Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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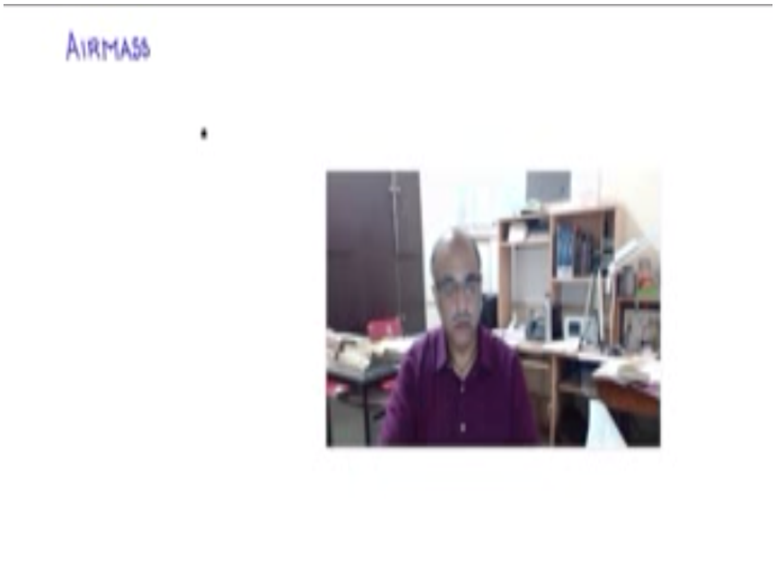

Let me now introduce you to the concept of the air mass they are most coefficient this is important figure of Merit which gives you an idea of the path length through which the spectral radians or the insulation vector passes through the Earth is atmosphere before it reaches the flat plate collector placed on the surface of the earth at a given locality.

So this path length will differ from time of the day time of the year and also the place geography and based on this the amount of attenuation was also a very though this does not give any idea on the climatic condition or does not even use the climatic condition but it uses the physical geometrical properties that is the zenith angle property to give you an idea of the amount of atmospheric length.

That the sun rays or the radiation vector has to pass through before it reaches the collector and the amount of absorption or the attenuation that may happen so this air mass coefficient is an important coefficient which is used as a parameter for comparison it is a benchmark parameter which is used to compare various panels under standard air masses it is also used to compare the spectral data or from the spectral irradiance data of various measurements of various people done at some standard air masses.

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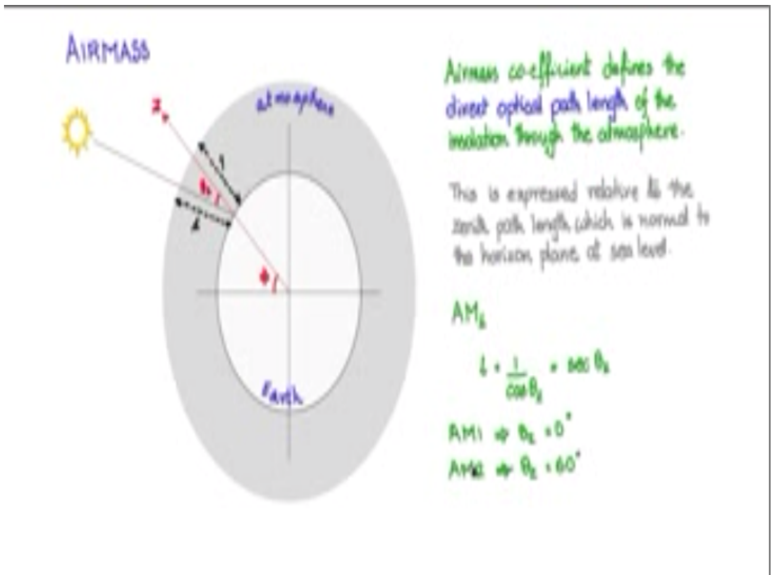

Let us now see how we calculate the air mass coefficient and also how it is visualized now let us consider this picture, this picture here as I am showing on this cursor which is tracing this circle is the surface of the earth and this second concentric circle which I am now tracing is the boundary of the atmosphere outer atmosphere beyond that is free space and in between the gray shaded area is the atmosphere.

Now there is this red line draw from the center of the earth passing through the point of interest which is the locality passing through straight up and this is actually these init axis and there is another line from the center of the Sun right up down to the point of interest which is the locality and this actually is the insulation line so we know these terms and using this let us try to define what is the air mass coefficient.

And let us see if we can calculate the air mass for a given place now this is the sun at axis Z and this white colored circle is the earth and this shaded area is the atmosphere and this angle is π the latitude and this angle is the zenith angle θz now let us let us try to define two distances length one length is here just along the movement of these cursor here just along the zenith axis from the surface of the earth at sea level along the zenith access up to the outer atmosphere.

Now that is a reference length and we shall denote it by unity that is the reference now the other length is this length which is along the insulation line starting from that locality at sea level and goes through the atmosphere in this path cuts the outer atmosphere at this point and goes on towards the center of the Sun now this length is a longer length and is basically the hypotenuse and this.

We shall define it as L lowercase yes now let us write the statement for the air mass coefficient let me write that statement first air mass coefficient defines the direct optical path length of the insulation through the atmosphere what it basically means is that these air mass coefficient defines the direct optical path length this is the direct optical path length of the insulation the insulation is the insulation line insulation vector is along this line what is this direct optical path link up to the character now that is actually defined by the air mass coefficient.

Now this is always referred the constraint for this statement is always with reference to this zenith access length so this is expressed relative to the zenith path length which is normal to the horizon plane located at sea level is the definition now knowing this now we can say the air mass is a symbol for air mass and the coefficient L, AML this is how the air mass coefficient is written so where else is actually obtained from the trigonometry L is actually the hypotenuse this is one of the sides of the right angle triangle θ that is the angle.

So cos θz is 1/L or L is 1/cos θz which is nothing but secant θz now air mass 1, let us say air mass 1 l is equal to 1 occurs when θz is 0 degrees what it means is that theta that is zero Degree this insulation line is in line with the zenith axis which means it is directly overhead during that time the insulation vector passes through minimum distance through the atmosphere and, and that is the reference distance but normally that is not what happens the air mass length is much more the path length is much more than the minimum distance.

And the standard is not a M1 the standard A, 1a.m 1.5 which is around 48.2^0 we will come to that later now am too occurs when θZ is 60^0 so when theta is at is sixty degrees cos θ it is 0.5 L is 2 and that is why call it as a M2 so the moment you see this symbol this air mass coefficient symbol like this you know that the zenith angle is 60^0 so this AM coefficients are pretty popular and used as benchmarks and many places in fact even in the PV photovoltaic panel datasheets.

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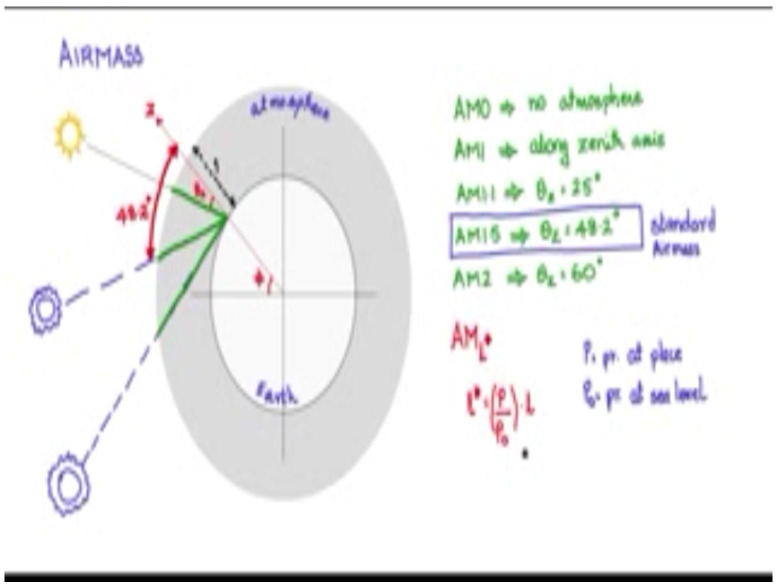

You will see the air mass parameter coming into the picture because they use it as a benchmark and comparing the PV panels and also it is used as a benchmark for the spectral studies especially when comparing the spectral irradiance data obtained from various locations what is the M0, M0 is generally used for hot lengths in free space that is when there is no atmosphere.

So for all the extra-terrestrial insulation vectors where there is not must fear attenuation or absorption M0 is used AM1 we know is along the zenith when the insulation is along the zenith axis am 1.1 implies θZ, Zenith angle is 25^0 AM 1.5 implies in zenith angle θ 48.2^0 versus angle and am to imply θ Z is equal to 60^0 which we saw and so on and so forth with what is important to note is standard what is the standard this AM 1.5 the θ that is equal to 48.2^0 is the standard for air mass and that is the standard pin benchmark which is used for comparison of the PV panels consider the following insulation line where drawn is the Sun position.

And also another Sun position like this see these are positions for the northern hemisphere this Sun position would be winter for this particular locality which is situated on the northern hemisphere so the family is moving like this from Tropic of Cancer down-low Tropic of Capricorn and then up again so as the Sun is moving the path lengths are varying which means that it travels through the atmosphere with a different path lengths and therefore you will have different attenuation factors over the year.

So you can say that is the path length at some value of θZ here and there is this path laying a different time in the year and this is the path length when it is at probably close to the topic of Capricorn are still near about so this angle let us say if it is 48.2^0 Zenith angle is considered as the air mass standard as this is applicable for most of the land masses which are occurring at the temperate zones in the northern latitudes and the southern latitudes one more point before.

We close this topic of the air mass is this air mass I will call it as L star what it basically means is that most of the air mass by definition is for the path length up to the sea level however on the surface of the earth the heights of the places are varying there are some places at sea level and there are some places on top of the mountains and how do you take care of the height of the place above sea level.

Because once you give a particular latitude it is mostly in terms of the zenith angle where the height of that particular place is not reflected however the pot length will vary depending upon the height of the place so one measure that is normally used is a M L star where L star is a modified value of L when it is given by P by P not into L where P is the pressure at the place which is at a raised altitude let us say and P not is the pressure at sea level.

So if the place is at sea level then P and P^0 will be same and therefore L star will be L and the usual, usual factor coefficient holds in case the place is at a height above sea level and the pressure is lesser and therefore this factor is a value less than 1 and therefore L star will be less than L and therefore the optical path length of the place at a height will be less than that of the place which is at sea level so this correction factor can be taken and he is normally used to address places which are above the mean sea level.