GREAH UR 3220 Research lab


# Energy Management of a Surface Water Heat Pump Powered by Wind and a Battery System

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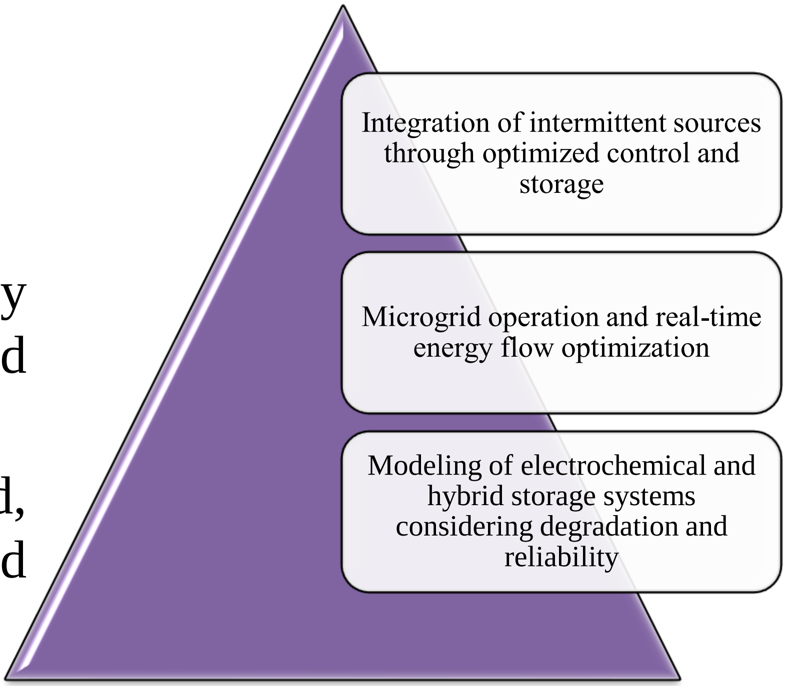
# MERS Team – GREAH ULHN

- Third-year Ph.D. candidate in the MERS team at the GREAH laboratory, Université Le Havre Normandie.
- My research develops an advanced energy management strategy for a surface water heat pump powered solely by renewable energy sources (PV, wind, and battery storage).
- I am actively contributing to WaterWarmth — a European Interreg North Sea Region project across 5 countries — deploying and validating this multi-energy system to decarbonize heating networks.

# MERS Team – GREAH ULHN

- The **Mastery** of **Renewable Energies** and **Storage Systems** group focuses on advanced management of renewable energy within power networks.
- The goal is to develop intelligent energy management methods for hybrid and marine renewable systems.

**Keywords:** renewable energy, wind, offshore, storage, microgrids, embedded systems, real-time control.



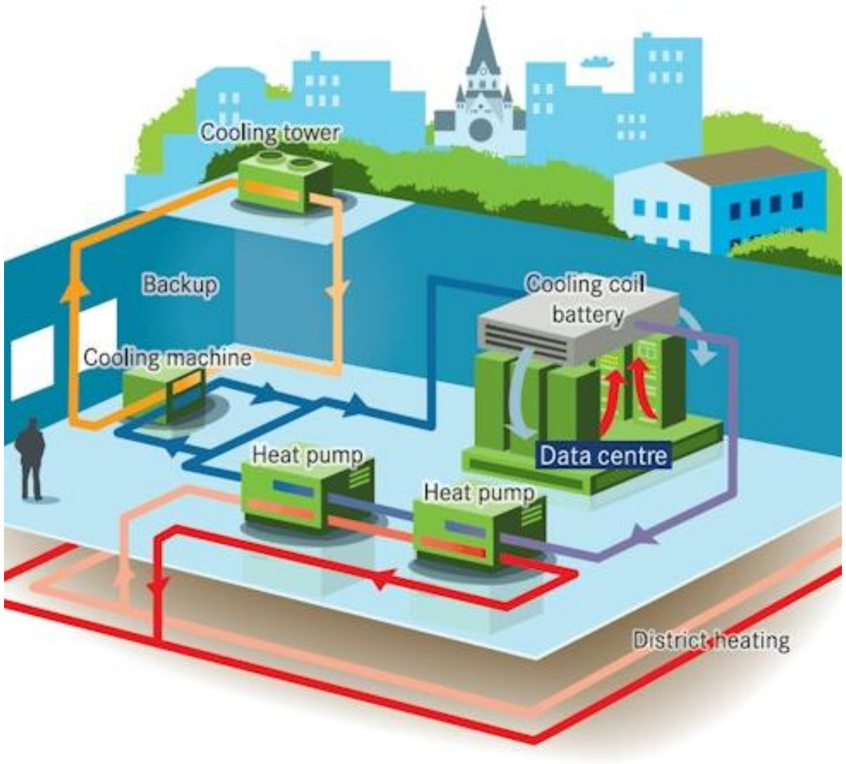
# Outline

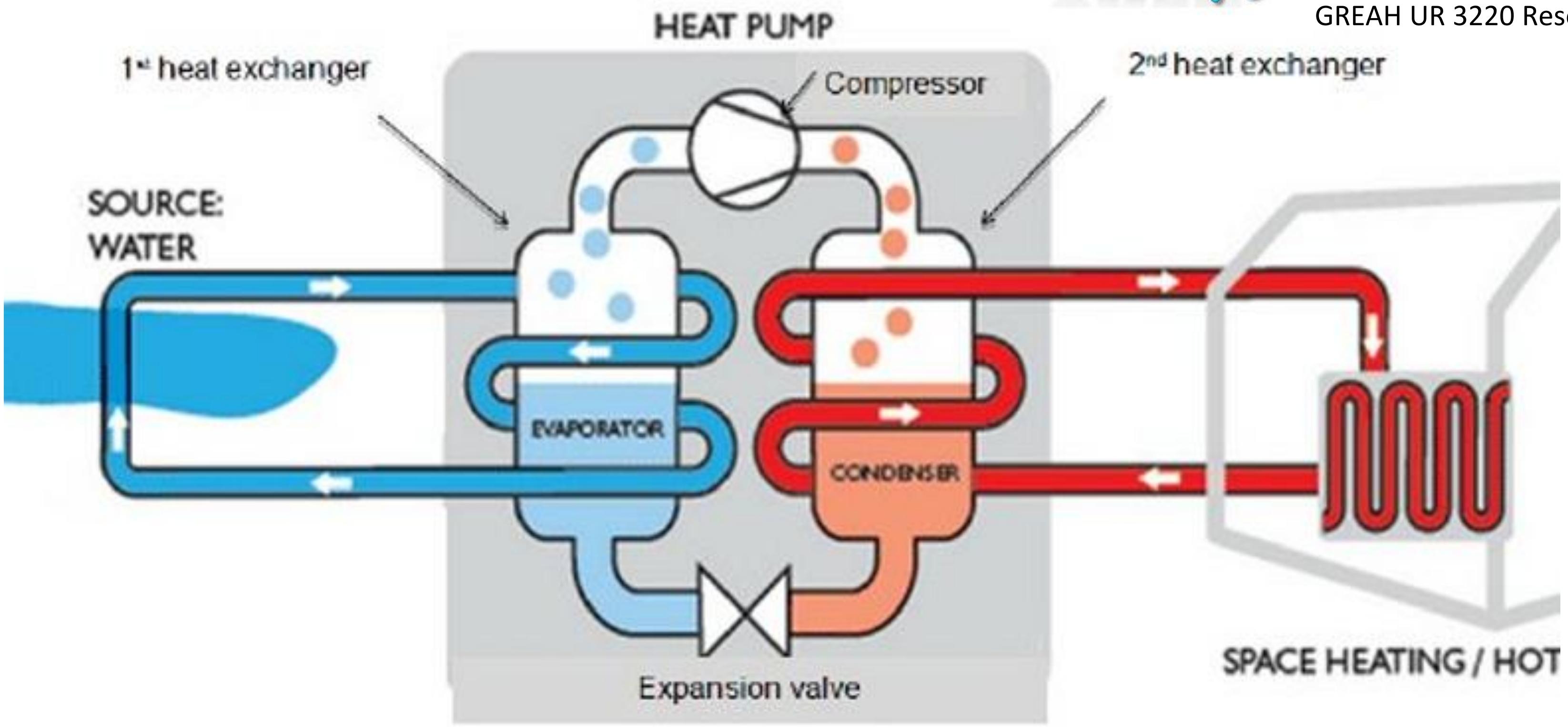
# 1) Introduction & Background

🌍 The **heating** sector represented 77.6% of the final energy consumed by households in **2023**.

🏭 67% of district heat in the EU met by fossil fuels in **2023**.

❄ HPs have emerged as key solutions to decarbonize the heating sector as they consume 25% less energy.





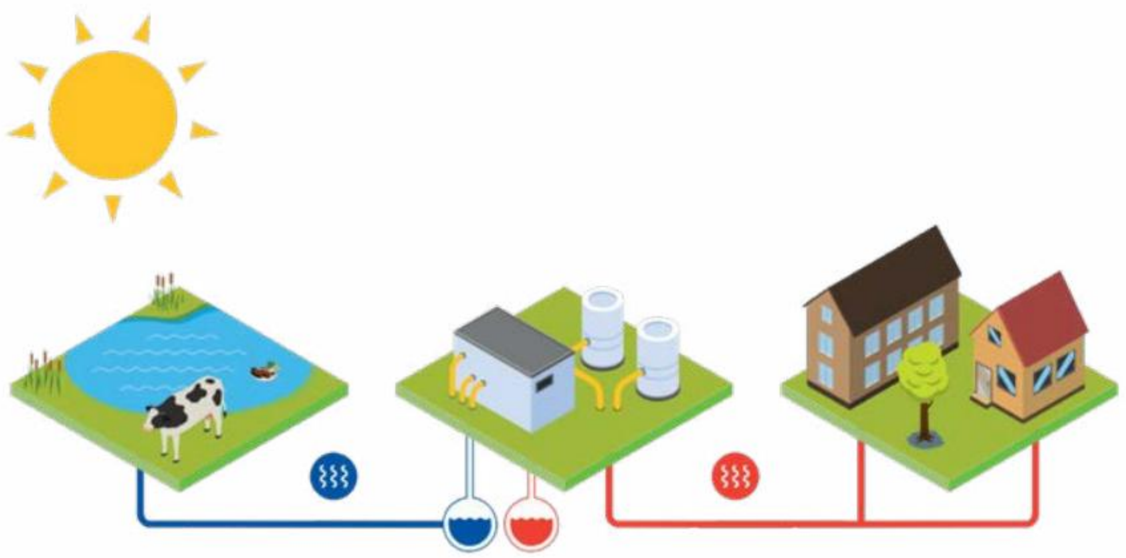

# 1) Introduction & Background

- Air-source HP
- Ground-source HP
- Water-source HP (including surface water, wastewater, etc.)

**What is aquathermal energy?**

It is the extraction, storage and distribution of heat from water. Within aquathermal energy there are three different main sources to extract heat from: waste water, drinking water and surface water.

With the help of a heat exchanger, warmth is extracted from a source and with the help of a heat pump this energy is used to bring water to an suitable temperature for heating and hot water supply. Aquathermal energy can also be used to cool buildings



# 1) Introduction & Background

# 2) Literature Gaps & Motivations

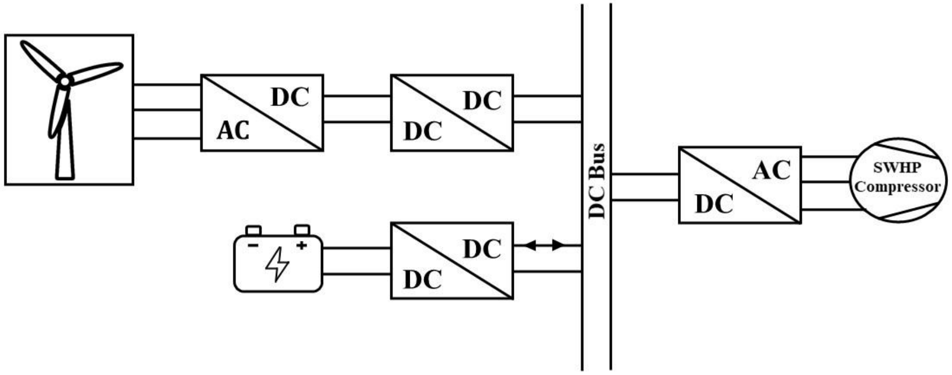
- Lack of detailed electrical modeling of hybrid WT-BESS-SWHP systems
- Neglect of DC-bus voltage dynamics and system-level control
- Limited attention to realistic operating conditions

# 3) Key Contributions

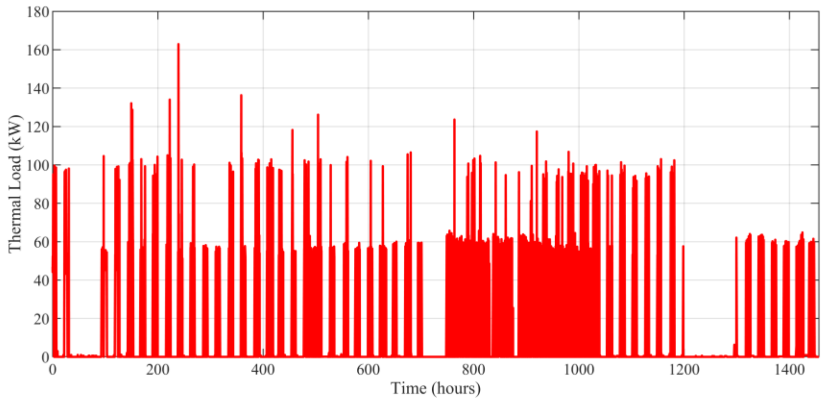
1. Simulation of a full hybrid WT–BESS–SWHPs system under realistic climatic and thermal demand conditions
2. Dual-loop control of the BESS converter to maintain DC–bus voltage stability and ensure dynamic power flow balancing
3. Detailed performance analysis of the system's electrical and thermal interactions, demonstrating suitability for decarbonized heating applications

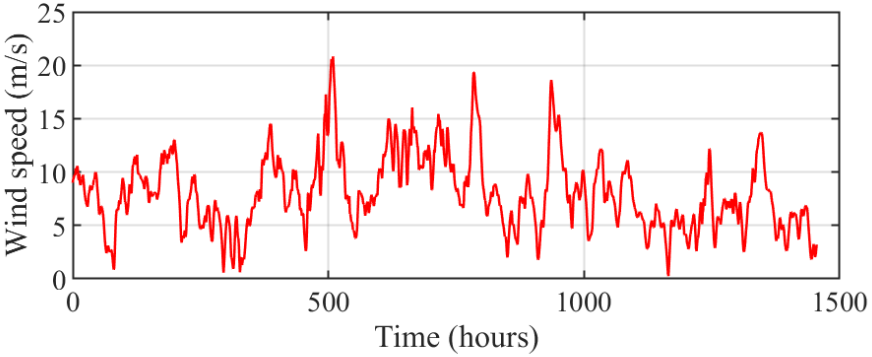
# 4) System Configuration & Inputs

| WT | BESS | SWHP |
| --- | --- | --- |
| 35 kW | 30 kW Lithium Ion | Two CIAT DYNACIAT LG 300A water-to-water HPs operating in parallel & providing 90 kW nominal heat capacity |



# 4) System Configuration & Inputs



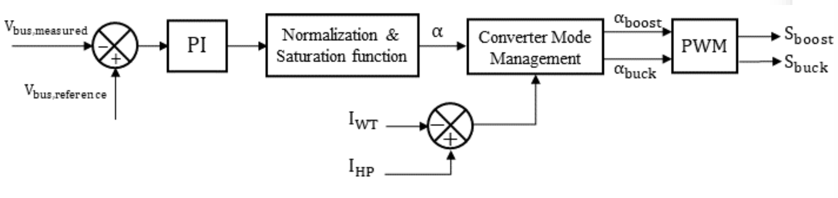

Simulation uses measured data from March 7 to May 7, 2024, at the 'Le Cano Ouistreham', Normandie, France pilot site:

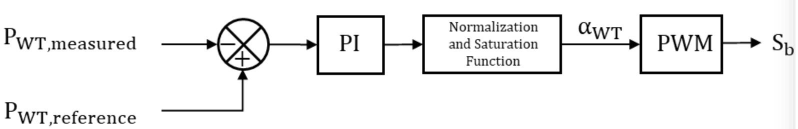
- **Windspeed:** Max: 20 m/s, frequent drops below 10.9 m/s
- **Sample time:** 5 second intervals

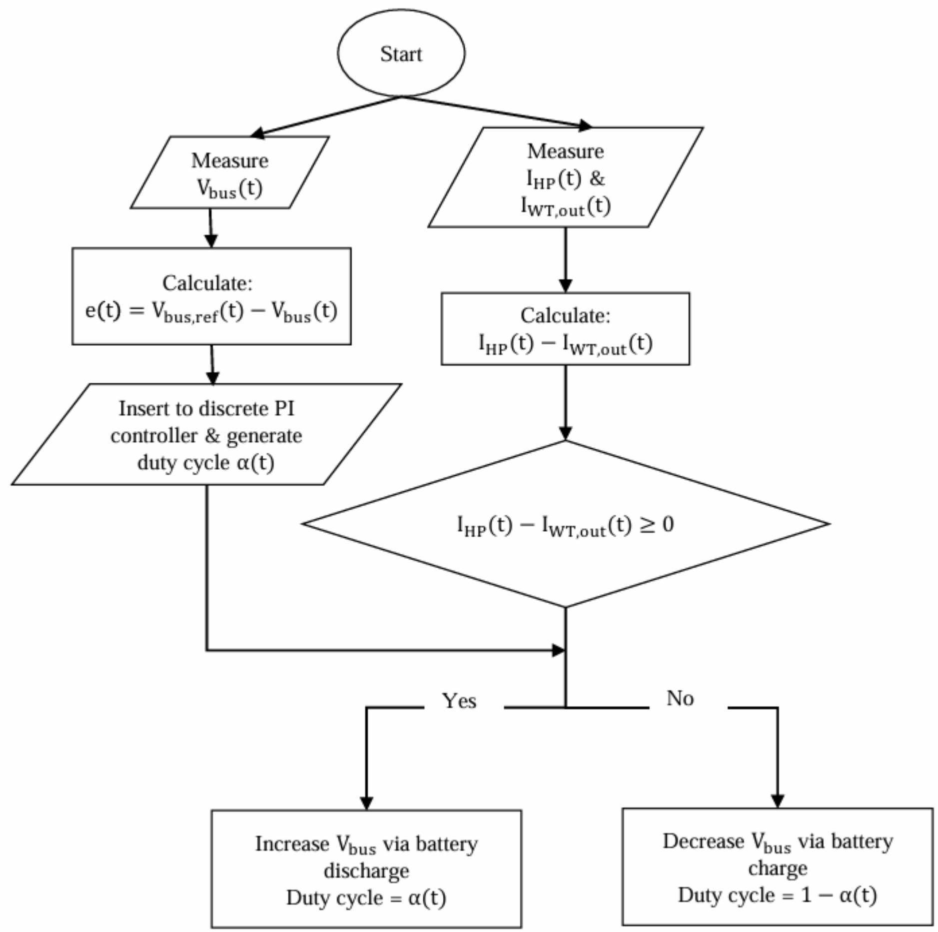
# 5) Control Strategy

- Adaptive step size and threshold control for faster, more accurate PV power tracking—dynamically scales duty cycle based on power changes
- Outer DC-bus voltage regulation combined with inner current tracking ensures dynamic power flow balancing
- Buck-boost operation charges during excess generation, discharges when demand exceeds PV output

# 5) Control Strategy

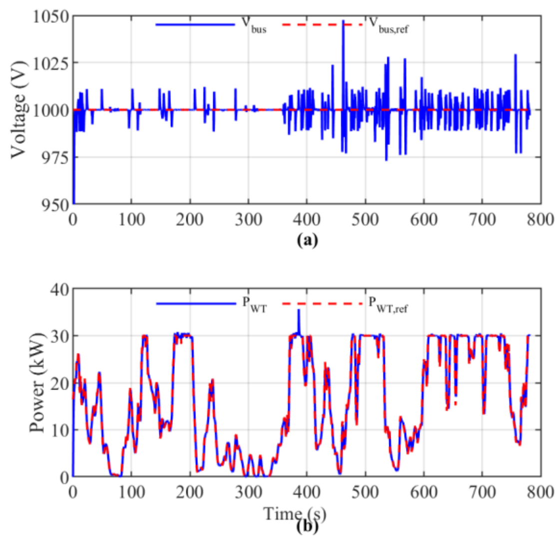


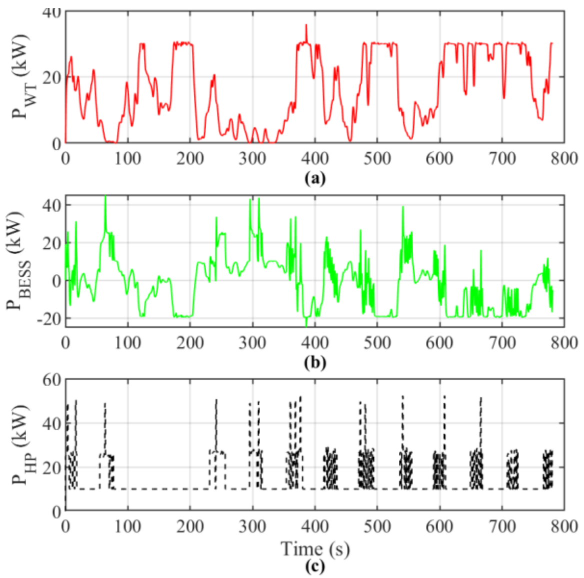



# 6) Simulation Results

| Simulation Parameters | |
|---|---|
| Switching frequency | 10 kHz |
| $V_{bus,reference}$ | 1kV |
| **Power Ranges** | |
| WT | 0-35 kW |
| BESS | −20 ; 45 kW |
| SWHP | 0-52 kW |



# 6) Simulation Results

| Voltage Tracking | Settling Time | Current Tracking | Power Balance |
|---|---|---|---|
| **0.42%** | **1.6s** | **4.76%** | **4kW** |
| RMS error for DC-bus voltage regulation at 1000V reference | DC-bus voltge stabilized within ± 5% | Maximum voltage overshoot | RMSE between generation & demand showing effective coordination |

# 7) Conclusions

**High-Resolution Simulation**

High-resolution thermal load data combined with realistic climatic variations

**Robust Control Strategy**

DC-bus stability & dynamic power flow balance

**Performance Validation**

Suitability for decarbonized heating applications,

# 8) Future Work

1. Alternative DC–DC converter topologies
2. Advanced control strategies
3. Experimentation results