VORTEX PROCESS TECHNOLOGY (VPT)

Sustainable Cooling Tower Technology

Funded through California Energy Commission EPIC Grant

Water-Energy Nexus

BACKGROUND

ELECTRIC PROGRAM INVESTMENT CHARGE (EPIC) PROGRAM

HTTP://WWW.ENERGY.CA.GOV/CONTRACTS/EPIC.HTML

- CEC electricity innovation investments follow an energy innovation pipeline program design
- Funds technology demonstration and deployment, market facilitation to create new sustainable solutions, foster innovation and bring clean energy ideas to the marketplace

- Electric Power Research Institute (EPRI) in Palo Alto, CA is an independent, nonprofit organization that brings together scientists, engineers, experts from academia and the energy industry to help address market & technology challenges
- EPRI selected the VPT technology based on a field assessment conducted by Cypress on behalf of SCE
- EPRI submitted a proposal in partnership with Cypress competing against other sustainable technologies and was selected by the CEC for two installations in the SCE service territory
- Goals:
    - A) Measure and demonstrate the efficacy of an innovative water – energy nexus technology, called **Vortex Process Technology (VPT)**
        - Focus for this application is cooling towers
        - Reduce water, energy and chemical usage
    - B) Conduct a market knowledge transfer of that technology to a variety of commercial and industrial end users and stakeholders

Background

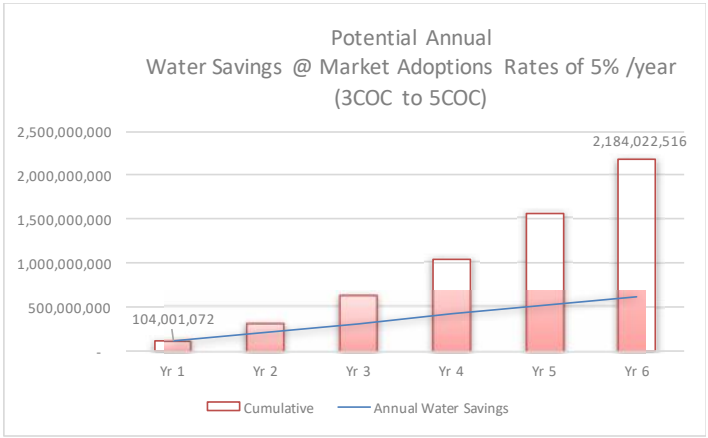
Cooling Towers Represent a Significant Opportunity to Reduce Water and Energy Use

- The water-energy nexus has been a focus of SCE and the CEC even prior to the recent CA draught
- Reducing water usage in cooling towers, the ability to re-use blowdown water and monitoring performance *cost effectively* are priorities
- The focus is on water cooled cooling towers and a physical water treatment technology (PWT) that has demonstrated a positive impact
    - Site Benefits: Reduced water, energy and chemical usage
    - Potential System Benefits: Reduced embedded energy for water distribution and treatment

2011

2015

- **Example CA: EPRI estimates that 6,985 GWh or ~35% out of the total 20,061 GWh on cooling and refrigeration is used in water cooled equipment**
- **If only 30% of the CA cooling towers were able to increase their COC from 3 to 5 estimated water savings is over 625 millions gallons annually – and this does not include any possible re-use of blowdown water**



TECHNICAL BACKGROUND

VORTEX PROCESS TECHNOLOGY (IVG-CT) FOR COOLING TOWERS

- Currently installed by 35+ customers in in the EU
- Recently evaluated* by SCE in California at a customer hospital R&D facility
  - **Challenge:** Demonstrate reduced water, energy and chemical usage through PWT
  - **Results:** Demonstrated 3.8% Energy, 42% Water, 33% Chemical reductions
  - COC from 1.8 to 4.2

- Created/Patented by Watreco A.B., Sweden (http://www.watreco.com/engelska.php)
- Worldwide DIstribution H2oVortex s.a.r.l., Luxembourg (www.h2ovortex.com)
- Successfully deployed and has achieved initial market adoption at installations in the EU: Breweries, Food Processing, Commercial Office, Data Centers, Ice Rinks, Chemical Manufacturing
- Example: HEINEKEN
- *'After deployment of the VPT-CT, the evaporative condenser can be operated without chemicals. The application was without the formation of lime scaling, corrosion or microbiological activity.*
  - *By recycling the tower water it is possible to achieve 100% water savings by deploying rinse water from the brewery.'*

- The same VPT technology was evaluated in a different non-cooling tower application to demonstrate electric and natural gas savings in ice rinks by SCE. There is a SoCal Gas sponsored incentive program http://www.realice.us/socalgas/

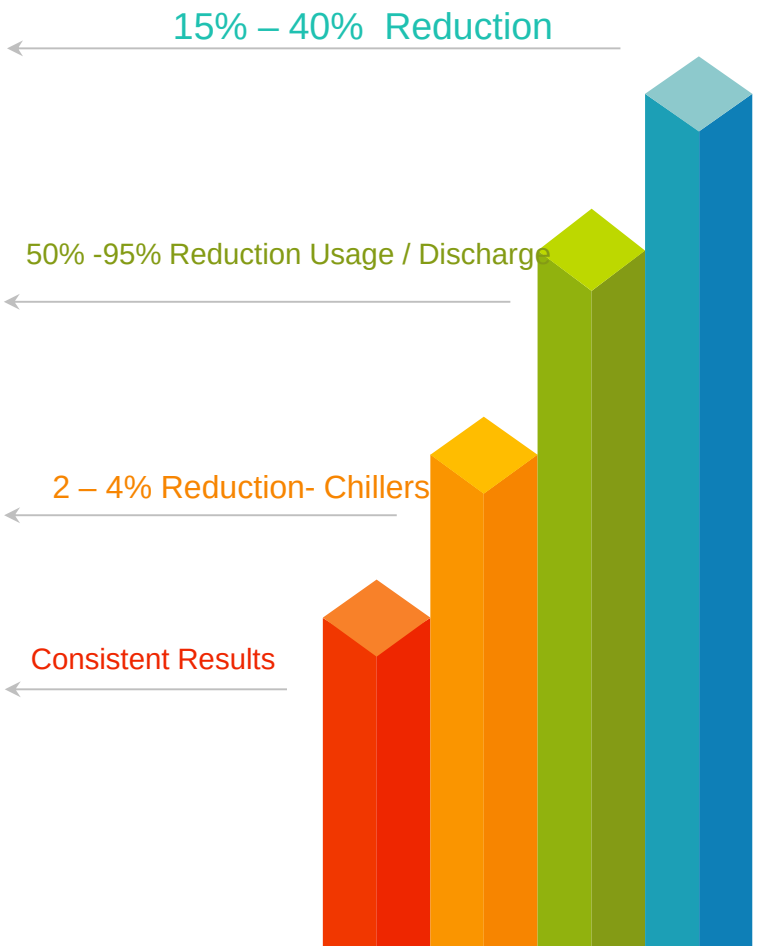
What Are a Typical IVG-CT Project's Goals?

Water savings
- Operating the cooling towers at higher COC (5 - 10)
- Saves Water though lower make-up water
- Depending on site water, can reuse up to 100% blow-down water for other purposes such as irrigation, lower sewer discharge
- Earns customer water incentives

Reduce chemical use
- Reduced operational costs of purchased chemicals and lower service costs
- Reduced toxic elements in blow-down water
- More sustainable, supports a circular economy

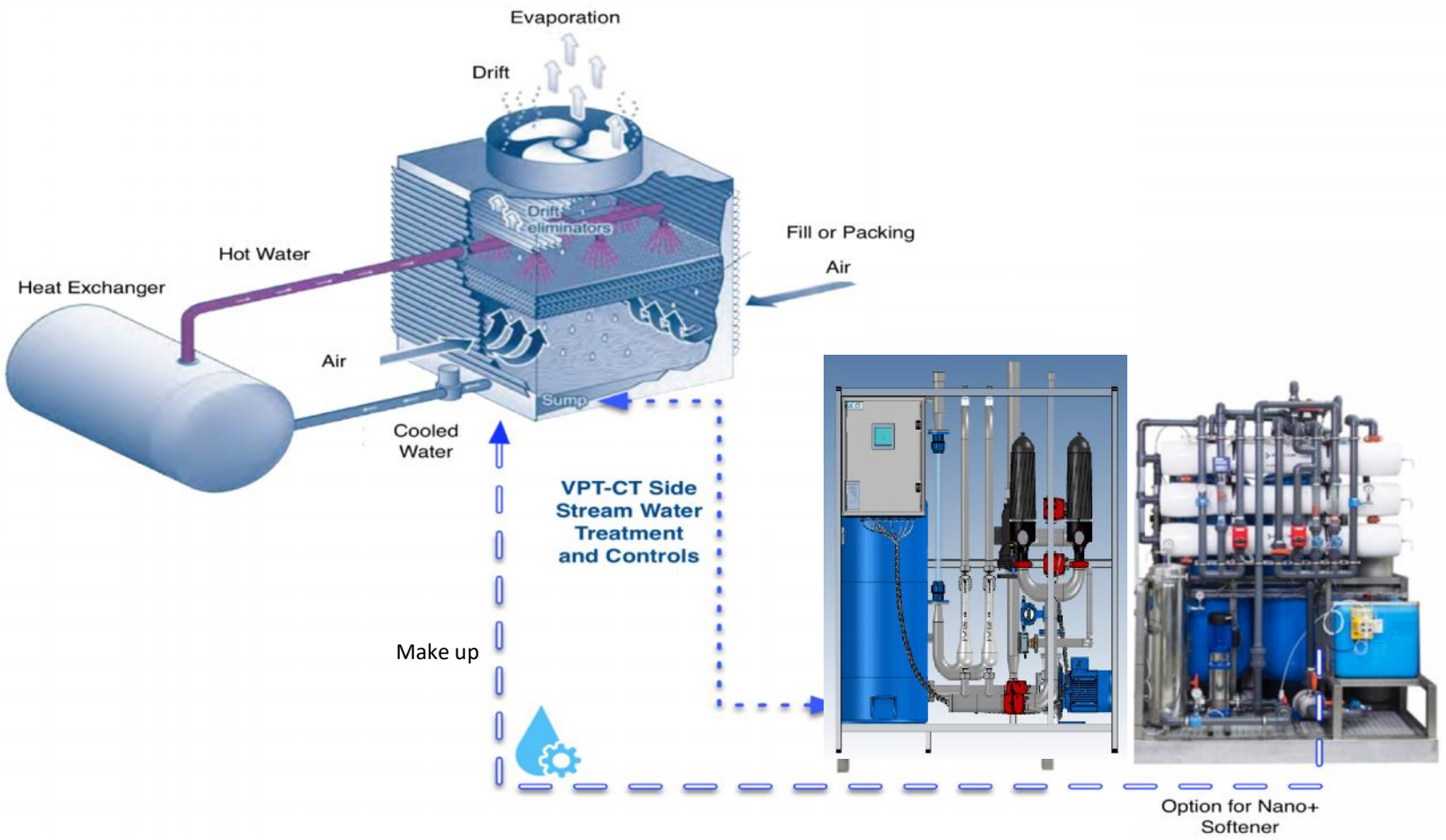
Save Energy
- Better heat transfer, degrades and prevents cooling tower scale
- Embedded Energy: Additional upstream/downstream kWh/kW savings from reduced water pumping and water treatment

Continuous Performance Monitoring
- Monitoring and Control system integrated with delivered technology
- Consistent with Best Practices
- Web access and reports



Typical Configuration

(VPT) for Cooling Towers



VPT PROCESS

1) Removes micro-bubbles of air resulting in a decrease in viscosity from 5-17% and has better heat transfer properties
Scale control *and partial bacteria cell wall disintegration*

- Removes unbound gasses (air, CO2) from the water by a vacuum in the middle of the vortex – controlled cavitation due to the design of the unit
- Calcium bicarbonate (CaHCO3)2 in the water is forced to precipitate out in the form of calcite (CaCO3) – primarily aragonite crystals which have minimal scaling properties – does not precipitate on surfaces

4) UV-C microbiological control system

2) Eliminates and/or significantly reduces lime scale in water treated using the IVG-CT system soluble forms of calcium such as calcium bicarbonate $(CaHCO_3)_2$ are transformed into calcite and aragonite, which do not attach to pipes, nozzles or other surfaces and a removed.

3) Filtering: By automatic filtering the cooling water continuously, the lime particles and other material is filtered out of water. There are manually and automatic filters provided with a range of 10- 20 microns of filter material

- Nano Filtration depending on target COC

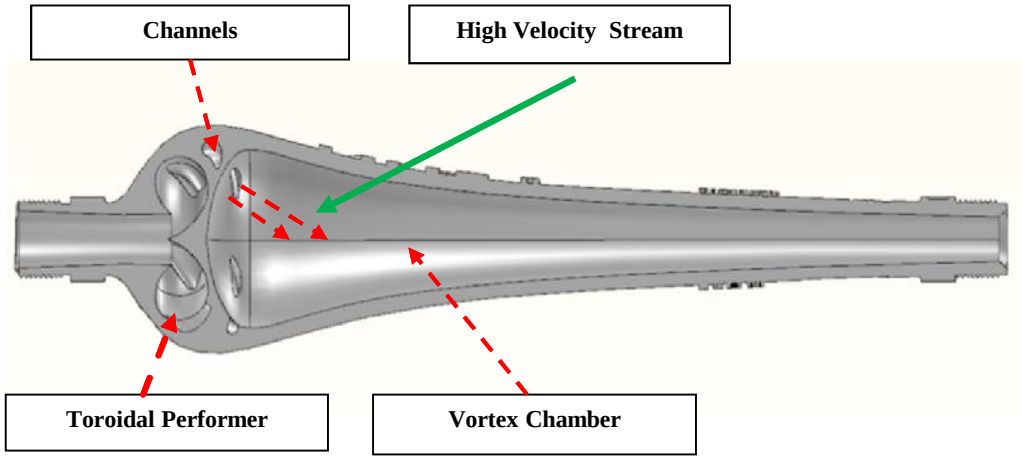
5) Continuous s Performance Monitoring (PBI)
SCADA control panel with sensor inputs with both local and/or remote monitoring and trending to control cycles of concentration based on water quality conditions including conductivity and/or flow-based controls.
Automatic blow-down control, Water flow monitoring etc.

TECHNOLOGY DESCRIPTION

VORTEX PROCESS TECHNOLOGY (VPT) FOR COOLING TOWERS

- Based on a low energy use Vortex Process Technology (VPT), developed in Sweden by Watreco and distributed worldwide by H_20 Vortex. Watreco A.B. holds the world-wide patents on the vortex process technology (VPT). http://www.watreco.com/engelska.php
- H2O Vortex (www.h2ovortex.com) is a Luxembourg-based company focusing on commercializing and distributing sustainable and energy saving solutions to a wide variety of global markets
- The design enables a consistent and low energy method to achieve physical water treatment (PWT) water treatment in a variety of end use applications.

- Pre-former: Inlet of the vortex generator provides smooth outward direction of the flow through toroidal motion toward a set of well-defined channels. Channels: The fluid is directed through a set of channels, each with vortex-forming geometry. Each channel delivers a very high velocity stream of vortex flow tangentially into a vortex chamber
- Vortex chamber: Vortices from the channels form a strong and stable vortex flow
- Causing a strongly reduced pressure along the vortex axis with a very low central pressure There is very high pressure at the periphery and almost vacuum in the center



TECHNOLOGY DESCRIPTION

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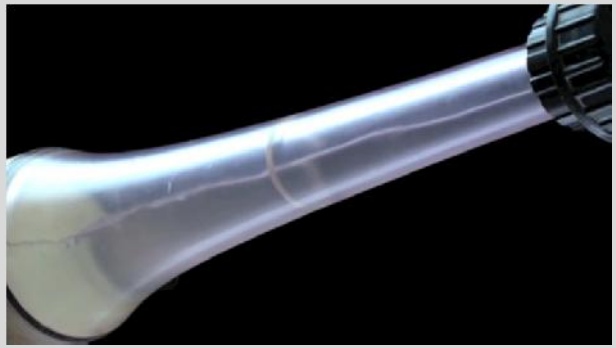

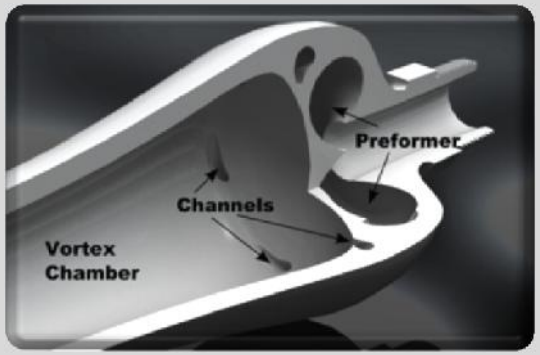

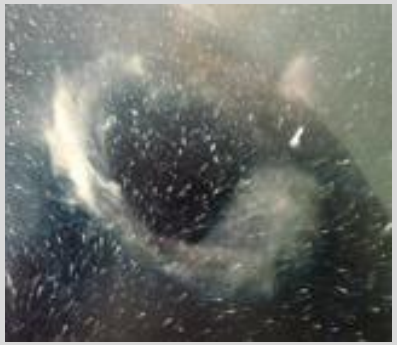

- Micro-bubbles in water pulled into the extreme **low-pressure chamber.** Micro-bubbles that are present migrate towards the center where the lowest pressure is and accelerated due to the pressure gradient https://www.youtube.com/watch?v=ZWcBEPlj2-I
  - The bubbles expand and combine in the center with a very low pressure
  - The strong **hydrodynamic force creates cavitation** changing the water balance and affects the calcium crystals in the water
- As bubbles are removed a decrease in **viscosity of 5%-17%** occurs.
- Heat capacity: + 5% for ice and **+ 3% for liquid water**
- **Controlled Cavitation:** leads to the formation of lime particles in hard water. The process results in low pressure and high temperature micro-zone (solubility of $CaCO_3$ decreases) causing the dissolved calcium and carbonate ions to react and form colloidal calcium carbonate crystals. This increases pH and allows the particles to act as incubation sites for dissolved calcium and carbonate ions to grow on, in lieu of, metal surfaces.
- **Fragmentation:** Already formed lime particles fragment as they move through the pressure gradients and shear forces
  - **Precipitation- nuclei formation:**
    - Calcium bicarbonate $(CaHCO_3)_2$ in the water is forced to precipitate out in the form of calcite ($CaCO_3$) – primarily aragonite crystals which have minimal scaling properties – does not precipitate on warm surfaces
    - Such particles act as seeds (crystallization nuclei) for new lime growth. New lime formation will add to the lime particles rather than cause lime-scaling on the equipment.

TECHNOLOGY DESCRIPTION

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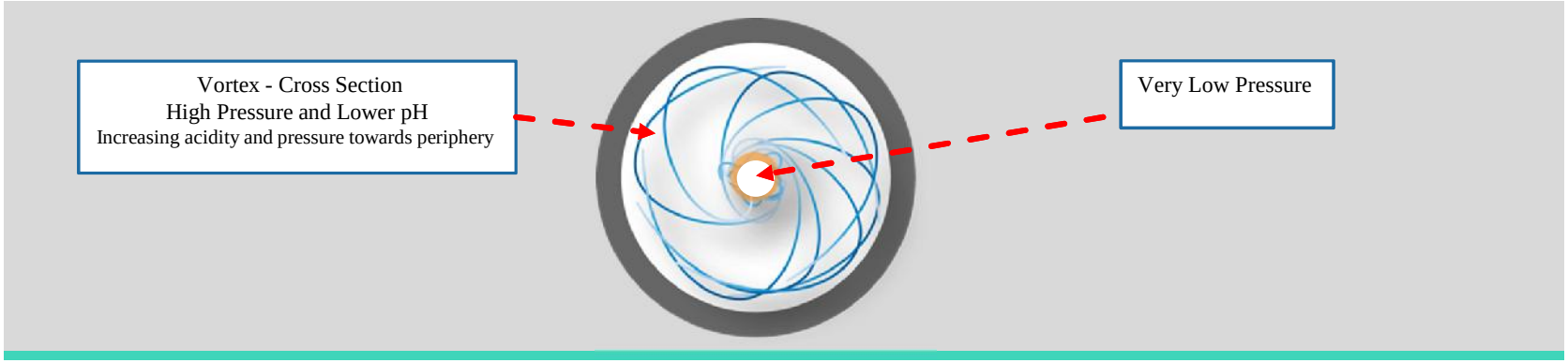
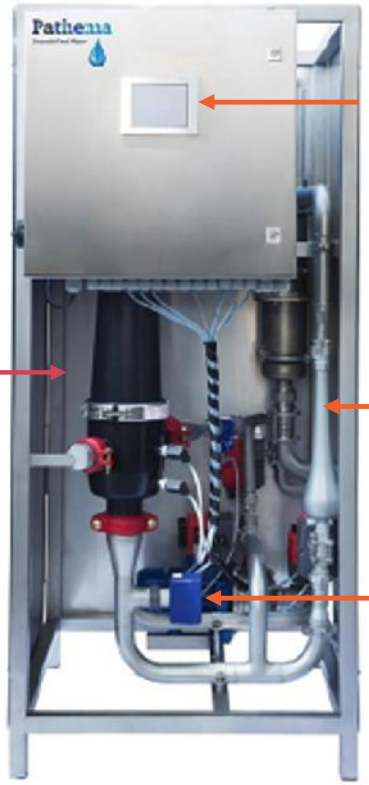


- As the pressure increases towards the periphery the remaining solubility for CO_2 also increases. When the pressure is increased towards the periphery there will be a difference in the pH level following the pressure gradient. In this case the pH level will decrease towards the periphery following the increased pressure.
- The calcium ion precipitates and forms calcium carbonate $CaCO^3$ at a specific pH level. The pH level varies from the center to the periphery where the calcium ion will begin to precipitate during the reaction with H_2CO_3. The precipitation will occur in the moving water, within the VPT.
- The calcium crystallization process in using VPT is due to the pressure gradient and the sheer forces inside the vortex. There is an interaction between water, the calcium ion and CO^2. Since CO^2 is more soluble in water as a function of pressure, i.e. higher pressure = higher solubility and makes the higher CO^2 concentration slightly acid together in the water. Since the pH level varies along the pressure gradient so that there is lower pH at the periphery and higher in the center of the vortex the calcium ion precipitates and forms calcium carbonate $CaCO^3$ at a specific pH level.
- The calcium carbonate in this way forms Aragonite and Calcite hard crystals due to the dynamic treatment in the vortex with its high sheer forces. Therefore, this precipitate is not available to coat warm surfaces such as heat transfer surfaces, reducing lime scale and can be both filtered with the PVT skid and/or blown-down as part of the typical tower maintenance.

EXAMPLE IVG 10 (UNDER 900– TONS)

(IVG-CT) FOR COOLING TOWERS AS A SIDE STREAM WATER TREATMENT



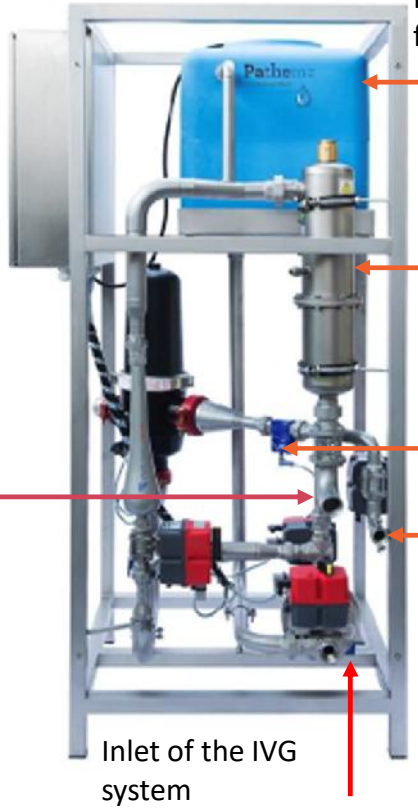
Touch HMI PLC
multiple I/O functions
Network Comm

Automatic micron
disc filtration

Industrial Vortex Generator IVG

Outlet of the IVG
treated water

Conductivity meter



Back wash
for disc filter

(UV-C) light to kill
or inactivate
microorganisms

Electromagnetic
flow meter

Blowdown outlet

Inlet of the IVG
system