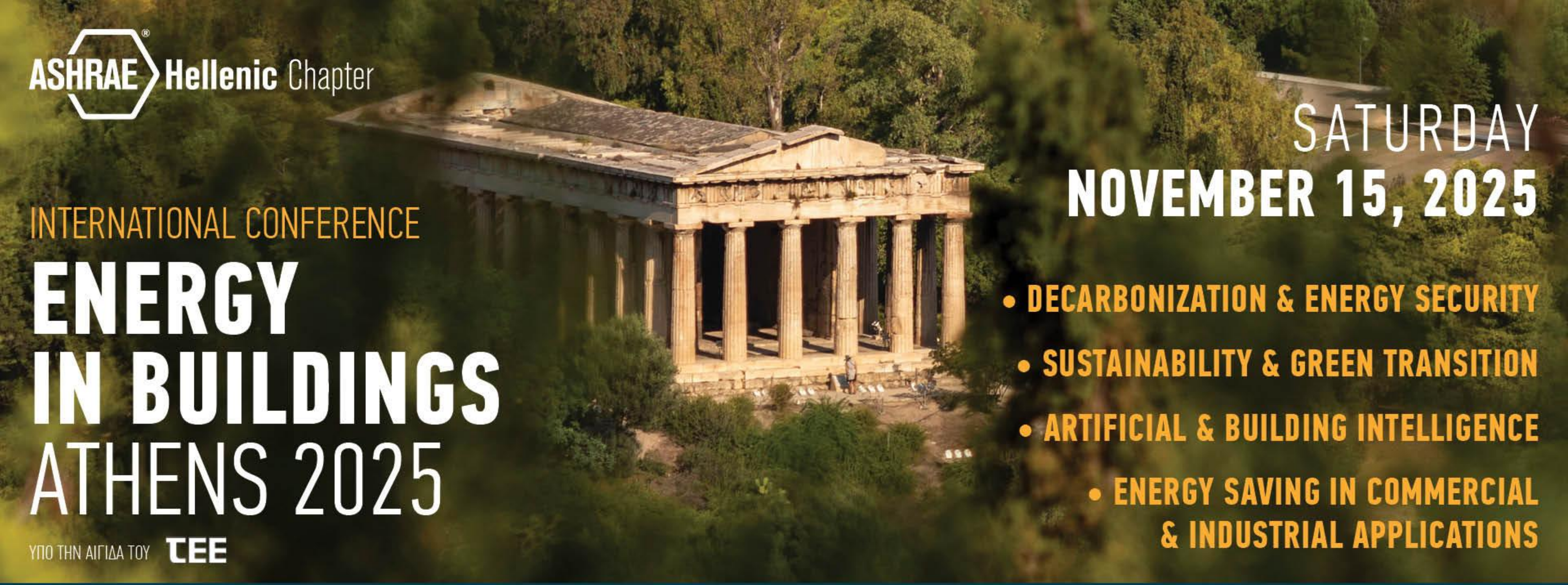

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INTERNATIONAL CONFERENCE

ENERGY IN BUILDINGS ATHENS 2025

ΥΠΟ ΤΗΝ ΑΙΓΙΔΑ ΤΟΥ ΤΕΕ

SATURDAY NOVEMBER 15, 2025

- DECARBONIZATION & ENERGY SECURITY
- SUSTAINABILITY & GREEN TRANSITION
- ARTIFICIAL & BUILDING INTELLIGENCE
- ENERGY SAVING IN COMMERCIAL & INDUSTRIAL APPLICATIONS

09:00-18:00 | @ DIVANI CARAVEL HOTEL, ATHENS

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SATURDAY NOVEMBER 15, 2025

INTERNATIONAL CONFERENCE

ENERGY IN BUILDINGS ATHENS

ΥΠΟ ΤΗΝ ΑΙΓΙΔΑ ΤΕΕ

ARISTOTELIS TSEKOURAS

CONSULTANT ENGINEER IN GRAND ALPHA – SUSTAINABLE ENGINEERING & CONSULTING

«COMMISSIONING AND PERFORMANCE VERIFICATION IN HYDRONIC HVAC SYSTEMS: PATHWAYS TO ENERGY OPTIMIZATION»

09:00-18:00 | @ DIVANI CARAVEL HOTEL, ATHENS

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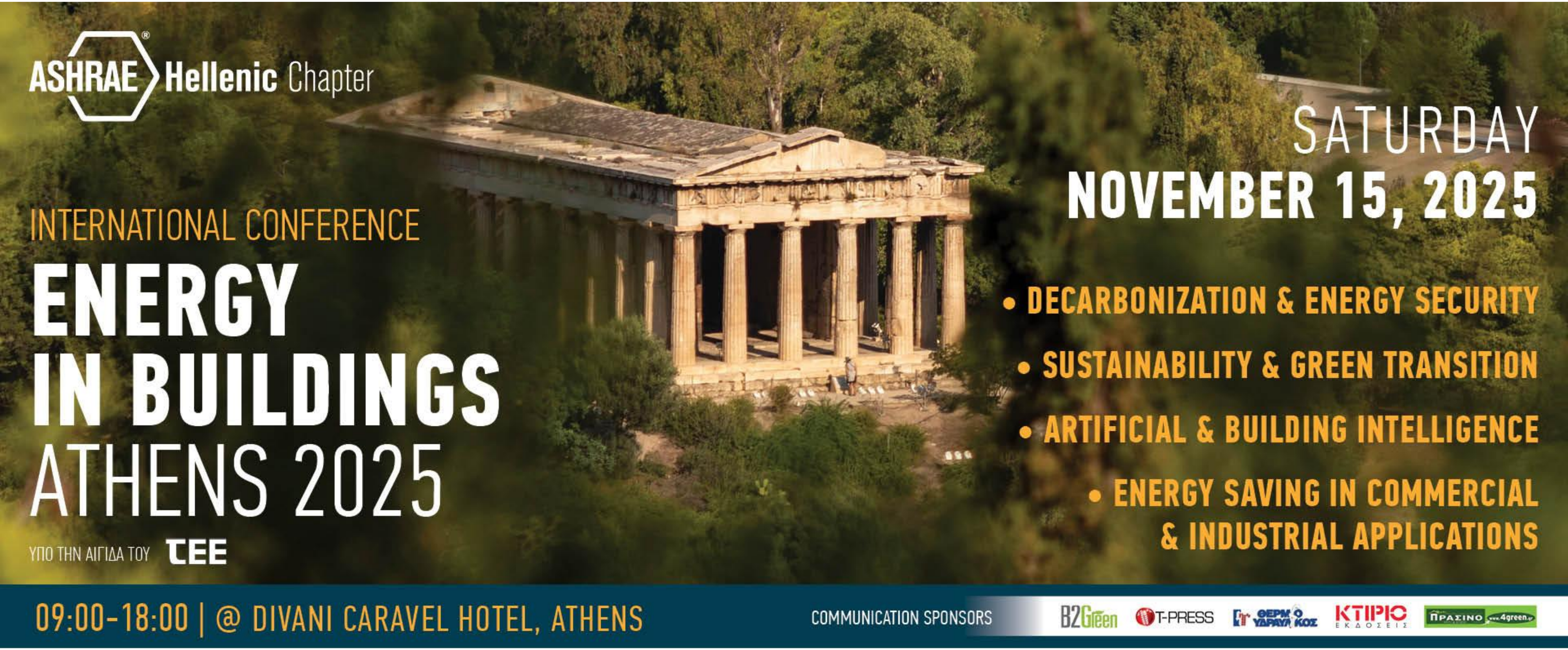
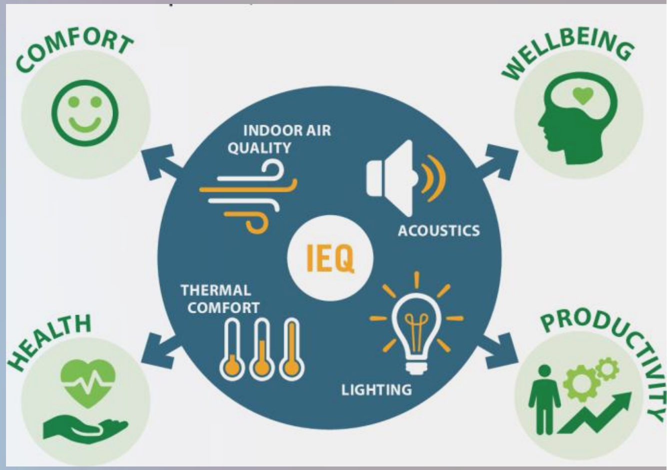
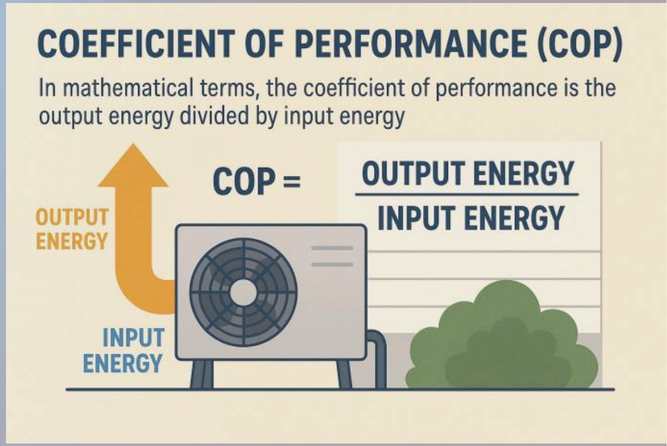


Commissioning and Performance Verification in Hydronic HVAC Systems: Pathways to Energy Optimization

Introduction – The Role of Commissioning in Energy Optimization

- In recent years, energy efficiency and consumption reduction have become **key priorities**.
- In Greece, 15–20 years ago, HVAC design aimed mainly **to be functionally**— not to measure real efficiency.
- Older chiller brochures **rarely mentioned EER or COP** (only maximum cooling and absorbed power).
- Climate change and the energy crisis accelerated the need for high efficiency.COVID-19 reminded us that Indoor Environmental Quality (IEQ) is **equally essential**.
- The pursuit of efficiency led to **more complex HVAC systems** — variable flow, advanced controls, and hybrid hydronic loops.





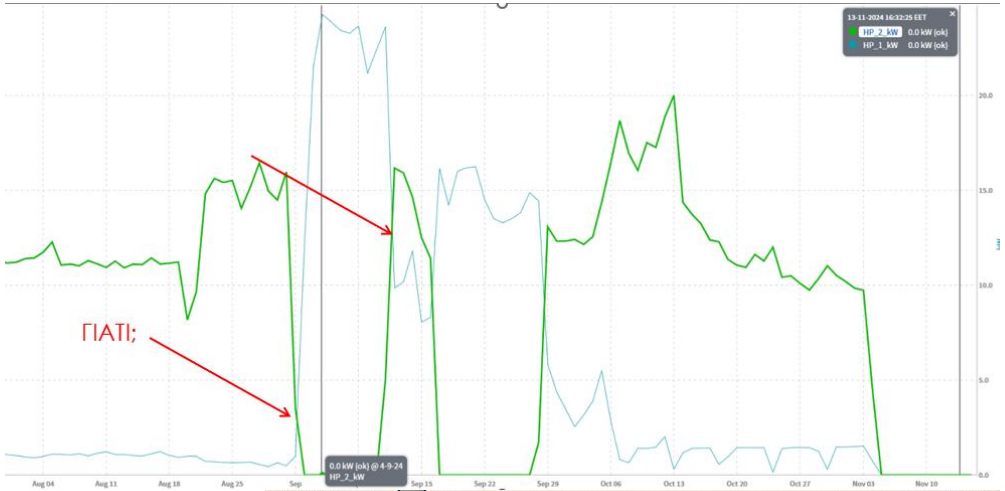
Key reference: ASHRAE Guideline 0 – "The Commissioning Process"

Why Commissioning Matters?

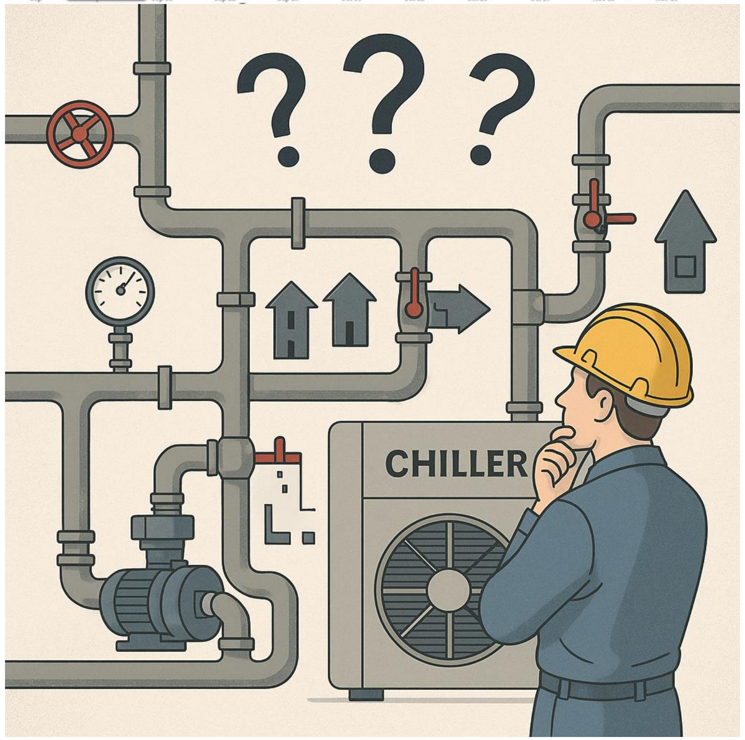
- Commissioning bridges the gap between **design targets and real operation.**
- It ensures systems are installed, tested, and fine-tuned to achieve **expected performance.**
- As defined by ASHRAE Guideline 0:“*A quality-oriented process for achieving, verifying, and documenting that the performance of facilities meets defined objectives and criteria.”*

Key reference: ASHRAE Guideline 0 – “The Commissioning Process”

Without Commissioning?



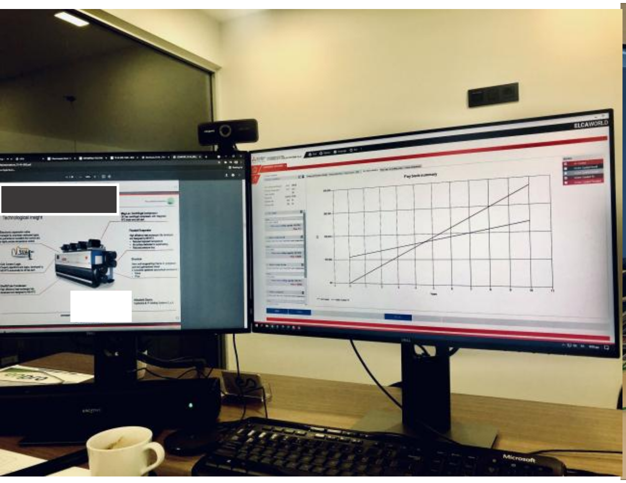
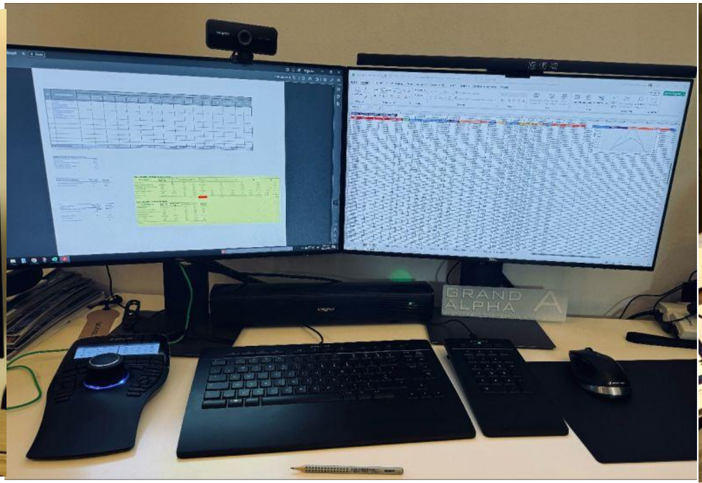
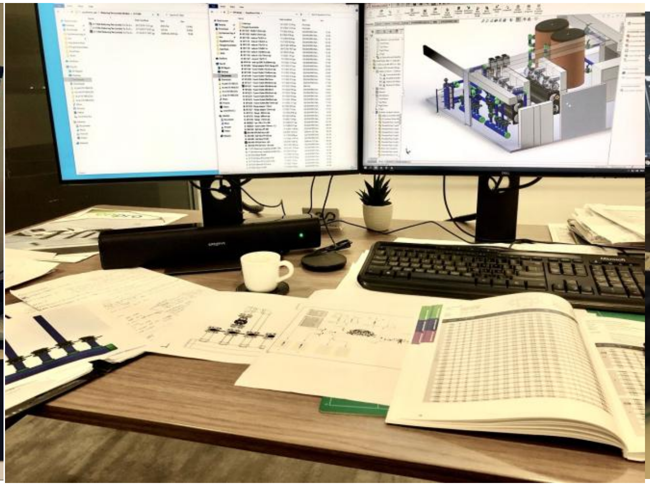
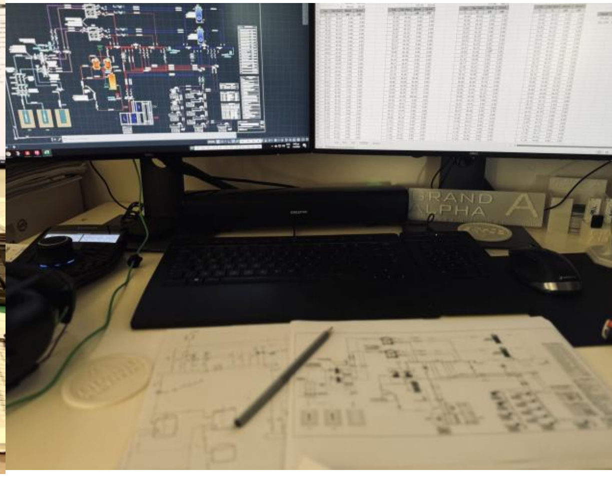
- *Who will ensure the optimal pump operation?*
- *What if we have overflow in a Chiller in terms of efficiency?*
- *How crucial is the Low-DT syndrome?*
- *Is it the right measurement of a Temperature sensor when we have less flow?*
- *If the sensor are in wrong position?*
- *Who will ensure that pumps operate without cavitation?*
- *Are the sensors and other instruments in the proper position?*
- *Is the by-pass branch right constructed?*



Key reference: ASHRAE Guideline 1.1 – HVAC&R Technical Requirements for the Commissioning Process.

The Commissioning Process Framework

- ***Project stages:*** ***➜*** *Pre-design → Design → Construction → Acceptance → Operations*
- ***Commissioning Authority*** *(CxA):Leads and coordinates all verification and testing activities.*
- ***Key documentation****: Owner's Project Requirements (OPR), Basis of Design (BOD), Commissioning Plan, and Checklists.*
- ***Performance verification:*** *Conducted through functional testing, trend logs, balancing results, and detailed reports.*

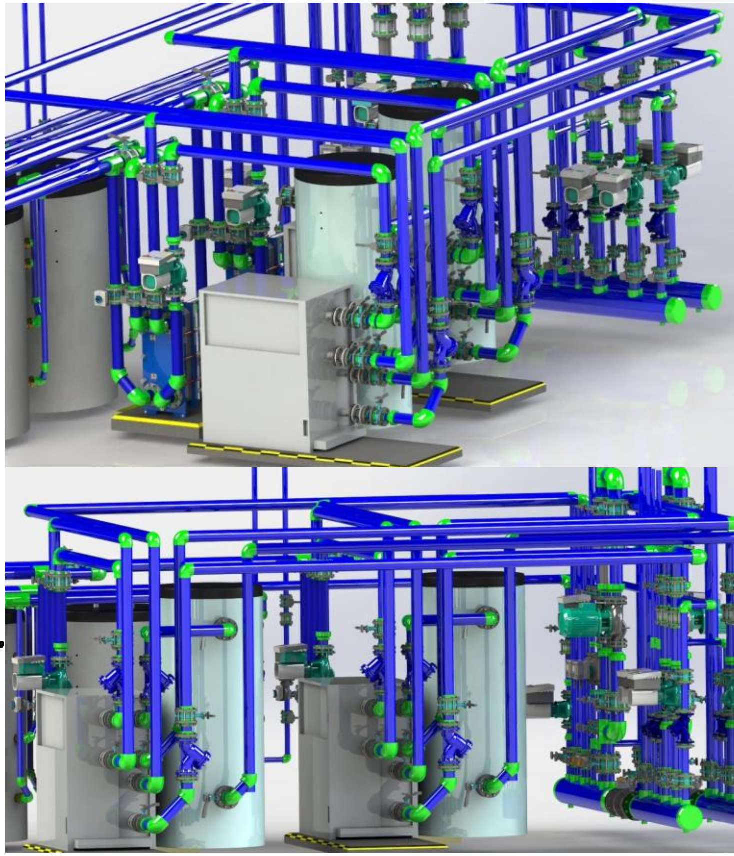
Key reference: ASHRAE Standard 202.

Hydronic HVAC Systems: Characteristics and Challenges

Hydronic systems offer high efficiency and flexibility — but only when properly balanced and controlled.

Without commissioning, several issues can compromise performance:

- *Poor hydraulic balance across loops and terminals.*
- *Unnecessary recirculation and excessive pump operation.*
- *Low ΔT syndrome, reducing chiller or boiler efficiency.*
- *Incorrect sensor readings due to low circulation or misplacement.*
- *Oversized equipment and unstable partial-load operation.*
- *Faulty or uncalibrated sensors and incorrect control tuning.*
- *The result: energy losses, reduced comfort, and poor COP/ΔT performance.*



Key reference: ASHRAE Standard 202.

Performance Verification and Optimization

- ***Commissioning introduces a data-driven method to verify real operation.***
- ***Key actions:***
  - ***Measure flow rates, temperatures, and ΔT across loops.***
  - ***Validate sensor accuracy and calibration.***
  - ***Analyze trend logs to detect inefficiencies or cycling issues.***
  - ***Optimize control logic and balancing for stable, efficient operation.***
  - ***Verified performance ensures hydronic systems operate as designed, maximizing both efficiency and comfort.***

CASE STUDY

Commissioning in a Geothermal HVAC Hydronic Plant

Central HVAC and Domestic Hot Water System for a 250 room Resort Hotel.

- Designed to provide **cooling, heating, and DHW**.
- Based on **two geothermal multifunctional heat pumps:** 520 kW_{th} total Cc
- **A water-cooled high-temperature booster heat pump:** 250 kW_{th} .
- **Open-loop geothermal system** of 2 production wells (up to **100 m^3/h**) & 2 **titanium plate heat exchangers** in parallel

Key reference: ASHRAE Guideline 1.1 – HVAC&R Technical Requirements for the Commissioning Process.

CASE STUDY

Hydraulic Layout

The installation includes multiple closed hydraulic circuits:

- Heat Exchanger – Geothermal HPs loops: 2 circuits
- Primary Geothermal HPs (cold & hot): 4 circuits.
- Booster HP: Source side, User side (primary & secondary): 3 circuits.
- Secondary HVAC distribution: 9 pumps.

Circuits equipped with:

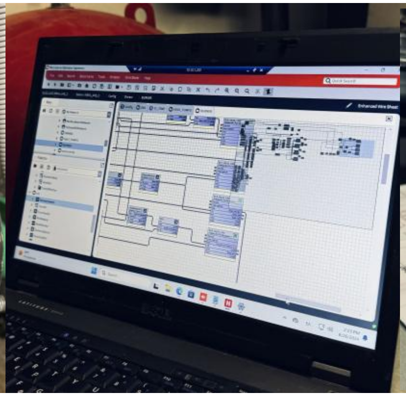
- Analog and On/Off motorized valves for isolation, bypass, and flow regulation.
- Pressure and temperature sensors at key points.

CASE STUDY

Commissioning Strategy: A Proactive Approach

- The **commissioning strategy** was embedded **before the project design**.
- Commissioning was not limited to start-up testing — it defined **requirements, opportunities, and design constraints** from the proposal stage.
- Early inclusion allowed optimization of design logic, system layout, and client expectations.
- **Goal:** Integrate commissioning as a **design-driving process**, not a post-installation activity.



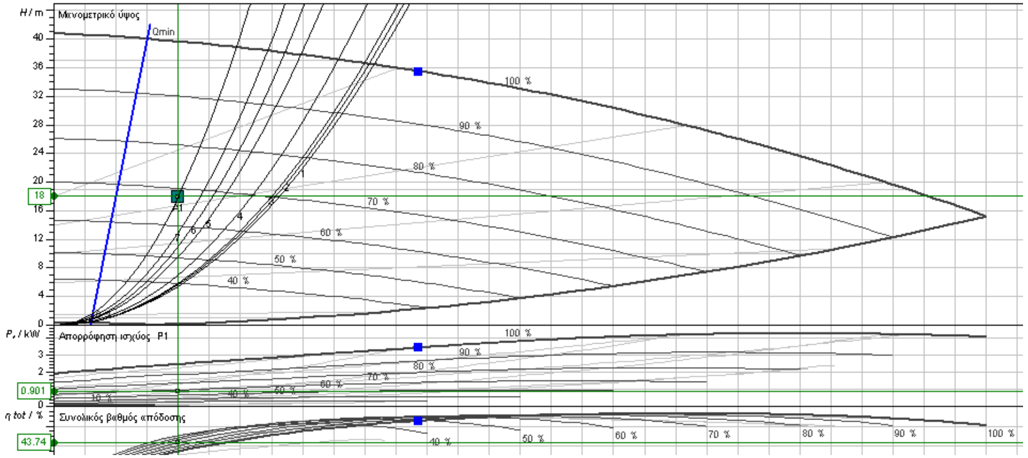




Key reference: **ASHRAE Standard 202** and **Guideline 1.1** requirements

CASE STUDY

Design Phase Insights

- Design initiated **prior to dismantling the existing system**.
- **Hydraulic curves** of each circuit were measured and plotted.
- Ensured **pump homogeneity** to minimize spare parts and simplify operation.
- Result: Reduced installation cost and improved system maintainability.

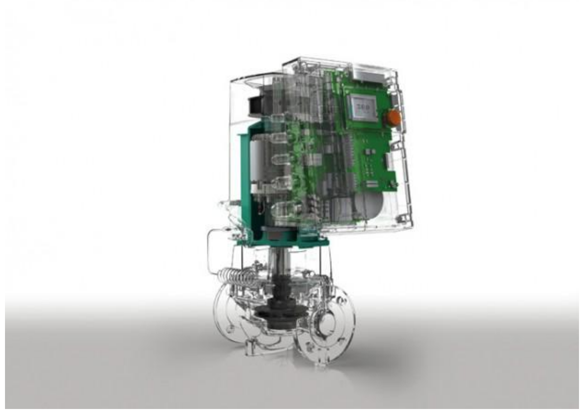


Key reference: **ASHRAE Standard 202** and **Guideline 1.1** requirements

CASE STUDY

Design Requirements Driven by Commissioning

- **SCADA-BEMS integration** with extensive sensor network (flow, temperature, pressure).
- All equipment designed for **full controllability**:
  - Inverter-driven pumps
  - Analogue motorized valves
  - Data-ready controllers.
- Enabled **standardization and modularity** across all hydraulic circuits.



Key reference: **ASHRAE Standard 202** and **Guideline 1.1** requirements

CASE STUDY

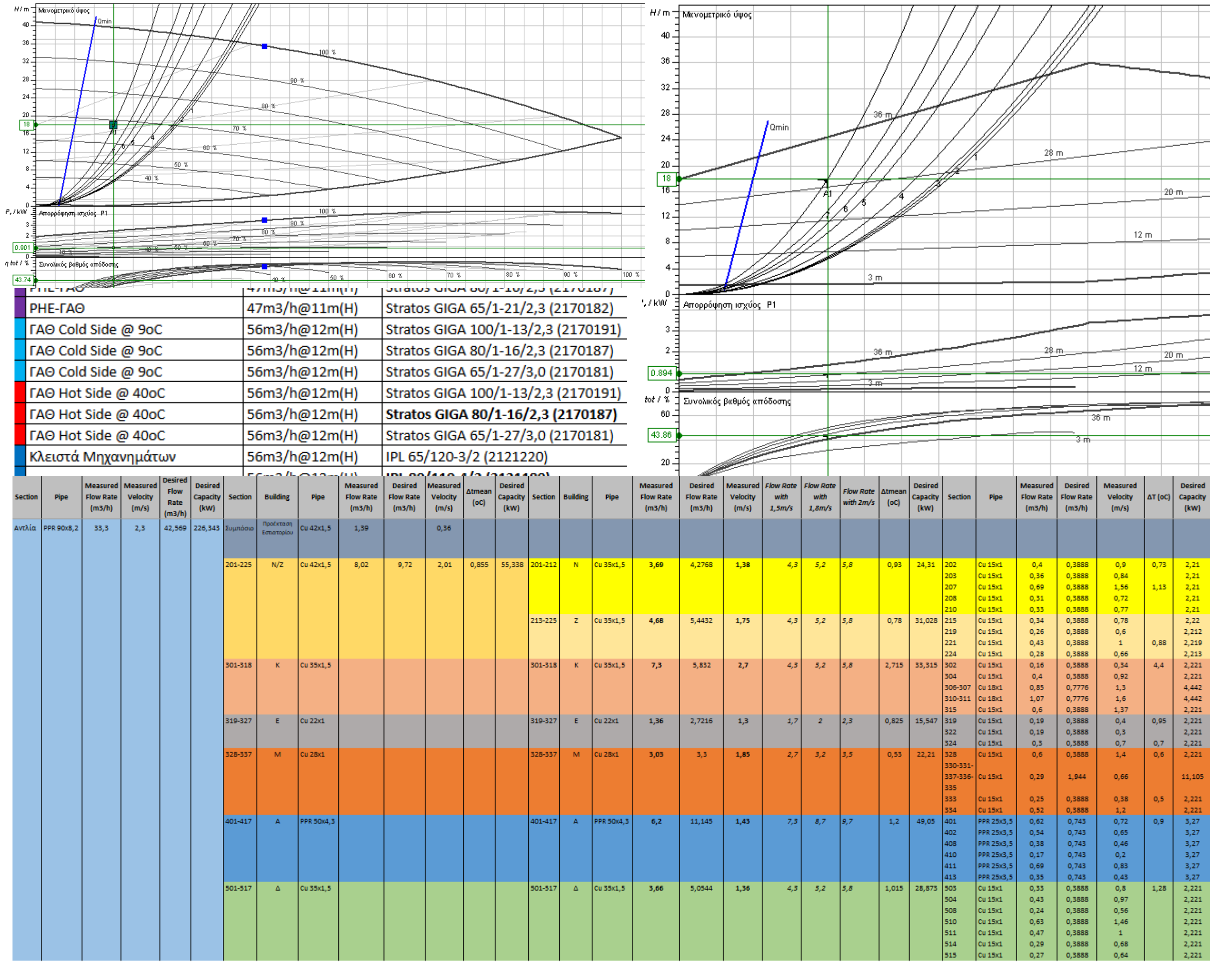
1.Commissioning Execution

- Before dismantling, **flow measurements** were taken using a **clamp-on ultrasonic flowmeter**.
- Defined **10–14 operational points** per circuit (flow, Hz, Amps, rpm).
- Determined target setpoints from real thermal loads and demand profiles.
- Searched for **single pump models** capable of covering all 9 circuits to ensure uniformity.
- **Outcome:** Full operational map of the hydraulic system before construction began.

CASE STUDY

2. Detailed Flow Design and Pump Selection

- Conducted a **detailed flow design** for every new primary hydraulic branch.
- Determined the **exact operational points** for each circuit based on thermal load and head loss calculations.
- Identified pump models capable of covering all eight remaining flow points.
- Selected **a single standardized pump model** to optimize spare part logistics, maintenance, and installation cost.
- **Outcome:** Complete flow characterization of each primary circuit with unified equipment specification.



CASE STUDY

3. Commissioning Preparation – Geothermal Wells

- Commissioning began with **geothermal well calibration**.
- Defined **maximum target flow** using hydraulic and thermal design parameters.
- Operated each production well **individually and in parallel** to simulate full-load conditions.
- Measured flow using a **clamp-on ultrasonic flowmeter** to determine inverter frequency corresponding to nominal well flow.
- Established this frequency as the reference for **automated SCADA control**.

CASE STUDY

4. Source-Side Circuits – PHEs-> GHPs

- Using manufacturer print-outs, recorded the **required design flow** under nominal temperature conditions.
- Verified actual flow via **clamp-on measurements** and set nominal points for each pump.
- Measured and defined **minimum allowable flow** for safe heat pump operation per manufacturer data.
- Programmed minimum flow limits into the **SCADA system** for automatic protection.
- Confirmed flow stability during **start-up and under-load operation** of geothermal heat pumps.
- **Outcome:** Full functional validation of the geothermal source-side hydraulic system.

CASE STUDY

5. User-Side Circuits of GHPs

- Verified nominal and design flow from heat pump manufacturer data.
- Measured actual flow rates and adjusted inverter frequencies to match design conditions.
- Conducted **live validation under operating load** to confirm thermal stability.
- Tested 3-way motorized valves for **continuous analog modulation** and **bypass flow control**.
- Using the flowmeter, confirmed that during the modulation range (thermoregulation), the **primary flow remained within design limits**.
- **Result:** Balanced and dynamically regulated primary circuits ensuring steady ΔT and optimal COP.

CASE STUDY

6. Secondary HVAC Circuits

- Based on defined design points, operated **secondary pumps in parallel** at representative speeds per manufacturer curves.
- Measured actual flow and established the **nominal operating point** for each pump.
- Defined both **maximum and minimum operating limits** through measurements at the most distant branches.
- Implemented in SCADA a **dynamic ΔT-based control logic** using **PID regulation** for adaptive speed control.
- Ensured consistent differential temperature and efficient pump operation across variable loads.
- **Outcome:** Stable hydronic operation with minimized pumping energy and controlled ΔT variation.

CASE STUDY

7. DHW Preparation Circuit

- Verified flow requirements for the **Booster Heat Pump** according to factory specifications.
- Measured and adjusted flow in the **secondary open DHW loop** (heat exchanger circuit).
- Defined **minimum desired flow** to maintain accurate average temperature data for control algorithms.
- Ensured proper sensor feedback for the system's **load-based decision-making logic**.
- **Result:** Optimized DHW heating performance and accurate feedback control through verified flow conditions.

CASE STUDY

8. Domestic Hot Water Recirculation

- Conducted **flow measurements** in the domestic hot water **recirculation loop**.
- Selected **a single pump model** for all recirculation circuits to standardize maintenance and replacement.
- Defined **minimum operating flow** for each pump using clamp-on flowmeter validation.
- Established **PID temperature-return control logic** in SCADA to maintain consistent DHW return temperatures.
- **Outcome:** Efficient recirculation control, reduced standby energy losses, and simplified spare part management.

CASE STUDY

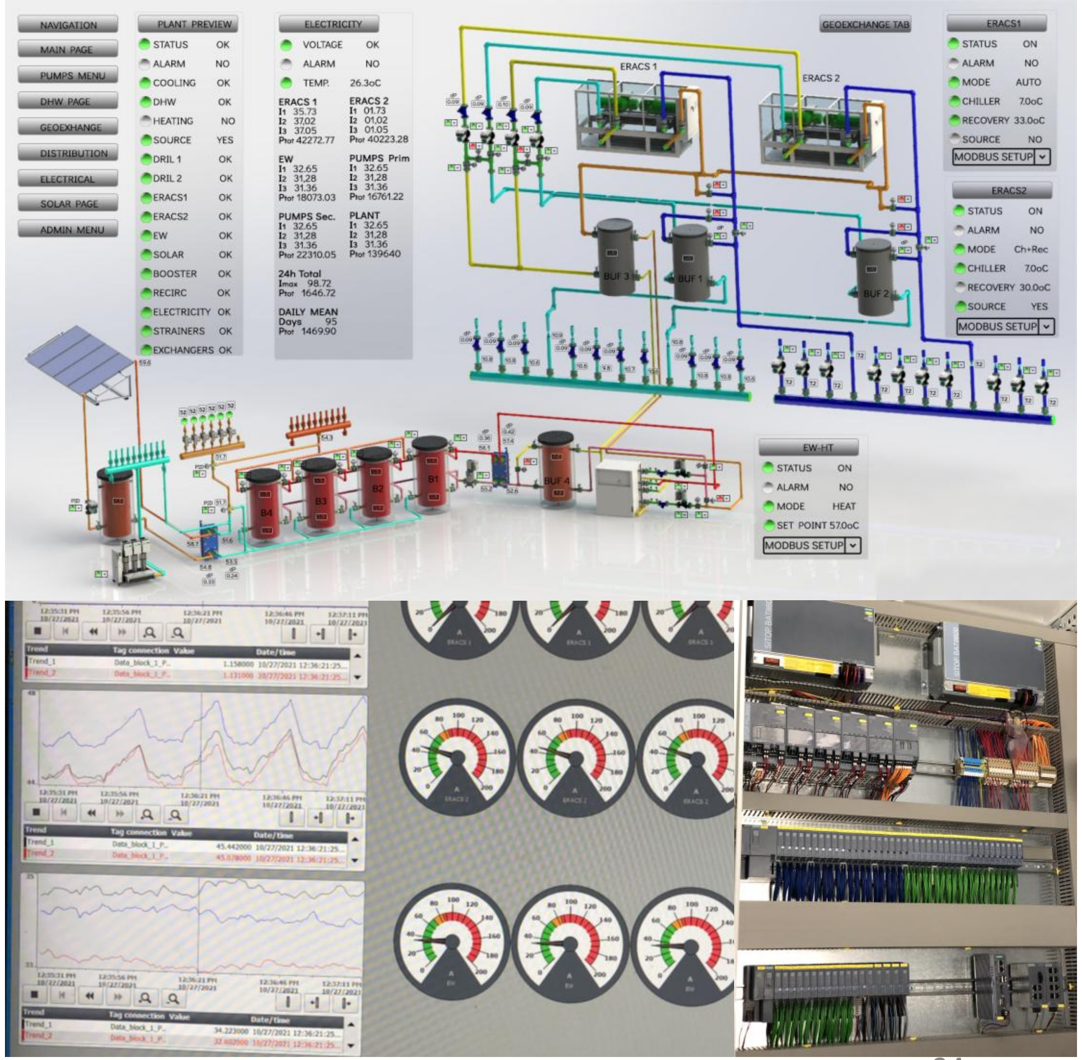
9. Synchronization of Heat Pump Operation with Real Thermal Load

- At this stage, we analyzed the **start-up and synchronization requirements** of the two geothermal heat pumps.
- Developed **operational efficiency scenarios** to identify the optimal configuration:
  a. Parallel operation: HP1 up to 50%, HP2 up to 50%,HP1 up to 100%, HP2 up to 100%.
  b. Comparative assessment of **pumping energy cost** versus **HP efficiency**.
- Field measurements were performed for each scenario using SCADA and energy metering.

CASE STUDY

9. Synchronization of Heat Pump Operation with Real Thermal Load

- Analysis led to the creation of a **control algorithm** that activates the second HP **only when load exceeds 70%** of a single unit’s capacity.
- Above this threshold, the **combined COP surpasses the critical point** where total energy (HP + pumping) becomes more efficient.
- The algorithm was implemented in SCADA, allowing **automatic load-based synchronization** and **optimal energy balance** between compressor and pump operation.



CASE STUDY

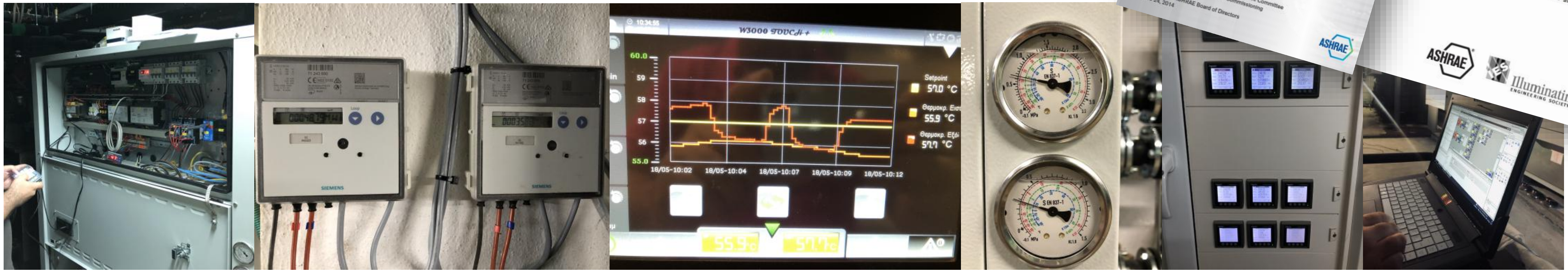
Final Results and System Outcomes

- Verified in-spec operation of all geothermal and booster heat pumps.
- Ensured adequate flow across all circuits and terminal units (fan coils).
- Achieved efficient DHW heating and reliable sensor feedback for control logic.
- Eliminated Low-ΔT Syndrome
- Reduced pumping energy consumption by >**31%,** approximately **42,73 MWh/year ≈ 8.546,40€/year**.
- With only two spare pumps, any of the 17 total circuits can be replaced immediately in case of failure.

	Pre-Commissionig	After
Primary Pumps (A)	25,88	16,65
Secondary Pumps (A)	38,35	27,66
Total (Amps)	64,23	44,31
kWh/y	137.772,00	95.040,00
Cost	27.554,40 €	19.008,00 €
Recuction	(mean)	**31%**
Energy Savings	(annual)	**42.732,00**
Cost Reduction	(annual)	**8.546,40 €**

ASHRAE & COMMISSIONING

- ASHRAE *Standard 202* – Commissioning Process for Buildings and Systems,
- ASHRAE *Guideline 0.2 – Commissioning of Existing Buildings*
- ASHRAE *Guideline 1.1 – HVAC&R Technical Requirements for the Commissioning Process*
- ASHRAE *Standard 90.1-2019*, Section 4 – *Enhanced Commissioning Requirements*
- ASHRAE BPA (2014) – *"Commissioning: The Foundation of Building Performance."*



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THANK YOU!
Q & A

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09:00-18:00 | @ DIVANI CARAVEL HOTEL, ATHENS

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