Methodology for Computing Aggregates and Averages

General Method of Constructing Aggregates over Sample Buildings

The CBECS is a national probability sample. Each building $\mathbf{b}$ in the data set has an associated weight $\mathbf{w_b}$, which is the number of buildings in the United States represented by that sample building.

Aggregate Totals

For any quantity $\mathbf{X}$ that is known for all buildings in the data base, the national total $\mathbf{X_T}$ is estimated as

$$\mathbf{X_T} \quad = \quad \Sigma_b \, \mathbf{X_b} \, \mathbf{w_b}. \tag{1}$$

Similarly, for any subgroup $\mathbf{G}$, such as buildings of a particular size or activity, the subgroup total is estimated as

$$\mathbf{X_G} \quad = \quad \Sigma_{b\epsilon G} \, \mathbf{X_b} \, \mathbf{w_b}. \tag{2}$$

In particular, setting $\mathbf{X_b} \equiv \mathbf{1}$ for all buildings in the data set, the estimated number of buildings in the group is obtained as the sum of the weights:

$$\mathbf{N_G} \quad = \quad \Sigma_{b\epsilon G} \, \mathbf{w_b}. \tag{3}$$

Building-Weighted Averages

The average value of $\mathbf{X}$ over all buildings in group $\mathbf{G}$ in the population is obtained by dividing the estimated aggregate total by the estimated number of buildings:

$$\overline{\mathbf{X}} \quad = \quad \mathbf{X_G}/\mathbf{N_G} \tag{4}$$

$$= \quad (\Sigma_{b\epsilon G} \, \mathbf{X_b} \, \mathbf{w_b})/(\Sigma_{b\epsilon G} \, \mathbf{w_b}). \tag{5}$$

Floorspace-Weighted Averages

The quantity $\mathbf{X}$ can be also be averaged over all floorspace in group $\mathbf{G}$. Because much of the analysis presented in this report is cast in terms of floorspace, floorspace-weighted averages are the statistics generally used to represent a group. Since floorspace is isolated as one of the key factors determining total energy consumption, floorspace-weighted averages of other factors are of direct use in constructing energy estimates. The floorspace-weighted average is obtained as

$$\mathbf{X}^{\#} \quad = \quad (\Sigma_{b \epsilon G} \, \mathbf{X_b} \, \mathbf{S_b} \, \mathbf{w_b})/(\Sigma_{b \epsilon G} \, \mathbf{S_b} \, \mathbf{w_b}). \tag{6}$$

The floorspace $\mathbf{S_b}$ used in creating the floorspace-weighted average $\mathbf{X}^{\#}$ can be the total floorspace in the building, the floorspace lighted during usual operating hours, or the floorspace lighted by a particular type of lighting equipment during usual operating hours.

Floorspace Lighted (by lamp type)

For each building $\mathbf{b}$, the CBECS data set has the total floorspace, $\mathbf{S_b}$, the fraction $\mathbf{q_b}$ of that floorspace lighted during usual operating hours, and the fraction $\mathbf{q_{Lb}}$ of the lighted floorspace served by each type of lamp $\mathbf{L}$. From these quantities, the building's overall lighted floorspace and floorspace lighted by each type of lamp were respectively computed as

$$\mathbf{S^o_b} \quad = \quad \mathbf{q_b} \, \mathbf{S_b} \tag{7}$$

and

$$\mathbf{S^o_{bL}} \quad = \quad \mathbf{q_{Lb}} \, \mathbf{q_b} \, \mathbf{S_b}. \tag{8}$$

Aggregating $\mathbf{S^o_b}$ and $\mathbf{S^o_{bL}}$ over buildings $\mathbf{b}$, as indicated above, gives the total lighted floorspace and the total floorspace lighted by each lamp type.

Within the building, the same floorspace may be lighted by more than one type of lamp. For most buildings in the CBECS sample, the sum of the lamp fractions $\mathbf{q_{Lb}}$ over the different lamp types $\mathbf{L}$ was 100. In some cases, though, the sum was greater than 100, indicating that some floorspace was lighted by more than one type of lamp. Any such overlapping floorspace was double-counted in the total floorspace lighted, summing over the different lighting combinations. The extent of the double counting was about 2 percent. Summing the percents across each row of Table 2 indicates the discrepancy for that subgroup.