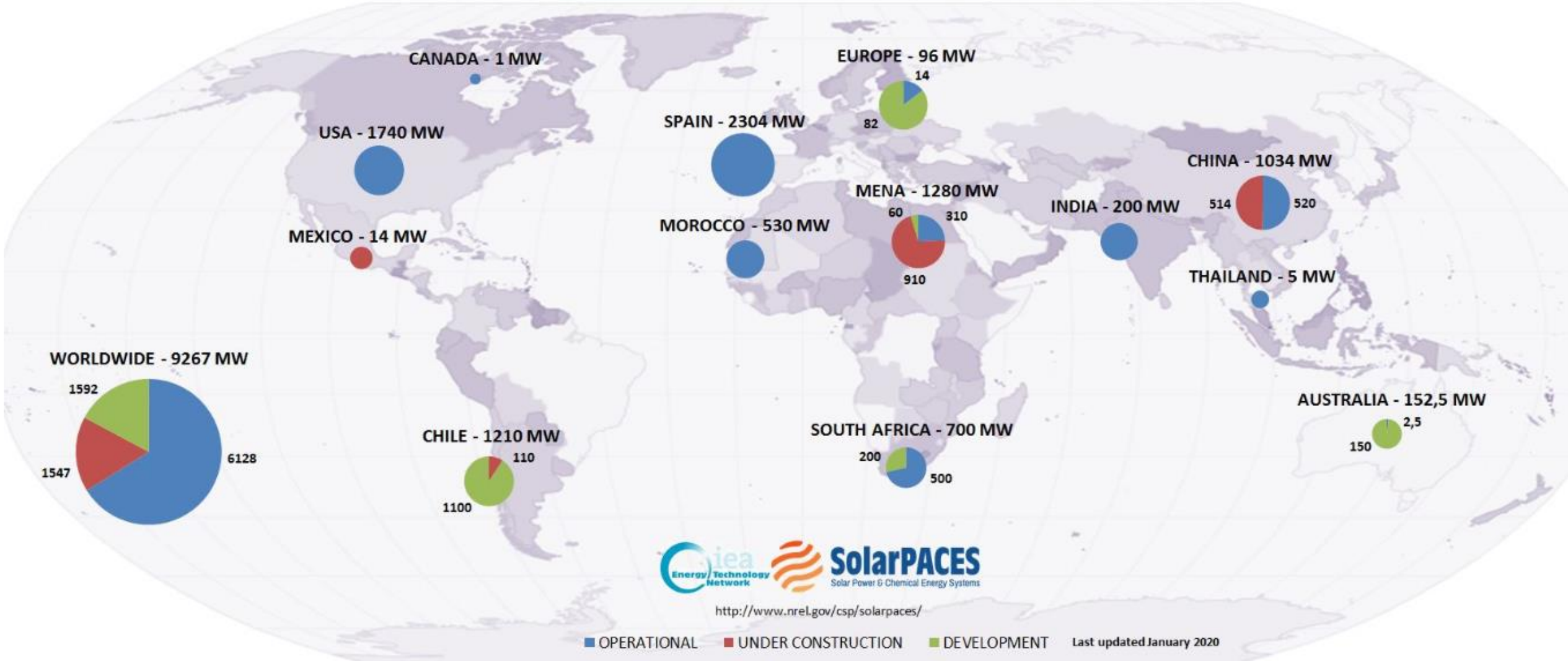
CSP projects around the world



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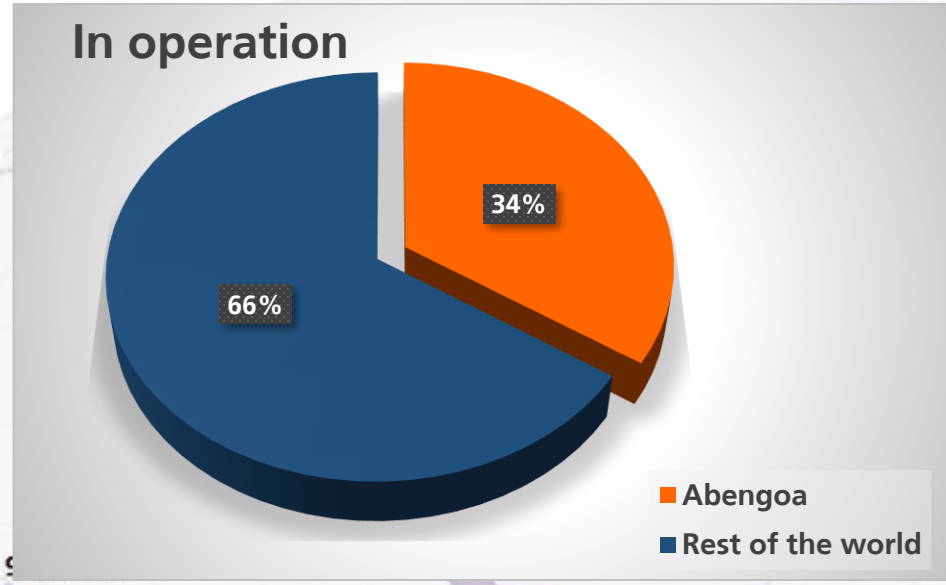
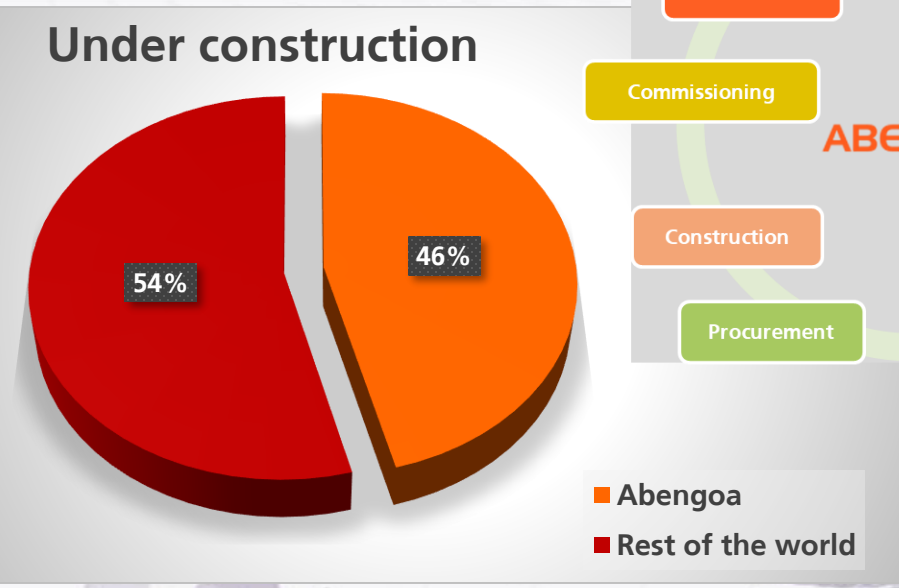
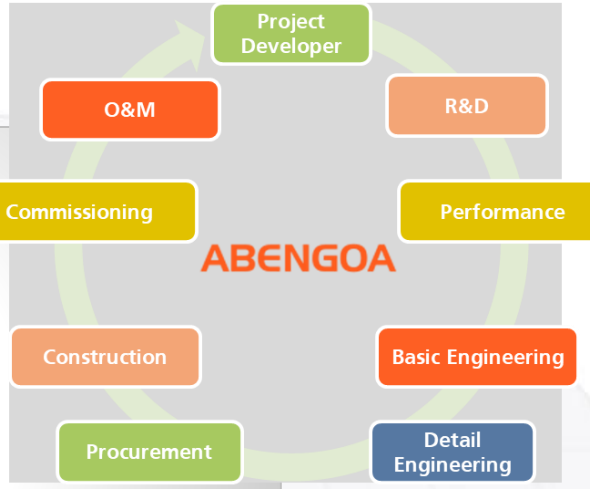
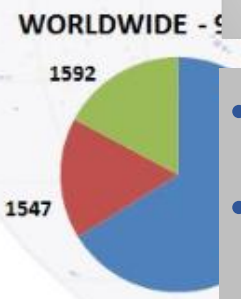
CSP projects around the world: Abengoa









- 25 CSP plants in the world
- Complete integration of lessons learned in the value chain: evolution of technology, improvement in the construction, PeM and the operation of our plants
- Lessons learned is the main value to reduce costs in technology and improve the reliability of the solution.

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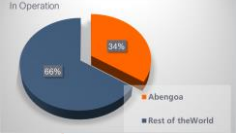
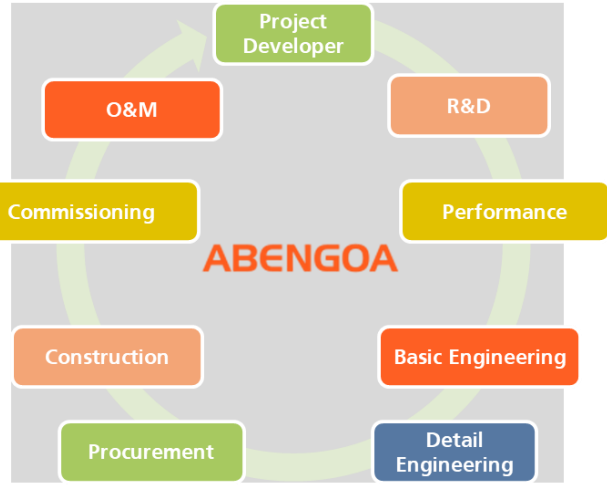


Lessons learned

CSP projects around the world: Xina, case of success (Abengoa)

Abengoa as **key player along all the stages** in Xina Solar One Project

- Developing, since the RFQ in 2013 – **Sponsor**
- Financial Process in 2014 – **Sponsor + Project Company**
- Construction 2015 – 2017 - **EPC Contractor + Project Company**
- Operation 2017 – 2037 - **O&M Contractor + Project Company**



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IDC Industrial Development Corporation

XiNa community trust

PUBLIC INVESTMENT CORPORATION

Sponsor - Project Company

Abengoa is the main partner in the Project Company with 40% of the shares

IDC, PIC and Xina Community Trust own 60%

EPC Contractor

Abengoa was the EPC Contractor

The Project was executed successfully within time and budget

O&M Contractor

Abengoa is the O&M Contractor. The Plant is currently under operation achieving the expected performance with a reliable operation

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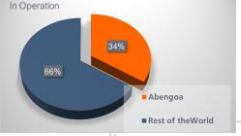
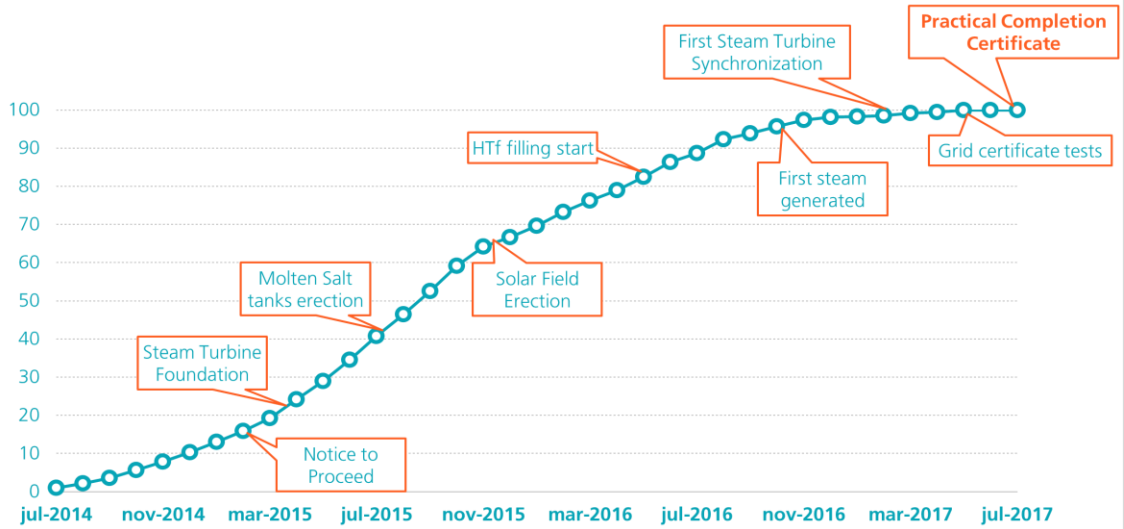


Lessons learned

CSP projects around the world: Xina

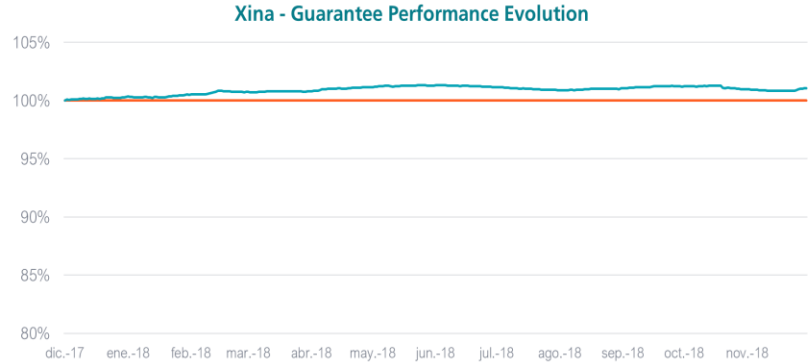
Planning and **Key Milestones** – Project Execution Schedule



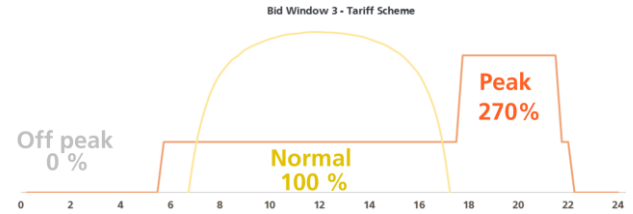
Project Completed before deadline (31st July 2017)

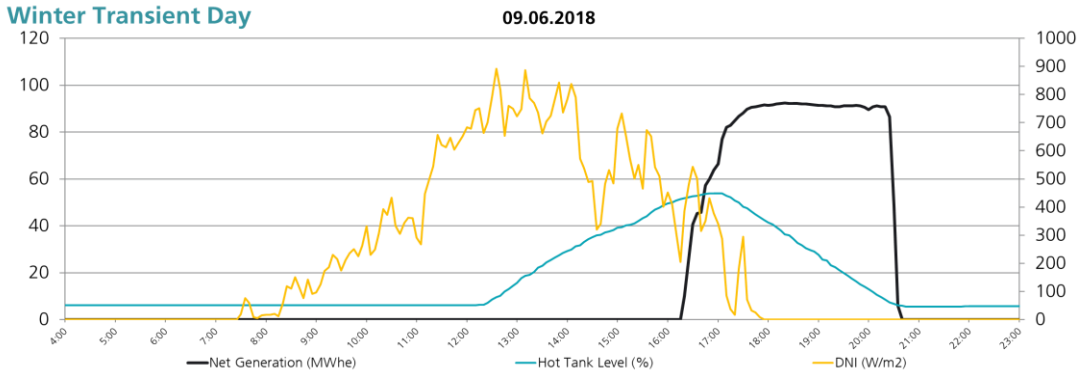
Production Guaranteed Period

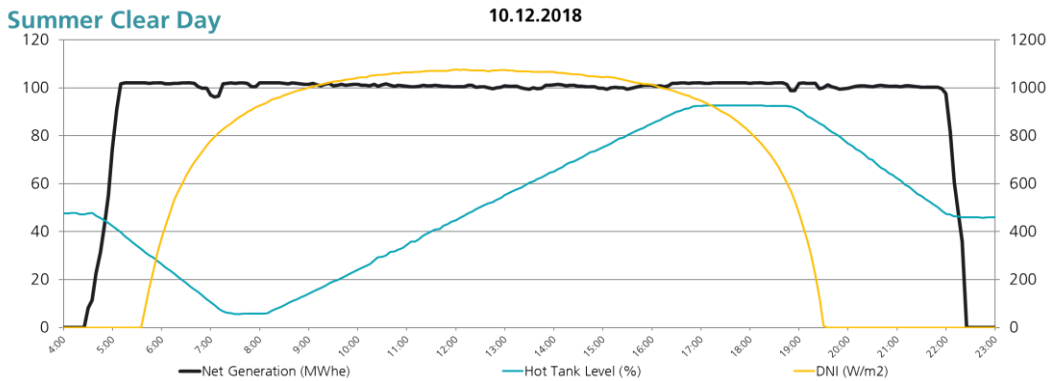
- Within the first 24 months of Operation the Contractor may select 12 consecutive Months to evaluate the Total Energy Generation and the Total Auxiliary Consumption.
- On the 30th November 2018, Xina Solar One achieved this very important milestone after **12 months operating above 100% of the expected generation** and below 100% of the expected auxiliary consumption
- On the 31st July 2019 it is expected to obtain the **Final Completion Certificate**, once the Liability Period of 2 years will expire.

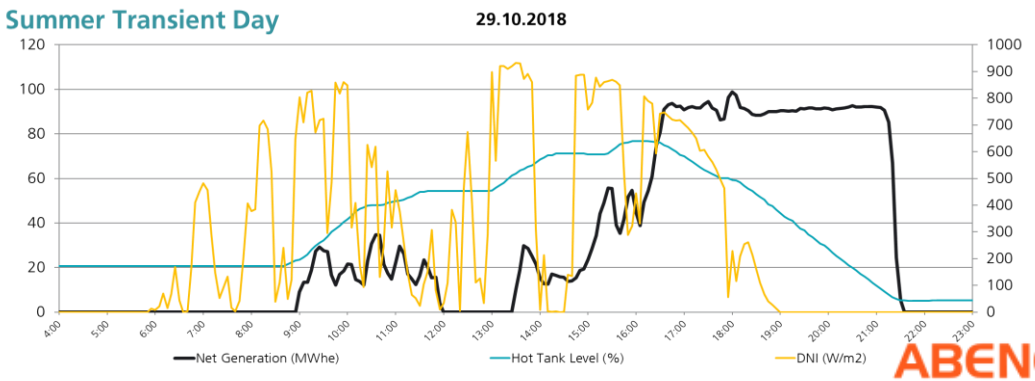


Avg: 101.8%









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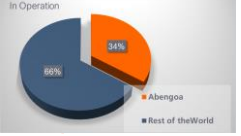

Lessons learned

CSP projects around the world: Noor Energy I, case of success (Abengoa)

هيئة كهرباء ومياه دبي
Dubai Electricity & Water Authority

ACWA POWER
كهرباء وماء

上海电气
SHANGHAI ELECTRIC

ABENGOA

Sponsor – Project Company	EPC Contractor	Technology provider
ACWA-led consortium (49%) together with DEWA (51%) form the Project Company Noor I	Shanghai Electric to be the engineering, procurement and construction (EPC) contractor	Abengoa is the key technology provider for the hybrid solar power facility

2.4 mill tons of CO_2 emissions prevented

190,000 UAE Households

World's largest solar power facility

Key numbers

Abengoa will provide for the whole project...

...and 157,000 tn of structures

Which were the key factors to win the project....?

- Economy of scale
- Agreements with OEMs and local contractors
- PPA 35 years
- Shared facilities
- Abengoa expertise
- Large PV, new concept of hybrid plant with PV integrated in the CSP

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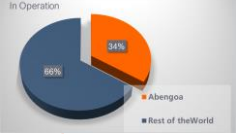
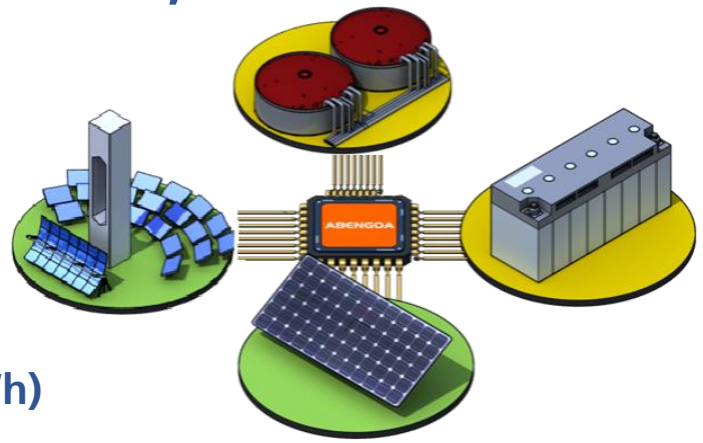


Lessons learned

CSP projects around the world: Cerro Dominador, case of success (Abengoa)



210MW Hybrid solar power plant with storage

- Solar thermal and photovoltaic plant with molten salt and li-ion battery storage
- Technologies: **STE (110MW) + MS TES (17,5h, 4900MWht) + PV (100MW) + BESS (4MWh)**
- World's largest dispatchable renewable energy plant: **93.5% energy availability factor**
- Heat transfer fluid: molten salt 565ºC
- 3 tanks molten salt configuration
- Land requirement: 1000Ha
- Market: mining area

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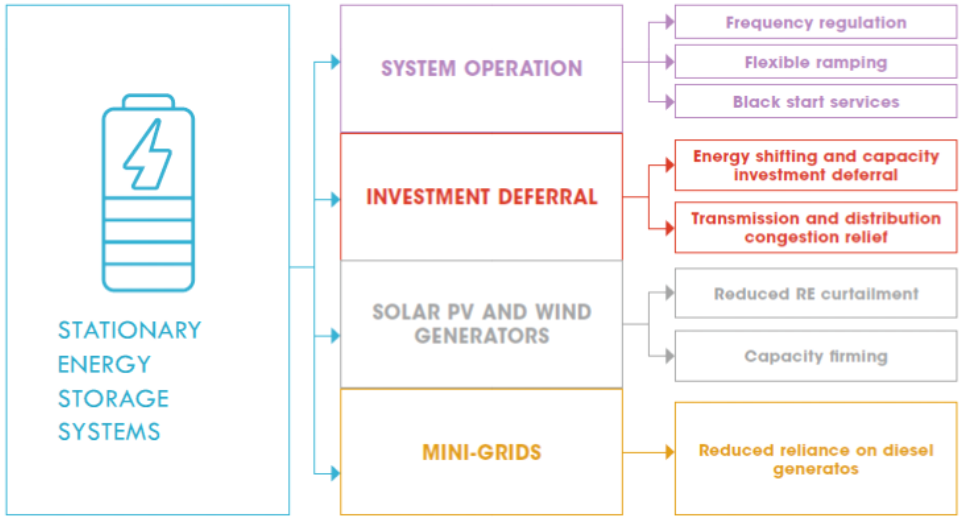
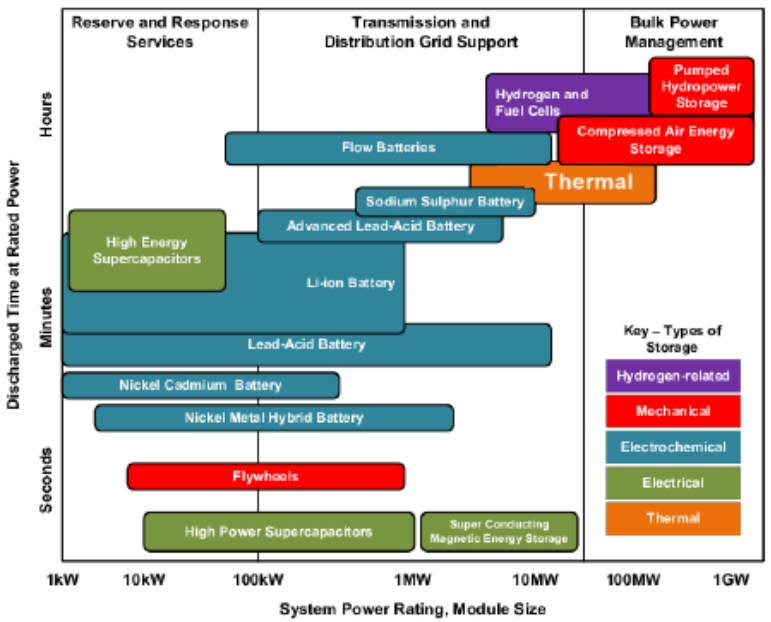
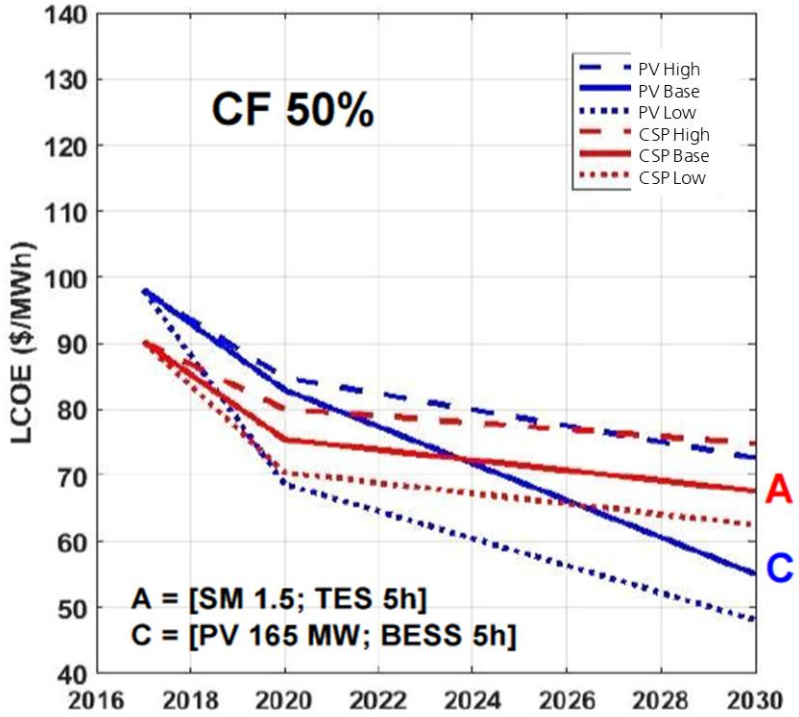
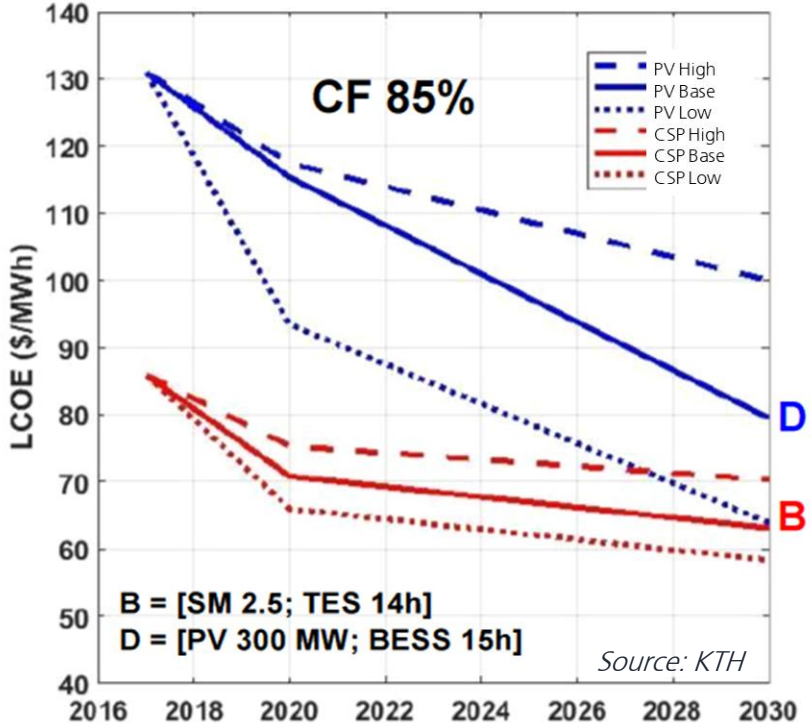
Energy transition is not possible without the role of storage



- Storage technologies can complement each other (and not necessarily compete)
- Technological development **is currently taking place in all of them**
- **Investment in this sector is exponentially increasing following mid-long term expectations**



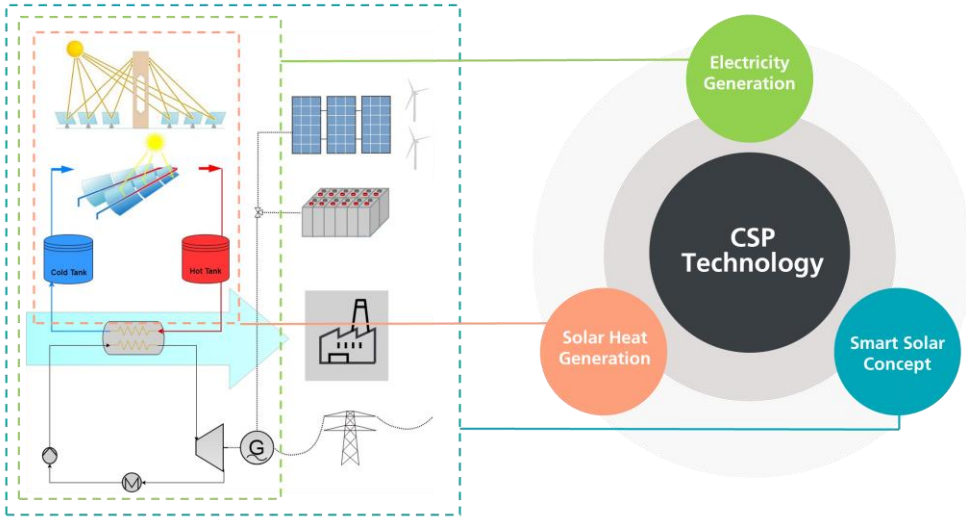


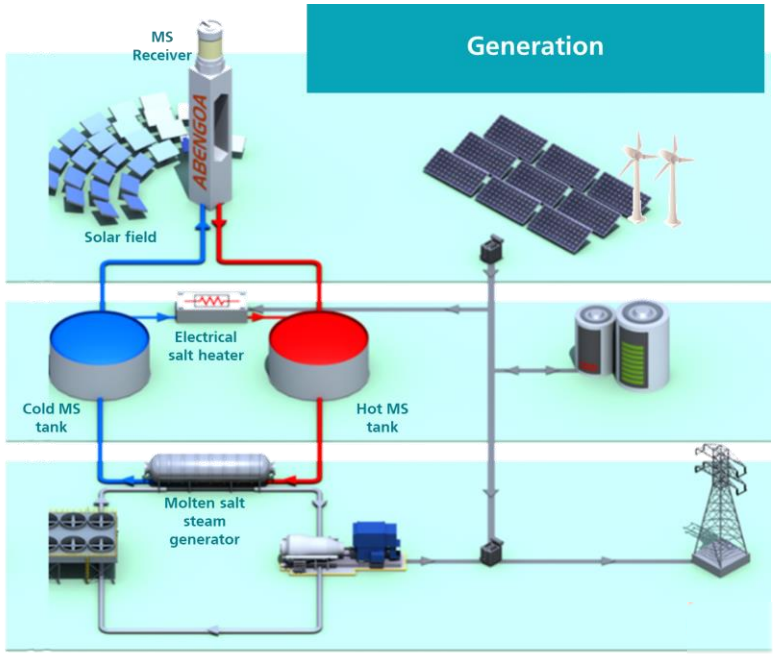


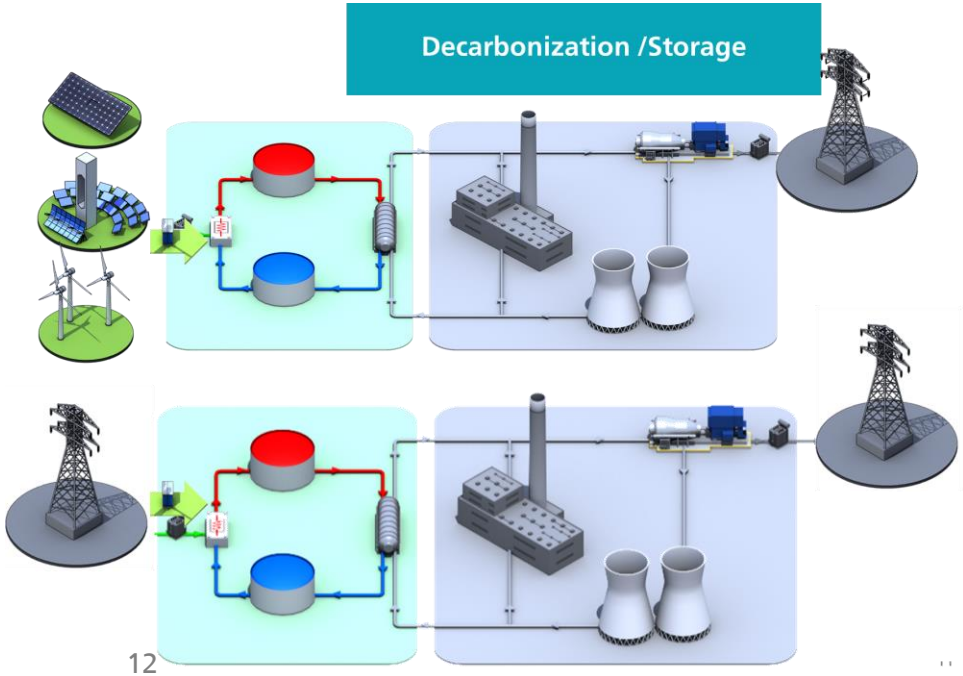
Energy transition is not possible without the role of thermal heat storage

- Thermal storage assets to support grid expansion with RES
- Scalable and highly modular large power capacities (100 MW – 1 GW +)
- Long duration (8 - 16 hours and more)
- Cost-effective (LCoS = 40-60 €/MWhe)
- High potential development after a massive implementation

  (η = 35% -> 55%)
- Can provide heat and power







Coal plants

- Forced to operate inefficiently due to RES
- 296 Plants in EU (185 GW)
- **33.000 + Employees**
- Most planned to be retired by 2040 (decommissioned)

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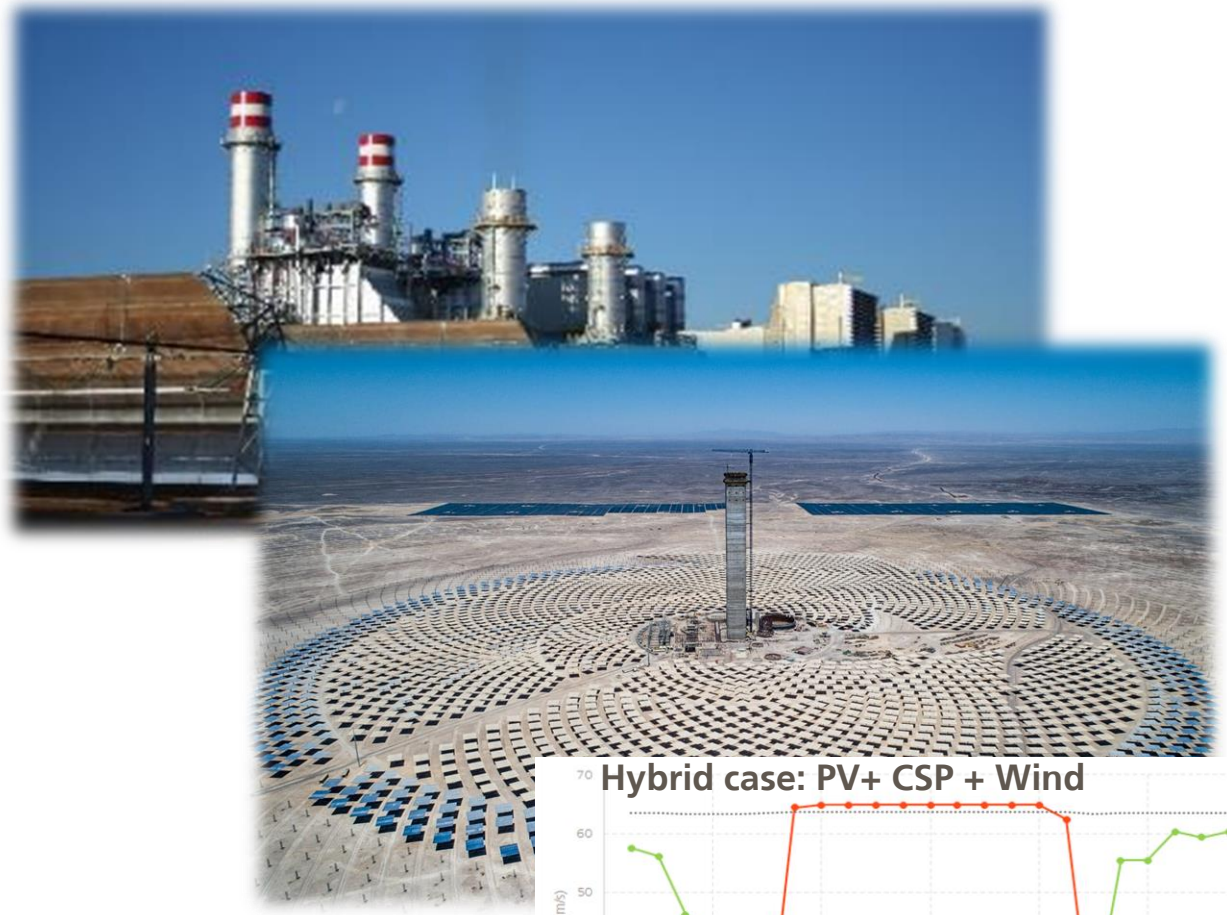
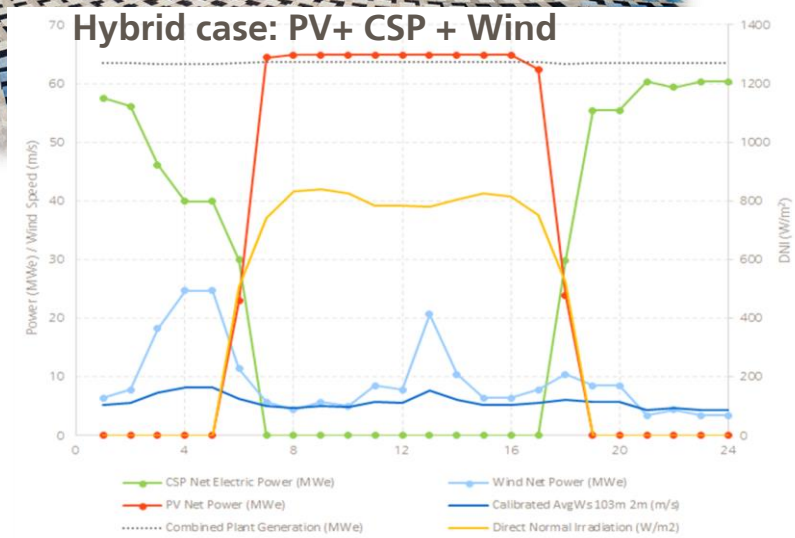
Conclusions

- **CSP / TES** fulfilled the main Western USA targets : flexibility, reliability, reduce dependence on conventional and reduce emissions
- **CSP / TES** is a proven and robust technology as long as there are companies that have the right experience.
- **CSP / TES** as part of customized solutions integrating any type of technology (eg PV + CSP + TES + BESS) to generate sustainable solutions.
- Abengoa is an expert in the **hybridization of power plants to provide dispatchable, clean energy solutions**.





* Image from daily generation forecast (corresponding to 4th of January) extracted from annual Simulation performed West Musgrave power plant using Abengoa's Performance Model tool.

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Innovative technology solutions for sustainability