MinWaterCSP

Minimized water consumption in CSP plants

Hybrid Cooling System Design
Work Package 2, Deliverable D2.4

Date of document
31/08/2017 [M20]

Version: REV00

Dissemination Level: Public

Author(s):

Riaan Terblanche (Kelvion Thermal Solutions (Pty) Ltd))
Stephan Krafzik (ENEXIO Germany GmbH)
Albert Zapke (ENEXIO Management GmbH)

This project has received funding from the European Union’s Horizon 2020 research and innovation programme under grant agreement No 654443

Document History

Project Acronym	MinWaterCSP	
Project Title	Minimized water consumption in CSP plants	
Project Coordinator	Falk Mohasseb (Falk.Mohasseb@kelvion.com)	
Project Duration	1st January 2016 to 31st December 2018	
Deliverable No.	D2.4	
Diss. Level	Public	
Deliverable Lead	*Kelvion Thermal Solutions (Pty) Ltd*	
Status		Working
		Verified by other WPs
	X	Final version
Due date of deliverable	Final version: 31/08/2017	
Actual submission date	Final version: 15/01/2018	
Work Package	WP 2 - Hybrid Cooling System Design	
WP Lead	*Kelvion Thermal Solutions*	
Contributing beneficiary(ies)	2 – Kelvion Thermal Solutions 9 – ENEXIO Germany 14 – ENEXIO Management	

Date	Version	Person/Partner	Comments
15/01/2018	Rev00	R Terblanche / Kelvion Thermal Solutions S Krafzik / ENEXIO Germany A Zapke / ENEXIO Management	First submission

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

Contents

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

List of figures

Nomenclature

Abbreviations

ACC	Air-cooled Condenser
CSP	Concentrated Solar Power
ESD	Exhaust Steam Duct
SDD	Steam Distribution Duct

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

1 Introduction

1.1 Background

The MinWaterCSP project is funded by the European Commission as part of the Horizon 2020 programme. The aim of the MinWaterCSP project is to investigate ways of reducing Concentrated Solar Power (CSP) plant water consumption. It includes water saving possibilities as part of an integrated water management plan, improved mirror cleaning methods as well as improved cooling system technologies making use of dry-wet or hybrid cooling.

This document demonstrates a 3D model, which was created for the newly designed hybrid cooling system, where deluge cooling is integrated into a conventional air-cooled condensing system. The detailed design of the hybrid cooling system is covered by Deliverables D2.1, D2.2 and D2.3 and these form the basis of a 3D CAD cooling system model covered by Deliverable 2.4.

1.2 Motivation

CSP plants make use of solar irradiation in a Rankine-type cycle to convert water to steam, before expanding the steam through a turbine, which generates electricity.

Locations that provide optimum solar conditions for CSP plants are generally also characterised by relatively low water availability. Air-cooled condensers (ACCs) are generally well suited for CSP applications due to their low water consumption. ACCs are, however, sensitive to the ambient dry-bulb temperature, which means that the net power output significantly reduces when the ambient dry bulb temperatures rise above the design ambient temperature. The design ambient temperature is typically an annual average temperature.

A hybrid cooling system was designed in Work Package 2 of the MinWaterCSP Project, comprising conventional ACC cells in parallel with water deluged cells. The purpose of a hybrid cooling system, or integrated dry-wet cooling, is to achieve improved cooling performance under a wider range of ambient conditions.

This document presents the 3D model of this hybrid cooling system. The 3D model is used for marketing purposes as well as to evaluate and demonstrate the construction sequence of the new hybrid cooling system.

1.3 Objectives and tasks

The objectives of Work Package 2 are defined as follows:

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

- *Create thermally optimized cooling system concepts for CSP plant applications and associated detailed designs.*
- *Perform a first iteration of cooling system capital and life-cycle cost and identify individual cost drivers.*
- *Provide cooling system performance and cost information as input for the ColSim overall CSP plant simulation exercise undertaken in Work Package 9 by Fraunhofer ISE.*

The creation of a 3D CAD model of the hybrid cooling system and the preparation of a basic construction sequence are the last tasks to be completed in order to reach the first objective above. The second and third objective are addressed by further tasks to follow.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

2 Hybrid Cooling System 3D model

This section presents various view of the 3D hybrid cooling system model developed in Work Package 2.

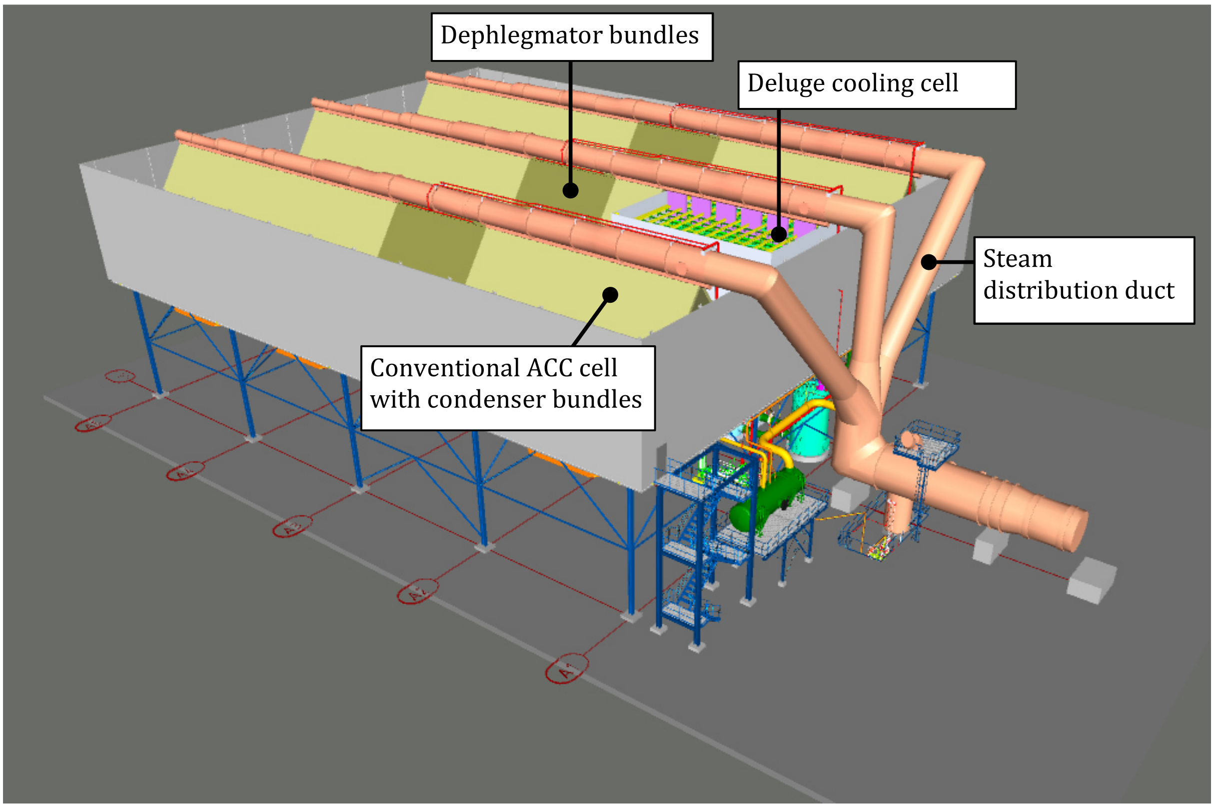


Figure 2.1: Hybrid Cooling System View (top).

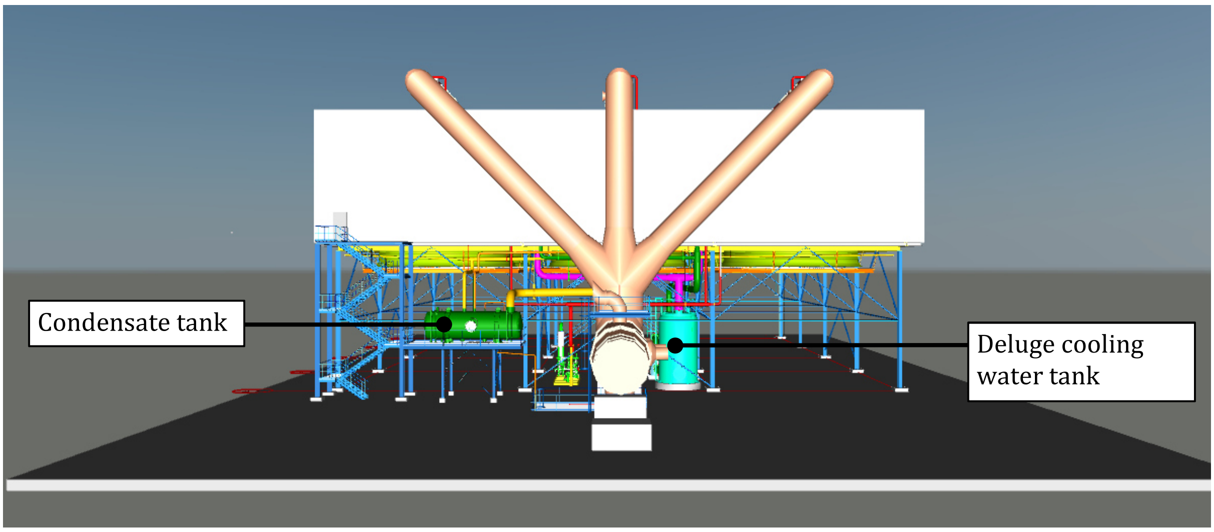


Figure 2.2: Hybrid Cooling System View (turbine end).

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

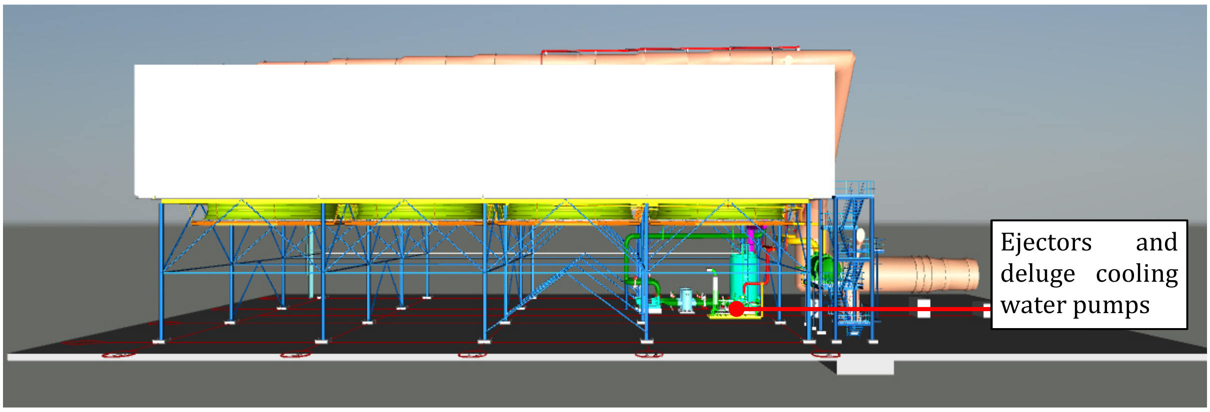


Figure 2.3: Hybrid Cooling System View (side).

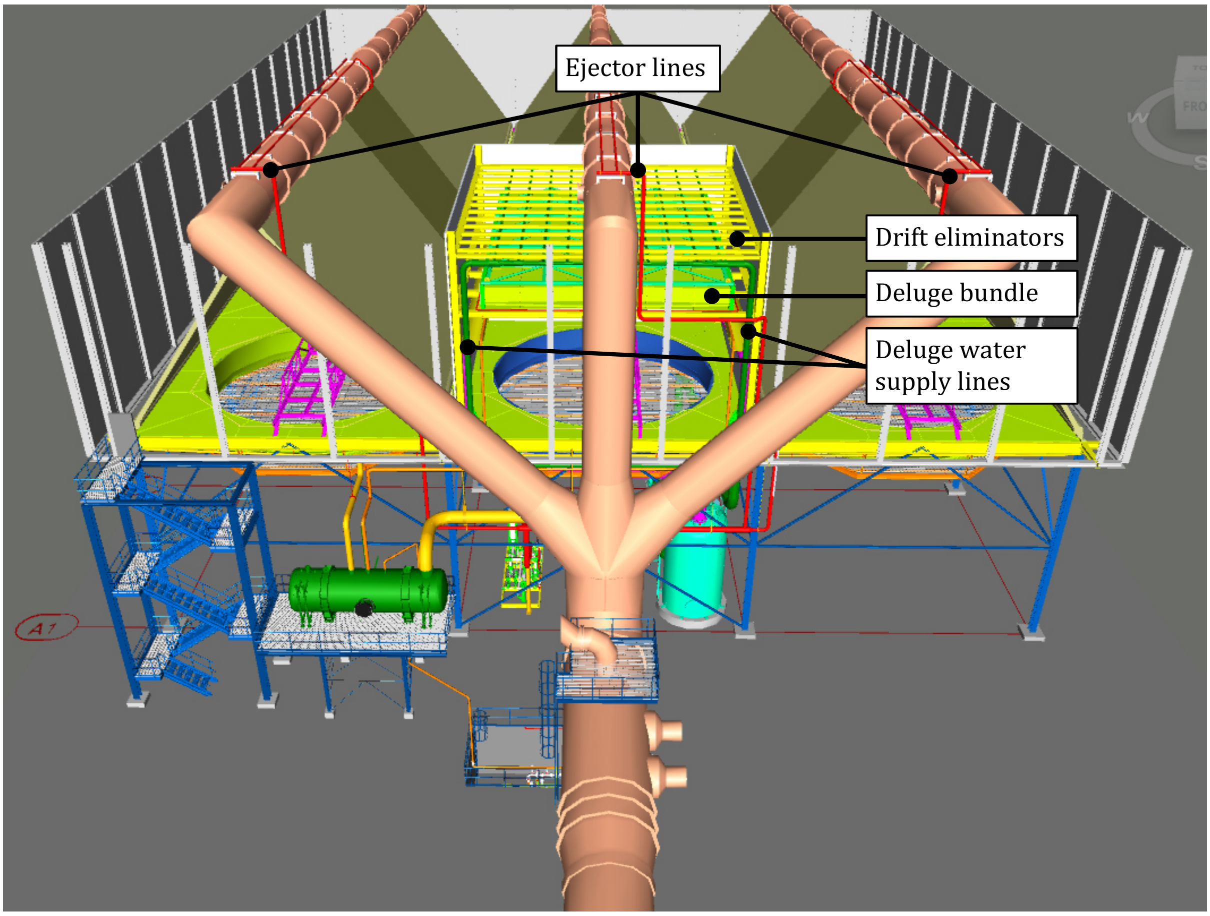


Figure 2.4: Hybrid Cooling System View (wind wall cut away).

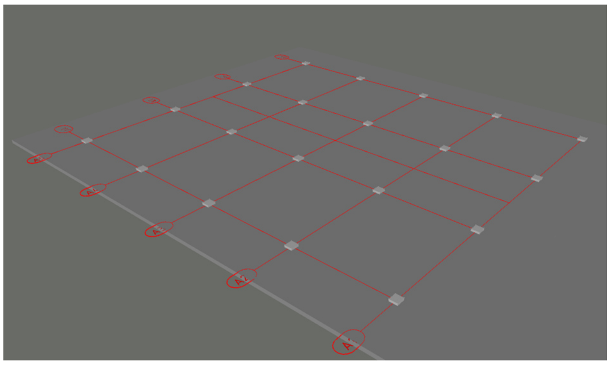
This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

3 Hybrid Cooling System constructability review

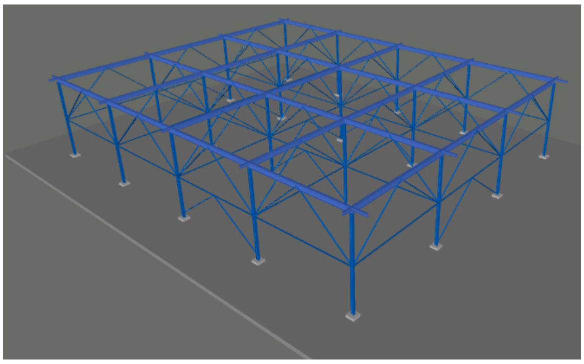
The hybrid cooling system, shown in the previous section, is constructed according to the following general steps. The exact sequence, however, may vary and is subject to an optimized construction plan.

3.1 Steel structure

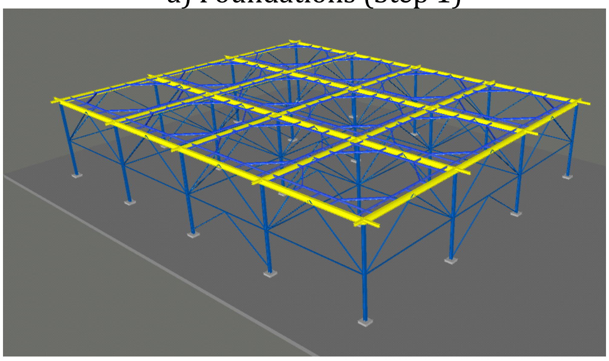
Figure 3.1 shows the main construction steps associated with the steel support structure of the hybrid cooling system.



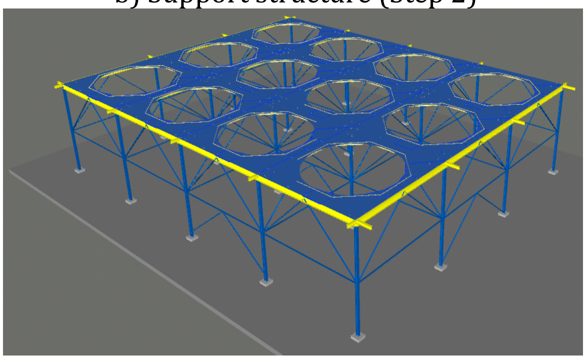
a) Foundations (Step 1)



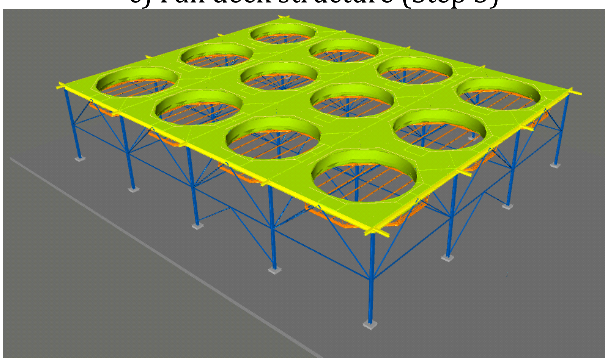
b) Support structure (Step 2)



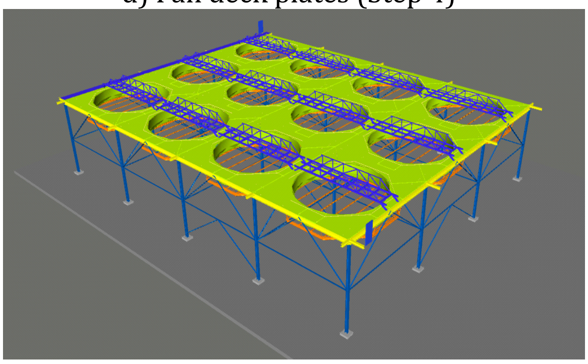
c) Fan deck structure (Step 3)



d) Fan deck plates (Step 4)



e) Fan rings and guard screens (Step 5)



f) Fans and fan bridges (Step 6)

Figure 3.1: Steel structure construction steps.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

3.1.1 Step 1: Foundations

The foundations for the support structure are designed according to the load requirements of the hybrid cooling system and cast by a civil contractor.

3.1.2 Step 2: Support structure

The support structure, constructed on top of the civil foundations, is made up of individual beams that are bolted together. The staircase (not shown) is also installed during this step.

3.1.3 Step 3: Fan deck structure

The individual beams, comprising the fan plate structure, are bolted onto the existing support structure.

3.1.4 Step 4: Fan deck plates

The fan deck comprises individual pre-fabricated plates, which are installed (bolted) onto the fan deck structure.

3.1.5 Step 5: Fan rings and guard screens

The fan rings are assembled at ground level and the fan guard screens, also pre-assembled at ground level, are bolted onto fishplates that form part of the fan ring assembly. The completed fan ring and guard screen assemblies are then lifted into place, from below the support structure, and bolted onto the fan plate structure.

3.1.6 Step 6: Fan and fan bridges

The fan bridges are pre-assembled at ground level. A completed fan bridge assembly (comprising the bridge structure, fan, gearbox and motor) is lifted from ground level to the appropriate height above the support structure before lowering it into position.

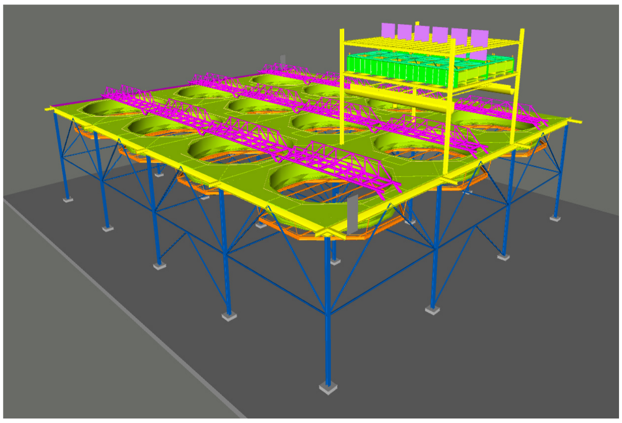
3.2 Bundles

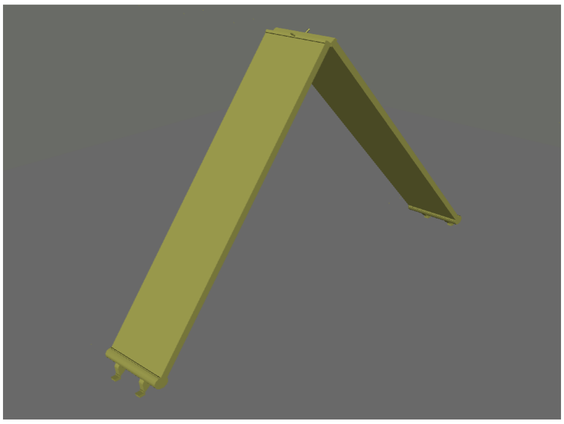
Figure 3.2 shows the installation steps for the different finned tube (dry-cooling) and deluge bundle (wet-cooling) types of the hybrid cooling system.

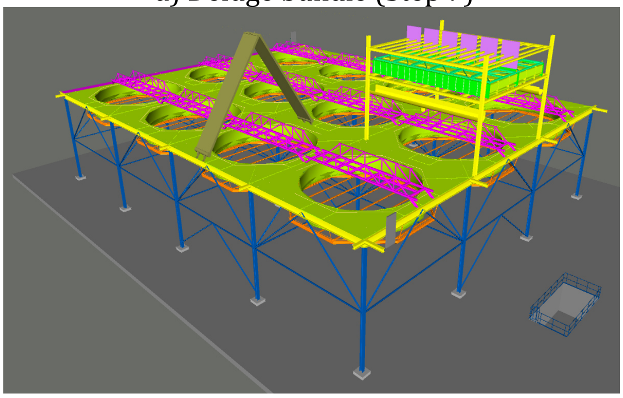
3.2.1 Step 7: Deluge bundles

The deluge bundle support structure is assembled (bolted) on top of the existing support structure before the deluge bundles are lowered into position. Any remaining structural components are installed afterwards.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443


a) Deluge bundle (Step 7)


b) Bundle pre-assembly (Step 8a)


c) Bundle installation (Step 8b)

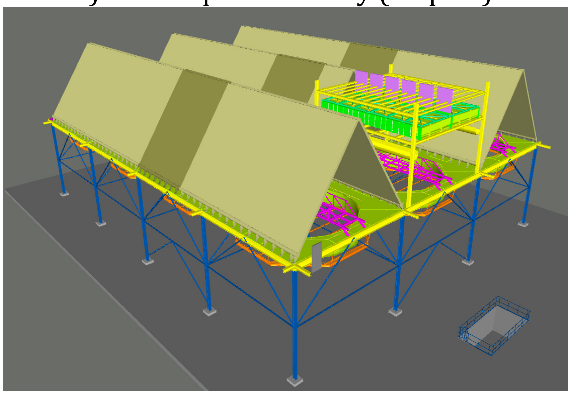

d) Completed bundle installation

Figure 3.2: Bundle installation steps.

3.2.2 Step 8: Conventional ACC bundles

The conventional ACC finned tube bundles are installed as pre-assembled units comprising two bundles (Step 8a). The two bundles are mounted onto an A-frame jig, at ground level, before the tube sheets of the two bundles are welded together at the interface where they meet. This pre-assembled bundle unit is then lifted into position (Step 8b), onto the support structure, with the aid of cradles that provide the correct support to the lifting unit.

3.3 Ducts (SDD and ESD)

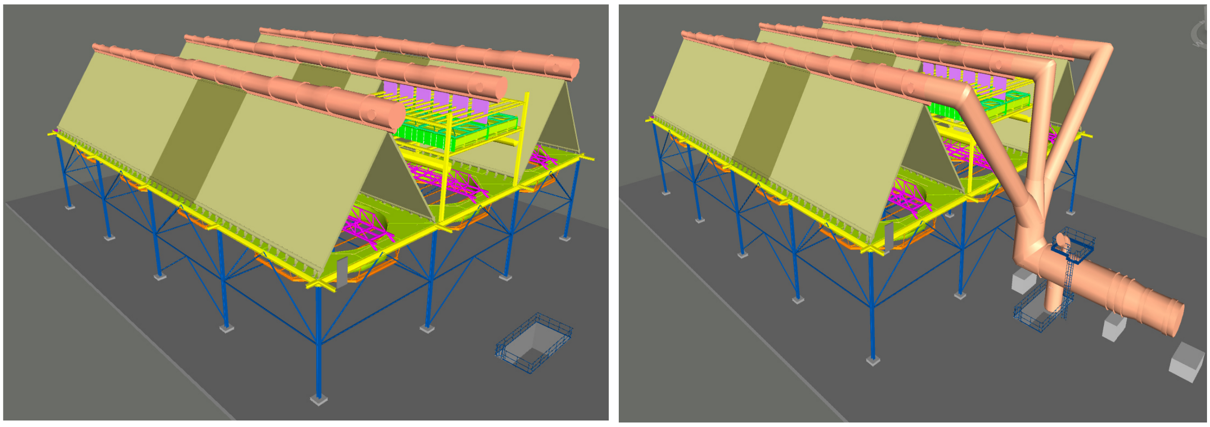
Figure 3.3 shows the installation steps for Steam Distribution Ducts (SDD) and the Exhaust Steam Ducts (ESDs).

3.3.1 Step 9: Steam distribution ducts

The SDDs are constructed as separate construction units, normally at factories located off-site. These construction units are then transported to site and lifted into the relevant positions before being welded together to form continuous ducts. Transition pieces,

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

welded onto corresponding tube bundles and construction units, connect the ducts to the bundles.



a) Steam distribution ducts (Step 9) b) Exhaust steam ducts (Step 10)

Figure 3.3: Duct installation steps.

3.3.2 Step 10: Exhaust steam ducts

The ESDs, similar to the SDDs, are constructed as separate construction units. These construction units are lifted into the relevant positions before being welded together to form continuous ducts. The horizontal portion of the ESD is bolted onto civil supports that are designed according to the load requirements of the ducts and cast by a civil contractor.

3.4 Tanks (Step 11)

Figure 3.4 shows the tank installation of the hybrid cooling system.

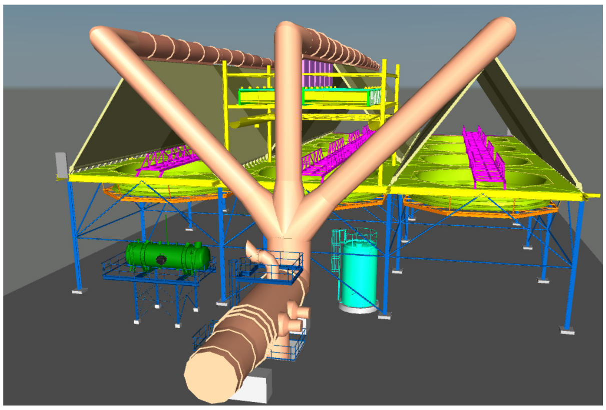


Figure 3.4: Tank installation.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

The condensate tank is installed on a support structure that rests on civil foundations while the deluge water tank is installed directly on a civil foundation. The foundations are designed according to the relevant load requirements and cast by a civil contractor.

3.5 Mechanical equipment (Step 12)

The mechanical equipment installation includes the following:

- Drain pot pumps (located below the ESD)
- Deluge water pumps
- Ejectors

3.6 Piping (Step 13)

The piping installation includes the following:

- Condensate piping
- Air extraction piping
- Deluge water piping
- Drain water piping

3.7 Wind wall sheeting and cladding (Step 14)

Figure 3.5 shows the completed hybrid cooling system. The wind wall sheeting is installed towards the end of the construction process together with all the other (deluge cell) cladding that is required.

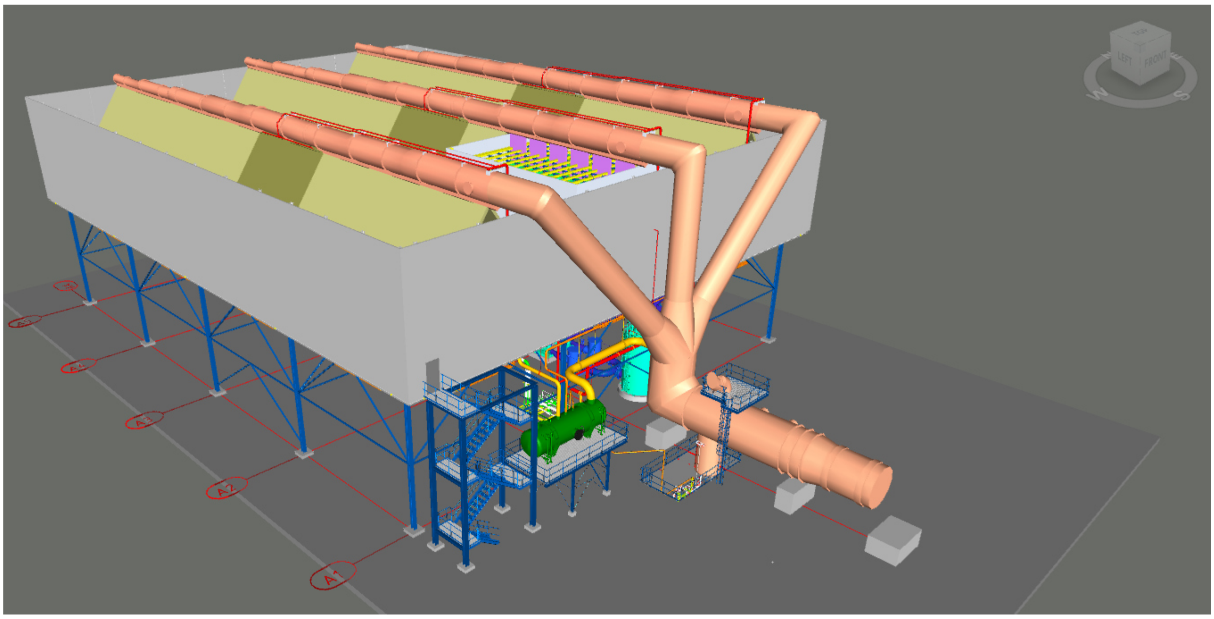


Figure 3.5: Completed hybrid cooling system.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443

4 Closing remarks

A 3D model of the newly designed hybrid cooling system has been completed and presented in Deliverable 2.4, together with a constructability review of the new system. This concludes the design activities under Work Package 2, Task 2.2 (detailed engineering design of a hybrid cooling system), with deliverables D2.1, D2.2 and D2.3 covering the detailed engineering activities already submitted.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 654443