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Stellenbosch University participation in H2020 MinWaterCSP project

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Certain sections of this presentation have been prepared by Dr Falk Mohasseb of Kelvion, Germany.

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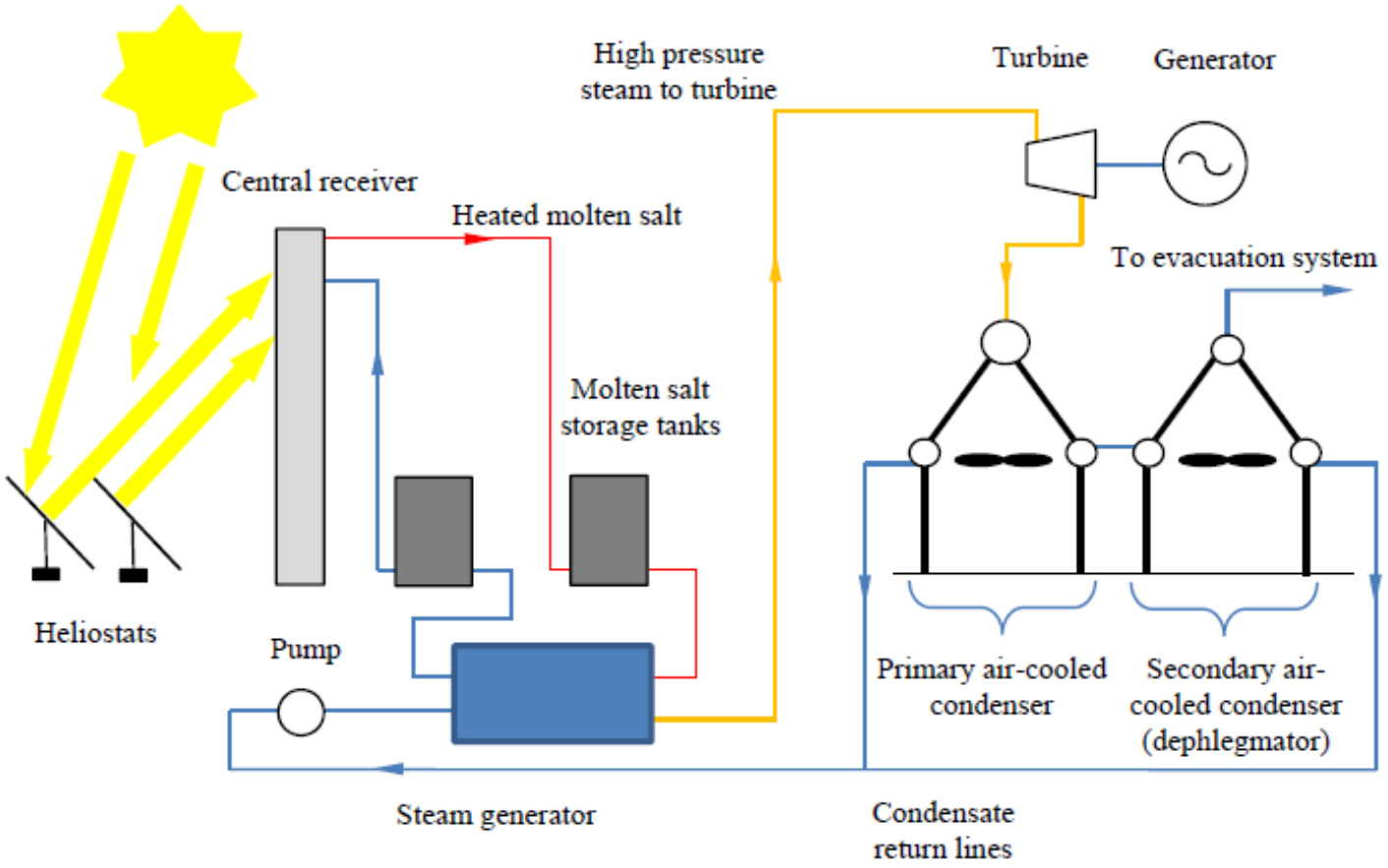
Typical CSP cycle



Call LCE -02-2015: Developing the next generation of technologies of renewable electricity and heating / Cooling

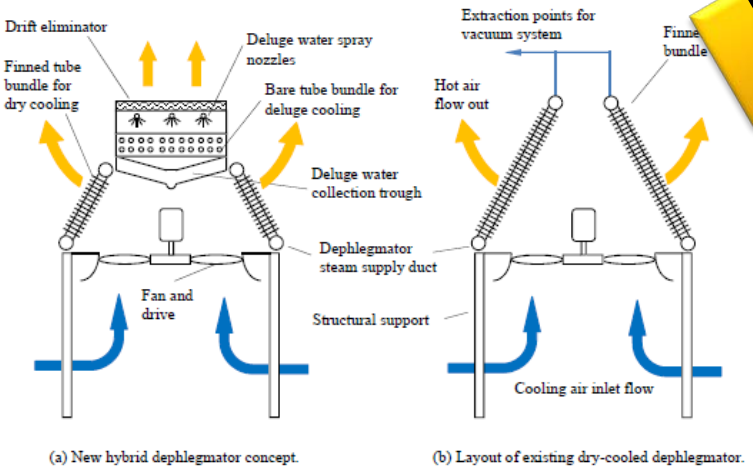
CALL FOR COMPETITIVE LOW-CARBON ENERGY

H2020-LCE-2015-1-two-stage — Sub call of: H2020-LCE-2014-2015

Opening Date	11-12-2013		
Publication date	11-12-2013	**Deadline Date**	03-09-2014 17:00:00 (Brussels local time)
		Stage 2	05-05-2015 17:00:00 (Brussels local time)
Total Call Budget	€95,000,000	**Main Pillar**	Societal Challenges
Status	Closed	**OJ reference**	OJ C361 of 11 December 2013

Topic: **Developing the next generation technologies of renewable electricity and heating/cooling** LCE

Horizon 2020 – European Research for Low-Carbon Energy



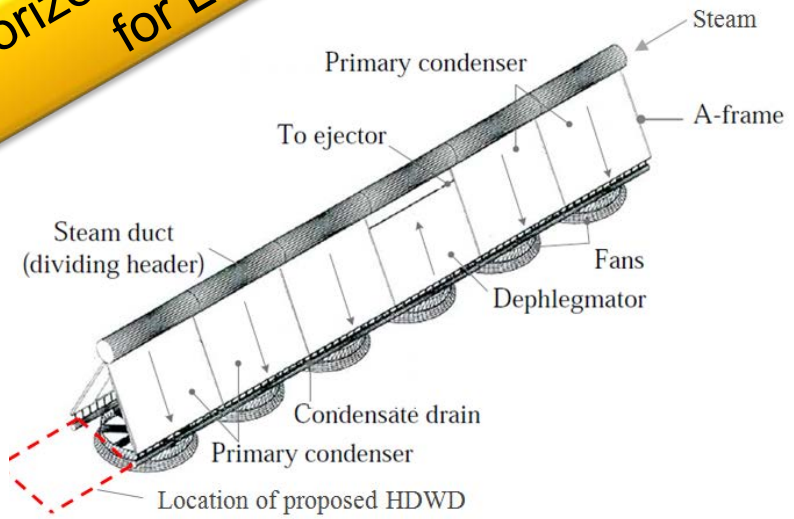


Figure 3: Schematic of a hybrid dephlegmator making use of dry cooling and deluge cooling.

2. **Concentrated Solar Power** (CSP): *Improving the environmental profile of the CSP technology* – CSP plants rely on water for cleaning the reflecting surfaces, for power generation and for cooling. Innovative solutions are needed to significantly reduce or replace the water consumption while maintaining the overall efficiency of the CSP plants, and limiting their environmental impact.

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Dry-wet cooling, recent trends

- **Water resources** are coming **under pressure world-wide**
- US market: **dry-cooling represents only 1%** of the of the cooling systems in power plant applications (only Wet Cooling applications)
- While the **US clients** are still mainly constructing either 100% wet or 100% dry systems, several hybrid systems are in operation and **clients are increasingly showing interest in this solution**
- US Policy: strong drive via US **EPRI** (Electric Power Research Institute) and **NSF** (National Science Foundation) funded R & D projects **to reduce water consumption in power plant cooling applications**
- **California Energy Commission:** has made **USD1.5m** available in 2015 for the development of **hybrid cooling systems**
- **European Commission** has made **EUR94m** available for R&D projects **reducing water consumption in CSP plants**

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Quantified targets

Increased net annual power generation by 2% with an increase of over 10% at high ambient temperatures.

Reduction in cooling water evaporation losses by 75% to 95% in comparison to existing wet cooling towers.

Reduction of the number of dry cooling system fan cells by 25% while maintaining similar thermal performance.

Improved fan performance (fan static efficiency) by up to 65%.

Saving 30-50% of material usually required for producing conventional heat exchangers by using novel wire based heat exchanger concepts.

MinWaterCSP Participants

No	Participant organisation name (role)	Country	Budget (k€)
1	Kelvion Holding (Project Coordinator)	Germany	178.9
2	Kelvion Thermal Solutions Pty Ltd. (Overall technical Coordinator, Deluge cooling)	South Africa	1,148.5
3	Fraunhofer ISE (CSP, heat transfer surfaces, water treatment)	Germany	1,092.5
4	University of Rome (Fan development)	Italy	202.1
5	ECILIMP S.L. (Mirror cleaning for parabolic trough collectors, especially for CSP power plants > 50 MWe)	Spain	231.4
6	Stellenbosch University (Deluge cooling, fan development, motor development)	South Africa	650.1
7	Notus Fan Engineering (Fan development)	South Africa	270.7
8	SOLTIGUA (Mirror cleaning for FLT collectors, especially for CSP applications < 50 MWe)	Spain	475.5
9	Enexio Germany GmbH (ACC design, product dissemination and exploitation)	Germany	788.6
10	IRESEN (Deluge cooler test site)	Morocco	337.4
11	Steinbeis-Europa-Zentrum (Administration, Communication, Dissemination, Exploitation)	Germany	255.2
12	WATERLEAU (Water management plan)	Belgium	230.6
	TOTAL BUDGET (k€)		***5,861.4***

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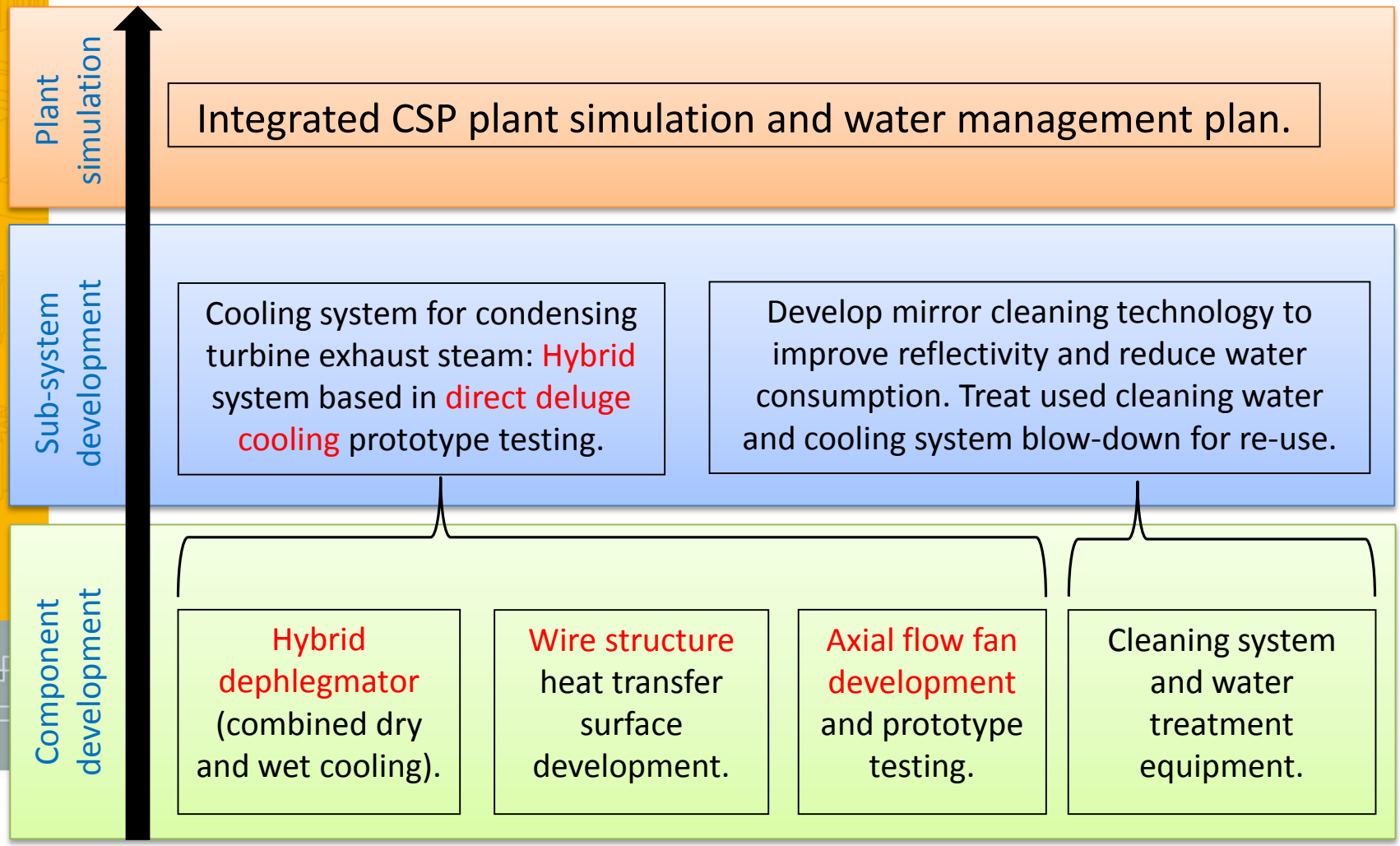
MinWaterCSP Project scope



Project lay-out

- 11 Work Packages

- "management WPs"
  - WP 1 – project management,
  - WP 10 – communication and dissemination,
  - WP 11 - exploitation

- Cooling-related WPs
  - WP 2 – hybrid cooling system design
  - WP 3 – axial flow fan design
  - WP 4 – advanced wire surface heat exchangers
  - WP 7 - Cooling system fouling test
  - WP 8 - Cooling system and fan full scale test

- Mirror cleaning WPs
  - WP 5 - Collector cleaning optimization
  - WP 6 - Water use and treatment
  - WP 9 - CSP plant system simulation

WP 5 Collector cleaning optimization

- Reduce water consumption performing:
  - Reuse and treatment of cleaning water previously collected
  - Improving the monitoring in the solar fields for optimisation of cleaning cycles
- Creation of a new robot for Linear Fresnel primary mirrors and a system for cleaning the secondary mirror and receiver tubes

WP 6 Water use and treatment

- Detailed analysis of water consumption in CSP plants by utilization of new developed simulation tools.
- Elaboration of an overall water management plan for CSP plants and particular case studies.

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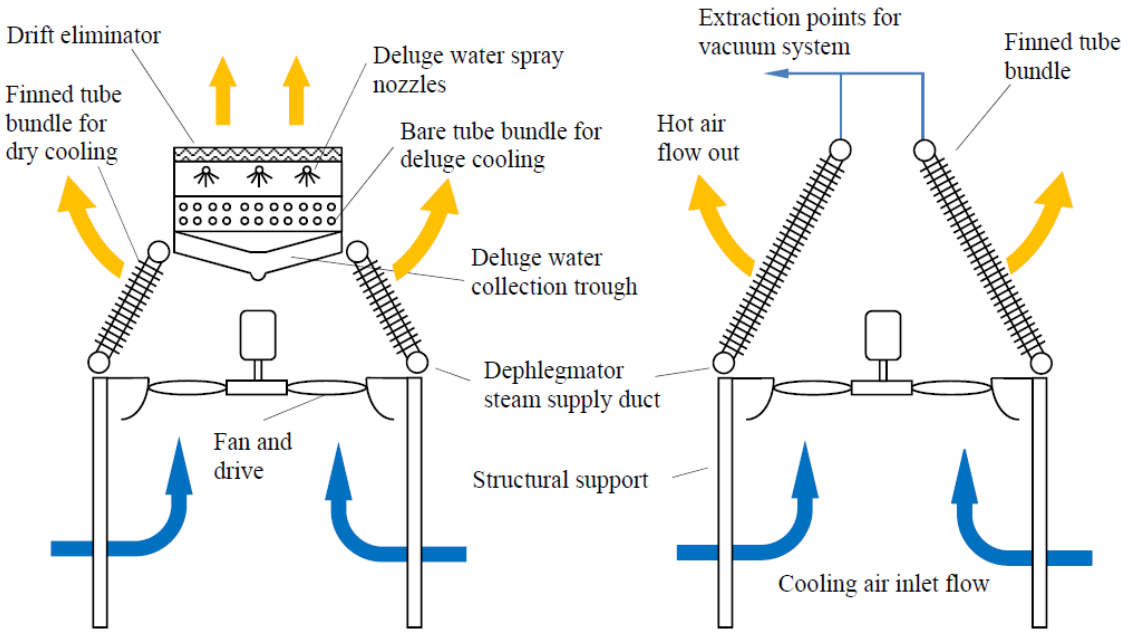
WP 9 CSP plant simulation

Extend the ColSim software to enable CSP plant simulation for the new hybrid cooling system, including the following novel features of the software:

- Detailed modelling of water flow and consumption, electricity production and energy consumption for water supply and treatment.
- Implementation of mirror cleaning schedules in plant simulation.
- Use of integrated system model for optimization of water management and consumption.

WP 2 hybrid cooling design

- Create thermally optimized cooling system concepts for CSP plant applications and associated detailed designs.
- Perform first iteration of capital and life-cycle costs, including data generated from sensitivity analysis and the identification of individual cost drivers.
- Deliver input information for the ColSim overall CSP plant simulation exercise undertaken in WP9.



(a) New hybrid dephlegmator concept.

(b) Layout of existing dry-cooled dephlegmator.

WP 3 Axial fan design

- Analysing the operational behaviour (aerodynamic and vibration characteristics) of the existing reference fan design under industry standard conditions.

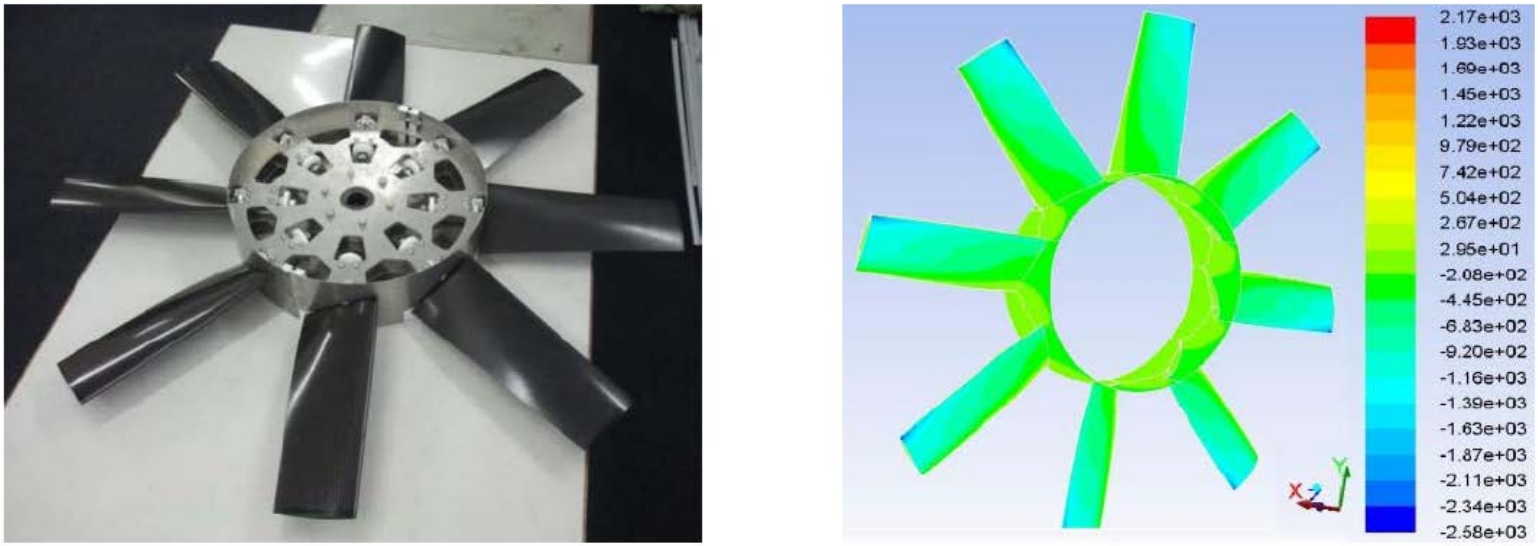
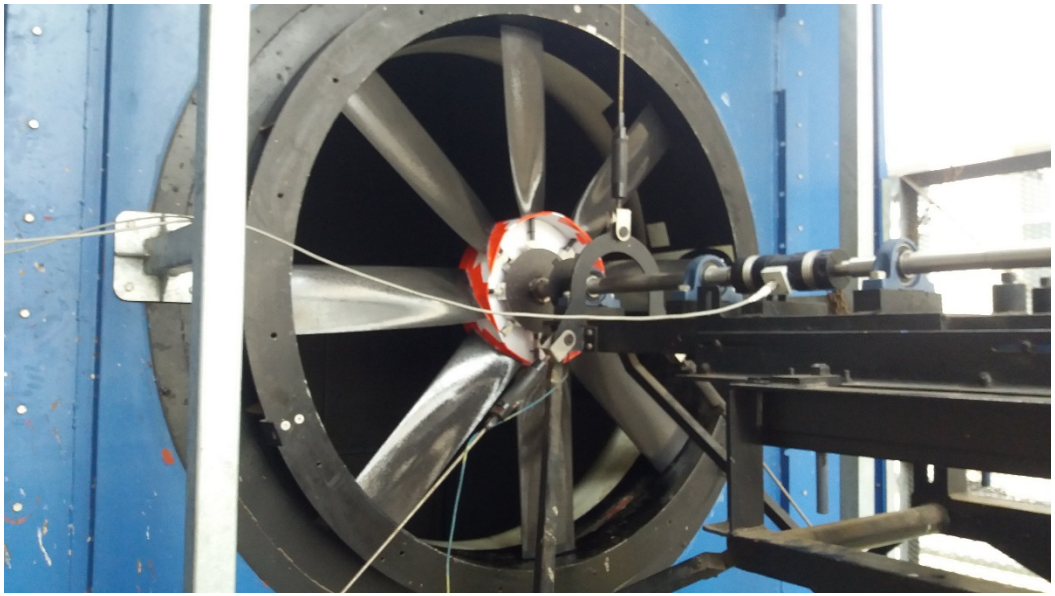


Figure 1.4: Pictures of axial flow fan scale models and CFD analysis.

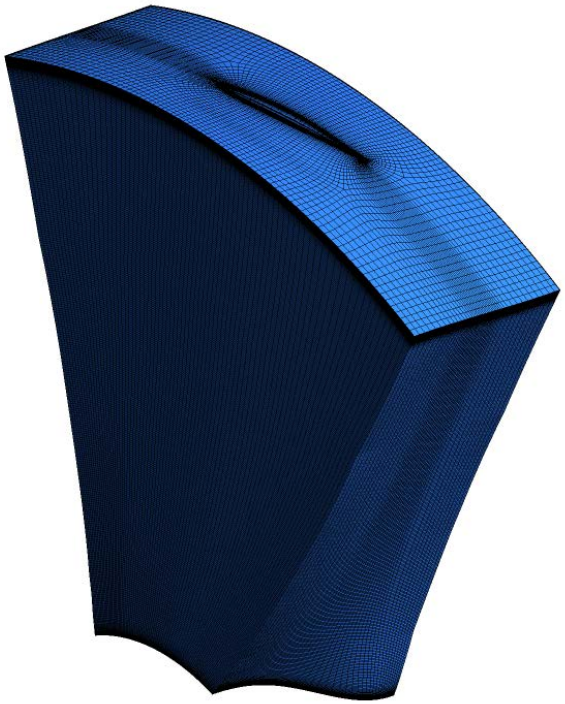
WP 3 Axial fan design

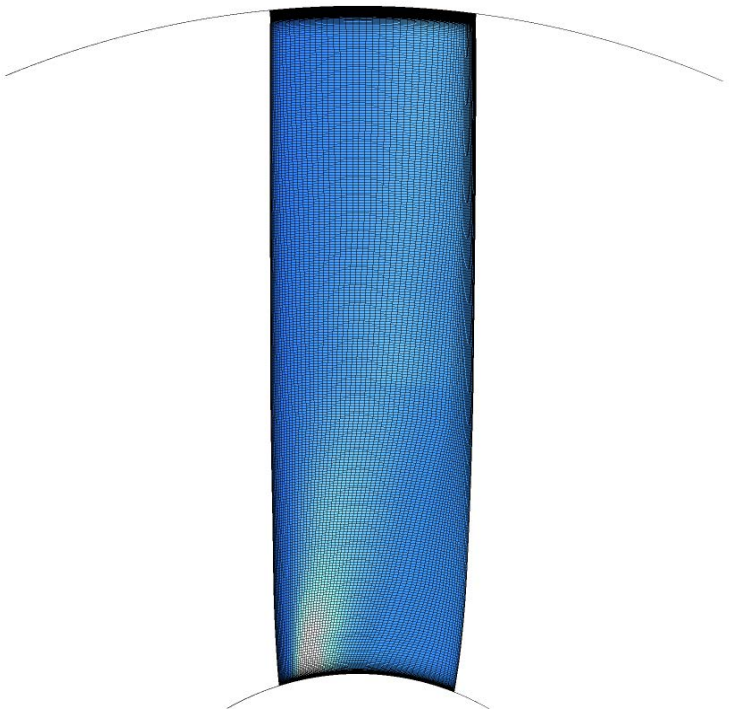
- Develop new high efficiency CSP cooling fan design with reduced noise levels and validated performance through scale model testing.



WP 3 Axial fan design

- Develop a new high efficiency fan drive system concept for application in CSP cooling fans.
- A final improved design methodology of the full-scale CSP cooling fan including computational fluid dynamics (CFD), finite element analysis (FEA) and dynamic simulation software tools.





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WP 4 Wire surface heat exchanger

- Design a concept heat exchanger bundle for air-cooled low-pressure steam based on wire structure technology.
- Construct laboratory scale heat exchanger samples with the use of wire structure surfaces.
- Quantify cooling system performance increases, cooling system size reduction and overall economic benefits.

WP 7 Cooling system fouling test

- Gain a better understanding of fouling and scaling rates of a deluge cooling heat exchanger located on a representative CSP plant site.
- Investigate cleaning methodologies for a fouled deluge heat exchanger bundle and quantify cleaning parameters and cleaning intervals.
- Verify and quantify the extent of corrosion which may occur in a deluge heat exchanger bundle exposed to a representative CSP plant site.

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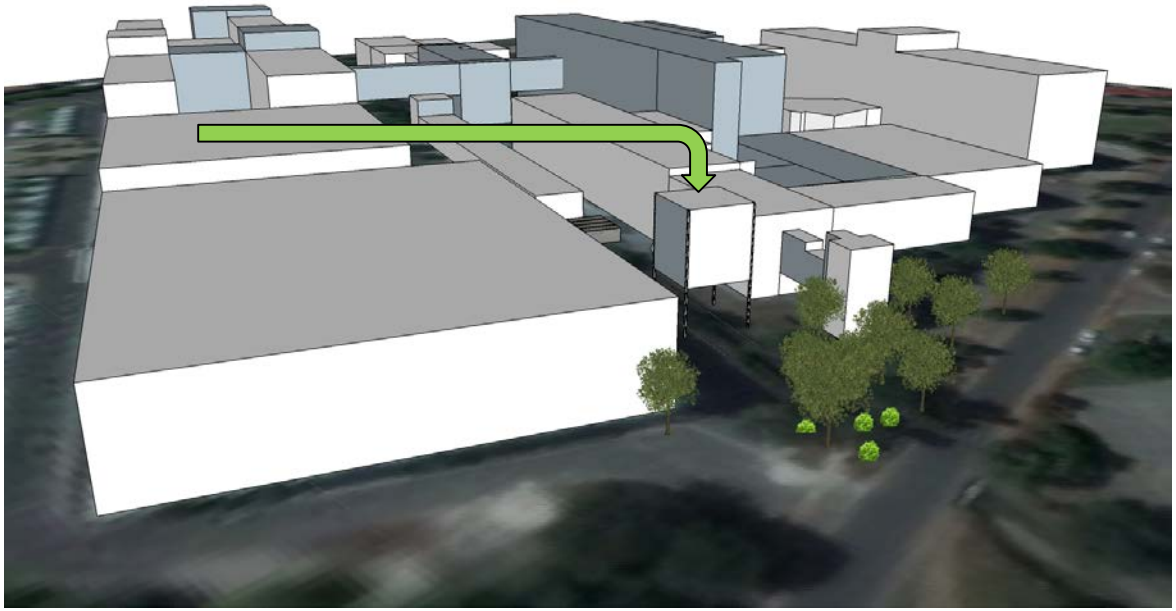
WP 8 Cooling system and fan full scale test

- Design, build and validate a novel test facility for testing the hybrid cooling system and the CSP cooling fan.
- Verify the deluge water cycle process performance criteria of the hybrid cooling system under full-scale industrial conditions.



WP 8 Cooling system and fan full scale test

- Verify the structural integrity and aerodynamic performance of a 30ft reference fan.
- Verify the structural integrity and aerodynamic performance of a CSP cooling fan.

WP 8 Cooling system and fan full scale test

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Conclusion

- Project due end 2018.
- Research focused on water conservation for CSP.
- Importance of international collaboration.
- International contacts
  - Dr. Albert Zapke, Enexio
  - Dr. Falk Mohasseb, Kelvion
  - Dr. Tom Fluri, Fraunhofer ISE
  - Prof. Alessandro Corsini, URome