

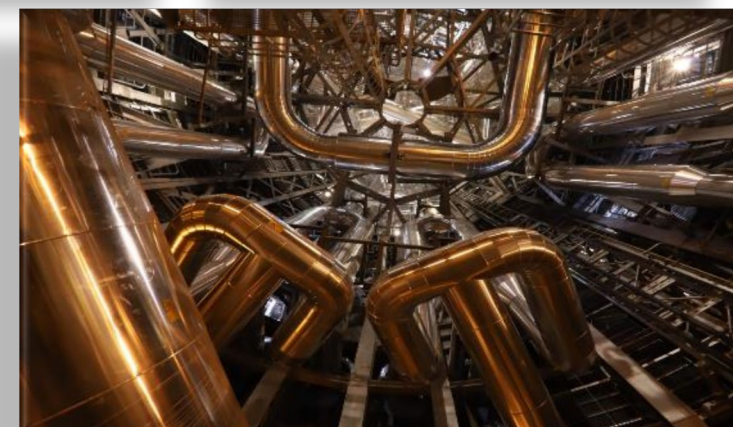
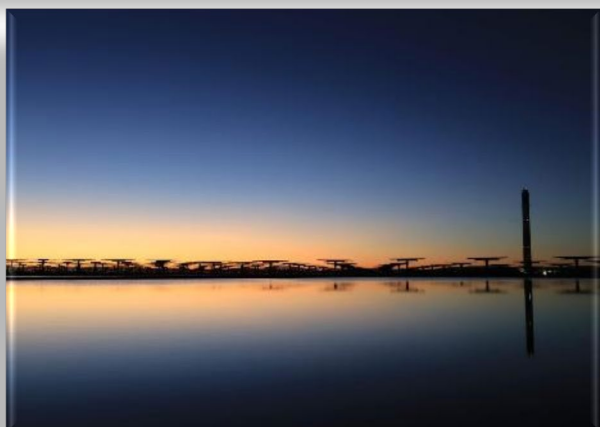
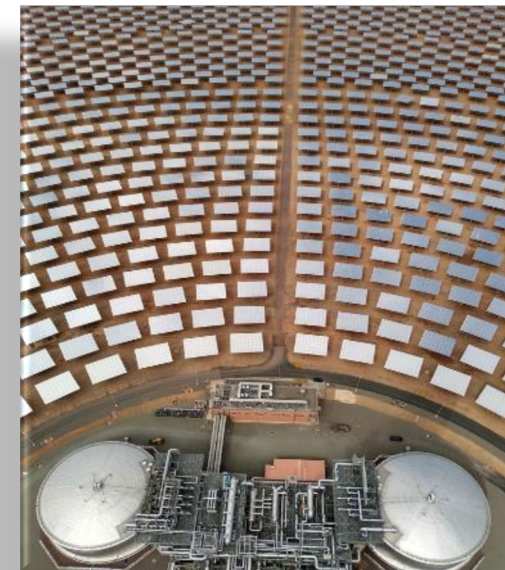


U.S. DEPARTMENT OF
ENERGY

CSP Development Around the World: SENER Experience
Mercedes Sierra, CEO SENERUSA

NOOR III is ONLINE

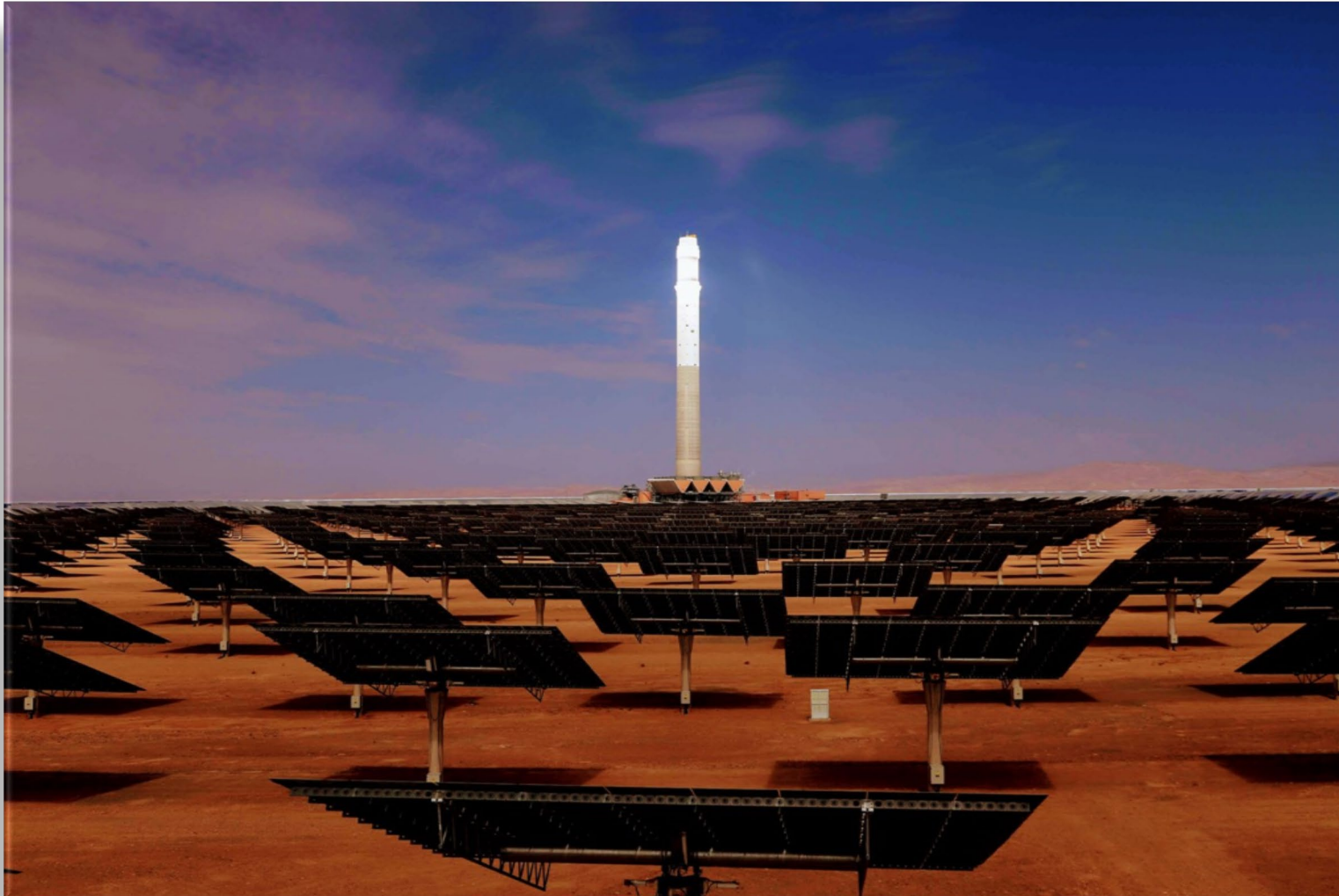
150 MW + 7.5 hours: the LARGEST Molten Salt Power Tower in OPERATION





NOOR III is ONLINE

150 MW + 7.5 hours: the LARGEST Molten Salt Power Tower in OPERATION



SENER ROLE

- TECHNOLOGY PROVIDER
- **50% EPC CONTRACTOR**
- O&M CONTRACTOR



MILESTONE in CSP TECHNOLOGY

- LARGEST MS TOWER PLANT in OPERATION
- UTILITY SCALE - 150 MW
- ADAPTED to PEAK DEMAND - 7.5 HOURS



PERFORMANCE FULFILLED

- **TARGET PERFORMANCE ACHIEVED in MONTH #1**
- AUTOMATIC OPERATION, DIGITALIZATION
- LESSONS LEARNED from GEMASOLAR

SENER, founded in 1956

Strategic business units



AEROSPACE



- Space
- Defense
- Aeronautics



INFRASTRUCTURE & TRANSPORT

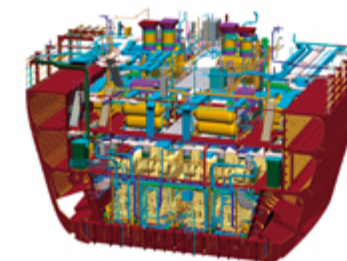
- High speed railways
- Freight & mainline railways
- Metro systems
- LRT's & tramways
- Roads & highways
- Airports
- Ports
- Architecture
- Water & environment



RENEWABLES, POWER, OIL & GAS



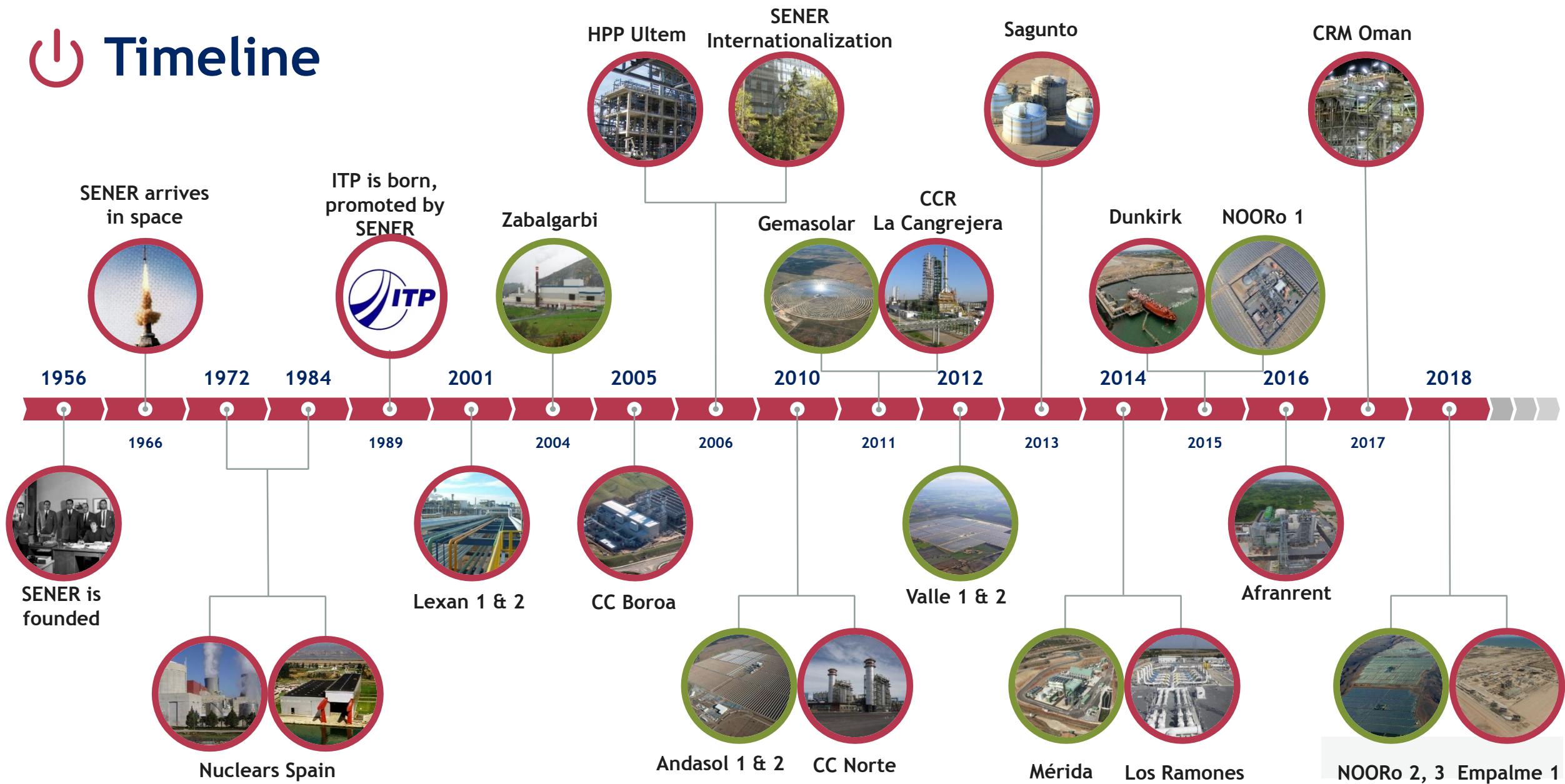
- Concentrated Solar Power
- Photovoltaic
- Storage
- Biomass
- Hybrid CSP+PV, CSP+Biomass
- Offshore wind
- Waste to energy
- Power & industrial solutions
- Oil & Gas



MARINE

- Marine engineering
- FORAN

Timeline



SENER experience in solar thermal power (CSP)

29 PLANTS

2,060 MW TOTAL

SENER PARTICIPATES IN THE DESIGN AND CONSTRUCTION OF 29 PLANTS IN MOROCCO, SOUTH AFRICA, SPAIN AND USA, WITH A TOTAL INSTALLED CAPACITY OF 2,060 MW



DATE OF COMMERCIAL OPERATION

2009

2010

2011

2012

2013

2014

2015

2018

ANDASOL 1&2
50 MW (2x) - PT+TES - EPC
.....
EXTRESOL 1
50 MW - PT+TES - EPC

EXTRESOL 2
50 MW - PT+TES - EPC
.....
SAMCA 1&2
50 MW (2x) - PT+TES - Engineering subcontractor

GEMASOLAR
20MW - CT-TES - EPC+O&M+PPC
.....
MANCHASOL 1
50 MW - PT licence

VALLE 1&2
50 MW (2x) - PT-TES - EPC+O&M+PPC
.....
EXTRESOL 3
50 MW - PT+TES - EPC
.....
SOLUZ-GUZMAN
50 MW - PT - solar field EPC

LA AFRICANA
50 MW - PT - solar field EPC
.....
ORELLANA
50 MW - PT - solar field EPC
.....
ASTE 1 A&B
50 MW (2x) - PT - solar field EPC

TERMOSOL 1&2
50 MW (2x) - PT+TES - EPCM
.....
CASABLANCA
50 MW - PT+TES - EPC
.....
VILLENA
50 MW - PT - solar field EPC

MANCHASOL 2
50 MW - PT licence
.....
GENESIS 2
140 MW - PT - EPCM

GENESIS 1
140 MW - PT - EPCM

Noor Ouarzazate I
160 MW - PT+TES - EPC
.....
BOKPOORT
50 MW - PT+TES - EPC

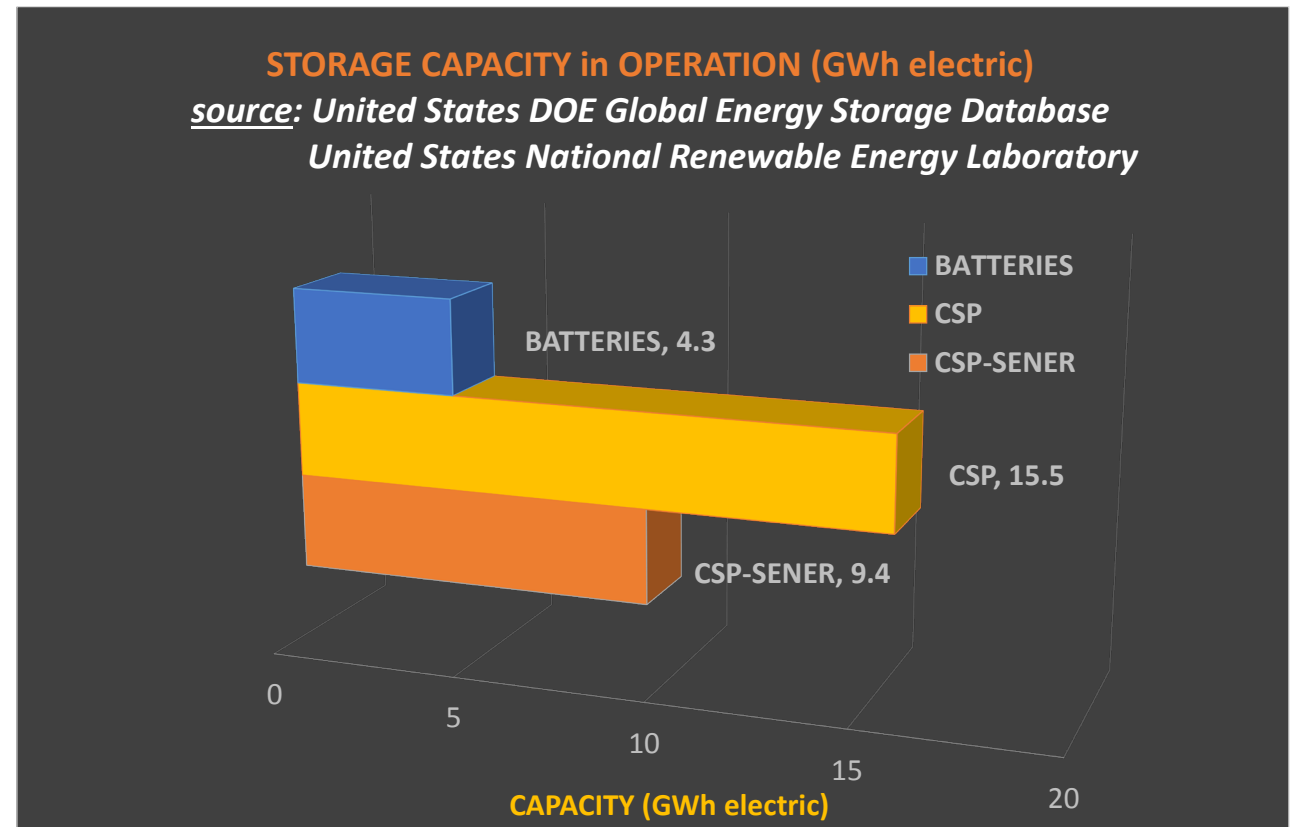
Noor Ouarzazate II
200 MW - PT+TES - EPC+O&M
.....
Noor Ouarzazate III
150 MW - CT+TES - EPC+O&M
.....
ILANGAI
100 MW - PT+TES - EPC+O&M+PPC
.....
KATHU
100 MW -PT+TES - EPC

All the plants are located in Spain except the ones marked with flags.

PT: parabolic trough technology | CT: molten salts central tower technology | TES: molten salts thermal storage system | EPC: engineering, procurement and construction | EPCM: EPC management | O&M: operation & maintenance | PPC: SENER participation in the project company

- ✓ **VALUE of CSP CONTRACTS for SENER (2006-2018):** >2500 MUSD
- ✓ **SHARE of WORLD CSP CAPACITY (MW):** 33%
- ✓ **STORAGE development:**

SENER is the company most involved in MOLTEN SALT STORAGE TECHNOLOGY



CSP + BIOMASS HYBRID

HIGH CAPACITY FACTOR PLANT



PROVEN TECHNOLOGY

- NOOR III (MOROCCO) CSP PROJECT
- PUERTOLLANO (SPAIN) BIOMASS PROJECT



BENEFITS of CSP+BIOMASS

- LCOE DECREASE:
 - *Only one turbine required, only one common area*
 - ***Biomass conversion efficiency increase: molten salt tower cycle is highly efficient (>45%)***
 - *O&M cost decrease: resources optimization*
- MORE FLEXIBLE/DISPATCHABLE PLANT
- NO DAILY STARTUPS of TURBINE
- HIGH CAPACITY FACTOR





CSP + PV HYBRID

PLANT ADAPTED TO PEAK DEMAND. CHEAP ENERGY during DAYTIME



PROVEN SOLAR ECHNOLOGY

- PV during DAYTIME
- CSP focused on PEAK HOURS at the end of day
- *SENER proprietary PV TRACKER for UTILITY SCALE plants*



BENEFITS of CSP+PV

- LCOE DECREASE:
 - *PV is the cheapest renewable energy and provides parasitics for CSP plant*
 - *CSP is optimized for Peak Hours, where electricity price is higher*
 - *O&M cost decrease: resources optimization*
- MORE FLEXIBLE/DISPATCHABLE PLANT
- CAPACITY FACTOR adaptable on demand



CSP to HEAT HYBRID

CSP CAN PROVIDE HEAT FOR INDUSTRIAL PROCESSES



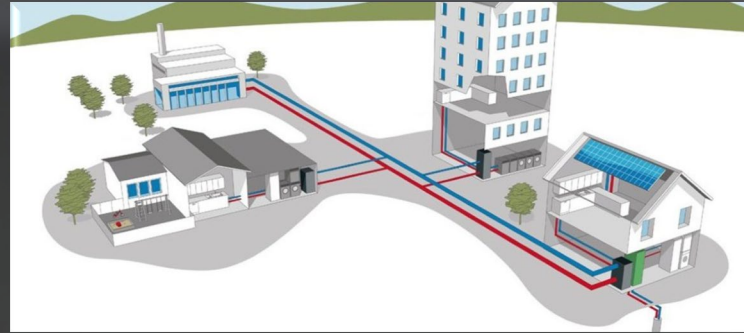
APPLICATIONS

- DISTRICT HEATING
- WATER DESALINATION
- MINING CHEMICAL PROCESSES
- ORGANIC RANKINE CYCLES



BENEFITS of CSP to HEAT

- DISTRICT HEATING:
 - *Surplus heat from cycle is used at a low cost*
- WATER DESALINATION:
 - *Decrease in desalinated water cost, fuel saving (SENER patent)*
- MINING CHEMICAL PROCESSES:
 - *Electrolyte heating (lithium...)*
- ORGANIC RANKINE CYCLES:
 - *Low temperature applications*



THANK YOU

 www.ingenieriyaconstruccion.sener

 www.linkedin.com/company/sener

 www.youtube.com/user/senerengineering