annual irradiation on unshaded east-facing surfaces was predicted to be a little lower than on unshaded west-facing surfaces. This was puzzling as weather files for other locations did not show this effect. Further investigation revealed that this is in fact a consequence of the San Francisco morning fog. The fog occurs so regularly throughout the year that its effect is present in the weather file: irradiation from the sun in the morning (in the east) is slightly attenuated compared to irradiation in the afternoon (in the west) when the fog has lifted. It is noteworthy that this subtle aspect of the locale should be discernable in the visualizations of the solar access. The use of the San Francisco model was also important to demonstrate the inherent scaleability of ICUE: the system does not contain any practical limits on the complexity of the model and it can be equally applied to small-scale architectural features as to large-scale city models.

Harvesting solar energy: building integrated photovoltaics

Of the renewable technologies that have been proposed to reduce the carbon emissions associated with the energy consumption of buildings, *in situ* generation of electricity by photovoltaics (PVs) is considered one of the most promising (IEA, 1998). PV devices at present are based on silicon in various formulations. New materials and novel approaches to PV fabrication are under vigorous investigation. Whatever the type of the PV module, the potential for exploitation of building integrated photovoltaic (BIPV) installations depends primarily on the available solar irradiation. A recent report by the Department of Trade and Industry gave details of 16 typical BIPV projects (DTI, 2000). For these demonstration projects recently completed, planned or speculative, shading issues were largely avoided by choosing open sites with minimal nearby obstructions. However, in the medium- to long-term BIPV in dense urban environments will need to be considered since this is where the majority of energy use takes place. The wider adoption of BIPV will depend on sound demonstrations of its economic viability. Foremost in the evaluation of PV economics is the calculation of the available solar energy. The ICUE images allow rapid identification of candidate facade and roof areas where the total annual irradiation is sufficient to warrant consideration as a site for BIPV. The ICUE images given in this chapter show cumulative totals of irradiation.

The performance of a BIPV installation is degraded by transient-shading effects, which are not revealed by cumulative totals. Therefore, detailed analysis of these effects would be required once a candidate site has been identified.[8]

Strategic irradiation mapping of city models

One of the conceivable uses for the ICUE system is the large-scale quantification of building facade areas, graded for total annual irradiation. This provides information on the potential for wide-scale deployment of various solar-dependent facade technologies (e.g. BIPV, electrochromic (EC) glazing, solar control glazing). Economic models for the wide-scale deployment of emerging facade technologies have often been based on estimates of the total facade area. However, the effectiveness of these technologies is critically dependent on the magnitude of the exposure to total annual irradiation. Thus, the true potential market for wide-scale deployment of these emerging technologies is more reliably determined from the quantified solar access. How this would be achieved in practice is as follows.[9] The building facade area, graded for total annual irradiation, was determined for the entirety of the 3D model. To gain further insight into this parameter (and to demonstrate the processing capabilities of ICUE), a two-dimensional (2D) grading was used. The facade area was sorted into bands of total annual irradiation and height above ground. The results are shown in Table 19.1. The total area for vertical and slightly sloping facades was determined to be $1.18 \times 10^6 m^2$. The target area was set to include the entire model (to remove the need for incremental steps) and the usual five views were generated. The irradiation

Table 19.1
Facade area (m^2) graded for total annual irradiation and height above the ground level for the San Francisco model.

	Total annual irradiation (Wh/m^2)			
Height range (m)	**4E5–6E5**	**6E5–8E5**	**8E5–1.0E6**	**>1.0E6**
3–25	1.04E+05	4.96E+04	3.73E+04	1.92E+04
25–50	1.03E+05	7.68E+04	4.78E+04	1.66E+04
50–75	6.96E+04	9.08E+04	5.71E+04	1.68E+04
75–100	3.54E+04	6.91E+04	6.31E+04	1.64E+04
100–125	1.85E+04	3.86E+04	4.94E+04	1.84E+04
125–150	7.47E+03	2.51E+04	3.52E+04	2.17E+04
150–175	6.44E+03	1.44E+04	2.11E+04	1.74E+04
175–200	2.68E+03	3.82E+03	6.80E+03	4.08E+03
>200	2.13E+03	3.36E+03	7.01E+03	3.17E+03