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Improvement of System Efficiency and Optimization with Automation and Controls of a selected HVAC System

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Abstract:

Now a days air-conditioning has major energy consumption of commercial buildings. This system consuming almost 55% to 60% of total building energy load. This study presents how we can optimize the HVAC energy consumption of an IT building in Delhi region. The study has shown that in-spite of the cooling load variation, chillers are running continues without any feedback of cooling load ,the analysis shows that variation on AHU's with the use of VFD as per heating load inside the building direct impact on AHU's load and optimize the chiller preformation throughout the year. The analysis also shown that system efficiency improved by 10% to 11 % . It has been shown that building automation system will be helpful to conserve significant energy.

Keywords – HVAC systems, VFD, VSD, Energy Efficiency, Energy Conservation, Building Management System , BACnet

Introduction

It's a well-established fact that Heating, Ventilation & Air-Conditioning (HVAC) consumes about 40 % - 60% of all energy used in a typical building [1-5]. Design of HVAC systems is based on maximum thermal load while there are enough days in a year when the heat load is much less than the designed load. The efficiency of HVAC drops considerably during low thermal loads. The use of variable speed drive (VSD) is a device can reduce the energy consumption between 30–60% by controlling the speed & rotational force of motor for varying thermal load condition [6]. The integration of VSDs in a HVAC can increase efficiency & reduce

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

operating costs of HVAC systems. These drives precisely matching motor speed with cooling demand and reduce significantly power usage [7.8]. Many scientists and researchers have studied on feasibility of VSD in HVAC systems in recent years and investigated energy saving of HVAC system. They found that VSDs can save 20-40% of energy in HVAC systems. Almedia et al. [9] and Thirugnanas et al [9,10] analyzed electricity savings potential with variable speed drives in HVAC components (pumps, fans and compressors). They found that it is a potential solution to optimize heat load and flow. Saidur et al. [11] showed that a substantial amount of energy saving & also emission reduction can be achieved by using VSDs in such systems. Chaudhry and Das {12] analyzed the use of advanced control mechanism along-with smart meters and smart grid and quantified the energy savings for creation of thermal comfort in a building.

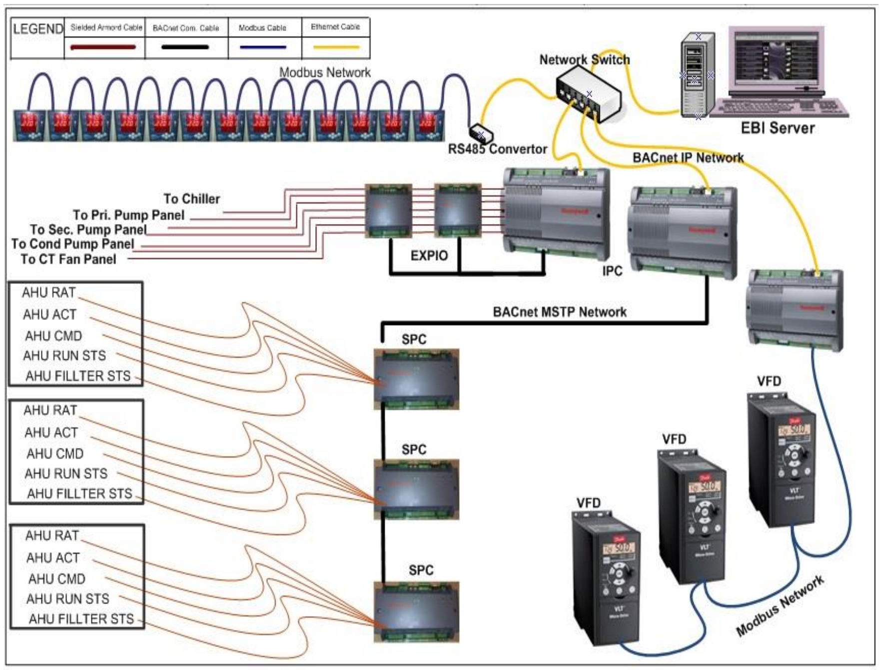
HVAC system has been studied in the composite climate of India. The building is having 921,157 square feet and air conditioned area 240,173 square feet. The objective of the paper is to install variable frequency drive (VFD) on AHU's and to identified the impact on cooling load and energy

Improved AHU System Architecture

System Architecture of Automation System for improvement of existing system in demand and drawn in figure 1.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019



Figuer 1: Improved AHU System Architecture

The HVAC field devices, control functions and software technical details are tabulated in tables 1 -3.

Table 1: Software required to monitor and control the system

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

ITEM	QTY	FUNCTION	FIELD DEVICE
Airconditioning Plant			
Chillers	**3**	Auto / Manual status	
		On / OFF status	
Common Headers	**1**	Chw Sup Header temperature	Immersion Type Temperature sensor
		Chw Ret Header temperature	Immersion Type Temperature sensor
		Cdw Sup Header temperature	Immersion Type Temperature sensor
		Cdw Ret Header temperature	Immersion Type Temperature sensor
Condenser Water Pumps	**3**	Auto / Manual status	Auto Manual Switch
		Pump status	Pot Free Contact from Starter Panel
		Pump start / stop	Pot Free Contact from Starter Panel
Chilled Water Primary Pumps	**3**	Auto / Manual status	Auto Manual Switch
		Pump status	Pot Free Contact from Starter Panel
		Pump start / stop	Pot Free Contact from Starter Panel
Chilled Water Secondary Pumps	**0**	Auto / Manual status	Auto Manual Switch
		Pump status	Pot Free Contact from Starter Panel
		Pump start / stop	Pot Free Contact from Starter Panel
Cooling Towers	**2**	CT Fan auto manual status	Auto Manual Switch
		CT Fan status	Pot Free Contact from Starter Panel
		CT Start / Stop	Pot Free Contact from Starter Panel

Table 2: software required to monitor and control the system

ITEM	QTY	FUNCTION
Software Options		
BACNET	**1**	
Third Party Interface	**Y/N**	**Device / Equipment**
MODBUS	**10**	Energy Meter
	10	VFD
Any Other Interface	**0**	
	21	
		Total Points
No. of Points in the Job		
No.of Physical I/O Points	184	
No.of Third Party Points	200	
Spare Points	77	
Total Points	**461**	

Table 3 : All HVAC control functions and field devices

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

ITEM	QTY	FUNCTION	FIELD DEVICE
		Total I/O For Plant Room	
	2	Total Capacity of Contoller XL8000-IPC (AI-8, DI-6,AO-6 & DO-4)	
Maximum 4 nos EXPIOs can be attached with 1 no IPC	3	Total Capacity of XL8000-EXPIO (I/O Expansion Modules AI-8, DI-6,AO-6 & DO-4)	
		Total Capacity of Contoller with Expansion Modules	
In case of - ve DI spares, spare AI Points can be used as DI points by S/W conversion		Spare I/O Points	
AHU w/ Filter	24	Auto / Manual status	Auto Manual Switch
		Run Status	Pot Free Contact from Starter Panel
		Filter Status	Pot Free Contact from DP Switch
		Fan Start / Stop	Pot Free Contact from Starter Panel
		Return air temperature	R.A. Temperature Sensor
		Chw Control Valve	2 Way Modulating Valve
		Total I/O Points	
Maximum 90 nos SPCs can be attached with 1 no IPC	24	Total Capacity of XL8000-SPC (I/O Expansion Modules AI-3, DI-4,AO-2 & DO-8)	
		Total Capacity of SPC Contoller	
In case of - ve DI spares, spare AI Points can be used as DI points by S/W conversion		Spare I/O Points	
		Total XL8000-IPC Controller	
		Total XL8000-EXPIO Expansion Modules	
		Total XL8000-SPC Controllers	
		Total XL8000-DIO Controllers	

The functions of system arctecture drawn in figure 1 are as given below.

ComfortPoint AP Connects to EBI (Enterprise Building Integrator) via BACnet Point Server Interface.

i) Working principal of Building Management System (BMS)

A standard set of rules that allow two electronic items to connect to and exchange information with one another.

BACnet

BACnet is communications protocol for building automation and control Network.

SPC – small Point controll, IPC – Plant Controll , EXPIO – Expansion IO(input/output) board

ii) Improvemental alaysis after installation of speed control device with BMS

ISSN: 0971-1260
Vol-22-Issue-17-September-2019

Now After Installtion of BMS & After installation of speed control device and taking feedback of cooling load through tempreature sensers kWh Cunsumption for AHUs is shown on table 4 and ploted in figure 2.

Table 4 : Month on month basis before and after automation kWh pattern of AHUs

	Consumption		Saving	
Month	**Before kWh**	**After kWh**	**kWh**	**Saving %**
Jan-17	159451	55412	104039	35%
Feb-17	144020	60384	83636	42%
Mar-17	159451	70863	88587	44%
Apr-17	154308	70647	83660	46%
May-17	159451	76936	82515	48%
Jun-17	154308	83608	70699	54%
Jul-17	159451	89024	70427	56%
Aug-17	159451	103413	56038	65%
Sep-17	154308	86148	68159	56%
Oct-17	159451	81936	77515	51%
Nov-17	154308	69746	84561	45%
Dec-17	164595	67874	96721	41%
Total	**1882557**	**915995**	**966562**	**49%**

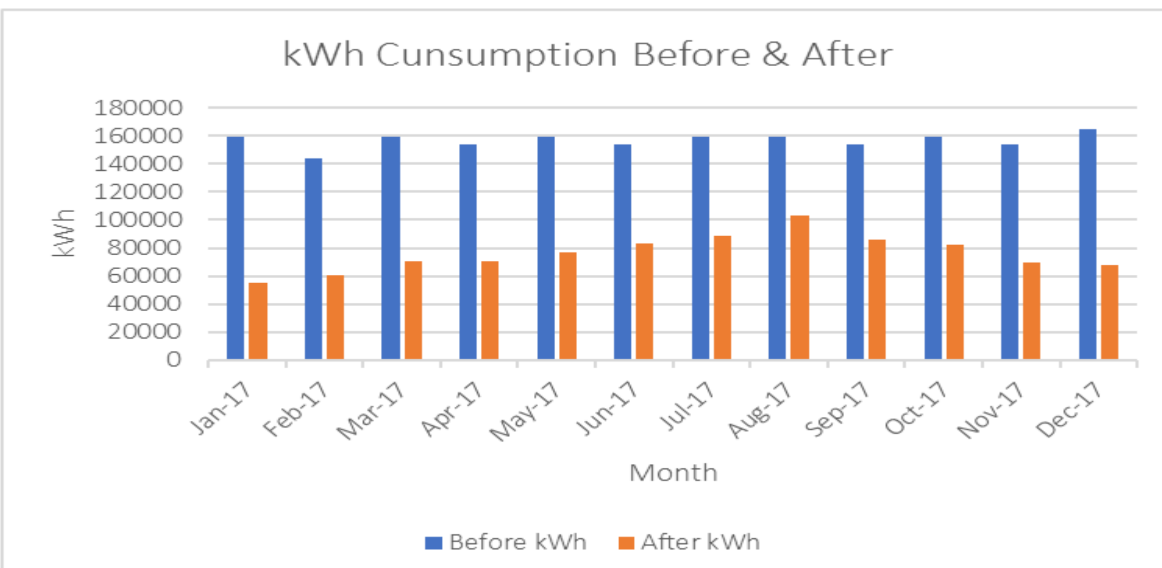


Figure 2: Energy consumption before and after installation of speed control device and feedback system of cooling load at AHUs

After installation of speed control device and feedback of cooling load through tempreature sensers kWh Cunsumption % saving variation from 35% to 65% of total cunsumption of without automation for AHUs as per building load shown figure 3.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

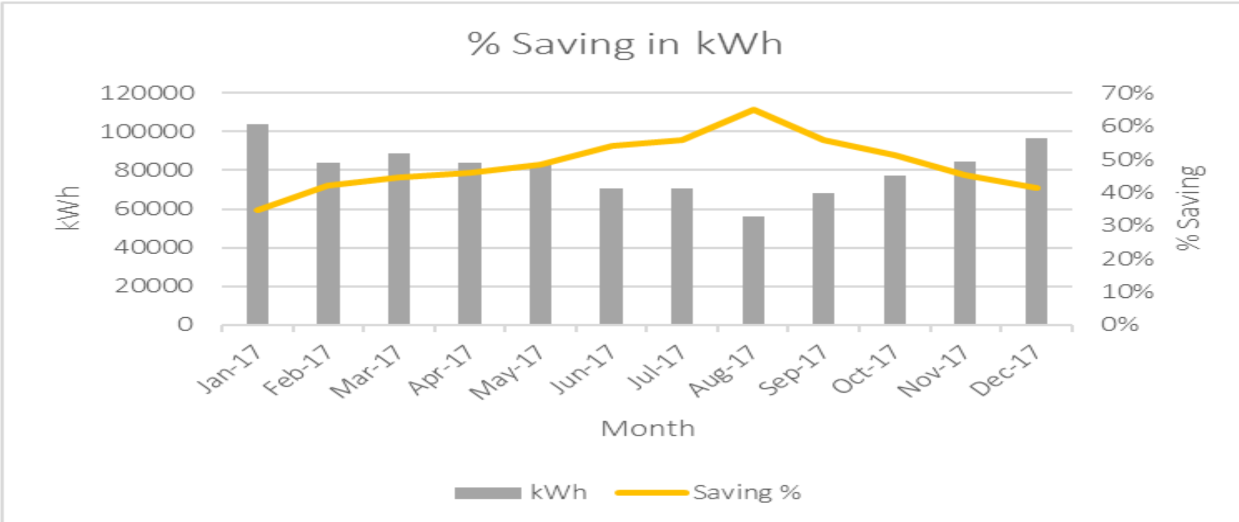


Figure 3: Percentage energy saving after improved architecture

Chiller Consumption Variation after automation on AHUs

iii) Improvement alaysis on chiller after installation of speed control device on AHU's with BMS Control

Now After Installtion of BMS & speed control device and taking feedback of cooling load through tempreature sensers cooling load on AHUs werevary as per requirment this shown on chiller load too is shown on table 5 & ploted in figure 4.

Table 5 : Month on month basis before and after automation kWh pattern of chiller

	Consumption		Saving	
Month	**Before kWh**	**After kWh**	**kWh**	**Saving %**
Jan-17	49240	46248	2992	6%
Feb-17	7180	6462	718	10%
Mar-17	28660	25794	2866	10%
Apr-17	135740	44817	90923	67%
May-17	221300	136300	85000	38%
Jun-17	281430	183946	97484	35%
Jul-17	231680	130828	100852	44%
Aug-17	236280	152406	83874	35%
Sep-17	187495	162202	25293	13%
Oct-17	187365	172280	15085	8%
Nov-17	164210	160462	3748	2%
Dec-17	79330	71397	7933	10%
Total	1809910	1293142	516768	23%

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

After installation of speed control device and feedback of cooling load through tempreature sensers kWh Cunsumption for AHUs impact on chiller is shown on figure 4.

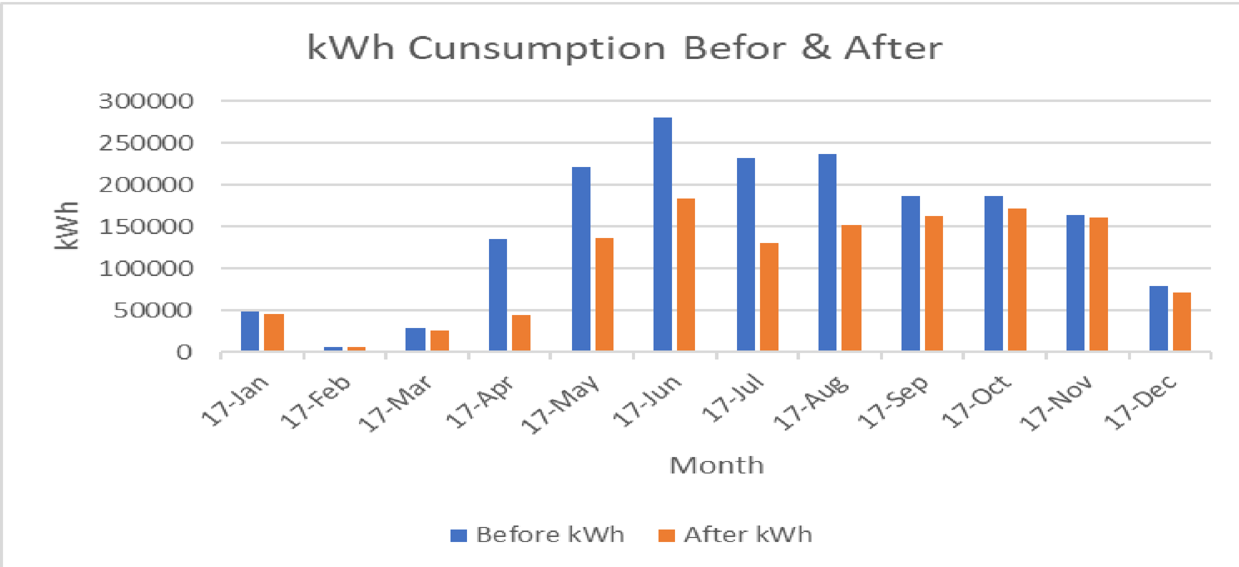


Figure 4: Energy consumption pattern before & after improved system architecture

Energy saving chiller system varies from 6% to 65% due to heat load changes inside the building shown in figure 5.

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

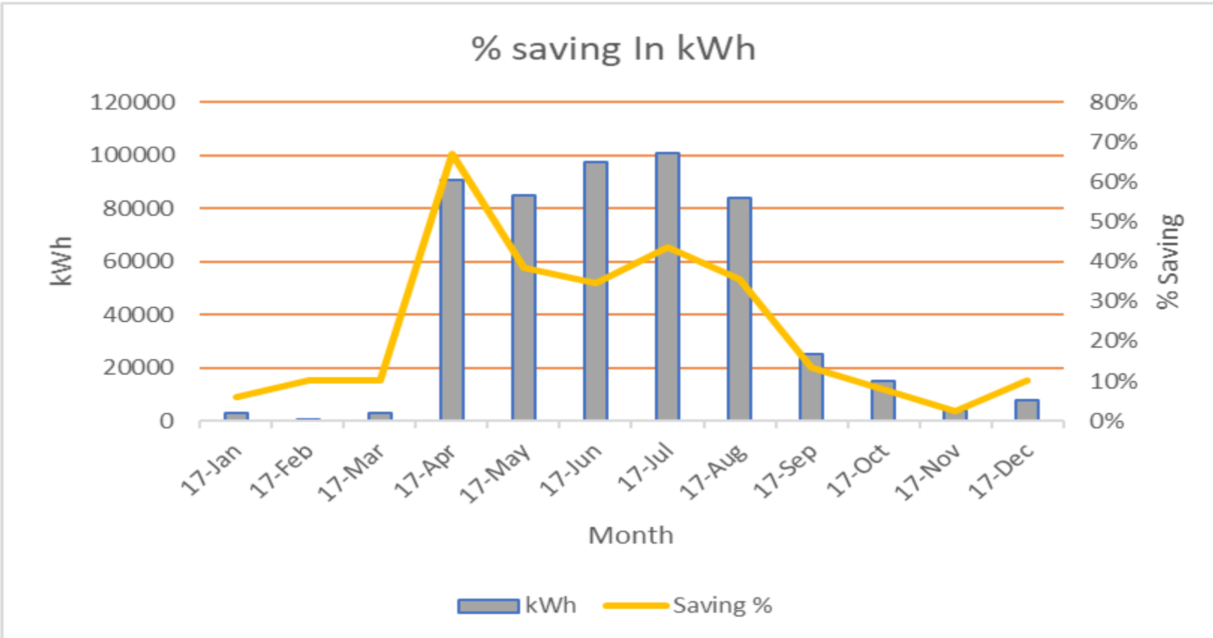


Figure 5: Energy saving pattern in chiller before and after improved architecture

Conclusion

After Installation of BMS & VFD's on AHU's energy consumption go down by 35 % to 65 % at the same time chiller consumption also go down by 6% to 67% and because of demand variation overall system efficiency improved by 11% shown in table 6 and figure 6.

Table 6: Overall system saving % 11% shown in table

AHU % saving	49%
Chiller saving %	23%
Over all System % saving	11%

ISSN: 0971-1260

Vol-22-Issue-17-September-2019

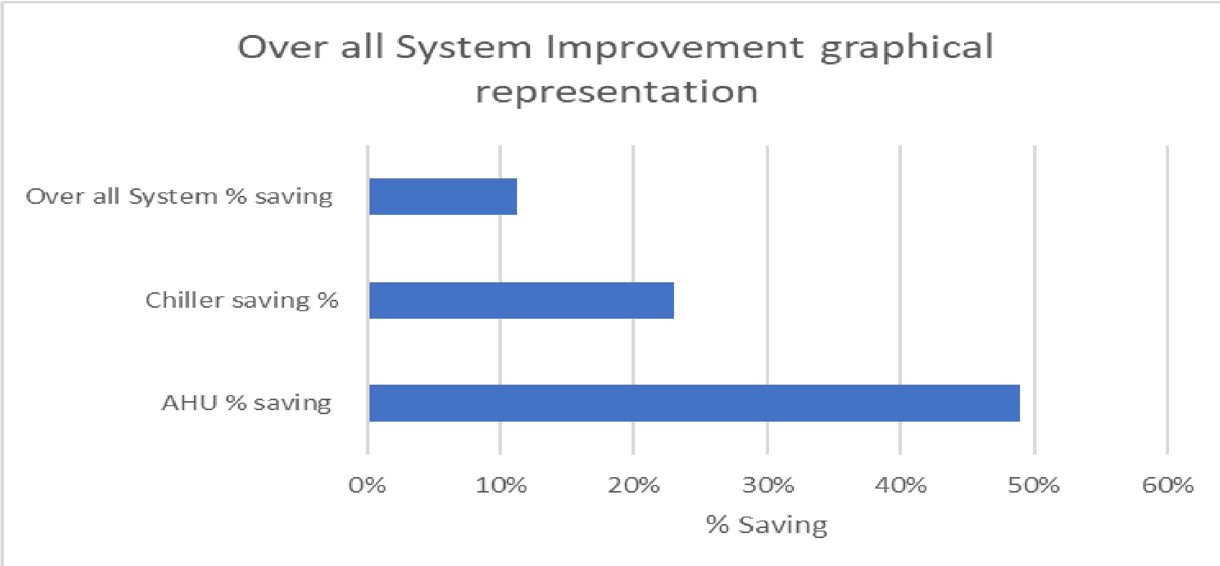


Figure 6: Overall system improvement

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