



ÉTS

Le génie pour l'industrie



Réseau Énergie
et Bâtiments

Learning-Based Model Predictive Control for Demand Flexibility

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I. Project Objective

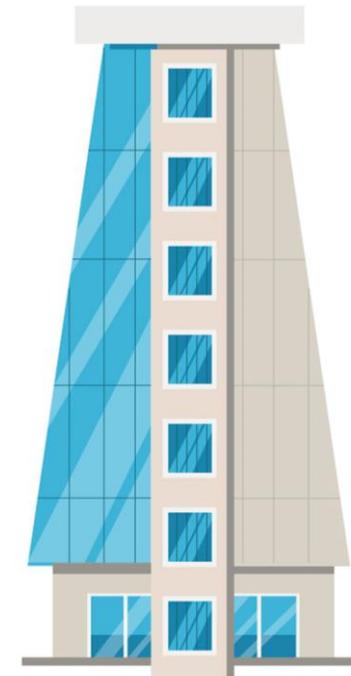
- Develop a learning-based MPC model that forecasts both power demand and indoor temperature, enabling commercial buildings to reduce peak load while maintaining occupant comfort.

- **Case Study:**

A 32,000 m² office building in Montreal

60 AHUs and electric boilers,

Simulated time-of-use (TOU) tariff scheme.



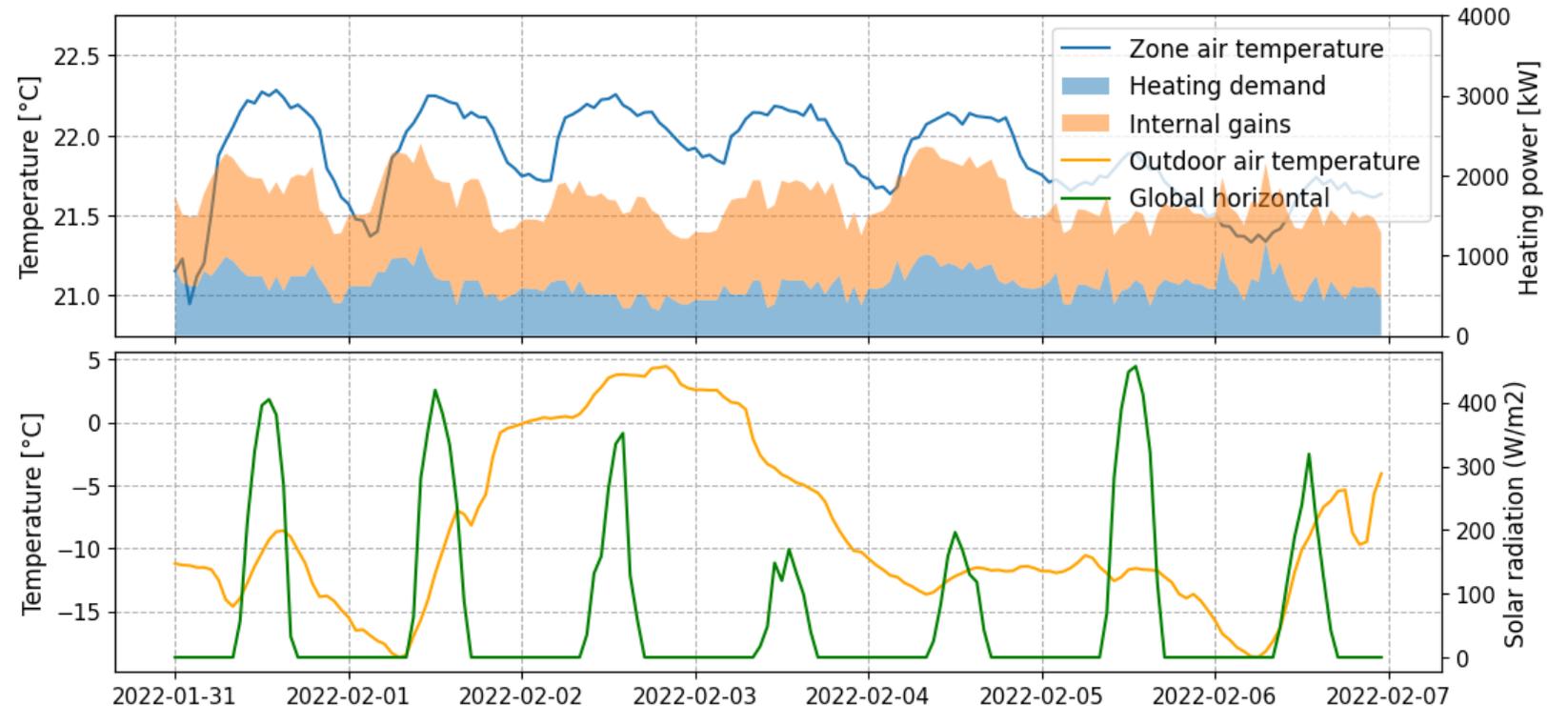
2. Method

Key variables:

- Outdoor temperature
- Solar radiation
- Internal gains
- Time-of-day indicators

Outputs:

- Heating demand
- Indoor air temperature



2. Method

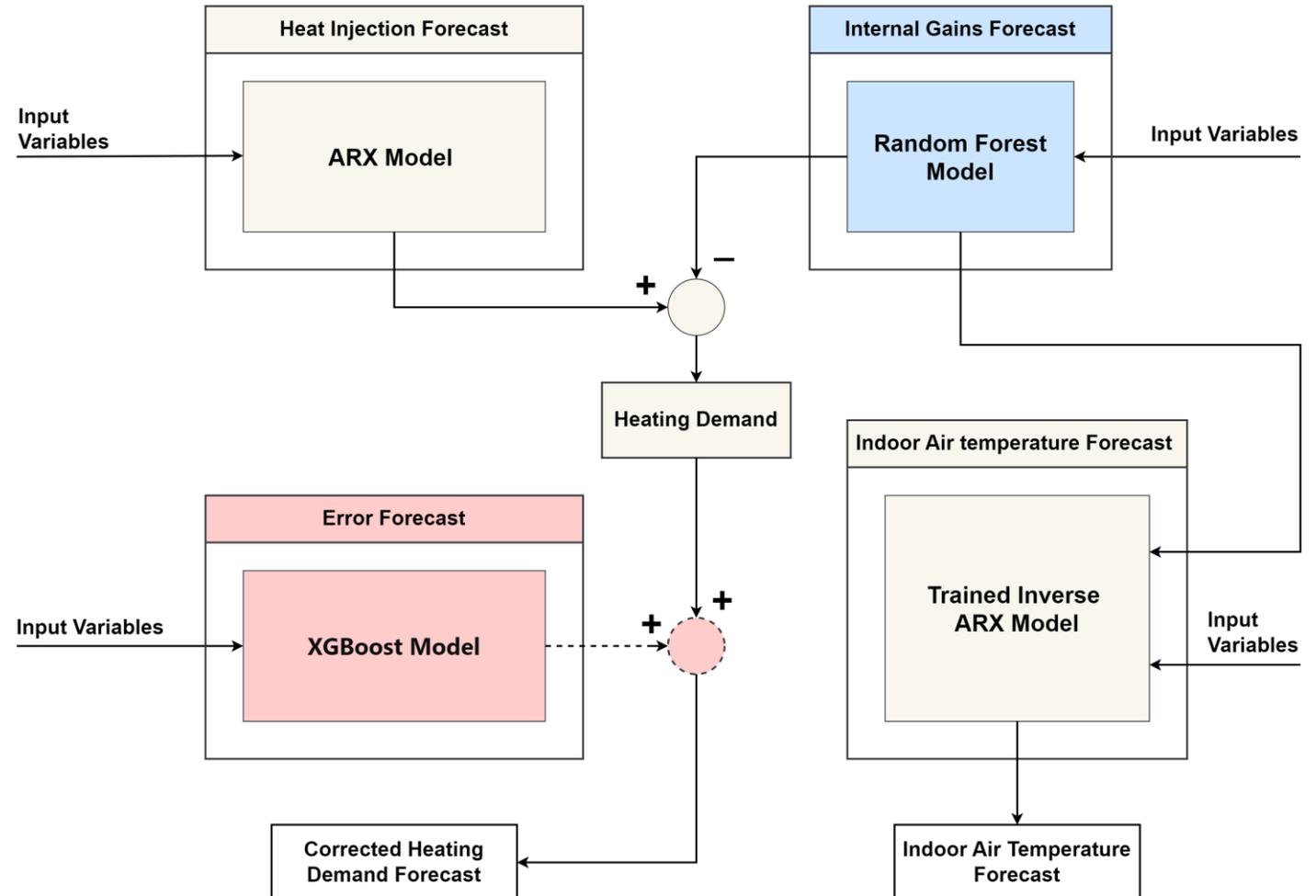
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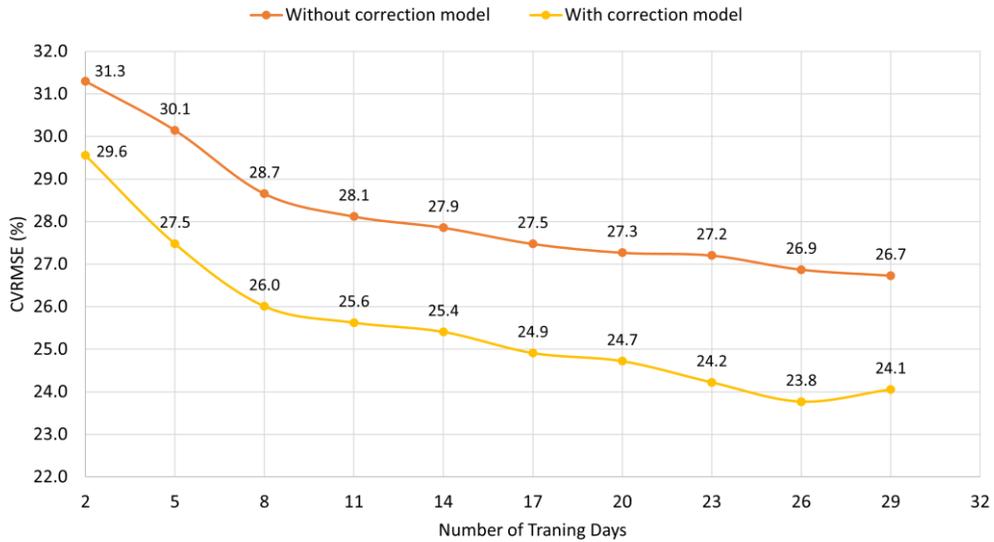
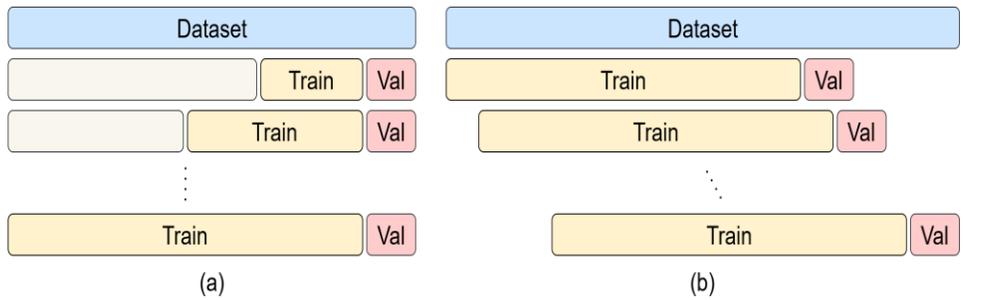
Outputs:

- heating demand
- indoor air temperature

Equation !

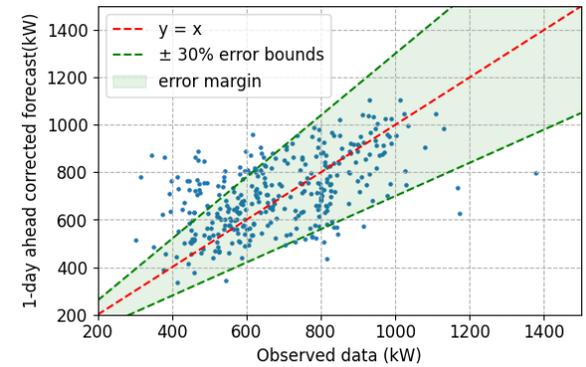
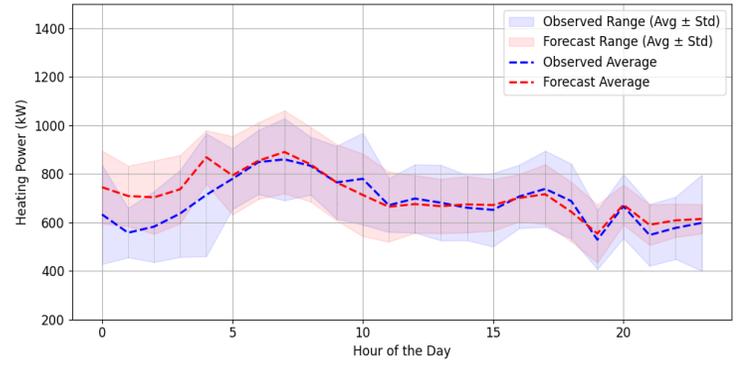


3. Model Validation and Results



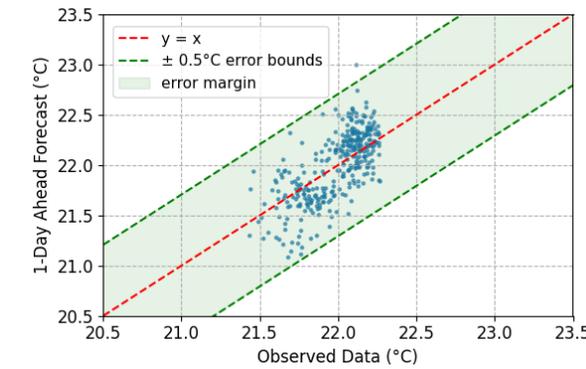
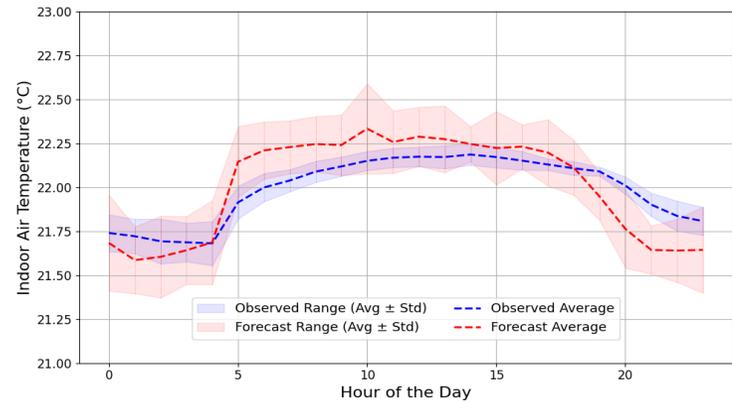
Heating Demand:

- Average CVRMSE: **23.8%**
- Meets ASHRAE Guideline I4 (<30%)



Indoor Temperature:

- Average RMSE: **0.24°C**
- Forecasts within $\pm 0.5^\circ\text{C}$ of observed values



4. Discussion – Demand Flexibility

Peak demand reductions:

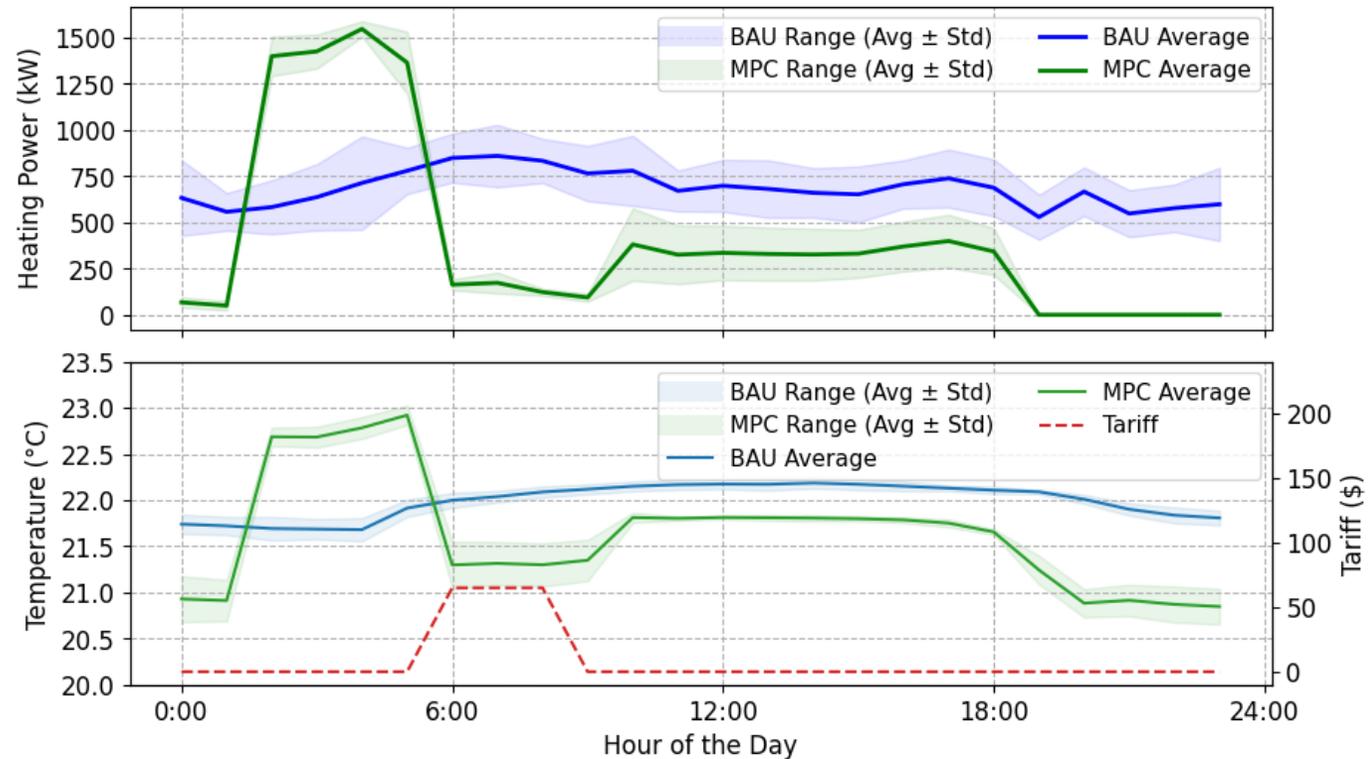
- 33% reduction during peak hours
- 42% reduction in total heating energy

Comfort Maintained:

- Indoor temperature deviation within $\pm 0.5^\circ\text{C}$
- Complies with comfort bounds (18–24°C)

Load Shifting Strategy:

- Preheats building before peak hours
- Uses thermal mass to coast through high-tariff periods



5. Conclusion & Future Work

Conclusion:

- Developed a hybrid MPC framework combining ARX and machine learning models.
- Achieved reliable day-ahead forecasts of heating demand and indoor temperature.
- Validated across multiple datasets, aligned with ASHRAE standards.
- Enabled peak heating load reduction up to 33%, while maintaining comfort.

Future Work:

- Integrate multi-zone control to capture spatial thermal variations.
- Include occupancy-driven modeling for internal gains and comfort targeting.
- Incorporate flexible tariff structures responsive to daily market changes.
- Model equipment efficiency dynamics (e.g., heat pumps).

*Thank
you*