Development of Generic Data-Driven Models for Optimal Load Management in Commercial Buildings

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Motivation

- School buildings represent a significant energy demand;

  14,600 public schools

- Understanding and predicting usage helps reduce peak loads

  & improve efficiency

- Supports designing smart control strategies and potential

  future retrofits

Background

- HVAC controls are too simple for today's needs
- HVAC must deal with more complex systems, and must address building-to-grid interaction to enhance flexibility
- We need to go beyond “one building at a time”

❌ Traditional MPC	✅ Generic Models
One model per building	One model per cluster
Time-consuming setup	Fast & scalable
High modeling effort	Leverages shared patterns
Limited generalizability	Transferable & reusable
Costly	Cost-efficient

Objectives

- Develop generic, data-driven models for control applications
- These models will be used to develop generic solutions, which will facilitate scalability
- These generic models will be developed based on typical mechanical system configurations

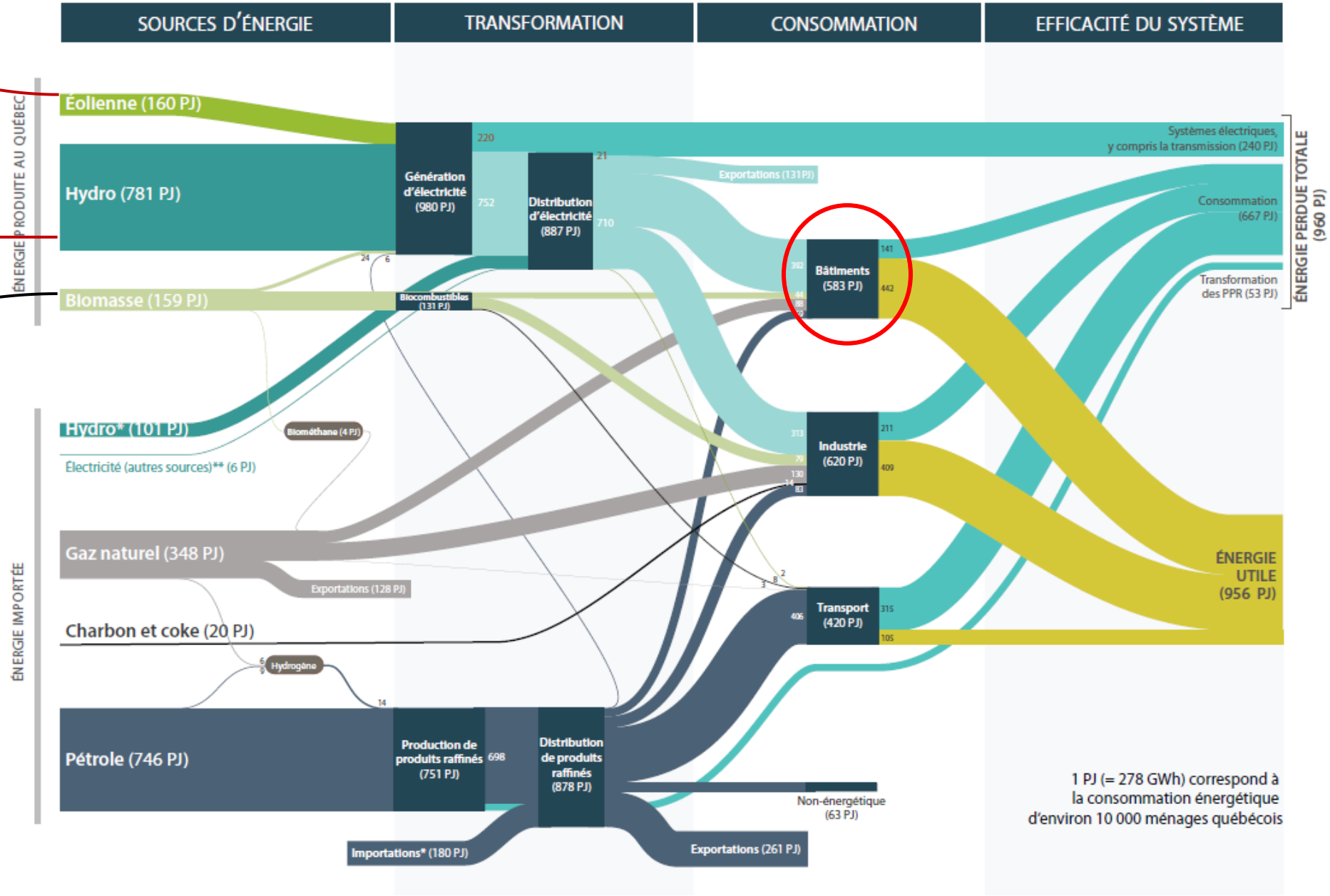
Wind: 16.3%

Hydro: 79.7%

Biomass: 2.4%

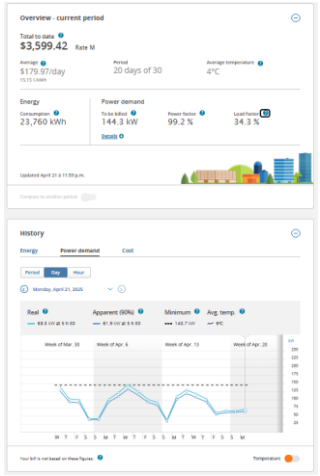
Oil: only 0.6%

GRAPHIQUE 2 • BILAN ÉNERGÉTIQUE DU QUÉBEC, 2020



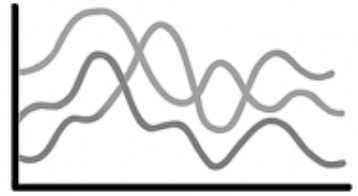
Source: État de l'Énergie au Québec 2023, Johanne Whitmore et Pierre-Olivier Pineau HEC

Methodology

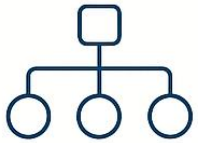


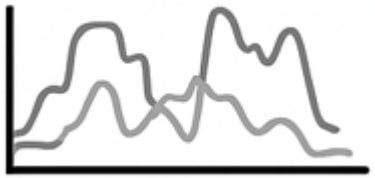
1. Data collection from multiple buildings of the same typology

2. Utilization of electric bills & BAS data

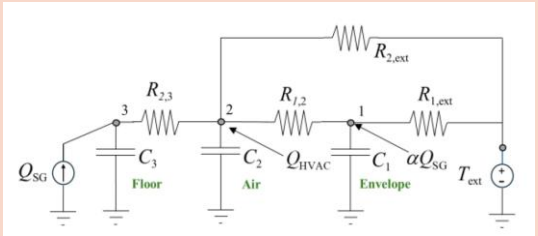


3. Classification procedure: mechanical system configuration, clustering of electric demand profiles



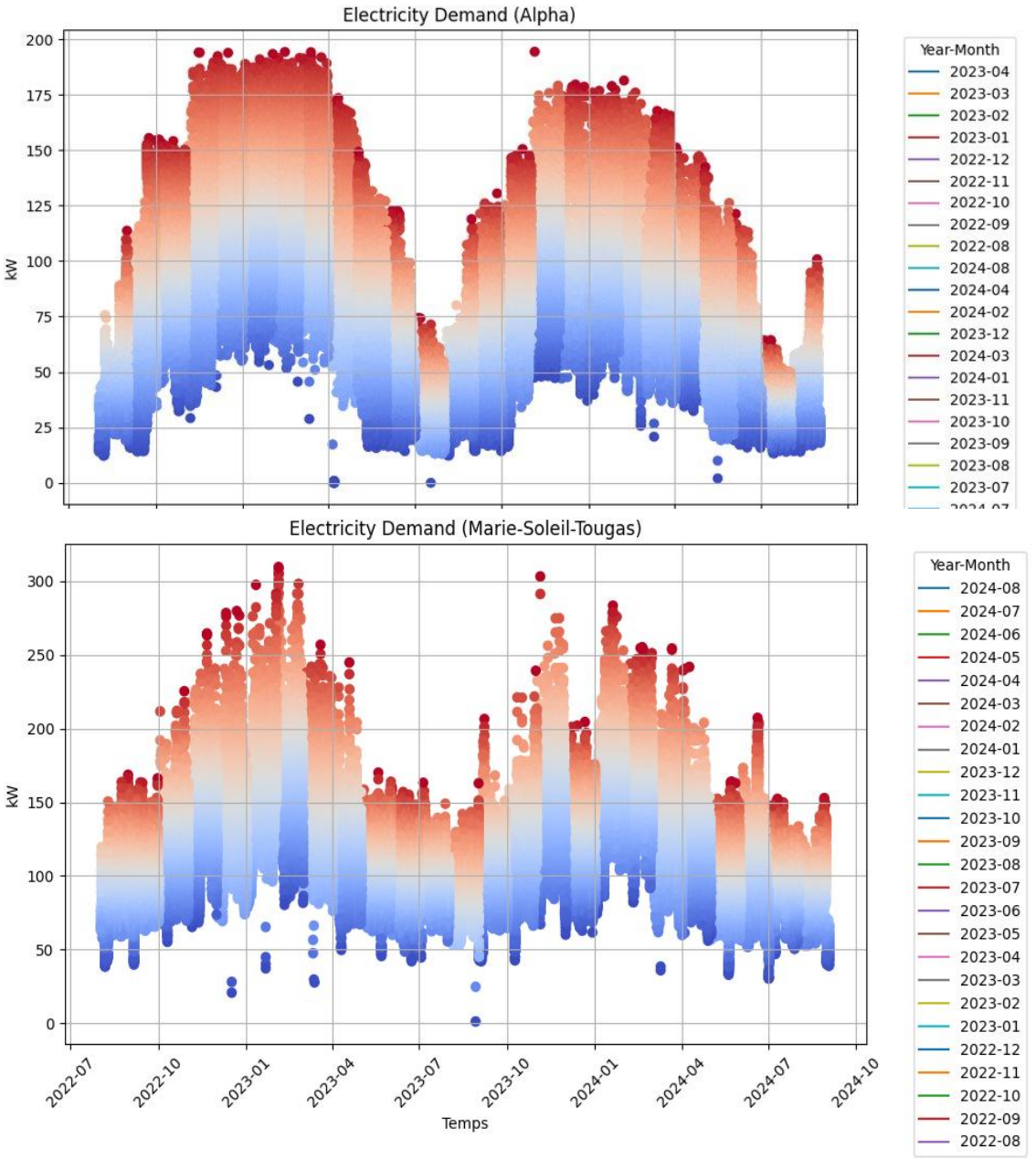


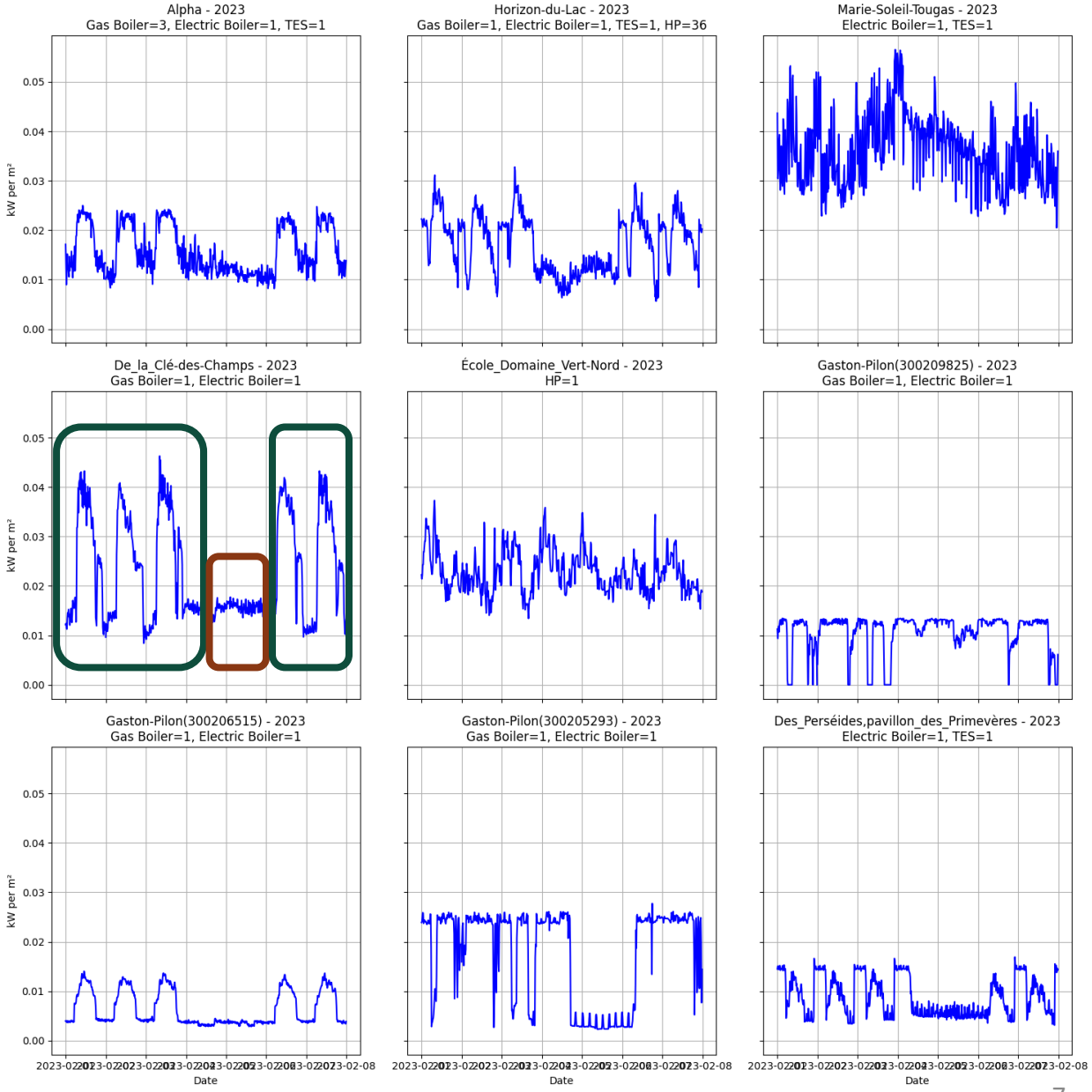
4. Appropriate RC models for each subtype



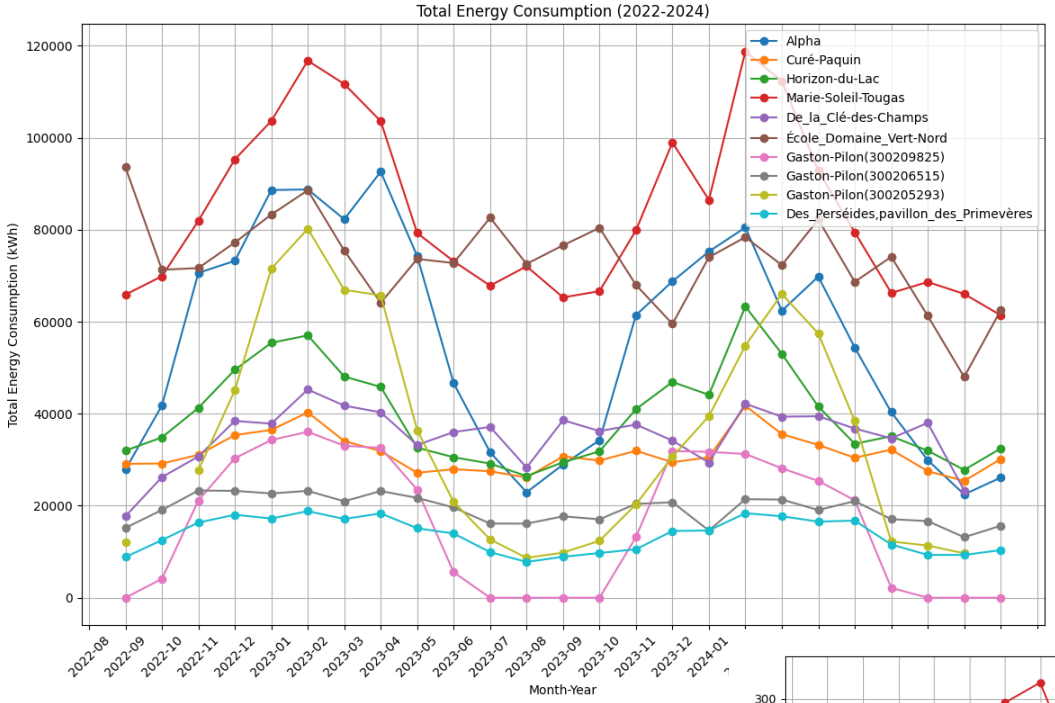
5. Application of RC archetypes/prototypes

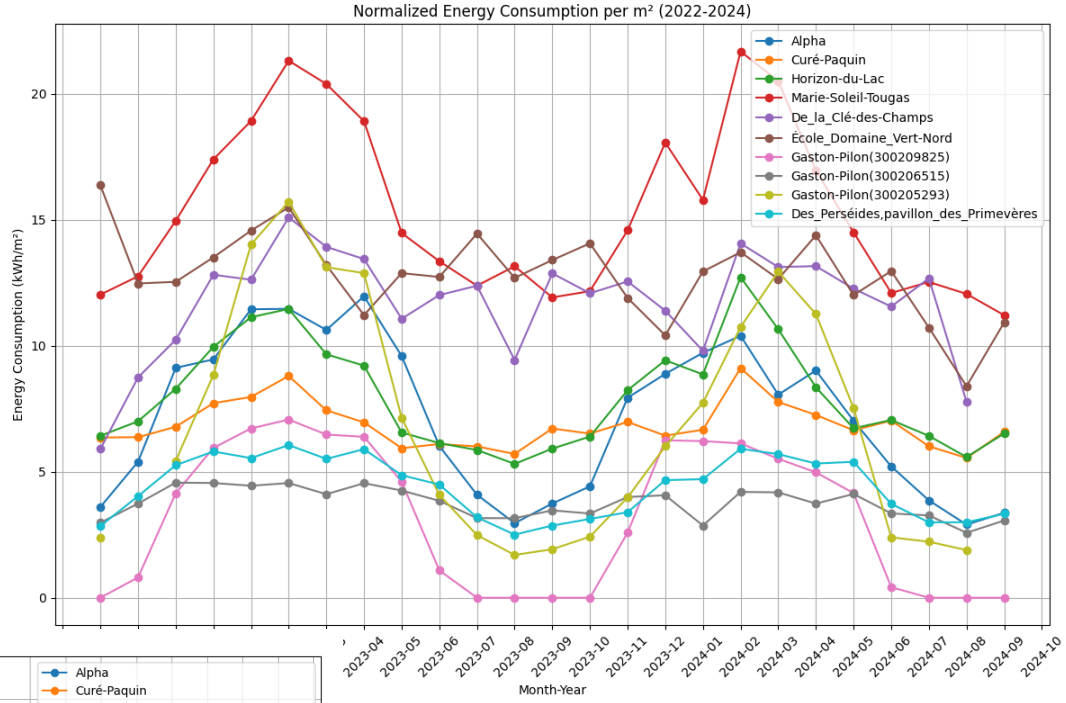
Electricity Demand & Normalized Electricity Demand for the Selected Week

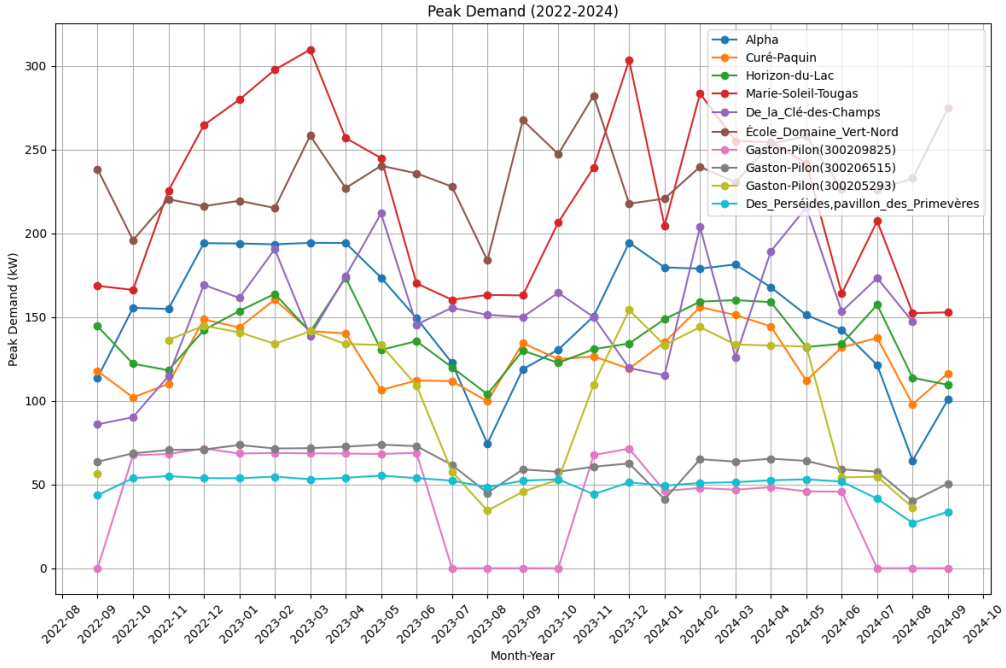




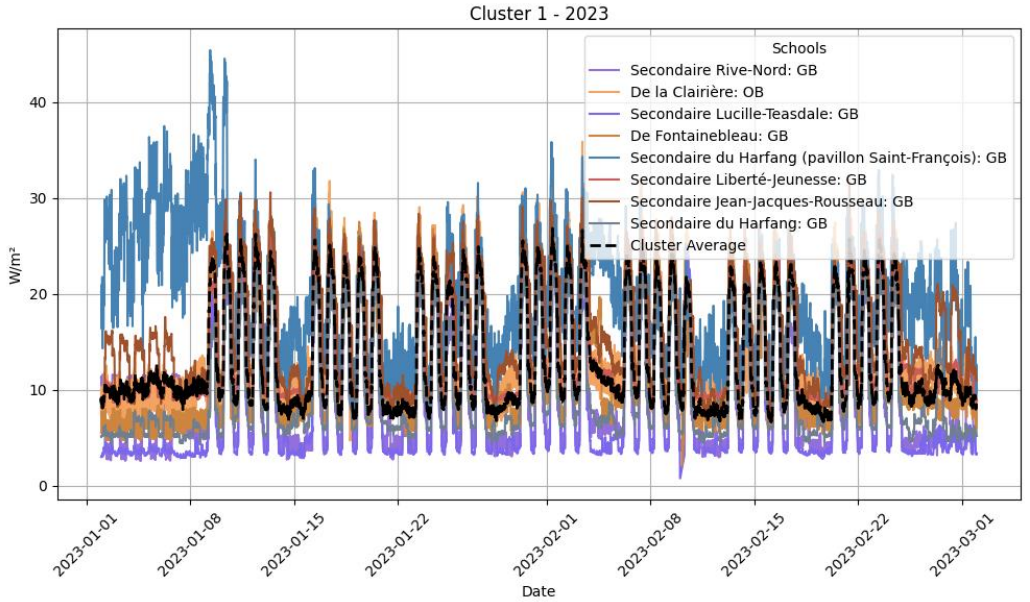
Total and Normalized Energy Consumption for the Selected Schools

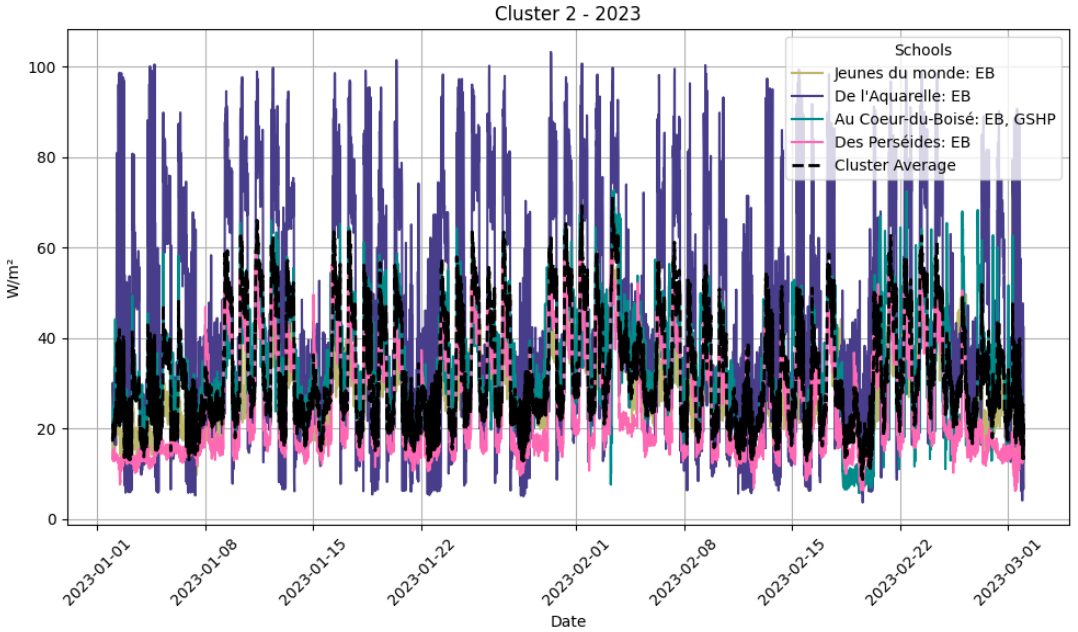


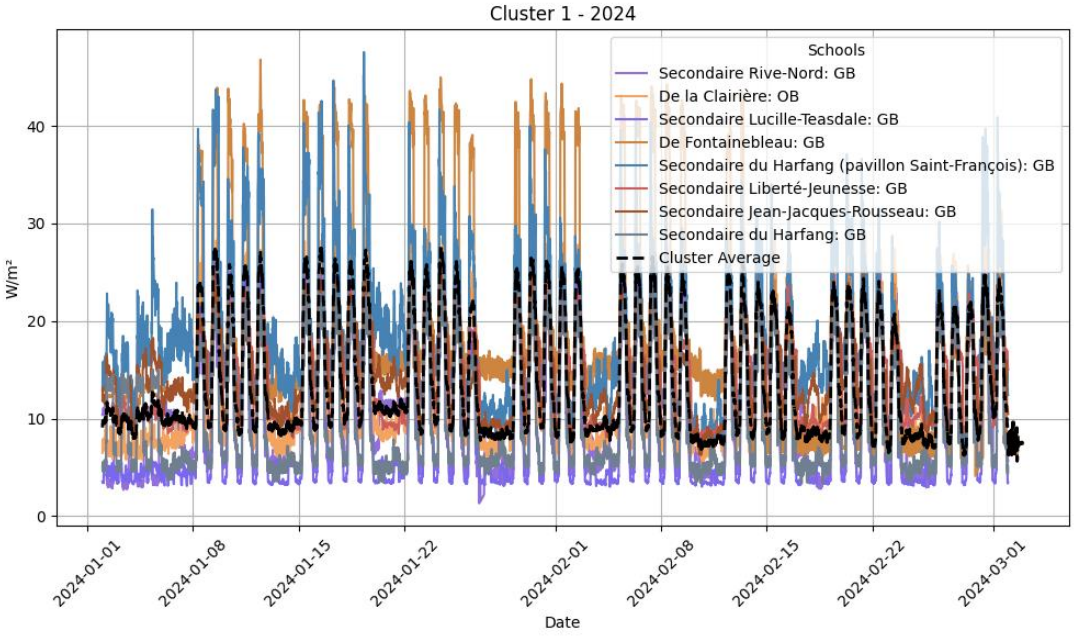


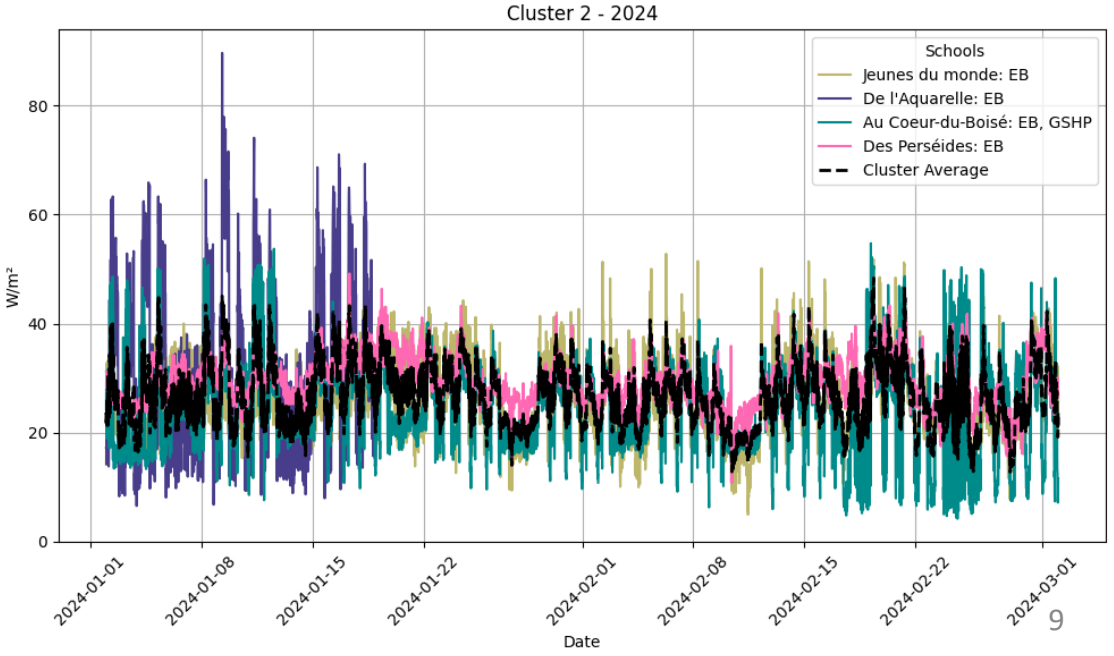


Clustering Based on Mechanical Equipment & Demand Using K-mean Algorithm

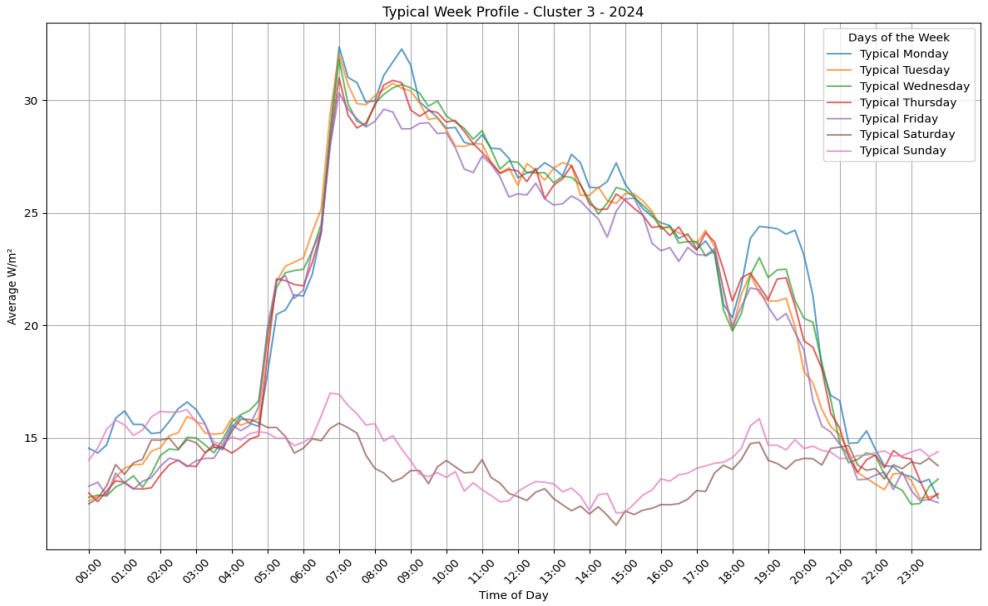


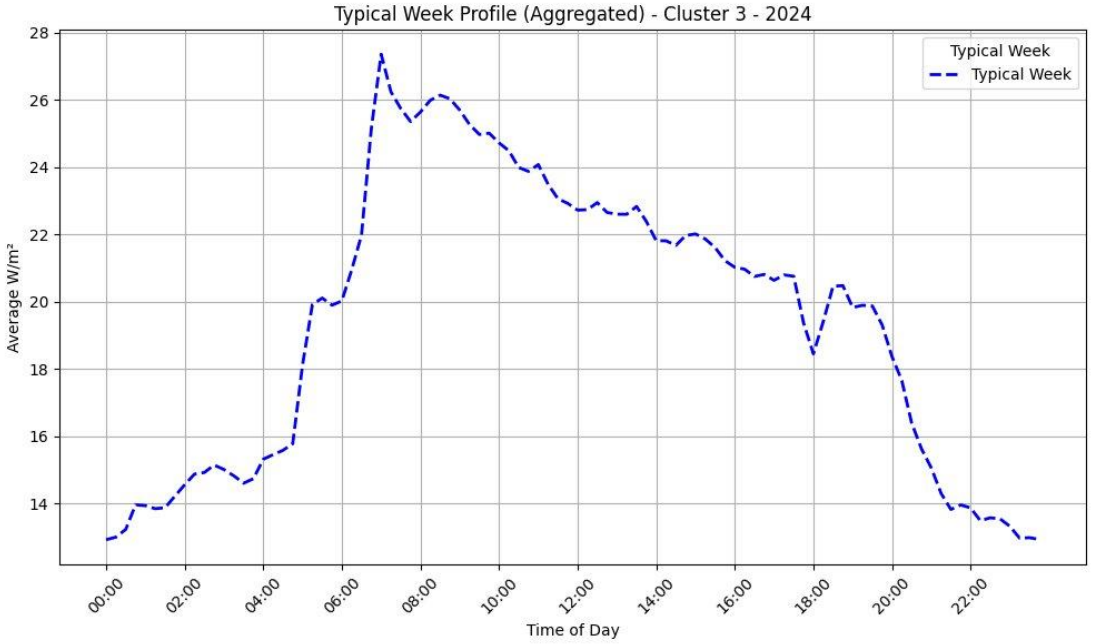


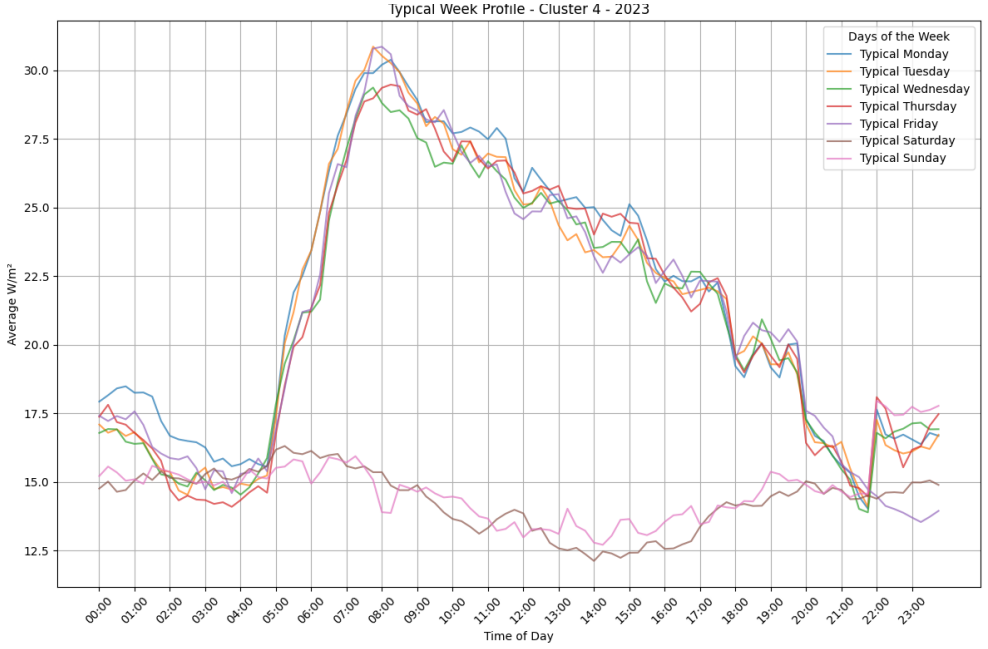


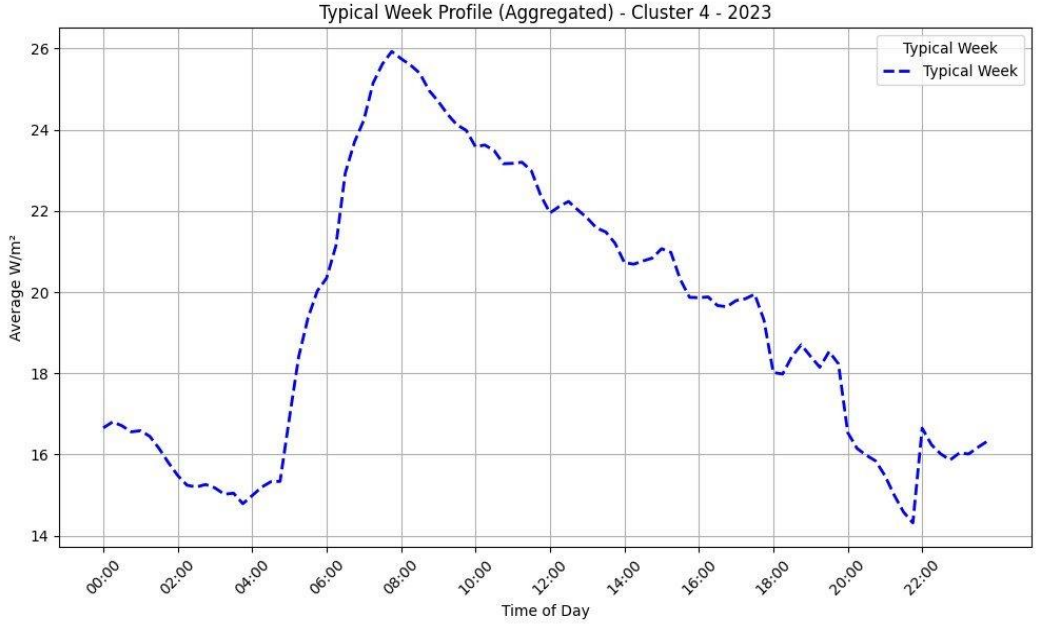


Typical Week and Day for Jan – Feb 2023 & 2024









Clustering results

Key Findings:

- Peak loads often occur at 8 AM in January/February
- Clusters reveal similarities that can inform future equipment planning
- Schools with thermal storage and electric boilers show distinct patterns

Development of Generic Models

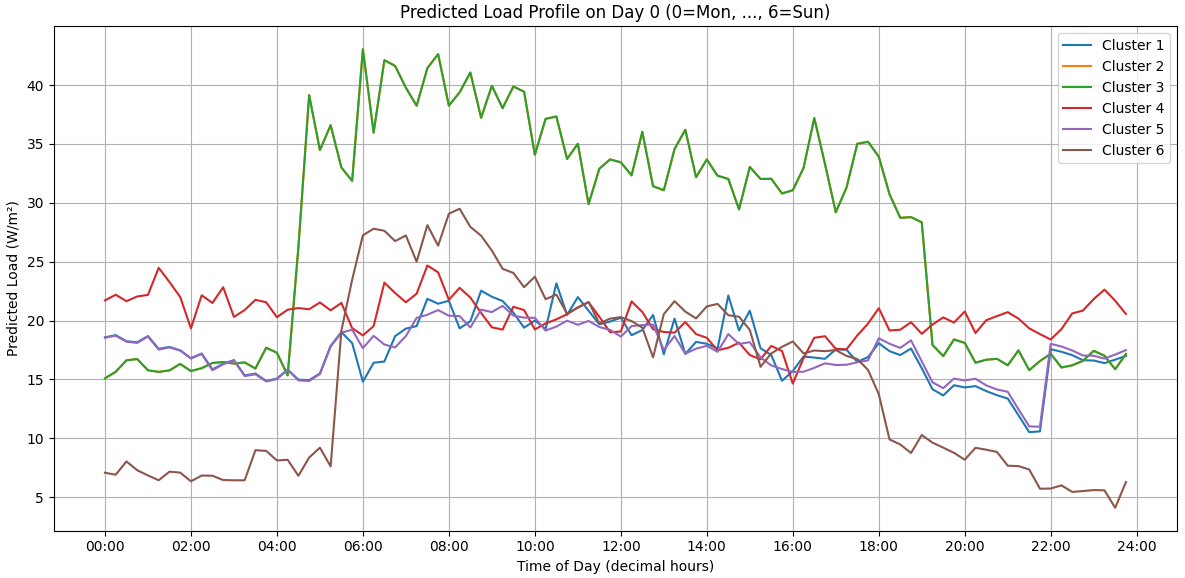
Predictive Modeling Impact:

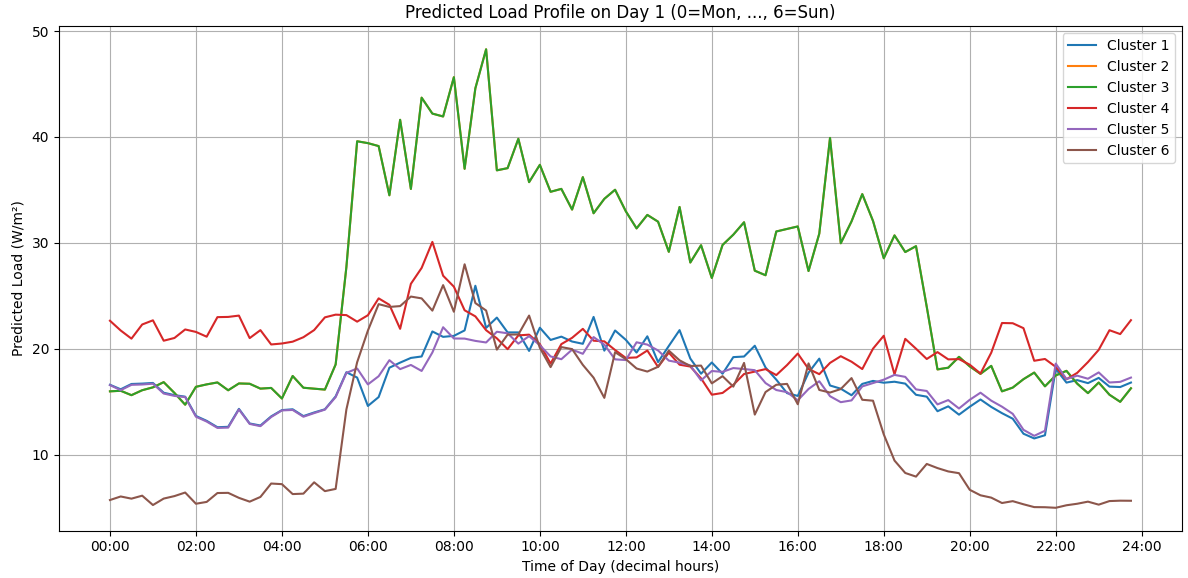
- Forecast energy load based on day, time, equipment, and floor area
- Simulate changes before physical upgrades
- Identify high-demand profiles for potential load shifting

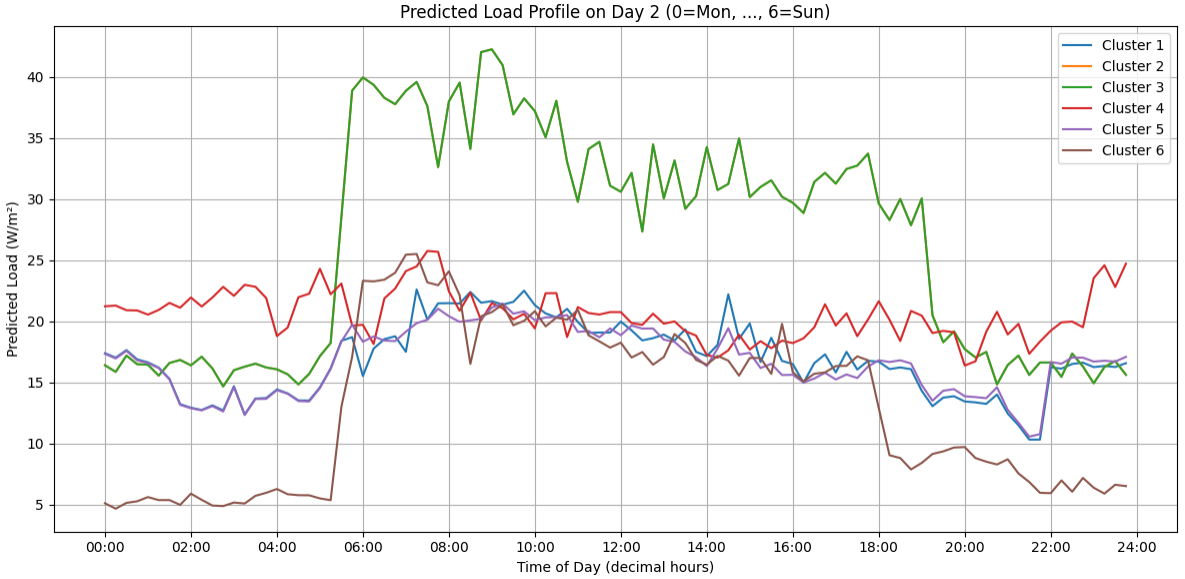
What This Means:

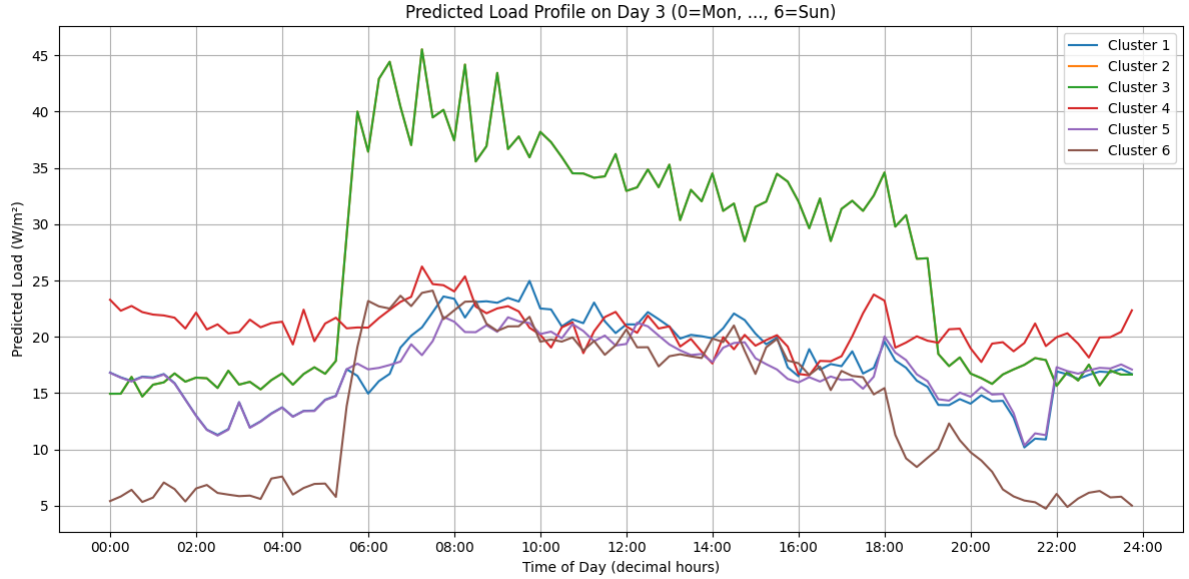
- Informed decisions about retrofits, scheduling, and equipment upgrades
- Opportunity to reduce energy bills and environmental footprint
- Path toward smarter, more resilient school infrastructure

Predicted Load Profiles for Jan – Feb 2023 & 2024









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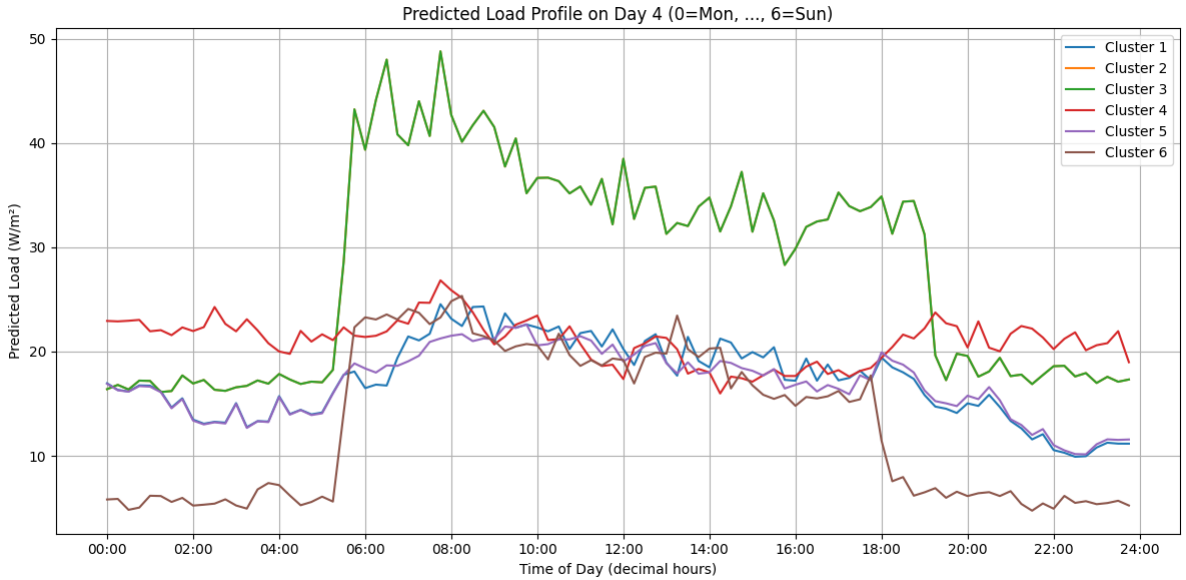

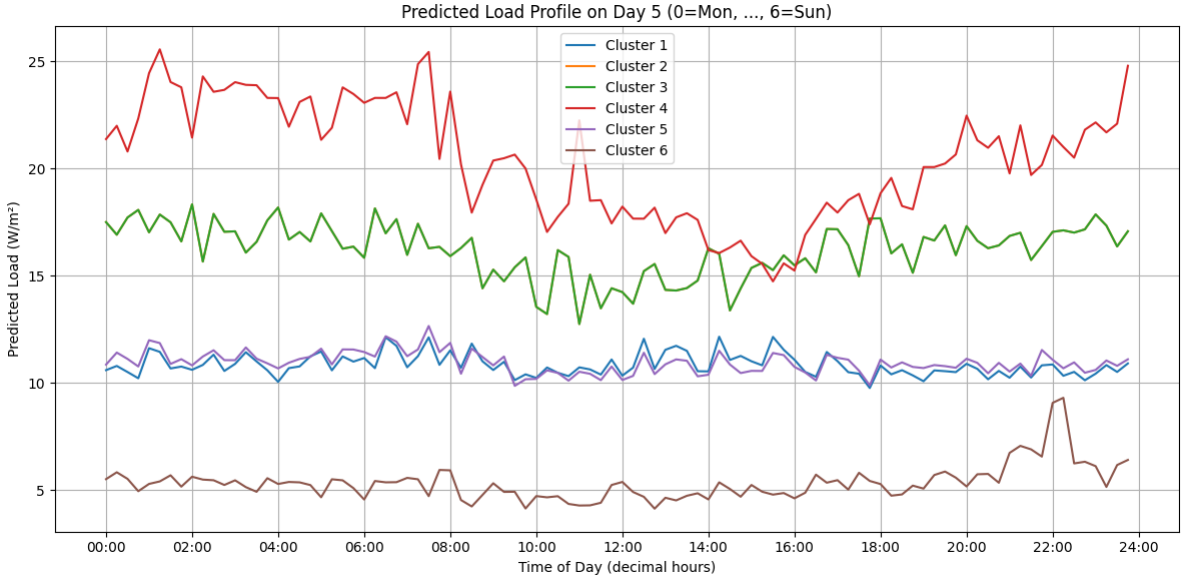

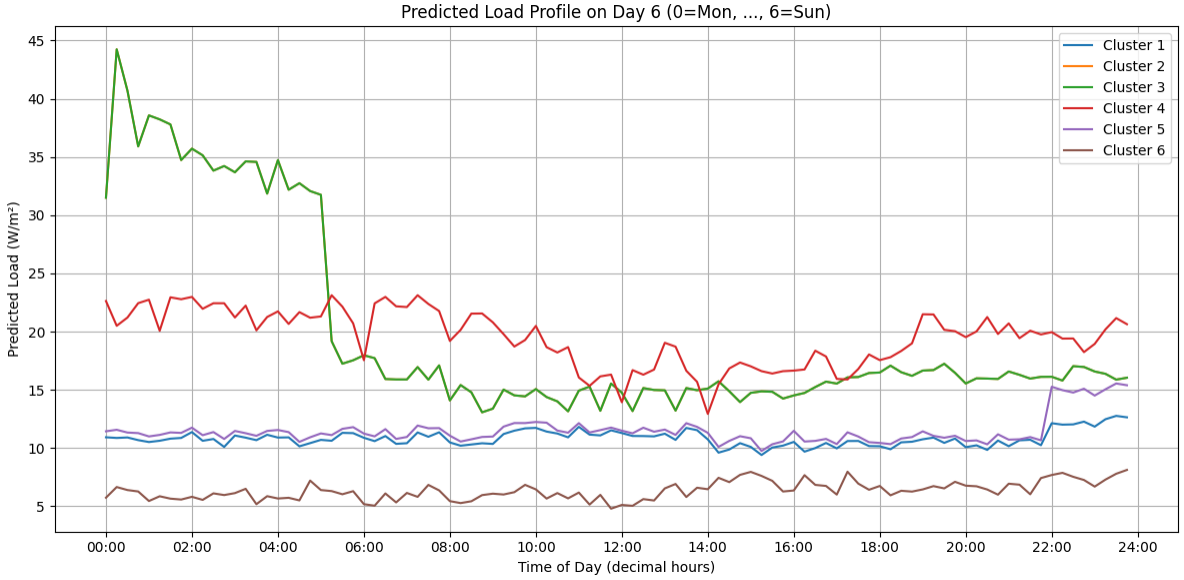

Thank you for your attention!

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