# ENERGY STAR®
# Data Center Infrastructure Rating Development Update

Web Conference

*September 29, 2009*

EPA

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# Agenda

- Welcome
- EPA Ratings
  - Objective
  - Technical foundation
- Data Collection Summary
- Preliminary Analytical Results
- Next Steps

# Rating Development Objective

- 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)

# Rating Development
# Data Center Efficiency Metric

- Define data center efficiency as:

  **Energy Usage Effectiveness (EUE) = Total Energy / UPS Energy**

- EUE is based on energy, not power
  - Total Energy includes all fuels (electricity, natural gas, diesel, etc.)
- EUE 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

# Rating Development
# EPA Methodology

- Express data center efficiency as an ENERGY STAR 1-to-100 rating
  - Each point on rating scale equals 1 percentile of data centers
- Adjust for operating constraints outside of the owner/operators control (e.g. Tier level)
  - Target efficiency will depend on operational constraints
- Factors for adjustment to be determined based on results of data collection and analysis

# EPA Ratings: Technical foundation

- Develop the regression model
  - Account for building operations (e.g., UPS Energy, Tier)
- Apply a linear regression model

$$EUE = C_o + C_1 * \text{UPS Energy} + C_2 * \text{Tier} + \ldots$$

  - Coefficients represent average responses
  - Coefficients provide adjustments for each operational characteristic
    - ***Does not*** add the kWh of each piece of equipment
    - ***Does*** adjust energy based on correlation between operating characteristic and energy use

# Rating Development Timeline

- October 2007 – March 2008
  - Consultations with industry stakeholders
  - Agreed on use of the ratio:  Total Energy / IT Energy
  - Developed data collection template
- March 2008 – June 2009
  - Data collection
- August & November 2008, May 2009
  - Updates to industry
- June – November 2009
  - Analysis & Rating Development
- Spring 2010
  - Data center model scheduled for release

# Data Collection Summary

- **Thank you for your participation!**
- Reviewed all data to identify records that were complete & correct
  - All required building attributes
  - 11 months of energy data
  - 11 months of IT data
- 121 Data Centers submitted complete data
- Good variability in data
  - Locations in 24 different states
  - Mix of sizes, types, Tier levels

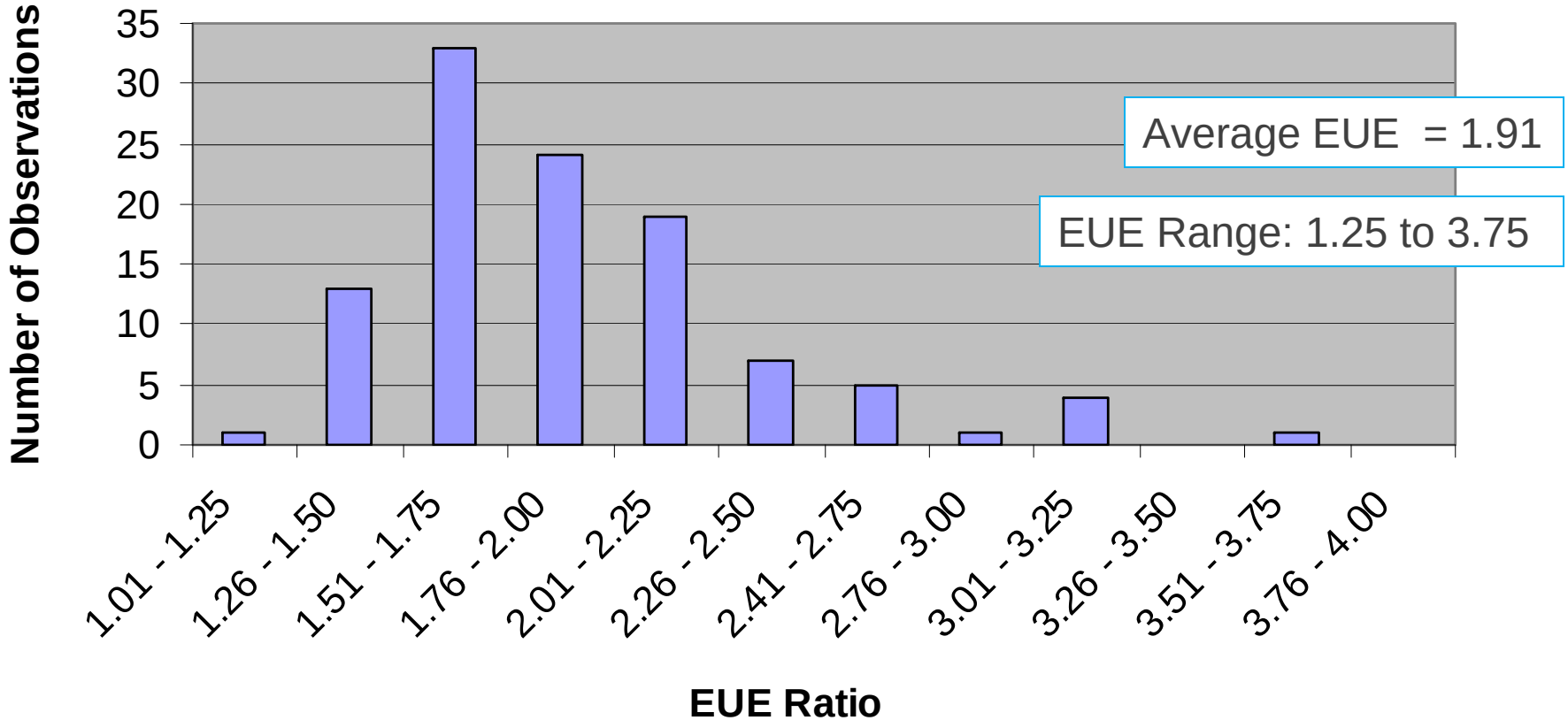
# UPS vs. PDU Data

- 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 likely be based on UPS readings as the proxy measurement for IT energy*

# Stand Alone vs. Enclosed

- Mix of Stand Alone and Enclosed data centers
  - 61 of the 108 data centers with UPS data are Stand Alone
  - 47 of the 108 data centers with UPS data are Enclosed
- Tested models with Stand Alone and All Data Centers
  - Energy performance ratings are similar
- Benefits of using Stand Alone Data Centers:
  - Overall significance of models is higher
  - Similar to EPA ratings for other space types
- Benefits of using All Data Centers:
  - Significance of certain operating characteristics is higher
  - Greater number of observations
- *No decision yet on which data to use for a final model*
  - *Model performance statistics will differ, but ratings will be similar*
  - *Rating should still apply to both Stand Alone and Enclosed*

# Distribution of EUE Ratios



# Data Center Analysis: Model results

- Some surprising results for operating characteristics to be included/excluded, but these are supported by data
- EUE 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

# Data Center Analysis: Model results

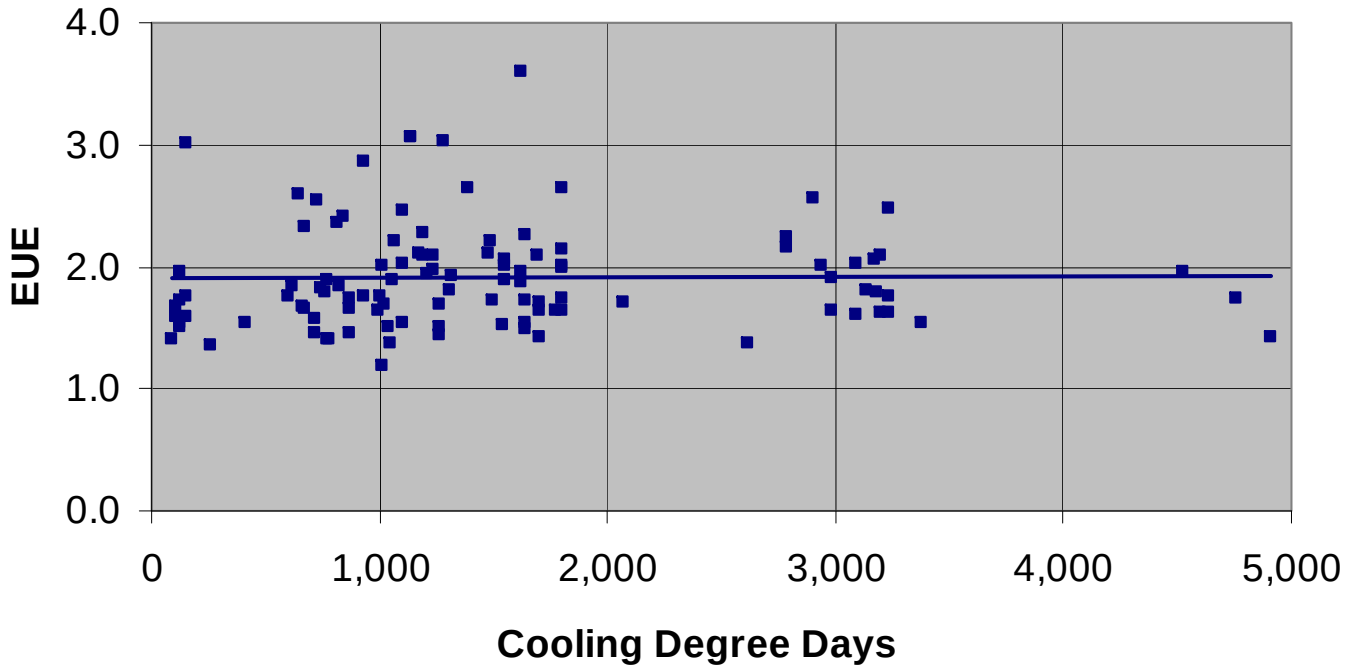
- Variables that ***may be*** included in the model and are still under investigation by EPA (*Statistically significant in some model options with 80% confidence or better)*
  - UPS Energy Intensity (IT energy per square foot)
  - UPS Energy (total IT energy)
  - Square Feet
  - Tier (or some similar measure of redundancy)

- Variables that are ***not*** likely to be included in the new model (*Not statically significant in most model formulations)*
  - Heating Degree Days (HDD)
  - Cooling Degree Days (CDD)
  - Data Center Type (traditional, hosting, internet, etc.)
  - UPS Utilization

# Variables ***Not*** Likely to be Included in a Data Center Rating Model

# Cooling Degree Days

- No dependence of EUE on Cooling Degree Days
- Unexpected result



# Heating Degree Days

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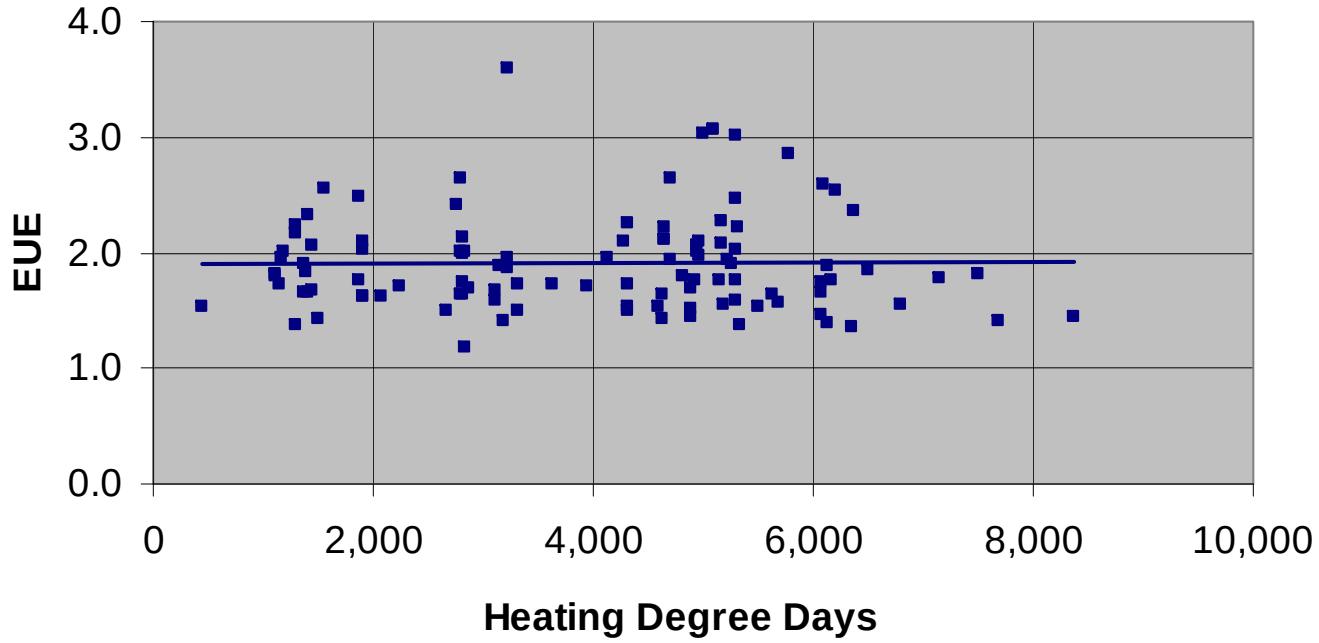
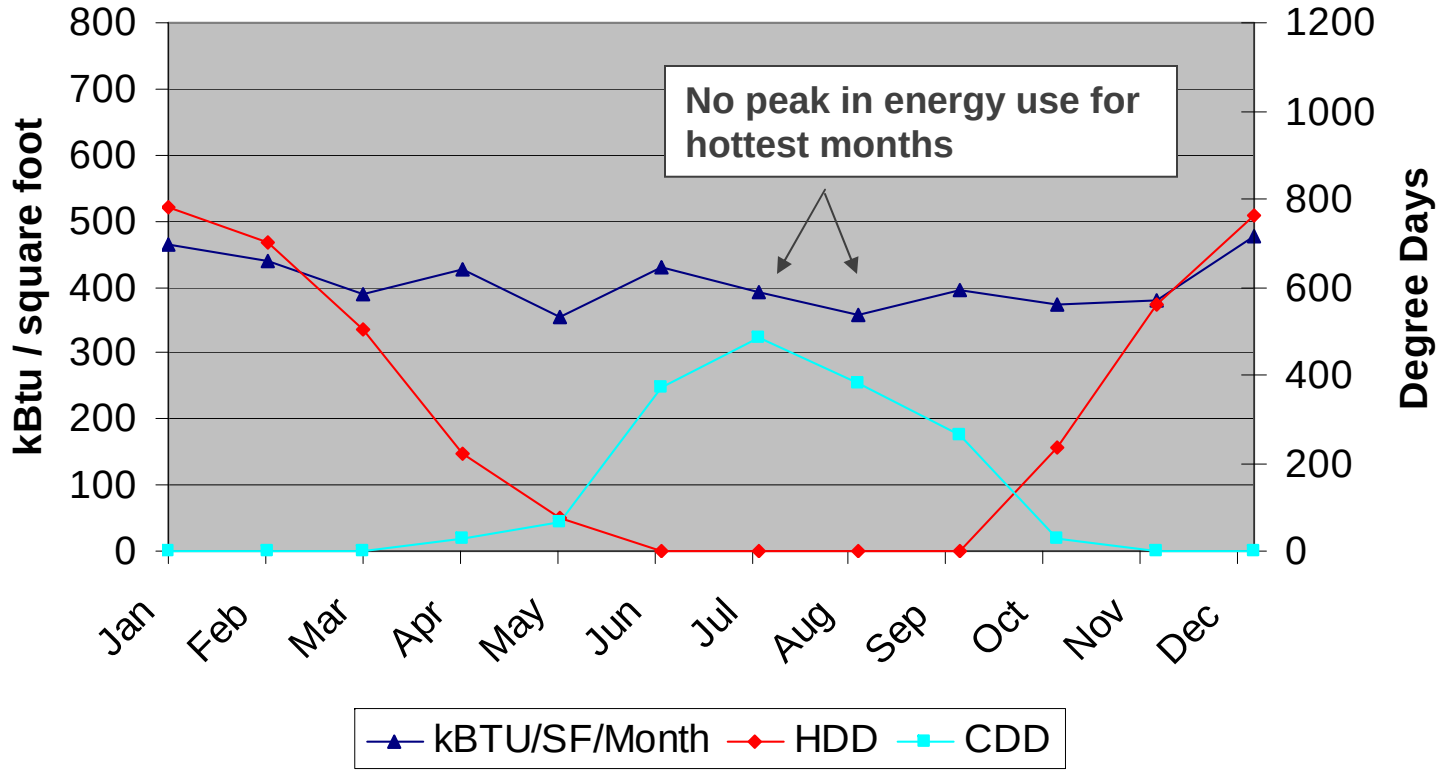


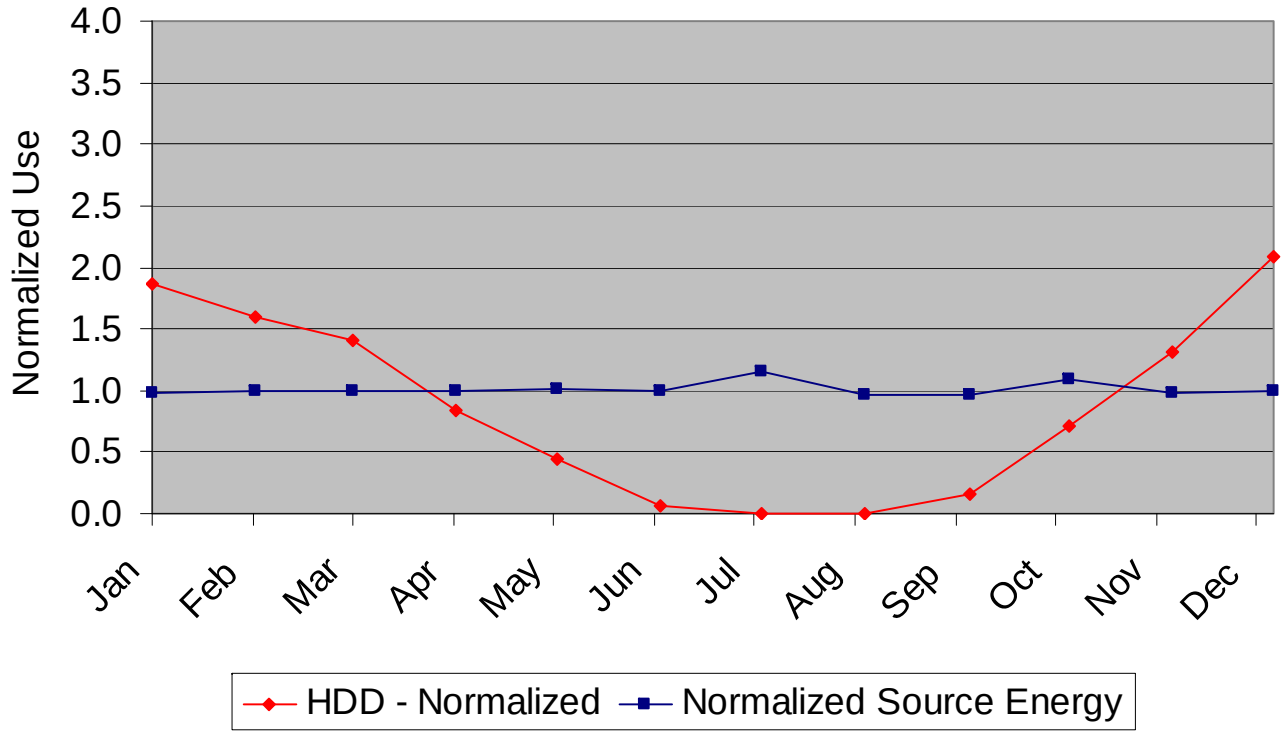
# Monthly Energy Consumption Sample Data Center

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



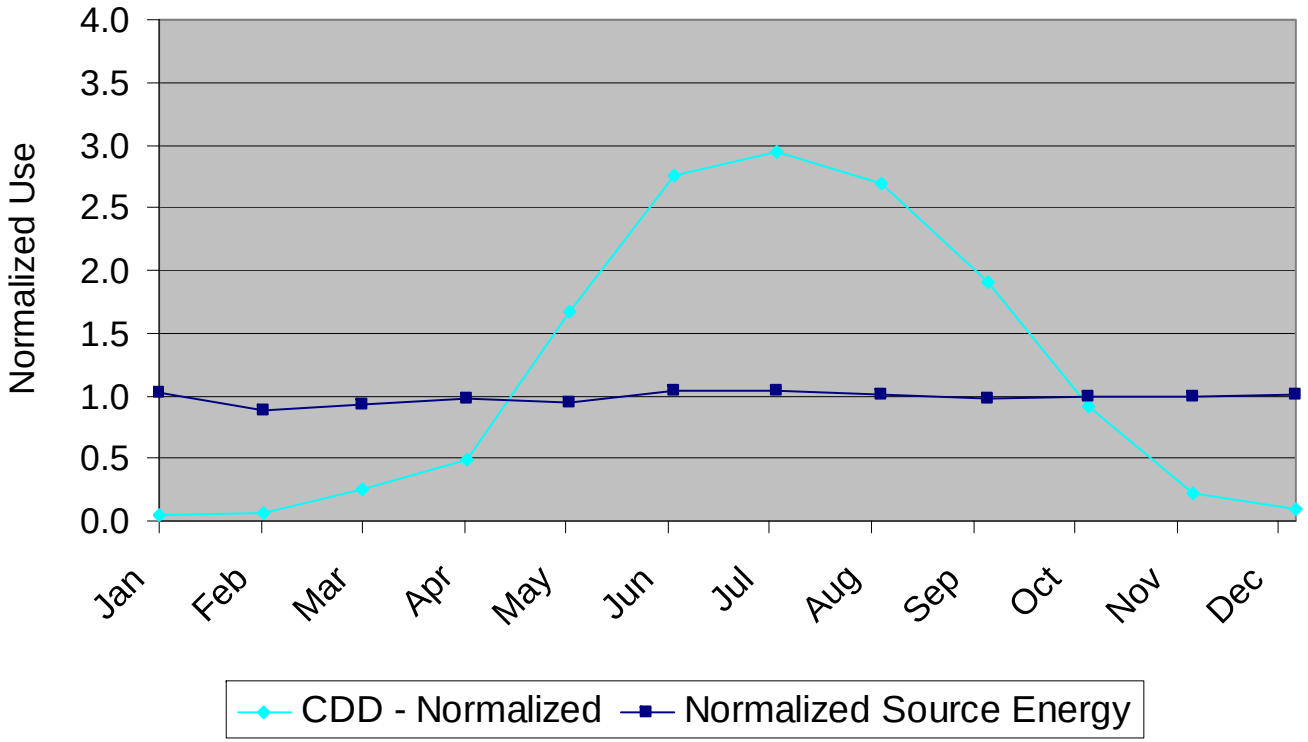
# Monthly Energy Consumption
# 10 Coldest Climates

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



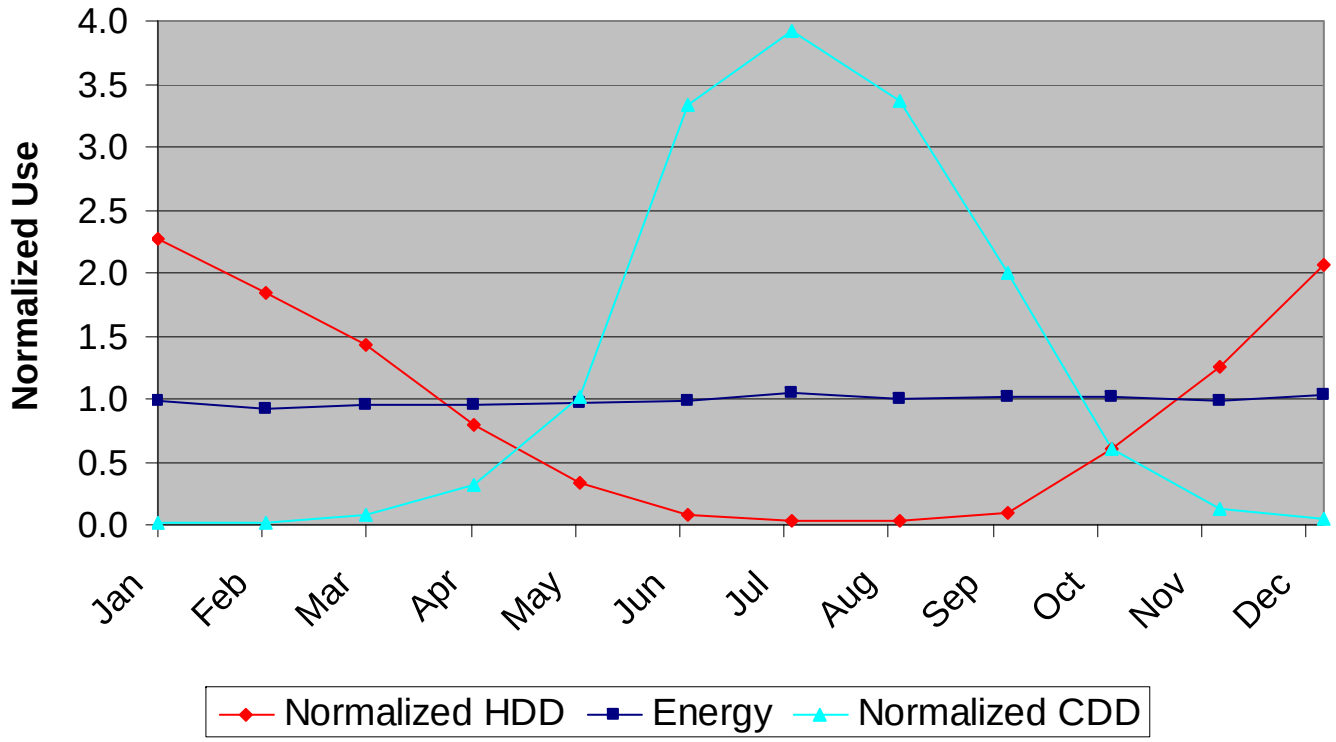
# Monthly Energy Consumption
# 10 Warmest Climates

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



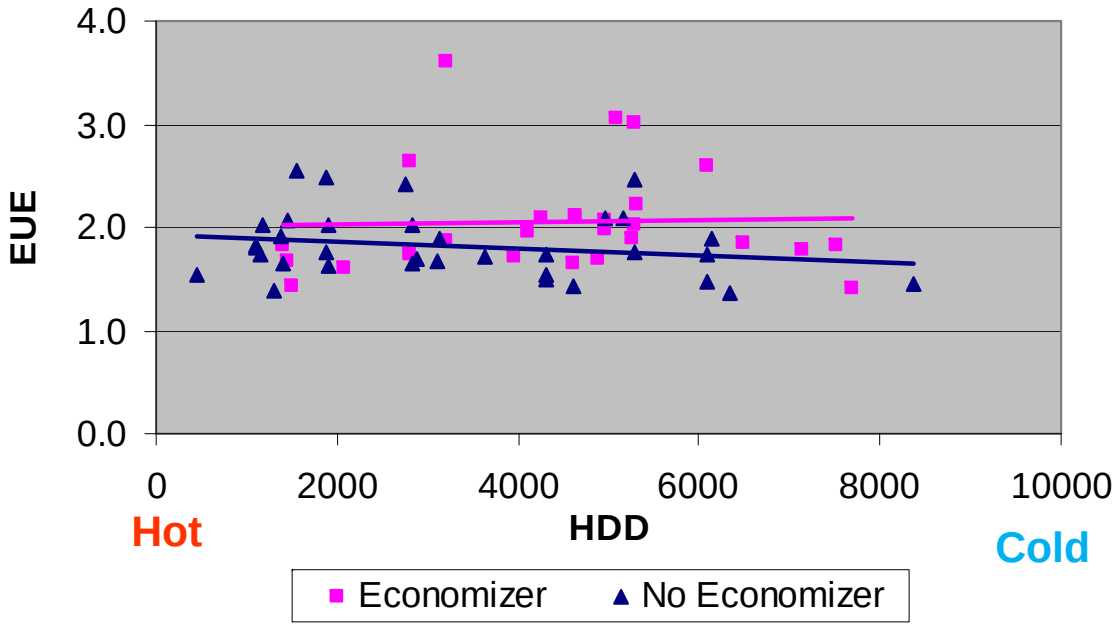
# Monthly Energy Consumption All Standalone Data Centers

- Average of all Stand Alone Data centers shows no variability in monthly energy consumption



# Economizers

- No Economizers:  In cold climates (high HDD), EUE is lower than warm climates, as expected
- Economizers:  In cold climates, EUE's are expected to be better than with no economizers, but not the case




*Economizers do not appear to be working properly.*

*This result has been observed in other building types, where economizers can be disabled or prone to failure.  The EPA rating can help identify operational problems.*

# Climate Conclusions

- No observed effect of climate on energy consumption
  - EUE not dependent on annual HDD or CDD
  - Monthly energy consumption shows little dependence on HDD or CDD for individual data centers in all climates
- Believed to be due to the fact that Internal loads are much higher than Climate loads
  - Reportedly a 10 to 1 ratio, much higher than commercial buildings
- EPA ratings adjust for ***observed*** relationships only
- *Heating and Cooling Degree Days are not likely to be included in a data center rating model*

# Data Center Type

- Traditional and Hybrid have higher EUE's than Hosting and Internet
- Not enough data to draw conclusions for On-Demand, Telecom, and High Performance
- Generally not significant in regressions

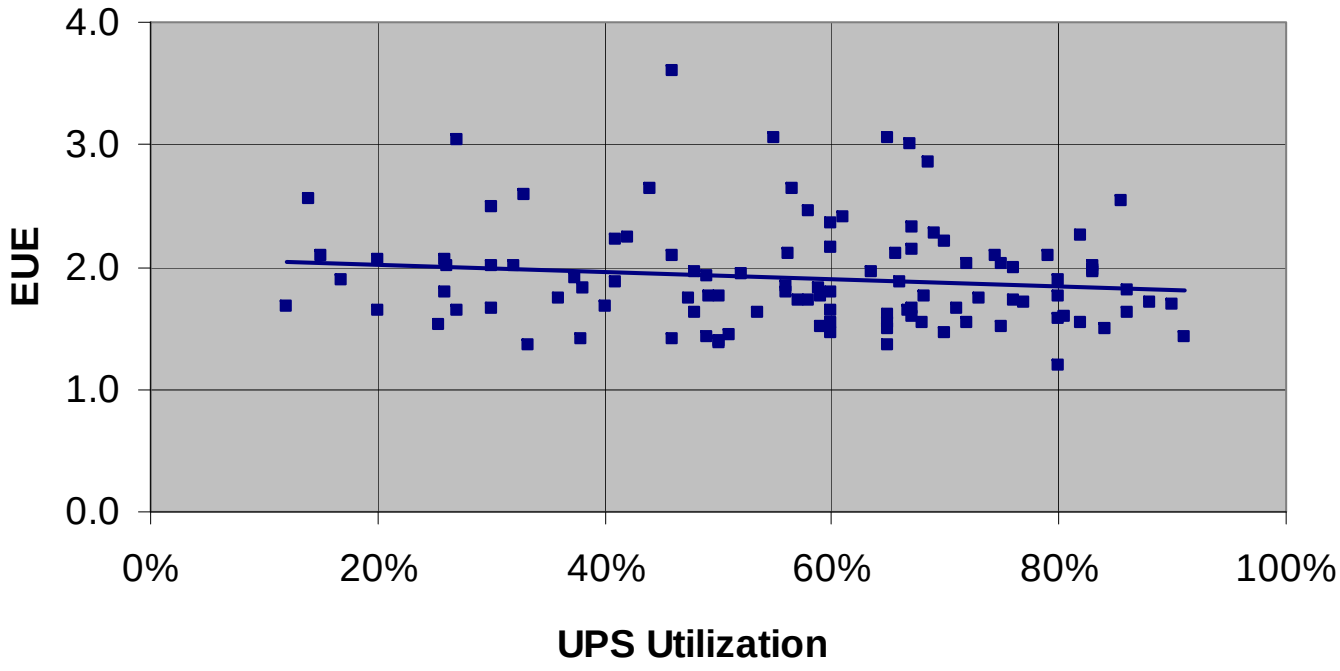
| Data Center Type | Count | Percent | Average EUE |
|---|---|---|---|
| Traditional Enterprise | 64 | 59% | 1.97 |
| Hybrid | 12 | 11% | 1.87 |
| Internet | 9 | 8% | 1.79 |
| Hosting | 16 | 15% | 1.77 |
| On-Demand | 3 | 3% | -- |
| Telecom | 3 | 3% | -- |
| High Performance | 1 | 1% | -- |
| All Data Centers | 108 | 100% | 1.91 |

# Data Center Type

- Conflicting theories exist for why certain data center types would have higher/lower EUE
  - Ex. Hosting: may have higher EUE due to less control over equipment specification
  - Ex. Hosting: may have lower EUE because data center operation is the primary business
- If there are no compelling reasons to include Data Center Type in a model, it would be best to exclude
  - Could be difficult for operators to classify data centers
  - Could result in gaming of the model
- *Question: Do you have any strong arguments for including a particular Data Center Type? Would excluding it result in bias against a particular type?*

# UPS Utilization

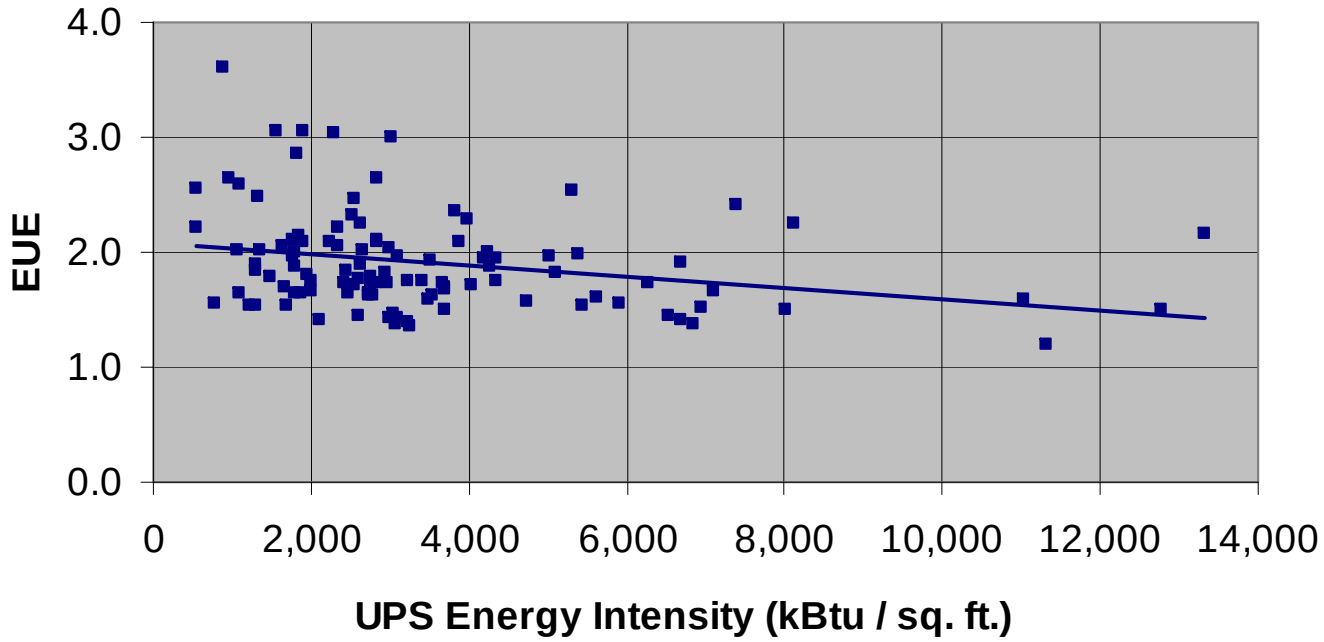
- EUE is slightly lower in buildings with high UPS Utilization, as expected
- Only significant in regressions if UPS Energy is excluded, but not nearly as strong as UPS Energy



# Variables that ***May be*** Included in a Data Center Rating Model

# UPS Energy Intensity (kBtu/Sq. Ft.)

- EUE is lower in buildings with high UPS energy intensity
- Consistently significant in regressions
- Dense arrangement of IT equipment likely results in more targeted (and efficient) cooling

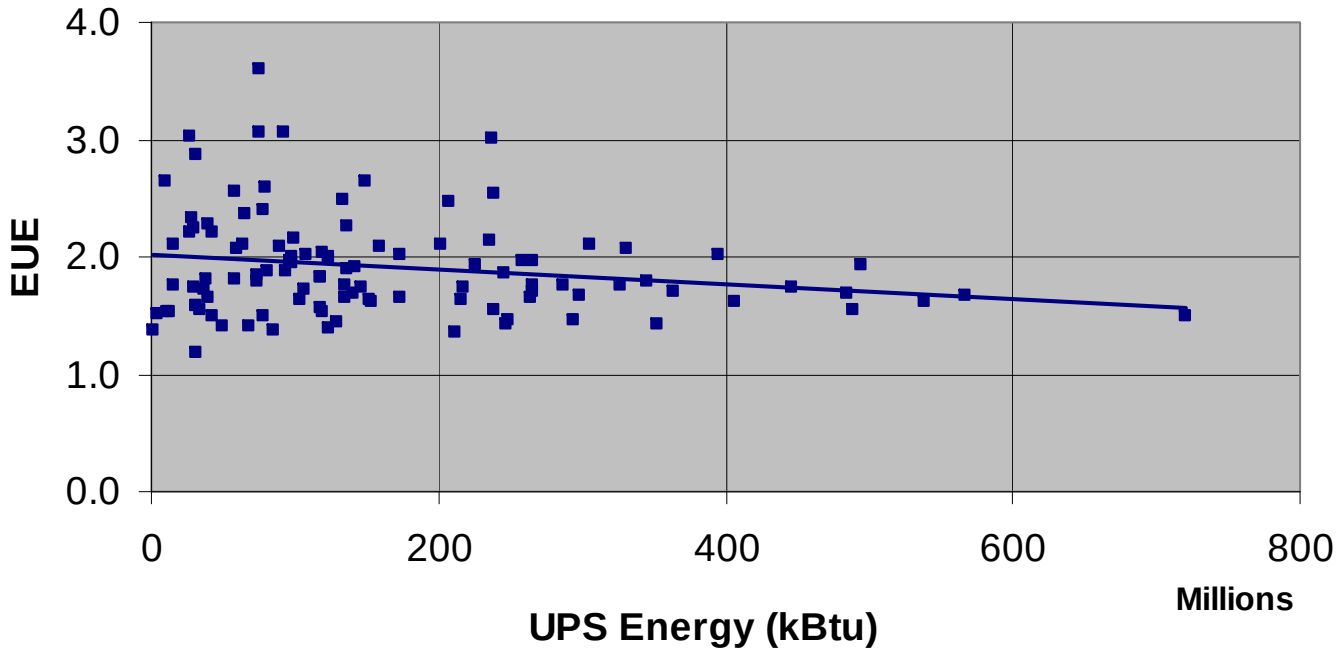


# UPS Energy Intensity (kBtu/Sq. Ft.)

- EPA believes UPS Energy Intensity may be a type of "efficiency measure"
  - Dense arrangement of IT equipment results in efficient cooling
- If so, it should be ***excluded*** from the regression model
  - EPA models normalize for operational characteristics outside of an operator's control (Ex. Operating Hours for Offices)
  - EPA models do not normalize for efficiency measures (Ex. High efficiency lighting for Offices)
  - Buildings utilizing "efficiency measures" use less energy, and therefore receive higher ratings
- *Question: Do you agree with this assessment? Is density of IT equipment considered in design?*

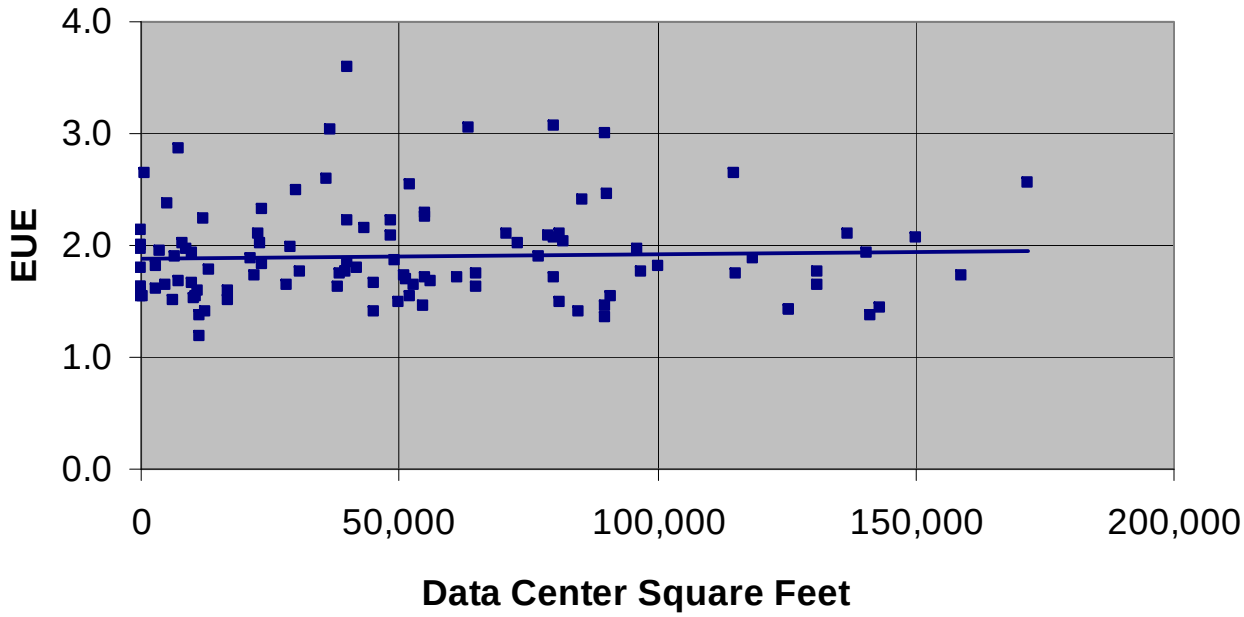
# UPS Energy

- EUE is lower in buildings with higher total UPS Energy
- Consistently significant in regressions
- Likely due to economies of scale



# Square Feet

- EUE is slightly higher in larger buildings
- Consistently significant in regressions
- Correlations exist between square foot, UPS Energy Intensity, and UPS Energy
- *Question: Do you have any theories as to why larger buildings would have higher EUE's?*



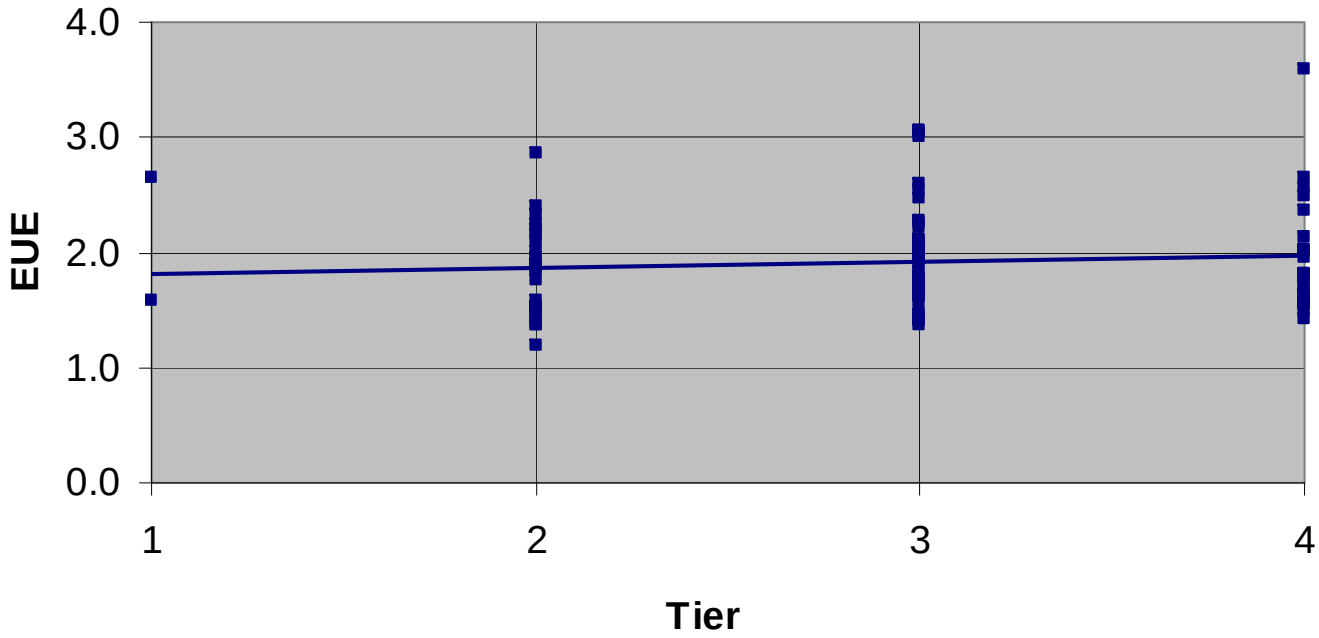
# Tier

- Small differences in EUE across Tier levels
- Only two Tier 1 data centers, both are Enclosed
- High Tier (3 & 4) vs. Low Tier (1 & 2) distinction also being investigated

| Tier level | Count | Percent | Average EUE |
|---|---|---|---|
| Tier 1 | 2 | 2% | -- |
| Tier 2 | 27 | 25% | 1.81 |
| Tier 3 | 56 | 52% | 1.92 |
| Tier 4 | 23 | 21% | 1.96 |
| **All** | **108** | **100%** | **1.91** |
| Tier 1 & 2 | 29 | 27% | 1.83 |
| Tier 3 & 4 | 79 | 73% | 1.94 |

# Tier

- Slight positive trend line in graph of EUE vs. Tier
- Marginally significant in regressions
- Inclusion in models results in more consistent ratings for each Tier level



# 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

# EPA Findings

- With over 100 data centers, EPA has identified that there will be adequate data to support a 1-to-100 Rating
- The EPA rating will incorporate energy usage effectiveness (EUE)
  - Defined as Total Energy / UPS Energy
- The data show a strong correlation between EUE and total UPS energy
  - This effect will likely be included in the rating algorithm
- The data show a weaker correlation between EUE and Tier Level than anticipated
  - This effect is still being evaluated for inclusion in the rating algorithm
- Data centers do not exhibit a strong weather dependence

# Next Steps

- By October 6, 2009
  - Submit comments regarding the analysis presented today
- November 2009
  - Webinar presenting additional results
  - Final model selected
- Spring 2010
  - Data center model scheduled for release

# For More Information

Please send questions to:

ENERGYSTARdatacenters@icfi.com

Check the ENERGY STAR Web site for updates:

www.energystar.gov/datacenters