

SFERA-III

Solar Facilities for the European Research Area



Smart STE

A meteorological forecast and simulation pipeline tool for a more efficient management of Solar Thermal Electricity (STE) Plants

Eduardo Zarza Moya (PSA-CIEMAT)

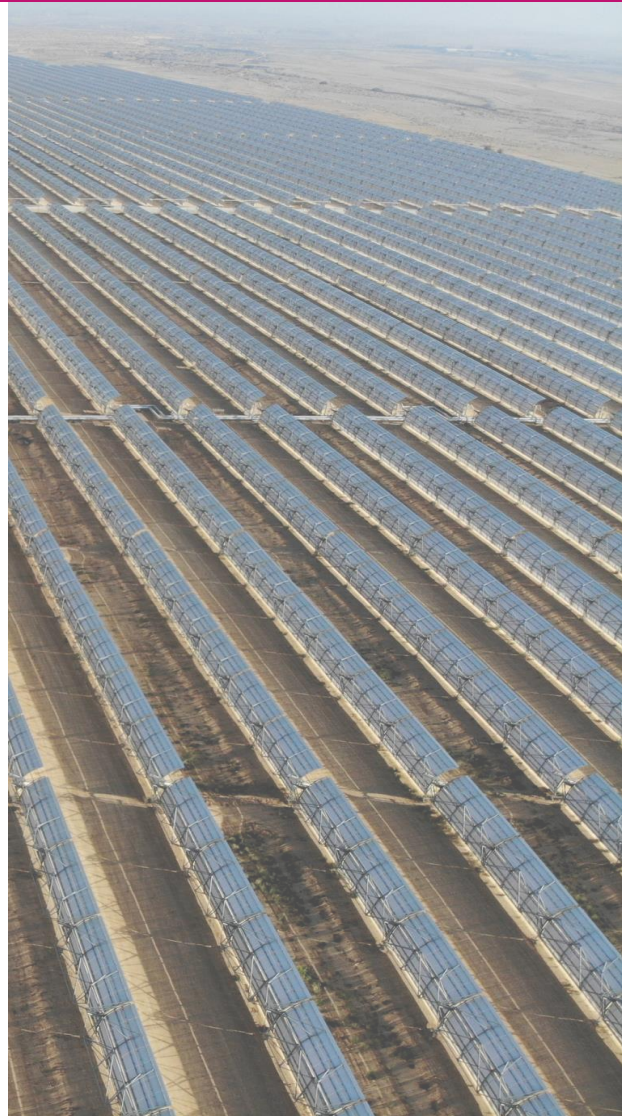


NETWORKING

Summer School: "Smart CSP: How Smart Tools, Devices, and Software can help improve the Design and Operation of Concentrating Solar Power Technologies" - WP1 Capacity building and training activities - Cologne, Germany, September 14th-15th 2023



THIS PROJECT HAS RECEIVED FUNDING FROM THE EUROPEAN UNION'S HORIZON 2020 RESEARCH AND INNOVATION PROGRAMME UNDER GRANT AGREEMENT NO **823802**



Smart STE

A meteorological forecast and simulation pipeline tool for a more efficient management of Solar Thermal Electricity (STE) Plants

Content

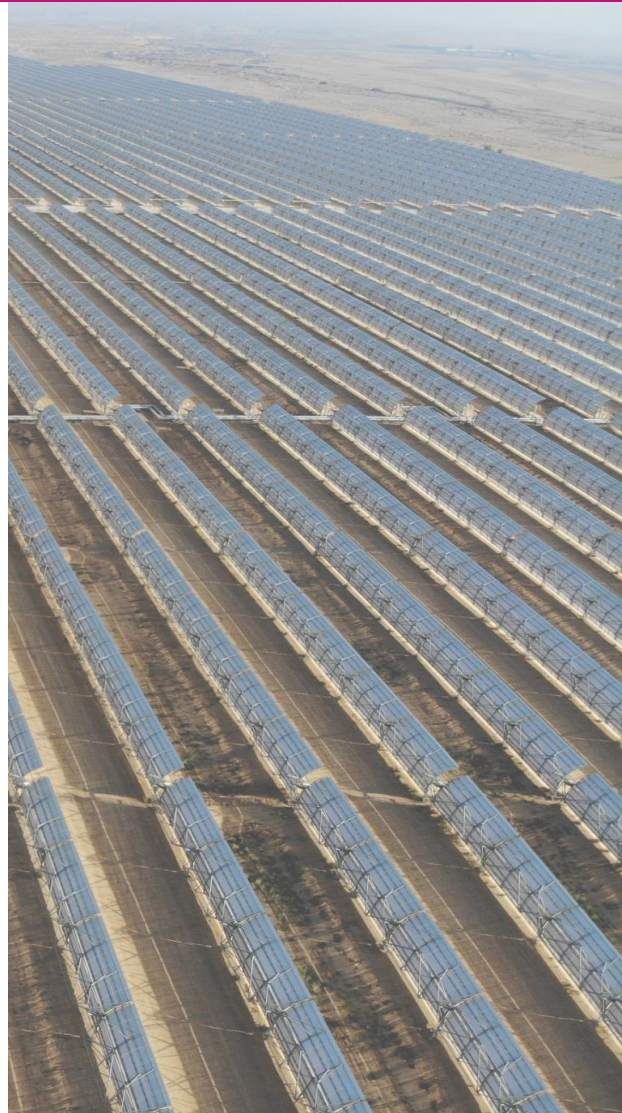
- Background
- SaaS services for STE plants
- SaaS service developed in Spain

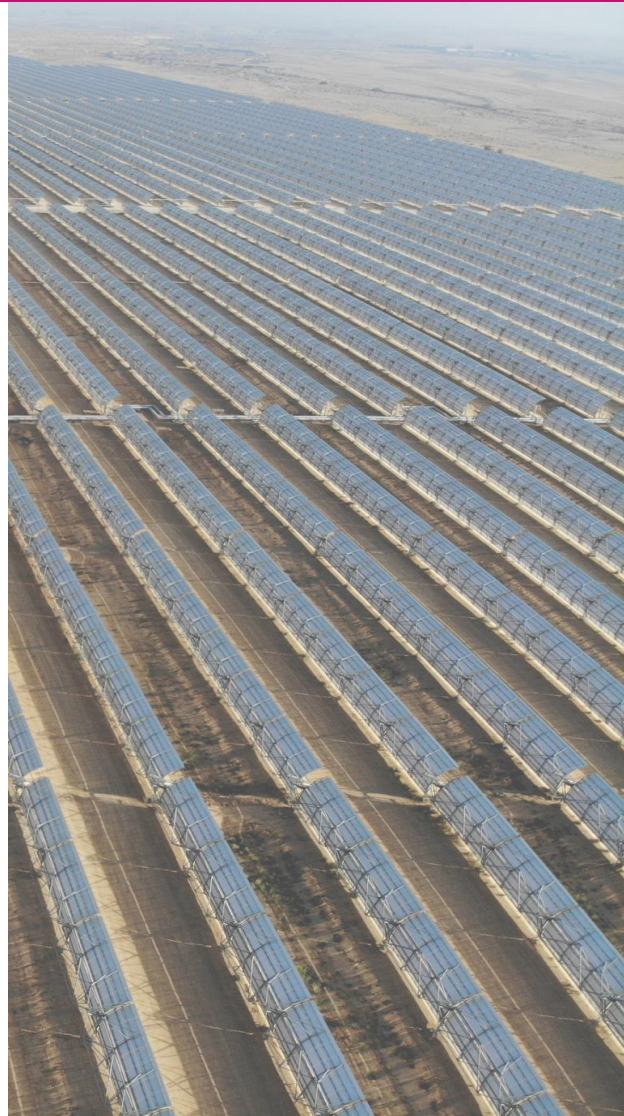
Smart STE

A meteorological forecast and simulation pipeline tool for a more efficient management of Solar Thermal Electricity (STE) Plants

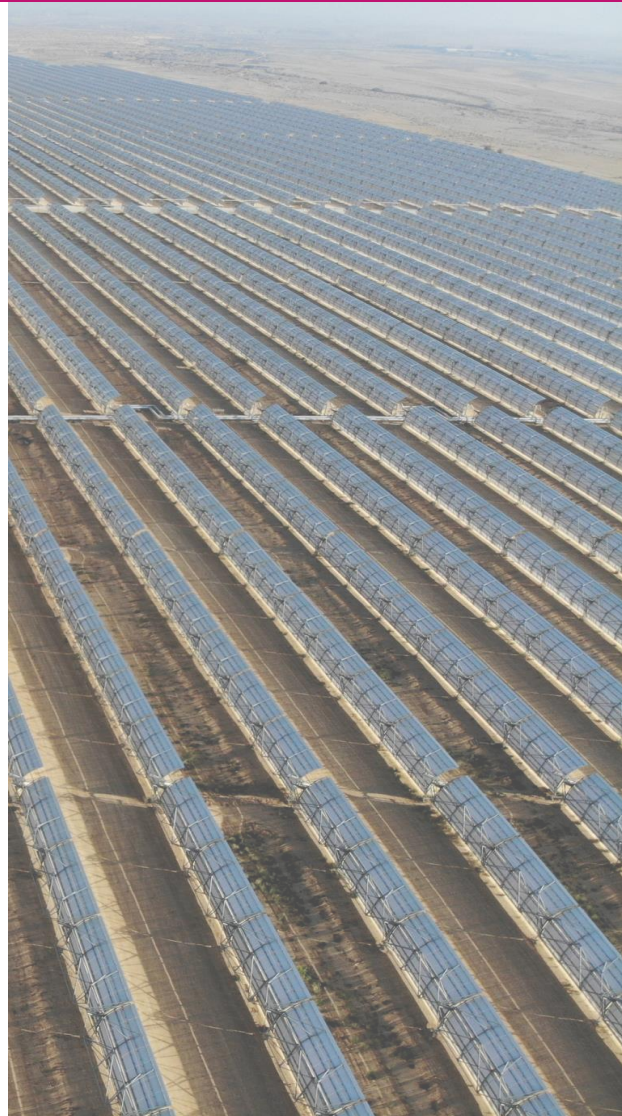
Content

- **Background**
- SaaS services for STE plants
- SaaS service developed in Spain





- ✓ Spain is currently a world leader on STE plants (49 plants with a total installed power of 2,3 GWe)



Spanish STE Plants in Operation

- 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:

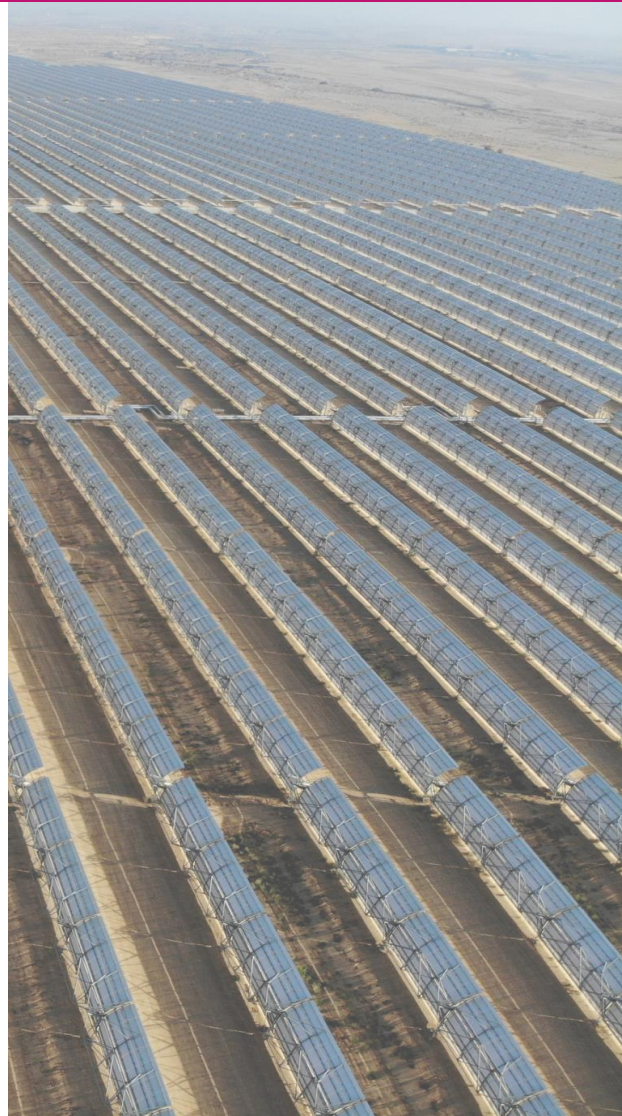
3 CR plants (49,9 MWe)

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

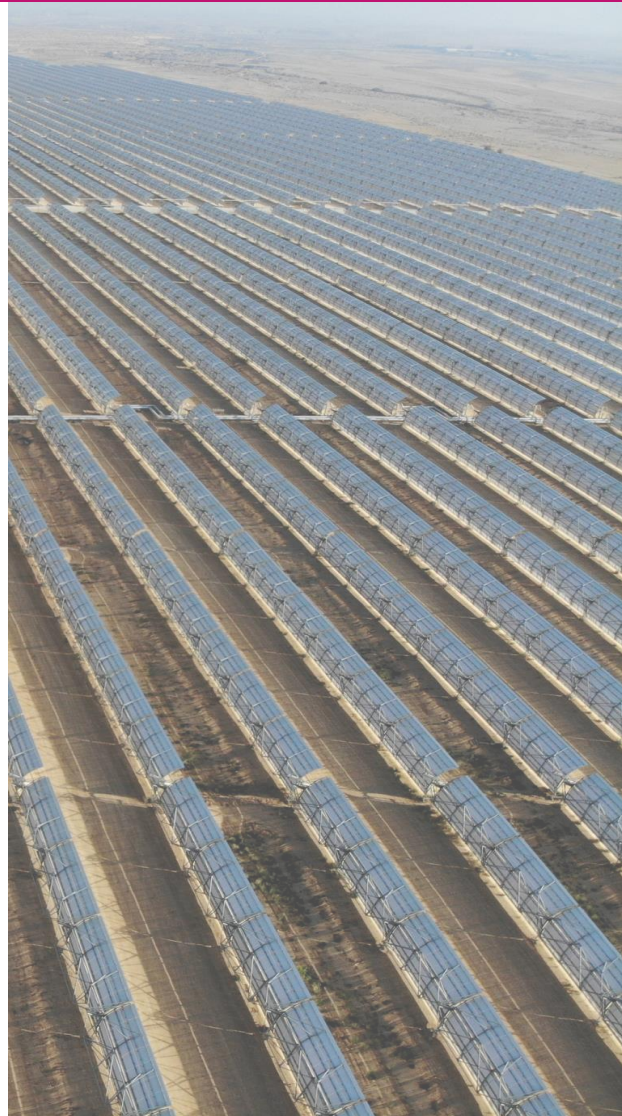
- Compact Linear Fresnel technology:

1 LF plant (30 MWe), with saturated steam and no TES





- ✓ Spain is currently a world leader on STE plants (49 plants with a total installed power of 2,3 GWe)
- ✓ All the Spanish STE plants were installed in the period 2007-2013, because a very good feed-in tariff implemented by law (RD 661/2007)
- ✓ No STE plant has been installed in Spain after 2013 because the incomes of Spanish STE plants were reduced by 37% due to great changes made by the Spanish Government in the legal framework for STE plants
- ✓ Due to the drastic reduction in their incomes, Spanish STE plants are looking for options to get revenues additionally to the incomes due to electricity generation
- ✓ Participation in the special mechanisms implemented in Spain to control the electricity grid and to assure its stability could provide extra incomes to the Spanish STE plants. However, they need special “tools” to participate in these mechanisms

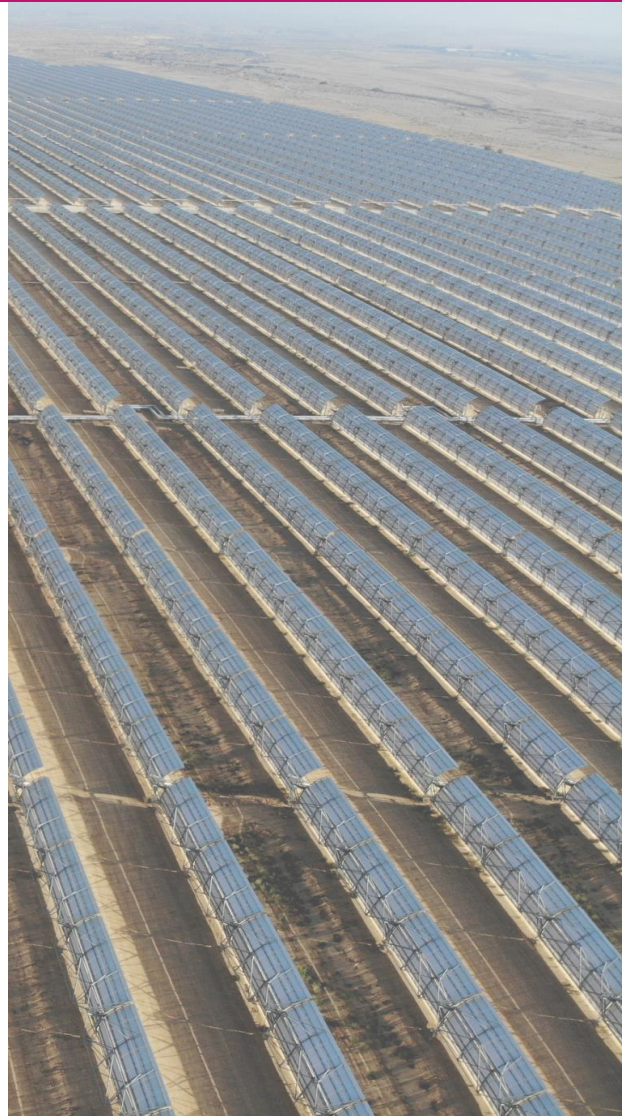


Smart STE

A meteorological forecast and simulation pipeline tool for a more efficient management of Solar Thermal Electricity (STE) Plants

Content

- Background
- **SaaS services for STE plants**
- SaaS service developed in Spain

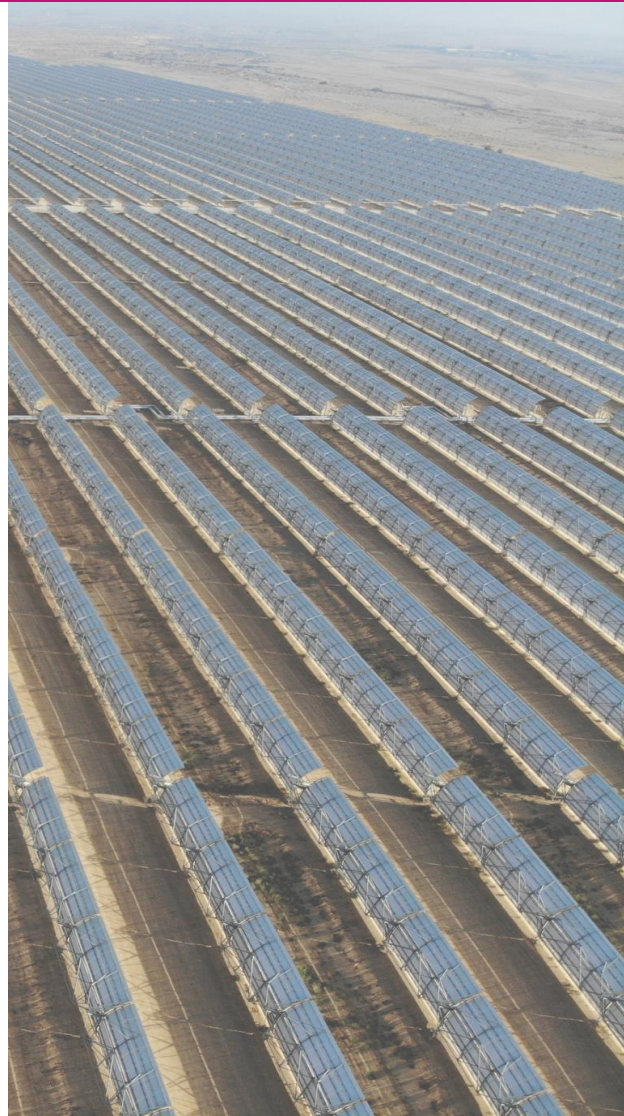


STE Plants

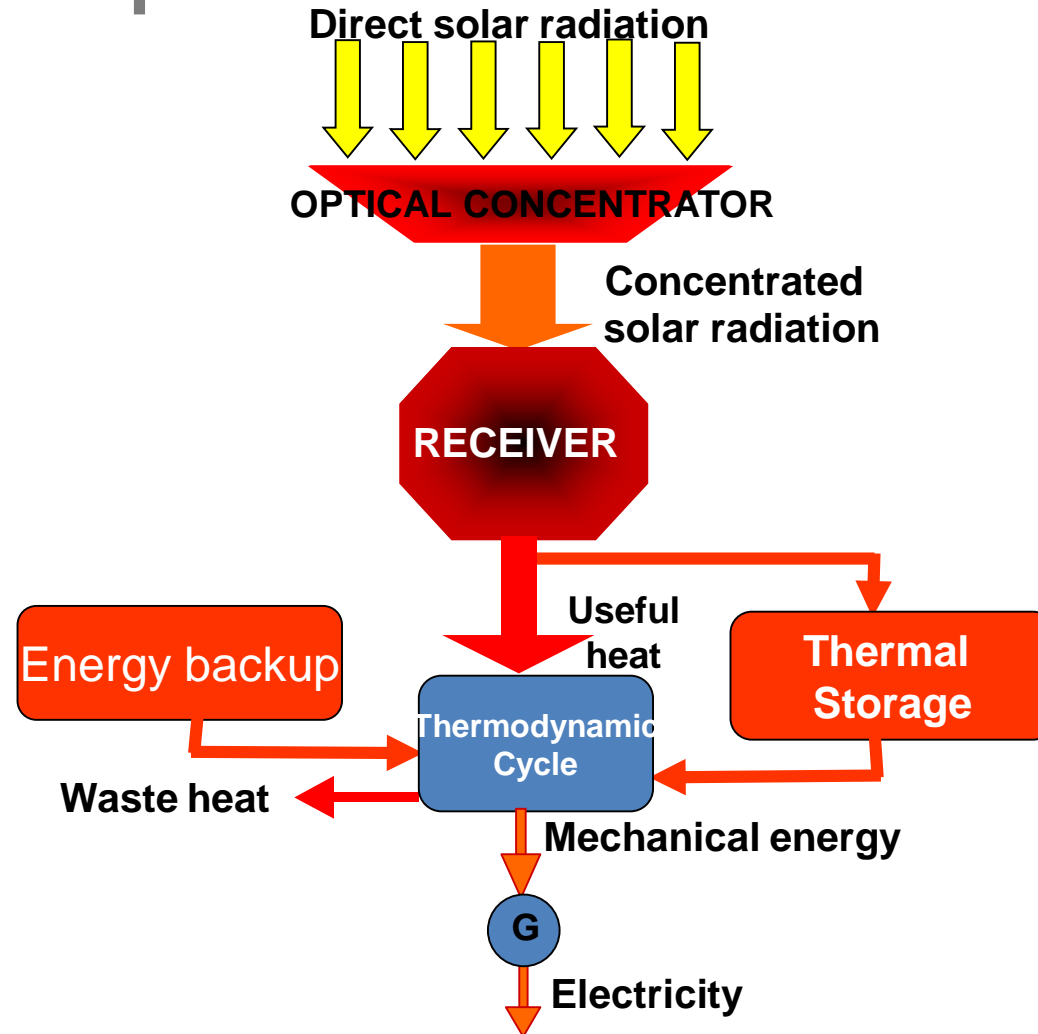
OPERATION REQUIREMENTS

Thermodynamic process engineering complexity

High accuracy operation and maintenance is required



Simplified scheme of a STE Plant



SaaS (“Software as a Service”)

FOR STE PLANTS OPTIMIZATION



Software as a Service



Information for O&M personnel



Digital twin



Current and upcoming electricity market insights



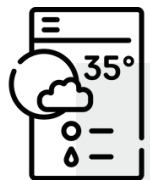
Data-driven electricity generation management



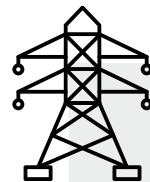


SaaS

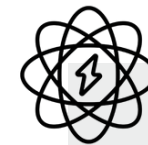
O&M OPTIMISATION OF STE PLANTS



Weather forecast



Market insights

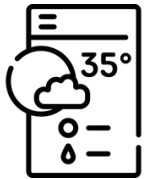


Simulator

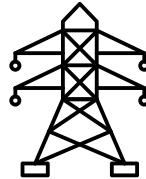


SaaS

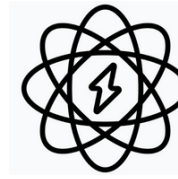
WEATHER FORECAST AND ELECTRICITY MARKET INSIGHTS FOR STE PLANT O&M



- DNI
- Ambient temperature
- Relative humidity
- Wind (speed + direction)



- SPOT prices
- Deviation costs
- Auxiliary services
- Technical restrictions



- Temperatures, pressures, and flowrates at:
 - Solar field
 - Thermal Energy Storage
 - Power block

- Plant load daily declaration
- Data-driven plant operation
- Optimised generation for top economical benefit



SaaS

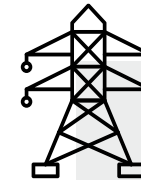
PLANT SIMULATION FOR STE PLANT O&M

Input data

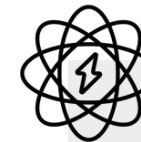
- Solar field availability
- Solar field reflectivity
- HTF
- Steam turbine temperature
- Salt tanks storage levels
- Molten salt tank temperatures
- Solar field temperatures
- Weather station data



Weather forecast



Market insights



Simulator

SaaS

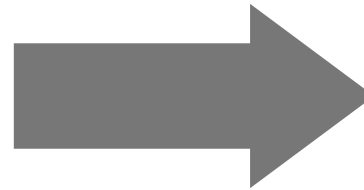
DATA-DRIVEN ENERGY GENERATION MANAGEMENT

Plant data monitoring

Weather forecast data

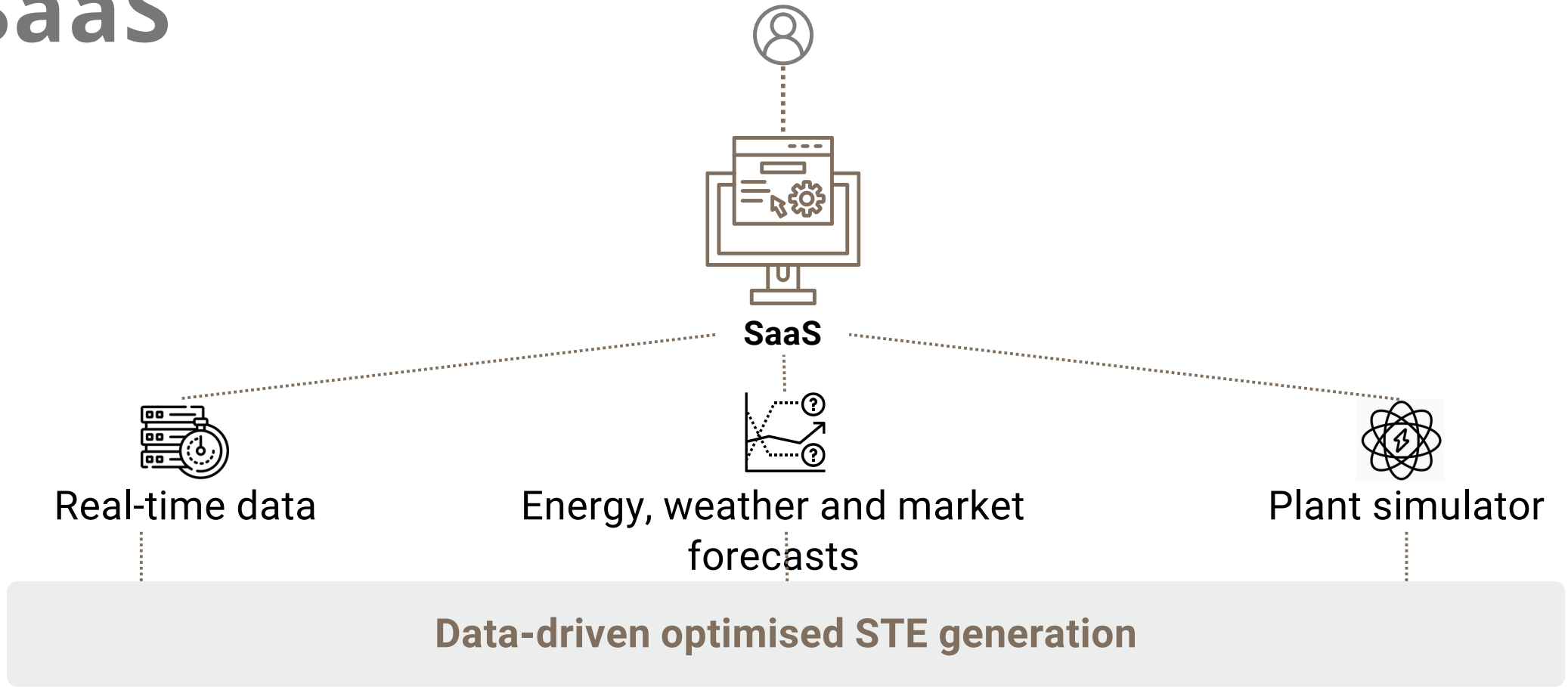
Electricity market data

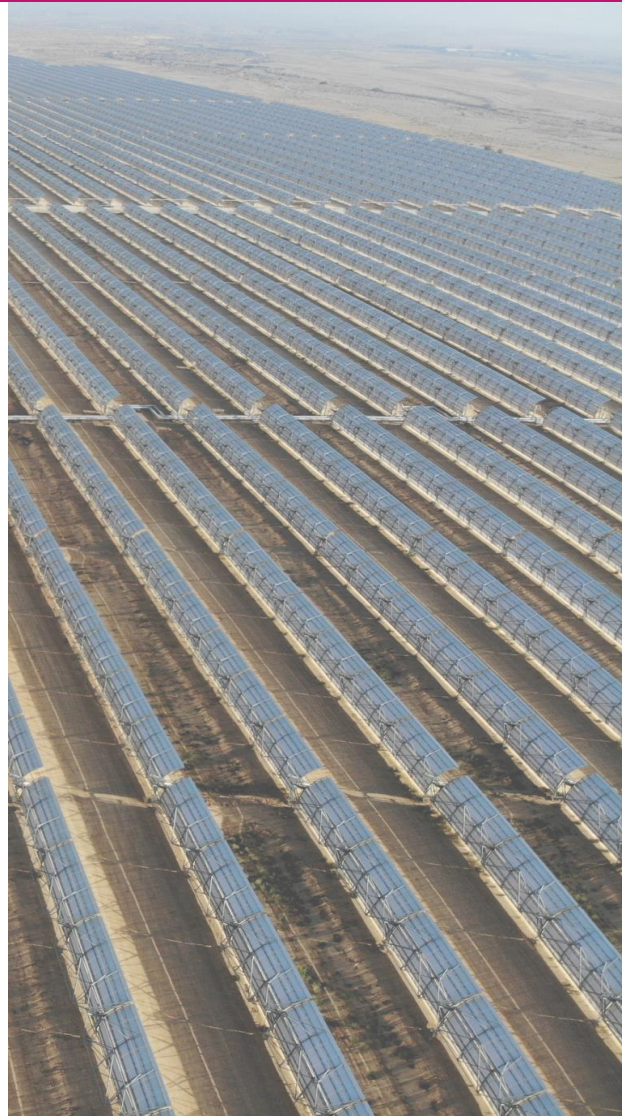
Simulator



- ✓ Best operation mode
- ✓ Economic performance optimization
- ✓ Deviation costs reduction
- ✓ Yield losses compensation

SaaS





Smart STE

A meteorological forecast and simulation pipeline tool for a more efficient management of Solar Thermal Electricity (STE) Plants

Content

- Background
- SaaS services for STE plants
- **SaaS service developed in Spain**



Meteorology *applied for energy efficiency*

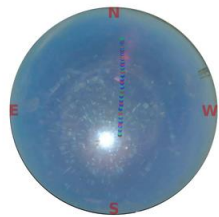
Meteo for Energy develops and implements advanced technologies using **Artificial Intelligence (AI), business intelligence, geographic information systems (GIS), and meteorology** to:

- Maximize energy production,
- Minimize risks in plant operation and maintenance, and
- Reduce operating and deviation costs

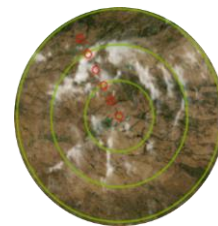


Forecasting services rendered by METEO for STE plants:

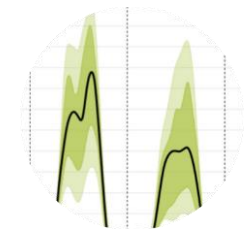
A) Short-term weather forecast Medium-term weather forecast Long-term weather forecast



Sky camera



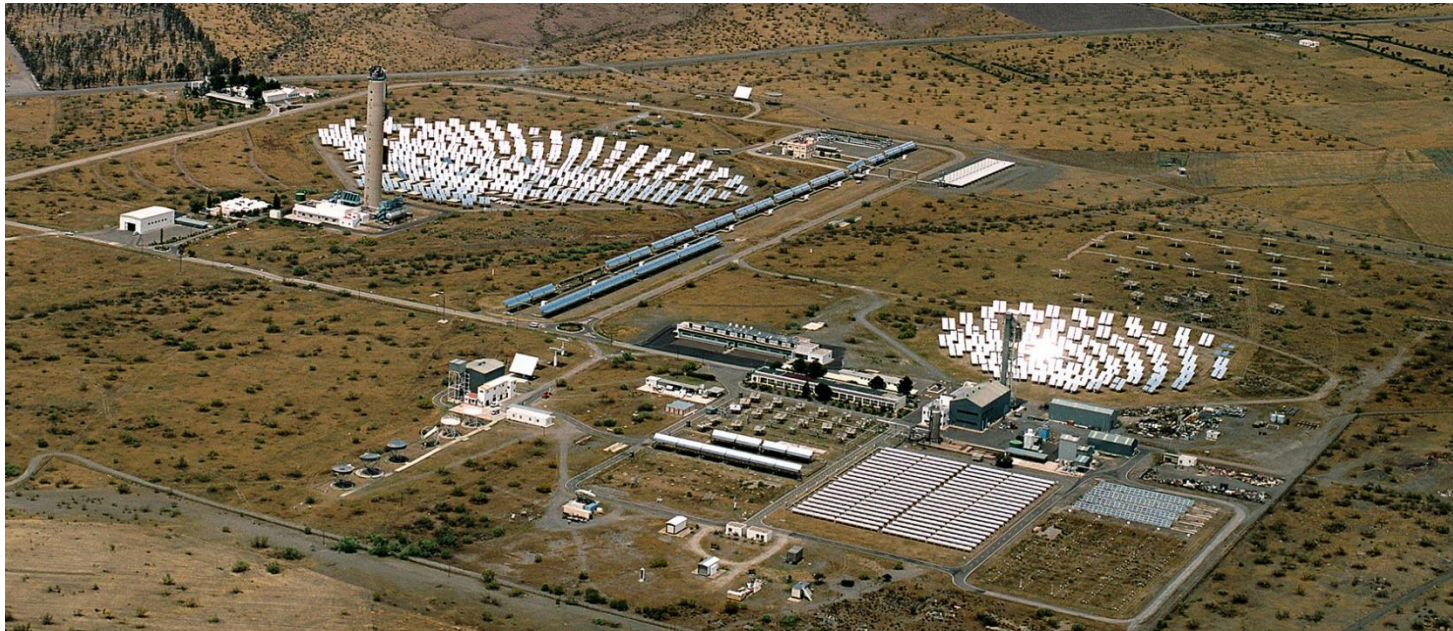
Meteosat imagery



NWP & AI

B) Electricity market forecast in Spain

The Plataforma Solar de Almería (PSA) is the **largest concentrating solar technology research, development and test center in the World**. PSA activities are integrated in the CIEMAT organization as an R&D division of the Department of Energy.



Aerial view of PSA facilities
(www.psa.es)

**PSA-CIEMAT**

The Plataforma Solar de Almería (PSA) is the largest concentrating solar technology research, development and test center in Europe. PSA activities are integrated in the CIEMAT organization as an R&D division of the Department of Energy.



Plataforma Solar de Almeria (PSA)

PSA has a long experience in the operation and simulation of solar thermal plants that allows to simulate the solar field, storage and power block of parabolic-trough STE plants with great precision.

PSA Research Units related to STE plants:

- Line-focus solar thermal technologies
- Point-focus solar thermal technologies
- Materials for concentrating solar thermal technologies
- Thermal energy storage unit

JOINT KNOW-HOW

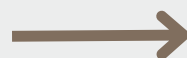
METEO FOR ENERGY & CIEMAT



Creation of a collaborative information pipeline for STE plant operation software. It is based on the following steps:

- 1 **SCADA parameters collection in real-time**
- 2 **Collection of recent meteorological and electricity generation data**
- 3 **Satellite and NWP weather forecasts for the next 48 hours**
- 4 **Collection of electricity market actual and foreseen data plus Transmission System Operator (TSO) information concerning technical restrictions or node saturation**
- 5 **Energy generation simulation running for either full, partial and optimised capacity**

**Simulator of optimised
energy generation**



Economic efficiency



IMPLEMENTATION

METEO FOR ENERGY & CIEMAT

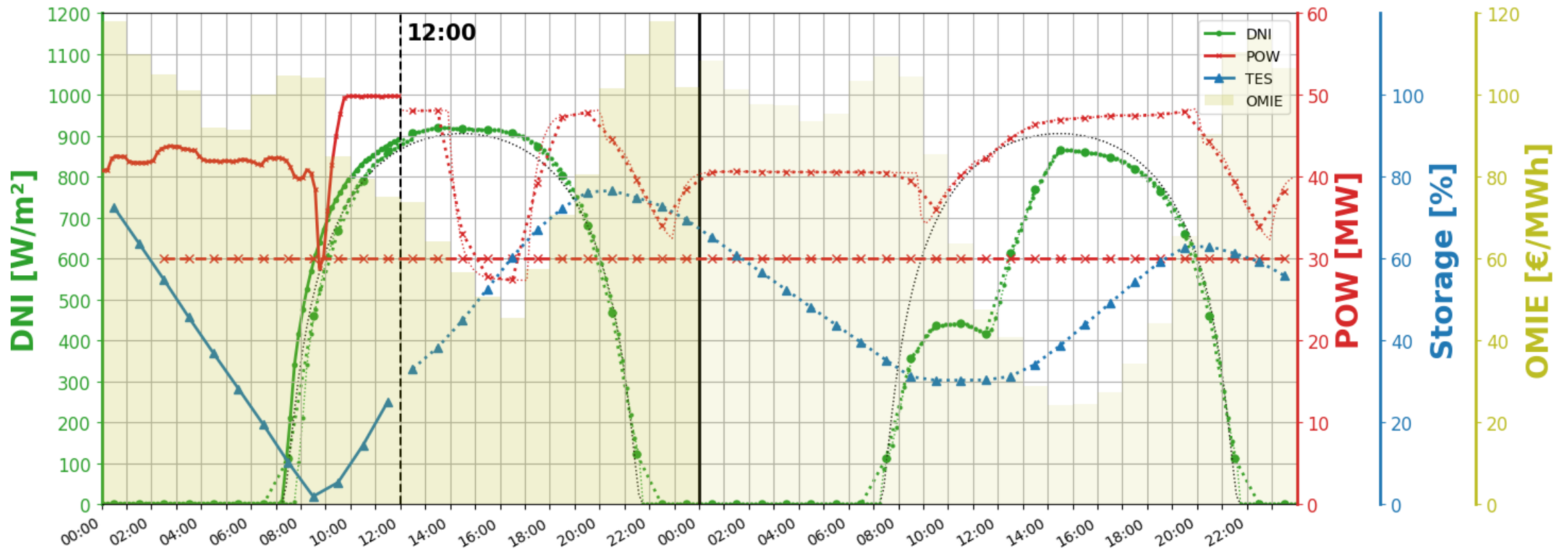


<p>Definition of STE plant configuration</p>	<p>Solar field technical data; TES; power block...</p>
<p>Plant simulator set up</p>	<p>Operation modes adjustment; processes losses; charging and discharging modes...</p>
<p>Meteorology setting</p>	<p>A.I. predictive models training for micro-meteorological events detection (fogs, convective clouds...)</p>
<p>Plant data synchronisation</p>	<p>SCADA synchronization with the central server of the SaaS service</p>
<p>Setting up and user training</p>	<p>API, web and FTP link</p>



RESULTS

Example of the information delivered by the Simulator



RESULTS

Implementation status

- ✓ 3 SaaS plant simulators already developed and running in Spanish STE plants
- ✓ 6 more SaaS plant simulators under implementation in Spanish STE plants
- ✓ It is expected that 11 Spanish STE plants will be using this SaaS service at the end of 2023

Contacts for additional information:

EDUARDO ZARZA

eduardo.zarza@psa.es

+34 950 38 79 31

IBON SALBIDEGOITIA

ibon.salbidegoitia@meteoforenergy.com

+34 666 29 88 30