Indian Institute of Science

Design of Photovoltaic Systems

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NPTEL Online Certification Course

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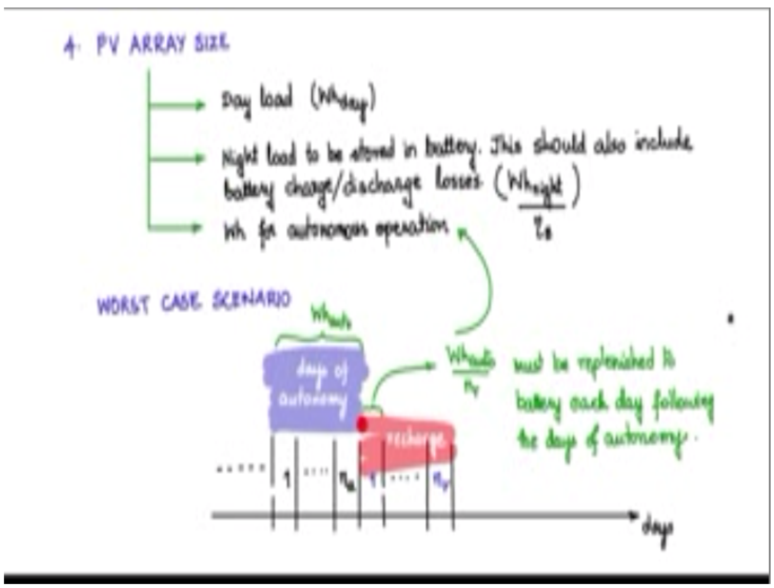

Let us see now how we go about sizing the PV array the PV array has to deliver rather words in the following way to the following loads the first one is the day load which we have called W_{hd} the second one is the night load, the night load is actually to be stored in the battery during the daytime so when during the daytime end the Sun power is present the PV array has to pump this much amount of whatever is where I was night load into the battery and the PV array or as.

Also to naturally supply the batteries charge and discharge losses so this is a major component which the PV array has to supply so this would be R at our night load by the efficiency of the battery the third component is at the batterer for autonomous operation so if there are days contiguous days without significant Sun power and on those days the battery has to support the load it has to supply energy to the load so for supplying the energy to the load on the days of autonomy.

That much amount of whatever is has to be pre-loaded into the battery by the PV array so taking these load constraints into account let us work out the worst case situation the worst case scenario will be something like this the x-axis is the days and let me divide that into the number of days like this now each segment is a day this is day 1day 2 so on up to day na, na is the number of days of autonomy meaning na the number of days continuous days.

When there is no significant Sun power so these are the days of autonomy and immediately following the days of autonomy you need to replenish the battery, the battery has to recuperate so following those days from 1 to nr and not these are the recharge days these are the days on which the battery has to be recharged such that the whatever lost during these days of autonomy is recuperated is replenished the latter were lost during the days of autonomy.

Let us say given by W_H auto the entire W_H Auto may not be possible to be replenished in one day because in such a way in such case the PV array size has to be extremely overrated and then such a system can be costly and that may not be worth having in such a huge PV array size just for this extreme worst-case so what is generally done is whatever energy is lost W_H auto we will try to recuperate it spread over few days and that is not number of recharge day.

So on each day the PV array has to supply an extra amount of WH auto by n R so this it has to do for not number of days then all this energy loss would have been recuperated so this W_h are Auto by nr has to be replenished to the battery each day following the days of autonomy now this W_H Auto by NR is what represent this the whatever is for autonomous operation.

This is the component which has to come from the PV array W_H night by efficiency the battery has to also come from the PV array and the wait hours for the day obviously has to come from the period taking all these things into account let us now write down the weight our PV requirement which will be like this what our PV is whatever day plus where overnight by the efficiency of the battery.

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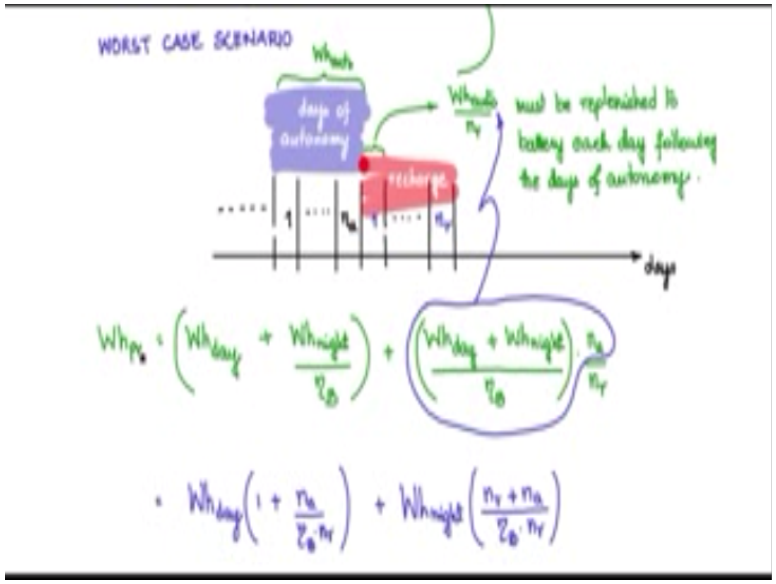

This is the standard requirement where the PV has to supply the day load plus the night load plus the battery charge and discharge losses apart from this it has to supply the energy required for the days of autonomy which is whatever D plus wait overnight so when the Sun power is not there both these has to be stored into the battery and therefore you have the F in the battery coming into the picture.

And this much amount of the power for any number of days so many number of days so this would be the total power that has to come out of the battery when the PV is not participating due to poor light conditions so these are the days of autonomy and this figure here this equation here represents W_H Auto and for recharging the worst case condition is apart from this the PV has to give immediately following the days of autonomy.

This much amount of extra charge which is WH Auto by NR so this much divided by n R so obviously you will be that this part of the equation represents the energy W_H photo so now rewriting W_h day load one plus NA my efficiency of the battery and then NR so this comes from taking this along with this part of the equation taking this part of the equations you will get W_H nine plus M^0 plus NA by and B efficiency of the battery.

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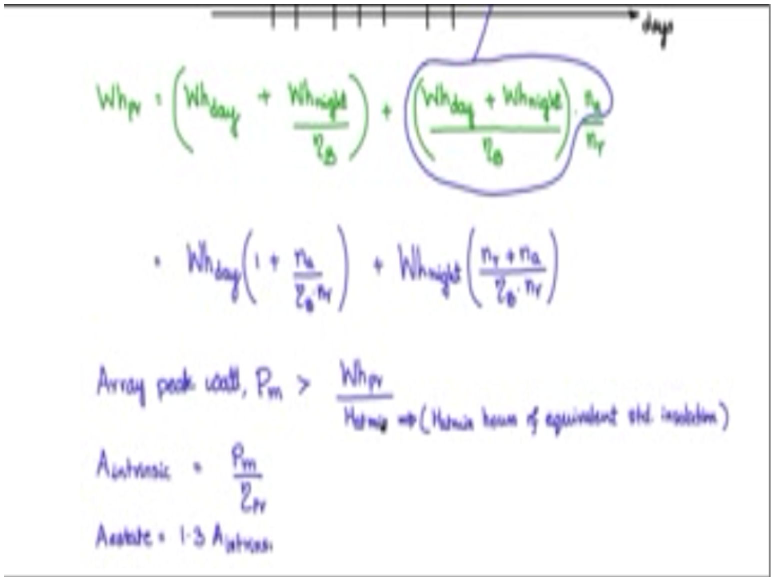

So this would be the equation for calculating the whatever of the PV so the NA cannot be calculated PM should be greater than whatever of the PV divided by H_{at} minimum so now you have to find out what is the H_{at} minimum that is the incident energy at a place on a tilted surface with atmospheric condition the minimum over the entire year this we know how to do we have also developed the necessary Program Files for that you feed in the latitude and the tilt and you will get what is H_{at} minimum.

We found out that it was around 4.5 a kilowatt hours per meter square per day so W_H PV/H_{at} minimum and here the sets at minimum is having the units of ours and not kilowatt hours per meter square per day because we are numerically using the value of H minimum to represent so many hours of one kilowatt per meter square radiation standard insulation so H_{at} minimum here will numerically be same as the hours of equivalent standard in solution.

And then we calculate the intrinsic area of the PV panel which is p.m. by efficiency of the panel and there all real estate area the actual real estate area which includes even the working area the walking the walkways and the service area maintenance area will be 1.3 times the intrinsic area so these are the equations that will be used in sizing the PV array.

Note that if NA is equal to zero that is number of days of autonomy is equal to zero and there is no recharge number of days then the watt or PV is given by just the first part of the equation which is whatever day it has to supply the day load plus the night load plus the battery charge discharge losses now, now let us try to apply it for the example that we have been discussing previously we discussed it for the battery sizing and also for load profiling recall.

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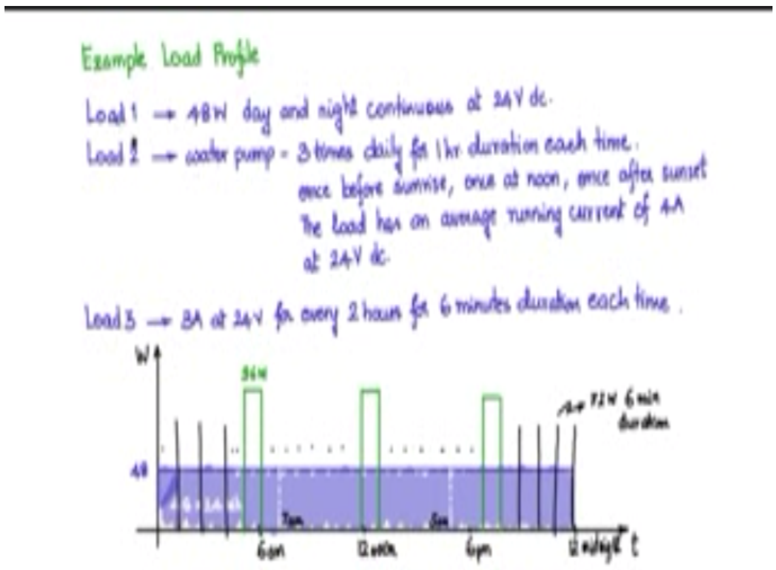

That we had discussed about this load you are load 1, load 2, load 3, and we had calculated the day load at our day 612 at hours 914.4 hours let us use these two numbers and try to calculate the PV array size that is required the whatever PV is equal to 612 watt hours for the day load 914.4 watt hours night load plus you have to include also the charge discharge losses so we have the .7 or 70% battery efficiency and all this works out to be 1918 watt hours.

The array peak fat pm should be greater than 1918 watt by H_{at} minimum and H_{at} minimum for Bangalore they are founded to be 4.58 kilowatt hours per meter square per and here we are using it with the unit hours so many hours of one kilowatt per meter square insulation it will give you 418.8 watt peak or0.4 per kilowatt peak.

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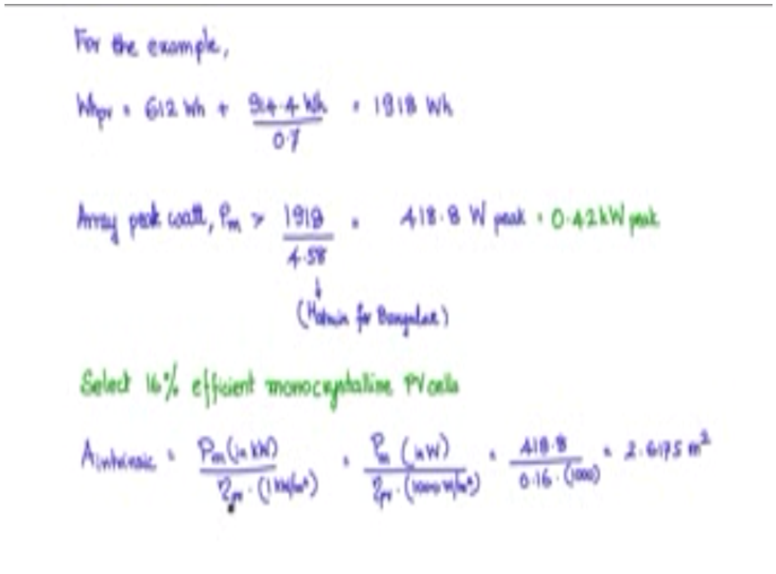

Now select a PV cell from standard manufacturers select a 16% efficient mono crystalline PV cell say for example and if we calculate the intrinsic area of the PV panel it works out to be p.m. by efficiency of the PV panel of course if p.m. is in kilowatts then in the denominator the input is 1 kilowatt per meter square incident insulation but if p.m. you take it inward then the input insulation you should take it as 1000watt per meter square so accordingly use the units.

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$$Wh_{pv} = 612\text{ Wh} + \frac{914.4\text{ Wh}}{0.7} = 1918\text{ Wh}$$

$$\text{Array peak watt, } P_m > \frac{1918}{\underset{\downarrow}{4.58}} = 418.8\text{ W peak} = 0.42\text{ kW peak}$$

(H_{min} for Bangalore)

Select 16% efficient monocrystalline PV cells

$$A_{intrinsic} = \frac{P_m(\text{in kW})}{\eta_{pv}\cdot(1\text{ kW/m}^2)} = \frac{P_m(\text{W})}{\eta_{pv}\cdot(1000\text{ W/m}^2)} = \frac{418.8}{0.16\cdot(1000)} = 2.6175\text{ m}^2$$

$$A_{estate} = 1.3\,A_{intrinsic} = 3.4\text{ m}^2$$

So if you are using 4 18.8watt peak as the peak back divided by efficiency 0.16 in 2000 watt per meter square you land up with 2.617 meter square as the intrinsic array area the actual area of the real estate will be 30% more than the intrinsic area of the panel and that we have discussed earlier that it is needed for maintenance purpose cleaning purposes 1.3 times 2.16175 works out to be 3.4 meter square. So 3.4 meter square of area should be made available on the roof top so that you can mount PV arrays having and net array capability of 418.8 at peak or 420 watt peak for this particular application so this is how you go about selecting the PV array size.