The last column of this table describes the losses due to both dirt and angular effects. Taking into consideration that dirt reduces normal transmittance by a factor of 3% ($T_{\text{dirt}}(0)/T_{\text{clean}}(0) = 0.97$), it can be noted that pure angular losses dominate for $|\omega| > 30^\circ$.

Finally, it should be stressed that angular-dependent reflection is often neglected in PV simulations. However, they become significant in many practical situations, for example, where vertical (façade-integrated PV generators) or horizontal (N–S horizontal trackers) surfaces are concerned. Furthermore, they help to explain the observed low irradiance effects in PV module performance. This is because low irradiance just happens when the incidence angle is large or when solar radiation is mainly diffuse. In both cases, angular losses are particularly important. As a matter of fact, the failure to consider angular losses has been signalled as the main cause of error in some energy models [34].

## 20.8 SOME CALCULATION TOOLS

### 20.8.1 Generation of Daily Radiation Sequences

Long series (many years) of daily irradiation data are sometimes required for particular purposes, for example, when studying the long-term reliability of stand-alone photovoltaic systems. However, long series of historical data are scarce and hard to obtain. This leads to the need for methods that are able to generate a series starting from widely available information, such as the 12 long-term average monthly mean values of the daily irradiation, $G_{\text{dm}}(0)$. The idea is that the generated series must keep some statistical properties believed to be universal, as they are also found in historical data, when available. In particular, the persistence of solar radiation, that is, the dependence of today's irradiation on the irradiation of the precedent days, is adequately described by a first-order autoregressive process [35]. Moreover, the probability function of the daily clearness index for any given period has a form associated with only its average value for the period. Several methods for the generation of daily irradiation sequences are available in the literature [36]. The method proposed by Aguiar [37] is the most widely used today.

### 20.8.2 The Reference Year

As already mentioned, the most widely available information related to the solar radiation resource at a given location is the set of 12 monthly mean values of global horizontal daily irradiation, $G_{\text{dm}}(0)$. The methods presented above allow estimation of all the radiation components incident on any surface of arbitrary orientation and at any moment of the average year, and even at any moment of a long sequence of years. This can be applied to all the problems related to the design of photovoltaic systems: sizing, prediction of energy yields, impact of shadowing, optimisation of tilt angles and so on.

Nevertheless, the solar radiation is still the object of systematic recording, and more and more irradiance and irradiation data are being accumulated and put at public disposal. Such data whether in the form of crude recorded data or in the form of elaborate mathematical tools, attempt to properly represent the climate of the concerned location. The most widely used is the so-called Reference Year, also called the Typical Meteorological Year [18], *TMY*, or the Standard Year. The *TMY* for a location is a hypothetical