PROPOSED TITLE

Development and validation of a concentrating solar power plant model with a focus on turbine performance enhancing measures.

GENERAL DESCRIPTION

Increasing worldwide demand for electricity coupled with growing concerns about climate change and the need to reduce the environmental impact of conventional fossil-fuel based power plants has led to the development of innovative and more sustainable power generation solutions based on renewable resources. In this context, concentrating solar power (CSP) has begun to achieve a growing penetration into global electricity markets. In the last 6 years the installed capacity of CSP has increased from 355 to 2550 MW [1][2] and according to reports from the International Energy Agency is expected to continue increasing up to 1500 GW by 2050 [3].

One of the main advantages of CSP technologies is their assistance in keeping grid stability by providing dispatchable energy through the integration of thermal energy storage (TES). TES systems have been shown to make plants more economically viable as it allows decreasing the levelized electricity cost, by increasing the capacity factor, or increasing the profitability by shifting the electricity production to peak demand hours [4]. Amongst the different CSP technologies currently deployed, TES has been successfully included on both central tower and parabolic trough systems. However, optimal and adequate operational strategies for these systems are still under study and definition in current state-of-the-art research.

Turbomachinery operated in CSP plants are subject to operating conditions that are significantly different from those that would be experienced in a conventional power generation setting. As a result of the variable nature of the solar supply and the daily operating cycle of solar power plants, the number of turbine starts per year for solar turbines is an order of magnitude higher than for base-load turbines. Start-ups are the most intricate of turbine transients and subject turbines to high thermal stresses. The high variability in operating conditions can be improved through the implementation of power plant operational modifications [5] [6].

In order to quantify the potential for power plant performance improvements, one of the main objectives of the work is the development and validation of CSP plant model in TRNSYS. This will allow for subsequent implementation of turbine-enhancing operational modifications and the analysis of their impact at power plant level in terms of increased net electric output and reduced LEC. The work is to be performed under supervision of the TESCONSOL and TURBOPOWER consortia, which are constituted by various research institutes and industrial partners, namely KTH, LiTH, Chalmers, LTH, UPC, Tecnalia, Gas Natural Fenosa, Siemens, GKN and Total.
SPECIFIC TASKS

T1 Perform a literature survey on CSP Plants with thermal energy storage
   - Understand how is the layout of these power plants and how they operate (flow control, live steam conditions and storage). Consider both projects under construction and already operative.
   - Review studies on power plant operation strategies, focus on:
     o Currently implemented operational strategies.
     o Proposed operational strategies at research level.
     o Impact of operational strategies on steam turbine component.

T2 Define and Model a CSP plant configuration
Define CSP plant upon which the work will be cased: select reference plant power block layout with TES. Elaborate a TRNSYS for the model of the power plant.

T3 Analyse obtained turbine transient operating conditions.
For the developed and validated CSP plant model, focus on the turbine operating conditions and account for the limitations imposed by the start-up of this component.

T4 Propose turbine-enhancing operational modifications.
Propose modification or power plant operating strategies that reduce start-up time limitations, focus on:
   o Modifications involving TES.
   o Modifications involving maintaining the temperature of the turbine metal*.
   * This should encompass available literature from published studies but the student is also granted with access to confidential reports developed within the TURBOPOWER consortium.

T5 Operate the CSP plant model under the proposed modifications
Decide on an optimal operating strategy to finally perform a whole years’ worth simulation of the plant in order to analyse its thermodynamic and economic performance.

T6 Provide final recommendations and conclusions
   - Highlight results from each of the tasks performed and provide final recommendations on the practical and economic feasibility of operational modifications.
   - How are the operational modifications affecting the power plant performance?

STUDENT REQUIREMENTS

- Strong theoretical background in heat transfer and thermodynamics.
- Expertise on energy systems analysis and simulation.
- General knowledge on turbomachinery.
- Expertise in programming with Matlab and TRNSYS. Experience with Fortran is advantageous.
EXPECTED DELIVERABLES

- **TRNSYS model of the CSP plant with TES**
- Final MSc. Thesis report. Three draft versions shall be submitted prior final submission; it is proposed that these drafts contain of the following:
  - **First draft**: Introduction, background and theoretical framework (T1 & T2).
  - **Second draft**: Describe modelling methodology (T2 - T4).
  - **Third draft**: Results, discussions and final conclusions (T5 & T6).

LOCATION AND DURATION OF THE PROJECT

The project is to be performed at the Department of Energy Technology at KTH Stockholm Campus. However, the student is expected to present work status and progress at the TESCONSOL meetings. The duration of the MSc. thesis is expected not to exceed **6 months**, and final results should be presented at the TESCONSOL mid-annual meeting to be held in July 2014. A tentative schedule for performance of specific tasks, report deliverables and consortium meetings is presented below.

SUPERVISION AND CONTACT

**Main Supervisors**
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REFERENCES