Weather Normalization

Presented by
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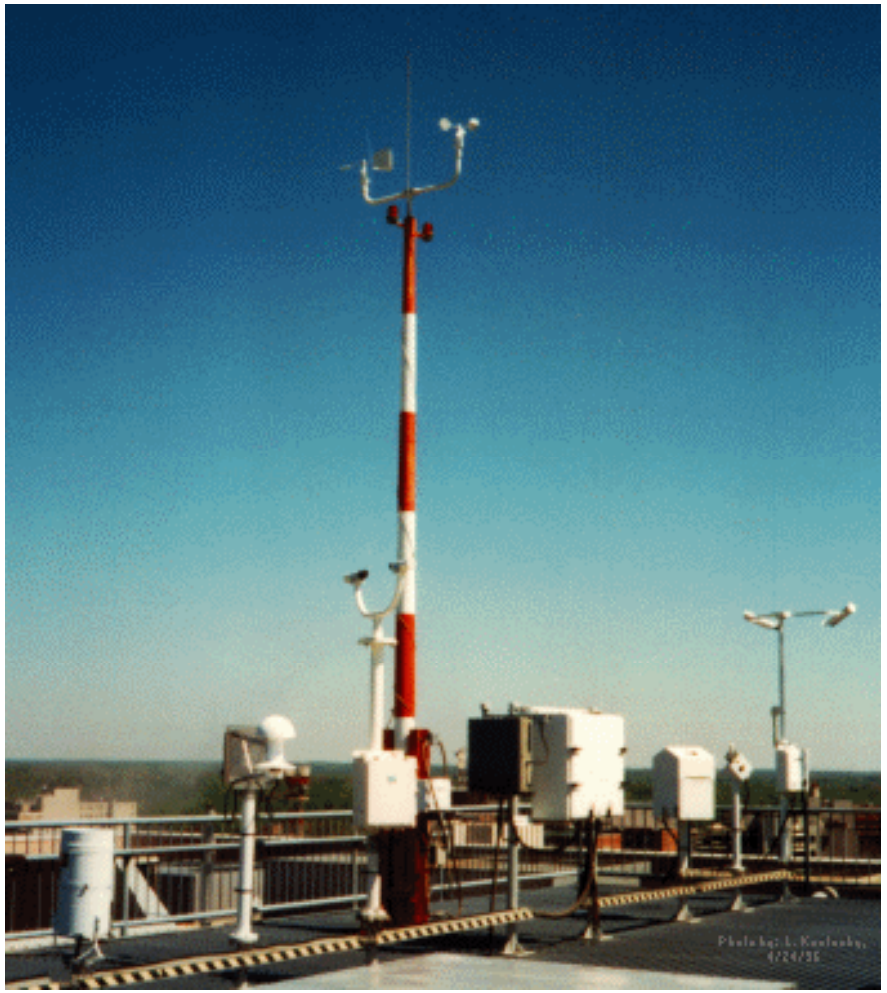
Agenda

- Overview of Weather Normalization Concepts

- Itron Benchmarking Study
  - Uses of Normalization
  - Definition of normal weather
  - Cold weather variables
  - Hot weather variables
  - Weather adjustment methods

- Review of study results
  - Discussion of issues
  - Presentation of industry practices
  - Recommendations

- Conclusion

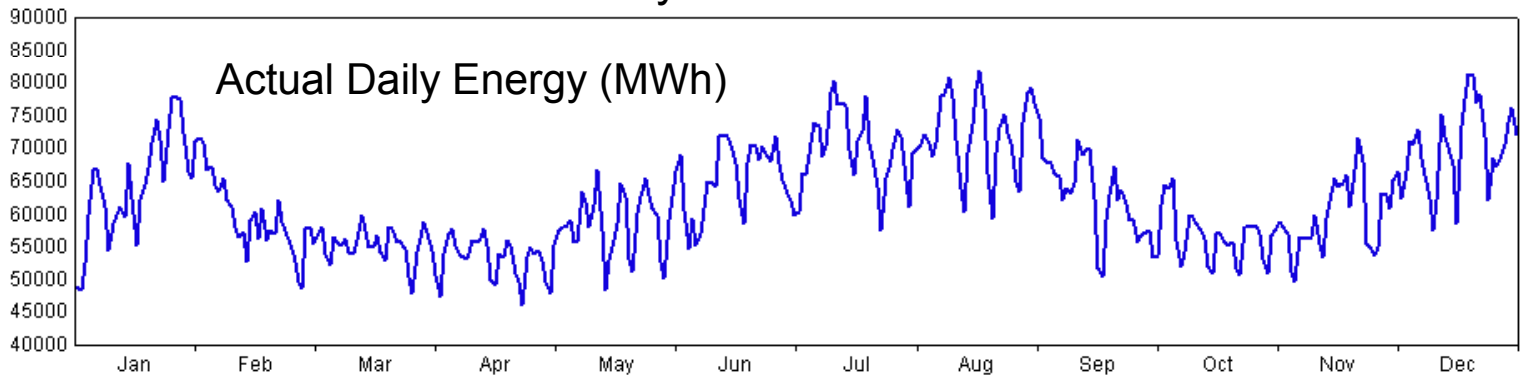


Applications of Normal Weather

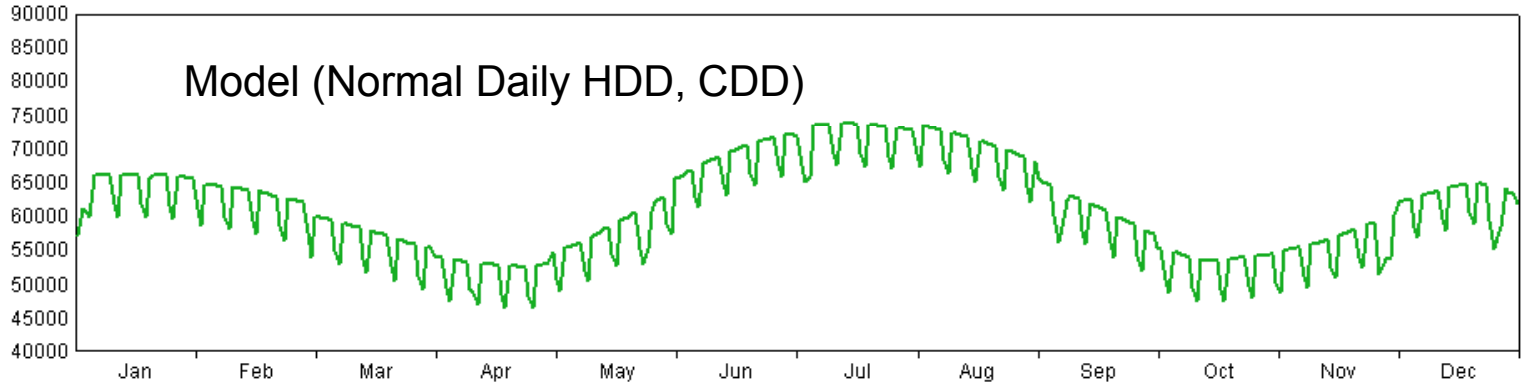
- Financial forecasting with normal weather
  - Budget forecast – usually calendar month energy use — Monthly, Averaged
  - Budget forecast of daily energy (for daily tracking) — Daily, Averaged
  - Monthly peak forecast — Daily, peak
  - Annual peak forecast — Daily, peak
- Financial variance analysis – adjusting from actual to normal
  - Adjust billed monthly energy use by class — Monthly, Averaged
  - Adjust booked (calendar month) energy use by class — Monthly, Averaged
  - Adjust system energy and peak demands — Daily, peak
  - Adjust daily system energy to track against budget — Daily, Averaged
- Facility Planning – weather scenario or simulations
  - Generate 8760 hour load forecast for dispatch simulations — Hourly, Chaotic
  - Design day forecast — Daily, Extreme
  - Simulate peak distributions, coincidence factor distributions,... — Daily, Multiple
- Market Analysis
  - Generate a “typical” load profile for a customer — Hourly, Chaotic
  - Generate facility baselines for budgets, pricing, ... — Monthly or Daily

Why Weather Normalization is Useful

- Actual energy use is chaotic. The main source of irregularity is weather. This is most obvious at the daily level



- Models using normal weather create order out of chaos, providing insights about underlying trends in energy use and revenues.

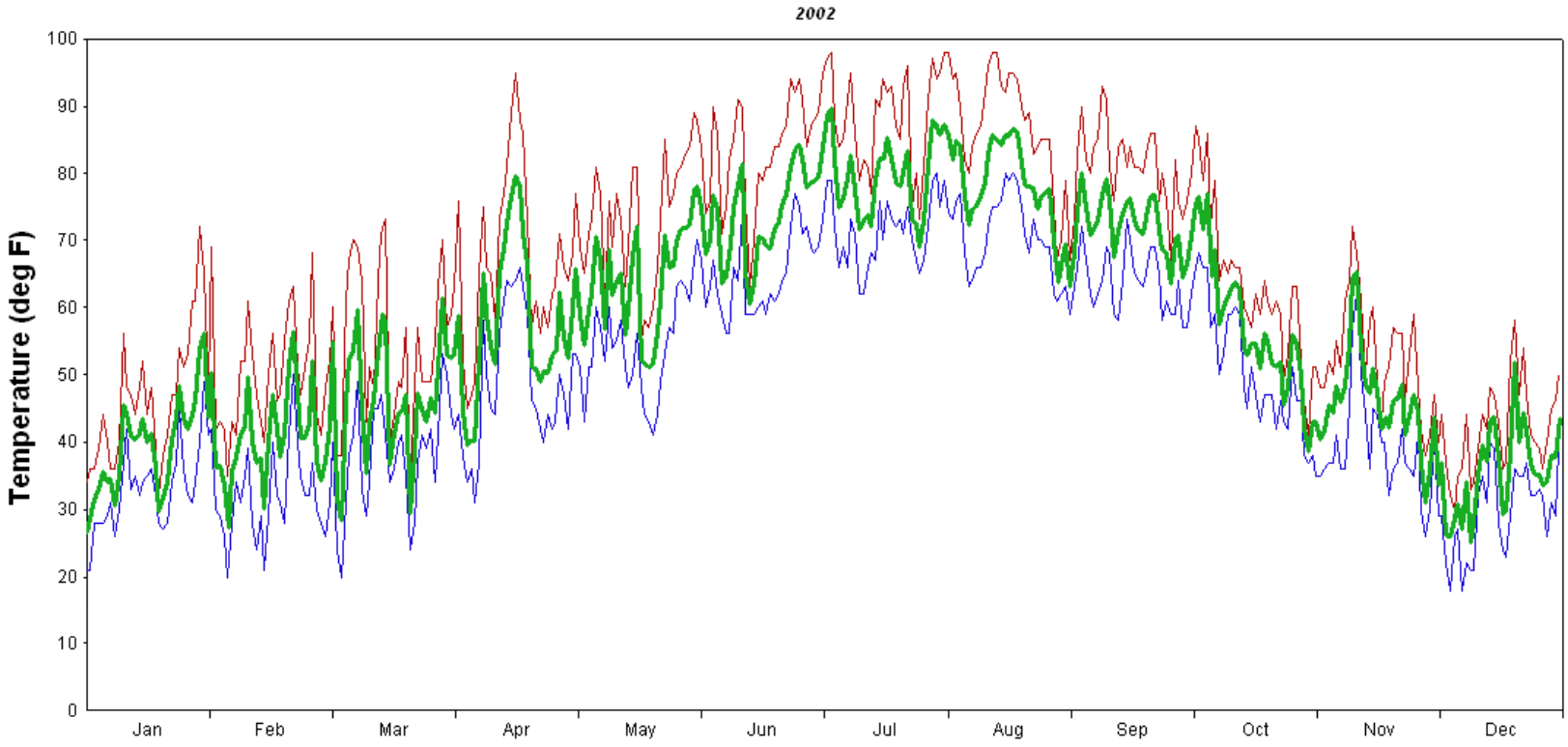


Types of Normal Weather

- Chaotic scenarios (daily or hourly)
  - Selected actual weather patterns (e.g., TMY files)
  - Rank and average, assign to calendar days. Intended to have normal extreme days as well as normal averages
- Daily Normals
  - Averaged by date
  - Apply nonlinear operations (HDD, CDD) before averaging
- Monthly Normals
  - Built up from daily normals (HDD and CDD values)
  - Average of monthly values – calendar month and/or billing month
- Peak Producing Weather
  - Weather based – hottest, coldest – normal extremes or design day (1 in 10)
  - Load based – weather on historical peak days
- Simulation Based
  - Multiple years of actual weather simulated through weather response function

Actual weather data is chaotic

- Actual weather data is chaotic. Some years are less irregular than others. But all years are irregular. So...what is normal?



Graph shows daily high, low, and average values for one year.

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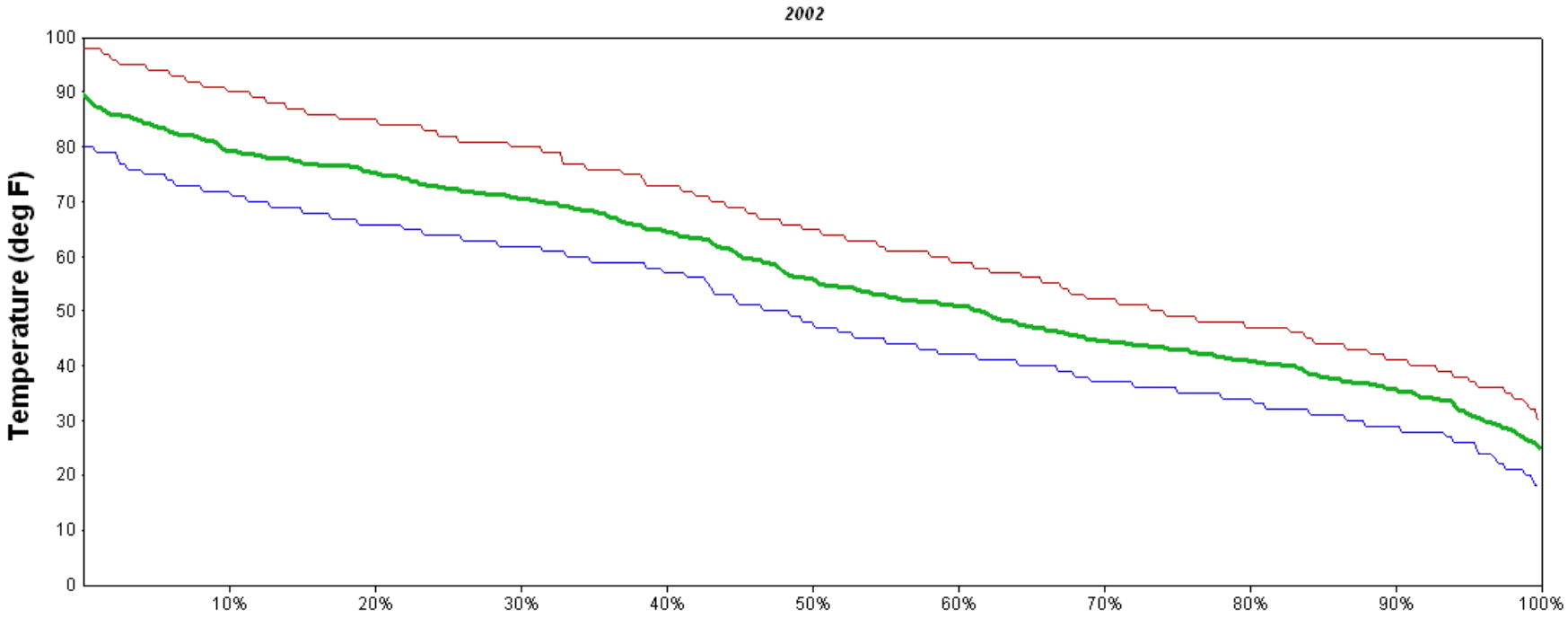
Rank and average methods

- Rank and average methods start by creating a “temperature duration” curve. The first number represents the hottest day in the year. Averaging across years gives a typical hottest day, second hottest day, ... , and on to a typical coldest day.



Graph shows sorted values for one year. High, low and average are sorted separately.

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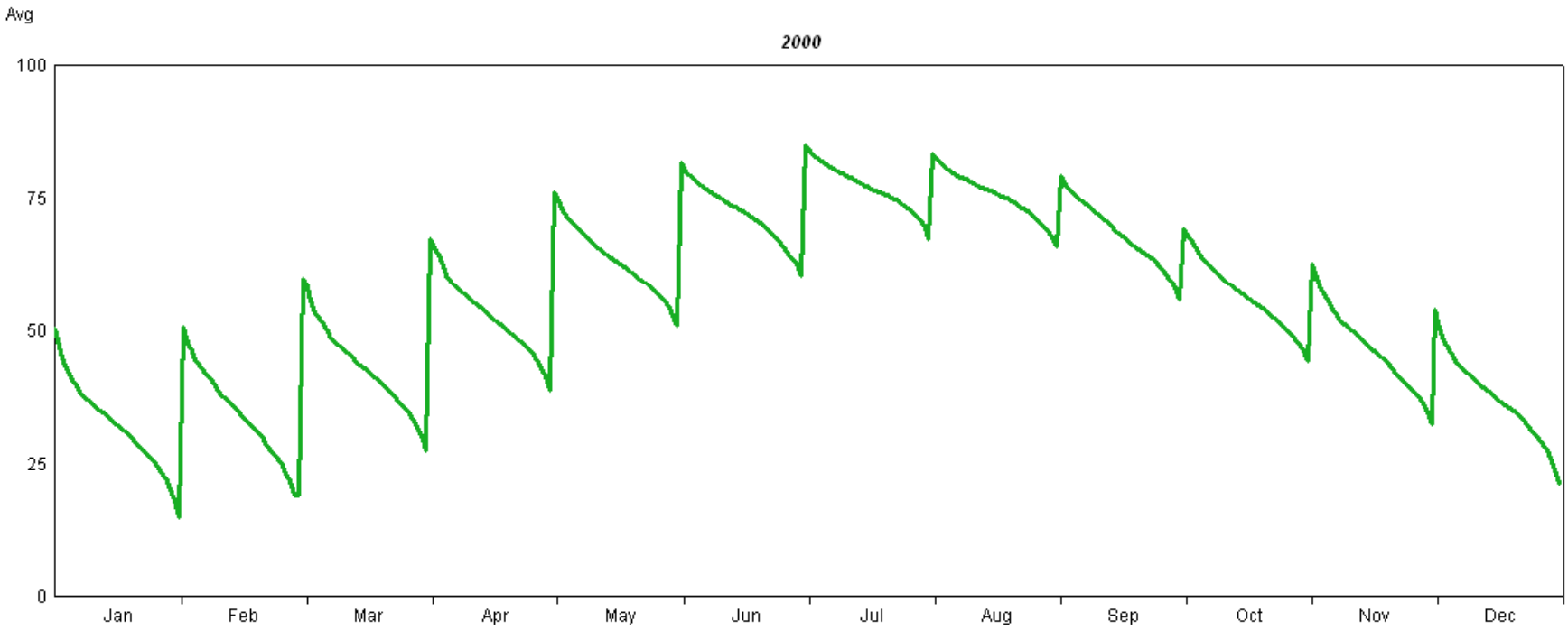
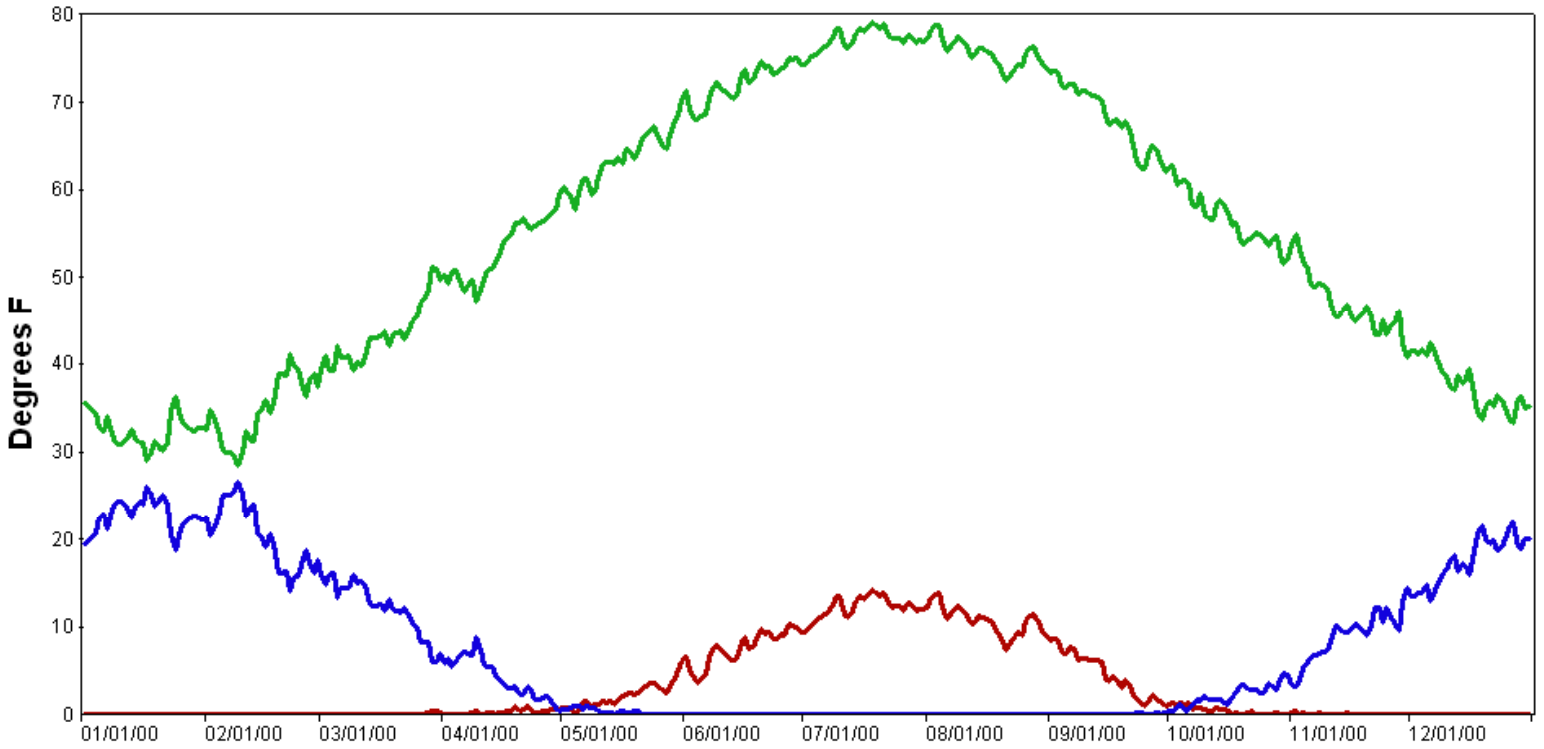
Rank and Average Methods

- Rank and average results have normal averages and normal extremes for each month (or season). They still need to be assigned out to specific dates, creating a chaotic scenario.



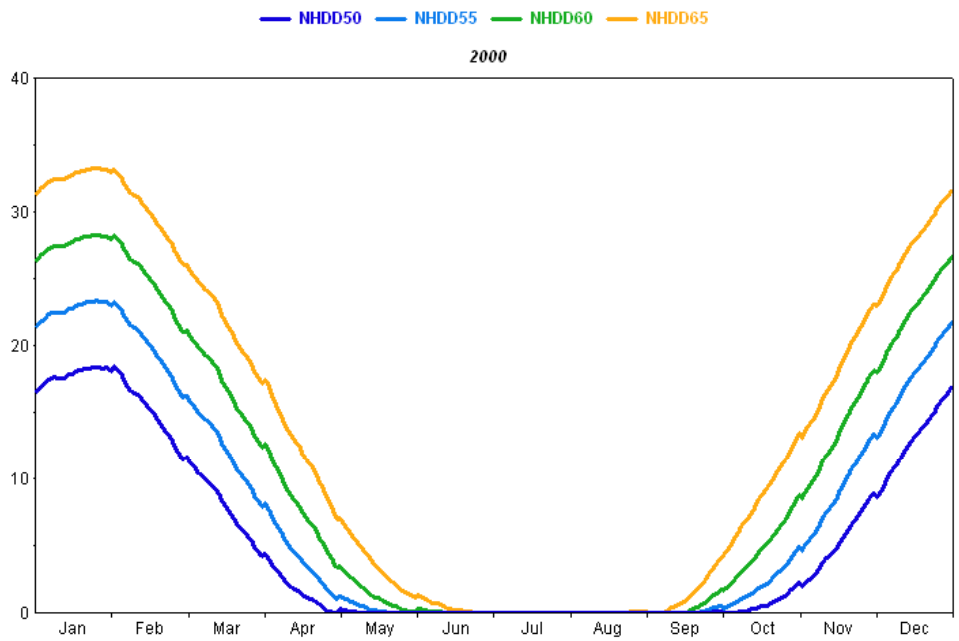
Averaging by Date

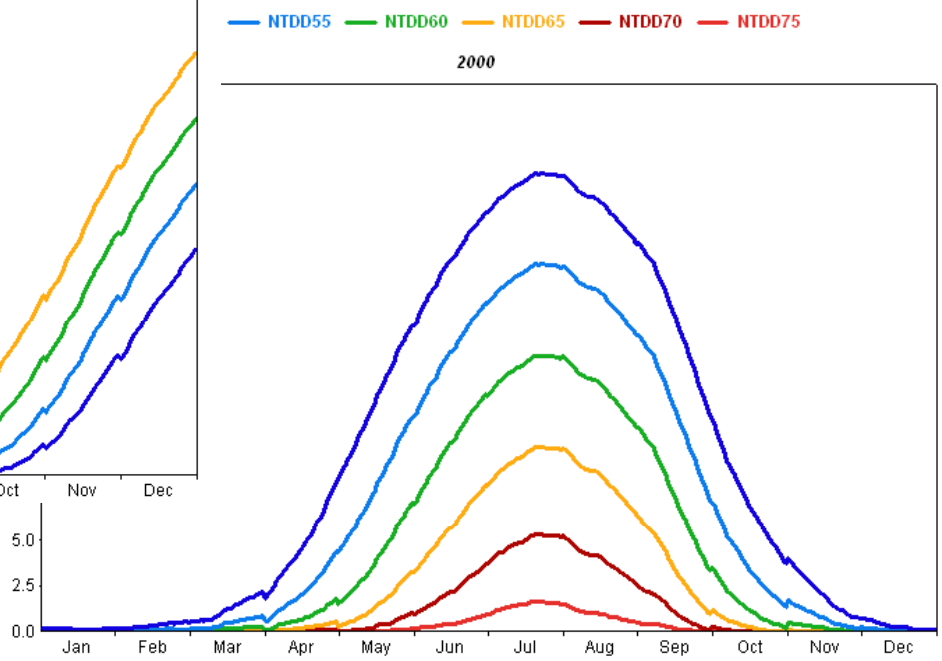
- Even after averaging across 30 years, average temperatures by date are a bit irregular. The same is true for HDD and CDD by date. Smoothing using centered moving averages will take the kinks out.



Smoothed Daily Normal HDD and CDD

- Smoothed daily normals look like this. By constructing these values for multiple CDD and HDD cut points, it is possible to distinguish between high powered and low powered degrees in the normalization process.





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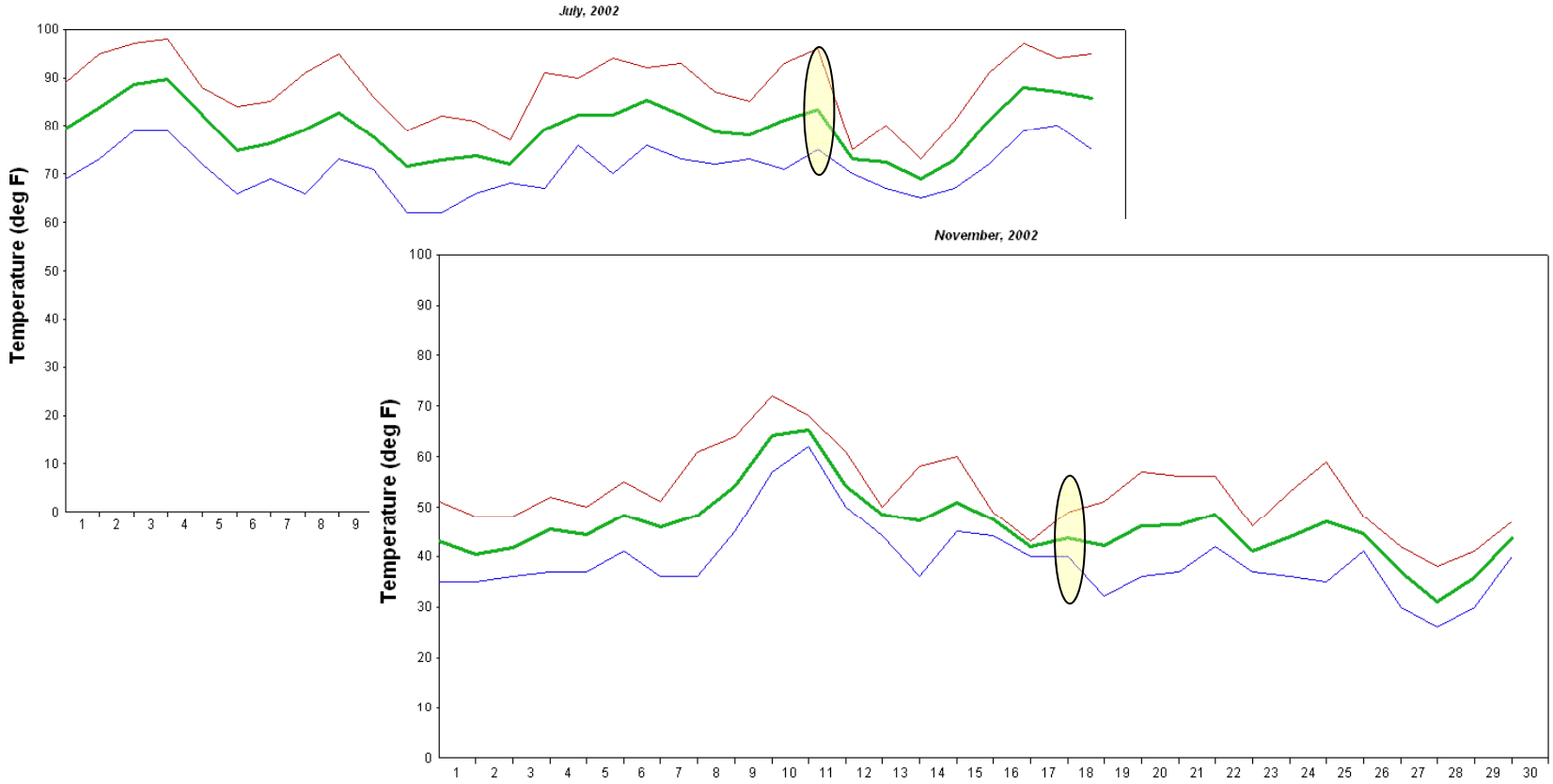
Peak producing weather is multidimensional

- Peak days are not necessarily the hottest or coldest days of the year. Peak producing weather is multidimensional – temperature, humidity, wind, clouds, prior day effects, ...



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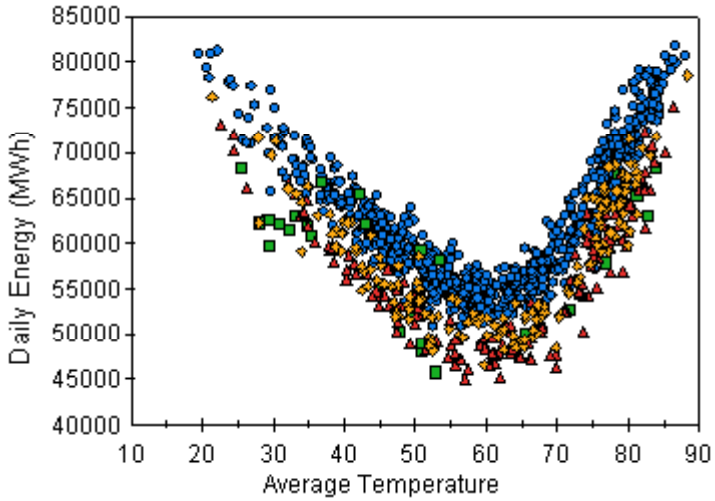
Why Weather Normalization is Tricky

- The response of energy usage to weather is not linear. As a result, averaging is dangerous. Accurate weather normalization requires nonlinear thinking.
- Weather slopes are changing rapidly in some areas.
- Weather response can differ significantly across months.



- The goal of weather normalization is to estimate the results of a simulation process with the following steps:
  - Estimate a model
  - Simulate energy use with the model for a variety of past weather patterns
  - Plot the distribution of energy outcomes
  - Compute the average of the distribution
- Conceptually we should measure our methods against this goal

Overview of Itron Benchmarking Study

- Internet survey with about 20 questions
- 172 respondents
- 170 employ some type of weather normalization process. 2 did not employ any weather normalization process
- Distribution of respondents
  - 76% electric companies
  - 8% gas companies
  - 16% electric and gas companies

Q. What are weather normal sales used for?

- 170 responses
- Weather normalized sales are used by 73 percent of the respondents as the base for forecasting.
- 59 percent of respondents use normalization for variance analysis and 44 percent use normalization for financial reporting.
- Other uses for weather normalized sales were cited by 14 percent of respondents. These uses include:
  - support for rate filings;
  - class load studies; and
  - capacity planning.

Q. What energy concepts do you weather normalize and report?

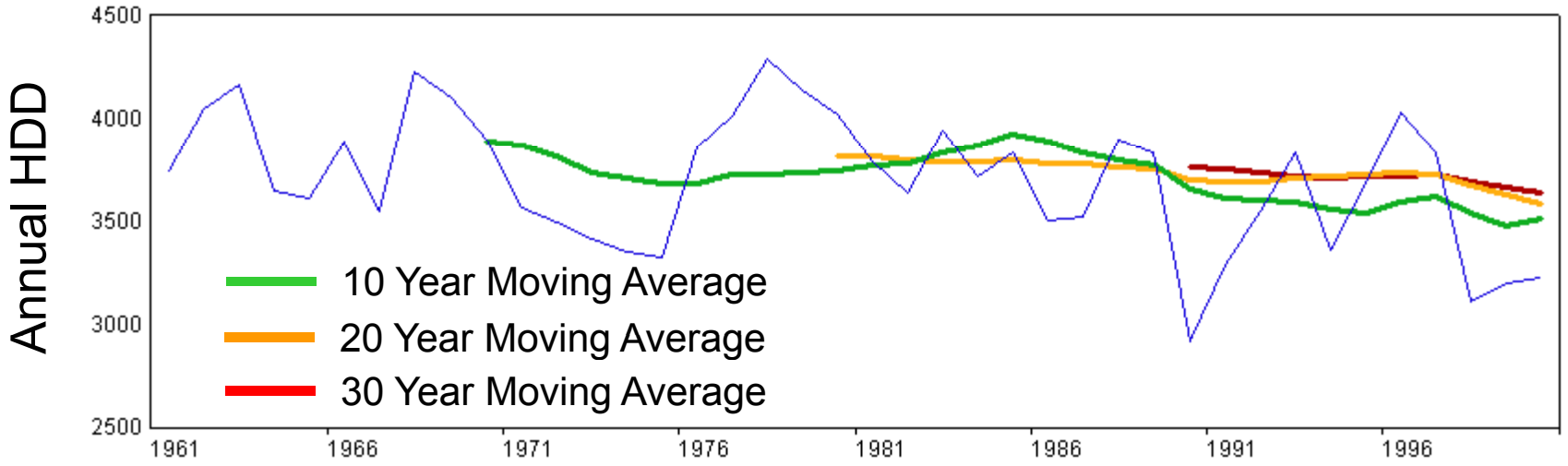
- The most common uses of weather normalization were reported to be:
  - Normalization of calendar month sales -- 59 percent
  - Normalization of system peak – 54 percent
  - Normalization of billed (cycle) sales – 45 percent
  - Normalization of unbilled sales – 13 percent

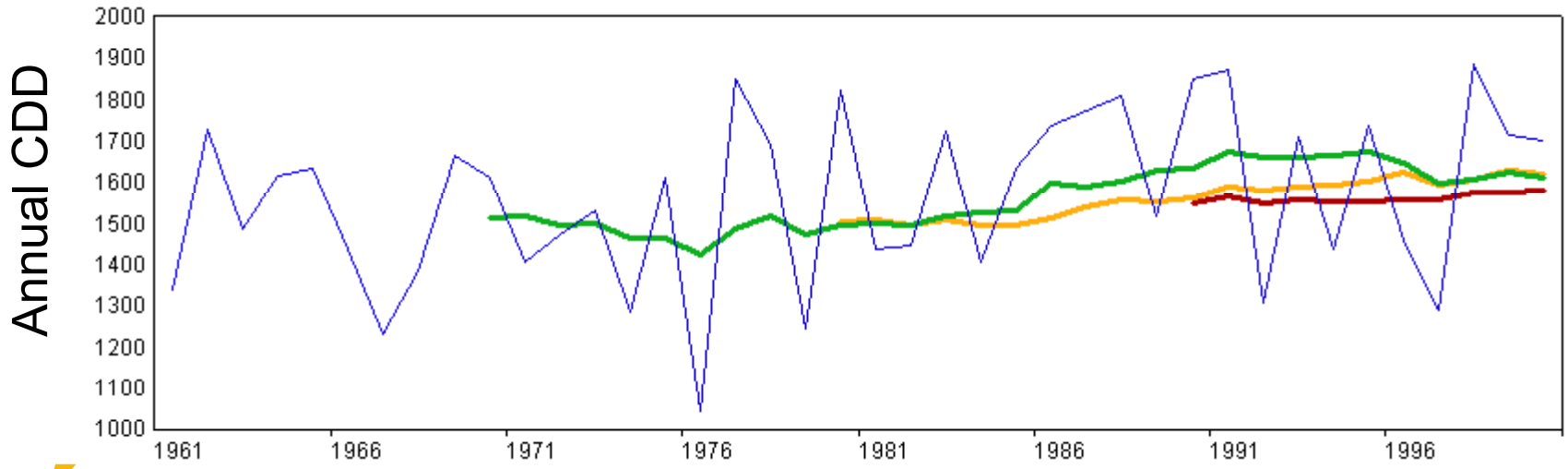
170 responses

Definition of Normal Weather

- Alternative definitions of normal weather?
  - A representative weather pattern (e.g., Typical Meteorological Year – TMY)
  - Average or median values computed from past weather patterns.
  - Typical extreme values.
- Weather variables covered
  - Temperature, humidity, wind, indexes (THI, Wind chill, ...)
- Frequency of the normal weather variables
  - Hourly, daily, monthly, annual
  - Cycle vs. calendar
- Source of the normal weather results
- Number of years of data used to calculate normal values

Trends in HDD and CDD





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Q. What do you use for normal weather?

- 167 responses
- Almost half (48 percent) of the respondents reported that they calculate normal weather using approaches developed by their company.
- The national weather services (NOAA and Environment Canada) are the source for roughly 40 percent of the respondents.
- Of this total, the vast majority use NOAA's 30-year normal weather.
- The remaining 11 percent of the respondents rely on commercial weather service providers or use typical year approaches.

Q. How many years of data do you use?

- 106 responses
- The majority (71 percent) of the respondents use 20 or more years to define normal weather.
  - Thirty years of data are used by 43 percent of the respondents.
  - Twenty years of data are used by 17 percent of the respondents.
  - Twenty-five years (2 percent) and
  - more than thirty years (9 percent) make up the balance of this majority.
- 6 percent of the respondents use 15 years of data.
- 16 percent use 10 years of data.
- Seven percent of the respondents use less than 10 years and most of those are using five years.
- The longest time span of data used is 60 years. The shortest span of data used is one year.

Q. Do you calculate an updated set of normal values every year?

- 114 responses
- Over two-thirds of the respondents (69 percent) update their normal values on a yearly basis
- The remaining 21 percent do not update their normal values annually

Q. Has the number of years that you use to define normal weather changed in the last few years?

- 115 responses
- Most respondents (75 percent) report that they have not changed their definition of normal weather.
- Of those that have changed the definition of normal years, the movement is, on average, to use a shorter data range.
- One of the reasons cited for change is that the 30-year normal is no longer relevant or does not reflect recent weather trends.
- Some cited the need to account for global warming as the reason behind moving toward a shorter time span.

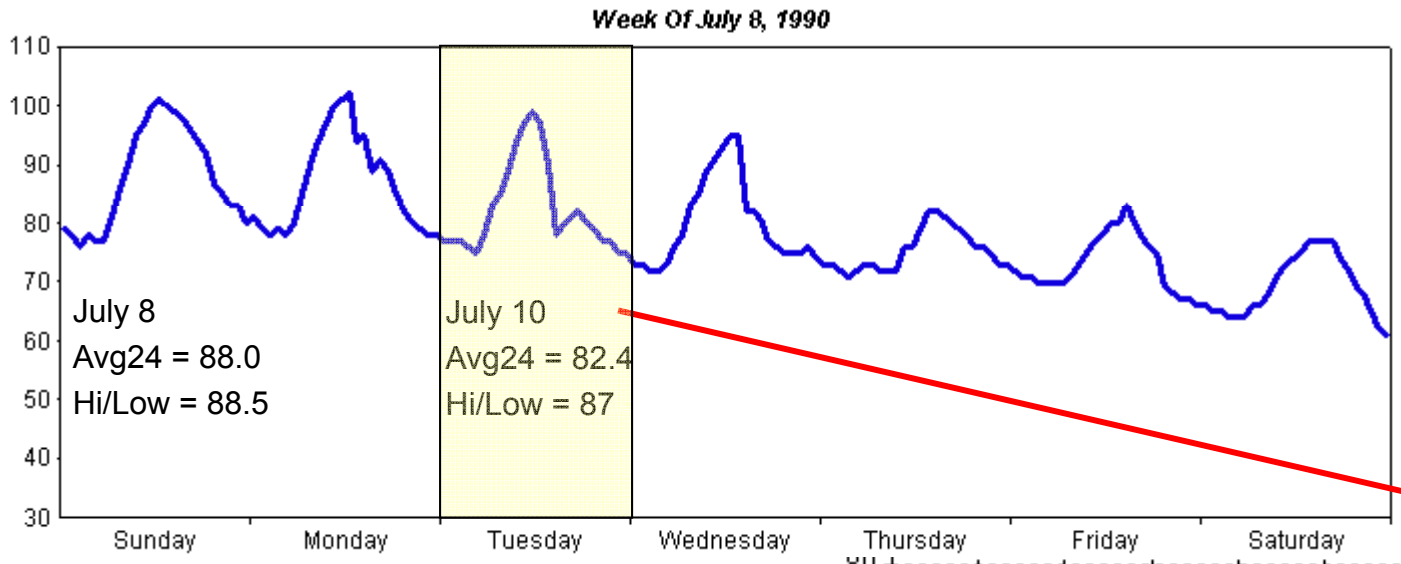
Definition of Weather Variables

- Heating Degree Day Variables
  - HD = heating degrees = degrees below a base temperature
    HD = Max(55-AvgTemp, 0)
    Example: AvgTemp = 43 implies HD = 12
  - HDD = heating degree days = Sum of HD over days in a cycle or month
- Cooling Degree Day Variables
  - CD = cooling degrees = degrees above a base temperature
    CD = Max(AvgTemp – 65, 0)
    Example: AvgTemp = 77 implies CD = 12
  - CDD = cooling degree days = Sum of CD over days in a cycle or month
- Issues:
  - Definition of average temperature
  - Inclusion of other factors (humidity, wind)
  - Base temperature value(s)

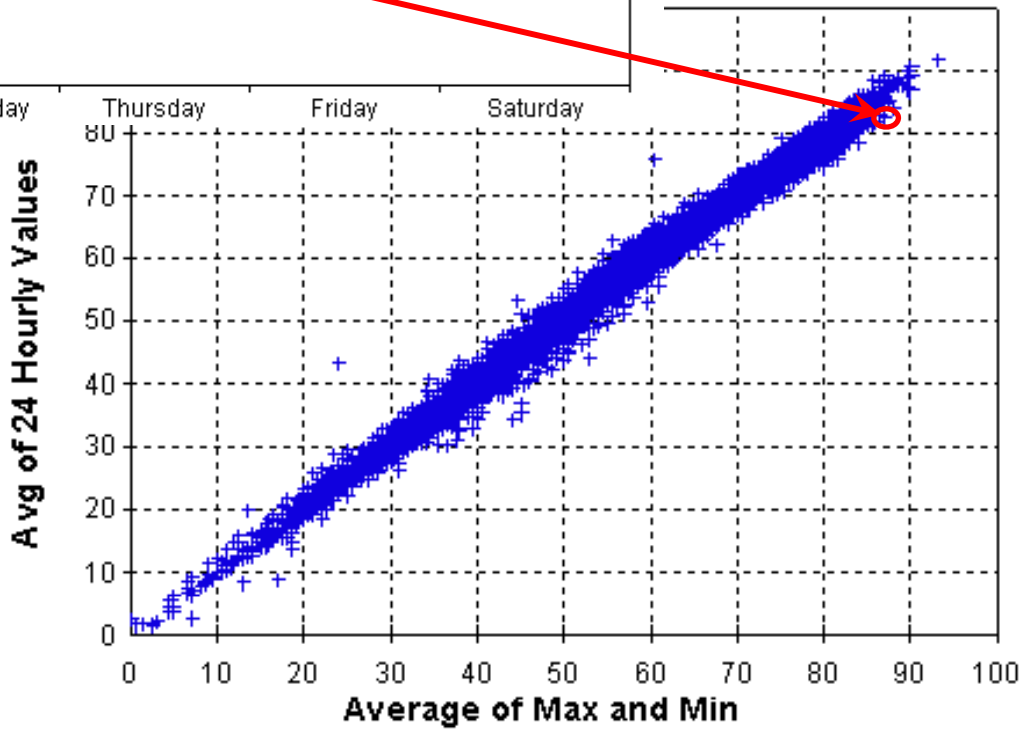
Q. If you use HDD and/or CDD that are calculated using a daily average temperature, how do you calculate the daily average temperature?

- 137 responses
- The majority (60 percent) of respondents compute average daily temperature as the average of the daily maximum and minimum temperatures.
- The average daily temperature is computed using an average of the 24-hour temperature values by 19 percent of the respondents.
- Seventeen percent use the average daily temperature provided by their weather service provider.
- The remaining 4 percent of the respondents use some form of THI or weighting of multiple days.

Example of Averaging Methods



- Average of Max & Min has been the industry standard for decades.
- Average of hourly values will work better on days where there are sudden temperature changes, such as caused by afternoon thunderstorms in summer.



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Calculation Logistics for Daily Normals

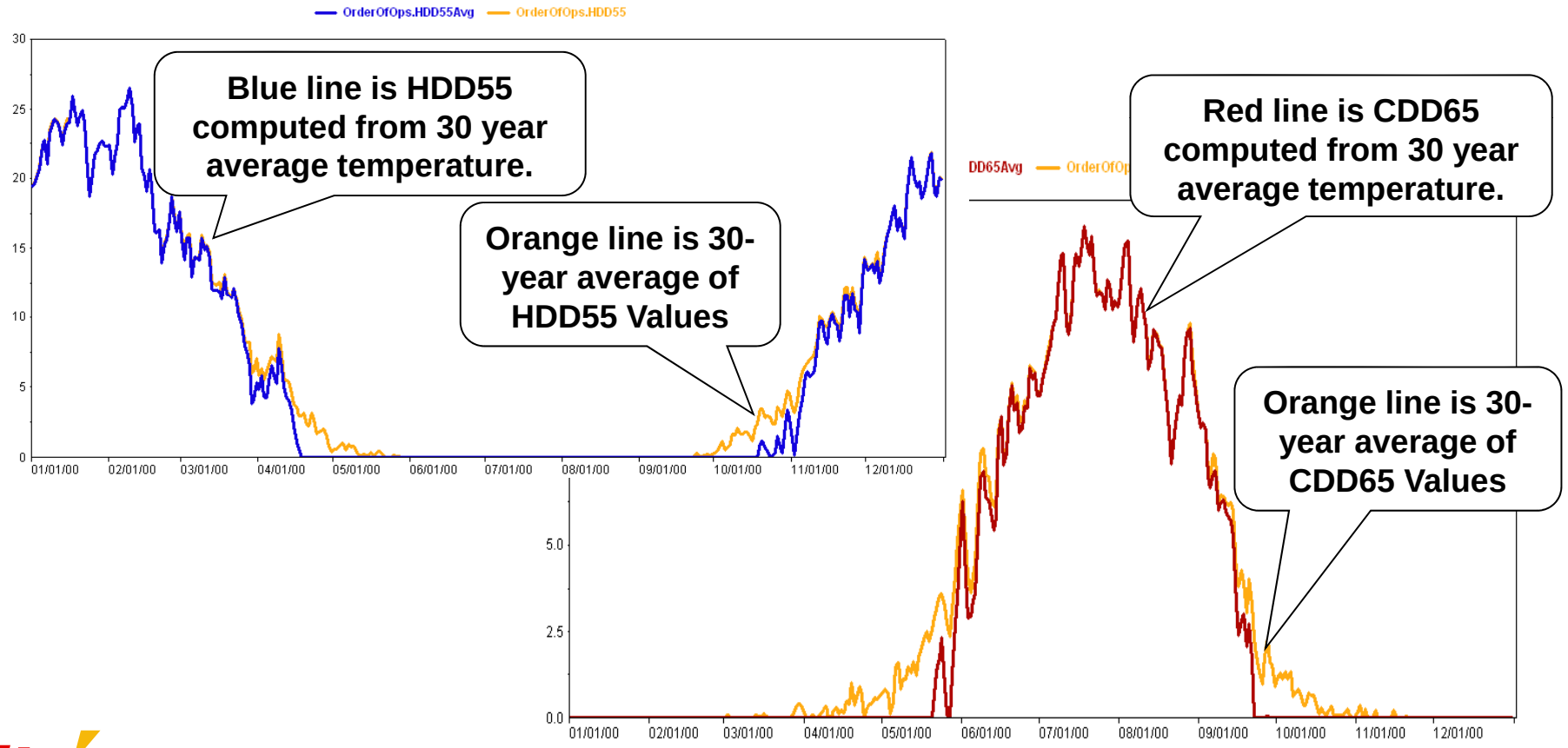
- Daily normals
  - NOAA has a daily normal series for HDD, CDD
  - Values are computed from 30 years and smoothed
  - DD values are computed for each date, then averaged across years
- The Rule: Always apply nonlinear operations first, then average. An example of the rule follows.

	Temp	CDD60	CDD65	CDD70
Year1	60	0	0	0
Year2	65	5	0	0
Year3	70	10	5	0
Year4	75	15	10	5
Year5	80	20	15	10
Avgerage	70	10	6	3

- A generalization of the rule is that we should compute predicted load with each historical weather pattern (a nonlinear transformation of weather) and then average the predicted loads.

Order of Operations Matters

- The order of operations matters. Compute nonlinear transformations (HDD and CDD) first, then average over years. Computing HDD and CDD from averaged values will cause a downward bias in swing months.



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Calculation Logistics for Monthly Normals

- Computed from Daily normals
  - Aggregate daily normal values by cycle
  - Average across cycles
  - Resulting normal monthly values reflect cycle schedules

- Computed from Monthly actuals
  - Compute DD variables for each historical month
  - Average across years for each month
  - Could also adjust for cycle days

- Calendar Month normals computed either way are about the same. The only fly in the ointment is Feb 29.

- Special calculations are required for peak producing weather.

Q. What variables do you use to adjust for cold weather?

- 166 responses
- The vast majority (80 percent) of the respondents report using Heating Degree Day (HDD) values based on temperature data.
- THI based HDD variables are used by 4 percent of the respondents.
- The remaining 16 percent of the respondents adjusted for temperature, humidity, cloud cover, and/or wind speed.

Q. If you use HDD, do you use a single base temperature or multiple segments?

- 86 responses
- The majority (85 percent) of the respondents report using a single trigger point.
- For companies using the Celsius scale, the average trigger point is 18°.
- The most commonly reported trigger points on a Fahrenheit scale are 55° and 65°.

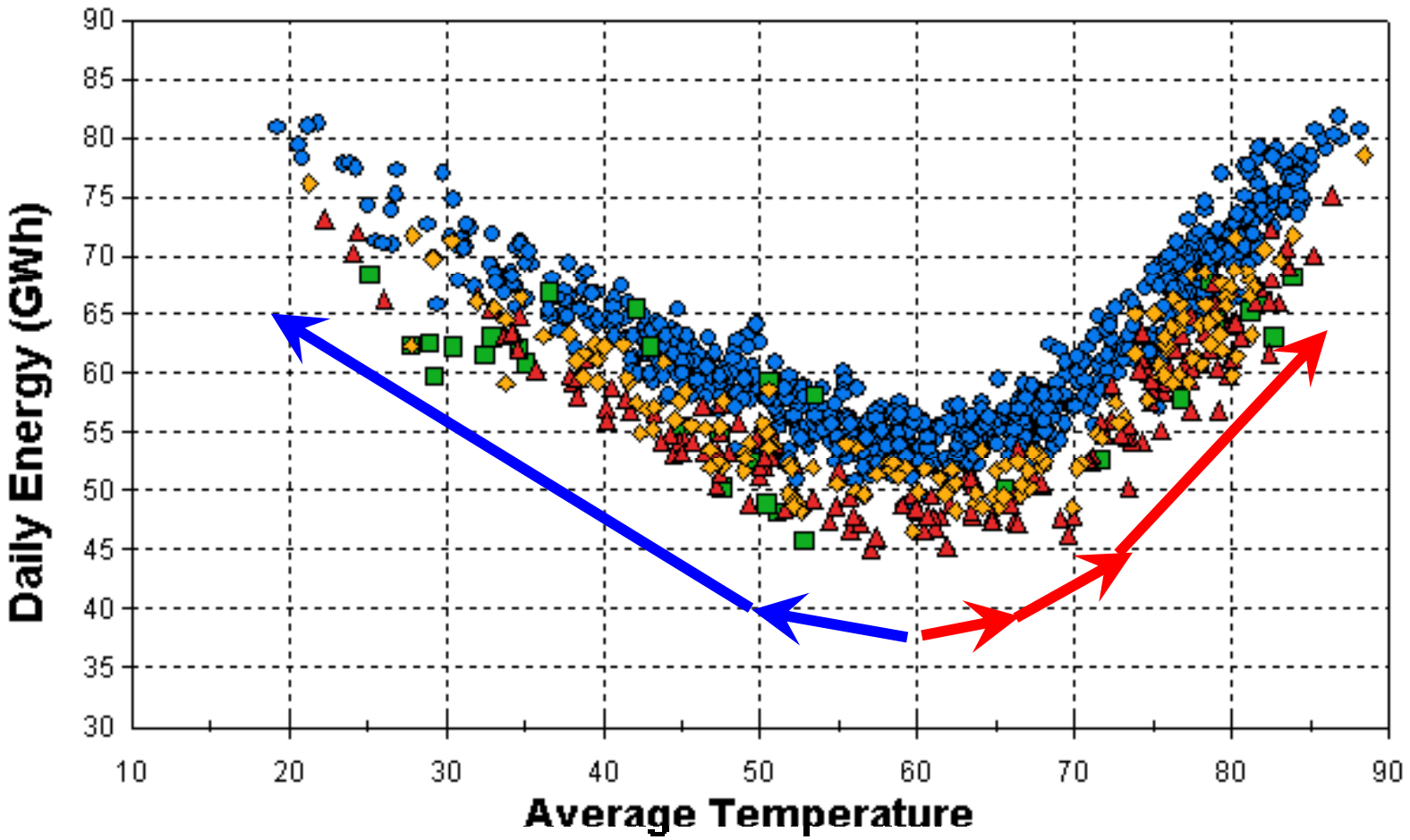
Q. What variables do you use to adjust for hot weather?

- 158 responses
- Roughly two-thirds (69 percent) of the respondents are using temperature data only to adjust for hot weather.
- Eight percent of the respondents use THI.
- The remaining 23 percent of the respondents report either that no adjustment is required for hot weather because they operate in climates with little to no cooling loads; or that they account for temperatures, humidity, cloud cover, and/or windspeed.

Q. If you use CDD, do you use a single trigger temperature or multiple segments?

- 123 responses
- Similar to the response for HDD, the vast majority (85 percent) use a single trigger point temperature for CDD.
- The typical trigger point is 18° Celsius or 65° Fahrenheit.
- For the respondents that use multiple trigger points, the trigger points that are used to separate cooling loads are between 65° F and 75° F and cooling loads above 75° F.

Example of Multiple Segments for HDD and CDD



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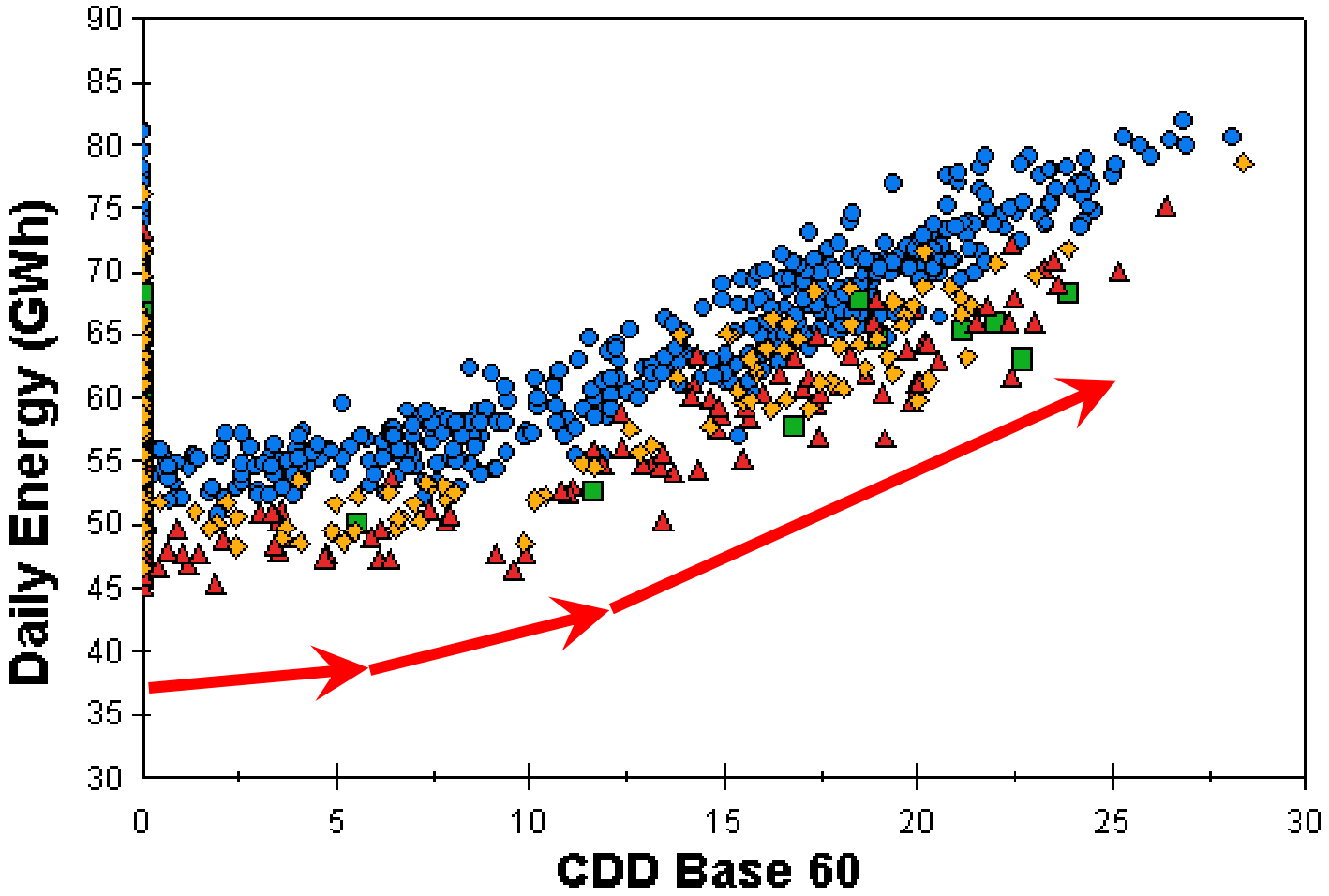
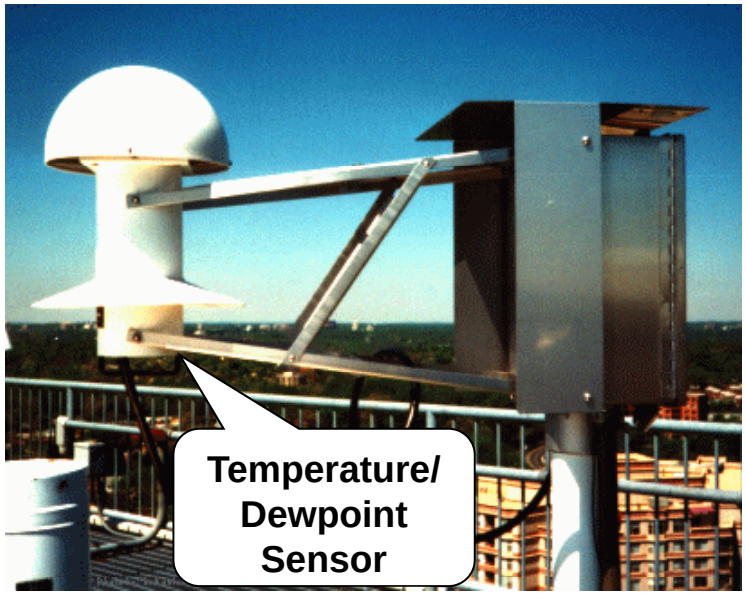
Example as a Regression Model Sees the Data



Q. If HDD and/or CDD are calculated using THI, which formula do you use to define THI?

- 108 responses
- (26 percent) THI = 15 + 0.4 x (DryBulb + WetBulb)
- (32 percent) THI = 17.5 + 0.2 x DewPoint + 0.55 x Drybulb
- (16 percent) THI = Drybulb - (0.55 x (1 - Humidity)) x (Drybulb - 58)
- (26 percent) Other



Q. How do you compute weather normalized sales?

- 159 responses
- The majority (60 percent) use weather adjustment coefficients to normalize sales.
- Thirty percent use model simulations.
- The remaining 10 percent use some other process to normalize sales.

Model Approach

Wthr Adj = F(Normal Weather) – F(Actual Weather)

Coefficient Approach

Wthr Adj = b*(Normal Weather – Actual Weather)

Q. How often do you update your weather normalization coefficients or models?

- 163 responses
- The majority (52 percent) update coefficients once a year.
- Monthly updates are generated by 13 percent of the respondents and quarterly updates by 3 percent of the respondents.
- The remaining 31 percent of the respondents update coefficients every few years or in response to a rate case.

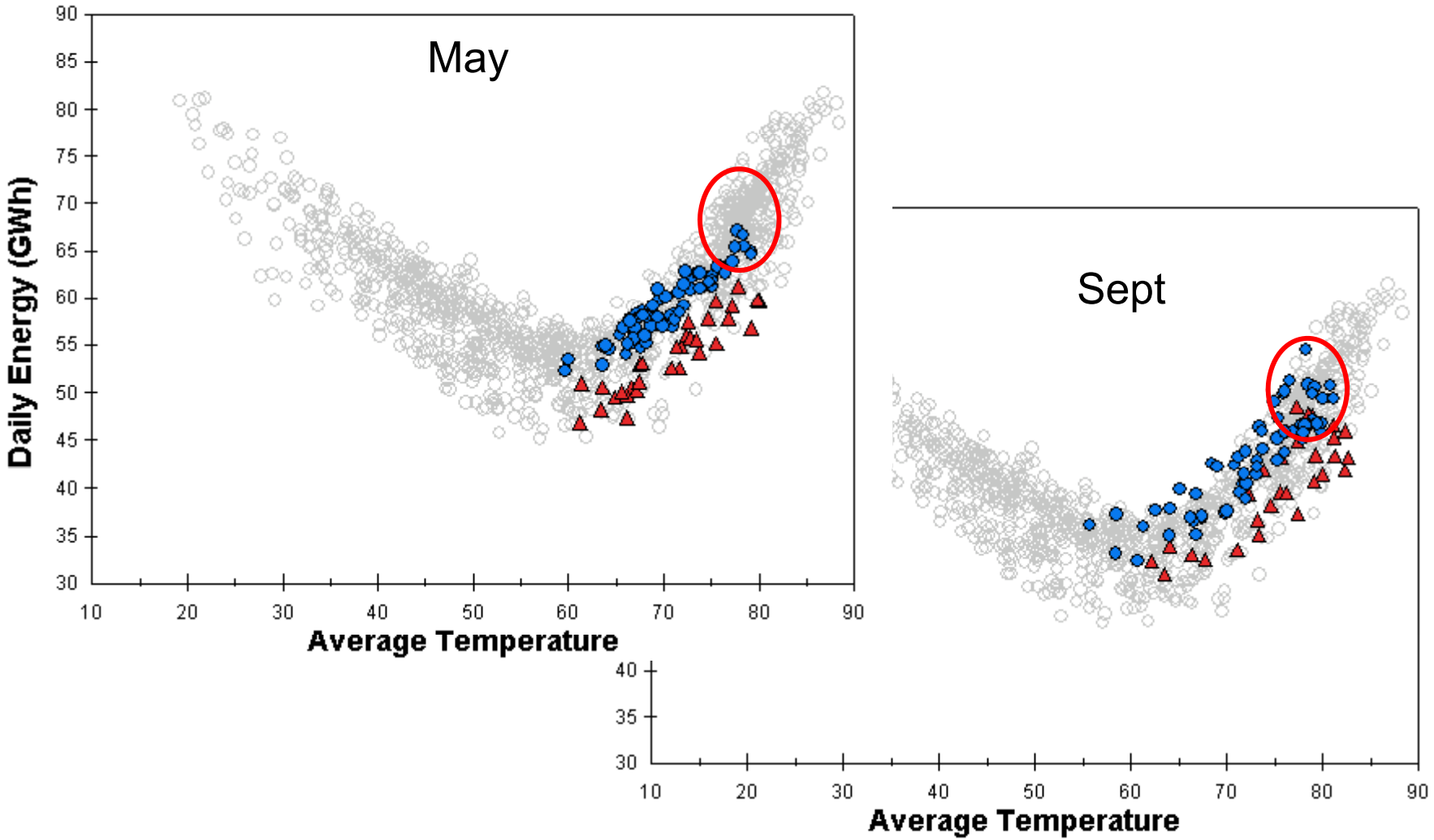
Q. Do you also re-calculate historical weather normal sales when you update your weather coefficients or models?

- 158 responses
- The majority (56 percent) of respondents do not re-calculate historical weather normal sales when they update their weather coefficients or models.
- Forty-four percent do re-calculate.

Q. Do weather adjustment parameters vary by month or season?

- 162 responses
- The majority of the respondents (66 percent) report that the weather adjustment parameters are allowed to vary either by month (45 percent) or by season (21 percent).
- Another 27 percent indicate that the parameters do not vary. Those that indicate some other method report that, for the most part, the parameters are allowed to vary although not necessarily by month or season.

Example of Weather Data by Month



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Q. Is the weather normalization process that you use specified by your state commission?

- 166 responses
- Roughly 13 percent of respondents use a commission specified normalization process.
- Eighty-seven percent cited that they use their own weather normalization process.

Q. In statistical models of class sales (e.g., residential, commercial, industrial) which do you use?

- 158 responses
- Calendar-month HDD and CDD variables are used by 40 percent of the respondents.
- An additional 12 percent use calendar-month HDD and CDD variables with weights on current and previous months.
- Billing-cycle weighted HDD and CDD variables are used by 32 percent of the respondents.
- The remaining respondents use some form of lining up the HDD and CDD data with the sales data that is being modeled. Others indicated using the system load as a means of weighting the weather data.

Q. Is the approach you use for normalizing energy the same as what is used for developing normalized peaks?

- 159 responses
- The same approach was used to normalize energy and peaks by 42 percent of the respondents.
- The majority of the respondents (57 percent) indicate that they use different approaches.
- A small fraction of respondents indicate that they do not normalize peaks.