Technical Description for the Hospital Model

12/11/2001

Data Source

Energy consumption and building characteristics data for the analysis of the hospital model was obtained from the Electric Power Research Institute's (EPRI) *Energy Benchmarking Survey* completed in 1997. This database contains energy expenditure, energy consumption, and building characteristics data for 701 hospitals located throughout the United States. Through careful examination, it was determined that the 1995 CBECS (Commercial Buildings Expenditures and Consumption Survey 1995, EIA) data was not sufficiently robust to fully account for the variation in service found in the healthcare sector.

Data Set

The EPRI Energy Benchmarking Survey data (EPRI Data) contained energy consumption and building characteristics data on 701 hospital complexes, however of these, 493 records contained the detailed information required to analyze the data. For each record, the following fields of data were known for a total of 493 records:

- Hospital classification
- Energy consumption by fuel type (electricity, natural gas, oil, district steam/hot water, district chilled water, and propane)
- Three-digit Zip Code
    - Heating Degree Days
    - Cooling Degree Days
    - Total Degree Days
- Number of beds
- Acute care provided (yes/no)
- Tertiary care provided (yes/no)
- Above ground parking (yes/no)
- Maximum # number of floors
- Presence of on-site laundry facilities (yes/no)
- Presence of on-site food service (yes/no)
- Presence of MRI facilities on-site (yes/no)
- Presence of Radiation Therapy facilities on-site (yes/no)
- Presence of Swimming/Therapy pool on-site (yes/no)
- Number of Employees
- Presence of University Teaching

Hospital Classification

Each of the 493 records was identified as being in one of five different service categories as compiled by EPRI. The five categories and their representation in the EPRI data set were as follows:

Category	**# of Records**
Acute Care/Children's Hospitals	415
Cancer Centers/Clinics	4
Skilled Nursing Facilities	45
Psychiatric Hospitals	10
Rehabilitation Centers	19
Total	493

Model Format

Given the lack of records in all but the Acute Care/Children's Hospital category, attempting to analyze each hospital category independently was not feasible. Thus, the data was combined for all five hospital categories and included dummy variables corresponding to each of the various hospital categories.

Dependent Variable

The basis of the regression, that is, the dependent variable chosen for the regression was the natural logarithm of annual source energy consumption (LnSource) where annual source energy consumption is measured in kBtu/year. A more detailed description of this is provided in the section on Source Energy.

Independent Variables

The following independent variables were examined for their significance and correlation with the dependent variable as well as with the other independent variables.

HDD	number of heating degree-days base 65
CDD	number of cooling degree-days base 65
DD	number of total heating and cooling degree-days base 65
LnBeds	natural log of number of hospital beds
LnFloors	natural log of the maximum number of floors present
LnEmployees	natural log of the average number of employees present at peak time
Acute	dummy variable where a value of 1 indicates the facility type as being Acute Care/Children's Hospital and a zero indicates that it is not
Tertiary	dummy variable where a value of 1 indicates the facility as providing Tertiary Care and a zero indicates that it is not
A.G. Parking	dummy variable where a value of 1 indicates the facility type as having an above ground parking structure
Laundry	dummy variable where a value of 1 indicates the facility type as having on-site laundry facilities
Food	dummy variable where a value of 1 indicates the facility type as having on-site food service
MRI	dummy variable where a value of 1 indicates the facility type as providing on-site Magnetic Resonance Imaging (MRI) facilities
Radiation	dummy variable where a value of 1 indicates the facility type as having on-site Radiation Therapy facilities
Pool	dummy variable where a value of 1 indicates the facility type as having on-site swimming or therapy pool
University	dummy variable where a value of 1 indicates the facility type as being a university teaching hospital

Source Energy

The analysis relied upon converting site energy consumption from the EPRI database to source energy consumption using the conversion factors below. A one-page discussion about source energy may be viewed and downloaded from www.energystar.gov. The following table lists the conversion factors applied.

Fuel Type	Site (kBtu)	Source (kBtu)
Electricity	1	3.013
Natural Gas	1	1.024
Fuel Oil	1	1
Steam	1	1.38
Hot Water	1	1

Regression Results

Table 1 presents the results of the regression analysis for hospital model. The explanatory power of the model was very good having an R-squared value of 0.83. The model used the natural log of annual source energy consumption (kBtu/year) as the dependent variable and contained Ln(SqFt), DD, Acute, Tertiary, Ln(Beds), Ln(Floors), and A.G. Parking as independent variables.

Table 2 presents the basic statistics of the independent variables for the hospital model. This includes the number of data records (observations) used to construct the model, the minimum, maximum, mean, and standard deviation values for each independent variable considered.

Note: Public testing of the model provided a sufficient quantity of Beta test records to allow the model to go forward for Acute Care/Children's Hospitals only. Other hospital categories may be included once a sufficient number of records have been obtained to validate the model to include additional categories.

Table-1 Hospital Regression Results

Dependent Variable: Ln(kBtu)
Method: Least Squares
Date: 10/16/01
Included observations: 493 after adjusting endpoints
White Heteroskedasticity-Consistent Standard Errors & Covariance

Variable	Parameter	Coefficient	Std. Error	t-Statistic	Prob.
C	C_0	7.50492	0.42164	17.8	<.0001
Ln(Sqft)	C_1	0.82798	0.04436	18.66	<.0001
DD	C_2	-0.00003	0.00001	-2.27	0.0239
Acute	C_3	0.14794	0.05121	2.89	0.004
Tertiary	C_4	0.09278	0.04255	2.18	0.0297
Ln(# Beds)	C_5	0.10439	0.04015	2.60	0.0096
Ln(Max # Floors)	C_6	0.11119	0.05079	2.19	0.0291
Above Ground Parking	C_7	0.10534	0.04864	2.17	0.0308
	R-squared	0.8322	Mean dependent var		18.604
	Adjusted R-squared	0.8298	S.D. dependent var		2.284

Table-2 Limited Descriptive Statistics for Hospital Model and Its Dependent and Independent Variables

Variable	# of Obs	Mean	Std Dev	Minimum	Maximum
LnSource	493	18.60	1.03	15.55	21.58
Source	493	120,102,344	2.80	5,656,109	2,351,277,889
Ln(SqFt)	493	12.54	0.92	9.97	15.32
DD	493	6220	1531	2185	10736
Acute	493	0.83	0.38	0	1
Tertiary	493	0.32	0.47	0	1
Ln(Beds)	493	5.18	0.81	2.77	7.32
Ln(Floors)	493	1.59	0.64	0	3.58
A.G. Parking	493	0.28	0.45	0	1

Look-Up Table

Table 3 is used compute the Energy Performance Rating (EPR) on a 1 to 100 scale seen by the user and it was generated by creating a histogram of energy consumption for Acute Care/Children's hospitals. The column Actual LnSource is the natural logarithm of source energy consumption of the buildings in the EPRI data set after normalizing for the level of business activity by applying the regression model in Table 1 above. The column of Fitted LnSource is the same data, only smoothed out by fitting column Actual LnSource to a gamma distribution. In fitting the Actual LnSource the value corresponding to an EPR of 75 — the minimum threshold for ENERGY STAR — is held constant. Users see EPRs from 1 to 100 based on the column Fitted LnSource.

Table-3 Energy Performance Rating, Adjusted LnSource, and Fitted LnSource for Acute Care/Children's Hospital Model

EPR	Actual LnSource (kBtu/year)	Fitted LnSource (kBtu/year)		EPR	Actual LnSource (kBtu/year)	Fitted LnSource (kBtu/year)
100	17.11	17.75		50	18.63	18.63
99	17.29	17.87		49	18.64	18.64
98	17.48	17.94		48	18.65	18.65
97	17.71	17.99		47	18.66	18.66
96	17.79	18.03		46	18.66	18.67
95	17.84	18.07		45	18.68	18.68
94	17.90	18.10		44	18.68	18.68
93	17.93	18.13		43	18.69	18.69
92	17.97	18.15		42	18.69	18.70
91	18.02	18.17		41	18.69	18.71
90	18.08	18.19		40	18.70	18.72
89	18.14	18.21		39	18.71	18.73
88	18.19	18.23		38	18.72	18.73
87	18.21	18.25		37	18.73	18.74
86	18.22	18.26		36	18.74	18.75
85	18.23	18.28		35	18.74	18.76
84	18.25	18.30		34	18.75	18.77
83	18.28	18.31		33	18.76	18.78
82	18.29	18.32		32	18.77	18.79
81	18.30	18.34		31	18.79	18.79
80	18.32	18.35		30	18.79	18.80
79	18.33	18.36		29	18.80	18.81
78	18.34	18.37		28	18.80	18.82
77	18.35	18.38		27	18.82	18.83
76	18.37	18.40		26	18.83	18.84
75	**18.41**	**18.41**		25	18.83	18.85
74	18.43	18.42		24	18.84	18.86
73	18.43	18.43		23	18.85	18.87
72	18.45	18.44		22	18.85	18.88
71	18.46	18.45		21	18.86	18.89
70	18.47	18.46		20	18.88	18.90
69	18.48	18.47		19	18.90	18.91
68	18.49	18.48		18	18.91	18.93
67	18.51	18.49		17	18.92	18.94
66	18.51	18.50		16	18.93	18.95
65	18.52	18.51		15	18.94	18.96
64	18.53	18.52		14	18.95	18.98
63	18.54	18.52		13	18.96	18.99
62	18.55	18.53		12	18.97	19.01
61	18.56	18.54		11	18.99	19.02
60	18.57	18.55		10	19.02	19.04
59	18.57	18.56		9	19.04	19.06
58	18.59	18.57		8	19.08	19.08
57	18.60	18.58		7	19.09	19.10
56	18.60	18.59		6	19.14	19.12
55	18.61	18.59		5	19.23	19.15
54	18.61	18.60		4	19.27	19.19
53	18.62	18.61		3	19.41	19.24
52	18.62	18.62		2	19.68	19.31
51	18.63	18.63		1	19.85	19.50

Assessing Performance

To assess the performance of a building via the Energy Performance Rating on the 1 to 100 scale, two calculations are made upon the user entering the requisite data. First, as explained in the Weather Normalization file (downloadable at www.energystar.gov), the user's actual annual source energy intensity, in kBtu/ft^2-yr, is weather normalized to reflect the annual source energy intensity the building would have seen in a normal (i.e. 30-year average) weather year. In the second calculation, the weather normalized energy consumption is further adjusted so as to normalize for the level of activity in the hospital. Once the energy consumption is normalized for weather and activity level effects, the look up Table 3 is used to report the final EPR.

To account for level of activity, the regression-model equation is used to calculate a predicted LnSource energy consumption value based on the operating characteristics entered by the user. This predicted LnSource energy consumption is then divided by the mean LnSource energy consumption of the regression model, which yields an adjustment factor. The adjustment factor is then multiplied to each of the Fitted LnSource energy consumption values in Table 3, corresponding to EPRs from 1 to 100 to provide a range of Customized LnSource values. Next, the exponential of LnSource values are taken and then divided by the user's actual building area (ft^2) yielding a table of Customized Source EUI values corresponding to EPRs from 1 to 100. Finally, to calculate the EPR of the building, the building's weather-normalized Source EUI is compared to the table of Customized Source EUI values.

Table-4 is intended for use with the following example to illustrate how an EPR is determined for a given hospital. In this example, the actual Source EUI was weather normalized down approximately 2%; in essence meaning that over the course of the year in which the hospital's energy consumption was reported it "experienced" a net 2% more severe weather year than normal.

Example Acute Care Hospital

Area	=	300,000 ft^2
DD	=	6220
# of Beds	=	200
Acute Care	=	yes ("yes" = 1; "no" = 0)
Tertiary Care	=	yes ("yes" = 1; "no" = 0)
Max # of Floors	=	5
Above Ground Parking	=	yes ("yes" = 1; "no" = 0)

Actual Source EUI	=	388.2 kBtu/ft^2-yr
Weather Norm. Source EUI	=	380.4 kBtu/ft^2-yr ←

Regression Equation

LnSource (kBtu/year) = $C_0 + C_1$ Ln(SqFt) + C_2 (DD) + C_3(Acute) + C_4(Tertiary) + C_5Ln(# Beds) + C_6Ln(Max # of Floors)+ C_7(Above Ground Parking)

LnSource (kBtu/year) = 7.50492 + 0.82798 Ln(SqFt) - 0.00002887 (DD) + 0.14794 (Acute) + 0.09278 (Tertiary) + 0.10439Ln(# Beds) + 0.11119Ln(Max # of Floors)+ 0.10534 (Above Ground Parking)

Predicted LnSource	=	18.85
Mean LnSource	=	18.60
Adjustment Factor	=	(18.85/18.60)
	=	1.0134

Table-4 Determining Energy Performance Rating

EPR	Fitted LnSource	Adjustment Factor	Customized LnSource	Customized Source EUI (kBtu/ft^2-yr)
100	17.75	1.0134	17.99	216.7
99	17.87	1.0134	18.11	244.3
98	17.94	1.0134	18.18	262.0
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
85	18.28	1.0134	18.52	368.1
84	18.30	1.0134	18.55	379.4
83	18.31	1.0134	18.56	383.2
…	…	…	…	…
…	…	…	…	…
…	…	…	…	…
1	19.50	1.0134	19.76	1272.1

Note that when the hospital model is placed onto the production site with Energy Performance Rating software tool, users can include other space types to further characterize their building. These space types include office, k-12 school, supermarket, hotel/motel, computer room/data center, garage space, and parking lots – though in reality only a few of these are applicable to hospitals. With the exception of parking lots, these other space types, if used to characterize the building that is denoted as being primarily a hospital, are incorporated into the benchmarking targets by using weighted averages. If defined by the user, the energy impact associated with parking lots is simply added to the customized look up table.