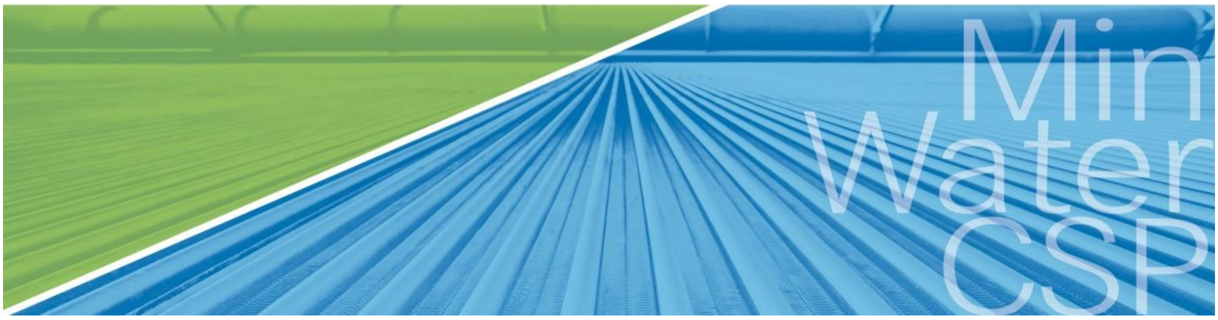


MinWaterCSP Newsletter

Edition: December 2018

Topics

1 Editorial

Dear Reader,

With the start of the project in 2016, MinWaterCSP set ambitious goals to create sustainable and sophisticated solutions with its thirteen partners from six different countries.

Now, in 2018 at the end of the project, MinWaterCSP can proudly present its results, produced during three years of committed work.

An introduction of a novel hybrid dry/wet cooling technology was planned, to increase the net annual power output of dry-cooled CSP plants by up to 2% while maintaining capital cost or to reduce the water consumed for cooling by 75 to 95% relative to wet only cooling systems, while maintaining plant peformance. These goals have been fulfilled and water savings of more than 80% compared to wet only cooling can be achieved, without compromsing performance.
Furthermore, MinWaterCSP tried to reduce the auxiliary power consumption of the cooling system by improving fan static efficiencies from the present typical range of 55 - 60% to a range of 65 - 70%. Comparing the performance of the axial fan developed in the MinWaterCSP project to an axial fan that is used in an existing power plant, an increase in efficiency by up to 8% and a noticable power consumption decrease could be reported. If you are interested to learn more about the hybrid deluge condenser and fan testing at the full scale test facility in Stellenbosch, please have a look at our **Special topic section.**

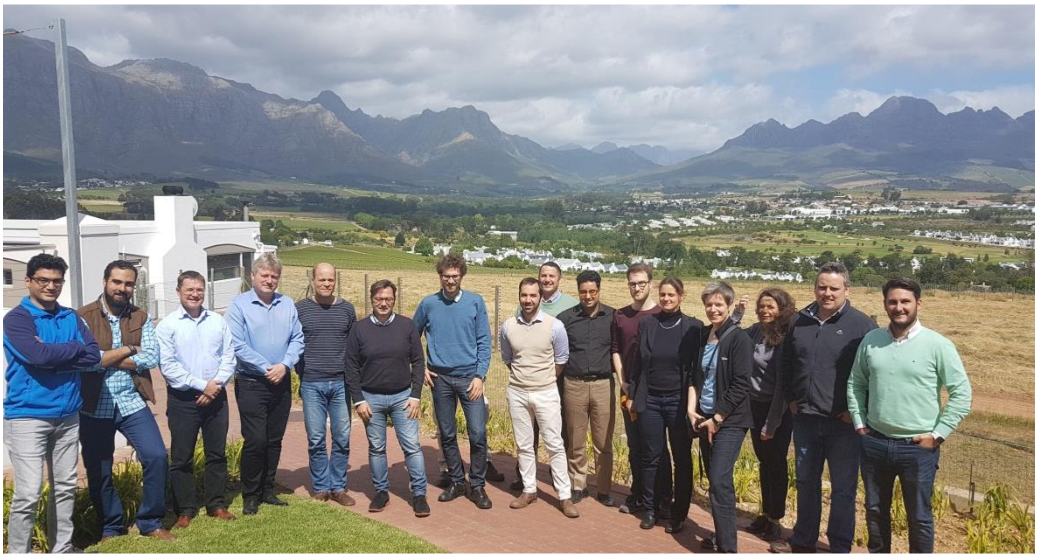
On the other hand, MinWaterCSP aimed to develop new solutions for mirror cleaning systems, to reduce the water consumption by around 25%. At the end of the project, the mirror cleaning systems for heliostats and parabolic troughs achieved a saving of around 35% of cleaning water consumption and the systems for linear fresnel mirrors of around 80%.

In a further work package, the development and use of compact heat exchanger technology was explored. The introduction of so-called wire structure heat transfer surfaces to replace conventional heat exchanger plate fins led to significant reductions in the fin material quantity required for dry-cooled heat exchangers.

New water management plans and strategies were created for CSP plants as part of the MinWaterCSP project. The new water management strategies made use of the technological advances achieved during the project with the particular focus on the reduction of water use in CSP plants. This also included the optimisation of mirror cleaning cycles through the extensive use of mirror cleanliness and soiling rate data.

The existing CSP plant simulation tool ColSimCSP of Fraunhofer ISE was also developed further as part of the MinWaterCSP project and all new technologies of the project were built into and simulated by the ColSimCSP tool to exactly quantify the effect on key parameters such as LCOE, net annual power generation, water consumption and capitial and operating costs. Reductions in LCOE could be demonstrated as well as how to optimise capitial investment in order to improve net annual power generation.

Final project results were presented at MinWaterCSP's **2nd International Conference on the "Reduction of water consumption in CSP plants"** in Stellenbosch, South Africa on 7th-8th November 2018. You will find more detailed information on the event and the inauguration of the full scale test facility in our **News section**. Besides, you can also find out more about the final activities of the MinWaterCSP partners in the blog and press release section.



Group picture of MinWaterCSP consortium members in Stellenbosch, ZA (© Steinbeis 2i GmbH)

We are sure that the new technological solutions developed by MinWaterCSP are of great value for you and would be happy to launch further cooperartion. This is our last newsletter edition. If you would like to stay in contact with us in the future, please visit our MinWaterCSP website and do not hesitate to contact our team members.

Let's keep in touch!

Falk Mohasseb
Coordinator of MinWaterCSP
Kelvion Holding GmbH

2 Special topic: Full scale test facility in Stellenbosch – Deluge condenser and fan system testing

MinWaterCSP project partners involved in this activity:

- Kelvion Thermal Solutions (Pty) Ltd, South Africa
- ENEXIO Germany GmbH, Germany
- ENEXIO Management GmbH, Germany
- Stellenbosch University, South Africa
- Sapienza University of Rome, Italy
- NOTUS Fan Engineering, South Africa

Two concerns related to the use of industrial forced draft air-cooled condensers (ACCs) in concentrated solar power (CSP) plants exist. The first is the excessive auxiliary power consumption of the large diameter axial flow fans used in these systems. The second concern is the underperformance of the ACC during adverse atmospheric conditions (peak atmospheric temperature levels or extreme windy conditions).

The MinWaterCSP project provides a cost and water effective solution to address both these concerns through two novel technologies:

The first technology is the design and manufacture of high efficiency axial flow fans, optimised for improved aerodynamic and structural performance. The use of fans will reduce auxiliary power consumption by 5 to 10 % (depending on the desired operating point) in existing plants or enable the designer to reduce plant size for newly built systems.

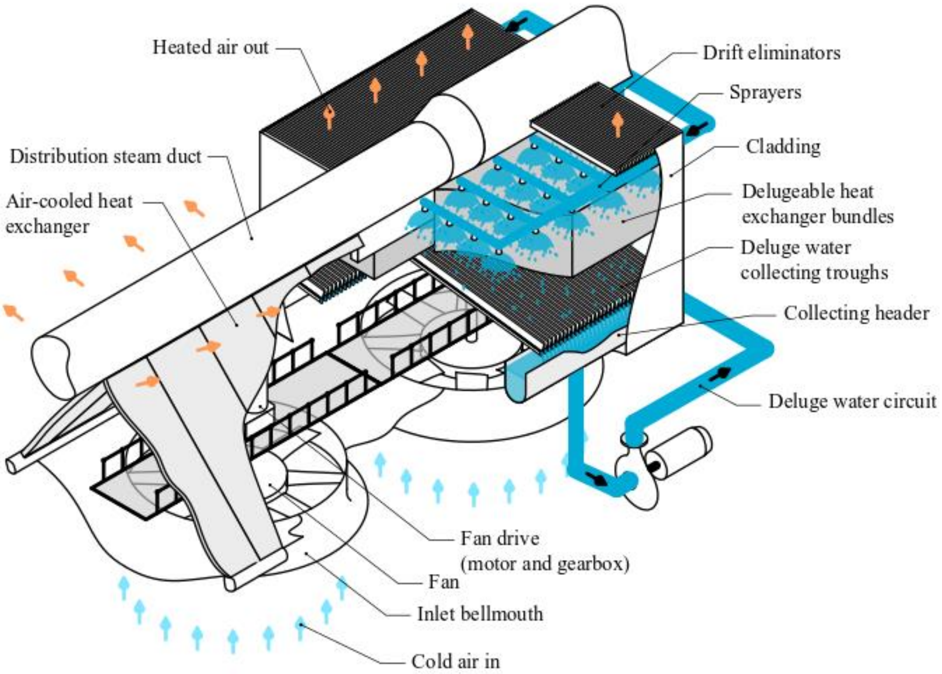


Figure 1: Directly integrated deluge condenser concept (© ENEXIO Management GmbH)

The second technology is the development of a so-called directly integrated deluge condenser cell (evaporative condenser cell) which would typically form part of a conventional ACC (figure 1). The deluge cells are only operated during adverse ambient conditions and are turned off when conditions become favourable for dry operation again. As such, the operator can exercise a philosophy to either protect or control turbine power output and to secure sufficient electricity on demand. This can be achieved while the water consumption would typically be in the order of 30 % (depending on the specific installed location) or lower compared to the consumption of wet-cooled towers.

Even though many technical queries can be resolved through analyses and laboratory scale testing, the practicality of such large systems needs to be tested and demonstrated at full scale. For this purpose, a full scale test facility was erected and recently opened during the 2nd MinWaterCSP Conference in Stellenbosch, South Africa (figure 2).

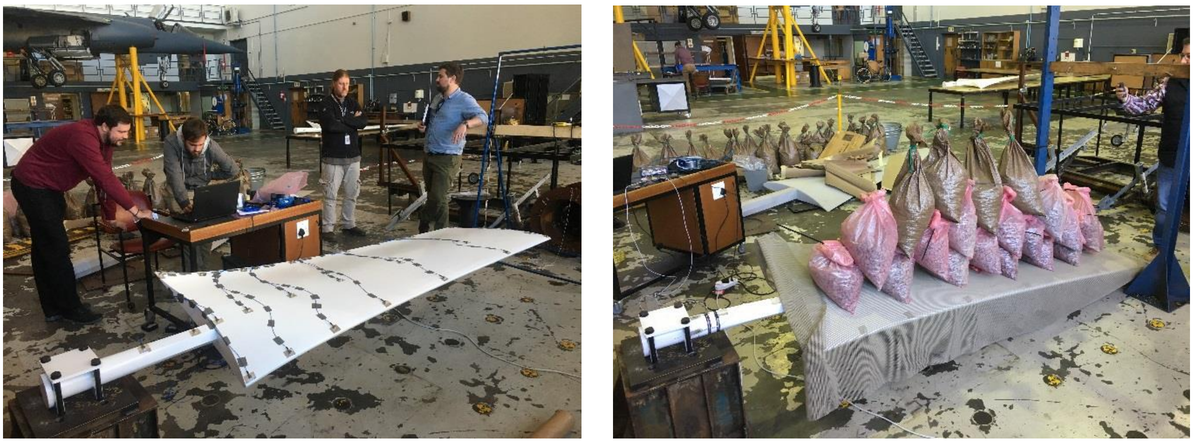
Figure 2: Opening of the full scale test facility on 8th November 2018, Stellenbosch, ZA (© Kelvion Thermal Solutions (Pty) Ltd and ENEXIO Germany GmbH).

The full scale test facility at Stellenbosch was purposely designed and constructed to conduct measurements and demonstrate the performance of:

- a large (24 ft) diameter axial flow fan under installed conditions (of which the CSP fan, designed within the MinWaterCSP project is the first) and
- to functionally test and develop the cooling water cycle of the newly developed deluge condenser cell under near iso-thermal conditions

It is the only test facility of its kind globally.

The aerodynamic design of the CSP fan is tailored for the operating conditions of a typical ACC fan installation. The design process followed a process of scale model development, scale model testing and computational fluid dynamics analysis to derive a final aerodynamic design. The structure of the full scale fan was designed and analysed using finite element analysis with the aim to be structurally strong enough to endure operating loads, but also avoid resonance at operating frequencies. Once the full scale blades were manufactured, two samples of these blades were tested to obtain their natural frequency modes and to determine their static failure load, as can be observed in figure 3, showing a photo of a full scale fan blade being tested in the Structures Laboratory of Stellenbosch University. The difference in natural frequencies between the two blades is less than 1 % and the static safety factor in excess of 3. The blade natural frequencies were close to or further than 10 % from operating frequencies, but further analysis on the effect of centrifugal stiffening should be considered. The latter results bear testimony to the repeatability and integrity of the design and manufacturing technique. Subsequently, the full scale CSP fan was installed for further testing in the full scale test facility, shown in figure 4. The facility allows, amongst other, for a fan power curve to be obtained, by measurement of fan shaft torque, speed, air flow rate and by varying the air flow through a set of louvres at the outlet. Any other form of structural blade testing is also made provision for.



(a) (b)

Figure 3: (a) Fan blade modal testing and (b) structural testing unto failure
(© Kelvion Thermal Solutions (Pty) Ltd and ENEXIO Management GmbH)

The test facility was also designed to accommodate a ¼ section of a deluge cooled condenser cell, as depicted in figures 5 and 6 to investigate, among other, the water reticulation capacity and retention capability of the cell at various water loadings and air flow rates. In this cell, water is pumped though a set of sprayers and distributed over a mock set of condenser tubes, to test water and air flow distribution and pressure losses. At the bottom of the tubes, a set of purpose-designed troughs collect the water dripping out underneath the tubes from where it is fed back into the reticulation system, while still allowing air to pass through in a counter-flow direction. The water entrained in the air stream above the sprayers is removed by means of a set of drift eliminators.

Figure 4: Installed CSP fan
(© Kelvion Thermal Solutions (Pty) Ltd and ENEXIO Management GmbH)

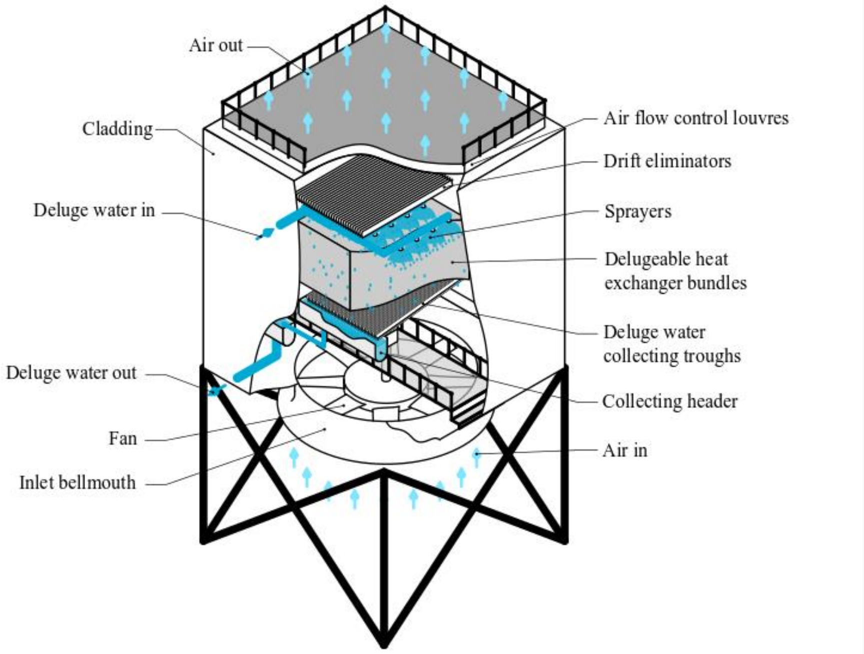


Figure 5: Schematic lay-out of the test facility with a cut-away displaying the delugeable condenser cell test section (© Kelvion Thermal Solutions (Pty) Ltd and ENEXIO Management GmbH)

(a) (b)

Figure 6: A (a) frontal view and (b) view from in between the bundle and sprayers of the deluge test section (© ENEXIO Management GmbH, Kelvion Thermal Solutions (Pty) Ltd, Stellenbosch University)

Considering the present trajectory at which water use, effluent management and emissions regulations are becoming stricter, a growing drive towards higher and cost-effective plant efficiency technologies should transpire. In addition to opening up new business and research opportunities, it is MinWaterCSP's goal to bridge the cavity between academics and industry, in the present case, through full scale demonstration and testing of the abovementioned cooling technologies. Hopefully through such initiatives, tomorrow's CSP plants would not only produce more clean electricity, but also do so more efficiently.

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Dr. Albert Zapke, ENEXIO Management GmbH, Germany

Check out our video on "The Future of CSP Cooling"!

3 News

- **Saving water when the sun shines!**
  2nd International MinWaterCSP Conference in Stellenbosch

After three years of intense work towards the reduction of water consumption in CSP plants, the international MinWaterCSP consortium presented final project results at its 2nd International Conference in Stellenbosch, South Africa.
Over 75 CSP stakeholders from six countries participated in the event to discover the MinWaterCSP solutions already tested at the project's demonstration sites in Spain, Morocco and South Africa.
The purpose of the two-day conference hosted by MinWaterCSP project partner Stellenbosch University was to introduce the South African industry and the wider international community to the project and the possible advantages that its results hold for the Concentrated Solar Power industry. Horizon 2020 CSP project Raiselife contributed to the conference programme with their expertise in the monitoring of soiling and associated cleaning strategies.
Read more in our blog #32 and our press release on the conference.

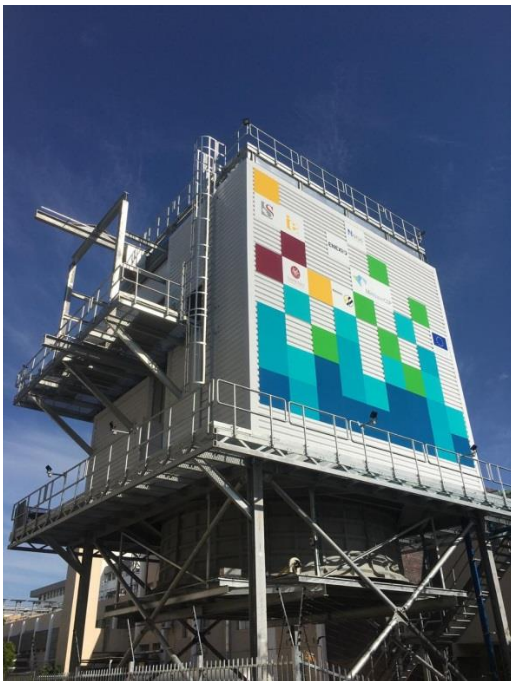

Photo: Full scale test facility in Stellenbosch, South Africa (© ENEXIO Germany GmbH, Kelvion Thermal Solutions (Pty) Ltd, Stellenbosch University).

- **Full scale testing in Stellenbosch inaugurated!**

At the occasion of MinWaterCSP's 2nd International Conference in Stellenbosch, South Africa, the new cooling system test facility was opened by the Vice-Dean Research of the Engineering Faculty at Stellenbosch University, Prof. Willie Perold. During the site visit to the test facility, which is the first of its kind, two main aspects of a novel cooling system, developed and tested within MinWaterCSP, were presented: A 24 ft diameter axial flow fan and a deluge cooling water circulation system.
Read more in our press release on the site-visit.

Photo: Prof. Willie Perold (right), Vice-Dean Research of the Engineering Faculty at Stellenbosch University, inaugurating the new cooling system test facility (©ENEXIO Germany GmbH, Kelvion Thermal Solutions (Pty) Ltd, Stellenbosch University)

- **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 32 blogs published to date.

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

- Blog #30 - Simulation software ColSimCSP: a tool to optimise CSP plant operation (by Fraunhofer ISE)
- Blog #31 – HELIOS & CURVE! The new cleaning solutions by ECILIMP for Heliostats and Parabolic Trough (by ECILIMP)
- Blog #32 – 2nd International MinWaterCSP Conference in Stellenbosch offered technical solutions to tackle challenges in CSP plants (by Steinbeis 2i GmbH)

Curious about earlier and future blogs? You can find them here: *http://www.minwatercsp.eu/news/blogs/*

- **MinWaterCSP press releases**

During the project, MinWaterCSP partners have published ten press releases about technological developments and events.

Click on any of these links to view our latest press releases:

- 18th October 2018 - Cleaning robot Soltibot® successfully tested on Linear Fresnel Collectors (by SOLTIGUA)
- 31th October 2018 - New Generation of Cleaning Tools for CSP Plants Reduces the Water Consumption (by ECILIMP)
- 8th November 2018 - 2nd International Conference on the "Reduction of water consumption in CSP plants" offers technical solutions to tackle challenges in CSP plants (by Steinbeis 2i GmbH)
- 8th November 2018 - MinWaterCSP Conference at Stellenbosch University (by Stellenbosch University)
- 12th December 2018 - Fraunhofer ISE Develops Solutions for Optimized Water Use in Solar Thermal Power Plants (by Fraunhofer ISE)

Interested in earlier pess releases? You can find them here: *https://www.minwatercsp.eu/news/mediapress/*

News from other projects

H2020 project MUSTEC

The H2020 funded project MUSTEC aims to explore and propose concrete solutions to overcome the various factors that hinder the deployment of concentrated solar power (CSP) projects in Southern Europe capable of supplying renewable electricity on demand to Central and Northern European countries. So far, MUSTEC outputs have focused on lessons learnt from the past, as well as experiences from the current market conditions and policy framework. Interesting reports for further reading focus on an analysis of the barriers to the use of the cooperation mechanisms and the Market Uptake of CSP in the EU, the technological and industrial trends of CSP over the last decade, as well as representative CSP project typologies. This material is available for download at the MUSTEC results section.Moreover, MUSTEC has recently updated the CSP.guru database with all the newest technical, economic, financial and industrial data on CSP stations larger than 10 MW). The complete dataset is freely available at https://csp.guru/

- **Joint activities with other H2020 CSP projects**

  MinWaterCSP continued the collaboration with other H2020 CSP projects:

  - **H2020 CSP Projects Joint Newsletter**
    Two times per year, you can read more about activities and results of 15 projects funded under H2020, all in the area of CSP:
    Read edition 4 published in November 2018!
    Subscribe to future editions: SUBSCRIBE

  - **Joint LinkedIN H2020 CSP group - Request membership!**
    Interested in the latest news of 15 H2020 projects linked to CSP?
    Follow us via the joint LinkedIn group
    https://www.linkedin.com/groups/13519618/

  - **Joint Twitter profile with tweets and re-tweets of several H2020 CSP projects:**
    https://twitter.com/H2020CSP

4 Events – Meet us at…

- **Turbo Expo 2019 - Turbomachinery Technical Conference & Exposition**, 17th-21st June 2019, Phoenix, AZ, USA; https://event.asme.org/turbo-expo
- **25th SolarPACES conference**, 1st-4th October 2019 in Daegu, South Korea; https://www.solarpaces-conference.org/home.html
- **POWER-GEN Europe**, 12th-14th November 2019 in Paris, France; http://www.powergeneurope.com/

Visit the event section on our MinWaterCSP website for further information.

5 Stay in contact with us

- Visit us on: http://www.minwatercsp.eu
  Interested in a specific **MinWaterCSP technology**? You will find more information and contact persons in the **technologies section**.
  You want to get in contact with one of our **team members**? Please visit our **team section** or write an e-mail to **contact@minwatercsp.eu**
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Minimized water consumption in CSP plants
MinWaterCSP

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