Managing the Impact of Thermal Power & Renewable Power Offerings on Water Resources:

Strategies & solutions towards a more water-constrained future

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THERMAL POWER
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The fresh water challenge of the global power generation sector

Water is required throughout the electricity value chain of most power generation technologies. Water use in upstream processes can be high for some of these technologies: in particular the extraction of fossil fuels – especially the exploration and processing of unconventional ones and also for biofuels production. In thermal power generation (Renewable and Non-Renewable), the impact on water is most important during the operation phase in comparison with any other life cycle phase, particularly for cooling purposes.

A large amount of the water needed for operating power plants is freshwater, making power generation sector only second to agriculture in terms of demand. The impacts of power generation units on water during operations involve withdrawal, consumption and impact on quality of surrounding water resources. At the same time, high water-dependent power generation may be especially vulnerable to conditions of water availability and quality. Recent high temperatures and droughts have emphasised the importance of water, in anticipation of a more freshwater-constrained future in many regions due to climate change coupled with population and economic growth.

The Alstom Power Sectors approach to address the freshwater challenge: an overview

Alstom recognises the growing importance of the "water footprint" as a criterion for assessing the physical, economic and environmental viability of energy projects. The Alstom "*Clean Power Clear Solutions*" approach is particularly valuable to develop and adapt water solutions to the specific regional and site specific needs and regulatory constraints of its customers. Alstom efforts to optimise the impact of its offerings on water resources while maximising assets values are organised around the following three main pillars (cf. Figure 1 for an overview):

1. Reducing water dependency
2. Enhancing water use efficiency
3. Lowering impact on water quality

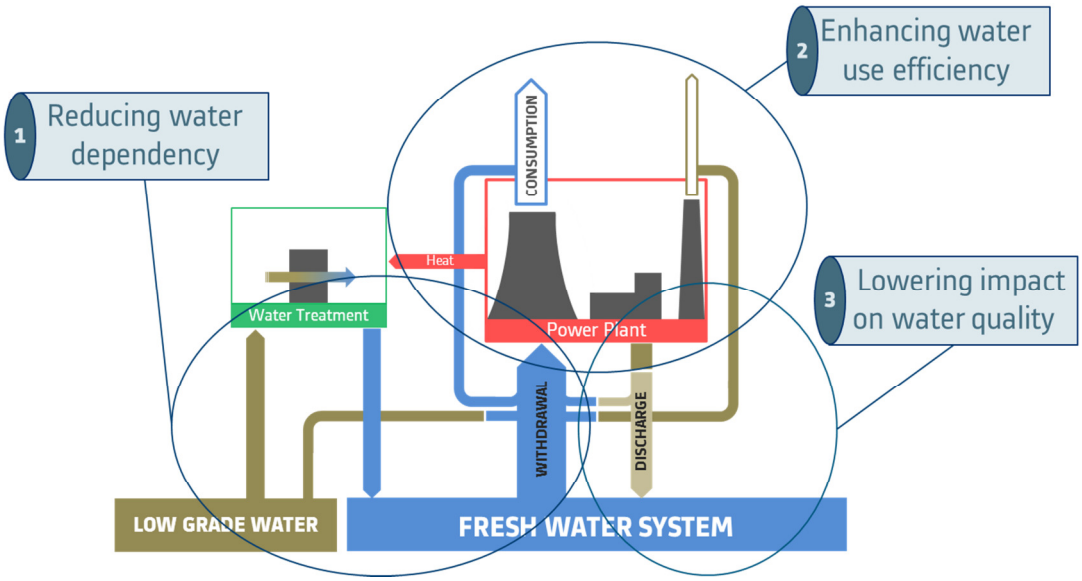

Figure 1: Overview on the three main pillars of the Alstom Power Sectors approach to address the freshwater challenge of the global power generation industry

In the following, these three main pillars are briefly introduced including a selection of corresponding existing solutions as implemented in some of the recently completed or engineered power plant projects:

1. ***Reducing water dependency:*** with a diversified portfolio of power generation technologies reducing both the volume and impact of water withdrawal from external sources

   - Solutions for water-independent cooling and operations: Wind and open cycle gas turbine solutions require almost no water for operating1. Furthermore, Alstom has developed some of the largest and most efficient air-cooled applications for large coal and gas-fired plants (recently completed projects include: the 847 MW *LANGAGE* CCPP in UK; 4'800 MW each *MEDUPI* & *KUSILE* STPP in South Africa)

   - Operating with lower water quality: Alstom solutions also enable the utilisation of seawater for cooling (e.g. 1'000 MW *SOHAR* CCPP in Oman) or flue gas desulphurisation (Seawater FGD: 38 GW installed or currently under construction – e.g. 1'200 MW *SHOAIBA Stage III* STPP in Saudi Arabia) or treated wastewater (for cooling and process requirements: e.g. 420 MW *MALAGA* CCPP in Spain). The withdrawal of fresh water can also decrease by reusing lower quality water (e.g. cooling tower blowdown) for flue gas desulphurisation (FGD) with the Alstom Wet FGD

[1] In case of open cycle gas turbines water is not required for cooling purposes as there is no need for cycle cooling. Gas turbine performance is highly sensitive to ambient air temperature. Rising ambient air temperatures result in a decrease of turbine performance. In regions with severe ambient conditions, water may be used for cooling inlet air (the air at the compressor entry), in order to maintain turbine performance.

(e.g. 2x350 MW *MARITZA* STPP in Bulgaria) or semi-dry NID™ technology (NID: Novel Integrated Desulphurisation).

- Reducing the impact of water withdrawal: water intake for thermal power cooling and use of hydro sources to generate electricity can cause adverse impacts on wildlife and other natural resources. Beyond reducing the volume and quality requirements, the Alstom approach to address water dependency includes solutions to reduce these impacts. This can be achieved, for instance, through fish-friendly turbine designs, as recently launched by the Hydro Business, in order to reduce fish mortality rate in specific regions.

2. ***Enhancing water use efficiency**:* with solutions for reducing the net consumption rate of high quality water during plant operations[2]

   - Enhancing thermal efficiency and reducing the need for cooling: for thermal power units, improving thermal efficiency and reducing the amount of heat discharged in the environment are the main levers to reduce water consumption in recirculating wet cooling processes (e.g. 876 MW *EMSLAND* CCPP with more than 59% net efficiency or 2'200 MW *NEURATH BoA 2&3* STPP global benchmark for lignite with more than 43%). Key applications to use the heat instead of dissipating it through a cooling system include co-generation for district heating and fresh water production through seawater desalination (more than 13'000 MW installed capacity of power and heat production solutions for various industries; key recent integrated power and water project: 2'000 MW & 130 Million Imperial Gallons per Day *FUJAIRAH F2* IWPP in UAE).

   - Reducing fresh water consumption rate: further non-cooling, fresh-water consuming processes are addressed. For solar thermal technologies, the technology of "Alstom/BrightSource Energy Inc. Central Receiver Concentrated Solar Power" is air-cooled and consumes one third of the water required for makeup and mirror cleaning compared to other solar thermal technologies.

   - Increasing water recovery for reuse: Alstom also develops solutions to increase the recovery of water from internal plant processes. As realised in recently executed geothermal projects, process (condensate) water replaces fresh-water for cooling (e.g. 2x25 MW *LOS HUMEROS II* Geothermal PP in Mexico).

3. ***Lowering impact on water quality:*** with solutions to control the thermal and chemical impact of operational discharge on the quality of surrounding water resources. A wide range of solutions enable to:

[2] It is worth mentioning that in case of Hydro projects, the estimation of water consumption of Alstom supplied hydro solutions through evaporation in reservoirs is problematic and can rarely be attributed to hydro power alone but to multiple uses (irrigation ,water storage, flood control, recreation,…).

- Reduce the volume of discharge into external water resources: this is achieved by integrating of zero liquid discharge (ZLD) concepts, as implemented in some recently-provided gas and coal-fired power plant projects (e.g. 800 MW *GISSI* CCPP in Italy). The ALSTOM NID™ technology also operates with ZLD avoiding the need for water treatment before discharge as in the case of Wet FGD systems (e.g. 800 MW *DUKE CLIFFSIDE 6* STPP in USA).

- Limit the thermal and chemical impacts of discharge: for coal-fired power plants, the Alstom Seawater FGD system produces no waste while almost restoring sea water quality before discharge. New Hydro solutions mitigate the depletion of dissolved oxygen in water that can be damaging to aquatic life. Furthermore, Alstom existing hydro turbines are capable of utilising water lubrication as well as biodegradable and low toxicity oil.

In addition to existing solutions, Alstom is committed to further strengthen the related R&D activities in order to provide economically and environmentally viable solutions to lower the impact of its offering on water resources in a water-constrained future

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