**Indian Institute of Science**

**Design of Photovoltaic Systems**

**Prof. L Umanand**

**Department of electronic systems engineering**

**Indian Institute of Science, Bangalore**

**NPTEL Online Certification Course**

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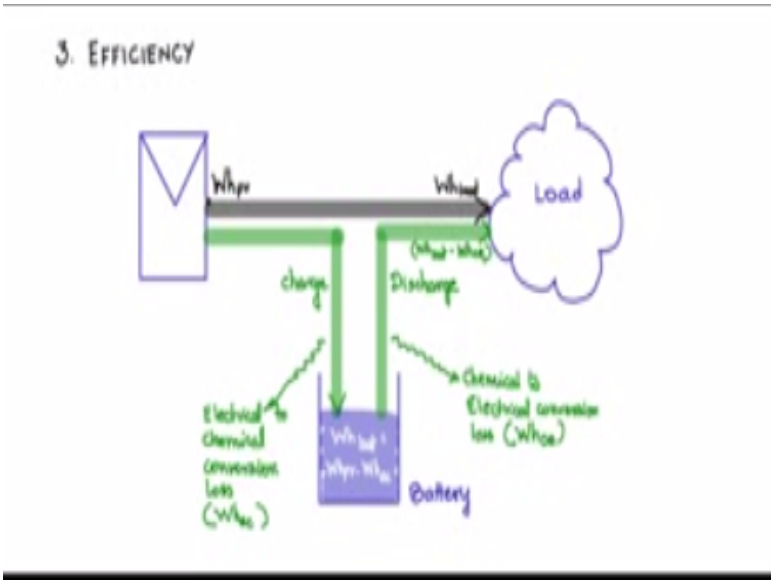


Another very important parameter is the efficiency of the battery, how do we define efficiency in the case of the battery is it power or energy, so normally efficiency is defined in terms of power output power by input power but in the case of the battery we consider energy backwards. So consider for example a PV source and a load like this and let us say energy travels from the source the PV source to the load in this fashion and there is a watt hours which is coming out of the PV and we will call it as $W_h$ PV and there is a lot of us which is going into the load and we will call it what our load.

So in this case in this type of a topological connection the PV will be equal to whatever load, as there is no loss in between except for the transmission. Then when we use a battery the energy from the PV is stored into the battery and then released later into the load, so if we consider the

case of energy storage element, let us say a battery in this fashion here let us put a battery the flow of energy is in this fashion you have energy flowing from the PV source into the battery, now this is called charging. So we charge the battery with the energy coming from the PV.

So in charging the battery we are converting the energy from the electrical to chemical and there will be conversion loss, we will call this as $W_h$ easy electrical- chemical C, so there will be this conversion laws and therefore what will be available within the battery slightly lived an $W_h$ PV what has been taken from the PV panel and we will call the battery that he stored in here the energy that is stored in the battery is $W_h$ and that is equal to $W_h$ PV - the conversion whatever is EC electrical to chemical conversion matters, so that much amount is lost.

Then the back the energy that is stored in the battery is discharged into the load, as and when required, so the flow of energy the direction is like that now this flow from the battery to the load is called discharging. So we discharge the battery now in the process of discharging energy gets converted from the chemical to electrical and therefore there will be chemical to electrical energy conversion loss and we will call it as $W_h$ C $_E$ and what is actually available at the load would be $W_h$ battery - $W_h$ chemical to electrical energy conversion loss.

So you have a loss during the charging portion $W_h$ $E_C$ you have a loss during the discharging portion - which is called $W_h$ C and these two have to be subtracted from the original $W_h$ PV that has been generated or given from the PV panel. So what the load will get would be lesser than that with $W_h$ PV and that he in effect leads to our definition of efficiency and it is in terms of energy efficiency in terms of the battlers, so whatever is given to the load divided by whatever is generated from the PV source or any source.

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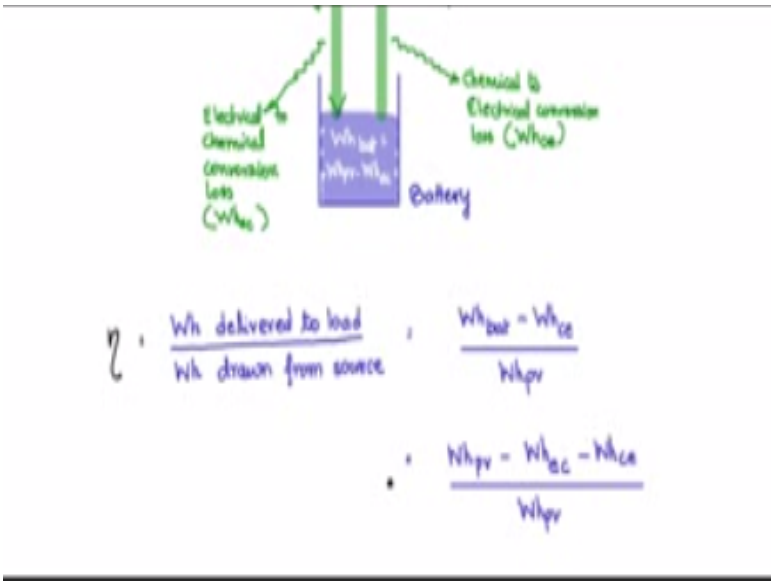


We can now write down the efficiency as whatever deliver to the load by the way our drawn from the source, referring to this figure we see that $W_h$ deliver to the load is this portion $W_h$ bat - $W_h$ chemical to electrical energy conversion loss and $W_h$ drawn from the source this is the $W_h$ drawn from the source which is $W_h$ PV. So we can write it as $W_h$ bat - $W_h$ C / $W_h$ PV we can further expand this $W_h$ bat can be written as a $W_h$ PV - $W_h$ electrical to chemical conversion loss - $W_h$ chemical electrical conversion loss by $W_h$ PV, this would be the definition of the efficiency in the case of the batteries it is dependent on the energy that the whatever so it is also called as the energy efficiency or the battery efficiency of the battery.

For most batteries this efficiency which inputs both the charge and the discharge cycles whatever electrical to chemical loss and whatever chemical to electrical Lars one during charge in one during the discharge is being included into the efficiency equation and this efficiency is generally around 70% for most batteries the lead acid batteries, that we commonly use is roughly about 70% efficient energy efficient likewise the nickel metal hydride and some of these lithium polymer batteries also how similar kind of efficiencies.