MASTER THESIS PROJECT PROPOSAL

NOVEMBER 2013 – Contact: ***rafael.guedez@energy.kth.se***

PROPOSED TITLE

Analysis on the integration of thermal energy storage systems for direct steam generation concentrating solar power plants – A simulation work

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]. Amongst the different CSP technologies, central tower direct steam generation (DSG) power plants emerge as an attractive option, as these allow reaching higher thermal efficiencies and eliminate the usage of different heat transfer fluids (HTF) in the power block. The current state of the art for central tower DSG-CSP plants can be exemplified by the Ivanpah power facility in the Mojave Desert shown below, which is still under construction. This project, however, does not consider the integration of thermal energy storage (TES). In such concern, the integration of TES systems has 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].

Fig. 1 Aerial picture of the Ivanpah DSG Solar Power Facility in the Mojave Desert

In order to analyze the influence that integrating TES can have on the performance of central tower DSG-CSP plants, one of the main objectives of the work is the design and development of a TRNSYS component for a TES system based on phase change materials (PCM). In such concern, different concepts concerning PCM usage for TES in CSP have been studied [5][6], all of which must be reviewed prior selection of a suitable one for DSG-CSP and further implement it in TRNSYS. The development of this component will allow subsequent thermo-economic analyses of the DSG plant as well as optimization of TES integration strategies in terms of operation and size of the solar field and storage systems. The work is to be performed under supervision of the TESCONSOL umbrella; a EU funded consortium constituted by three research institutes and two industrial partners, namely *KTH, UPC, Tecnalia, Gas Natural Fenosa* and *Total*.

SPECIFIC TASKS

T1 Perform a literature survey on Direct Steam Generation – CSP Plants

- Understand how is the layout of these power plants and how they operate (flow control and live steam conditions). Consider both projects under construction and already operative.
- Review studies on TES integration strategies for DSG-CSP plants*. Focus on:
  - 2-Tank molten salts / concrete + latent heat evaporation.
  - 2-Tank molten salts / concrete + latent heat preheating.

** Literature survey should encompass available literature from published studies but the student is also granted with access to confidential reports developed within the TESCONSOL consortium.*

T2 Define DSG-CSP plant configuration upon which the work will be based

Select reference plant power block layout and a suitable TES integration strategy to get a final plant layout for a DSG-CSP with TES. For such layout, define and describe all possible operation modes accounting for limitations imposed by the PCM materials (melting T).

** Final layout and respective operating modes will be decided based on discussions performed within the TESCONSOL consortium, with emphasis on input from industrial partners (GNF and Total).*

T3 Select PCM TES concept

Review existing PCM based TES concepts (encapsulation, immerse heat exchangers, PCM flux) with focus on characterizing the charging/discharging behaviour. Understand how the charging/discharging time varies with regards of unit size, geometry and HTF flow conditions.

T4 Develop TRNSYS component

Create a TRNSYS component to model transient behaviour of chosen PCM TES concept. This will be used for modelling of the proposed configuration in T2. The model should be verified and validated based by comparing with literature reviewed in T3.

T5 Model the proposed DSG-CSP plant with integrated TES

Elaborate a TRNSYS model of the power plant, then decide an operating strategy and TES unit size to finally perform a whole years worth simulation of the plant in order to analyze its thermodynamic and economic performance.

T6 Provide final recommendations and conclusions

- Highlight results from each of the tasks performed and provide final recommendations for integration of PCM based TES systems in DSG-CSP plants.
- How is the PCM unit operation influencing the overall plant performance?

STUDENT REQUIREMENTS

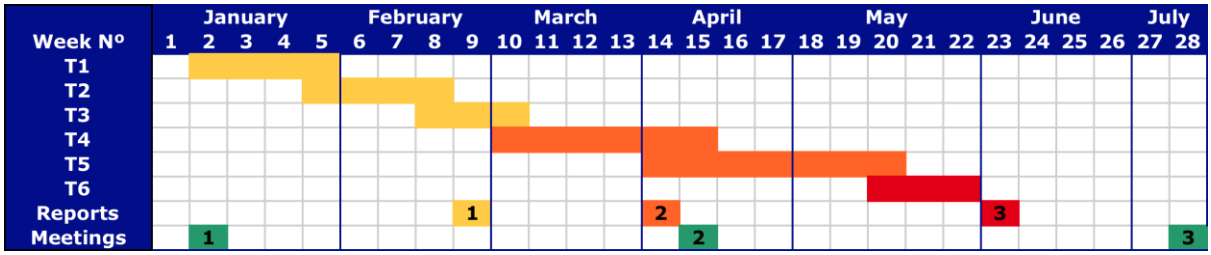
- Strong theoretical background in heat transfer and thermodynamics.
- Expertise on energy systems analysis and simulation.
- Expertise in programming with Matlab and TRNSYS. Experience with Fortran is advantageous

EXPECTED DELIVERABLES

- **New TRNSYS component of PCM based TES systems for DSG-CSP plants.**
- **TRNSYS model of the DSG-CSP plant**
- 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 - T3).
  - Second draft: Describe modelling methodology (T4 & T5).
  - 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

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	Piedad Martínez (Gas Natural Fenosa)
	Zhor Hassar (Total)
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[2] CSP World, 2013, "CSP Facts and Figures", retrieved from www.csp-world.com

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