ASIA'S LEADING POWER REPORT

PI POWER INSIDER

VOLUME 9 ISSUE 5

CHINA FRIEND OR FOE?

IoT & Asia's Energy Market

Fuel Cell Roundtable, Dry Cooling Insights, Nuclear Simulation, Interviews & Much More Inside!

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DRY COOLING

FOREWORD

Ever growing water use, increasing environmental pollution combined with the threat of climate change and enhanced shrinking of resources make imperative water conservation. Seemingly, there is limitless quantity of water in the Earth. Though majority of the water resources are saline water (ocean and sea) – only approx. 2.5 % of freshwater. More than two third of the freshwater is frozen, thus the available freshwater for consumption is less than 0.7 % that of the total water resources. Even the vast volume of salt water is endangered by man-made pollutions (chemicals, plastic, oil, CO2 and thermal) – resulting in dead zones, red tidal, strange species and flora, especially in the shallow coastal marine areas. One such polluting source is water withdrawal for thermoelectric power.

The major stress is on the freshwater use. The mentioned eligible 0.7% of the total water quantity (abt. 80% surface water, 20% stored in undersurface aquifers) is distributed unequally in the Earth. There is a fierce competition between the different sectors (domestic, agriculture mainly irrigation, industry, thermoelectric) for the available sources.

The thermoelectric water consumption is only 3%. This relatively small percentage value on global basis, however, represents very intensive use locally, exerting an extra stress on water availability at the whole region.

In this respect it shall be taken into account that proven water conserving power cooling solutions have been available for decades whereas “it is not easy” to substitute water for irrigation and domestic use. For example opting for a wet cooling system now has lasting effects. It influences not only the economics of the power plant itself (through making dependent the stability of electricity production on long term water availability), but also influences the surrounding region environmentally and economically by depriving of water use the other sectors (agriculture, industrial processes or domestic) for 3-5 decades – i.e. the whole life-span of the power plant. On the other hand, water conservation in itself is not enough to justify the application of any water saving cooling method, it shall also be a cost effective one to make its use attractive for power plant owners.

Therefore, it is important to improve the economics of cooling systems by applying novel ideas. Subject of the present article is introducing the whole portfolio of ENEXIO’s dry/wet cooling systems what are intended to extend the economic viability of water saving cooling against traditional water thirsty ones. The best is to base decision on a comprehensive evaluation comparing the most promising cooling system options for a new power plant. However, it is vital for such an evaluation to consider a realistic water cost, which reflects the total value of the water (regarding also its value for other sectors and the environmental impacts).

Cooling technologies

Presently the overwhelming part of thermoelectric cooling uses either once-through (OTC) or wet cooling systems. Share of each is over 40% - somewhat higher for OTC than that of the wet (2/3 of the nuclear power capacity is cooled by OTC, nearly 1/3 by wet). The share of cooling and spray ponds is over 10%. This is the situation both, globally and in the USA. Thus, the water thirsty solutions dominate the market.

The water conservation type cooling systems have only a tiny portion: presently (2017) a bit more than 10% globally and only abt. 2% in the USA. Within these figures the dry cooling systems dominate, whereas the share of dry/wet solutions is still low, though their features promising an increasing demand rate worldwide.

Main power cooling options

The use of water saving solutions are governed either by the physical scarcity of the water or by environmental reasons, including foreseeing lack of water in the future (unfortunately the latter is rarely regarded). It is interesting to note that in the South African Republic and some Middle-and Near-East countries (Turkey, Syria, Iran) the ratio of dry cooling systems exceeds traditionally more than 20% - due to the mentioned physical scarcity of water and meanwhile incentives to site power plants also in the inland areas. However in the last decade, in parallel with the dynamic increase of new power demand brought with it a significant demand for dry cooling in China. More recently, measurable number of existing wet cooled plants are targeted to be converted to dry/wet ones.

SELECTION OF COOLING SYSTEMS

ENEXIO is supplier for any of the power cooling systems except the OTC. However, the water conservation type cooling methods represents its core

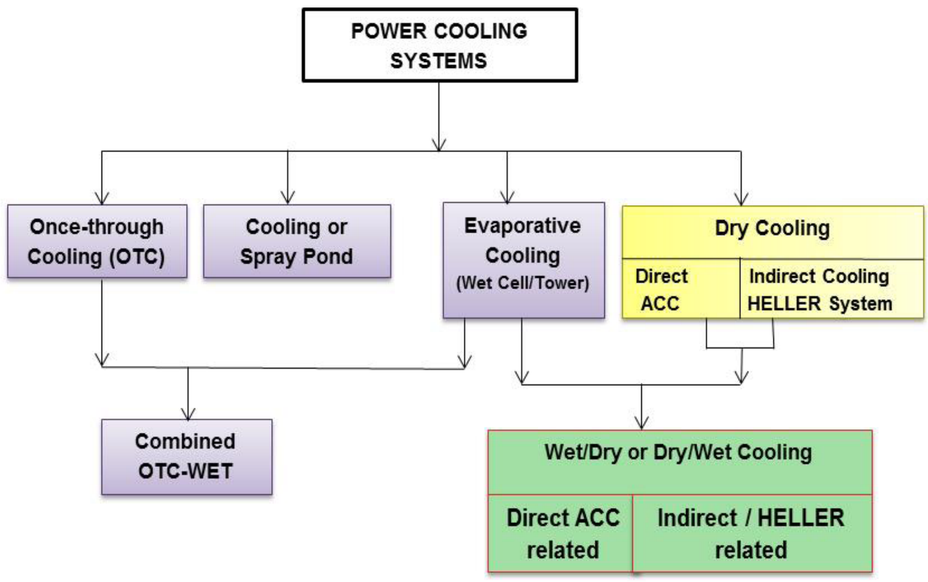

Fig. 1. Cooling system classification

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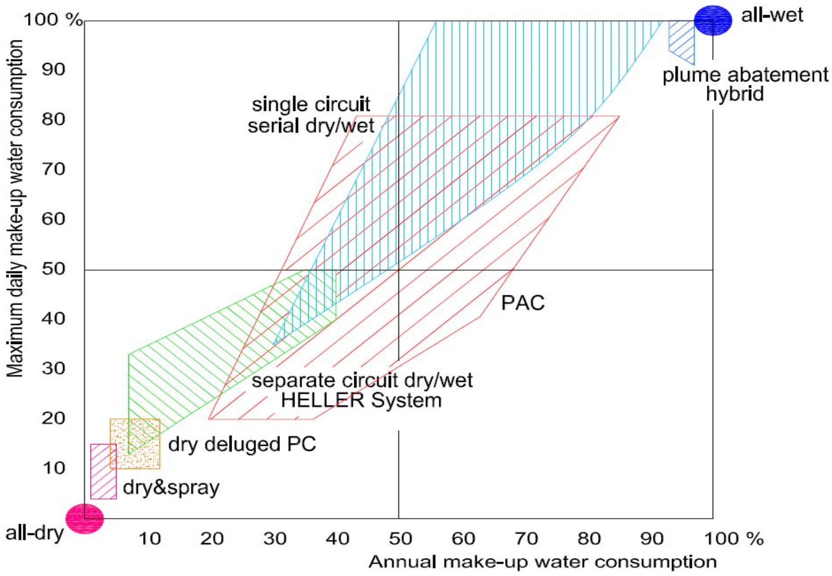

competence: dry and dry/wet solutions. Most of these cooling systems have been developed and introduced by ENEXIO and its predecessor companies.

Given the numerous variants, it is important to select optimum solutions. Based on a range of evaluations, ENEXIO determined several charts for orienting selection among these cooling system variants related to targeted yearly and daily water consumptions. Such charts (see Fig. 2.) specify promising areas for applying different water conserving solutions, valid only for certain range of economic factors.

Fig. 2. Areas for different cooling system configurations

METHOD OF INVESTIGATION

Environment

Selecting the most economic water conservation type cooling system from the promising methods for a certain thermal power plant a comprehensive investigation and comparison shall be conducted based on indispensable data. In some cases, these data are not completely available, therefore assumptions shall be made.

Since any cooling system types for power plants are translating the environmental conditions into turbine backpressure variation, actual and historical local weather conditions are extremely necessary, such as: average air pressure, absolute minimum and maximum Dry Bulb and Wet Bulb ambient air temperatures and the most important data is the hourly Dry Bulb Temperature for a typical year (see Fig. 3.) or average of five years with the corresponding Relative Humidity or Wet Bulb Temperature.

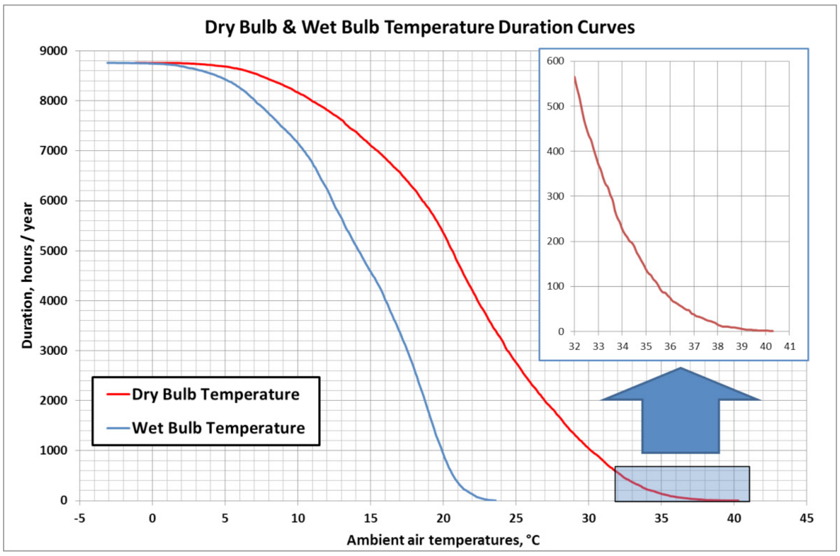

Fig. 4. Temperature duration curve for DBT and WBT

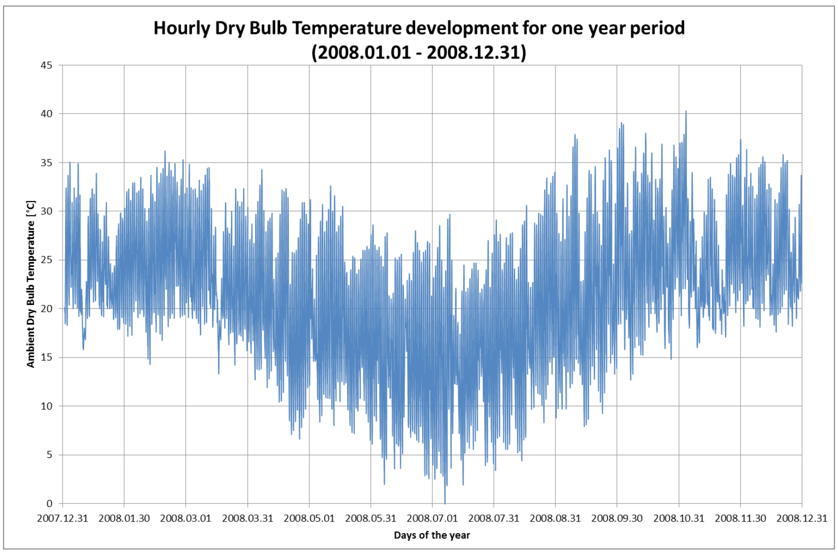

Fig. 3. Example of Temperature variation for DBT on the site

Behavior and year round performance of cooling systems are depending on the so-called temperature duration curves (see Fig 4.) by which annual power output; annual water consumption can be calculated.

Steam turbine

Beside the environmental conditions the actual (or considered) steam turbine type and characteristic is also essential for correct evaluation. The operational backpressure ranges shall be taken into account when configuring DRY or DRY/WET cooling system vari-

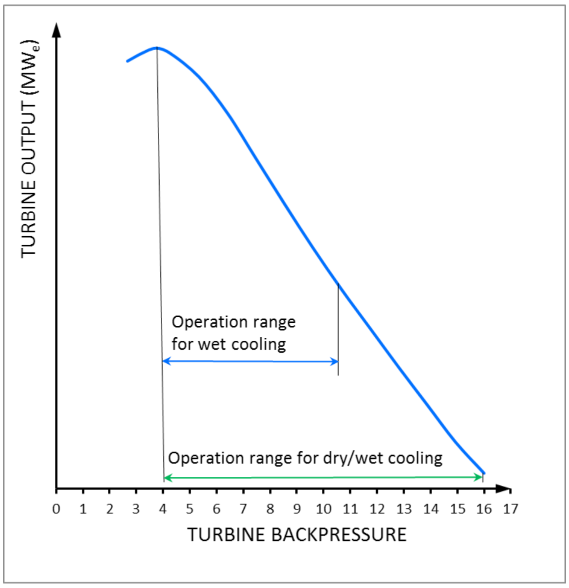

Fig. 5. Steam turbine characteristic curve

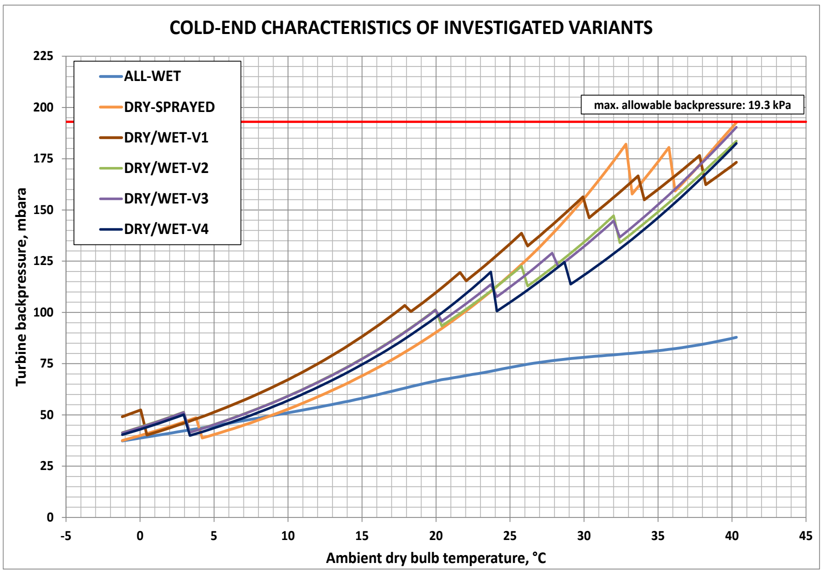

Fig. 6. Backpressure variation vs. DBT

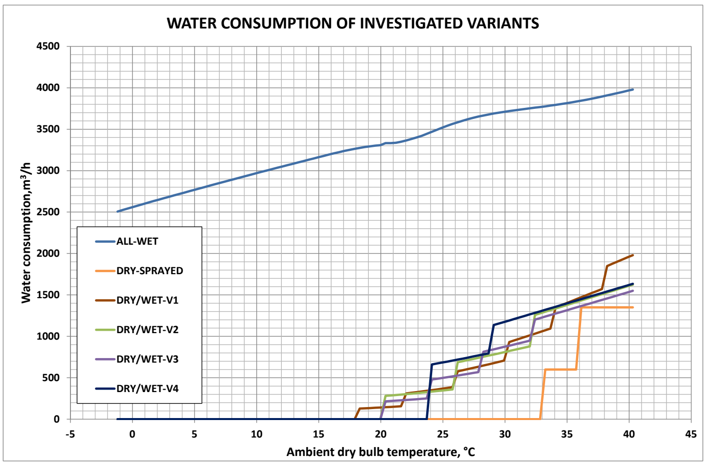

Fig. 7. Net output variation vs. DBT

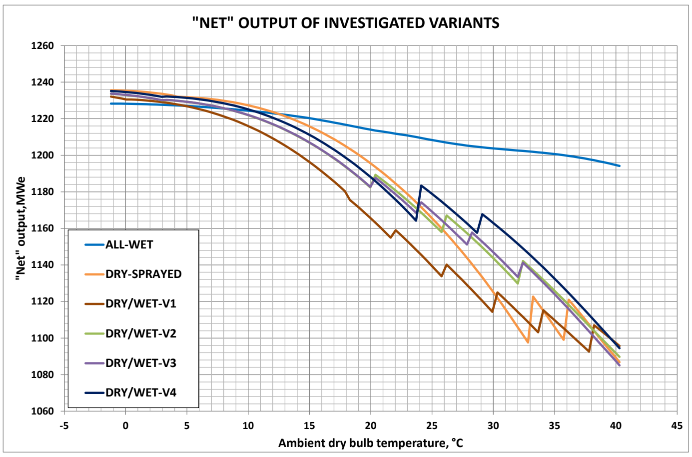

Fig. 8. Water consumption variation vs. DBT

ants for the investigation (see Fig. 5.)

RESULTS

Performances, characteristics, water consumptions

To support comparison among different variants their characteristics are plotted on the same charts in different grouping:

cold-end characteristics (i.e. turbine back-pressure vs. DBT) (see Fig. 6.)
similarly „net" output variations versus DBT (here „net" output is gross output less cooling system auxiliary power only) (see Fig. 7.)
further charts for variation of water consumption of different variants vs. DBT (see Fig. 8.)

Based on the results of "net" output & water consumption of investigated variants bar charts for relative year round "net" electricity generation and year round water consumptions are introduced (see Fig. 9. and Fig.10.). Mentioned characteristics and their evaluation for different periods (including year-round period divided to peak and off-peak periods) all production and consumption values can be determined and used for annual evaluation.

ECONOMIC EVALUATION

For the economic evaluation of the cooling systems their impact on the

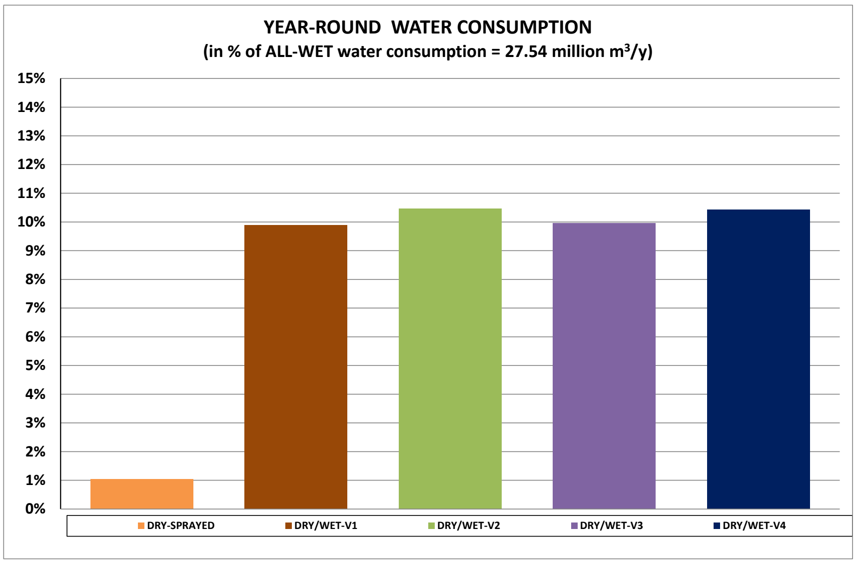

Fig. 9.

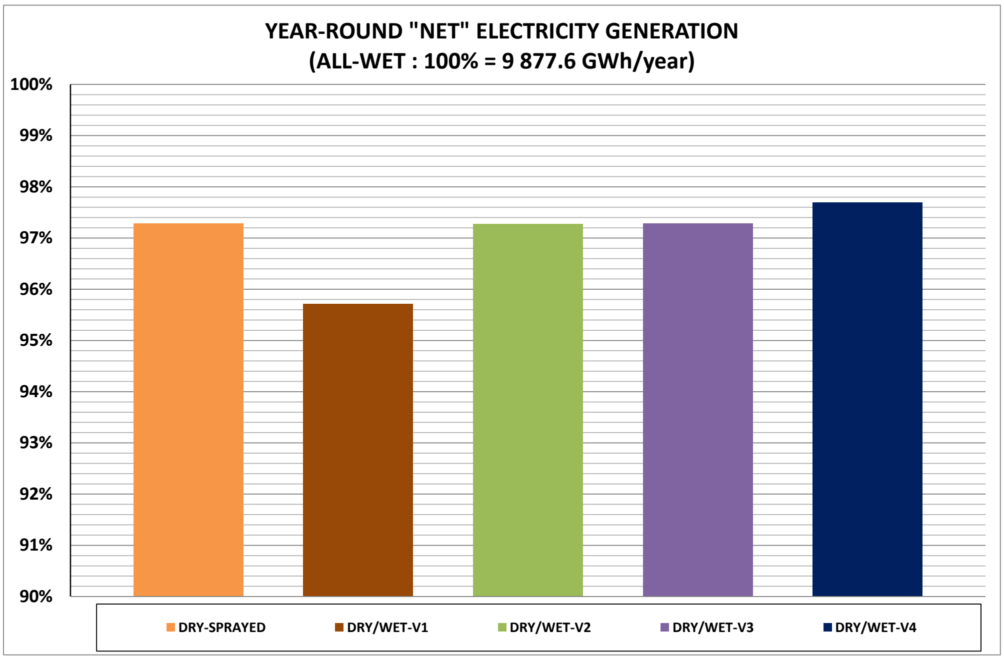

Fig. 10.

power plant is to be investigated with a simplified present value based life-cycle evaluation considering the main economic factors.

Capital cost: Functionally equivalent cooling systems with complete scope are investigated independently if the required scope is usually supplied by the cooling system vendors or not.

Costs or gains coming from differences in electricity production: Evaluation is based on the year-round „gross" electricity generation.

Costs or gains coming from differences in auxiliary power consumption: Auxiliary power consumption shall be deducted from the "gross" output value for evaluate the year-round "net" electricity generation (i.e. gross turbine electricity generation reduced only by the cooling system auxiliary power consumption).

Water Costs: Specific make-up water costs are applied for the annual water consumptions to determine the yearly water cost of the different variants. Such specific costs shall include all potential items: acquisition of raw water or water rights, cost of delivery (potential reservoir), in-plant treatment, blow-down treatment and disposal.

Maintenance Cost: Maintenance cost is assumed to cover the costs of planned and unplanned maintenance activities and also the foreseeable replacements, too.

Costs from cooling system affected equivalent unavailability differences: Effects reducing efficiency and performance or causing forced outages and extended maintenance periods are the main sources of equivalent unavailability. Not only the unavailability of a cooling system itself shall be taken into account but also its impact on the unavailability of the power cycle as a whole. The percentage equivalent unavailability difference can be regarded as proportional reduction in net electricity production.

ECONOMIC VIABILITY ENVELOPE

The results of the present value evaluation opens route to determine to make sensitivity analysis in function of the most important economic factors as well as developing so called economic viability envelopes introducing the relative cost or gains compared to a base solution – e.g. in most of the cases an ALL-WET cooling system.

See exemplary chart on Fig. 10.

SUMMARY

Given the growing need for fresh water, the importance of water conservation type solutions in the thermoelectric power industry is increasing. The wide variety of water saving cooling methods developed by ENEXIO offer attractive solutions for power industry considering any constellation of environmental and economic conditions. To give the right answer to the demands makes an emphasis on a comprehensive evaluation considering the cooling solutions as part of the complete power plant.

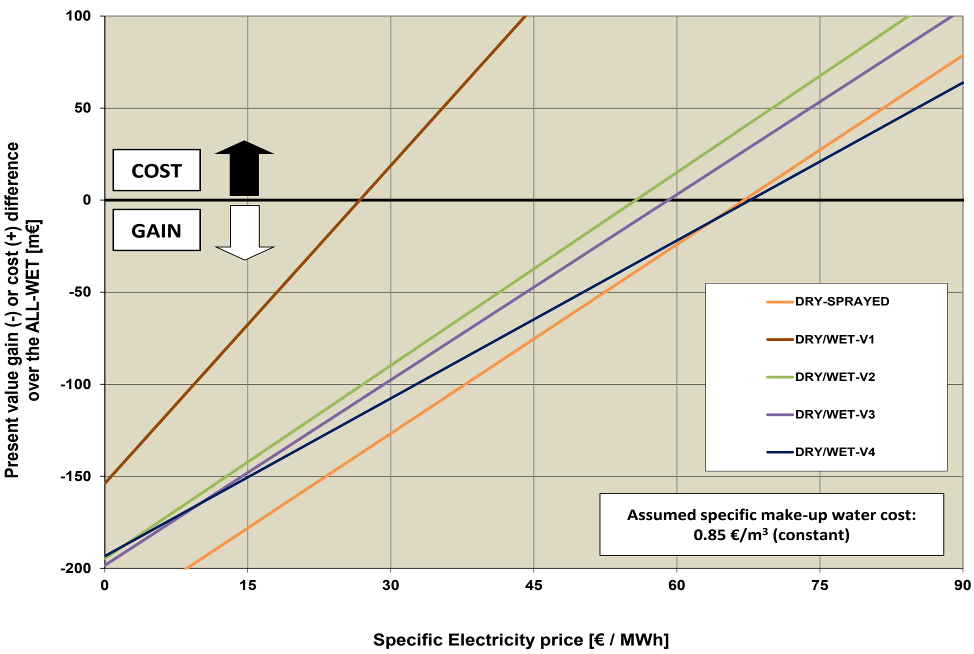

Fig. 11.