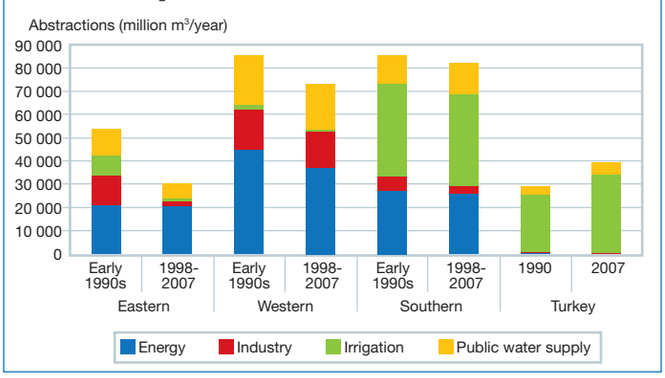
Reducing the abstraction of fresh water in power plants

The MATChING H2020 project, still in its early days, has been set up to minimise one of Europe's most demanding challenges in its use of fresh water – reducing that employed as a cooling medium in power generation.

Staff report

As Pontes demonstration plant

EU water abstraction per sector – European Economic Area in the 1990s compared to 2007



Only 3% of the water that falls on the land is used by human society, and more than two thirds of that, 2.1% of the total, goes directly to irrigation. 0.3% of the total is supplied for domestic use while the remainder, 0.6%, is used by industry, mainly for cooling.

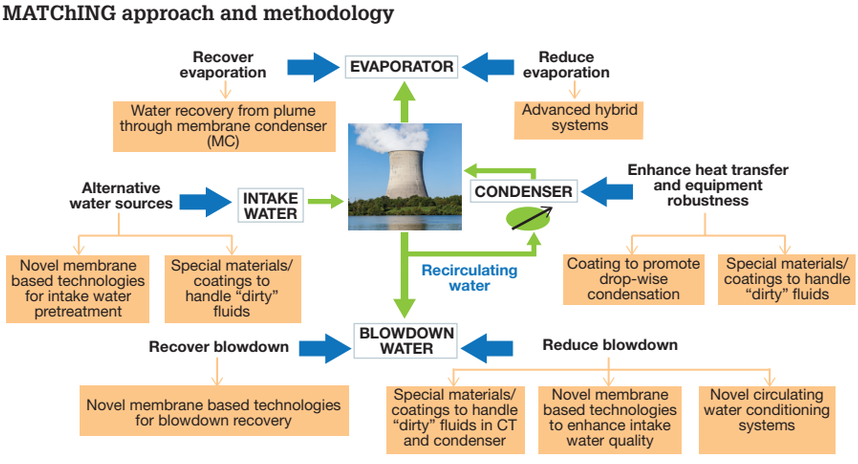
With so much more water available than we use, one might imagine that there could never be a shortage. But there are two problems. First, water is not conveniently distributed in time or in space, and its quality is deteriorating around the globe. Second, the quantity of accessible, reliable, environmentally sustainable water is a very small part of the total of raw water available in nature. Power generation is a sector requiring great amounts of water for cooling. In the EU is accounts for 45% of total water abstraction in the EU, second only to agriculture. MATChING – 'Materials & Technologies for Performance Improvement of Cooling Systems performance in Power Plants' – is a collaborative project, funded by the EU Horizon 2020 programme, which aims to significantly reduce cooling water demand in the energy sector.

The MATChING consortium includes four utilities (EDF, ENDESA, ENEL, ENEL Green Power), five technology providers (Aquasill, Integasa, Ionics, Pathema, SPIG), six research institutes (AIMEN, CNR ITM, DTI, Laborelec, Materia Nova, VITO) and one consulting firm, Sweco. There is also a stakeholder community composed of power industry representatives, European bodies concerned with environment, water and materials, as well as market players in the water treatment field. A total of nine test sites or facilities will be used to prove and develop various different methodologies.

Hoped for results include a 15% reduction in geothermal steam emitted to atmosphere, a 10% extension of well life, an overall plant efficiency increase up to 0.5% by enhancing the heat transfer efficiency of condensers on the steam side and water side, and an overall reduction of fresh water abstraction in fossil fuelled power plants of about 30%.

A broad set of technologies is proposed acting on intake, blowdown, make-up, and evaporated water. Hybrid cooling systems are proposed for the geothermal sector. For the thermal power sector, innovative materials will be applied to steam condensers, and membrane based solutions developed for water treatment and recovery.

MATChING approach and methodology

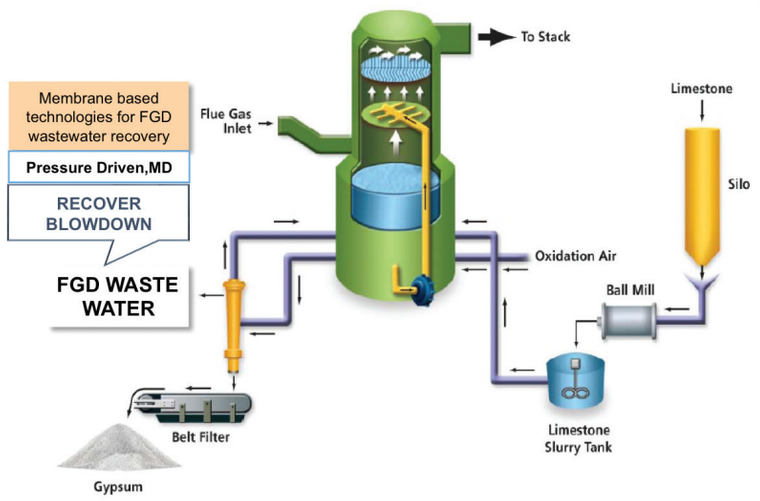


Geothermal sector

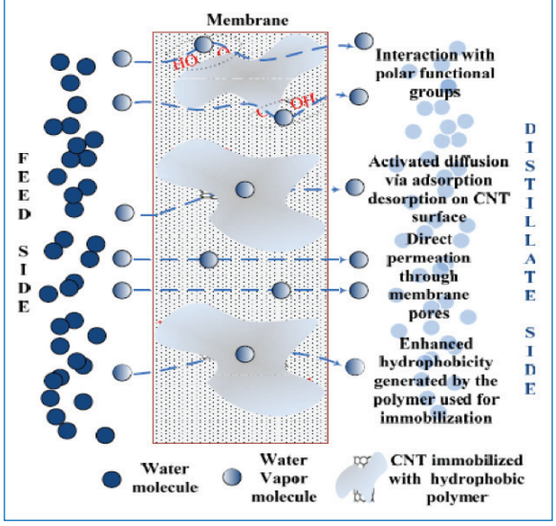
Where the geothermal fluid is available at low temperature, a new cooling concept, based on the use of closed loop groundwater (GWC) integrated in a binary cycle, will be investigated and compared with dry type cooler condenser with the aim of reducing overall water withdrawal without compromising the energy efficiency of the system. New materials (coatings with anti-fouling and anti-corrosion properties) will be developed and experimentally validated in order to create equipment that allows the use of lower grade materials and makes the overall process economically viable, mitigating the effect of geothermal fluid aggressiveness that leads to fouling and clogging phenomena.

Where instead there is availability of geothermal steam, which permits a direct exploitation of the geothermal source, a hybrid cooling tower is proposed. Advanced CT filling will be installed in the wet section of the tower with the aim of reducing the

Flue gas treatment section



Membrane distillation



volume of packing while maintaining a high heat transfer efficiency. The dry section will be strengthened using new nano-coatings with anti-fouling, fouling-release and anti-corrosion properties to be applied on the internal side of dry modules in order to increase the robustness of the equipment. This is necessary where hybrid towers are to be deployed in a geothermal field. The results coming from this demonstration may in due course be extended to fossil fuelled power plants using lower quality water and higher cycles of concentration.

Thermal power sector

New coatings with high hydrophobic functionality and/or exhibiting new laser texturing techniques will be applied on the steam side of condenser tube bundles to promote condensation.

Stainless steel with biocide proprieties and/or antifouling coatings will be applied on the cooling water side of condenser tube bundles, allowing the use of alternative water sources. Different approaches will be investigated – bio-functionalisation of coatings with enzymes or with peptide-like compounds, and embedding of nanoparticles with anti-fouling properties, such as ultra smooth surfaces.

Innovative nano-technologies, mainly membrane based, will be applied for cooling water conditioning and/or for water recovery, with the final aim of increasing the availability of water supply through the treatment of low quality water (for example CT blow-down, process waste water, municipal waters) and through the recovery of water vapour from evaporative losses in, for example, a CT plume. The five technologies selected for water treatment are membrane capacitive deionisation (MCDI), vortex degasification technology (VPT), membrane distillation (MD), and a combination of micro filtration (MF), ultra filtration (UF), nano filtration (NF), and reverse osmosis (RO). Membrane condensers will be applied to recover the water evaporative losses in cooling towers.

Demonstration sites

A total of seven test sites and facilities will be used within the project, as follows:

Balmatt, a VITO geothermal power plant. This will be a demonstrator for anti-corrosive coatings, and is located in the northern part of Belgium. A bypass in the main brine circuit will be installed for the evaluation of different coated materials in contact with the geothermal fluid at extraction temperature.

Nuova San Martino, an EGP geothermal power plant. This will also be a demonstrator, but of hybrid cooling systems with advanced CT filling media and innovative anti-corrosion coating applied to the dry section. Nuova San Martino is located in the Cornia valley, Tuscany, in central Italy. The installed electric capacity is 40 MW, with one generating unit and six forced-draught cooling towers. For the project, one tower will be retrofitted to a hybrid configuration, that is, one wet and one dry section.

As Pontes, an Endesa coal-fired power plant. This will be a demonstration of anti-bio-fouling and condensation-promotion surfaces in a pilot condenser, vortex de-gasification and membrane distillation. As Pontes is located in the northwest of Spain. A pilot condenser, a vortex degasification module and membrane distillation modules will be installed and integrated.

Brindisi Sud, an Enel coal-fired power plant in southern Italy, is to be a demonstration of a novel kind of membrane effective in the FGD process. A new membrane test facility will be integrated to recover water from waste streams of the flue gas desulphurisation unit.

Chatou, an R&D site owned by EDF . This will be a demonstration of condensation-promoting surfaces in the TRHyCo facility and anti-fouling surfaces in the site's 'Pericles' facility. The laboratory in Chatou is one of the three main EDF R&D sites. The site is located near Paris on the "Island of The Impressionists" where research activities are historically dedicated to hydro power and fluid flow dynamics.

Merades, a mobile cooling unit owned by Engie Lab Laborelec. This is to be a demonstrator of membrane de-ionisation, membrane distillation and chemical-free water treatment by vortex technology

The pilot unit is located at Linkebeek, in Belgium. The expectation is that use of the facility makes it possible to evaluate new cooling water designs or water conditioning in a 'budget friendly way'.

Mistral/Bugey, a nuclear power plant owned by EDF. The facility will demonstrate water recovery by the use of specialist membranes. Bugey, located on the river Rhone, is a site near Lyon dedicated to electricity production. Four nuclear power plants each of 900 MWe are in operation. The site hosts the Mistral loop, a 25 MWt cooling loop which is used for the investigation of various cooling fills under performance tests in operating conditions. MPS

Pressure-driven membranes and membrane distillation