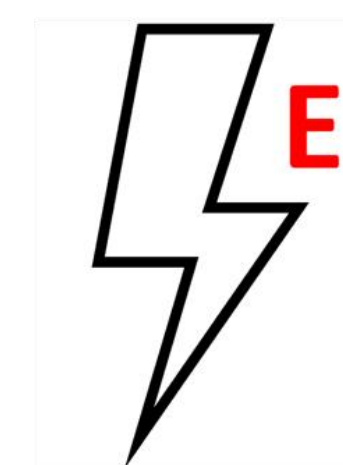


Optimization of Cooling Tower Systems in Organic Rankine Cycle (ORC) Applications: A Sustainable Engineering Approach

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Introduction

Elevator Pitch

Cooling towers waste water, energy, and recoverable heat due to fixed-speed fans and manual dosing. We integrate an ORC for heat recovery, automated fan control, and smart dosing to create a more efficient, cleaner, and self-regulating cooling system.

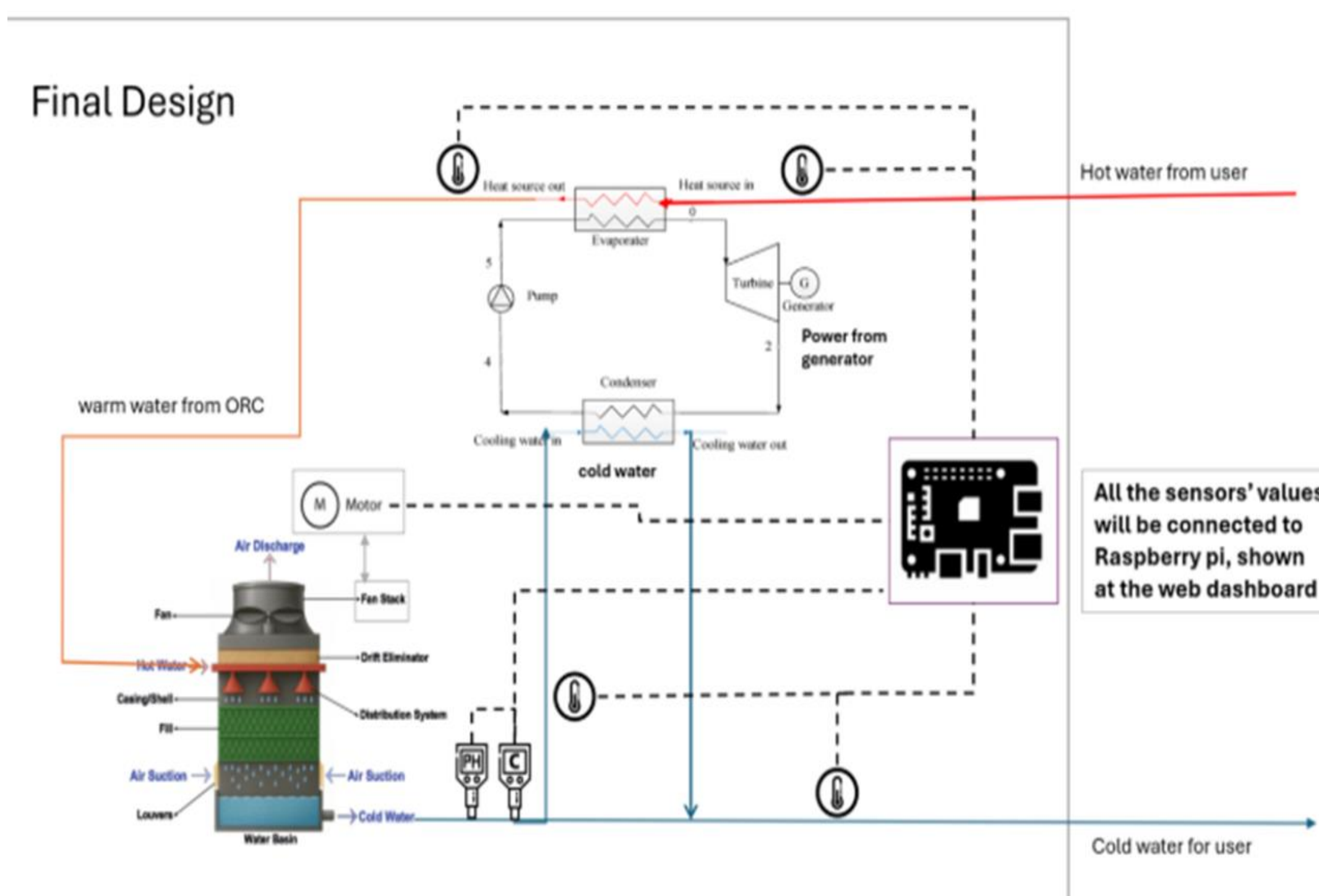
Problem Statement

Cooling towers use excess energy, lose low-grade heat, and depend on inaccurate manual dosing. These issues increase cost and reduce reliability, highlighting the need for an automated and energy-recovering solution.

Objective

- Develop an upgraded cooling tower with automated control and improved efficiency.
- Recover waste heat using an ORC module.
- Stabilize water quality through smart dosing.
- Demonstrate a sustainable design suitable for real industrial use.

PFD & Discipline contribution



Process flow diagram

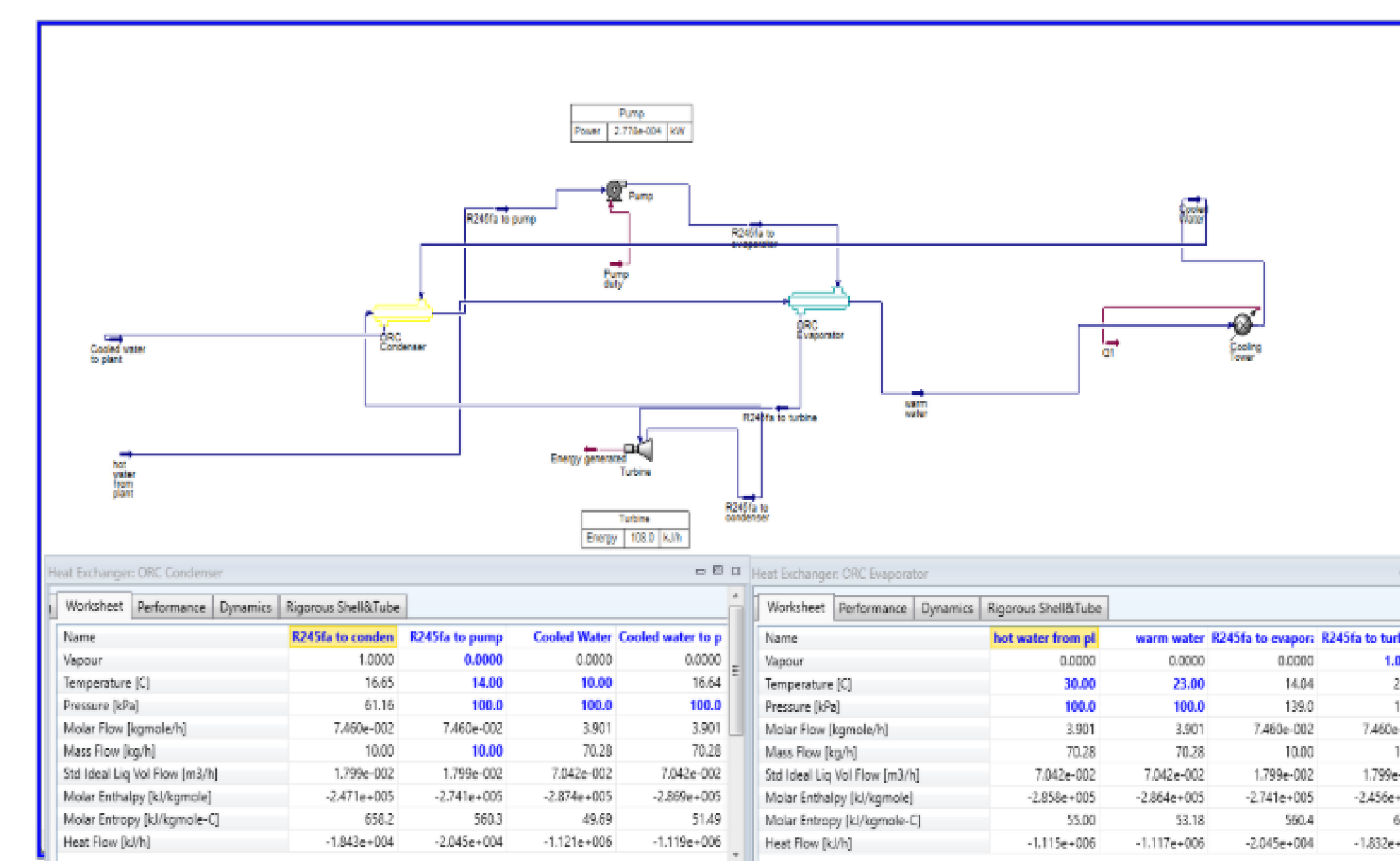
Constraint

- Harsh conditions: 60° C ambient, >85% humidity.
- Water quality degradation with time.
- ORC fluid must be low-toxicity (R245fa).
- Safe fan minimum load must apply if sensor fails.
- Fan speed operation: 40–80% range
- Turbine output $\geq 90\%$ of predicted

Specifications

- Wireless sensor latency: ≤ 1 s
- Sensor accuracy: $\pm 0.5^\circ$ C, ± 0.1 pH, ± 10 μ S/cm
- The system must track at least one critical factor and use control charts to monitor its impact on productivity.
- Stable operation $\geq 95\%$ of time (SPC requirement)
- Positive net ORC power generation
- Cost-effective: payback < 5 years

Design verification

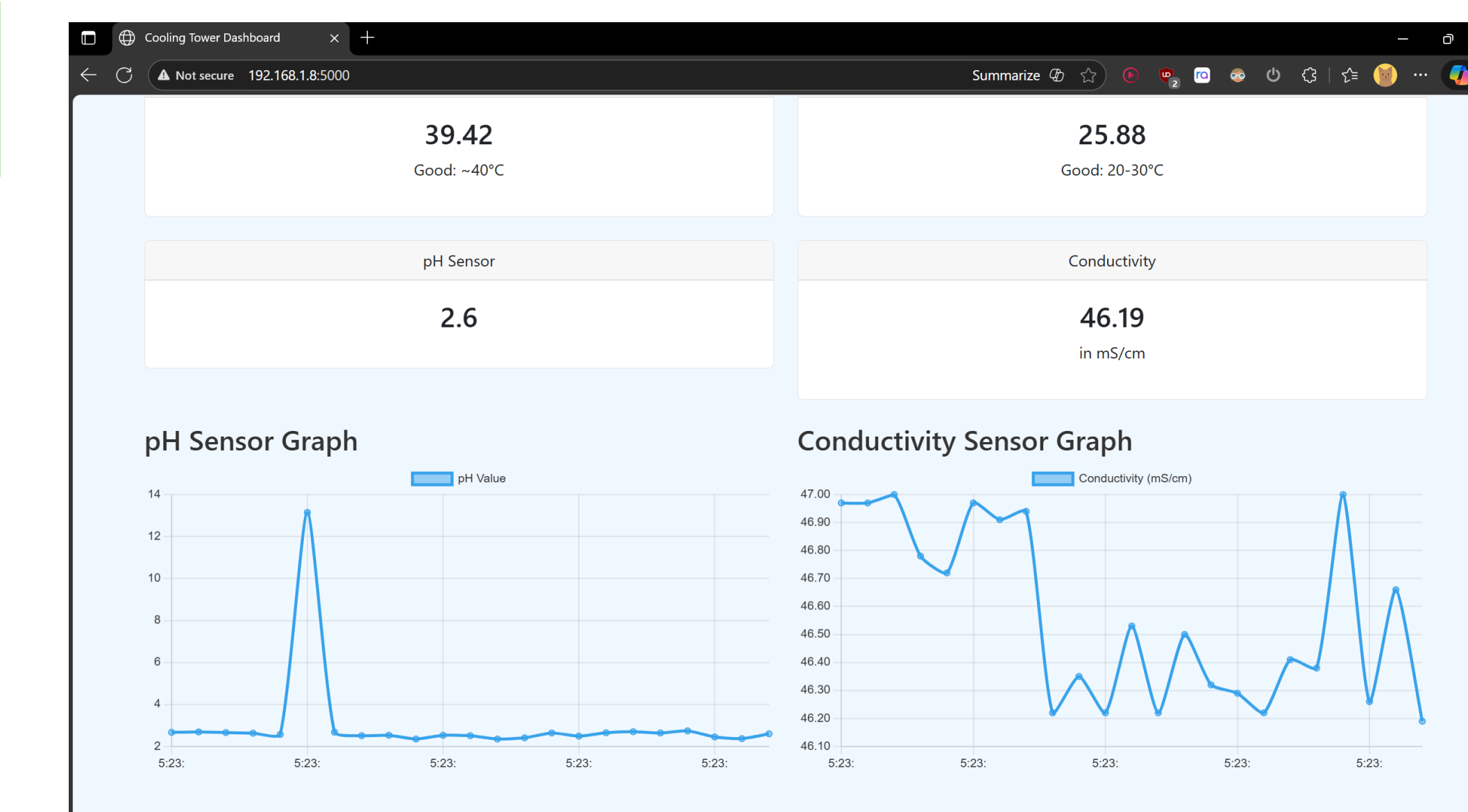


ORC/Cooling Tower simulation

Validation & Results



- ORC power consumption: 4.8 W
- heat removed from water: 1.36 kW



Web dashboard: It shows the values of the temperature sensors (before and after the cooling tower), the pH and the conductivity sensor.