Building Services III
Lecture 6

Selection of AC System Based on Load

How does one decide on a particular type of system for their use? As we have already discussed about this heat load estimation. The load is the primary deciding factor for the type of AC. The load itself by nature, maybe of the following types. It could be a single large load like in a theatre or a computer centre or multiple small loads. For example a hotel with rooms, restaurant, bar, lobby, etc. How do you differentiate this? Whether your requirement or your building has a single large load or multiple small loads. To simplify it further, in a theatre or a computer centre. One huge space which is continuously used and used by all the occupants, everyone uses the same space, there is no separate partition or separate division, there is one single space or huge space, everyone works there and uses the space, this is called a single large room. When it comes to a hotel project or a hospital project, it could be called as multiple small rooms, even though in terms of area, the hotel and the hospital might be the same but the hotel or the hospital have multiple spaces within the big building. Each and every space in a hospital has different requirements, they work at different times, the occupancy level is different, the kind of interiors are different. All these are factored in and that is why it is considered as multiple small rooms.

Let us go into how do we design a particular type of AC. In the first case for a single large load, we can go in for the direct expansion system in which the refrigerant directly flows into the cooling coil. For the second case, considering the complex case of distribution of cooling media required, we can select a Chilled water system, in which the water cooled by the refrigerant pumped into various loads in the multiple load system. Systems that are too large use Chillers to cool this water. Of course this has an exception consequent to invent of VRF/VRV system. Hence, selection will depend upon the type or the nature of the load. There is one more aspect called load diversity, which plays a major role when you are choosing a Chilled water system. Water Chillers can be considered relatively inefficient as there are two heat transfers involved and consequent losses; what are the two heat transfers? At first, the heat from the refrigerant is transferred to the water or rather the water picks up the heat and condenses it as a refrigerant. This water is taken out to the conditioned space. There is one major advantage in using the water chiller for multiple load application. All the loads will not peak simultaneously, consequently we can go in for a Chiller which is of much lower capacity than sum of all the loads in a multiple load system. They are not always going to use the entire hospital or entire hotel on full load, always. This is known as Load Diversity. For a typical Hotel Project this can be as much as 10 to 20%. Thus, if is the sum of all the loads is around 100 tonnes, 85 ton litre water will be sufficient. This is an advantage we have in this system.

Now, we come to the specifics. What type of equipment do I choose? Equipments based on load size. If your load is between 0.5 to 3 tonnes. The ideal choice will be to go in for a window AC or a conventional split unit. If your load is between 3 to 22 tonnes, you can go in for a ceiling suspended or a floor standing packaged unit. If your load is between 20 to 100 tonnes, you have to choose a condensing unit with AHUs and if your load is more than 100 to few thousand tonnes, you have to choose a chilled water system with AHUs and FCUs.

We also have to choose an appropriate compressor for both the AHU system and FCU system, once again this is based on the load. The approximate capacity range of compressors available in the market is a reciprocating compressor can be used for a load between 0.5 to 80 tons. A Rotary compressor can be used for a load between 0.5 to 8 tons. A scroll compressor, a load between 5 to 20 tonnes and a screw compressor for 60 to 300 tonnes and a Centrifugal compressor for all higher loads; 200 to few '000 tons.

Selection of AC System Based on Air Cooling

The next, there is another aspect to it. Previously, we decided to choose an AC system based on the load. If you have chosen for a chilled water system, as we have seen there are two types for cooling a condenser, one is an air cool and the other, water cool type. Depending on the resource you have, whether you have plenty of water resource or not, then you have to go for air based cooling systems.

Heat removed from the load by the refrigerant or by circulating chilled water is to be rejected somewhere. It can be dispensed by the cooling caused by evaporation of water in case water resource is available. Here we go in for a Water Cooled Condenser and the requirement of water may be around 0.1 to 0.2 liters/hour/TR and it can be rejected into the atmosphere air by blowing air into a heat transfer device called the Air Cooled Condenser. The water cooling is obviously more efficient but the availability, quality of water and cumbersome water management prohibits use of water cooling now a days except for a high capacity system.

Next, we will look into the different energy conservation measures which we can adopt while using an air conditioner. This part has been designed as an FAQ or as a frequently asked question type. Every energy conservation method or measures has a question to it and then an answer. The first question; Does the orientation of my building affect air conditioning load? Yes, it does. Since the heat of the sun is your major source of load on your air conditioner and the directional orientation of your building can significantly affect your air conditioning power bills. Why and how? Much of India lies between the Equator and the Tropic of Cancer. Hence, heat from the sun enters your building essentially from the eastern and western direction. In the

mornings, your building is relatively cool, having been without the sun for almost 12 hours. Since the heat of the morning sun is not felt that much, by noon you can feel the heat more. As the sun sets down, the heat is at its peak. While designing it is best to avoid making rooms face the west especially having a lot of glass on the west and therefore, it will get heated less causing the air conditioned load to be less.

Second question will be, Do glass walls or glazing make any difference to the efficiency of my air conditioner? Yes indeed! This is particularly true of walls facing west as we saw in the previous question. Say for an example, there is a room with brick wall facing the west, heat inflow is of the order of 750 BTU (translating into 0.06T of airconditioning load). If the same wall is entirely made of glass, in the earlier example we saw a house made of brick wall, then the load was 0.6T. Now, if the same wall is entirely made of glass, the heat inflow is 18625 BTU (1.55T, a whopping increase of 2500%). Naturally this involves an annual power bill of Rs.16,000 more.

How can we avoid this or mitigate this? Hence, avoid glass walls unless absolutely necessary. However, if you want to have, there is no choice, then you can go in for these types of glasses; double glazing. These double glass walls have air insulation in between, you can use tinted glass, you can provide some additional blinds against the sun. However, nothing like a brick wall. Next question will be like this - What about the heat from the roof? How do I reduce it? If your space has a floor above, particularly an air conditioned space, there is very little heat entering from the roof. However, if your roof is exposed to the sun, direct heat inflow into the building is tremendous. For example, as much as 0.6T of air conditioning is wasted to compensate the heat flow from a 300 sq.ft. ceiling. In such cases, you need to insulate your roof. This minimises heat inflow into the building through the roof. Under-deck insulation can be used for 2 inches in thickness, it can reduce the heat inflow by as much as 80%, thereby saving on your air conditioning bill or the load. This is how you do Under-deck insulation. Normally you use styrofoam, sheets to under-deck insulations.

Next question is, Will tube lights and lamps add to the heat within my space? Yes. We have already seen during heat load estimations that all the electrical equipments inside the room or the space will add to the heat load. Every tube light adds 50 Watts of heat. Roughly, if you calculate 35 tubelights need 0.5T of air conditioning just to compensate their heat! The bigger culprits are spotlights used to focus light on displays. Each lamp may contribute as much heat as 2-3 tube lights. Hence, avoid artificial lighting wherever possible. But in cases like your shops and showrooms, you naturally have to use it and factor in all those lights also, the heat load for those lights also. Natural lighting is best from both the comfort and energy points of view. Even when artificial lighting cannot be avoided, seasonal variation of natural light can be used to best advantage. In summer, for example, maybe half your lights can be switched off. This results in

direct power saving and reduces the air conditioning load too! You have to be conscious about your light usage in the room as well.

The next question we have, Are there any other 'heat-producing' objects that can similarly go outside the air conditioned space? Equipments that produce heat and can possibly be kept out of the air conditioned space are photocopying machines, stabilisers, UPS and electronic power inverters. Some of these equipments may work well with outside air conditioned space, but may need adequate ventilation. Some large ones, however may themselves need air conditioning to operate efficiently. It is best therefore to consult the manufacturer of each such equipment before deciding on placing them outside or inside the airconditioned space.

The next question is, How do I 'prepare' my office for air conditioning?. The first and foremost will be to minimize the entry of the heat from the sun into the air conditioned space and prevent the leakage of cooled air outside. You have to cut the heat entering your space and whenever the space is cooled, you have to prevent the leakage of the cooled air to the exterior. How do you do it? You can minimize the entry of the sun by planting trees around the building to dramatically reduce the heat from the sun entering the space. It provides sunshades, awnings, etc, outside the windows and doors. Using sunfilm, curtains or venetian blinds on glass doors/ windows and you can also opt for insulating exposed roof. How do I minimize the leakage of air conditioned air? All the corners and edges around joinery i.e doors and windows, are sealed airtight. Doors and windows should be closed perfectly, door closers are fitted on doors that are used frequently. Doors and windows are not necessarily and too often opened and closed. These are the aspects that they can call planning or designing aspects which we saw until now. Now, we will look into aspects like how to place my equipment and where to place my equipment, how does it affect the efficiency etc.

The question goes like this, Can I locate the indoor unit IDU of my split air conditioner anywhere I wish? Does the cooling efficiency depend on the location? No, you can't and yes to the second, it does depend on the location. Let us see the do's and don'ts here. Do not place a wall mounted or ceiling mounted IDU directly opposite or above a constantly opened door. The cold air is blow out, wasting a lot of cooling. Here is a graphic showing that, do not place your indoor unit above the door. Similarly, do not place a floor mounted IDU below a shelf. Much of the cold air will short cycle back into the machine and once again wasting the cooling. As we have seen that a floor mounted unit throws the air upward, this air goes and hits the loft of whatever shelf and comes back to the machine, in turn wasting the cooling. The second question here is, How important is good installation for energy-efficiency? It is very important. Even the best air conditioners, designed to perform efficiently, can be power guzzlers if installation is not perfect. Reputed air conditioning companies allow strict installation standards that govern the

processes, tests and materials used during installation. You can also have a check of these aspects when someone comes to install an air conditioner in your home or your office. What are the commons which people make and result in major losses? The first thing is, as far as window ACs are concerned, leakage of cooled air around wooden framework. You have to control this and seal the openings or the leakage. In case of non-ducted splits, unsealed piping exits like here where the indoor air gets connected (in the picture). If you provide inadequate insulation, you have to insulate the refrigerant pipe properly in order for the refrigerant to not get affected by the outside temperature and you have to avoid the refrigerant piping with too many bends which naturally leads to the loss of the refrigerant. In Ducted systems - Short-cycling, poor design of ducting, inferior quality of ducting and lack of tail-end insulation on long ducts lead to wastage of cooled air or leads to inefficient systems. This poor design of ducting, we have seen extensively in the previous chapter regarding the aspect ratio, what is the correct size of ducting and the higher standards that guide the kind of metal sheet to be used. If you take care of all these things, this can be minimized. When it's central plants, abnormally high duct velocity, leakage in ducts, improper balancing of water and air, lack of tail-end insulation leads to inefficient systems. Ensure therefore that your installation is carried out by trained personnel only.

Central Plants

When talking about Central plants? How do you further increase your power savings? There are a few innovations or inventions like small devices that can be added to your central plants which will surely help him power save when you see a central plant. When a central plant is a complete air conditioning system, custom-made to suit your need. A detailed study of various components and possibilities in a Central Plant is beyond the scope of this booklet. However, the following slides will discuss some innovations - Variable Speed Drives, Open Drives, Subcooling and Compressor Head Reduction which bring about major power savings to Central Plant users.

Let us look into detail about what is a Variable Speed Drive. Some major advances in air conditioning technology has contributed significantly to energy savings i.e the development of Variable speed drives for compressors. A VSD converts standard 3-phase AC power input of 415 V 50 Hz into an adjusted voltage and frequency output that controls the speed of an AC motor. Air conditioning systems are generally designed to operate efficiently only at peak-load conditions. In practice, however, most systems actually operate at part-load conditions for a major part of their operating lives. A centrifugal chiller in Delhi for example could spend up to 90% of its life in part-load conditions, working at peak-load conditions only for 10% of the time! This is a small graph which shows for majority of the time, it works at part-load conditions and only at small portions of the time, it reach its peak. Under such practical conditions, machines

with constant speed drives result in unnecessary exertion on the part of the compressor drive, wasted energy. This is particularly true in the case of Central Plants. Keeping this factor in mind, international standards now rate Chillers not just by their PLV (Peak Load Values) but more importantly, by their IPLV (Integrated Part Load Values). The IPLV takes into consideration the efficiencies of the Chiller in part-load and off-load conditions as well. Thus, representing the efficiency of the Chiller more accurately. It is very important therefore that more attention is paid to part-load design of the system. The IPLV ratings are important indicators of overall efficiency of a Chiller. By using these Variable Speed Drives (VSDs), the chiller power consumption can drop dramatically as low as dramatic lows as 0.3km/ton! For this VSDv to function, you have to give a lot of input data like several operating conditions such as stilled water temperature, still point, refrigerant pressures, etc. Microprocessors then work out the most efficient parameters of operation and optimize the motor speed and vein position to save power. This is how it works. The outstanding feature of this starter is that, the starting current of the centrifugal compressor never exceeds full load current, unlike other types of starters where the starting current would be 2 - 6 times the full load current. Why must one worry about this starting load? This is because, usually in hospitals or hotels, the spaces have to air conditioned 24/7 even during power cuts and in a country like ours where there are frequent power cuts during summer months, the air conditioners run on diesel generators. When you use such kind of VSD starters, the initial startup current for the AC is lower, so that greatly reduces the cable and also in the transformer in GD setting, resulting in initial cost savings. This variable speed drive, VSD can also be used in pumps and fans. Similarly chilled water pumps are designed for peak load capacities whereas the VSD helps to run it to the required demand only whereby saving a lot of energy. When it comes to fans in AHU, the temperature of the returned air is sensed and the speed of the fan is lowered during off conditions. This not only saves power but also provides more comfort in the conditioned space. Once again, saves upto 25% of the energy.

Our next component is called the 'Open Drive'. In lower tonnage air conditioning products, namely the Window ACS, non-ducted splits and ducted systems, compressors are always hermetically or semi-hermetically sealed. Hermetically sealed meaning the total compressor is inside a cabinet and sealed, you can't take it out. This means that the compressor, and the motor that is needed to drive the compressor, are both packed into one single sealed unit. However, compressors use for larger tonnages, the screw and centrifugal types to be precise, drive motors are naturally written much higher and tend to heat up quite a bit. In hermetic chillers, therefore, a separate liquid refrigerant line is taken from the condenser and injected into the motor chasing. The refrigerant cools the motor. Thus, in hermetic chillers, the produced refrigeration effect is expended in cooling the motor, thereby making a net refrigeration effect lower than the open drive chillers. The loss of refrigeration effect is around

3-4%. To eliminate this waste of energy, you can opt for the 'Open drives'. In such chillers, the motor driving the compressor is not packaged with the compressor. Instead, it is housed separately. This enables the motor winding to be air-cooled, which is more than sufficient to maintain the motor at its recommended operating temperature. Hence, there is no load on the air conditioning cycle at all.

There is another aspect called 'Sub-cooling'. How it works is, the most efficient air conditioning systems use the principle of 'sub-cooling' to further enhance energy savings. A sub-cooler is a component where the cold refrigerant vapour exiting the evaporator, exchanges heat with the liquid refrigerant coming out of the condenser. This process increases the cooling capacity per unit of refrigerant flow. Therefore, small units use tube-in-tube heat exchanger for subcooling while larger systems use plate or shell-and-tube heat exchangers. This will also save energy upto 10%.

There is one last question regarding this central systems with regard to energy efficiency; Does the quality of ducting affect power consumption? Yes, it does. Most ducting is hand-made at site and sometimes poor in workmanship. This results in leaks at ducting joints and bend, which result in additional load on the AC. Today, the computer-aided machine made ducting is available (from Rolastar) in India, which is revolutionary in nature. From design to production, computers take over the manufacture of ducting. Ready-made duct profiles are transported to site to be easily fitted together. This results in perfect leak-free ducting, aesthetic looks, airtight joints and of course, no nuisance at site.

This is for home users, like tips. Say you have an air conditioner at home and you want tips on peak efficiency. These are the following tips; All air conditioners have air filters. These filters are present to trapt the dust particles for the return air that goes from the room into the system. These will trap the dust particles before the air takes it in for cooling. This removes the dust from the conditioned space, however, overtime the filters get clogged with dust accumulating on it and if you don't maintain it properly, this will increase the load of the AC. Unclean filters mean an additional load on the air conditioner in pulling the air in through the clogged pores and ultimately inefficient air throw and in Central plants, filters are present in the AHU, you must clean them regularly. You must also keep the cooling filters clean, maintain proper flow of chilled and condensed water.

You have to keep your doors and windows closed. You have to avoid frequent opening of doors/windows. A door kept open can result in doubling the power consumption by your AC. Pull the curtains over west-facing windows. Then, you have to avoid increasing the heat-load. For instance, if a space has been designed based on a particular heat load, you shouldn't change

it later i.e by adding additional electrical lights, adding another system, which generate a lot of heat. Naturally, the system has to work more to condition the space. Please keep in mind if you want to change the use of the room or add more equipments to the room, it is best to do a fresh heat analysis and then go in for a proper air conditioner for that space. The last tip would be, you shouldn't leave your thermostat in a particular setting for long. People tend to believe that if they use the air conditioner at a lower temperature than the desired value will force the air conditioner to cool faster and the space would get cooled faster, but this isn't true. It will only make your air conditioner operate longer and if you forget to turn off your thermostat, you will end up having an over cooled space which is not required. Every degree lower on the temperature setting, results in an extra 3-4% of power consumed. Hence, once you have found for yourself a comfortable temperature and set the thermostat to that level, avoid touching the thermostat thereafter.