the market that is glued on expanded polystyreen (XPS) insulation material. This type of warm roof construction (construction on the warm side of the insulation) system is very well suited to renovating large flat roofs (Figure 22.8).

The designer may well use building elements such as canopies and shading systems to integrate PV systems, but will need to look in detail at shading and PV technology to understand the details of how to design this PV integration. One of the first things that the designer will discover is the fact that an efficient PV system is not automatically a good shading system. In general, a PV system on louvres will need a certain mutual distance between the louvers to prevent shading of the cells, which may let too much sun through at a lower sun angle in spring and fall (Figure 22.9).

Figure 22.8 Powerguard flat-roof PV system including thermal insulation at the Coastguard building in Boston, MA (USA). The 3 kWp system has a special wind-tunnel-tested profile at the edge to keep the system on the roof in heavy winds. Adapted from Eiffert P, Kiss G, *Building-Integrated Photovoltaic Designs for Commercial and Institutional Structures – A Sourcebook for Architects*, 42–44, NREL, Golden, CO (2000). Reproduced with permission by NREL USA [18]

Figure 22.9 Colt shading system that is optimized for sun control. The distance between the louvers with PV modules cause shading on 50% of the PV cells; 47 kWp PV system at Stadtwerke in Winterthur (CH). Reproduced with permission by BEAR Architecten T. Reijenga