2.18 The Sun's Position

太阳的位置

The azimuth angle and the elevation angle at solar noon are the two key angles which are used to orient photovoltaic modules. However, to calculate the sun's position throughout the day, both the elevation angle and the azimuth angle must be calculated throughout the day. These angles are calculated using "solar time". In conventional time keeping, regions of the Earth are divided into certain time zones. However, in these time zones, noon does not necessarily correspond to the time when the sun is highest in the sky. Similarly, sun rise is defined as the stage when the sun rises in one part of the time zone. However, due to the distance covered in a single time zone, the time at which the sun actually clears the horizon in one part of the time zone may be quite different to the "defined" sun rise (or what is officially recognized as the time of sun rise). Such conventions are necessary otherwise a house one block away from another would actually be different in time by several seconds. Solar time, on the other hand is unique to each particular longitude. Consequently, to calculate the sun's position, first the local solar time is found and then the elevation and azimuth angles are calculated.

对于太阳能电池板的朝向来说，太阳的方位角和正午时的太阳仰角的值是两个非常重要的参数。然而，如果需要知道一天中太阳的位置，我们需要计算太阳仰角和方位角在一天中的变化情况。我们将通过太阳时来计算这两个角的角度值。按照传统的计时方式，地球被划分成不同的时区。然而，对于这些时区来说，所谓的正午并不一定对应太阳在天空中位置最高的时候。类似的，日出时间也是针对时区内的某一区域而言的。因为对于某一地区而言，由于其距离跨度很大，太阳真正通过地平线的时间可能与所定义的太阳升起时间（或者官方认可的日出时间）不同。即使是这样，这种传统的计时方式也是有必要的，否则两座一街之隔的房子的时间都会相差几秒。从另一方面来说，太阳时对于不同的经度来说是不同的。因此，在计算太阳位置时，我们需要先确定地方太阳时，而后再计算太阳仰角和方位角。

Local Solar Time (LST) and Local Time (LT)

地方太阳时与地方时

Twelve noon local solar time (LST) is defined as when the sun is highest in the sky. Local time (LT) usually varies from LST because of the eccentricity of the Earth's orbit, and because of human adjustments such as time zones and daylight saving.

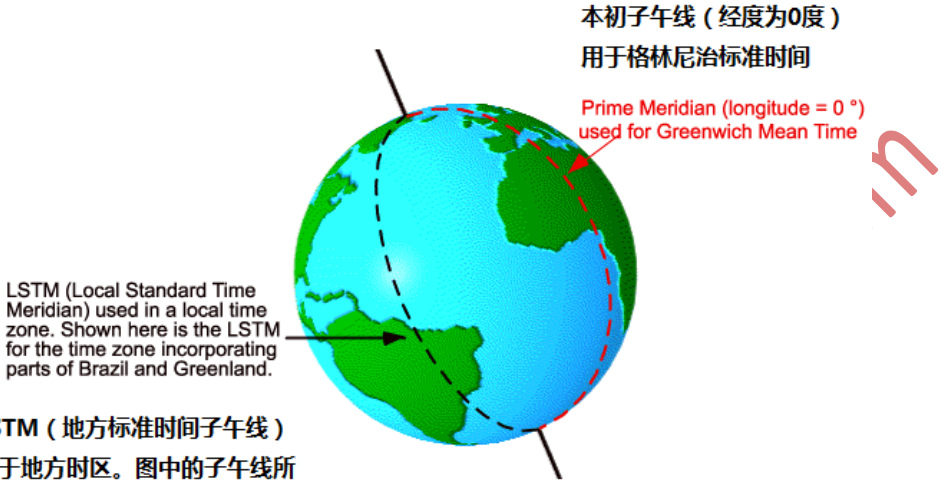
地方太阳时（LST）中午 12 点指的是当一天中太阳升到最高处的时刻。由于地球轨道的离心率以及人们对于时区和夏令时的调整，地方时（LT）一般不等于地方太阳时。

Local Standard Time Meridian (LSTM)

地方标准时间子午线

The Local Standard Time Meridian (LSTM) is a reference meridian used for a particular time zone and is similar to the Prime Meridian, which is used for Greenwich Mean Time. The LSTM is illustrated below.

地方标准时间子午线（LSTM）是对于某一特定时区的参考子午线，它与格林尼治标准时间使用的本初子午线很类似。地方标准时间子午线如下图所示。



The (LSTM) is calculated according to the equation:

$$LSTM = 15° \cdot \Delta T_{GMT}$$

where ΔT_{GMT} is the difference of the Local Time (LT) from Greenwich Mean Time (GMT) in hours. $15° = 360°/24\ hours$.

地方标准时间子午线可通过下面的公式计算

$$LSTM = 15° \cdot \Delta T_{GMT}$$

公式中，ΔT_{GMT}为地方时与格林尼治时间的小时差。$15° = 360°/24$ 小时。

Equation of Time (EoT)

时间公式

The equation of time (EoT) (in minutes) is an empirical equation that corrects for the eccentricity of the Earth's orbit and the Earth's axial tilt.

$$EoT = 9.87\sin(2B) - 7.53\cos(B) - 1.5\sin(B)$$

where

$$B = \frac{360}{365}(d - 81)$$

in degrees and d is the number of days since the start of the year. The time correction EoT is plotted in the figure below.

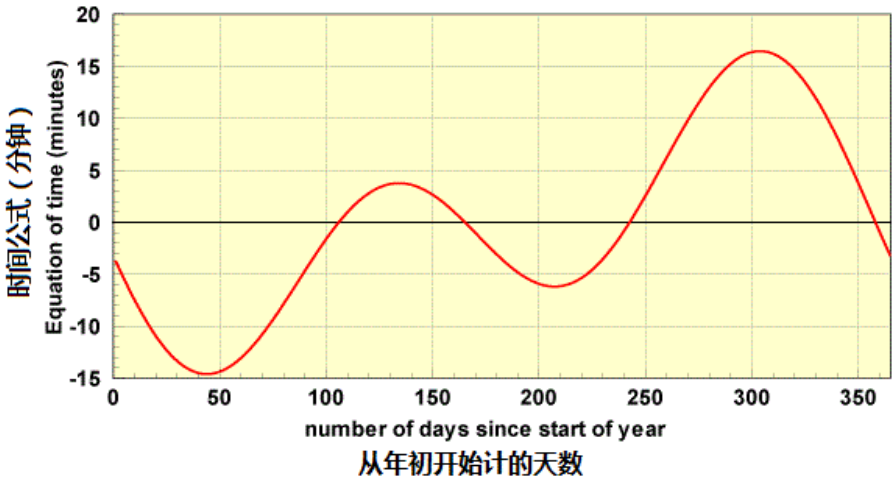
时间公式（以分钟为单位）是一个用于修正地球轨道离心率和地球轴向倾角的经验方程。

$$EoT = 9.87\sin(2B) - 7.53\cos(B) - 1.5\sin(B)$$

公式中

$$B = \frac{360}{365}(d - 81)$$

单位为度，d是某一天在一年中的序数（以一年的第一天为 1）。下图描绘了时间修正公式。



Sundials include the equation time as a table to provide the correct time throughout the year. The other time corrections are either incorporated into the design of the sundial or given as a constant offset.

图中的日晷包含了时间公式表格，在一年中，它都可以给出的准确时间。另一个时间修正因子或者是在设计日晷时就考虑在内，或者是被当做一个固定的偏移量给出。

Time Correction Factor (TC)

时间修正因子

The net Time Correction Factor (in minutes) accounts for the variation of the Local Solar Time (LST) within a given time zone due to the longitude variations within the time zone and also incorporates the EoT above.

$$TC = 4(Longtitude - LSTM) + EoT$$

The factor of 4 minutes comes from the fact that the Earth rotates 1° every 4 minutes.

净时间修正因子（TC，以分钟为单位）考虑了某一时区内因为经度变化和时间公式造成的地方太阳时的变化。

$$TC = 4(\text{经度} - LSTM) + EoT$$

方程中的 4 分钟源于地球每 4 分钟转过 1 度。

Local Solar Time (LST)

地方太阳时

The Local Solar Time (LST) can be found by using the previous two corrections to adjust the local time (LT).

$$LST = LT + \frac{TC}{60}$$

运用之前的两个修正因子来调整地方时，我们可以得到地方太阳时。

$$LST = LT + \frac{TC}{60}$$

Hour Angle (HRA)

小时角

The Hour Angle converts the local solar time (LST) into the number of degrees which the sun moves across the sky. By definition, the Hour Angle is 0° at solar noon. Since the Earth rotates 15° per hour, each hour away from solar noon corresponds to an angular motion of the sun in the sky of 15°. In the morning the hour angle is negative, in the afternoon the hour angle is positive.

$$HRA = 15°(LST - 12)$$

通过小时角，我们可以把地方太阳时转换成太阳在天空运动过的角度数。按照定义，太阳时正午对应的小时角为 0 度。因为地球每小时转过 15 度，与太阳时的正午每差一个小时，相当于太阳在天空中多运动了 15 度。上午的小时角是负值，下午的小时角为正值。

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博主邮箱：nkukarl@gmail.com

$$HRA = 15°(LST - 12)$$

Declination

太阳倾角

The declination angle has been previously given as:

$$\delta = 23.45° \sin\left[\frac{360}{365}(d - 81)\right]$$

where d is the number of days since the start of the year.

前文已经给出了太阳倾角的计算公式：

$$\delta = 23.45° \sin\left[\frac{360}{365}(d - 81)\right]$$

公式中的d表示某一天在一年中的序数（以一年的第一天为 1）。

Elevation and Azimuth

太阳仰角和方位角

$$\text{Elevation} = \sin^{-1}[\sin\delta \sin\varphi + \cos\delta \cos\varphi \cos(\text{HRA})]$$

$$\text{Azimuth} = \cos^{-1}\left[\frac{\sin\delta \cos\varphi - \cos\delta \sin\varphi \cos(\text{HRA})}{\cos\alpha}\right]$$

Sun's position throughout the day

一天中的太阳位置

A calculator to find the elevation and azimuth throughout the year at any location is given on the following page.

后文将给出计算一年中任意位置的太阳仰角和方位角的计算器。

原文地址：http://www.pveducation.org/pvcdrom/properties-of-sunlight/suns-position
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