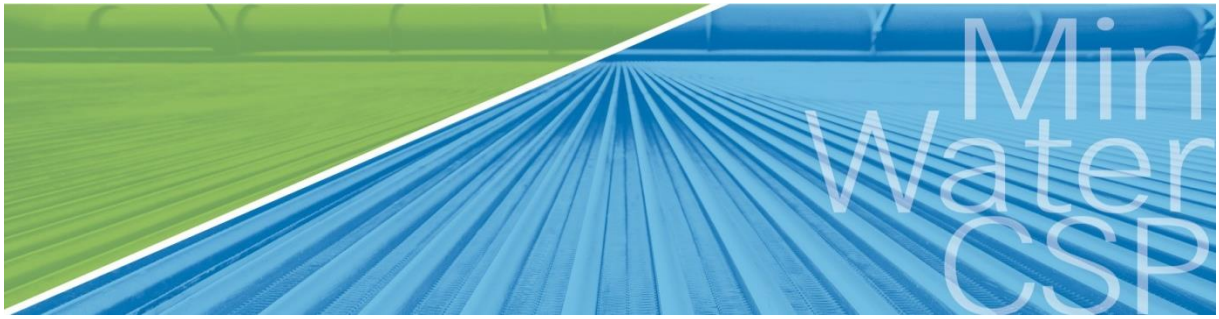

MinWaterCSP Newsletter

Edition: April 2018

Topics

1 Editorial

Dear Reader,

In order to optimize water management and consumption in CSP plants, a CSP plant simulation tool can offer valuable information. MinWaterCSP project partner Fraunhofer ISE has developed such a software tool chain for simulation, economic evaluation and optimization of CSP plants. Read more about the ColSimCSP software in the special topic section of this sixth newsletter edition.

If you are eager to learn more about new approaches in mirror cleaning, cooling system solutions and overall plant performance simulations, then don't miss the International Conference on "Reduced water consumption in CSP plants" hosted by the MinWaterCSP consortium in Marrakech, Morocco on 24th-25th April 2018. Registration is still possible. Read more about this conference in our news and event section and discover further interesting CSP related events where you can meet us. You can also find out more about the recent activities of the MinWaterCSP partners in the blog section.

This newsletter is issued approximately every four months. It is addressed to all interested stakeholders active in the field of concentrated solar power plants, from power plant developers / operators and technology suppliers to the scientific community as well as governmental bodies.

If you have received this newsletter via a project partner's contact, please feel free to subscribe at our website to have the newsletter automatically forwarded to you in the future.

Enjoy reading!

Falk Mohasseb
Coordinator of MinWaterCSP
Kelvion Holding GmbH

2 Special topic: ColSimCSP – A Software tool chain for optimization of CSP plants

MinWaterCSP project partners involved in this activity:

- Fraunhofer Institute for Solar Energy Systems ISE , Germany
- Kelvion Thermal Solutions, South Africa

Introduction

The Fraunhofer in-house system simulation tool ColSimCSP is employed to carry out the assessment of the overall cycle performance and water consumption in the MinWaterCSP project. Power plants with different collector technologies and various thermal energy storage capacities are taken into consideration in order to assess the developed water saving solutions integrated in a CSP plant based on annual simulation.

ColSimCSP is a simulation software initially designed, developed and used at Fraunhofer ISE to perform calculations for solar thermal systems. ColSimCSP can perform fast quasi-dynamic hydraulic simulations and allows for the integration of complex control strategies at adjustable level of detail.

For a customizable plant layout, each component can be connected by inputs and outputs and its parameters can be set in a graphical user interface. Fraunhofer ISE has developed an extensive library of detailed models for all components in solar thermal plants, such as parabolic trough collectors, linear Fresnel collectors, flat plate collectors, central receiver systems, stratified storage, 2-tank storage, steam drum, heat exchangers, pumps and power block. The code is accessible and can be further adapted to new developments like innovative cooling techniques. Most of the models consider transient effects which enables dynamic system simulation. For this reason, it is not only possible to assess annual plant performance but also detailed plant operation and the use of different operating strategies. In addition, ColSimCSP simulations can be parallelized which allows for large numbers of simulation runs as needed for optimization purposes and parameter variations. As ColSimCSP is written in the programming language C/C++, the code is compiled before it is executed. Hence, the simulations run very fast compared to other available simulation tools that use interpreted languages. In a previous project, Fraunhofer ISE ran 100,000 annual yield simulations with one minute temporal resolution in the course of only two days.

Within MinWaterCSP, ColSimCSP has been extended to enable CSP plant simulation for the new hybrid cooling system, including the following novel features of the software:

- Detailed modeling of water flow and consumption as well as electricity production and energy consumption for water supply and treatment.
- Use of integrated system model for optimization of water management and consumption.
- Integrated operating strategies with forecaster unit for the optimization of water consumption and electricity costs.
- Integrated model for MinWaterCSP hybrid dry/wet cooling system.

Further development of ColSimCSP

Within MinWaterCSP, ColSimCSP has been expanded to enable simulation-based evaluation of the technologies further developed in the project as well as to optimize the operating strategy and the design of a CSP plant in order to reduce water consumption and the levelized cost of electricity (LCOE). Performance models representing each CSP technology were created and validated in ColSimCSP. Different operating strategies with a weather forecaster unit were also added to the models.

Additionally, different cooling system models including but not limited to a novel hybrid dry/wet cooling system with deluged units were added to the software. One of the novelties of the new CSP performance models is that each relevant sub-system model has been expanded in order to allow for the complete modeling of water flows within the CSP system. Not only the water consumption itself but also the energy required to supply and treat water have been modeled. The following list gives an overview of relevant water streams:

- Water for mirror cleaning
- Make-up water streams
- Blow-down water streams
- Cooling water
- Bundle cleaning for finned tubes and deluge section
- Other water consumers

Overall Approach

To evaluate the amount of water saving comprehensively, various CSP technologies, different geographical locations, various market situations as well as different CSP plant configurations in terms of plant nominal capacity and thermal storage size are taken into consideration. An additional tool was implemented to design the reference plants and to identify all input parameters (plant design parameters) needed for the annual yield simulation. Furthermore, a detailed financial evaluation tool for CSP plants is developed for processing the simulation result. The main output of this tool is the levelized cost of electricity (LCOE) which is the main figure of merit resulting in a techno-economic evaluation.

The procedure of the simulation-based evaluation from designing a plant to simulation and optimization is shown in Figure 1.

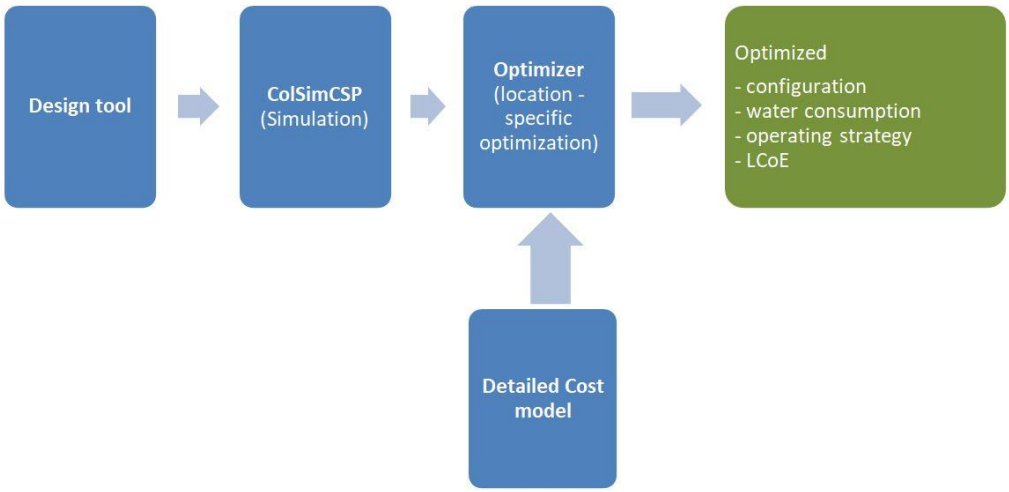

Figure 1: Software tool chain for design, simulation and optimization of CSP plants (©Fraunhofer ISE)

MinWaterCSP performance models in ColSimCSP

Detailed performance simulation models of CSP plant components have been developed in ColSimCSP to represent the pilots. This includes the implementation of three CSP plant technology models i.e. Parabolic Trough Collector (PTC) with Thermal Oil (VP-1) and Molten Salt (MS) as Heat Transfer Fluid (HTF), Linear Fresnel Collector (LFC) with thermal oil, and the Central Receiver System (CRS) with molten salt. The performance models contain a two-tank thermal storage system with molten salt as the storage medium. The integration of the storage tanks is either direct or indirect depending on the heat transfer fluid. Therefore, there are two different plant layouts implemented in ColSimCSP (Figure

2). One is the plant with indirect molten salt storage and thermal oil as HTF which can be combined with PTC and LFC technologies. The other one contains the direct storage and molten salt as HTF and storage medium which can be combined with CRS and PTC technologies.

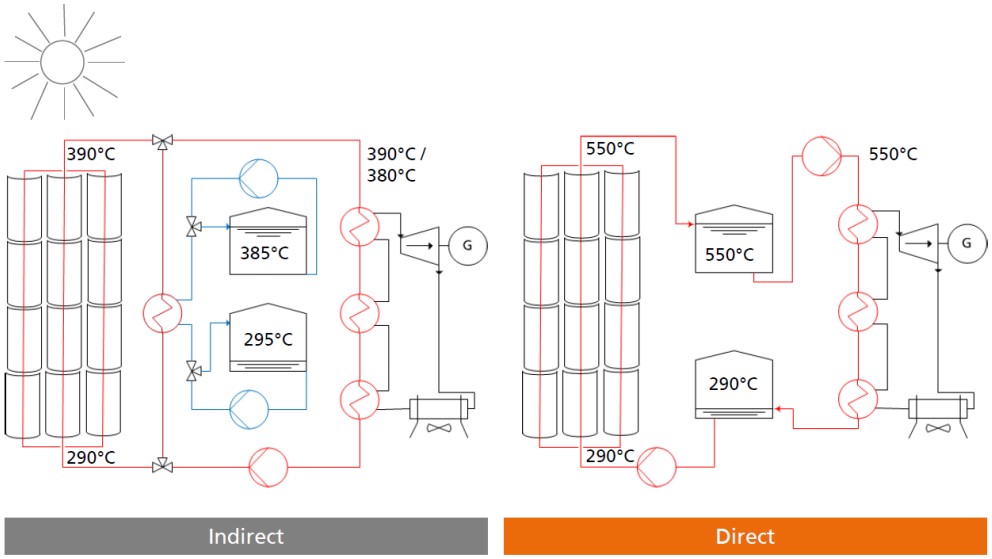

Figure 2: Simplified schematic of the implemented CSP plant layouts in ColSimCSP (©Fraunhofer ISE)

Plant operating Strategy

In order to evaluate the effect of the plant operating strategy (dispatch control) on the performance of the cooling system and subsequently the water consumption, different strategies were implemented in the models. The ultimate goal is to determine the optimum operating strategy in different market situations for reducing water consumption and LCOE.

The plant operating strategy is an input to the plant control system which changes mainly the control strategy of the thermal storage system (TES dispatch control). The plant control will follow the demands of the operation strategy taking into account any limitations on plant model level (e.g. restrictions on ramp rates, start-up times etc.). Figure 3 illustrates the different production profiles (left) and storage levels (right) resulting from two different operating strategies. The blue curve shows an operating strategy that aims at maximizing the annual yield by operating the power block at full load as often as possible as the power block efficiency is at its maximum then. The green curve shows an operating strategy that aims at reducing the number of power block shut downs by trying to run the power block at part-load during night-time. By changing the operating strategy, the plant production is shifted within day and night which can affect the performance of the cooling system and water consumption.

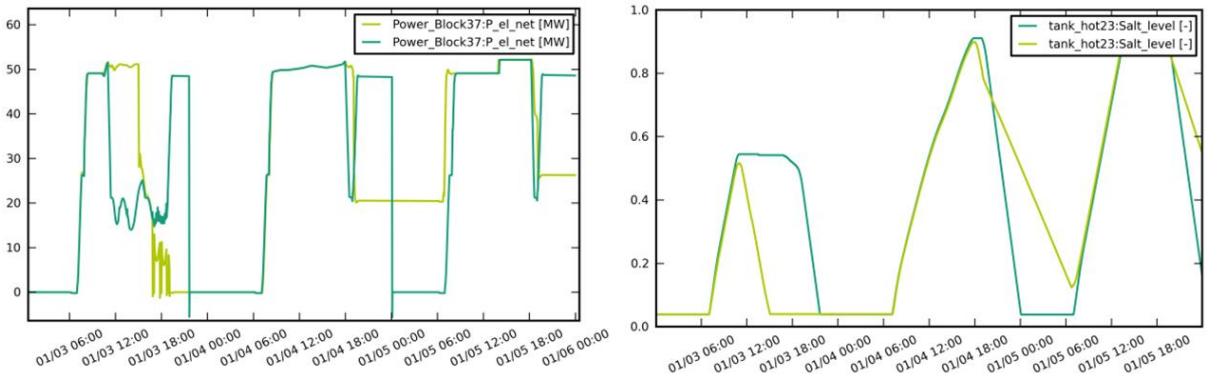

Figure 3: Simulation result of a 50 MW CSP plant using two different operating strategies (©Fraunhofer ISE)

Four different operating strategies are implemented in MinWaterCSP performance models that can be selected by the user: Solar-Driven Strategy, Increased Full Load Hours, Continuous Night Operation, and Reduced Stops Strategy. In two cases of the operating strategies, virtual weather forecasting is enabled in order to assess the available solar energy of the following days.

Impact

ColSimCSP is capable of predicting the annual net electricity yield as well as the detailed water demand of large-scale CSP plants with a high level of confidence. It can also accurately simulate the behaviour of individual components. The possibility to parallelize simulation runs as well as the use of a compiled programming language enables fast dynamic system simulation. The developed MinWaterCSP models may now be used for finding the most efficient operating strategy for various market situations as well as for minimizing the LCOE by optimizing the number of loops and/or storage size in different geographic regions.

A preliminary simulation result of a 50 MW CSP plant with the MinWaterCSP hybrid dry/wet condenser in Upington, South Africa, is presented in Figure 4.

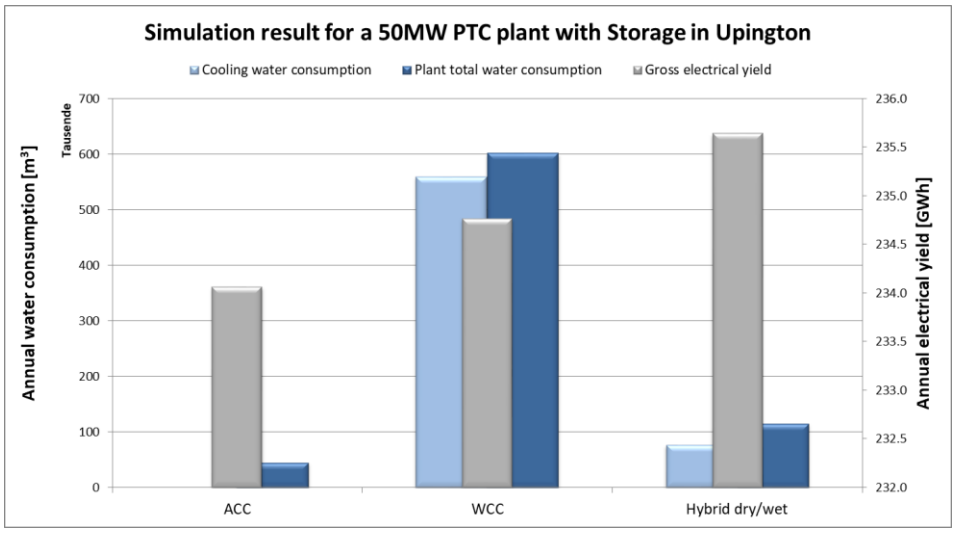

Figure 4: Preliminary simulation-based comparison with ColSimCSP between MinWaterCSP hybrid condenser and conventional condensers (©Fraunhofer ISE)

Turbine output and raw water consumption are compared with conventional air cooled and wet cooled plants of similar size. The plant water consumption is significantly reduced through the deployment of the Hybrid dry/wet condenser while turbine output is increased.[1]

In conclusion, the CSP plant simulation tool ColSimCSP software already offers valuable information to optimize water management and consumption in CSP plants.

Authors: Shahab Rohani, Theda Zoschke, Fraunhofer ISE, Germany

[1] *It should be noted that the presented preliminary result in this article is not yet sufficient to perform a technology evaluation.*

3 News

- **Erection of the MinWaterCSP Full Scale test facility in Stellenbosch has started**

Erection of the Full Scale test facility got off to a start on Monday, 19th March 2018. With mechanical and electrical installations to follow soon after, commissioning of the test facility is aimed to be finalized by the end of May 2018. The facility opens up new horizons for testing, verifying and demonstrating cooling system axial flow fans and the novel delugeable heat exchanger in full-scale. It is a one-of-its-kind in the world and could contribute to technologies that would significantly decrease water and energy consumption in cooling systems, while maintaining or possibly even improving net-power output to the client, especially in drought-stricken regions where CSP plants are customary. With the hot climate prevailing, this is cool business indeed…

Erection of the Full Scale test facility at Stellenbosch University.
© ENEXIO Germany GmbH & Kelvion Holding GmbH

- **Join us on 24th April - 25th April 2018 for the first MinWaterCSP Conference**

Reduction of water consumption in CSP plants -
new approaches in mirror cleaning, cooling and simulations
International Conference by the Horizon 2020 project MinWaterCSP

Date: 24th April - 25th April 2018
Marrakech, Morocco
The two-day conference will present the current development status of:

- Different mirror cleaning systems
- Measurement and analysis of soiling and its impact on reflectors
- Innovative developments for air cooled condensors and cooling towers
- Axial flow fan developments done within MinWaterCSP
- Simulation based analysis of water consumption in CSP plants
- Strategies for water management
- Best practices in water consumption reduction in CSP – stated by different invited CSP projects

The conference will include a site visit to Green Energy Park in BenGuerir. Registration is open until 13th April 2018. Register here!

Conference website: http://www.minwatercsp.eu/conference-marrakech-april-2018/
Conference programme: http://www.minwatercsp.eu/programme/

- **MinWaterCSP blogs published monthly**

Project partners are publishing monthly blogs on experiences, technological developments, events they are organising or have attended and activities they want to share on the MinWaterCSP website. Visit our website to find out more information in the 24 blogs published to date.

Click on any of these links to view our latest blogs and articles:

- Blog #24 – Performance testing of a Reduced scale fan
- Blog #23 – Wire Structure Heat Exchangers: A Better Design for Air Cooled Condensers?
- Blog #22 – Announcement of the first MinWaterCSP Conference in Marrakech, Morocco

Stay tuned! - *http://www.minwatercsp.eu/news/blogs/*

News from other projects

- **SCIS: Sign up and be informed about Smart City projects**

EU Smart Cities Information System

Want to stay up to date with Smart City projects in Europe? Benefit from the knowledge of other projects – find out what works and what does not. Hear it right from the people – the latest Smart City stories and find out about exciting events. Sign up to the Smart City Information System (SCIS) monthly newsletter. Click here for the newsletter. Go to the SCIS main page and scroll down to sign up.

- **MATS project: Novel Solar Thermal Power Plant opens in Egypt**

The parabolic trough power plant with collector area of 10,000 m² has an electrical power of one megawatt. © Fraunhofer ISE

On 27th February 2018, the MATS power plant was officially inaugurated in the City of Science and Technology in Borg El Arab, which is located in Egypt west of Alexandria.
The first of its kind, the new solar thermal power plant was developed within the project "Multipurpose Applications by Thermodynamic Solar – MATS", carried out by a consortium of European and Egyptian partners and co-financed by the European Union.
The Fraunhofer Institute for Solar Energy Systems ISE provided scientific support for the project.
READ MORE

- **CAPTure project publishes video-clip**

capture
COMPETITIVE SOLAR POWER TOWERS

The Competitive Solar Power Towers (CAPTure) project has produced a video-clip of the CSP facility at the Plataforma Solar de Almería, Spain.

Watch the video here: http://capture-solar-energy.eu/

- **Joint activities with other H2020 CSP projects (CAPTure, MOSAIC, WASCOP, Raiselife)**

  MinWaterCSP continued the collaboration with other H2020 CSP projects:

  - H2020 projects WASCOP and Raiselife will contribute with their know-how and experience to the **International Conference** on "Reduction of Water Consumption in CSP plants" hosted by MinWaterCSP on 24th - 25th April in Marrakech, Morocco. WASCOP will be presenting a toolbox to assess economic and environmental impact of WASCOP solutions (Peter King, Cranfield University). In addition, they will share their expertise in mirror degradation and soiling (Sahar Bouaddi, MASEN) and water saving by anti-soiling coatings (Gema Perez, RIOGLASS). The Raiselife project will present their best practices in soiling characterization of solar mirrors (Anna Heimsath, Fraunhofer ISE). Fore more details, please see the conference programme: https://www.minwatercsp.eu/programme/
  - Interested in the latest news linked to CSP and the projects CAPTure, MOSAIC, WASCOP and MinWaterCSP? Follow the four projects via the joint LinkedIn Group **"H2020 CSP projects"**: *https://www.linkedin.com/groups/13519618*

4 Events – Meet us at…

- **Fan 2018 - International conference on fan noise, aerodynamics, applications and systems**, 18th - 20th April 2018 in Darmstadt, Germany, http://www.fan2018.org/
  MinWaterCSP partners at this event: ENEXIO Management, Sapienza University of Rome, Stellenbosch University
- **"Reduction of water consumption in CSP plants - new approaches in mirror cleaning, cooling and simulations"- International Conference,**
  Conference by the Horizon 2020 project MinWaterCSP, 24th-25th April 2018 in Marrakech, Morocco, http://www.minwatercsp.eu/conference-marrakech-april-2018/
  MinWaterCSP partners at this event: whole consortium
- **North Africa Renewable Energy Summit 2018**, 09th - 10th May 2018 in Casablanca, Morocco, http://www.moroccorenewable.org/
  People who have to survive years of drought would certainly appreciate some of the rainfall that other regions of the world receive or in general to have more water resources available.
  That's why ENEXIO and MinWaterCSP are partnering to develop customized, reliable and sustainable solutions conforming to the signs of the times.
  Convince yourself and visit us at ENEXIO's exhibition stand at the North Africa Renewable Energy Summit 2018 in Casablanca.
  MinWaterCSP partner at this event: ENEXIO Holding GmbH
- **turboexpo2018**, 11th - 15th June 2018 in Lillestrom, Norway, https://www.asme.org/events/turbo-expo
  MinWaterCSP partner at this event: Sapienza University of Rome
- **Save the date: MinWaterCSP Final Conference**, 7th - 8th November 2018 in Stellenbosch, South Africa
  After three years of intense work dedicated to the reduction of water consumption in CSP plants, the conference will mark the end of the MinWaterCSP project. Join us for celebrating this special occasion and to learn more about our achievements and innovative technological developments to save water in CSP plants! More information will be available on https://www.minwatercsp.eu/.

5 Stay in contact with us

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