New GSA data process and weather normalization

GSA project

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1 Question

Weather normalization: is it only weather or both weather and climate

2 Terms

Heating balance-point temperature The temperature above which no thermal energy is needed for space heating.

3 Introduction

The document records the literature search of weather normalization. The weather normalization, as described in the PM EnergyStar Technical Reference, "is the energy your building would have used under average conditions (also referred to as climate normals)". The difference of weather condition each year can affect the energy consumption of a building, taking this influence into account is the reason for weather normalization. As is mentioned in the document, "the normalization process is performed separately for each fuel that is present (electricity, gas, district steam, etc.)"

Climate normals could be obtained from `http://www.ncdc.noaa.gov/oa/climate/normals/usnormals.html`

4 Common Method

4.1 Energy Star method

The document of Energy Star Portfolio Manager has the following steps.

1. Retrieve 24 (or at least 12) calendar months of energy data.
2. Plotting energy-temperature (energy is y axis), a plot is created for each type of energy fuel
3. Using linear regressions to calculate the fit line maximizing the R^2, after this step one gets a function maps from temperature to energy consumption of some fuel

   $$F : T \mapsto E$$

   where T: temperature and E: energy This step is the trickiest one, the following document would describe this step in more detail.

4. Compute the ratio
$$r = \frac{F(T_{normal})}{F(T_{current})}$$
where T_{normal} is

5. Compute normalized energy:
$$E_{norm} = r \cdot E_{current}$$

In the steps above, the step 3 is not very clear on the regression computing process. From other technical document, the model uses HDD or CDD as the independent variable (input to the function) in regression computation: "ENERGY STAR model is a amount of raw fuel regression-based model that builds on the PRISM approach by using that is required to degree-day models." [1]. Some other independent variables such as occupancy and equipment are also included. The dependent variable is the source EUI. The HDD and CDD are retrieved by Zip code.

4.2 LEAN Energy Analysis, Using Regression Analysis to Assess Building Energy Performance

LEAN analysis uses monthly bills, gross or conditioned area, building typology and current and normal weather data. The steps are as follows:

1. For each energy usage type, create a regression model of energy vs. weather condition. The model has three parameters: base load, "weather dependent energy use", and "balance point".

2. Use historical energy and weather data to build a historical model.

3. Use recent energy and weather data to build a current model

Seems very confusing, what is the first step doing?

4.3 PRISM Method

"The PRISM (PRInceton Scorekeeping Method) is one of the earliest applications of using regression analysis to measure energy savings in commercial buildings." [1], this method computes a "weather adjusted index of energy consumption" from 12 month of energy consumption data.

4.4 Inverse Model Toolkit by ASHRAE

This document is cited by [1], describing how to build the regression model.

The model uses a generalized least square regression.

There are several models described in the document

- Variable-based degree-day model: used for single zone buildings, in this model, the IMT searches the balance that maximizes R^2 as follows: Take heating for example:

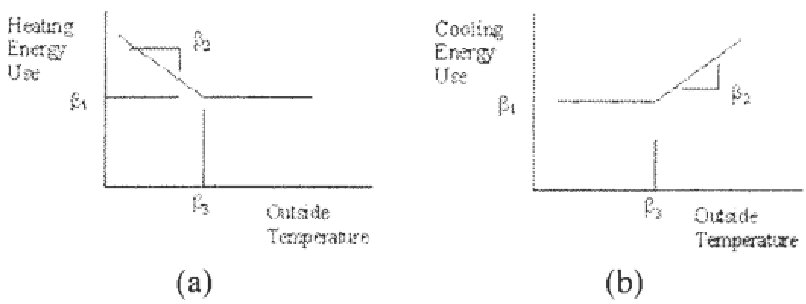

Figure 1: Single zone building energy use patterns

IMT VBDD model is defined as

$$Y = \beta_1 + \beta_2 HDD(\beta_3)$$

where $HDD(\beta_3)$ is the heating degree days with β_3 as the base temperature. Monthly degree days with different base temperature is calculated and stored in a table. Each row is one month and each column has a different base temperature. In the document the base temperature search range is 41 F to 80 F. However I propose to search within the range of [40, 45, 50, 55, 57, 60, 65] for HDD and [45, 50, 55, 57, 60, 65, 70, 72] for CDD for weather normalization usage, since one need to acquire a corresponding climate normal with the same base temperature, and these are the available base temperature for climate normal in NCDC. For the HDD example, the algorithm will compute a regression line for each base temperature in the search range and return the regression line with the maximum R^2

4.5 ASHRAE Guideline 14

4.6 IPMVP Volume I

5 Weather data

Might be available from `http://www.wunderground.com/history/airport/KTUS/2012/1/22/MonthlyHistory.html?req_city=Pittsburgh&req_state=PA&req_statename=Pennsylvania&reqdb.zip=15217&reqdb.magic=1&reqdb.wmo=99999`

References

[1] Melissa Donnelly. LEAN Energy Analysis Using Regression Analysis to Assess Building Energy Performance. Technical report, Institute for Building Efficiency, 03 2013.