



Figure 20.18 Sun's trajectory map corresponding to a latitude $\phi = 40.5^\circ$, with a skyscraper superimposed on the map. For example, on the winter solstice, shadows occur from sunrise to about 10:30 (solar time) and from 14:30 to sunset

Why not just be simple? The proper answers are best found in human psychology. Many people simply desire not to believe in some ideas. Hence, the ones daring to declare them are automatically impelled to provide strong arguments in favour of such ideas. To a large extent, this is usually the case when defending the argument that modern complex software tools do not necessarily yield better results than simple (but judicious) traditional methods. That was the position of the IES-UPM in 1992, and today for the author of this chapter the position remains the same.

20.8.3 Shadows and Trajectory Maps

Surroundings of photovoltaic modules can include trees, mountains, chimneys, walls, other PV modules and so on. Because of that, photovoltaic modules cannot always be positioned entirely free of shadows. This reduces their potential energy yield, and must be taken into account when designing photovoltaic systems. Equations (20.3 to 20.5) allow the plotting of the trajectories of the sun, in terms of elevation versus azimuth angles, as already explained in Figure 20.6.

These types of diagrams are called sun trajectory maps. They are a very useful tool for determining the duration and effect of shadowing cast by any obstacle. A correctly placed theodolite can measure the azimuth and elevation angles of the most relevant points (corners, peaks etc.) of any kind of obstacle. The *local horizon* can then be superimposed on the trajectory map, as Figure 20.18 shows. The effect of the shadow is calculated with the assumption that the direct and circumsolar radiations are zero when the sun is below the local horizon. Unless the shadows are very large, the effect of the local horizon on the diffuse radiation (other than the circumsolar component) can be neglected. Several tools have been proposed [40, 41] to simplify the practise of this calculation.