



CENER

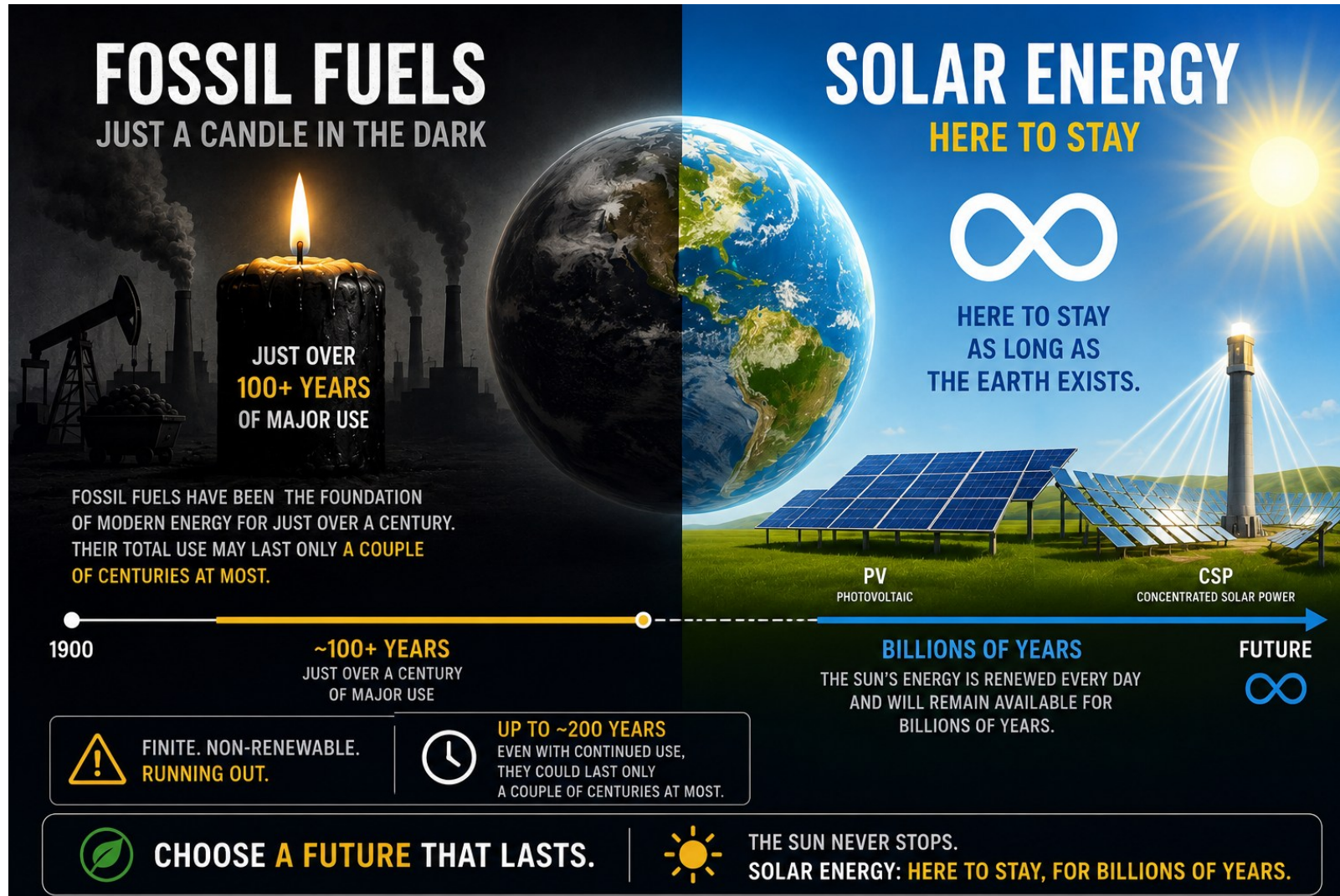


CSP 4.0: The Era of Intelligent Solar Energy

From Digitalization to Intelligent Energy Systems
Based on SUN-DT project experience

Webinar “Harnessing the Sun, Driven by Data: Digital Innovation for Solar Thermal Systems”
June 23, 2026

WHY INTELLIGENT SOLAR ENERGY MATTERS NOW



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Renewable energy systems are becoming **too complex** for conventional operation and control



Achieving an effective energy transition requires the **intelligent integration** of renewables into the energy mix



AI, digital twins, and advanced analytics are **transforming** industrial energy infrastructure



CSP is an **ideal testbed** for next-generation intelligent renewable energy systems



RENEWABLES



AI & ANALYTICS



DIGITAL TWIN



OPTIMIZED PERFORMANCE



SUSTAINABLE
ENERGY FUTURE

WHAT IS CSP?

Concentrated Solar converts sunlight into high temperature heat

- This heat can be converted into:
 - **Electricity**
 - Industrial **process heat**
 - **Green hydrogen** production
- **Dispatchable renewable energy with thermal storage**

CSP should play a key role in:

- Industrial decarbonization
- Energy transition
- Sustainable energy systems

CSP TECHNOLOGIES



SOLAR TOWERS: THE MOST ADVANCED CSP TECHNOLOGY



- **Higher Performance**
 - Higher solar **concentration ratios**
 - Higher operating **temperatures** ($>560^{\circ}\text{C}$)
 - Higher conversion **efficiency**
- **Better Energy Storage**
 - **More kWh stored** per unit volume
 - **Low-cost, massive** energy storage using **environmentally friendly** molten salts
 - **Dispatchable electricity** day and night
- **Strategic Value**
 - **Grid** flexibility and reliability (synchronous generation)
 - High-temperature **industrial heat**
 - Green **hydrogen** production
 - **Environmentally friendly storage** solution



Solar Tower CSP uniquely combines renewable generation and large-scale energy storage, making it a critical technology for a secure and carbon-neutral energy system.

WHY CSP IS A DIGITALIZATION TESTBED?



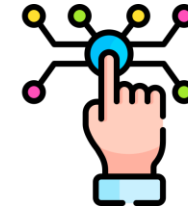
CSP TOWER PLANTS ARE:

- Highly complex
 - Thousands of heliostats
 - Thermal and optical interactions
- Dynamic
- Data-intensive
- Multi-physics systems



REQUIRES:

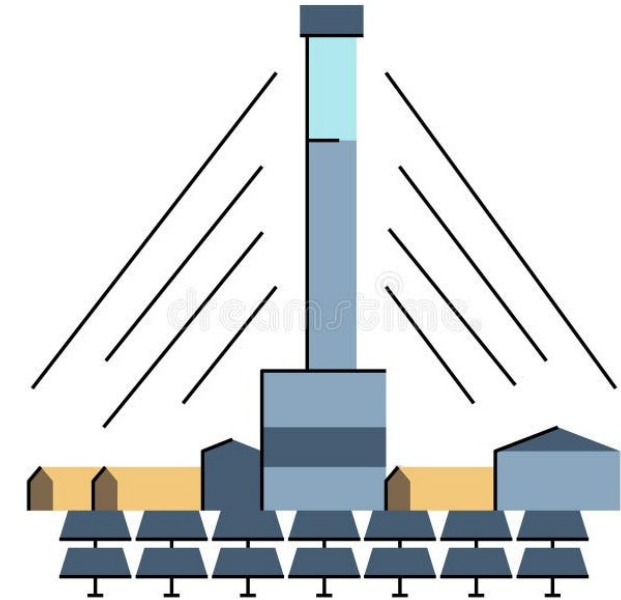
- Advanced sensing
- AI-based prediction
- Digital Twins
- Real Time Analytics



If it works in CSP, it's highly valuable for any other energy systems

CSP + Digitalization enables:

- Smarter Operation
- Lower O&M costs
- Higher reliability
- Better grid integration
- Industrial Decarbonization
- Smart Energy transition



Digitalization connects **3 layers**:

MEASUREMENT

- Sensors (irradiance, temperature, electrical variables)
- Drones, cameras, remote sensing
- SCADA and high-frequency data

MODELING

- Physical and performance models
- Digital twins
- Degradation models

DECISION-MAKING

- AI & machine learning
- Predictive O&M
- Dispatch & energy optimization

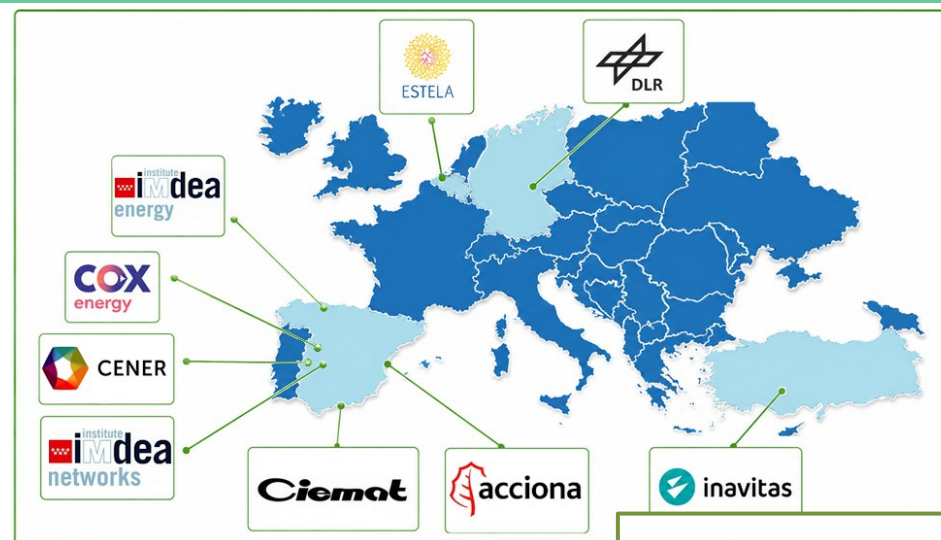


**VALUE COMES FROM
INTEGRATION OF ALL 3!!**

THE SUN-DT PROJECT

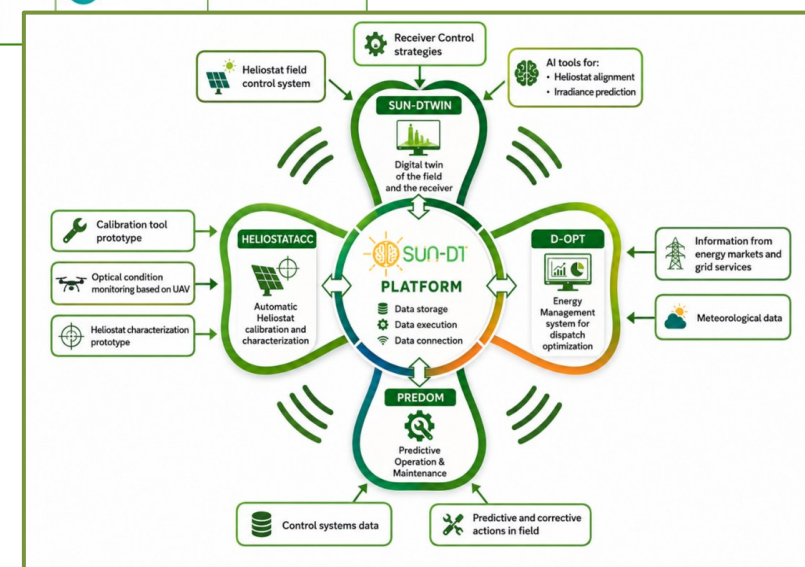


Smart Use of Novel Digital Tools for advanced performance and reduced costs in CSP tower plants



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Objective

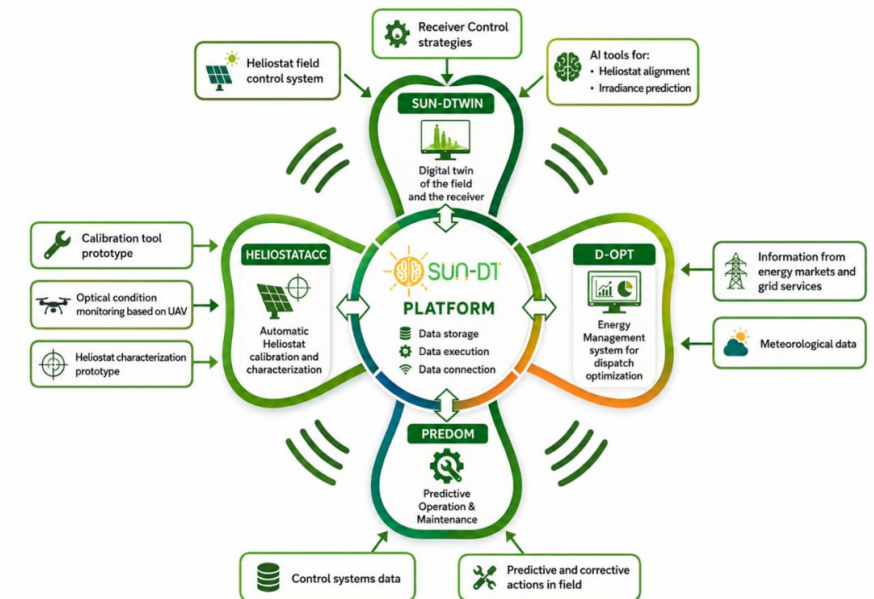


IMPROVE PERFORMANCE, REDUCE O&M COSTS, ENABLE SMARTER PLANT OPERATION

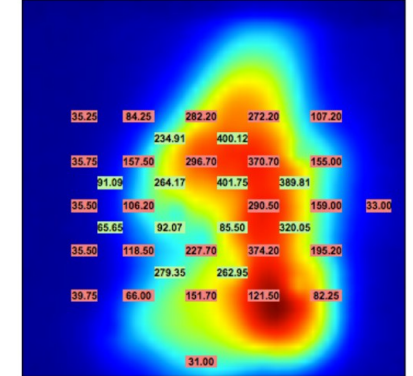
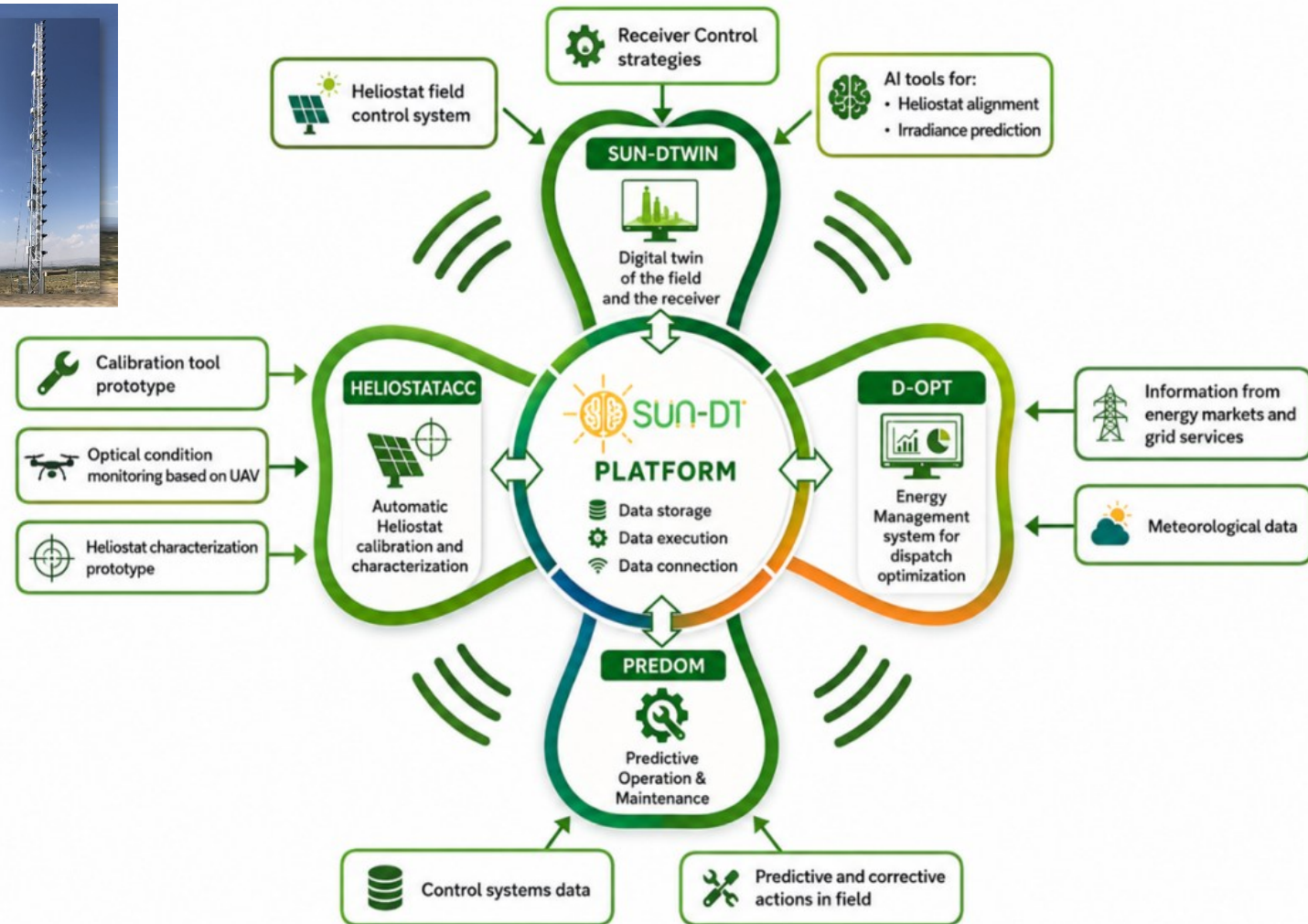
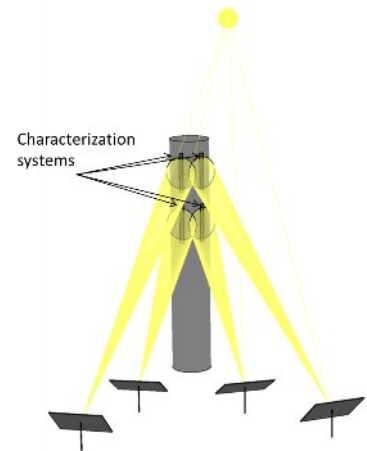
SUN-DT – Develops the Smart Use of Novel Digital Tools

- Advanced **measurement & calibration tools**
- **Digital-twin** of solar field and receiver
- **Energy Management System (EMS)**
- **Predictive O&M tools**

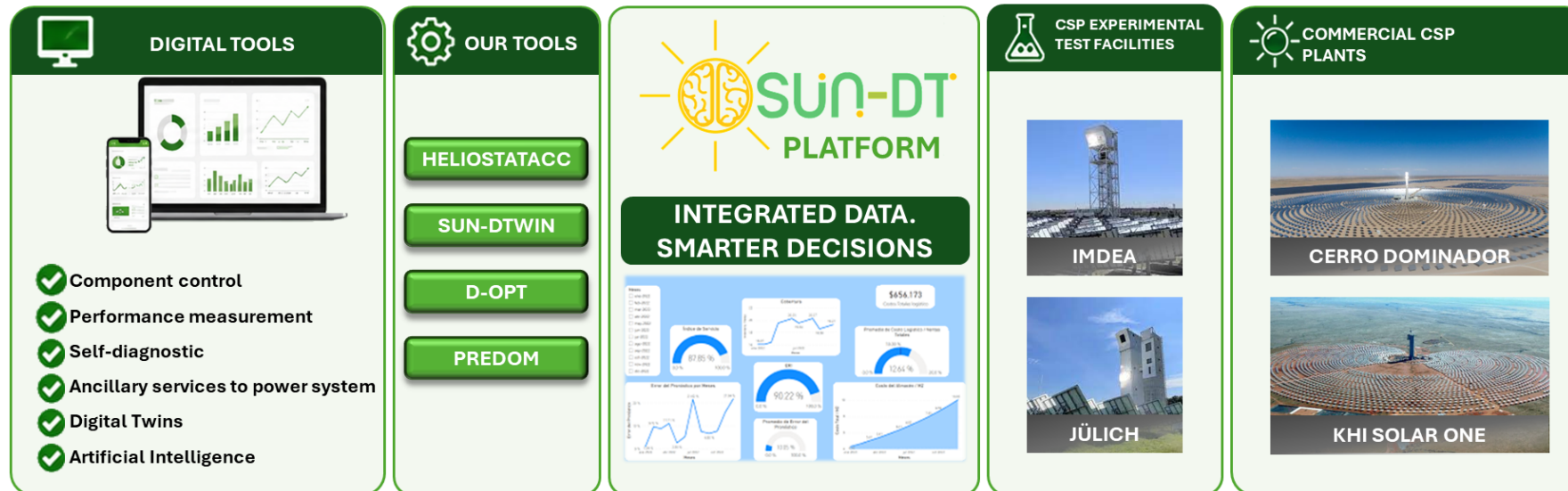
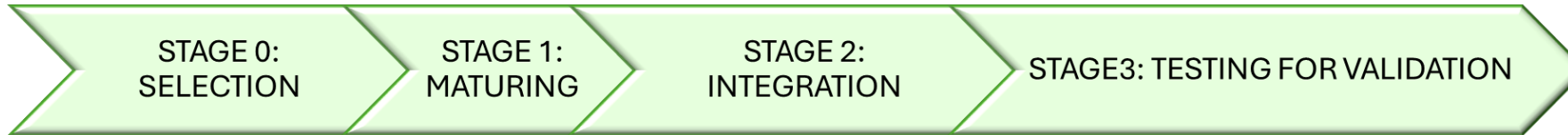
Integration into a **unified decision-support platform**



THE SUN-DT PROJECT



Methodology



OPTIMIZE

Smarter design and operation

INTEGRATE

Seamless tools and workflows

VALIDATE

Reliable testing in real conditions

DELIVER

From R&D to commercial plant

Expected results (I/II)



- **Increase in overall plant efficiency (4–10%):**



- Improved efficiency of the heliostat field and receiver.
- Fewer faults thanks to predictive maintenance.
- Less unplanned downtime (higher availability).

- **Improvement in annual output (+5%):**



- Up to 99% availability of the solar field → +2–3% in thermal output.



Expected results (II/II)



- **Reduction in OPEX (~15%) through:**



- Automation of tasks and reduction in human error.
- Predictive control of operating modes.
- Reduced need for corrective maintenance.

- **Reduction in CAPEX (~3%):**



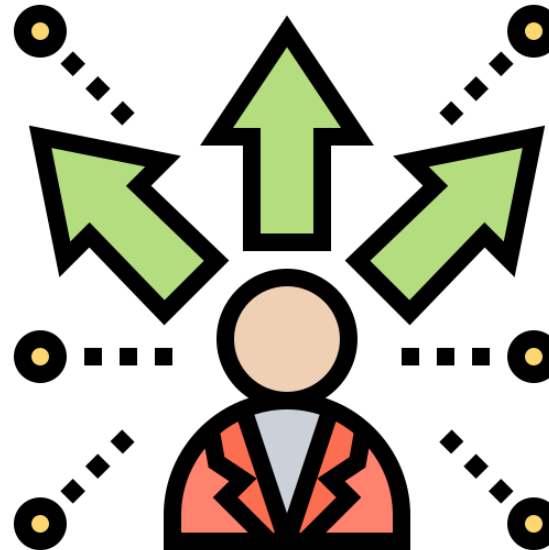
- Optimized design of the solar field without oversizing.



DIGITALIZATION IN SOLAR ENERGY AND THE ENERGY TRANSITION: CHALLENGES AND OPPORTUNITIES

CHALLENGES:

- Data management, **cybersecurity**, and standardization
- Implementation and training **costs**
- Need for **regulation** and industry **collaboration**



OPPORTUNITIES:

- **New** data-driven **business** models
- **Digital twins** for design and optimization
- **Greater reliability** and transparency

Digitalization for an Inclusive Energy Transition

- The model shifts from a single consumer to a system with **prosumers**
- **Real-time data availability** on energy generation, consumption, and storage
- Greater **transparency** on environmental footprint, costs, and energy origin
- More **informed energy decisions**: what to consume, when, and why
- **Grid management** becomes a **shared responsibility**



CSP + Digitalization = Intelligent Renewable Energy

- ✓ Digitalization is transforming renewable energy systems
- ✓ CSP is an ideal platform for AI, Digital Twins and advanced analytics
- ✓ Solar Tower CSP provides renewable electricity, large-scale storage, grid flexibility and industrial decarbonization
- ✓ SUN-DT demonstrates how intelligent tools can improve efficiency, reliability and competitiveness

The future **energy system needs** renewable assets that are **clean, dispatchable and intelligent**. Through AI, Digital Twins and advanced analytics, **SUN-DT is helping Solar Tower CSP evolve** towards that vision.



Smart Use of Novel Digital Tools for advanced performance and reduced costs in CSP tower plants

Thank you for your attention!

Marcelino Sánchez

Email: msanchez@cener.com



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