PreFlexMS: Making CSP predictable and flexible with a once through steam generator

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What is PreFlexMS

Predictable, Flexible Solar Power with Molten Salt Energy Storage

PreFlexMS is a consortium of 13 partners from 8 European countries. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654984. Swiss partners are funded by the State Secretariat for Education, Research and Innovation of the Swiss Confederation.
PreFlexMS: The Rationale

Why are Predictability and Flexibility important?

Regulators
are reducing flat tariff incentives and promoting incentive/penalty schemes for CSP plants to match electricity demand
→ Improve “timing” of production – Forecast and shift production to high priority hours

Grid operators
want stable, responsive, reliable, committed power supply
→ Increase “quality” of production – Forecast reserves and provide fast response to grid

Plant operators
want flexibility to diversify revenue streams in mature (liberalized) markets
→ Improve “effectiveness” of production – Participate in electricity trading; Forecast and dispatch as most economical

The plant of tomorrow:
✓ Economically viable with no incentives
✓ Flexible, predictable and dependable power
PreflexMS: Predictability

Integration of Weather Forecasting, Machine Learning and Dispatch Optimization

- Development and validation of advanced techniques for GHI and DNI prediction based on probabilistic and deterministic weather forecasts.
- Development and validation of machine learning algorithms capable of accurately quantifying actual plant performance for integration into the dispatch optimizer.

Advanced DNI predictions, market electricity price forecasts, reality-tuned plant performance models are integrated into a dispatch optimizer that defines optimal dispatch trajectory of the plant, also handling the uncertainty of electricity price and DNI forecasts.
PreFlexMS: Flexibility

Achieved using a Molten Salt Once-Through Steam Generator

**Today:** drum-type steam generators not conceived to have flexible operation

**Tomorrow:** when flexibility will be needed from CSP plants, OTSG is best because:

- It is successfully used in conventional combined cycle plants where flexibility is valued
- Has a potential for cost reduction by removing costly equipment
PreFlexMS: The Project

- 36 months
- 17.8 M€
- A complex project including:
  - Technology development
  - Technology integration
  - Technology demonstration

- **Development** and **Integration** of technology for OTSG, Weather Forecasting, Machine Learning and Dispatch Optimizer
- **Demonstration** of technology in a pilot plant to be built at the Evora Molten Salt Platform (in Evora, Portugal)
- **Evaluation** of the technology (risk assessment, life cycle analysis, business case analysis, performance evaluation and benchmarking)
What is ESE?

Engineering Services for Energy

- A high-level engineering company working in all fields of power generation

- Capable to provide services to owners, contractors, R&D departments, from the feasibility study to the end of the plant lifetime
What is ESE doing in the CSP business?

Since 2005 with top industrial partners

- Designing and following the manufacturing of **Brightsource Energy**’s pilot tower receiver
- Developing the design of the power block for **ABB Renewables’** 100 MW reference plant
- Developing the design of the molten salt storage and steam generation system for **Alstom/GE**’s 100 MW reference plant

*Many others, above all PreflexMS*
What is ESE doing in PreFlexMS?

ESE is covering the following roles in the consortium:

- **Responsible for the process** and control design of the Molten Salt OTSG, from concept to detail
- **Work Package Leader of Work Package 6** «Molten Salt Once Through Steam Generator Integration»
- **Coordination and Management** of the different engineering aspects of the OTSG, including interfaces between different partners involved
PreFlexMS OTSG: Rationale

Why a Once-Through Steam Generator?

✓ Gives **higher flexibility** compared with a conventional design:
  - Limitations given by steam drum thermal stresses are removed, thus allowing faster load changes, start-ups, shut-downs
  - Thermal inertia of the steam generator is lower, thus allowing prompter reaction during transients and load ramps

✓ Has a **potential for cost reduction**:
  - Steam drum itself is avoided
  - Evaporator circulation pumps are avoided
  - Equipment can be assembled in a more compact fashion
  - Lowered operational costs (no power consumption of Evaporator Circulation Pumps, no blowdown heat loss)
  - System costs challenge: the Condensate Polisher
PreFlexMS OTSG: An innovative design process

Iterative design process taking into account mutual interaction of:

- Equipment design
- Overall plant performance
- OTSG dynamic behaviour
- OTSG operation and control

Process is designed to optimize efficiency and plant cost

Operation and control concepts are defined to attain maximum flexibility

Equipment design is carried out based on defined process

Dynamic simulation checks design effectiveness, as input to next design step
PreFlexMS OTSG: Full scale and pilot design

Parallel design of:

- **Full scale plant (250 MWth)** is developed at a conceptual level, as required to understand all the phenomena to be tested on the pilot.

- **Pilot plant (5 MWth)** is carried out with the target of achieving maximum representativity of the full scale, up to the level required for execution.
PreFlexMS OTSG: The importance of simulation

**Dynamic simulation** of the entire plant and OTSG is carried out to:

- Check that the designed process and equipment responds to functional and procedural requirements on the full scale plant;
- Check on a virtual plant that molten salt-related risks are correctly taken into account in all operating modes;
- Develop the control system of both full scale and pilot plant;
- Check representativity and differences between full scale and pilot plant;
PreFlexMS OTSG: Where we are are now

Reference conceptual full scale design has been just completed:
✓ Process scheme frozen
✓ Process optimized
✓ Control concepts and procedures developed
✓ Equipment design carried out

Pilot is being developed in parallel:
✓ Testing concepts defined
✓ Downscaling criteria defined
✓ Design ongoing
✓ Differences pilot-full scale under evaluation
PreFlexMS OTSG: Timeline

- Pilot basic design completed by February 2016
- Pilot detailed design completed by September 2016
- Pilot delivered on site by March 2017
- In parallel, optimization of reference design and control strategies to be tested on pilot

Test and demonstration on the pilot shall be carried out in 2018

Validation of full scale design in parallel with pilot demonstration, in 2018

...then, see you in 2018!
Thank you for your attention!
Any question?