MATChING

MATERIALS & TECHNOLOGIES FOR PERFORMANCE IMPROVEMENT OF COOLING SYSTEMS IN POWER PLANTS

ETIP-DG Annual Conference 2018

Bruxelles, June 19th ,2018

H2020 – Lessons learnt and projects results : Overview of geothermal projects

Sandra Scalari, Enel Green Power Innovation & Sustainability

Background and Rationale

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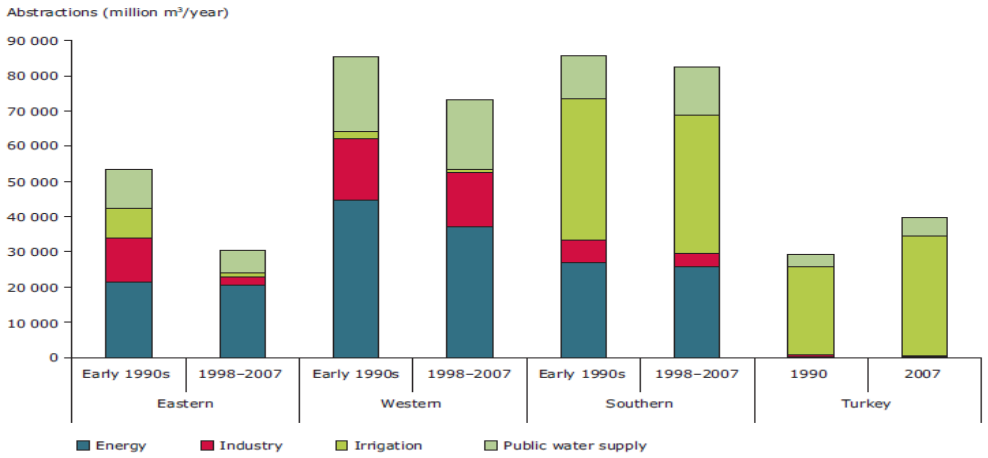
EU Water abstraction per sector – EEA 90's vs 2007



Power generation is a sector requiring great amounts of water: Cooling water for energy production accounts in fact, for 43-45% of total water abstraction in European Union

MATChING is a collaborative project, funded by EU H2020 program. The project aims, to reduce the water demand and to improve the energy efficiency of cooling systems in the power generation sector

(1)Roadmap to a Resource Efficient Europe, EC COM (2011) 571 Final (2) The European Environment State and outlook (2010) EEA (3) Charting Out Water Future, 2030 Water Resource Group (2009);(4)Rübbelke and Vögele, 2011

Consortium, quick facts and main outcomes

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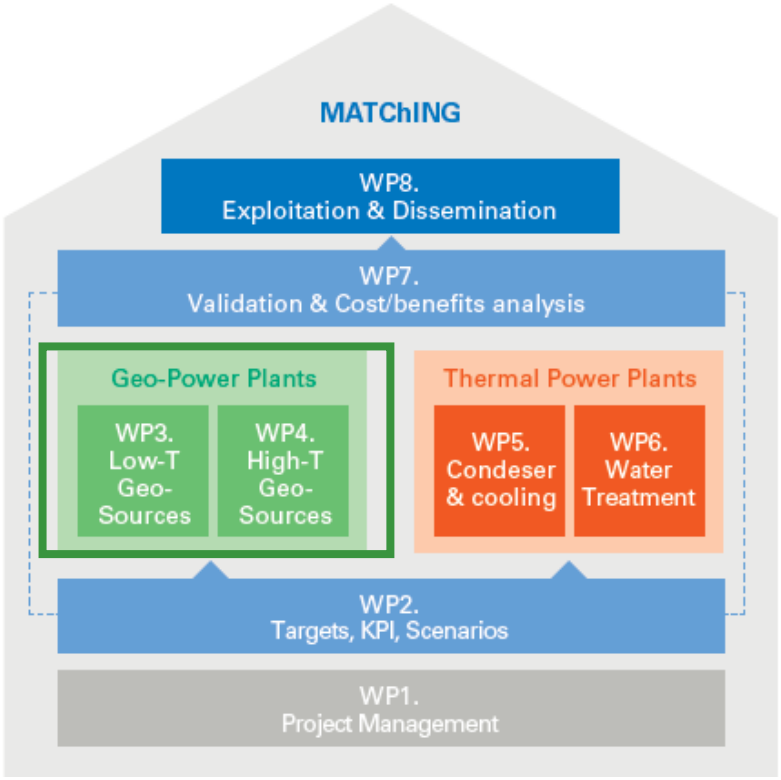

Expected Outcomes

Overall reduction of geothermal steam emitted into the atmosphere up to 15% and extension of production wells life up to 10% using hybrid solutions for cooling towers and advanced materials and coatings for dry modules

Overall plant efficiency increase up to 0.4-0.5%, enhancing the heat transfer efficiency in the condenser both on the steam side and water side via the use of advanced nano-engineered coatings and surfaces..

Overall reduction of fresh water abstraction in fossil fuelled power plants of about 30% validating a set of solutions (6) for the recovery and treatment of cooling water in CT equipped plants.

Starting Date	**First of March 2016**
Duration:	**42 months**
Partners:	**15**
Overall Budget	**€ 11.847.291,75**
Grant Amount	**€ 9.706.413,77**

Technologies

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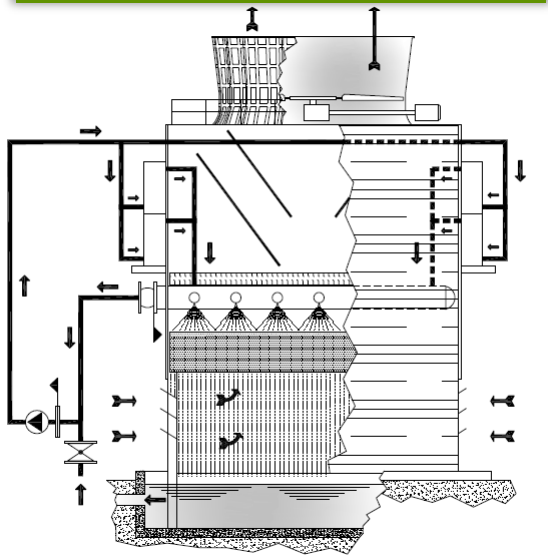
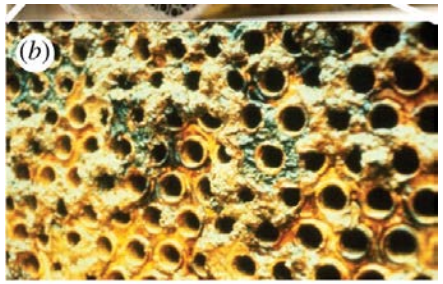
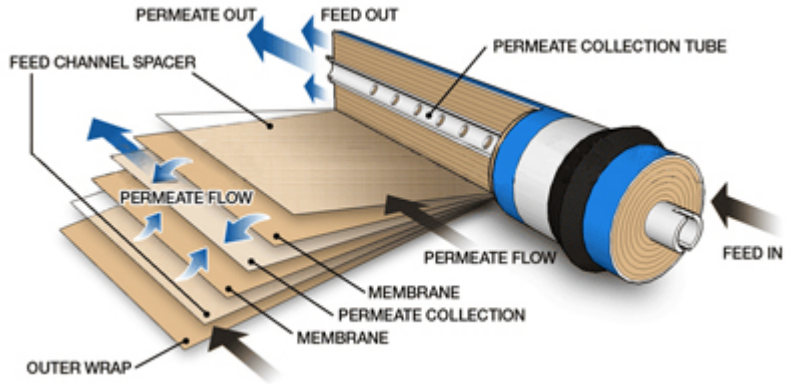
Hybrid CT for Geothermal application



Materials for steam condenser& heat exchangers



Water treatment systems



Geothermal Focused Activities

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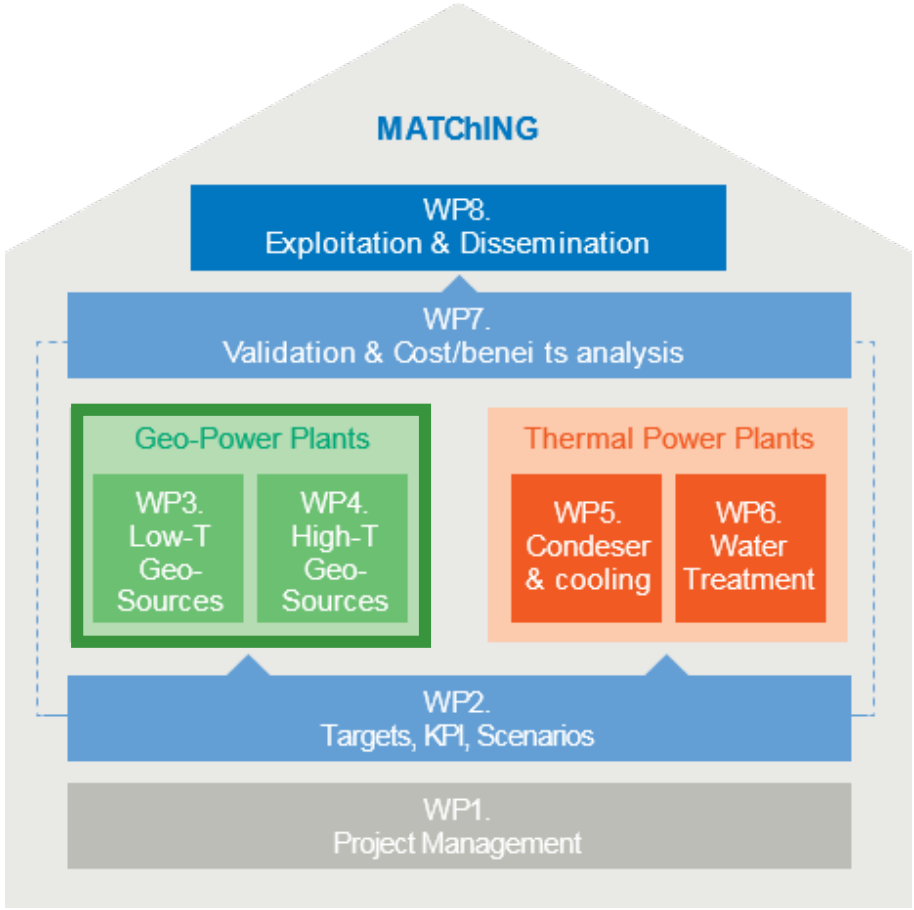
WP3, Hybrid Cooling Systems for Low-T Geothermal Sources, led by VITO: To improve electricity production processes from Low-T geothermal sources (100–175°C) considering both the geothermal fluid and the cooling water, maximizing the exergetic efficiency of the geothermal plant and support their exploitation in DG application.

WP4, Cooling Towers for High-T Geothermal Sources, led by EGP : To demonstrate the use of advanced/ innovative materials solutions to increase the robustness of hybrid CTs in High T geothermal power plants, in order to make them a competitive alternative of currently used wet CTs. The hybrid CTs are expected to allow the reduction of about 15-20% of evaporative losses.



The MATChING project demonstration program

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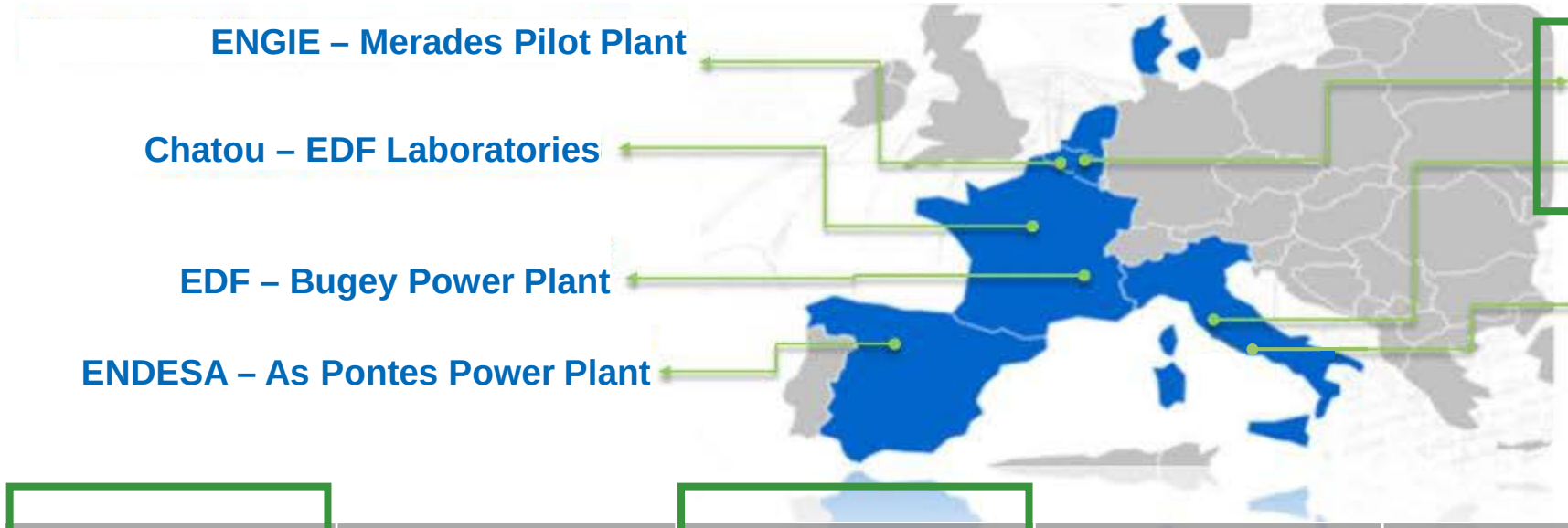
ENGIE – Merades Pilot Plant

Chatou – EDF Laboratories

EDF – Bugey Power Plant

ENDESA – As Pontes Power Plant



VITO – Balmatt site

EGP – Nuova San Martino

ENEL – Torrevaldaliga Nord Power Plant

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Coatings for geothermal heat exchangers	Membranes for water recovery from FGD	Hybrid CT for geothermal application	Coatings/materials for steam condenser and membranes for cooling water treatment	Coatings/materials for steam condenser	Membrane condensor	Membranes and technologies for cooling water treatment
						
Balmatt in Mol, Belgium	Torrevaldaliga Nord Italy	Nuova San Martino, Italy	As Pontes, Spain	Chatou, France	Bugey, France	Bruxelles, Belgium

Lesson Learned from the first 2 years of the project

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Matching has a very important and extensive demonstration scope, 7 pilots/ demonstrators across Europe, taking advantage of existing facilities and building new ones.
It is important in the first phase of the project to focus on a thorough assessment of the sites where the tests are carried out: despite an accurate planning at proposal level, we needed to move some pilots in different locations, since the boundary conditions were not satisfactory(eg: composition of adequate water, interest in the plant, etc.).
Pilot management has to be taken into account, considering risks connected to complex installations, in terms of time and budget (eg, subcontractors for the management of pilots).

A step by step process – Where we are now

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MATChING is now in its 3rd year, with most of demonstrations on-going. Its methodology has revealed to be a robust support, accompanying the project along its lifetime.

WP2: KPI & Success Indicators at LAB. LEVEL

WP2: KPI at Pilot/Demo level

WP2: Global KPI (Capex/Opex ecc..) + Scenario definition + Parameters for sensitivity cases

Work package 3 ÷ 6

Laboratory screening process

- Test of a wide range of different technologies (like different kind of coatings/substrate materials/different kind of membranes)

Work package 3 ÷ 6

Pilot Scale Testing

- Selection of the most promising solutions at lab scale for pilot scale testing;
- Monitoring of more general performance parameters (like heat transfer performances/water savings/operational issues)

Work package 3 ÷ 6

Demonstration in intended environement

- **One/two solutions will be upscaled and tested in intended environment for long run test when needed/ applicable**

Work package 7

Cost Benefit analisis

- Tecno economic evaluation of the selected technology in the context of reference geothermal and thermal power plants.

Communcation, Dissemination, and Exploitation

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Matching has a strong Communication and Dissemination Plan, to which all the partners contributed.

Besides a special focus has been given to the Stakeholders' Community activities. This group include important stakeholders from Europe and beyond Europe.

Putting together the outcomes of experimental WPs and of Cost Benefit analysis, the project will provide a final guidebook including Best practise emerged from the overall Project results.

Communication Activities

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A. Website creation and updating

Possibly 3 separate areas: private, public and for USERS GROUP.
Aim is to target at least 25.000 individual site visits during the duration of the project.

B. Scientific & technical publications

Aside from the public deliverables, a total of at least 30 publications are aimed for.
Publications include those in peer reviewed magazines as well as oral presentations in international conferences

C. WORKSHOP AND FINAL CONFERENCE

Four workshops will be organized all along the project duration.
A final international conference will be organised in Brussels
The conference aims to attract more than 50 key organizations / parties.

D. PRESS MEDIA

Press media will include general presentation of the project and more technical press releases in occasion of important event. **At least two press releases on the EU continental scale are envisaged,** target size >250.000.

E. SIX MONTHLY Newsletter

Every six months a newsletter will be released illustrating the main achievements and will be primarly distributed to the group of stakeholders. The newsletter will be also available on the website

F. SOCIALS

A LinkedIn page will be set up and continuously updated

G. VIDEO

A Technical video and a video of project presentation will be produced and put on the website

H. BROCHURE/ POSTER

Brochure presenting the project overview will be ideated, printed (around 1000 copies) and distributed during conference/ workshops/events. Every year a poster with the main project outcomes will be made available on the website.

Communication and dissemination, in summary

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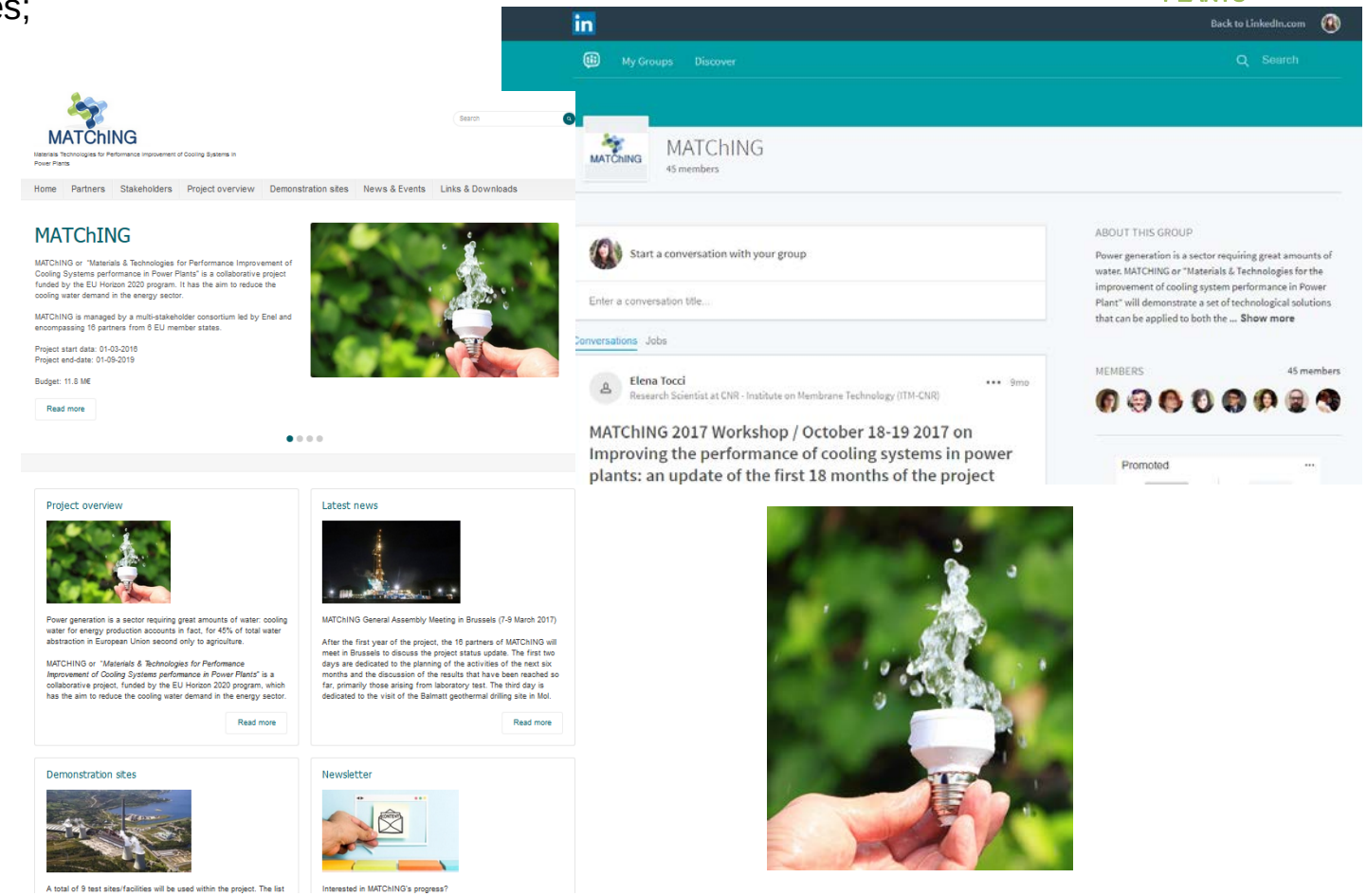
2016-now

- ✓ 14 Oral Presentations to workshops and Conferences;
- ✓ 4 Public deliverables
- ✓ 3 Poster presentations;
- ✓ 3 Articles in technical magazine;
- ✓ 2 press release;
- ✓ 1000 brochure printed, 2 general posters
- ✓ 3 newsletters;
- ✓ 3 MATChING workshops;
- ✓ 2 General Assembly (including As Pontes 2018)
- ✓ Linkedin Account

2018

- ✓ 9 Foreseen conference participations;
- ✓ 2 Publications in ISI journals;
- ✓ Contribution in EMIRI “success story” booklet
- ✓ 2 Publication in Technical magazines;
- ✓ 1 press release/publication?
- ✓ *1 General video*
- ✓ *1 Technical video*
- ✓ 1 Newsletter
- ✓ 1 MATChING Workshop

*…**and what about a twitter account?***



http://matching-project.eu

Users' Group, in summary

MATChING has a stakeholder community which has been established with the aim to have an audience constantly informed on the project outcomes providing important feedback on policies, regulations, and business cases.
MATChING's stakeholder community is composed of 14 relevant power industry representatives, European bodies and platforms on environment, water and materials as well as market players in the water treatment field.
Their role is to bring their own expertise, to share their point of view and to disseminate project relevant outcomes to other potential end-users, policy makers and public bodies.

MATChING's stakeholders are regularly invited to dedicated workshops and meetings where the projects results are presented and discussed.

Thank you

WP4 - Cooling Towers for High-T Geothermal Sources

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An overall change from TRL 4 to 6 is expected for the specific technologies.

Specific objectives:

- Demonstrate advanced filling packs for wet modules with higher robustness and thermal efficiency, making then possible longer filling operation life and reduction of operation costs.
- Demonstrate advanced materials/ coatings (nano-coating applied to dry modules) to increase the robustness and efficiency of Hybrid CTs.

Task n°	Content	Task Leader	Partners Involved	
Task 4.1	**Developing of hybrid (wet/ dry) module**	**SPIG**	**EGP**	**Completed**
Task 4.2	**Demo facility realization**	**EGP**	**SPIG**	**Completed**
Task 4.3	**Hybrid CT demonstration**	**EGP**	**SPIG, AIMEN**	**On-going**
Task 4.4	**Final assessment of coatings and materials**	**EGP**	**SPIG, AIMEN, EIR**	

WP4 - Cooling Towers for High-T Geothermal Sources

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The hybrid CTs are expected to allow a reduction of about 15-20% of evaporative losses, increasing the reinjection capability and extending well life.

- Increased reinjection into the reservoir will slow the pressure drawdown, with **immediate effect in reducing the production decline, the gas/steam ratio, and keeping more stable the well production**.
- In case of complete refurbishment of a standard 40-MW plant cooling tower (six modules), **30 t/h** of reinjection increase are expected, corresponding to about **10 GWh/y of extra production**.
- **First known attempt to implement a hybrid cooling tower technology in a geothermal plant.**

WP4 - Cooling Towers for High-T Geothermal Sources

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- **Nuova San Martino, built in 2005 in Lago Geothermal Area (Grosseto).**
- **Installed capacity: 40 MWe, 1 generation unit.**
- **<u>Six forced CTs</u> (Mechanical Induced draft counterflow): One has been modified in MATChING, based on an innovative hybrid technology and is being operated in parallel with the five conventional ones.**
- **Instead of sequential phase 1 (wet assessment) and phase 2 (hybrid assessment) a unique demonstration phase will be carried on with a weekly switch from wet to hybrid (M24→M36).**

DEMO Facility realization

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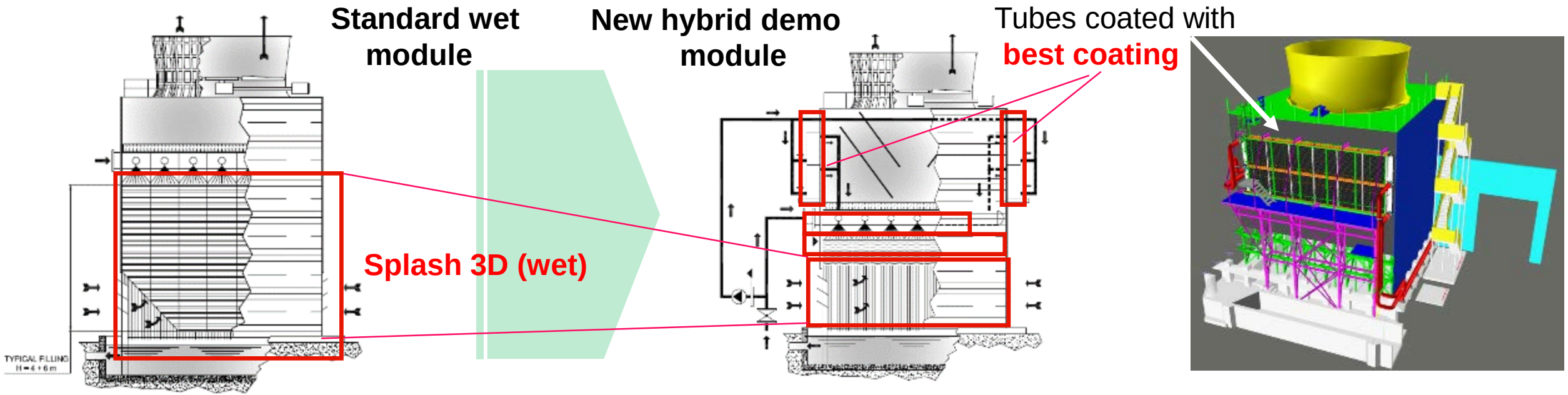
The features design of process equipment are:

- (wet) Reduction of the wet filling height down to 1.8 m: SPLASH 3D **STAR X20**
- (dry) 2 heat exchangers equipped with tested coating materials: 1 Carbon steel tubes coated with **best coated** and 1 equipped with aluminium tubes coated by the same;



DEMO Facility realization

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	2017												2018												2019											
Month	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Mx	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36						A	S	O	N	D

CT Process design

GA project meeting
Mar 07, 2017

Test of coatings (dry sect.) and adv. Filling (wet sect.)

Equipment design of the N.va San Martino CT

Foundation design

Permits to start construction
Jun 07, 2017

Permits for civil works

Equipment supply

Shut down of CT and partial load operation
Nov 17, 2017

Civil works

Dism. of CT

Commissioning CT
Mar 22, 2018

Erection of CT

Start of DEMO operation
Mar 23, 2018

DEMO operation

End of demonstration

SPIG (ext)

EGP -INN

EGP - E&C

EGP - O&M

Hybrid CT demonstration

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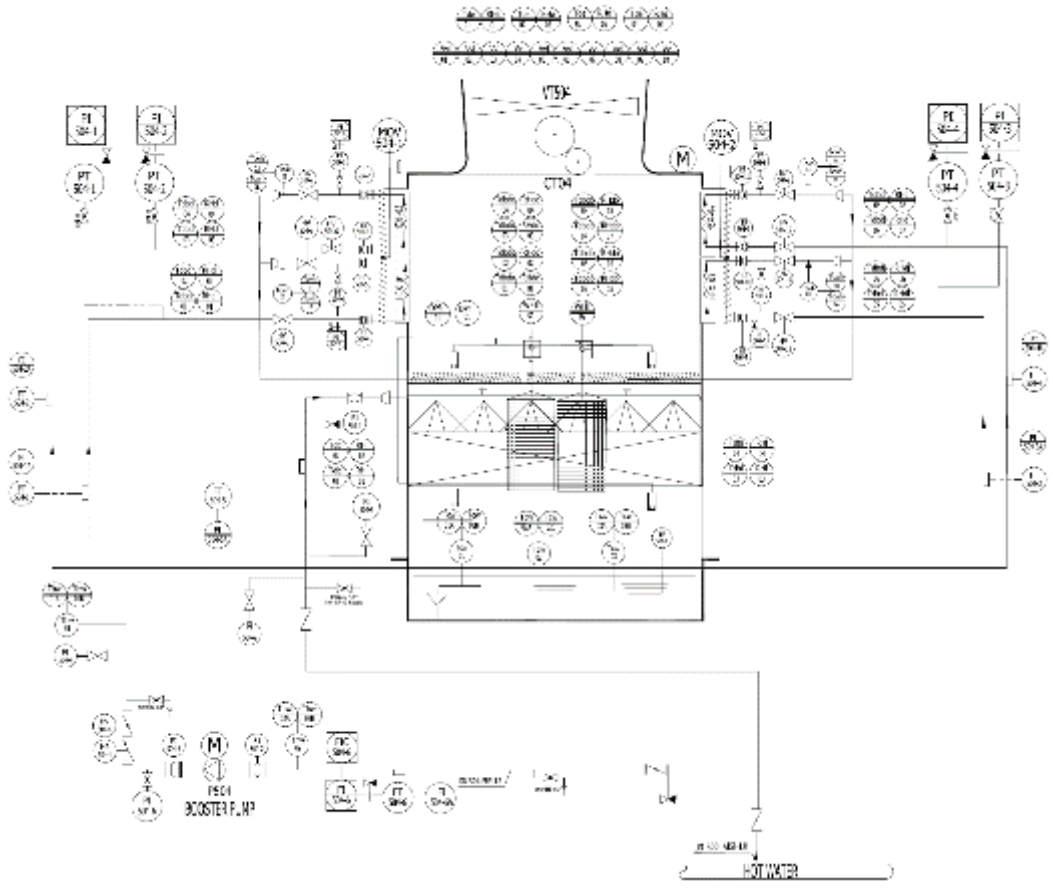
Subtask 4.3 –KPI evaluation → Dedicated Automation & Control

Wet section KPIs	Scale	Variable measured
4.1.1 Filling cooling capability for filling height of 1 meter [-]	Lab/DEMO	*Inlet/out air DBT, RH, inlet/outlet water temp. , water flow rate*
4.1.2 Filling cooling capability per fan power consumption [kW^{-1}]	Lab/DEMO	*See 4.1.1 + Fan Power,*
4.1.3 Material costs of innovative fillings per MW [€/MW]	Lab/DEMO	*CAPEX*
4.1.4 Reduction of filling cooling capability over the time [$month^{-1}$]	**DEMO**	***See 4.1.1***
4.1.5 Increase of pack weight due to clogging [kg/month]	**DEMO**	***filling weight***
4.1.6 Increase of air pressure drop through filling due to clogging (Pa/month)	**DEMO**	***water pressure***
Dry section KPIs		
4.2.1 Reduction of dry module heat transfer coefficient due to fouling [W/(m^2*K*month)]	**DEMO**	***Inlet/outlet air temp., water flow rate, inlet/outlet water temp.***
4.2.2 Increase of dry module water pressure drop due to fouling [Pa/month]	**DEMO**	***water pressure***
4.2.3 Coating corrosion resistance [Ωcm^2]	**DEMO**	***Electric current***
4.2.5 Cost increase compared to standard dry module sections [%]	**DEMO**	***CAPEX***



DEMO Facility realization: instrumentation

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WER

Hygrometer

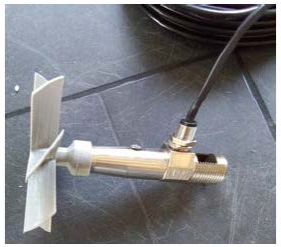
Accuracy = 0,2% RH

Range = 5 ÷ 95%

Termometer

Accuracy = 0,2% K

Range = -20 ÷ 50 °C



Velocimeter

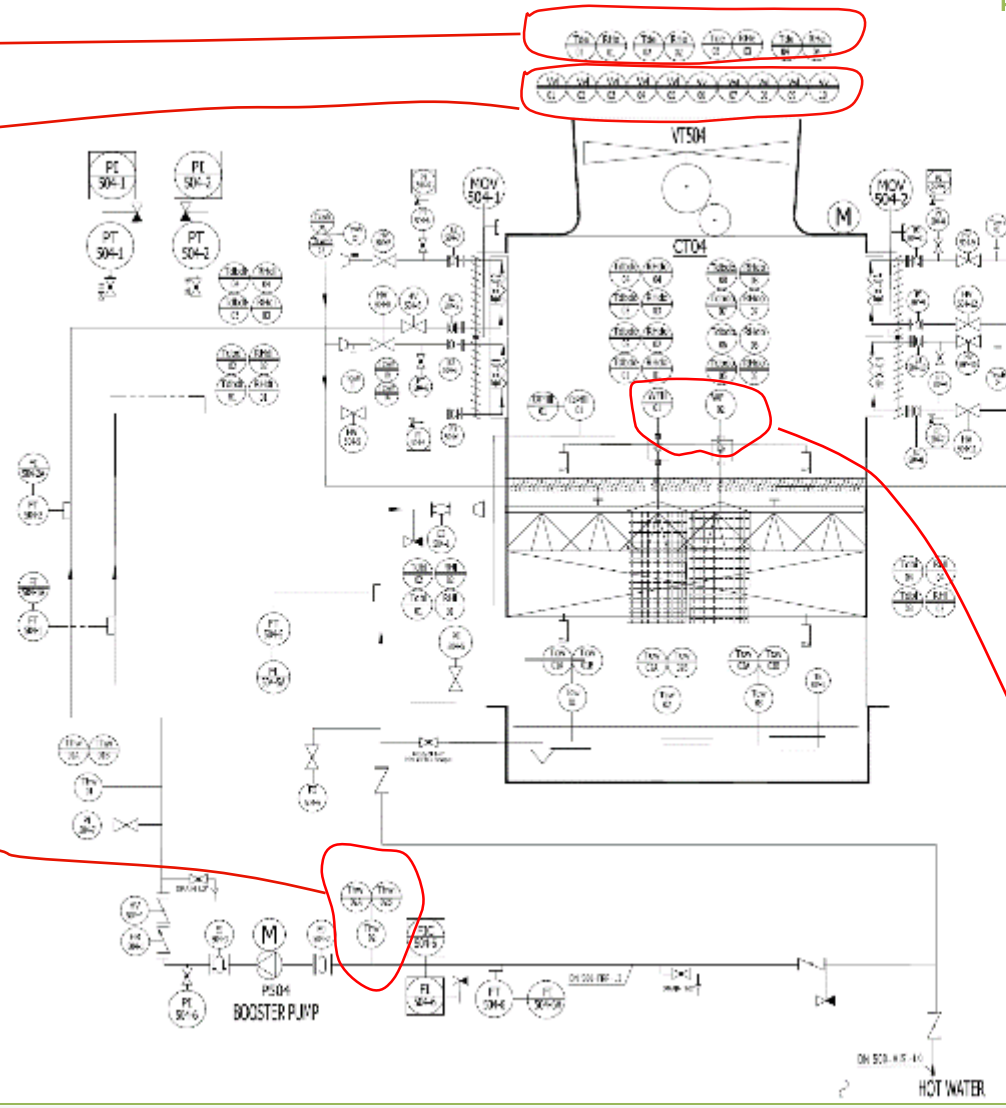
Accuracy =0,3 m/s

Range = 0-30 m/s

Anemometer

Accuracy = 0,2% K

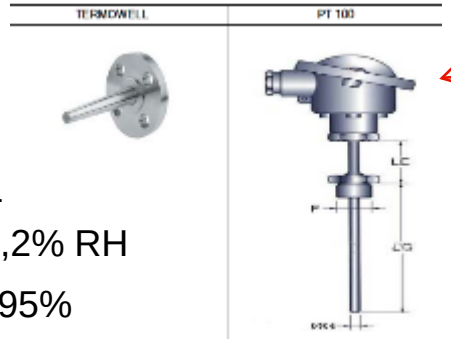
Range = -20 ÷ 50 °C



Load cell

Accuracy =0,023%

Range = 1 ÷ 7,5 ton



Termocouple

Accuracy = 0,2% RH

Range = 5 ÷ 95%

Hybrid CT demonstration: global KPI

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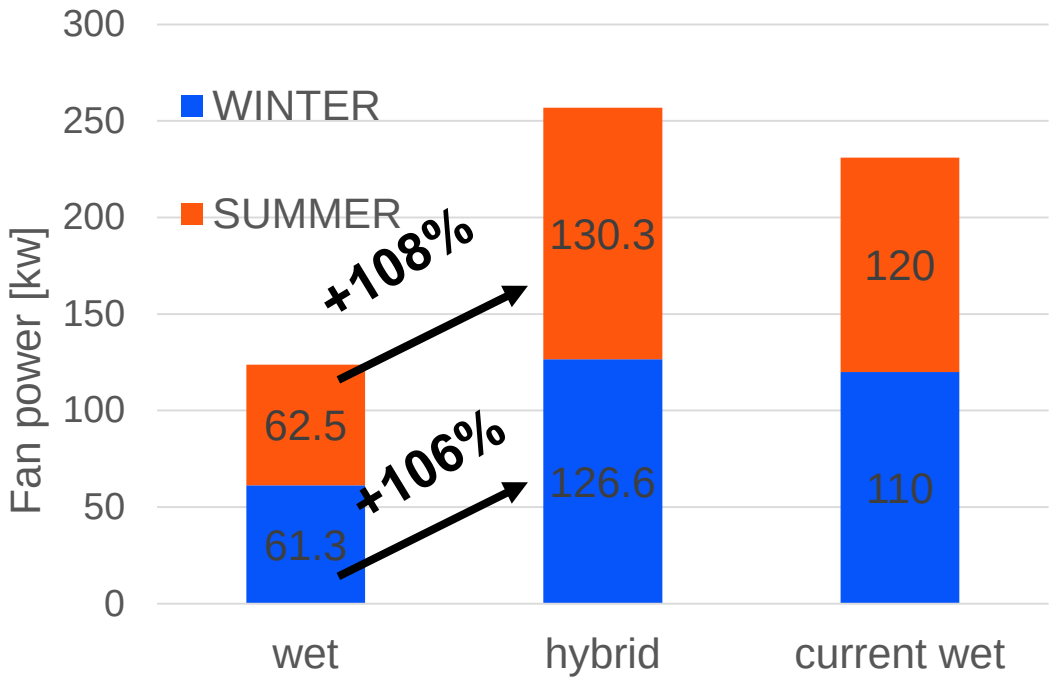
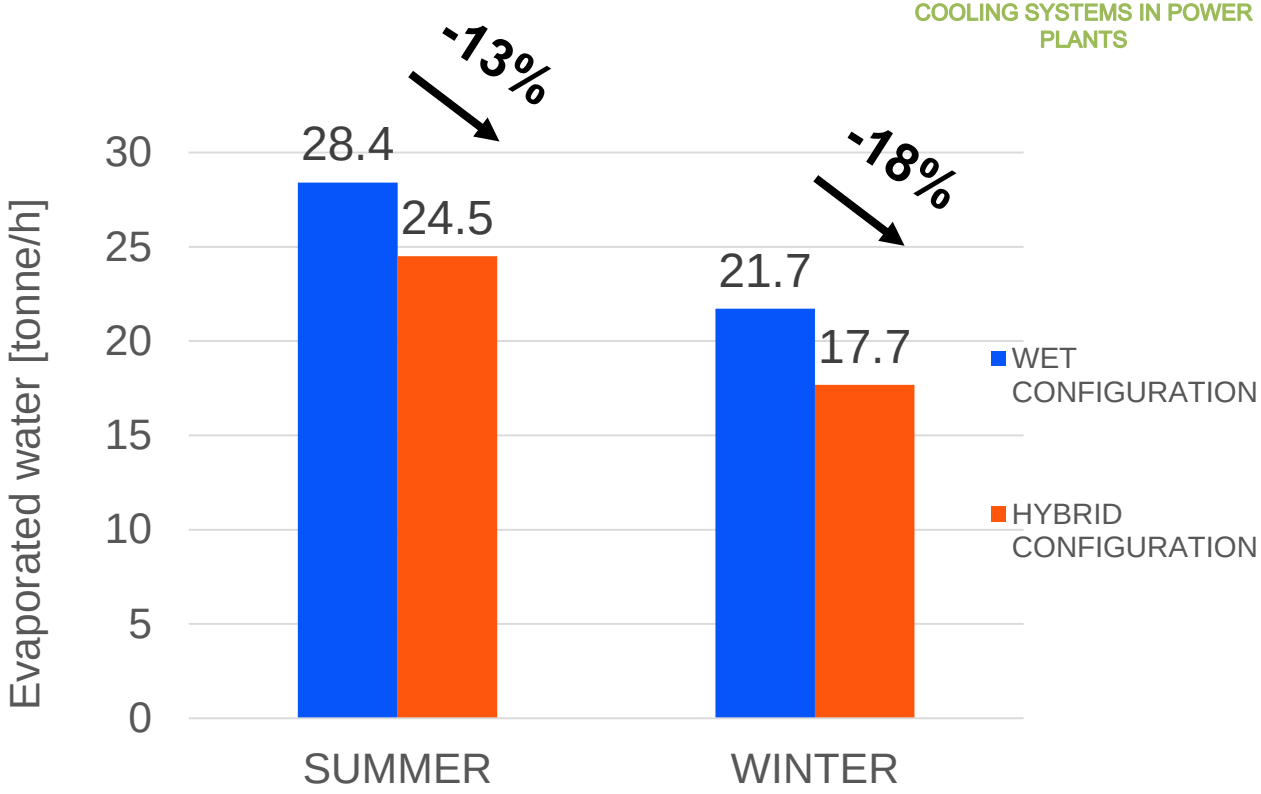
Expected performances

On the basis of simulations with ambient data the expected evaporation rate was calculated for summer and winter season.





A yearly estimation of evaporated water is going to be calculated by-means of historical data.

Background and Rationale

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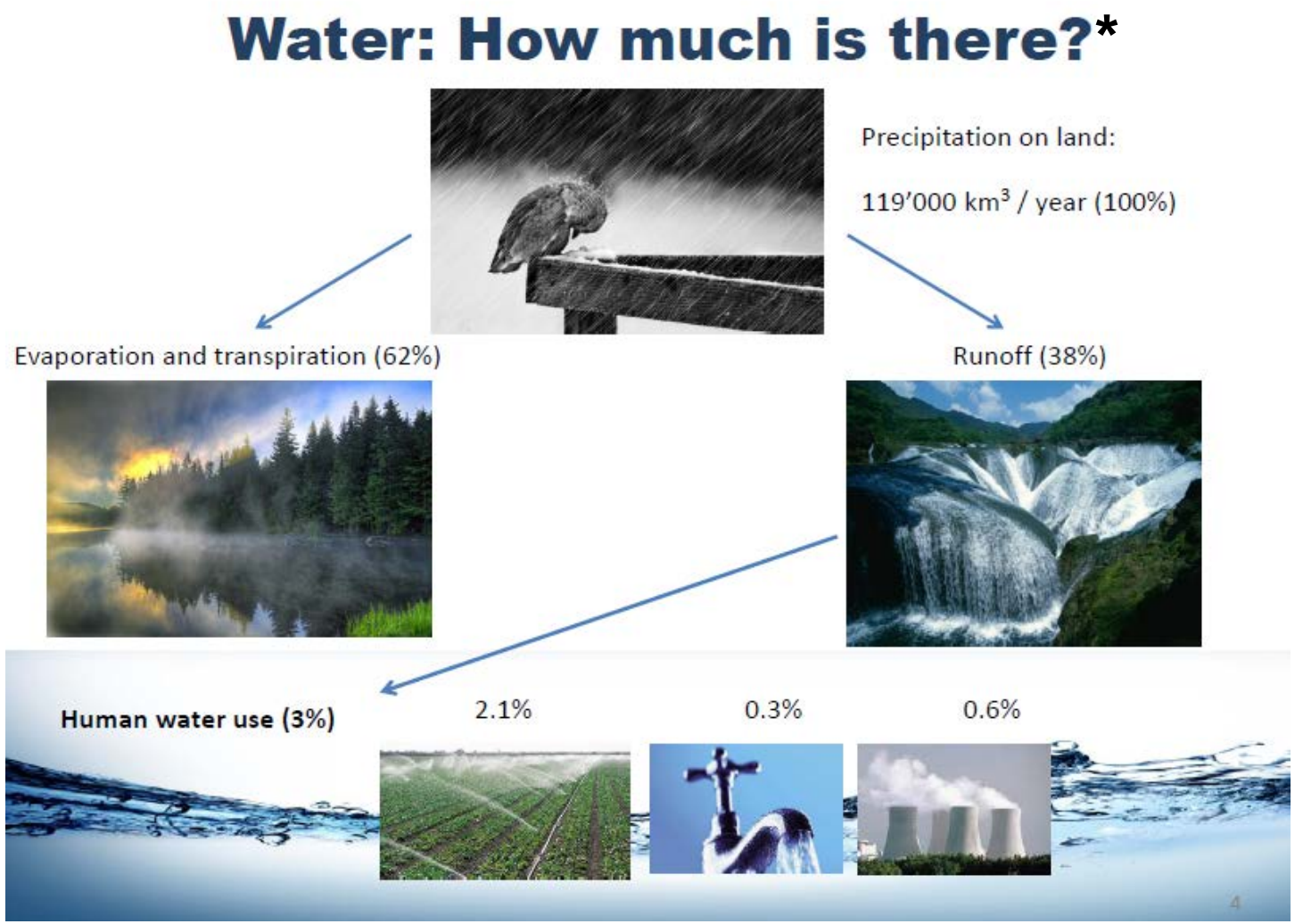

Human water use is a so small percentage of the total amount of water precipitated on the land…

Then what is the problem ?

First**: Water is not well distributed in time and space and its quality is deteriorating around the globe: **quality issues

Second:** The quantity represented as accessible, reliable, environmentally sustainable supply is a much smaller quantity than the absolute raw water available in nature and that is the amount that truly matters**:** **quantity issues

* ***Source:***
Anne-Marie Boulay, Ph.D. WULCA,
Water footprint training, San Francisco, October 8th, 2014

WP4 status update: demonstration started on April 2018

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WP 4

Task 4.2: Demo facility realization

Task 4.3: Hybrid CT demonstration

Task 4.4: Final assessment of coatings and materials

WP 7

Task 7.3: Techno-economical evaluation of cooling concept for geo p.p.

KPIs DEMO

KPIs Laboratory

KPIs Global

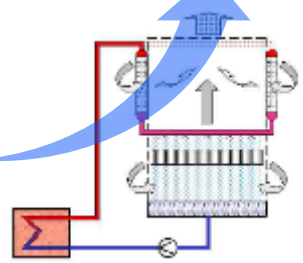
MS6: Commissioning of DEMO module

- Advanced packing performance assessment
- Hybrid configuration assessment

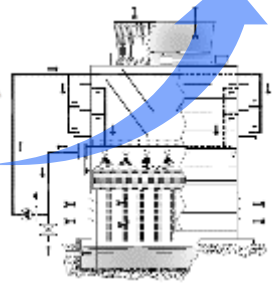
Final assesment

CAPEX/OPEX → NPV analysis

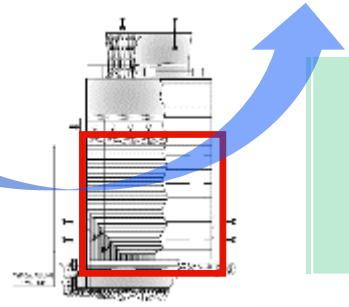
Design and erection

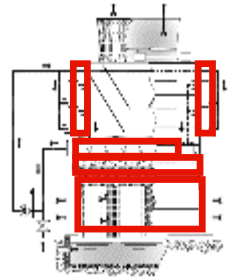


Demonstration



Sensitivity anlalysis





DEMO Facility realization: CT data sheet

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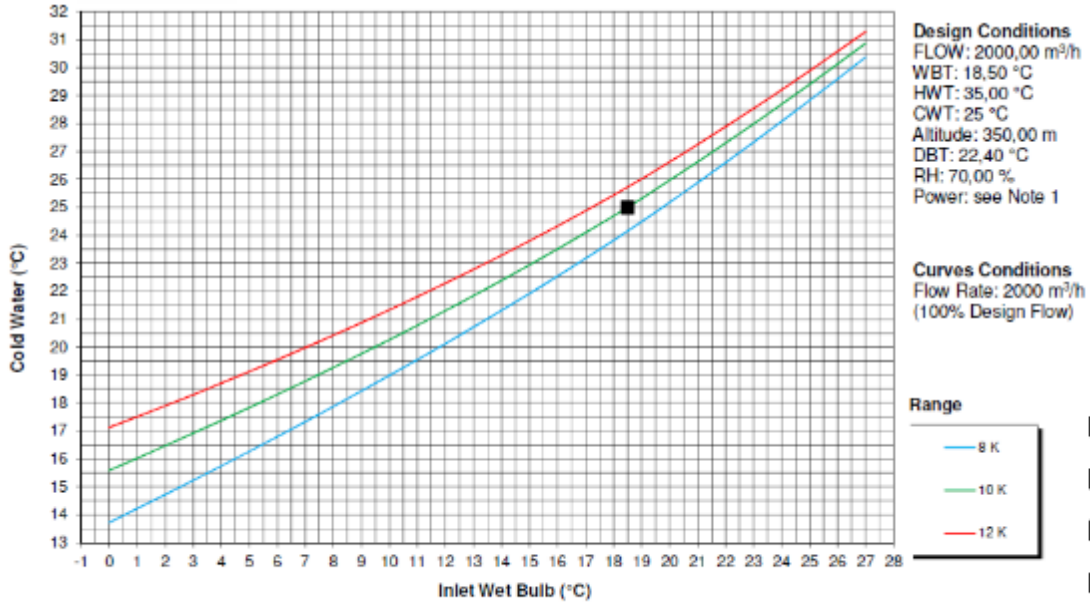
PROCESS DATA - DESIGN CONDITION

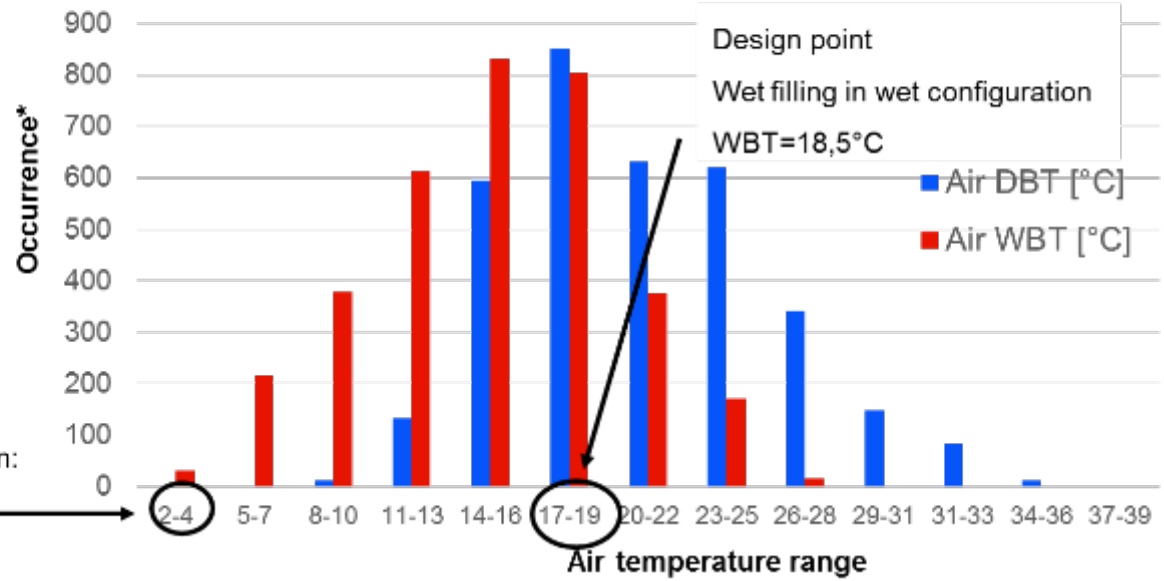
Cell Waterflow WF (m^3/h)	2000
Hot water temperature HWT (°C)	35.0 (wet mode)
Cold water temperature CWT (°C)	25.0 (wet mode)
Range HWT-CWT (°C)	10.0 (wet mode)
Entering Wet bulb temperature WBT (°C)	18.5
Approach (°C)	6.5
No plume condition	5°C / 90%
Drift loss (%)	≤ 0.0005
Evaporation loss (%)	1.40% wet mode / 1.25% hybrid mode
Water specific load ($m^3/h*m^2$)	11.02

The design of new hybrid unit was based on heat load demand and main approach temperature difference → (most likely seasonal ambient WBT)

The NO PLUME condition had to be respected for the most likely lowest WBT



Note 1: For fan speed and power consumption in wet and hybrid mode see data sheet S-HORA16-IT-D-004



DEMO Facility realization: civil works

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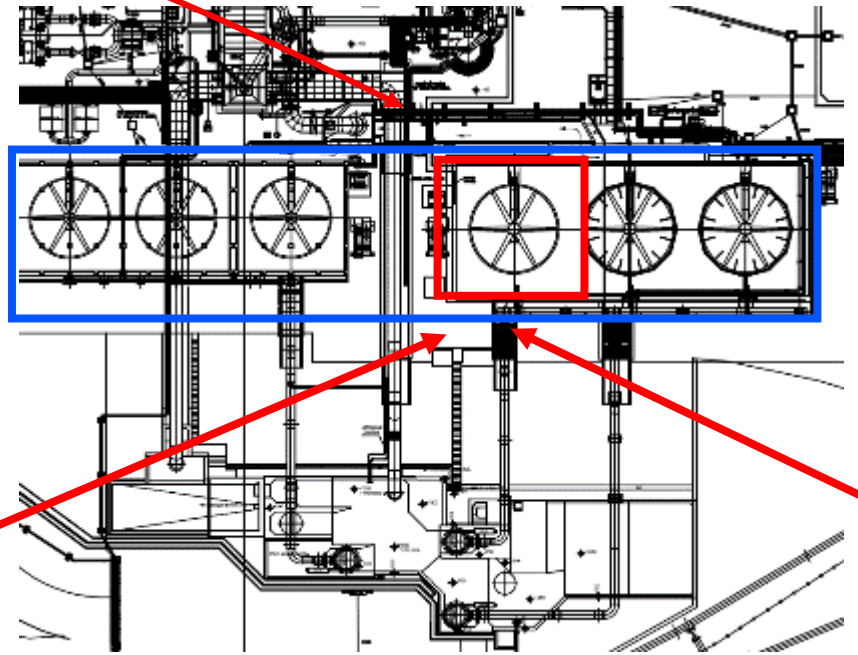
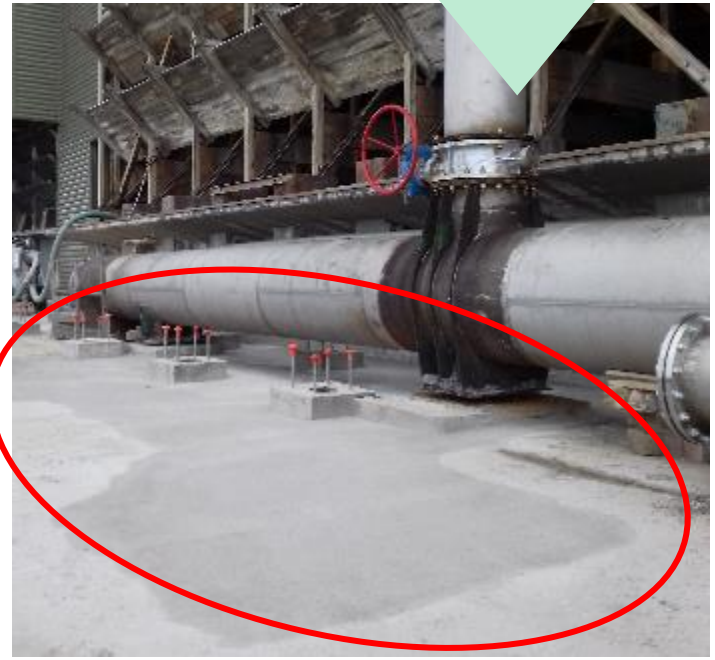
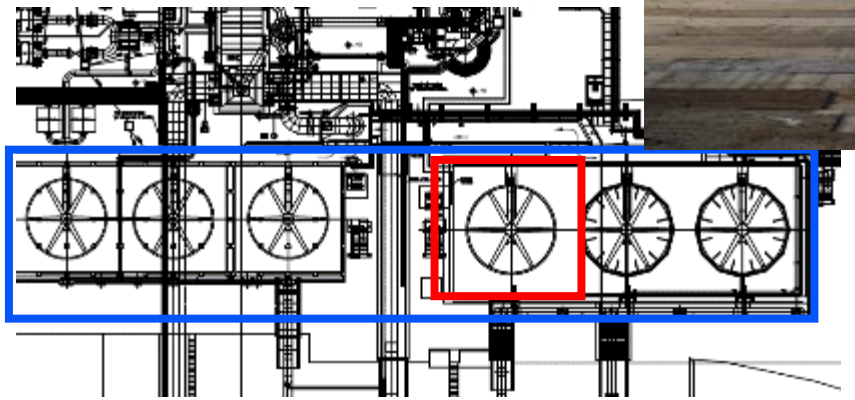
Civil works





DEMO Facility realization: existing CT dismantle

Dismantle of chimney and fan



Dismantle of existing filling

DEMO Facility realization: process & mech works

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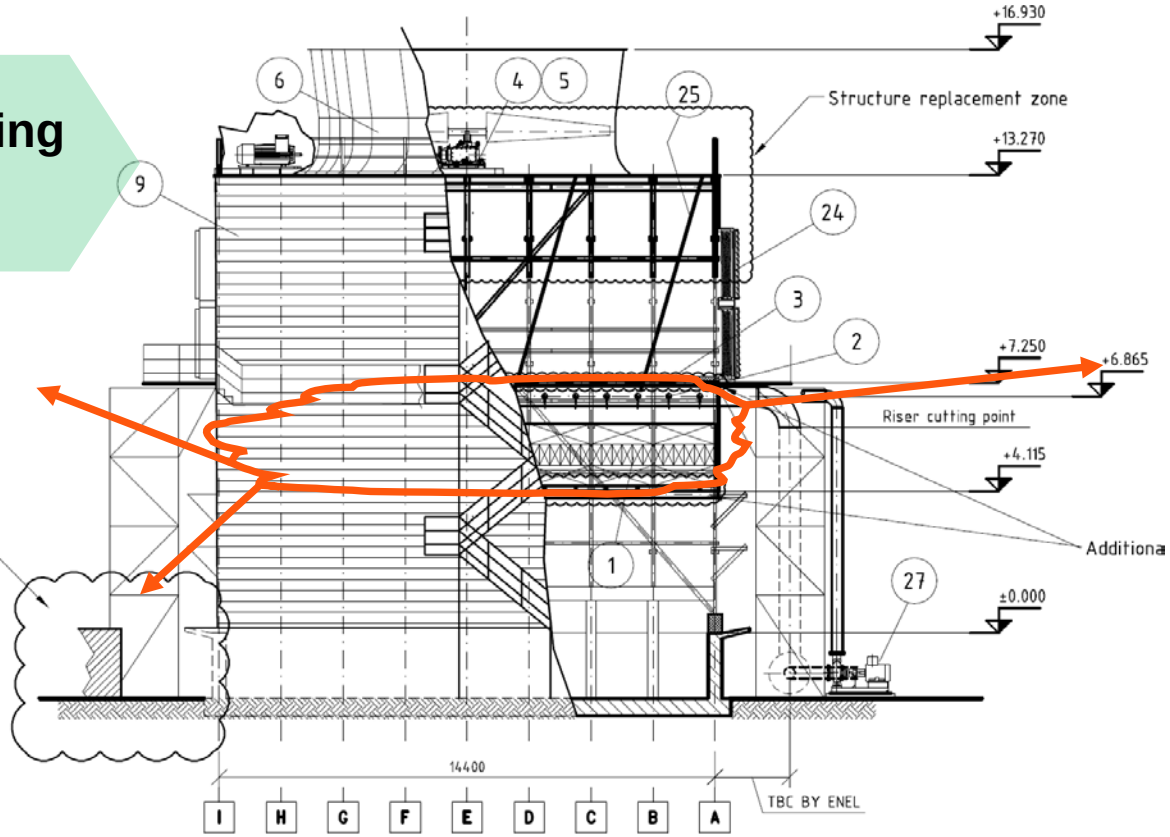
Installation of new existing filling media



DEMO Facility realization: piping modification

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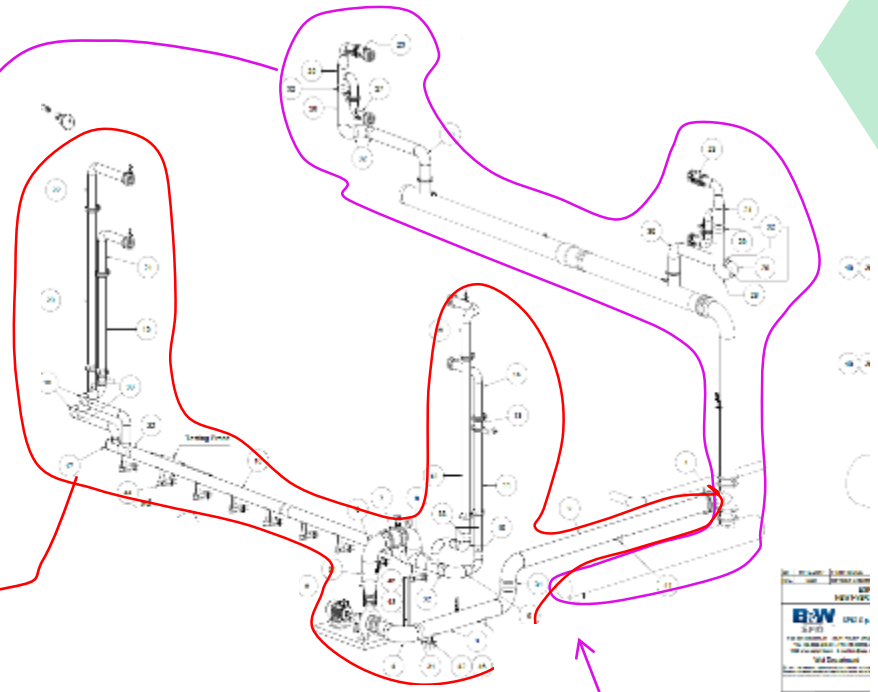
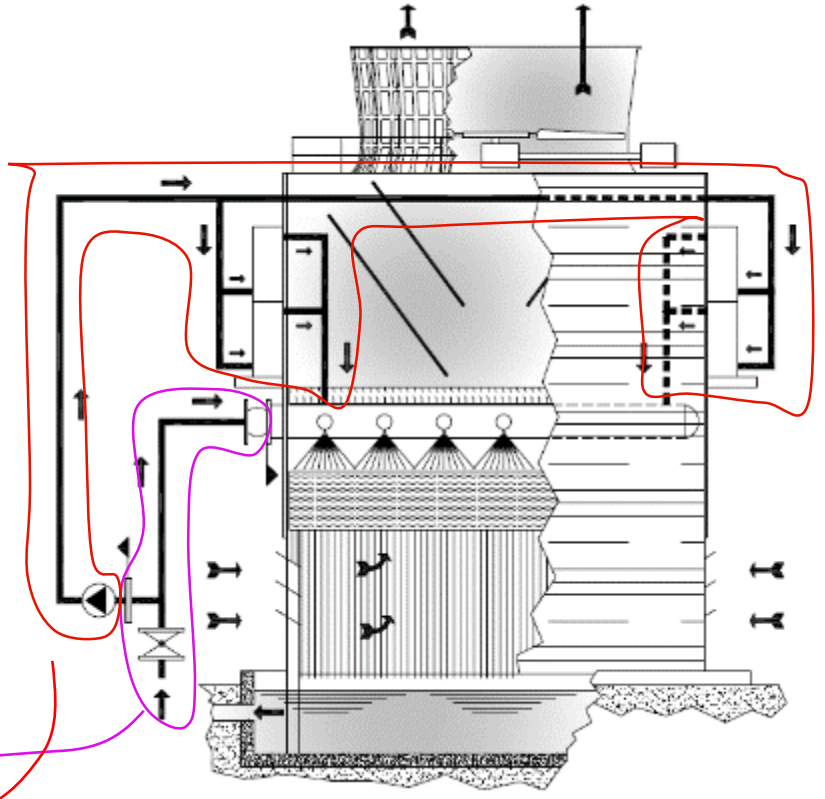
Piping modification





Piping modification of feeding hot water:

- Hybrid configuration → 35% to wet section, 65% to dry section;
- Wet configuration → 100% to wet section;

DEMO Facility realization: dry section & carpentry

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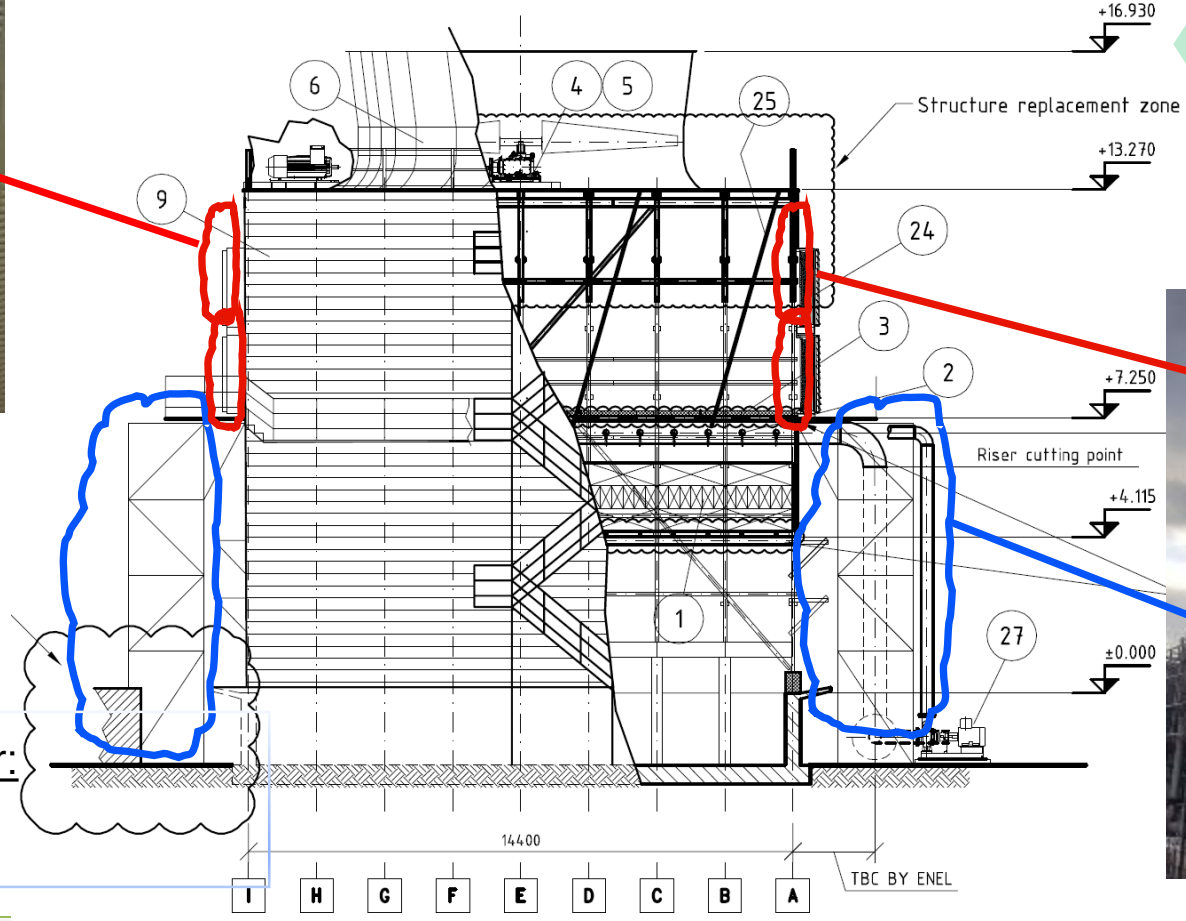
Dry section & carpentry



Piping modification of feeding hot water:

- 2 HX, 7 tonnes each side