Energy Modeling with Real-Time Weather: Understanding Utility Bills

RESNET 2008

February 20th, 2008

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Presentation Overview

- Real-time weather data is an important component of building analysis
- Real-time weather data is abundant
- Case study illustrating how real-time weather data was used to improve utility bill allotments

Definitions

- Heating Degree Days (HDD):

  HDD = Base Temp – Average Daily Temp

- Cooling Degree Days (CDD):

  CDD = Average Daily Temp – Base Temp

- Annual Degree Days is the sum of these for 365 days

  Annual HDD = (65 – 55) * 365 = 3,650

Important Component of Building Analysis

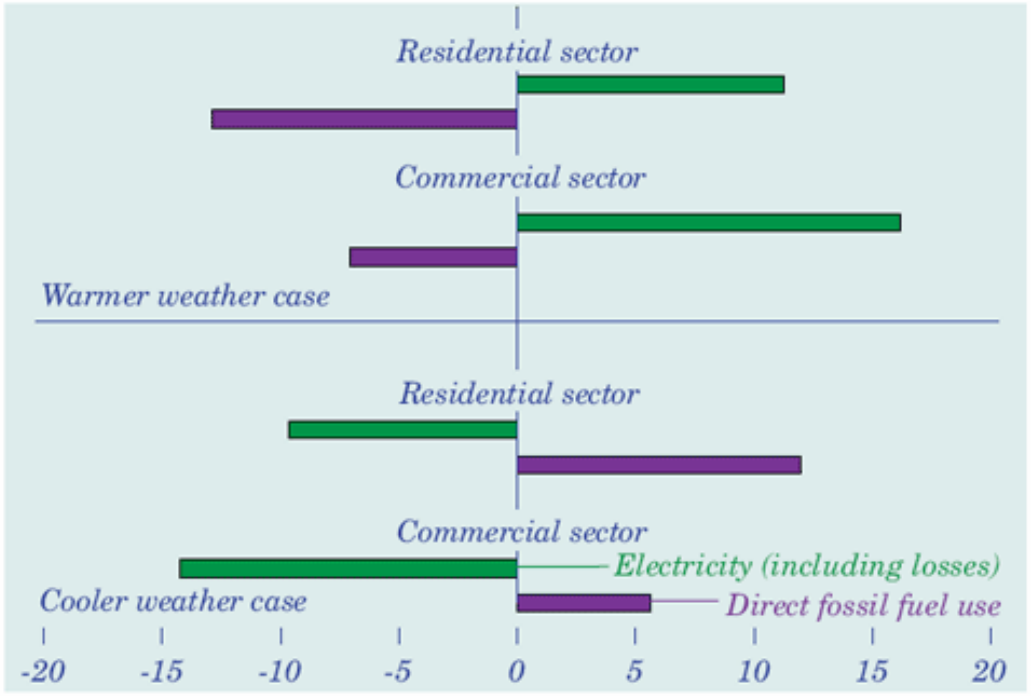
Variation of -11% to +12% in heating degree days

Variation of -16% to +15% in cooling degree days

Source: EIA

Important Component of Building Analysis

Present Values of Change in Building Sector Energy Due to Weather Variations



Billion 2003 $

Source: EIA

Real-Time Weather Data is Abundant

- Multiple free, public sites with data:
  - http://www.engr.udayton.edu/weather/
  - http://www.eere.energy.gov/buildings/energyplus/cfm/weatherdata/weather_request.cfm
- Though some data processing may be needed prior to use

More Than Just Degree Days

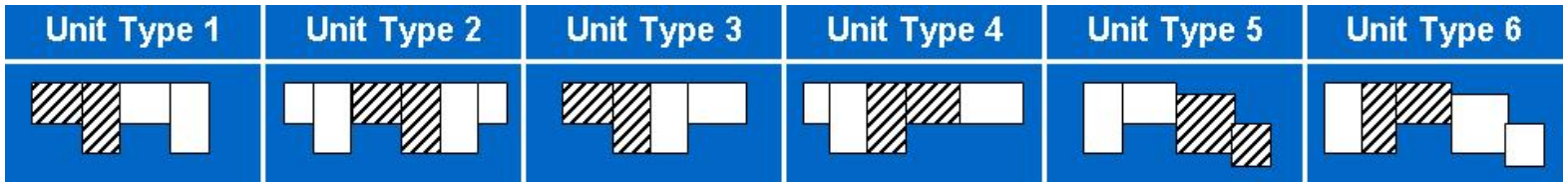
- DOE-2 relies upon numerous weather parameters for each hour, such as:
  - Wet bulb temperature
  - Dry bulb temperature
  - Cloud Type
  - Presence of snow
  - Presence of rain
  - Wind speed

- Custom weather files can be created by replacing certain parameters with real weather data

Real-Time Weather & Program Design: Example

Context:

- Residential tenants provided with a monthly utility bill allotment
- Development consisted of six housing configurations, with two to sixteen units for each configuration:



- Allotments were defined by simply averaging consumption across all units.
- Residents were billed/credited for deviating from the allotment

Real-Time Weather & Program Design: Example

Challenge:

- Existing methodology did not properly account for differences in:
  - architectural characteristics
  - energy efficiency features
  - actual weather
  - occupant behavior
- Impact from anomalous energy consumers was distributed across all occupants rather than being attributed to outliers
- Existing methodology produced high tenant dissatisfaction
- Could the existing methodology be improved?

Real-Time Weather & Program Design: Example

Solution:

- Use energy modeling to create profiles of each unit type

- Account for:
  - Exact architectural characteristics
  - Exact energy efficiency features
  - Actual weather conditions
  - Allotted occupant behavior

Real-Time Weather & Program Design: Example

Solution:

- To account for real-time weather:
  - Developed custom weather files for time period that matched consumption data
  - Completed hourly simulations for each unit type using custom weather files

- Benchmark resulting profiles against utility bill data to ensure accuracy

Real-Time Weather & Program Design: Example

Comparison of TMY vs. Actual Degree Days

	TMY	Actual	% Difference
HDD	4032	3576	11%
CDD	1671	1565	6%

Real-Time Weather & Program Design: Example

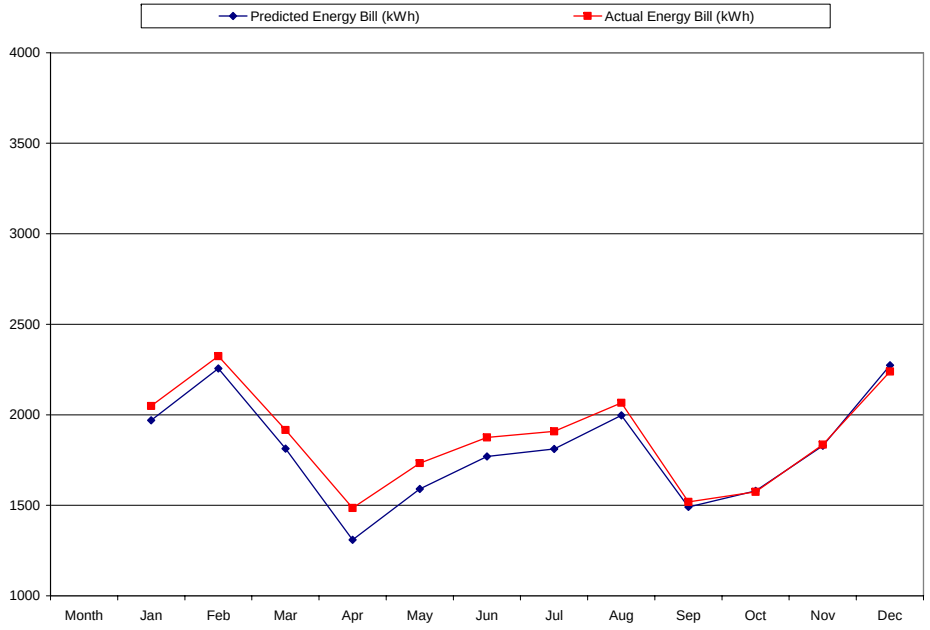
Impact of Using Real Weather Data

	Energy Consumption (kWh)			Actual Vs. Real Weather Simulation (%)	Actual Vs. TMY Weather Simulation (%)
	Actual	Predicted Using Real Weather Data	Predicted Using TMY Data		
Jan	2,108	2,163	3,158	3%	33%
Feb	2,293	2,305	2,548	1%	10%
Mar	1,859	1,613	1,751	-15%	-6%
Apr	1,329	1,180	1,272	-13%	-4%
May	1,363	1,152	1,157	-18%	-18%
Jun	1,614	1,771	1,879	9%	14%
Jul	1,723	2,135	2,148	19%	20%
Aug	1,731	2,158	2,084	20%	17%
Sep	1,225	1,523	1,867	20%	34%
Oct	1,571	1,165	1,083	-35%	-45%
Nov	1,538	1,375	1,449	-12%	-6%
Dec	2,020	1,962	2,104	-3%	4%
Total	**20,373**	**20,503**	**22,501**	**1%**	**9%**

Real-Time Weather & Program Design: Example

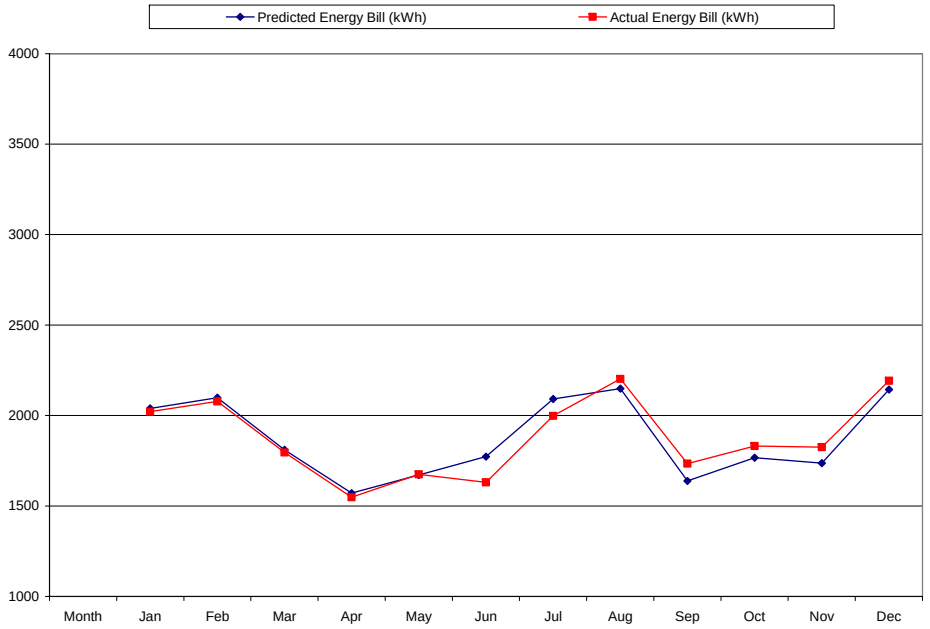
Results:

Unit Type 1 – 8 Units



Close Alignment

Unit Type 2 – 8 Units

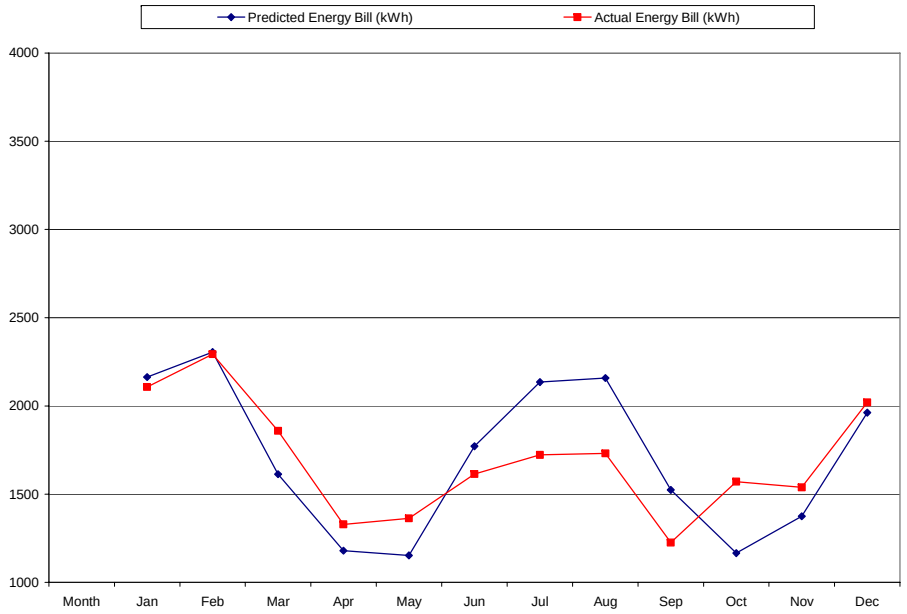


Close Alignment

Real-Time Weather & Program Design: Example

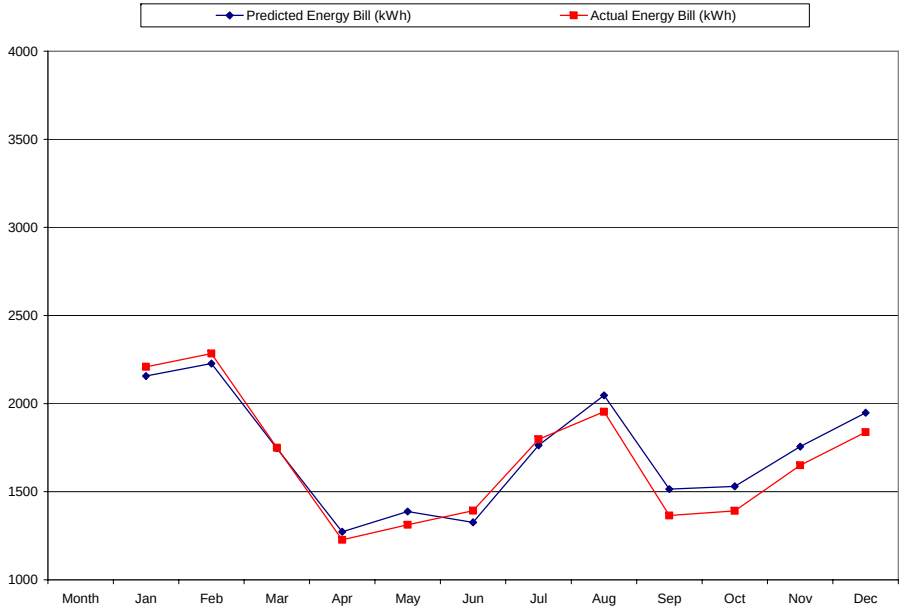
Results:

Unit Type 3 – 16 Units



Generally Close Alignment

Unit Type 4 – 10 Units

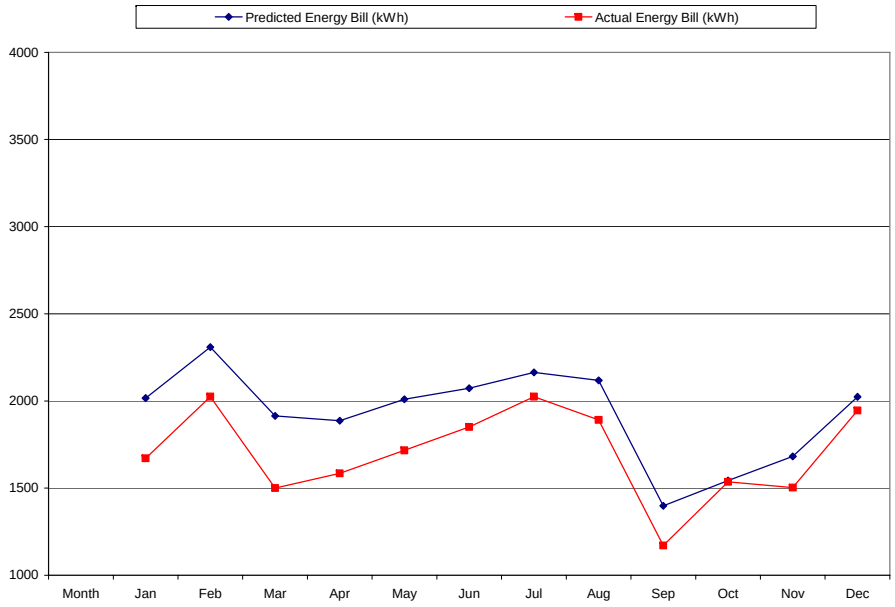


Close Alignment

Real-Time Weather & Program Design: Example

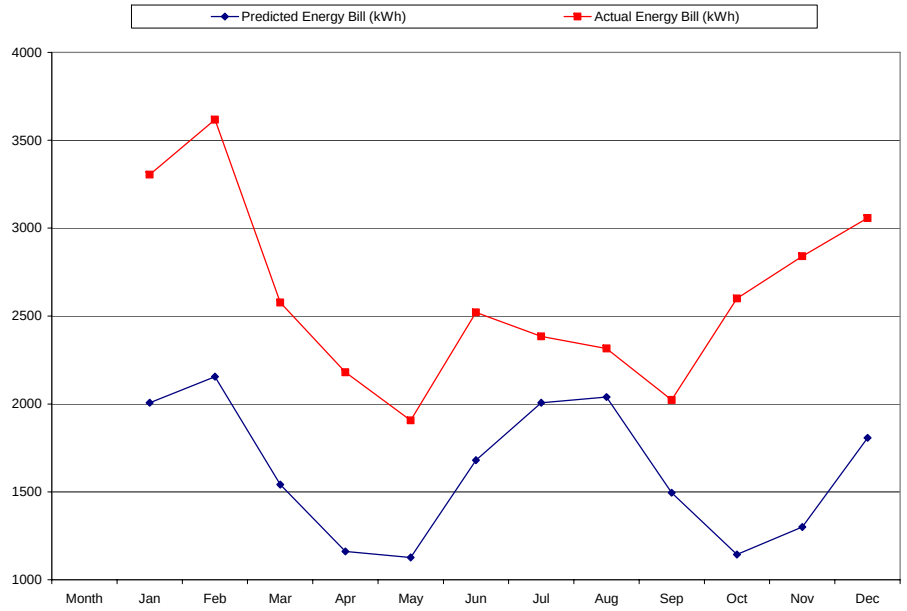
Results:

Unit Type 5 – 4 Units



Generally Close Alignment

Unit Type 6 – 2 Units

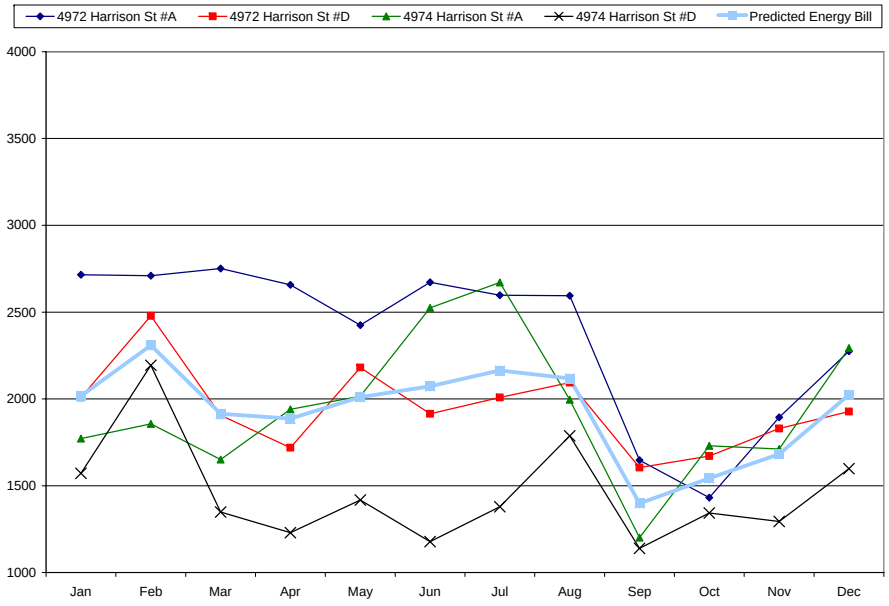


Alignment Not Close Due to One Outlier

Real-Time Weather & Program Design: Example

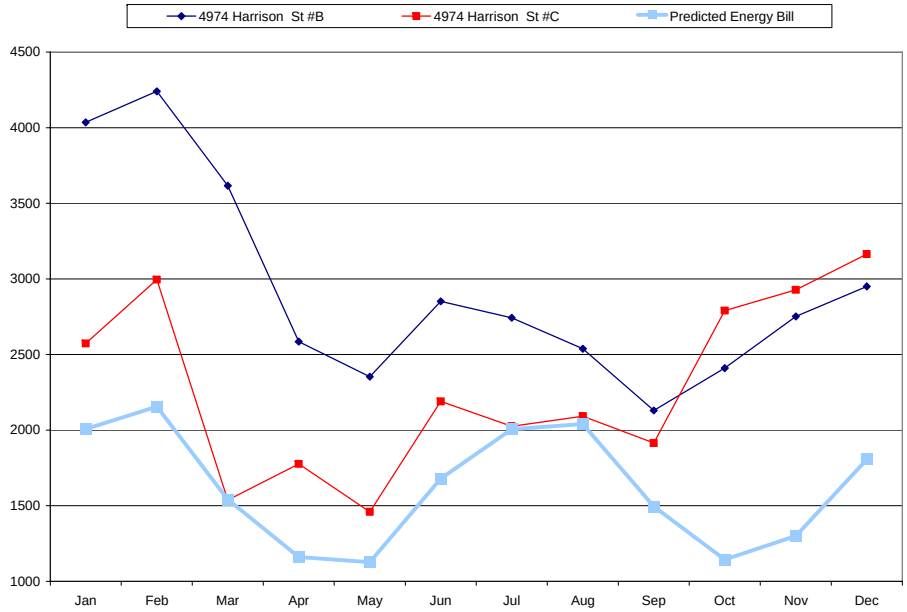
Analysis of Anomalous Results:

Unit Type 5



Actual consumption for all Unit Type 5 units

Unit Type 6



Actual consumption for all Unit Type 6 units

Occupant behavior likely cause of outliers

Real-Time Weather & Program Design: Example

Conclusions:

- Program design can be improved by using building simulation to account for:
  - Architectural characteristics
  - Energy efficiency features
  - Actual weather conditions
  - Allotted occupant behavior
- This improved approach can help identify outliers and properly credit or charge them for their variation in behavior
- In contrast, averaging utility bills does not properly credit or charge outliers

Overall Conclusions

- Actual weather conditions are a key driver of building consumption
- Real-time weather data is free and publicly available
- Incorporating real-time weather data into building analysis can improve accuracy and reduce number of unknown variables related to consumption
- Incorporating weather data into hourly simulations provides the highest level of accuracy