

Energy Management in Buildings

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World energy situation has driven up energy prices which unavoidably affect business operating cost. In order to make the best use of electricity and energy bills, it is essential that the management of every commercial building put energy conservation schemes into practice in the most efficient way. Moreover, from social point of view, since commercial buildings are among top energy users therefore their effort in saving energy will significantly contribute to reduce the country's energy demand.

In all commercial buildings, Shopping Mall type has the highest growth in energy consumption due to its spacious size and long service hours per day.

“Shopping Mall” is a commercial center in which varieties of shops and other facilities such as parking spaces and restaurants are available. The Energy Conservation Decree identifies buildings with total transformer capacity equals to or more than 500 kVA or 600 kW, and buildings with annual energy consumption from 50000 KWHr onwards as Designated Buildings where their energy consumption must be closely monitored. Currently there are enormous Buildings in the country which can be classified into 6 categories

- office building (Corporate / Government buildings)
- hotel (boarding as well as lodging)
- hospital / cliniques / medical labs
- shopping mall / shopping plazas
- school / colleges / Educational Institutions
- others. (Markets , Bus stand , railway stations , Airports)

Among these, majority are “shopping mall” / commercial typed buildings that consume energy, especially electricity, in a high range mostly to provide comforts for their customers.

In energy perspective, shopping mall category accounts for 40 – 50 % (yet to be measured) of total energy consumption, the highest among other Building categories.

Therefore in order to realize significant energy savings, Shopping Mall typed buildings should be prioritized to activate energy conservation measures immediately.

Energy Consumption Overview

As for the energy aspect, shopping mall typed commercial buildings alone consume around 2.5 (yet to be measured) percent of the national electricity demand

By definitions and business classification, commercial buildings can be categorized into 4 main groups as following:

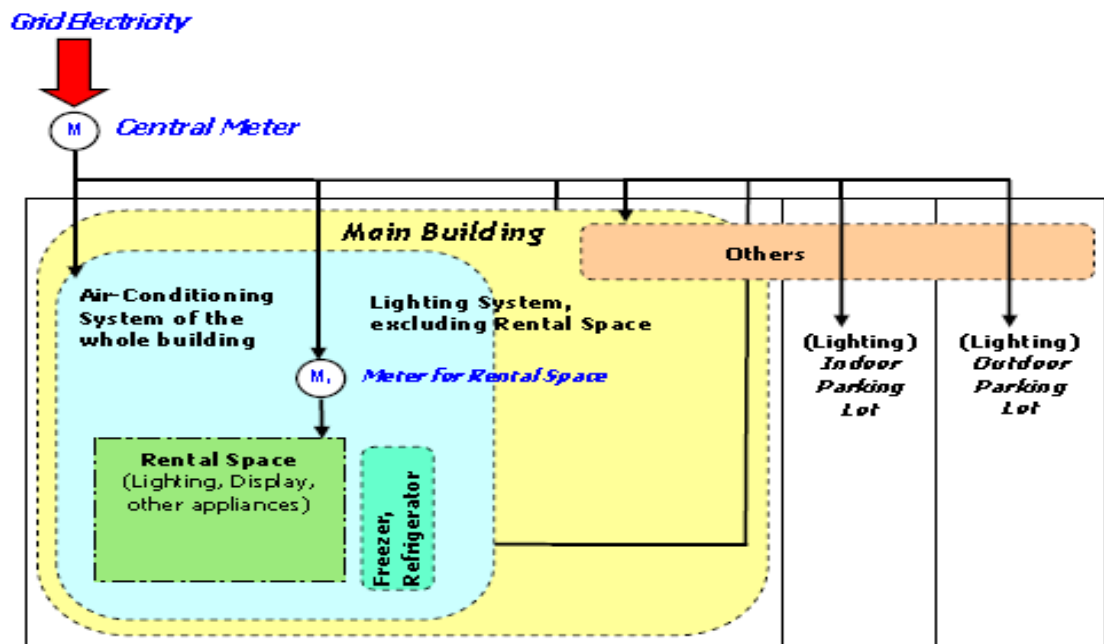
1. **Retail store** that that specializes in wholesaling / retailing of numerous consumer products especially foodstuff with bargained price. Target customer is middle to lower economic class.
2. **Department Store** (a large retail store) that sells numerous goods. Its name suggests for the way the store separates different kinds of goods for various consumer groups in different sections. Target customer is middle to upper economic class
3. **Shopping Plaza** – a building that allocates almost all space for rental shops. There are specialized plazas like Spencer's Plaza that concentrates in all types goods, and plazas that combine different kinds of shops and goods for different needs such as City Center , both located in Chennai .

4. Supermarket - a retail shop that focuses on groceries of all kinds and some necessary goods for home, thus the location is mostly in suburbs near residential area .

Those supermarkets are isolated buildings with car park area, and some are located on the ground floor as a part of the shopping mall.

Examples of this group are Food World , supermarket and Spencers , Reliance etc etc

In each of several kinds of shopping mall typed buildings, the energy is consumed for different purposes and areas as can be shown in the diagram below: (This one is common for all)



The Energy consumption pattern in commercial buildings and this will commonly apply for all buildings .

Now let us see how to derive **SEC Bench mark**

Specific Energy Consumption (SEC) Benchmark is to be derived from database of energy consumption of Commercial Buildings This can be obtained from State Electricity Boards .

A survey has to be performed to analyze energy consumption in different systems, i.e. air conditioning, lighting, and refrigerating systems, with consideration of other factors that could affect SEC such as the building's service hours, space and volume of the building.

Thus 10 different SECs of each system have been identified in Table details below

Energy Usage	Specific Energy Consumption (SEC)	Measurable Units	Data Source
Gross Energy Consumption SEC	SEC per service area	KW Hr / Year Area in sq mtr	Electricity Bills Service area Exclude parking etc etc
	Consumption SEC per service hours per service area	KW Hr / Year Area in sq mtr hour / year	Electricity Bills Service Area Utilisation hour
Energy Consumption in airconditioned system	SEC in A/C system per air-conditioned area	KW Hr / Year Area in sq mtr	Energy Consumption details / record Air conditioned area
	SEC in A/C system per air-conditioned volume	KW Hr / Year Volume in Cubic meter	Energy Consumption details / record Air contioned volume
	SEC in A/C system per annual service hours per air-conditioned area	KW Hr / Year Area in sq mtr hour / year	Energy Consumption details / record Air conditioned area Total hours of peration in one year
	SEC in A/C system per annual service hour per air-conditioned volume	KW Hr / Year Volume in Cubic mtr hour / year	Energy Consumption details / record Air conditioned area Total hours of peration in one year
EnergyConsumption in Lighting System	SEC in Lighting System per service area, excluding parking and rental space	KW Hr / Year Area in sq mtr	Energy consumption in lighting system: Details / record / Metering Size of service area, excluding parking and rental space
	SEC in Lighting System per annual service hours per service area, excluding parking and rental space	KW Hr / Year Area in sq mtr hour / year	Energy consumption in lighting system: Details / record / Metering Size of service area, excluding parking and rental space Total service hours in 1 year
EnergyConsumption in Refrigerating System	SEC in Refrigerating System per refrigerated volume	KW Hr / Year Volume in Cubic meter	Energy Consumption details / record Refrigerating systems area Refrigerating systems Volume
	SEC in Refrigerating System per annual service hours per refrigerated volume	KW Hr / Year Volume in Cubic mtr hour / year	Energy Consumption details / record Refrigerating systems area Refrigerating systems Volume Total service hours in 1 year

Out of 10 different SECs above, there are a set of SEC values that has to be choose to use as benchmarks in representing energy consumption pattern, and for comparing energy efficiency of Commercial Buildings , with respect to these criterion:

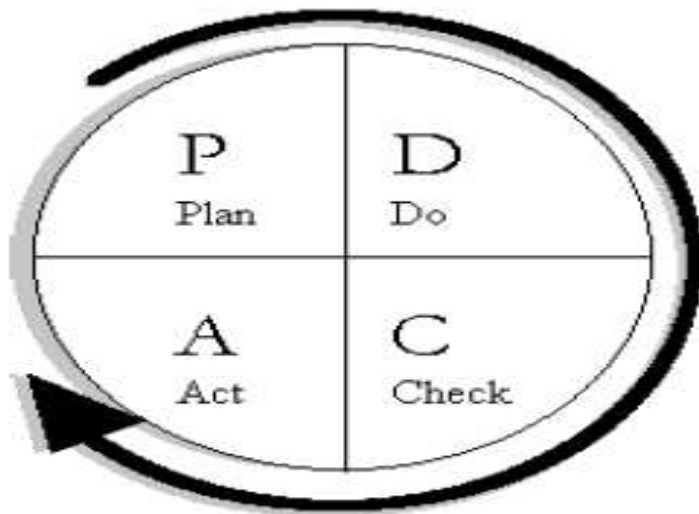
- (1) Must be of common use, for example, energy consumption per area
- (2) Must cover major systems with high energy consumption in each and every type of buildings

Specific Energy Consumption	Symbol	Calculation	Unit
1. SEC per service area	SEC	$\frac{\text{Annual Electricity Use}}{\text{Size of service area, excluding parking space}}$	$\left(\frac{kWh / yr}{m^2}\right)$
2. SEC in A/C system per air-conditioned area	SEC- AC_{AREA}	$\frac{\text{Annual Electricity Use in A/C system}}{\text{Air-conditioned area}}$	$\left(\frac{kWh / yr}{m^2}\right)$
3. SEC in Lighting System per service area, excluding parking and rental space	SEC-LT	$\frac{\text{Annual Electricity Use in lighting system}}{\text{Size of service area, excluding parking and rental space}}$	$\left(\frac{kWh / yr}{m^2}\right)$
4. SEC in Refrigerating System per refrigerated volume	SEC-RF	$\frac{\text{Annual Electricity Use in refrigerator system}}{\text{Total refrigerated volume}}$	$\left(\frac{kWh / yr}{m^3}\right)$

Then SEC values were calculated to represent energy consumption behavior of each category of buildings and to be summarized so that we can establish bench mark on consumption pattern .

Energy Management for Building (This will apply for all sectors)

In order to carry out energy conservation measures in any organization, energy management system is vital for improving management efficiency and preparing suitable program for each organization. Based on Value Engineering concepts, the energy management system has been developed and implemented for numerous buildings to improve their operation process and find out the energy saving solutions which are suitable for their conditions. In general, the energy management system is developed based on the PDCA concept. It is often referred to as the “Deming Cycle”, as the name of the famous Quality Management expert, Dr. W. Edwards Deming.



PDCA process comprises of:

Plan to improve operations first to identify current problem, then come up with solution for solving those problems.

Do as planned to solve problems on a small or experimental scale first. to minimize disturbance on routine activity while testing validity of the change.

Check whether small scale or experimental changes can achieve the desired result. Also, continuously evaluate to ensure the quality of the output and be alert when any new problem arises.

Act to implement changes on a larger scale if the experiment is successful. Making the change as a part of your activity routine. Also act by inviting other parties (other departments, suppliers, or customers) those who might be affected by the changes who directly involved in the implementation, or who may simply benefit from the program to share the experience and understanding.

Energy Conservation in Lighting system ::

1) High Intensity Discharge Dimming Technology (HID)

In all High Intensity Discharge lamps, light is produced by passing electricity a current through a metal vapor. An arc is established between two electrodes in a gas-filled tube which causes a metallic vapor to produce radiant energy. The wavelength (lighting color) of radiation depends on the energy zone of the disturbed electron and on the type of metal vapor used in the arc tube. These kinds of lamp are suitable to use where high lumens are required or have high ceiling to floor more than 3.5 meters. Examples of these kinds of technology are High Pressure Mercury, Metal Halide, and High Pressure Sodium.



High-intensity discharge (HID) lamp dimming has grown in popularity in recent years. Dimming reduces energy costs by reducing the input power to the lighting system by using Lighting Power Controller (LPC).

Generally the HID dimming technology can provide:

- (1) Reduce power up to approximately 30–40%, depended on HID lamp technology
- (2) Able to control at various dimming level, for example, at rated voltage (100% rated lumens) and lower voltage (lower lumens)
- (3) No sine wave distortion
- (4) No effect to power factor



Testing result of implementing HID Dimming Technology

Case	Power (kW)	Reduced (%)	Lumens Flux (Lux)
Full Lighting Capacity	4.21	-	12
Dimming Step 1	3.71	12 %	10
Dimming Step 2	3.46	18 %	9
Dimming Step 3	3.10	26 %	8
Dimming Step 4	2.96	30 %	7

Investment :::: Rs .130400 .00

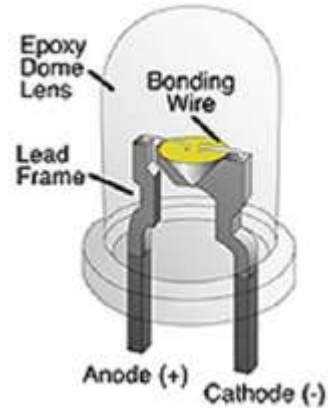
Savings on Energy Cost : Rs .58000.00

Simple payback ::::: 2.24 Years

NO	DETAILS	BEFORE	AFTER	SAVING	% SAVING
1	ENERGY CONSUMPTION KW Hr / Year	70300	50470	19830	28%
2	Energy Cost @ Rs.2.90 per unit) (204000	146000	58000	

2) LED Lamp (Light Emitting Diode)

LED is a type of solid state lighting (SSL) that utilizes light-emitting diodes (LEDs) as a source of illumination



Benefits of LED:

- **High durability** - no filament or tube to break
- **Long durability** - LEDs last more than 35,000 hours
- **Low power consumption** - approximately 2 Watt/lamp
- **Low heat consumption** - very little dissipation heat loss, no effect to room temperature rising
- **Application** - Produced to replace Halogen (Incandescent) lamp

Example of investment return on using LED lamp, replacing Halogen lamp:

Halogen lamp = 50 watt/lamp

LED lamp = 2 watt/lamp

Number = 1 lamp

Lamp using hours = 4,380 hours/year

Energy saving = $((50-2) / 1000) \times 4,380 = 210.24$ kWh/year

Average electricity price = 3.30 Rs /kWh

Energy cost saving = $210.24 \times 3.30 = 694$ Rs /year/lamp

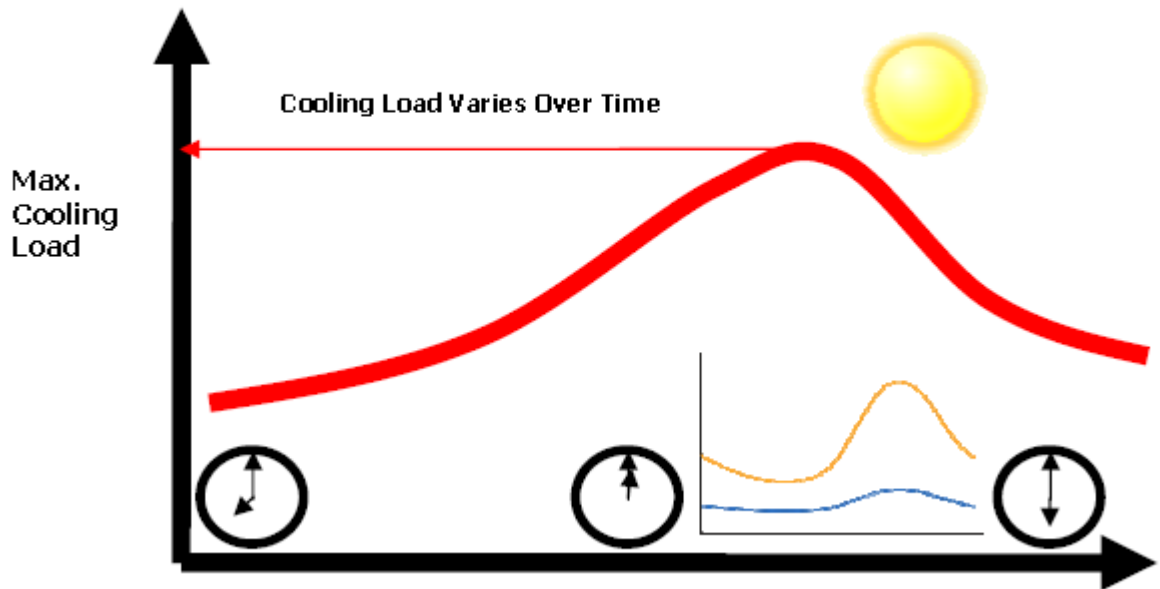
LED price = 250 Rs /lamp

Simple payback period = 0.36 year

Energy Conservation in Air Conditioning system ::::

1) Criteria for chiller selection based on Load Profile of a Building To select appropriate chiller, the chiller efficiency (kW/Ton) is the major concern to evaluate and select from various suppliers.

However, the cooling load required for any building is varied throughout the day due to variation of ambient temperature, solar radiation, number of occupants, and others, therefore the efficiency of chillers at different part loads should be taken into consideration instead of their rated capacity only.



COOLLING LOAD VARIATION – (1 DAY)

The Air Conditioning and Refrigeration Institute (ARI) has developed the definitions to calculate chiller efficiency at part loads, which is referred to ARI Standard 550/590-98 as follows:

- IPLV (Integrated Part Load Value) is a single number; part-load efficiency indicator calculated using the ARI method at standard rating conditions.
- NPLV (Non-Standard Part Load Value) is a single number; part-load efficiency indicator calculated using the ARI method referenced to rating conditions other than ARI standard.

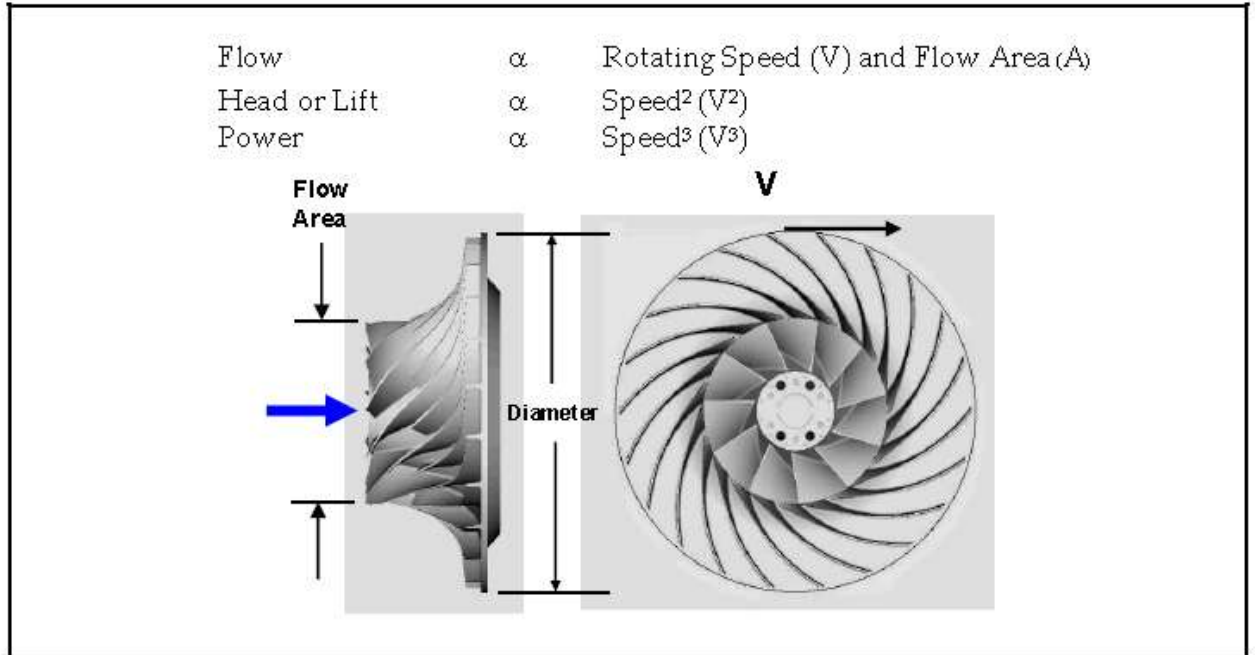
To calculate chiller efficiency at IPLV, the calculation formula is:

$$\text{IPLV} = \frac{1}{\frac{1\%}{A} + \frac{42\%}{B} + \frac{45\%}{C} + \frac{12\%}{D}}$$

Where A, B, C and D is the chiller efficiency (kW/Ton) at 100%, 75%, 50% and 25% Load respectively

2) Implementing Variable Speed Drive with Rotating Machine

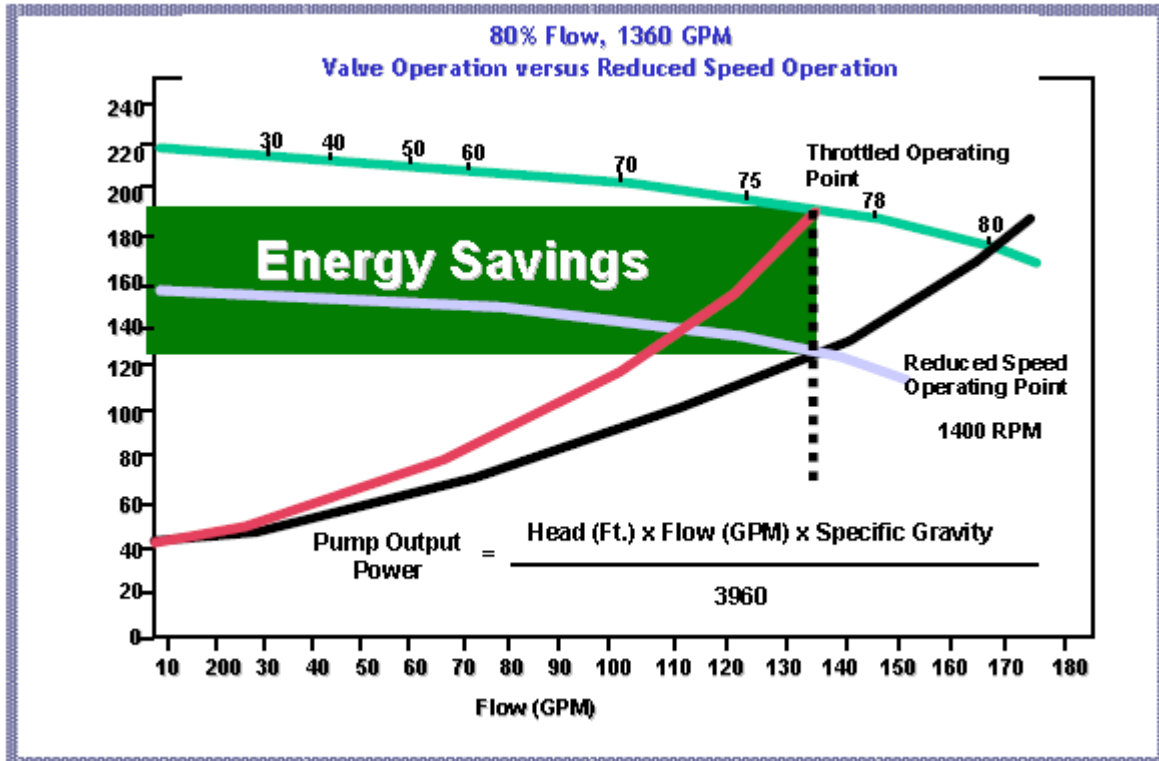
Variable Speed Drive (VSD) is generally applied to improve efficiency of motor equipped with centrifugal machine according to following affinity laws:



VSD takes advantage of the affinity laws which state: As the speed of a centrifugal load decrease, the horsepower requirement will decrease with the power three of the speed. If the flow is 50% of rated capacity, the power consumption shall be 12.5% of rated consumption at full load. Application of using VSD with Air Conditioning System components are:

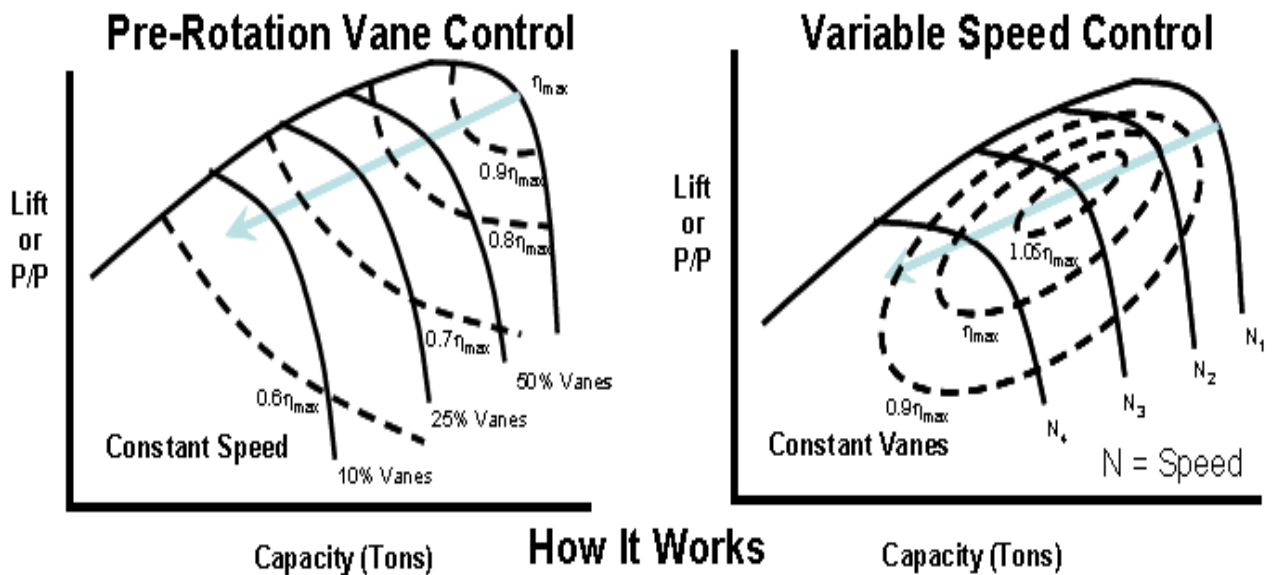
- Rotary chiller, such as, Centrifugal Chiller
- Chilled water & Cooling water system
- Fan at Air Handling Unit: AHU

Energy saving from applying VSD with pump

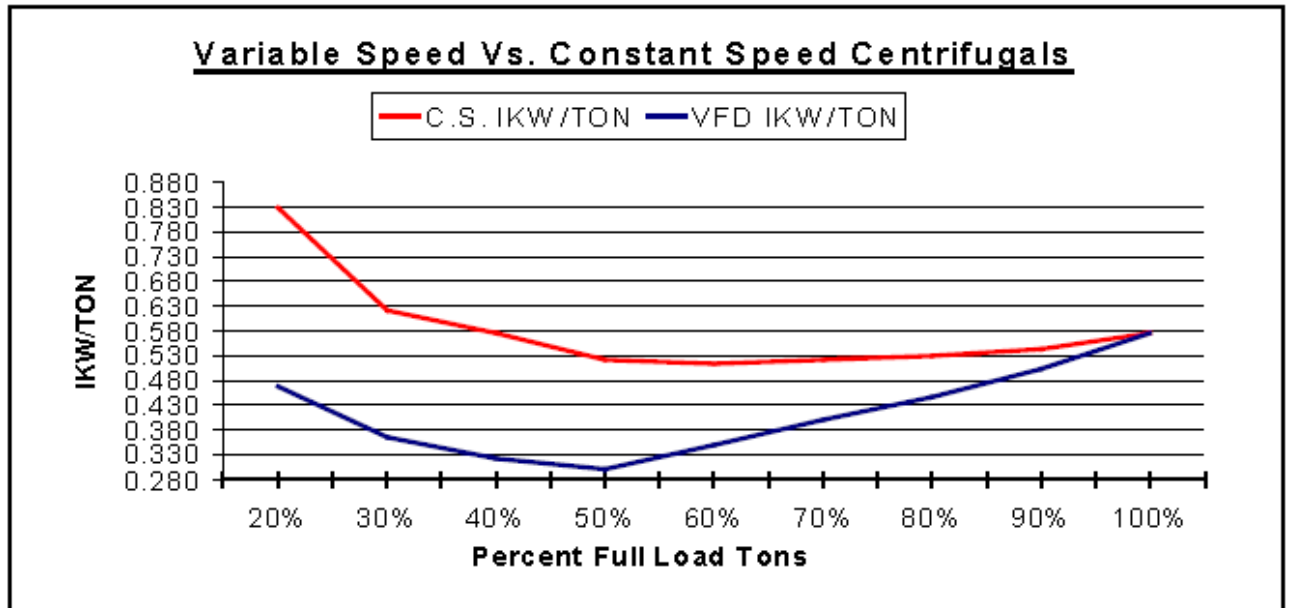


Since a centrifugal chiller is a volumetric device, which inlet guide vane is used to create a flow restriction to reduce capacity, VSD is able to be used to reduce chiller capacity while the chiller is still operating at high efficiency region.

Centrifugal Chiller with Method of Decreasing Capacity



Variable Speed VS Constant Speed Centrifugal Chiller



Suggested Energy Conservation Program :::::

To achieve 10% energy savings target, there are energy conservation plan especially for commercial Buildings which can be aimed in 3 different stages; short-term, medium-term, and long-term; as following:

The following are details suggested for each plan:

Short term Energy Conservation Program (1-2 years):

Training – a series of training courses should be continually organized to build up knowledge and skills of all technicians involved

- **Awareness raising campaign** – public relations activities to create awareness on energy conservation issue, environmental impact from energy consumption, and climate change / global warming for the management and staffs and shop owners / keepers
- **Consultation support** – a subsidizing scheme can be established to encourage shopping malls to engage experts or specialized consultants in planning and executing energy management system and energy conservation program
- **Effective monitoring system** – there should be effective monitoring and control system that Designated Buildings must regularly update their energy database, consistently submit the energy report, including their energy management target and planning on a regular basis

- **Equipments and personal supports** – some of the measurement instruments are very costly and the building owner do not want to purchase, there could be a new service function set up for equipment borrowings, technician assistants with some service fees
- **Information sharing and distribution** –DEDE information center gathers news and useful information and distribute to all concerned shopping malls

Medium term Energy Conservation Program (3 – 5 years):

- **Monetary subsidy for further actions** – the government can encourage private mall owners to take further step by investing in Proven Technology and Emerging Technology of energy conservation with various monetary subsidy programs such as partial investment subsidy, interest rate subsidy
- **Energy efficient building labeling** – set up a Labeling program to indicate different levels of energy efficiency in all shopping malls. By this way, energy efficiency assessment will be done annually and the label itself will help raise awareness of all persons involved regarding the energy usage, CO2 release, and all activities affecting energy - environment conservation
- **Law and regulation update** – law and regulation should be up-to-date for encouraging energy efficient building from the designing step to daily operation
- **Establish ‘Energy Management Network’** – there should be a network of key persons in charge of each shopping malls and related government offices so that effective information flow, knowledge sharing, and other cooperation can be assured

Long-term Energy Conservation Program (5 years onwards):

- **Continue the labeling program and revise necessary standards** to increase energy efficiency□
- **Effective monitoring system** - for Designated Buildings to act according to the energy regulation

Courtesy: www.energymanagertraining.com

About the contributor:

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