ENERGY STAR®
for Data Centers

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EPA

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Agenda

- ENERGY STAR
  - Buildings Overview
  - Energy Performance Ratings
  - Portfolio Manager
- Data Center Initiative
  - Objective
  - Development Process
  - Analytical Findings
  - Model Recommendations
- Model Release Schedule

ENERGY STAR

EPA

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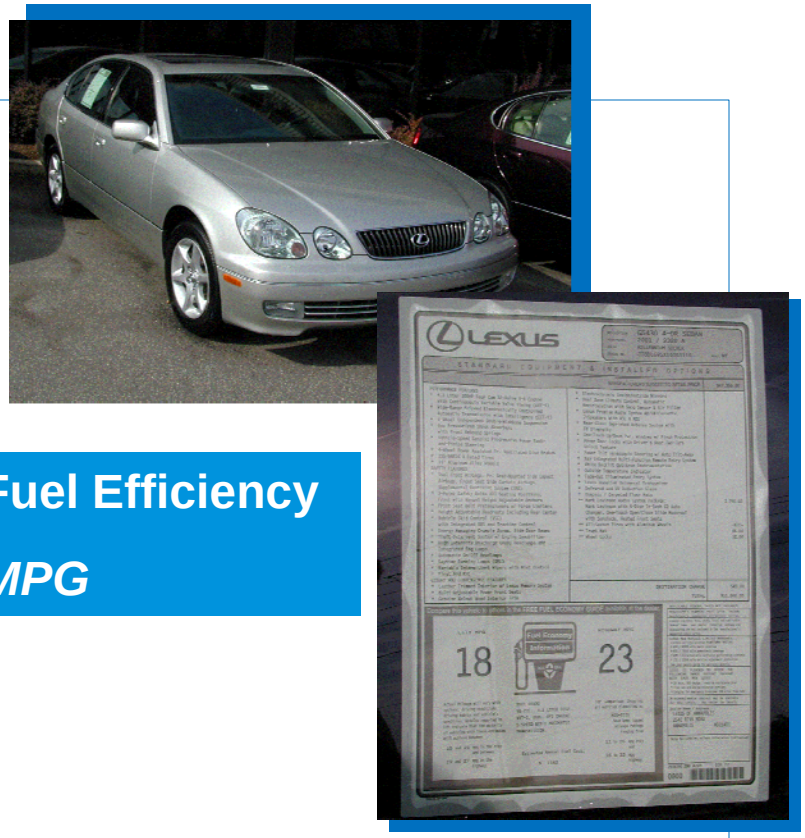
ENERGY STAR for Buildings Overview

- Energy management program that provides proven solutions to help building owners and managers reduce their energy consumption
  - Help businesses protect the environment through superior energy efficiency
- Numerous technical and managerial resources
  - National rating system for buildings to benchmark and track energy use
  - Energy management guidelines
  - Advice on design for energy efficient buildings
  - Online case studies and best practice stories
  - Calculators to track returns on energy efficiency investments
  - Training opportunities
- Opportunities for national recognition

ENERGY STAR for Buildings Overview

- Work in markets with a focus on:
  - Commercial Property (offices, retail, hotels)
  - Public Sector (government, education)
  - Healthcare
  - Small businesses and congregations
- Provide an online tool to rate energy performance on a scale of 1-to-100
  - Over 80,000 buildings have rated
- Buildings that earn a 75 or higher can earn the prestigious ENERGY STAR label
  - Over 8,000 buildings have earned the ENERGY STAR
- Learn more: www.energystar.gov/buildings

Is Your Building Performing Well?

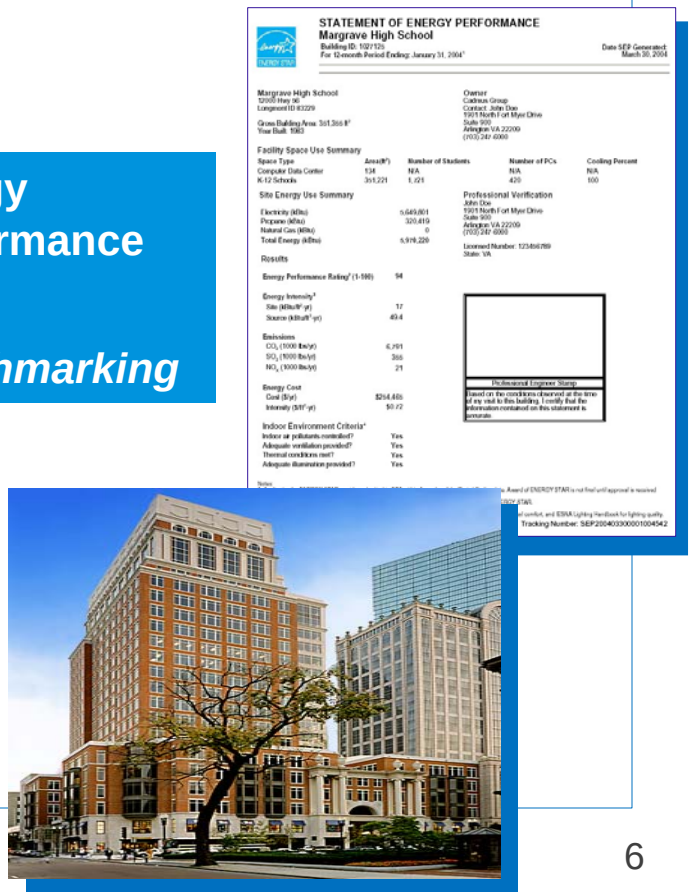


Fuel Efficiency

MPG

Energy Performance

EPA Benchmarking



EPA Rating Objectives

- Help businesses protect the environment through superior energy efficiency
- Motivate organizations to develop a strategic approach to energy management
- Convey information about energy performance in a simple metric that can be understood by all levels of the organization

EPA Rating Requirements

- Monitor actual as-billed energy data
- Create a whole building indicator
  - Capture the interactions of building systems not individual equipment efficiency
  - Track energy use accounting for weather and operational changes over time
- Provide a peer group comparison
  - Compare a building's energy performance to its national peer group
  - Track how changes at a building level alter the building's standing relative to its peer group

EPA Rating
Technical Foundation

- Analyze national survey data
  - Commercial Building Energy Consumption Survey (CBECS)
- Develop regression models to predict energy use for specific space types based on physical and operational characteristics
- Create scoring lookup table
  - Ratings are based on the distribution of energy performance across commercial buildings
  - One point on the ENERGY STAR scale represents one percentile of buildings
- Buildings that perform in the 75th percentile or better can earn the ENERGY STAR label

EPA Rating
Technical Foundation

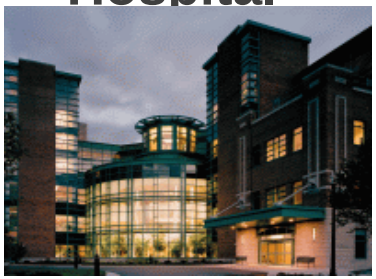
- Developing the regression model
  - Account for building operations
    - Employees, Hours, HDD, CDD, etc
  - Apply a linear regression model
    - Energy= C + C_1*Sqft + C_2*Workers + C_3*Number of computers + C_4*HDD + C_5*CDD + …
    - Coefficients represent average responses
    - Coefficients provide adjustments for the operational characteristic
      - ***Does not*** add the kWh of each piece of equipment
      - ***Does*** adjust energy based on correlation between operating characteristic and energy use (i.e. the coefficient on PCs approximates a “work station”)

EPA Rating
Technical Foundation

- The rating ***does***
  - Evaluate as-billed energy use relative to building operations
  - Normalize for operational characteristics
    - Size, Number of employees, Weekly operating hours, Climate
  - Depend on a statistically representative sample of the US commercial building population
- The rating ***does not***
  - Attempt to sum the energy use of each piece of equipment
  - Normalize for technology choices or market conditions
    - Type of lighting, energy price
  - Explain why a building operates as it does

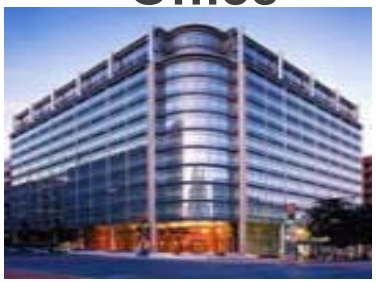
EPA Rating Building Types

Hospital



Retail

Office



Hotel

Medical Office

Wastewater Treatment Plant

Courthouse

Bank/Financial

Warehouse

Dormitory

Supermarket

K12 School

Portfolio Manager

- Free on-line benchmarking tool
  - Secure environment
- Available for any building
- Track energy use
  - Site EUI
  - Source EUI
  - Energy performance ratings (for selected spaces)
  - Weather normalized source EUI
  - National average comparisons
- Track energy costs
- Track greenhouse gas (GHG) emissions
- Track water consumption
- Apply for ENERGY STAR recognition (for selected spaces)
- Learn more: www.energystar.gov/benchmark

Data Center Initiative

EPA

Learn more at **energystar.gov**

Data Center Initiative Objective

- Develop a useful rating for industry
  - Can be available for use as soon as possible
  - Based on items that are commonly measured and tracked
- Build on existing ENERGY STAR methods and platforms
- Apply to stand-alone data centers and data centers housed within office or other buildings
- Assess performance at the building level to explain how a building performs, not why it performs a certain way
- Provide users with information and links to additional resources to aid in their efforts to determine next steps
- Offer the ENERGY STAR label to data centers with a rating of 75 or higher (performance in the top quartile)

Data Center Initiative Objective

- Develop regression model to predict PUE
  - Include factors that are outside of the control of the owner/operator
  - Factors for adjustment determined based on data collection and analysis
- Compare actual PUE to predicted PUE
  - More efficient data centers will have lower PUE than is predicted
- Express data center efficiency as a 1-to-100 ENERGY STAR rating
  - Each point on rating scale equals 1 percentile of data centers
- In Portfolio Manager
  - ***ANY*** data center can earn a rating
    - Enclosed or free standing
    - Good performer or poor performer
  - Data centers with ratings of 75 or higher can apply for the ENERGY STAR

Data Center Initiative Development Process

- October 2007 – March 2008
  - Consultations with industry stakeholders
- March 2008 – June 2009
  - Data collection, Updates to industry
- June – September 2009
  - Analysis & Preliminary Rating Development
- September 29, 2009
  - Preliminary model results presented to industry *(Recording available)*
- October – November 2009
  - Analysis of industry feedback & Final Rating Development
- Spring 2010
  - Data center model scheduled for release

Data Center Initiative Analytical Findings

- Data collection requested both UPS and PDU data for IT energy, if available
- UPS more common than PDU
  - 108 Data Centers with data from the UPS meter
  - 42 Data Centers with data from the PDU meter
  - Above totals include 29 that provided both UPS and PDU data
- Not enough PDU data to develop a rating
- Using UPS data provides more data centers with the ability to rate performance

→ *EPA rating will be based on UPS readings as the proxy measurement for IT energy*

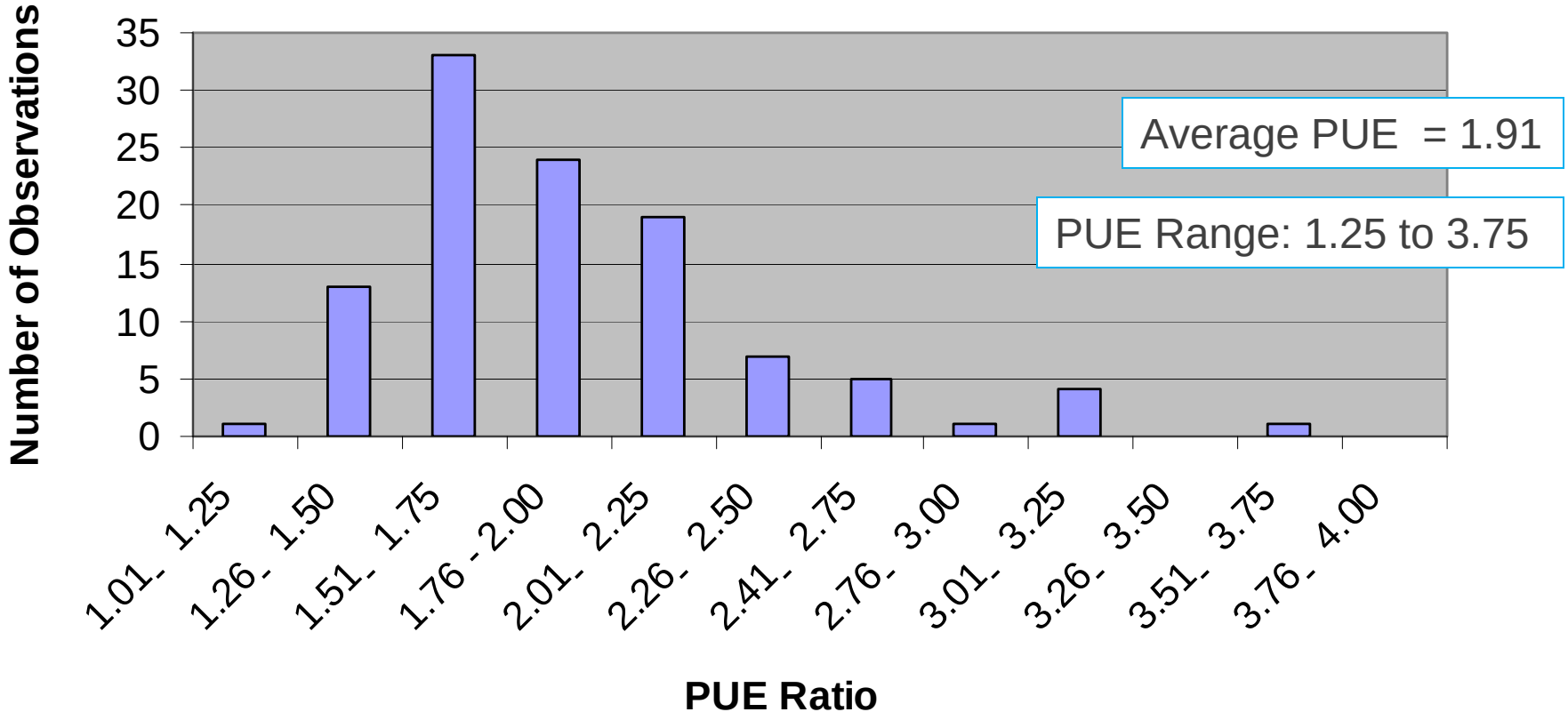
Data Center Initiative Analytical Findings

- Evaluate data center energy consumption:

  Power Usage Effectiveness (PUE) = Total Energy / UPS Energy

- PUE is based on energy, not power
  - Total Energy includes all fuels (electricity, natural gas, diesel, etc.)
- PUE is based on source energy, not site energy
  - Source Energy is the total amount of raw fuel required to operate the building
  - Results in equitable comparisons for buildings with different fuel types utilized
  - For a 100% electric building, the use of source energy will not change PUE

Distribution of PUE Ratios



Data Center Initiative Analytical Findings

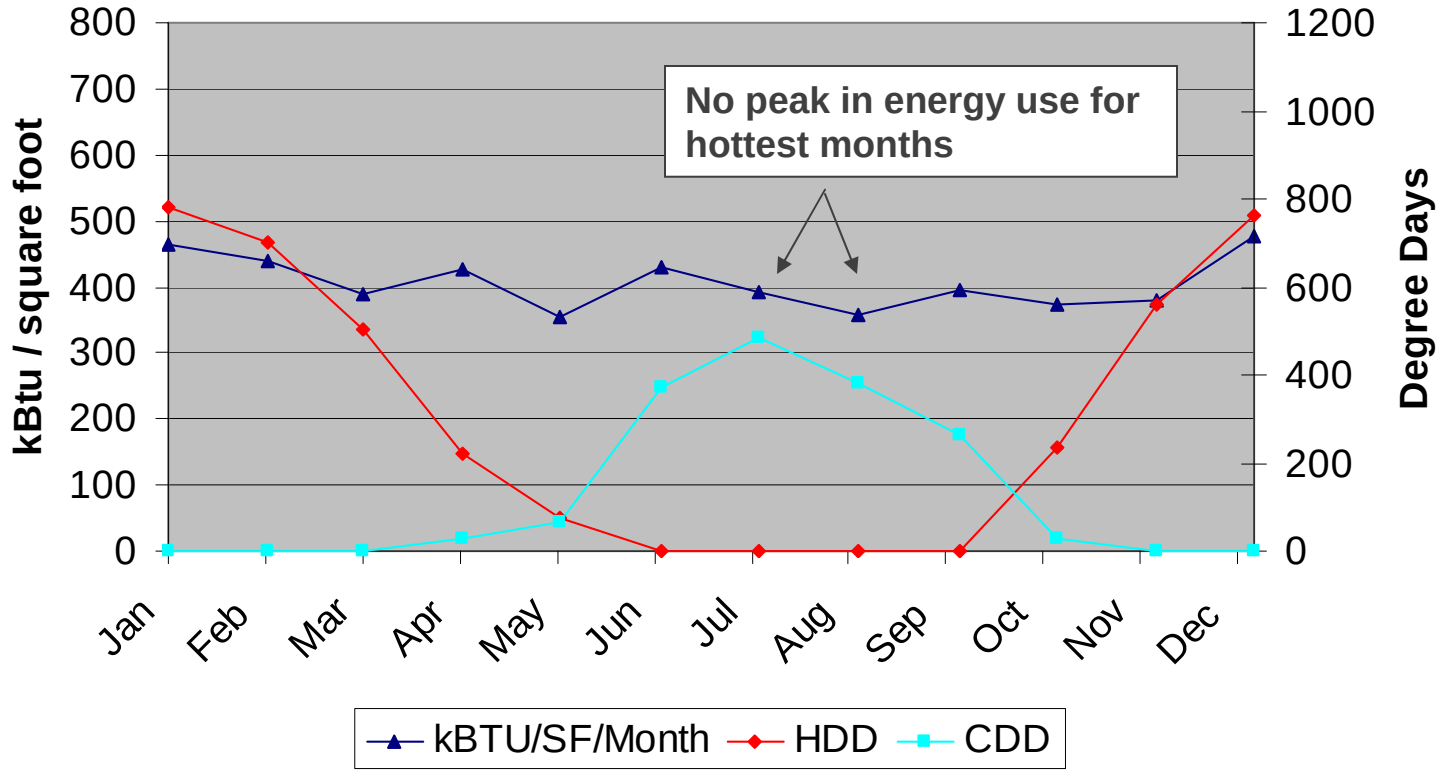
- Some surprising results for operating characteristics to be included/excluded, but these are supported by data
- PUE is fairly independent of operating characteristics, as compared with similar models for commercial buildings
- Few operating characteristics expected to be included in a final model
- Relatively low R-squared expected, but still acceptable

Conclusions:

- Variability in energy use is more dependent on energy management practices than operating characteristics
- Despite the low R-squared, regression modeling results in meaningful adjustments for some operating characteristics

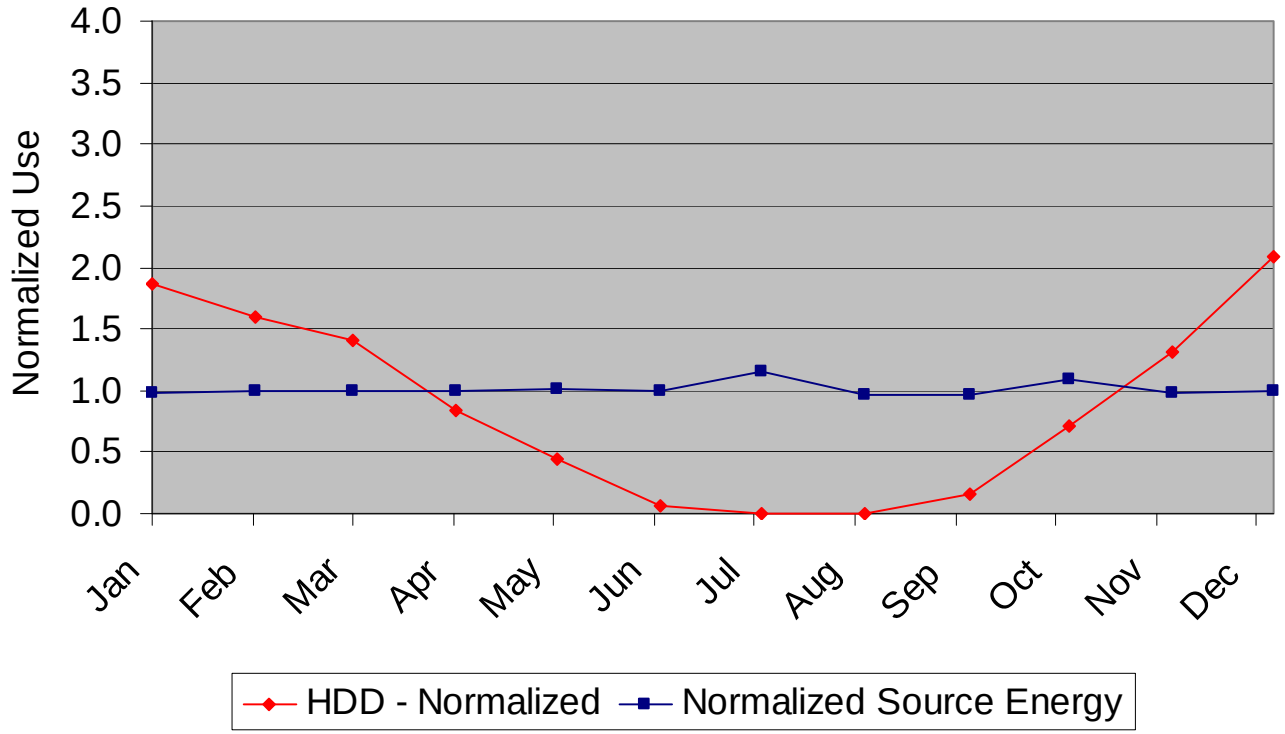
Monthly Energy Consumption Sample Data Center

- Sample Data Center shows little variability in monthly energy consumption
  - *Annual HDD = 4121, annual CDD = 1623*



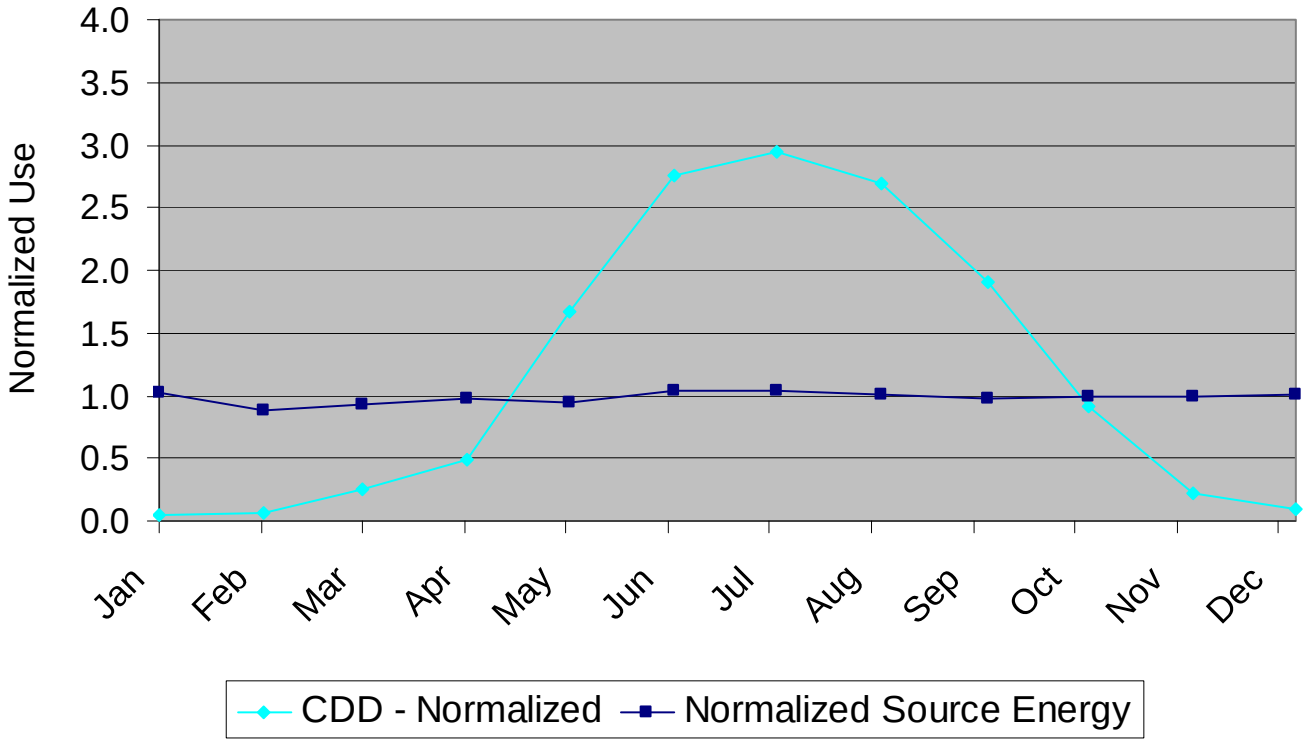
Monthly Energy Consumption
10 Coldest Climates

- Data Centers in 10 coldest climates show no variability in monthly energy consumption
- *10 buildings with annual HDD > 5976*



Monthly Energy Consumption
10 Warmest Climates

- Data Centers in 10 warmest climates show no variability in monthly energy consumption
- *12 buildings with annual CDD > 2400*

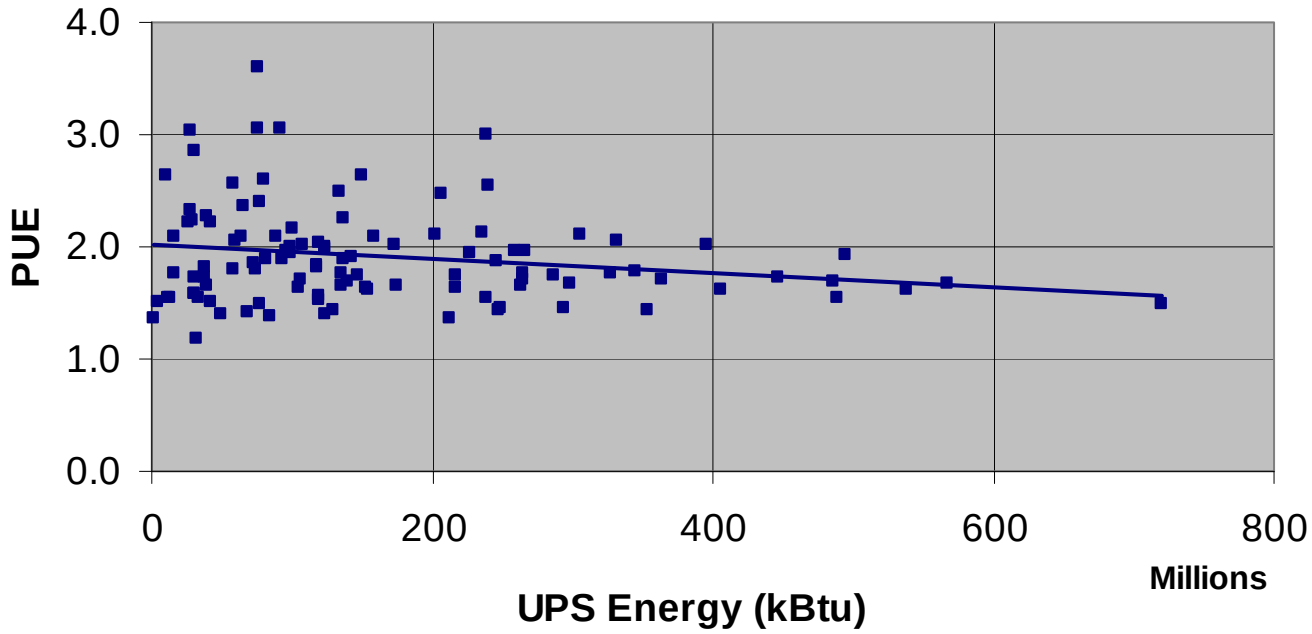


Data Center Initiative
Analytical Findings - Climate

- Analysis does not show a statistically significant relationship between climate and energy consumption
  - Some stakeholder participants agreed that energy consumption is dominated by internal loads, as opposed to climate
  - Others provided theoretical reasons why climate should influence load
  - EPA does not dispute the fact that climate can have an impact on energy consumption
    - This impact is not significant enough to show up in the regression analyses that form the basis of EPA models
    - Variability in PUE as related to climate is less significant than variability caused by other factors (IT Energy, management, etc)
  - EPA ratings must reflect ***observed*** relationships
- Climate variables will not be included in the final model

Data Center Initiative
Analytical Findings – UPS Energy

- PUE is lower in buildings with higher total UPS Energy
  - Consistently significant in regressions
  - Likely due to economies of scale
- UPS Energy will be included in the final model



Data Center Initiative Analytical Findings – Tier Level

- Tier level did not show strong, statistically significant correlations with energy consumption
- Industry feedback indicated that Tier level should not be included in a model
  - Facilities can have multiple Tiers within one data center
  - Facilities may have unnecessarily high Tier levels thinking greater redundancy is better, even if it is not required for all components in the data center
  - Normalizing for Tier level provides a disincentive for efficient design
  - Based on industry feedback, Tier will not be included in the final model
- Tier level will not be included in the final model

Data Center Initiative Analytical Findings – Type

- Data collection included seven types of datacenters
  - Traditional Enterprise; On-Demand Enterprise; Telecom; High Performance Computing Center (Scientific); Hosting; Internet; 7 Hybrid
  - Majority of respondents were traditional enterprise and hosting facilities
  - No statistically significant correlations were observed between a particular type and energy consumption
- Industry stakeholders recommended that Type was not a good variable for inclusion in the ENERGY STAR model
  - Many different categories of data center and even multiple categories within certain centers
  - Operators agreed that the data (average PUE values, regression results) does not support the inclusion of data center type in a model
- Type will not be included in the final model

Model Selection Process

- Multiple factors to evaluate
  - Regression model statistics (F, p, R^2)
  - Individual variable statistics (t-stats)
  - Distribution of ratings
    - By 10% bin
    - Average rating
    - Number and percent above 75
    - By Data Center Type
  - Residual and rating plots
  - Physical understanding of results
    - Do variables make sense?
    - Industry feedback
  - Magnitude of impacts
    - How much does each variable affect the model?
- Best model must show a good balance using all criteria

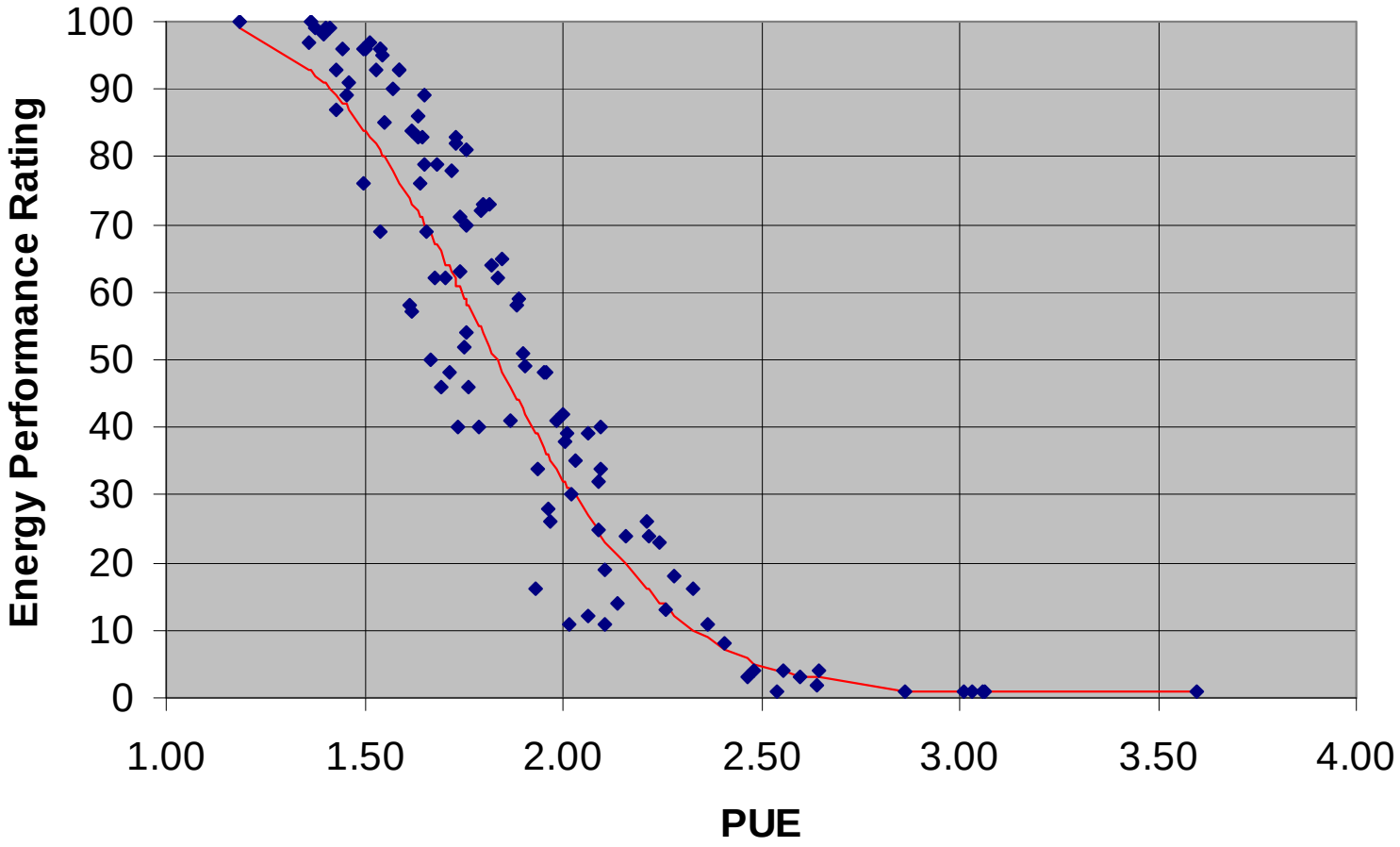
Model Recommendation

- Data: 61 Stand Alone Data Centers collected by EPA
- Dependent Variable: PUE
- Independent Variable: UPS Energy
- Overall Model Statistics
  - R-squared values are low (0.10) for a PUE model because UPS Energy explains a large percentage of Total Energy
  - R-squared values for a Total Energy model would be > 0.90
  - F-statistic: 7.56
  - P-level: .0079
- Individual Variable Statistics
  - The adjustment for UPS Energy is significant with 99% confidence
  - T-statistic is 2.75

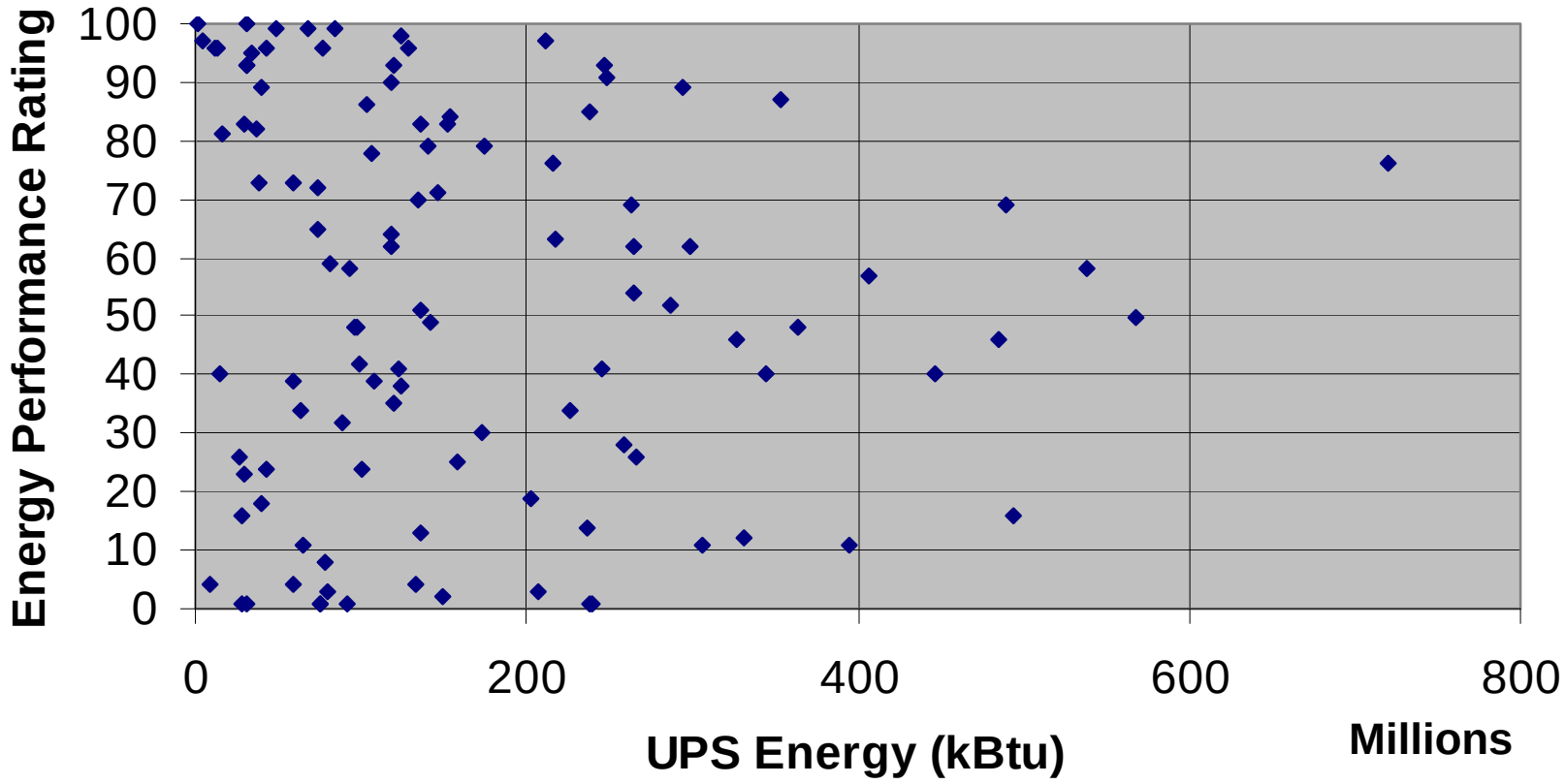
Model Performance

- Model produces appropriate ratings
  - Average Rating: 49
  - Percent Rating > 75: 23%
- Model produces a uniform distribution
  - Approximately 10% of the population falls within each 10 point rating bin
- Residual plots exhibit random scatter
  - Buildings with particular operating parameters do not have systematically higher (or lower) ratings
  - Buildings in different climates do not have systematically higher (or lower) ratings
- Strong model
  - Based on these results, the model appears robust

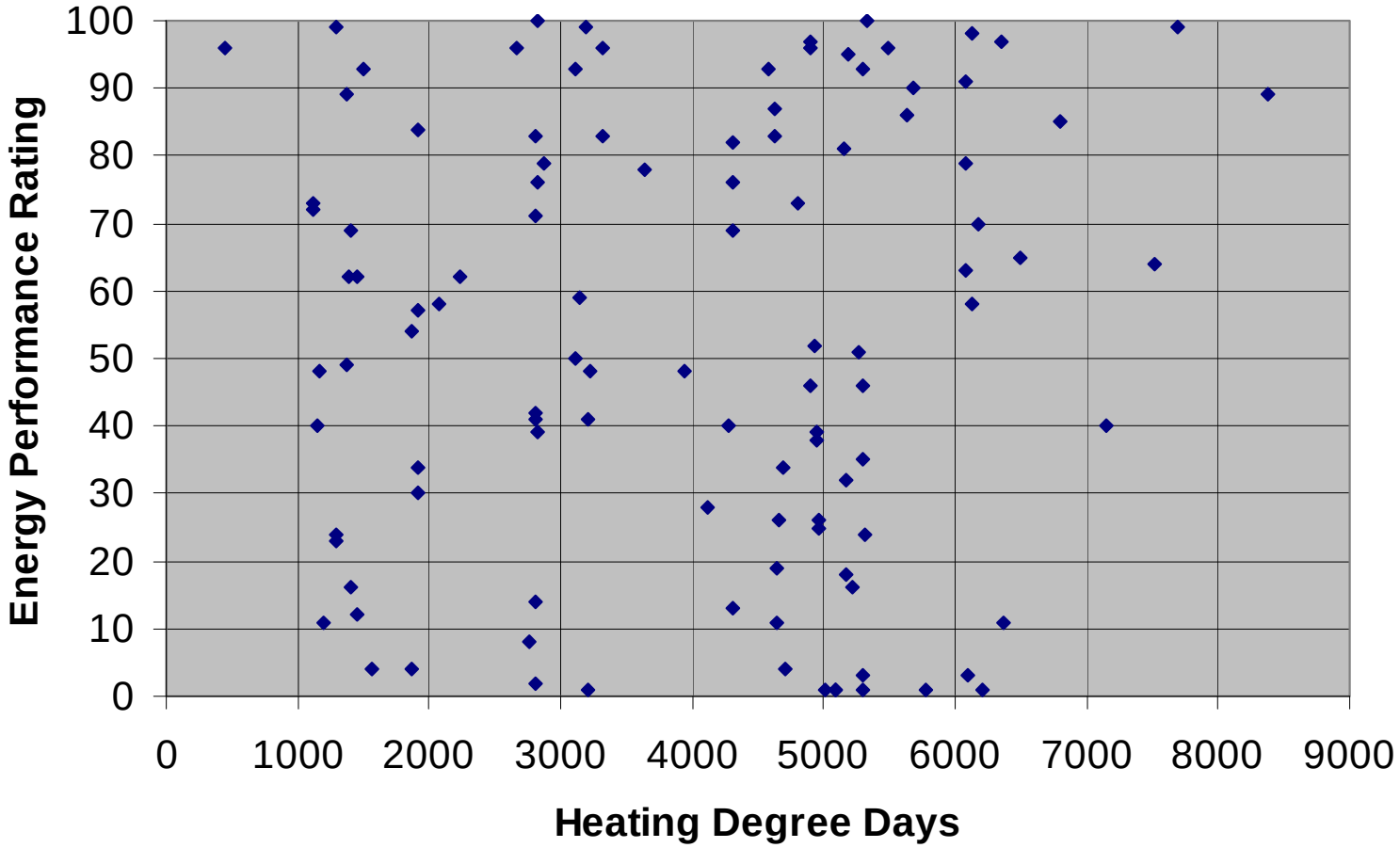
Rating vs. PUE



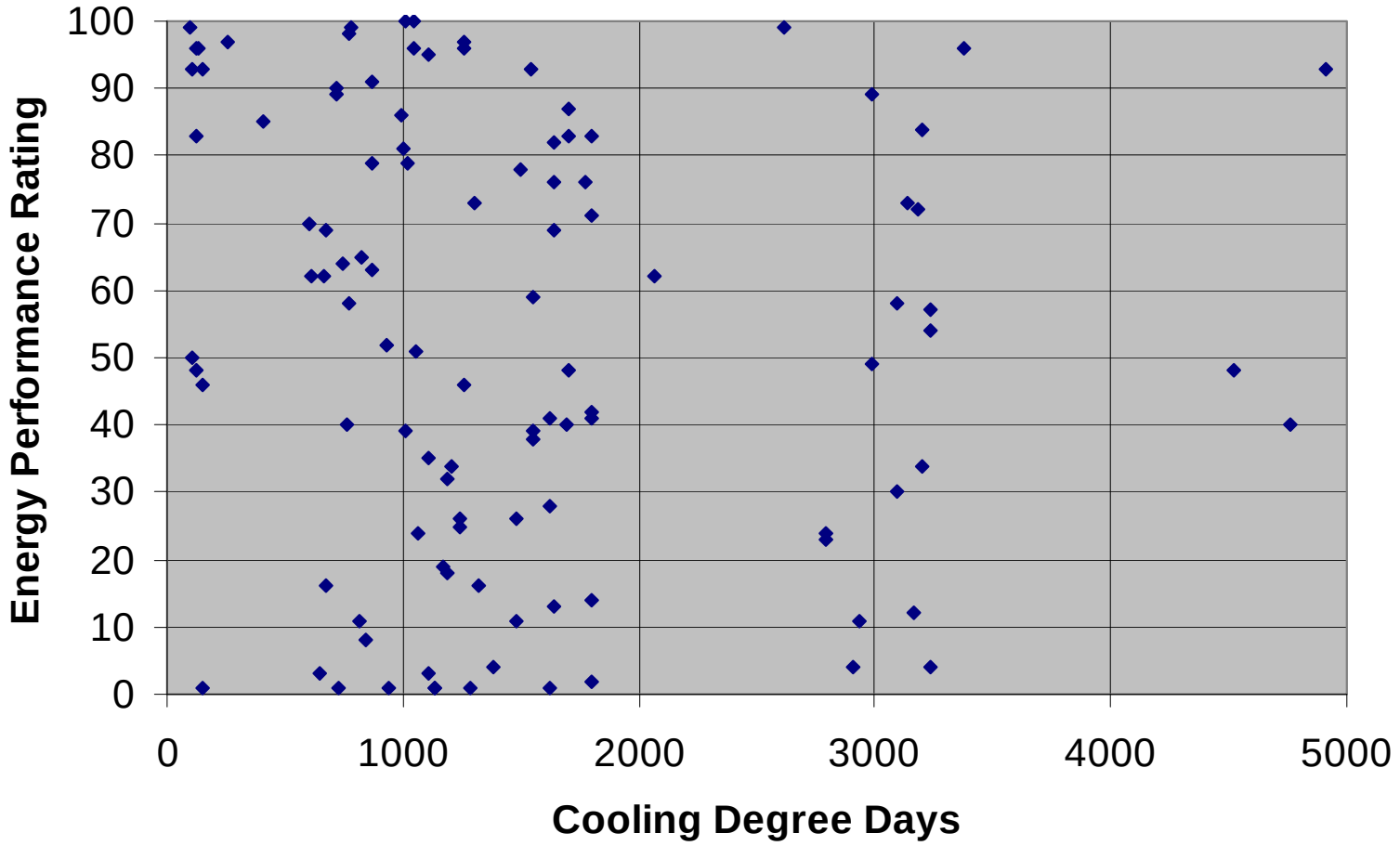
Rating vs. UPS Energy



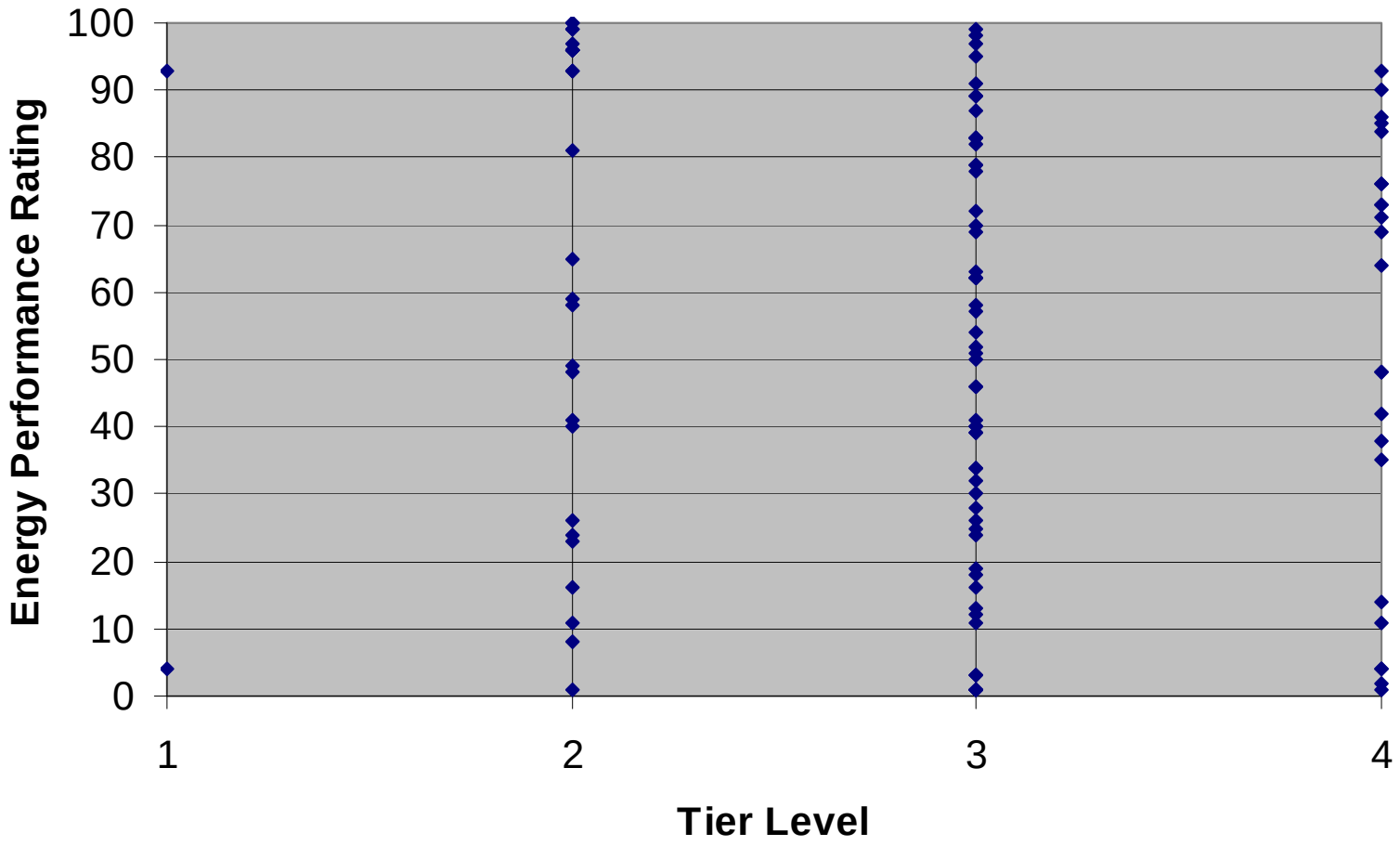
Rating vs. HDD



Rating vs. CDD



Rating vs. Tier



Economizer Rating Example

- Two example buildings
  - Same UPS Energy, Size, Climate
  - Same Predicted PUE
  - Facility with economizer has lower Total Energy and Actual PUE
  - Different ratings

	No Economizer	With Economizer
UPS Energy (MBtu)	220,000	220,000
Total Energy (MBtu)	380,000	360,000
Predicted PUE	1.87	1.87
Actual PUE	***1.73***	***1.64***
Rating	***60***	***70***

Model Release and Next Steps

- Model will be released in Portfolio Manager in ***June 2010***
- Next Steps
  - Start measuring energy consumption at the UPS output
  - Learn about Portfolio Manager and create an account
    - www.energystar.gov/benchmark
  - Take training on ENERGY STAR benchmarking with Portfolio Manager
    - www.energystar.gov/businesstraining
  - Prepare to start using Portfolio Manager in June!

Questions and Discussion

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