The Sub-metered HVAC Implemented For Demand Response (SHIFDR) Dataset

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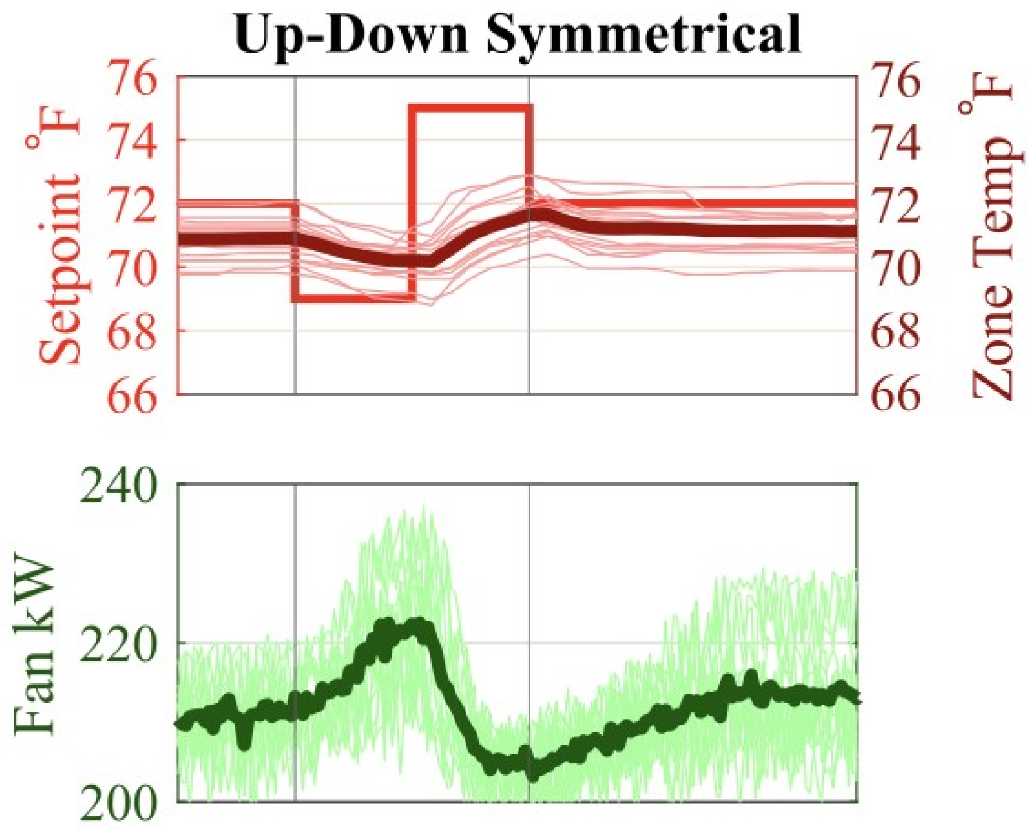
Demand Response Experiments

Over 5 years of experiments, 17 buildings in MI and NC

- Load shifting experiments
- Open-loop Global Thermostat Adjustment (GTA)

- Fan power submetering data
- Building Automation System (BAS) data
- Whole-building electric load data

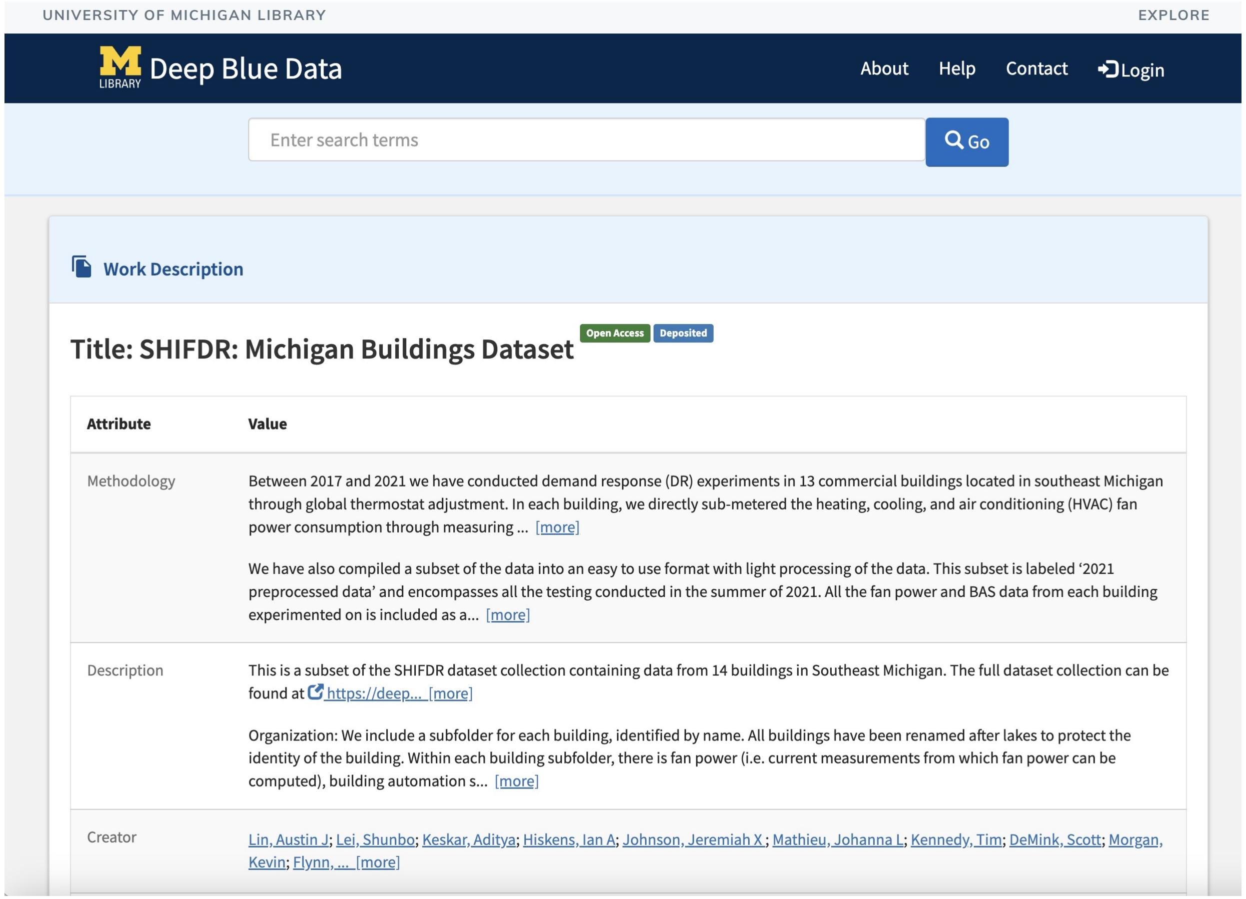


Open Access Dataset

https://deepblue.lib.umich.edu/data/collections/vh53ww273?locale=en

Michigan data available →

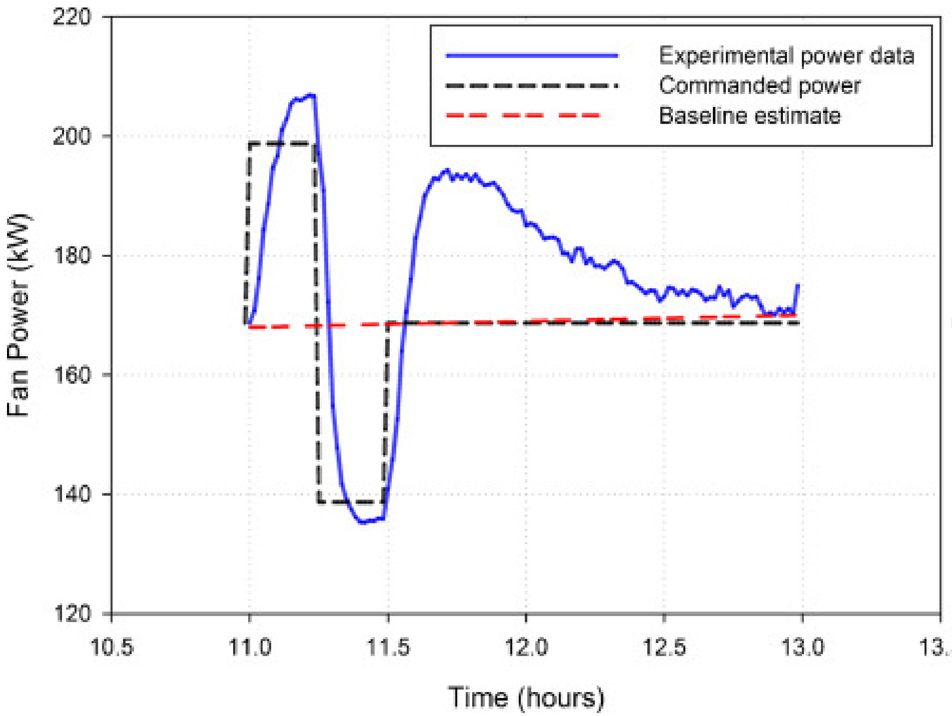
North Carolina data forthcoming



What can we learn from this data?

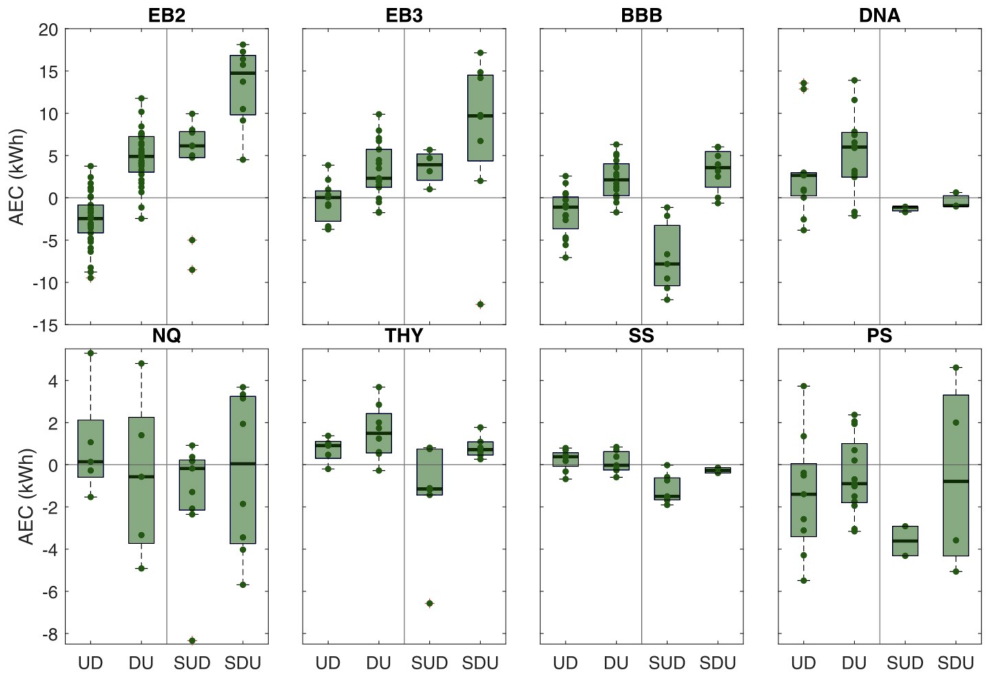
Example 1 – Efficiency of Load Shifting DR

- Are buildings inefficient “batteries”?



Beil et al. 2015

Additional Energy Consumption (AEC) of HVAC Fans

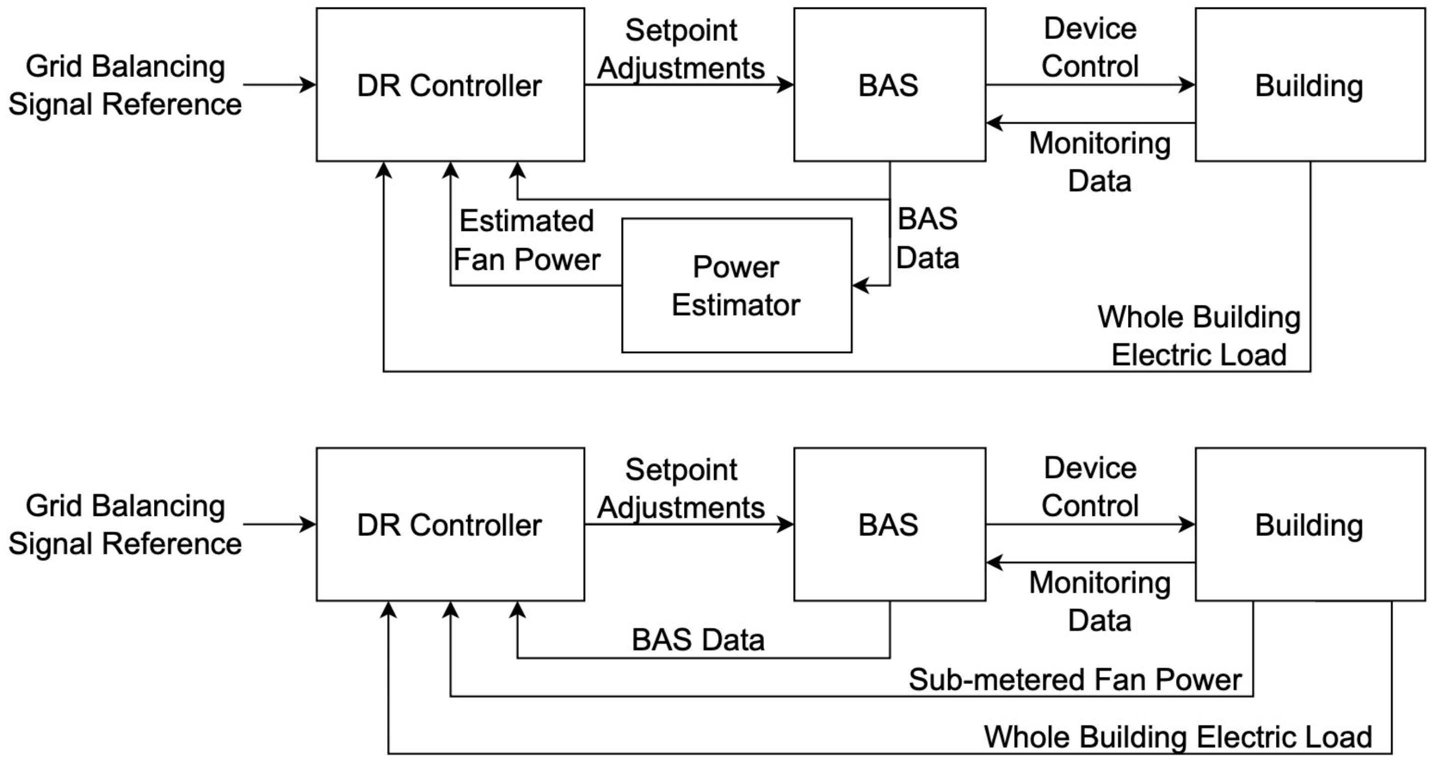


Keskar et al. 2012

What can we learn from this data?

Example 2 – Challenges of Closing the Loop

- We'd like to close the loop on a power measurement
- Building Automation Systems don't usually capture power
- We can estimate power, but is that good enough for closing the loop?



Lin et al. (in review)

Value of HVAC Submetering

How well can we estimate HVAC fan power?

- Four models:
  - Linear $p_{est,j}(t) = \alpha_j V_j(t),$
  - Quadratic $p_{est,j}(t) = \beta_j V_j(t)^2,$
  - Cubic $p_{est,j}(t) = \gamma_j V_j(t)^3,$
  - Regression $p_{est,k}(t) = \chi_k M_{bas,k}(t),$

Air flow volume, measured by BAS

All measurements by BAS

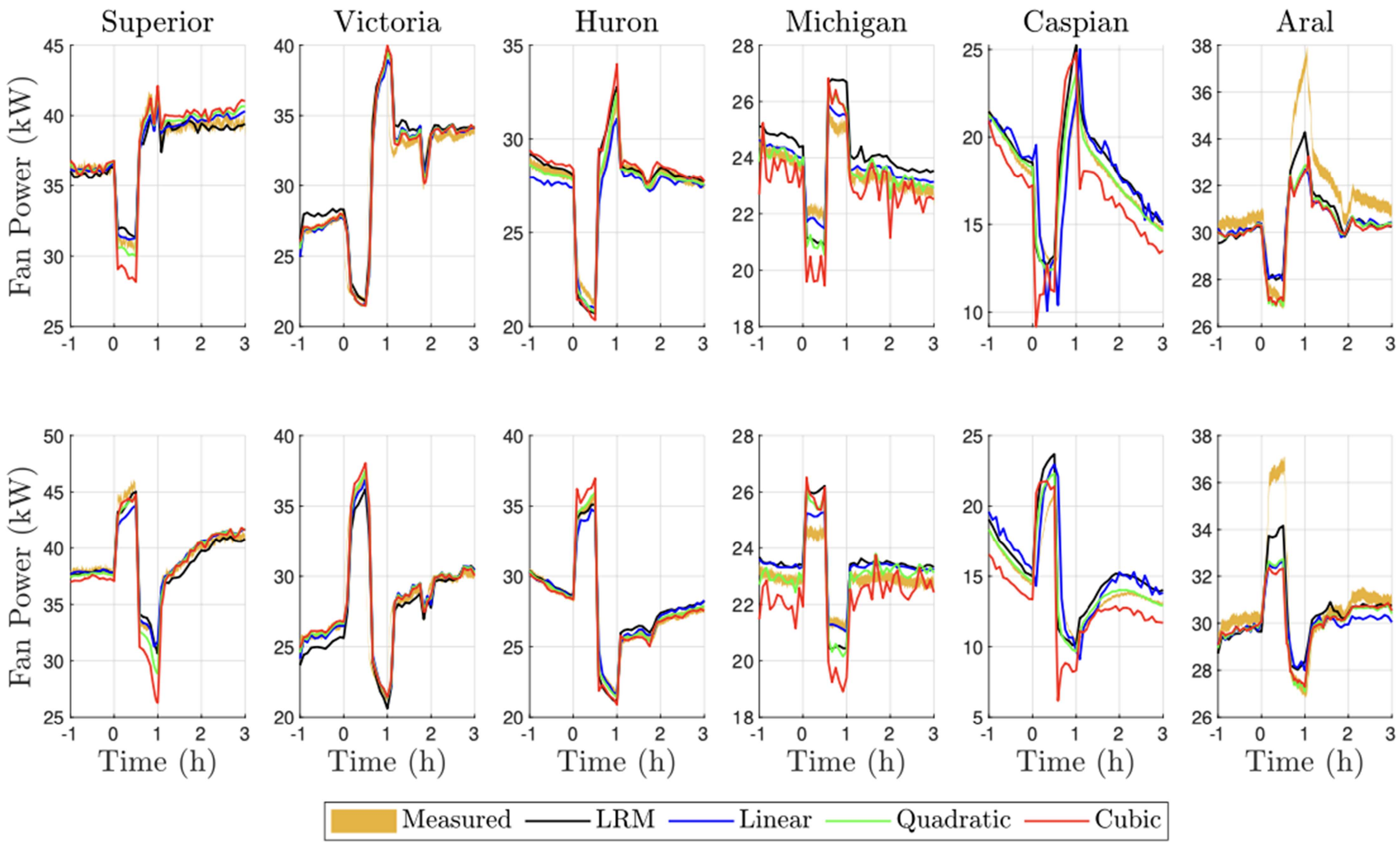
→ Physics tells us the relationship should be cubic; however, BAS operation and control affect the empirical relationship, which often has a better fit to a linear or quadratic function

Value of HVAC Submetering

Mean measured + predicted HVAC fan power – 6 Buildings

Down/Up Events

Up/Down Events



Looks OK, right?

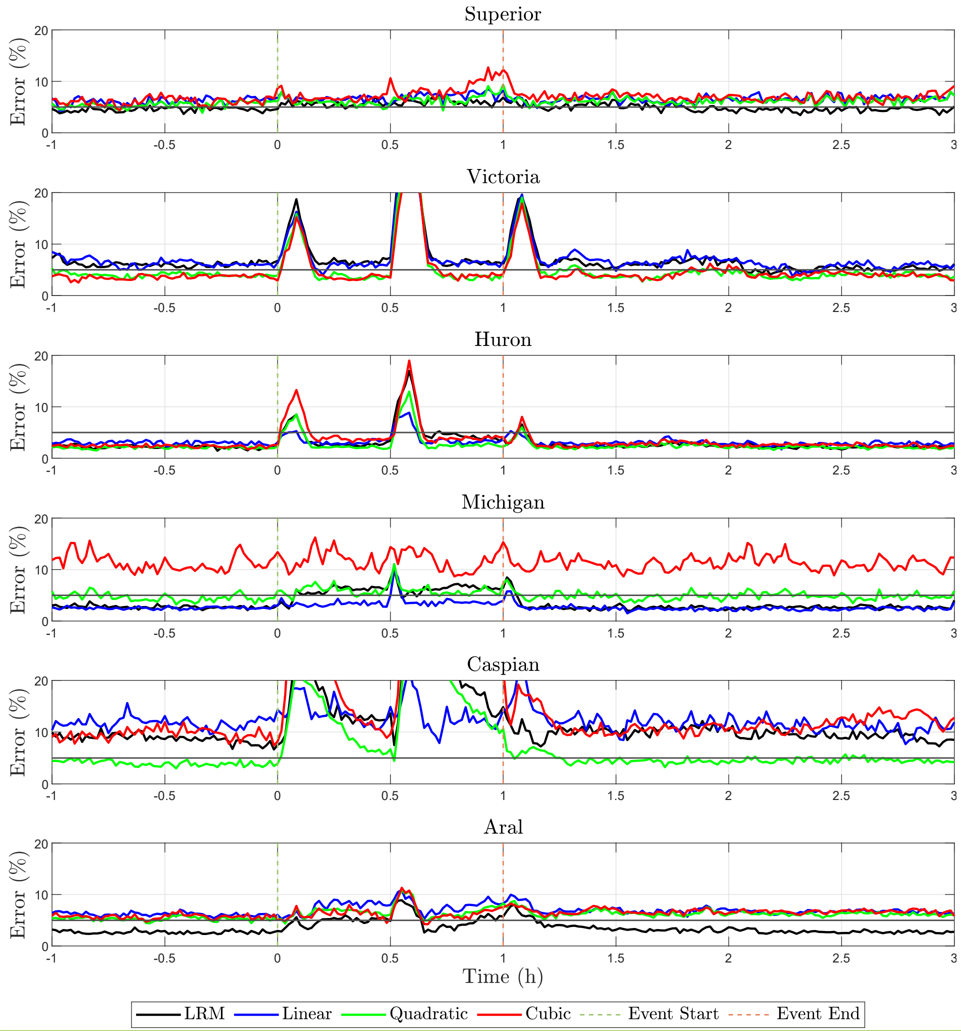
Value of HVAC Submetering

Median prediction error

- Often, error spikes when temperature setpoint changes → models don't capture transients

Table 3. Means and standard deviations of normalized RMSEs between measured and estimated fan power.

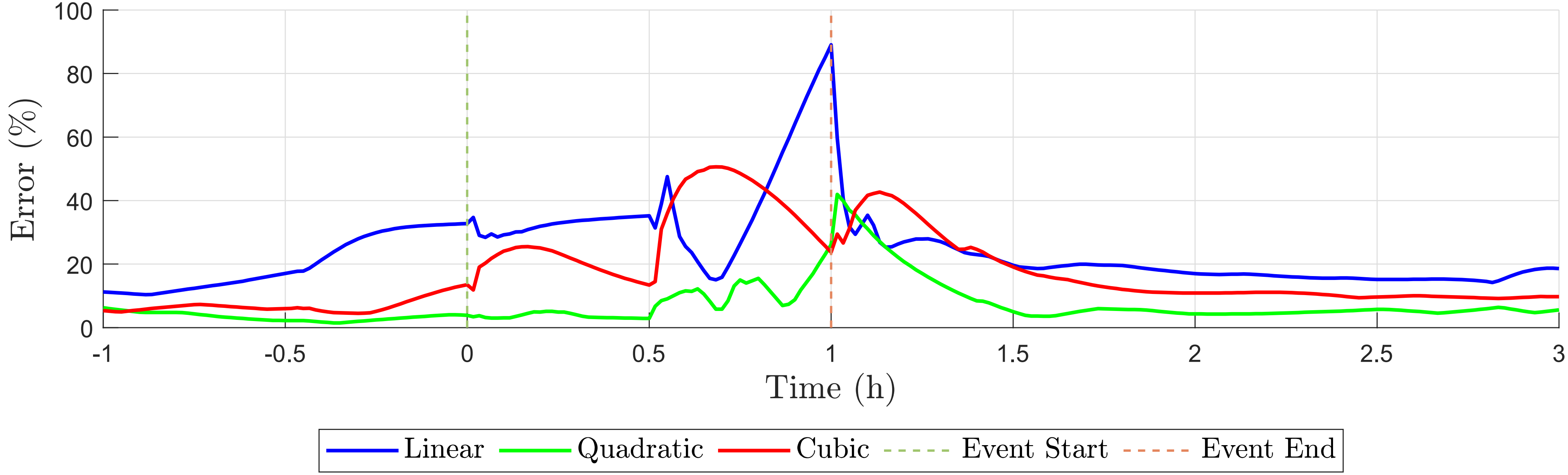
	LRM		Linear		Quadratic		Cubic	
Bulding	Mean	Std	Mean	Std	Mean	Std	Mean	Std
Superior	0.0698	0.0213	0.0807	0.0309	0.0816	0.0368	0.1000	0.0427
Victoria	0.1158	0.0478	0.1139	0.0313	0.0906	0.0247	0.0884	0.0251
Huron	0.0447	0.0135	0.0480	0.0195	0.0380	0.0096	0.0568	0.0334
Michigan	0.0613	0.0356	0.1529	0.3181	0.1803	0.3085	0.2408	0.2883
Caspian	0.1717	0.0662	0.1766	0.0490	0.1083	0.0400	0.2163	0.0650
Aral	0.0555	0.0216	0.0913	0.0284	0.0882	0.0329	0.0939	0.0413



Value of HVAC Submetering

Simulation Results

- We see the same issues in simulation, using the Modelica Buildings Library → We need submetering for closed-loop control?



Final Thoughts

- We should do more experiments on real buildings!
    - J. de Chalendar: “While the prevailing method is “model first, experiment second”, there is also strong value in “experiment first, model second” and in improving our understanding of a system through experimentation before modeling it.”
- We should make our data open access!
- We should accelerate our efforts to use buildings as grid assets!

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