MinWaterCSP

Minimized water consumption in CSP plants

# Full scale CSP fan installed for testing

## WP 8, Deliverable 8.6

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Authors:
*Francois Louw (Kelvion Thermal Solutions)*

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## Executive summary

One of the main auxiliary power consumers on forced draft air-cooled condensers (ACCs) are axial flow fans, typically consuming between 150 to sometimes in excess of 200 kW per fan (where systems could typically consist of 40 to above 60 fans). Another concern is that of fan lifespan due to various non-uniform loading conditions exerted on fans as well as increased fatigue due to fans operating close to their natural frequencies. Within MinWaterCSP an attempt is made to provide a cost effective solution to address both these concerns. The 24 ft CSP fan in the present document is the second product of a customized design procedure after the Reference fan in Deliverables 8.4 and 8.5. For the CSP fan the blade design is tailored to a specific operating point and the structural aspects of the blade designed to avoid blade natural frequencies to coincide with operating excitation frequencies. The following document gives a short description and evidence of the successful installation of the 24 ft CSP fan.

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# 1 Introduction

## 1.1 Background

As part of the MinWaterCSP H2020 project, a 24 ft. axial flow fan, termed the CSP fan is manufactured and tested. This CSP fan design differs from the previously installed Reference-fan (Deliverables 8.4 and 8.5) with respect to the operating point. Similar to the Reference fan, the CSP fan testing is divided into two categories:

- Structural laboratory testing at Stellenbosch University (SUN) of two CSP fan blades.
- Full scale aerodynamic and structural testing within the newly constructed full-scale test facility at Stellenbosch (to be described in Deliverable 8.2).

For the latter testing (full-scale testing) the installation of the 24 ft CSP fan was stipulated as a deliverable (8.6) in the H2020 MinWaterCSP grant agreement. This document serves as a confirmation of this deliverable. The remainder of this document gives some information and pictures serving as evidence that the fan has been installed successfully and is operable. The on-site testing is presently in progress and will be included in the final testing document (Deliverable 8.7, due in M36).

## 1.2 CSP fan overview

The CSP fan is an 8 bladed axial flow fan, similar to the Reference fan, specifically designed by SUN as part of the MinWaterCSP project, within work package 3. The application is for low pressure and high volumetric flow rate air cooled condensers (ACCs) with the goal of:

1. Improving on present state-of-the-art fan static efficiencies: The aerodynamic design of the CSP fan is purposely conducted for the plant specific operating point, allowing higher efficiencies to be obtained. This is in contrast to present fan installations, where installed fans are mainly selected from a catalogue of available designs, resulting in maximum efficiency operation to be missed. Higher efficiencies provides advantages on two fronts being that either:
    a. ACC plant sizes can be reduced due to increased fan performance or
    b. Auxiliary power consumption can be reduced for existing plants, if the older fans are retrofitted. The reduction would be specific to each plant.
2. Extending fan blade lifespan: The structural design process is such that the blade composite lay-up is decided based on an FEA optimization, attempting to have the blade natural frequencies not coincide with multiples of the rotation frequency at which it operates. In addition, state-of-the-art resin infusion techniques are used to ensure a high similarity between manufactured blades, reducing fan off-balance loading on the fan drive and therefore lowering fatigue on bo-h the fan blades and drive.

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## 1.3 Full scale test facility station

The full-scale test facility (part of Deliverables 8.1 and 8.2) is constructed at Stellenbosch University, Stellenbosch, South Africa and depicted in figure 1.1. It serves as a test bench for the testing of full-scale (24 ft in diameter) fans as well as the novel deluge condenser system (developed extensively in Work package 2 of the present MinWaterCSP project).

Figure 1.1: Full scale test facility (near completion)

## 1.4 Reference tasks as per the grant agreement

Deliverable 8.6 is a result of the completion of Tasks 8.4.1 and 8.4.2 as well as Task 8.1.1 to 8.1.7. The remaining Task 8.4.3 involves the testing of the CSP fan, of which more than 50 % has already been completed. The results will be included in the final test report due in month 36 as part of Deliverable 8.7.

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# 2 CSP fan installation

## 2.1 Overview

The requirement for full scale testing, originates from uncertainties around:

1. Blade vibrational characteristics under various loading conditions, which differs as a function of the air flow rate.
2. Fan scaling effects, which cannot be considered at scale model level. Normally axial fans are aerodynamically tested for performance in a standardized test facility at scale level (typically 1.5 m in diameter). These performance results are scaled through turbomachinery scaling laws, but do not account for effects such as the change in Reynolds number.

For this reason full scale testing could provide valuable insights to research and verify fan vibrational, fatigue and aerodynamic performance characteristics.

## 2.2 Fan system description

The CSP fan test section, shown in figure 2.1, will be described in more detail in Deliverables 8.2 and 8.7. The test facility allows the fan to be run at operating speed as well as off-design speeds through a variable speed drive (VSD). The fan drive (motor and gearbox) is mounted on a bearing allowing free rotation, but held in place by means of a load cell for torque measurement from which fan power can be calculated. Velocity measurements are conducted at the fan inlet by a line of 6 anemometers mounted along the fan radius on a rotating beam. The beam allows for a full measurement sweep to be conducted over the entire inlet area. From these values, the total air flow rate can be calculated. In addition to these, the inlet dry- and wet-bulb temperatures are also measured and weather data from a local weather station is used as part of the data processing. The flow through the facility is controlled by a set of louvres at the outlet of the test facility, allowing tests to be conducted at various flow rates.

The full view of the installed 24 ft. CSP fan is also visible in figure 2.1 within the fan bellmouth. A fan blade clamping mechanism together with an indexing system, allowing for quick and accurate blade angle adjustments, are also implemented. Hence, each blade is mounted at exactly the same angle, reducing aerodynamically induced off-balance loads. Finally, the running fan is shown in figure 2.2, confirming successful commissioning of the fan and achievement of deliverable 8.6.

Deliverable 8.6 is herewith concluded with all associated tasks having been completed.

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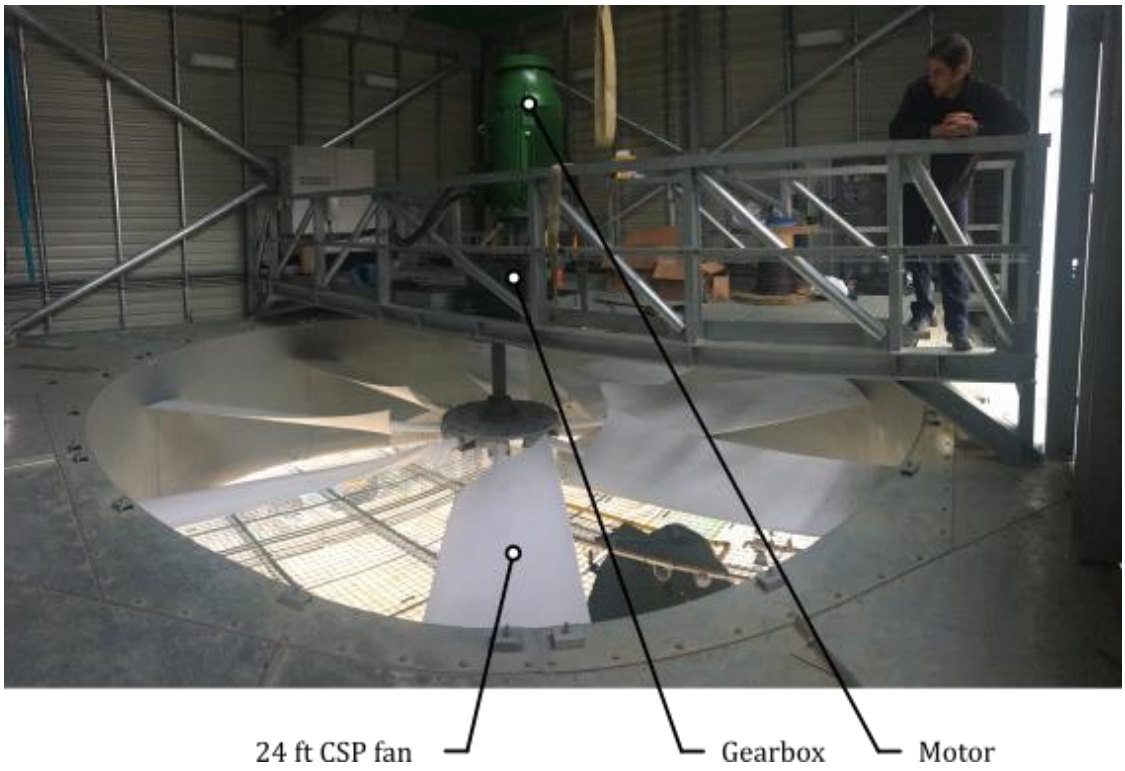


Figure 2.1: CSP fan assembly as installed in the SUN full-scale test facility

Figure 2.2: CSP fan operating at full speed (151 rpm)

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