OFFICE AREA AIR CONDITIONING OPTIMIZATION USING VARIABLE REFRIGERANT VOLUME SYSTEM

Geraldo Peña Guzmán
Engineering Management Graduate Program

Professor: Héctor J. Cruzado, PhD, PE
Civil and Environmental Engineering Dept.
Polytechnic University of Puerto Rico

ABSTRACT

An office area located in a food industry manufacturing plant of Puerto Rico was analyzed, and a variable refrigerant volume air conditioning system (VRV) was proposed. Calculations showed an expected energy consumption reduction of around 45%, while optimizing the cooling system in general. Temperature and humidity levels could be better controlled, providing better comfort at each space. Also, the VRV proposed design can individually operate the areas, allowing turning on and off smaller equipments while providing more operation flexibility to the site and users.

INTRODUCTION

Air conditioning systems in general are a need in most commercial buildings. These account for a considerable proportion of total energy consumption in a building; typically it ranges from around 50% to 75% of total energy use. Nowadays, inverter types of systems are a rule of thumb in terms of energy efficiency.

The staff of a food industry manufacturing plant indicated that they are spending a lot of money in electricity. Because of this reason, several target projects were proposed in order to gradually reduce their electricity consumption. The air conditioning system of the office area of this plant was selected as one of the target projects.

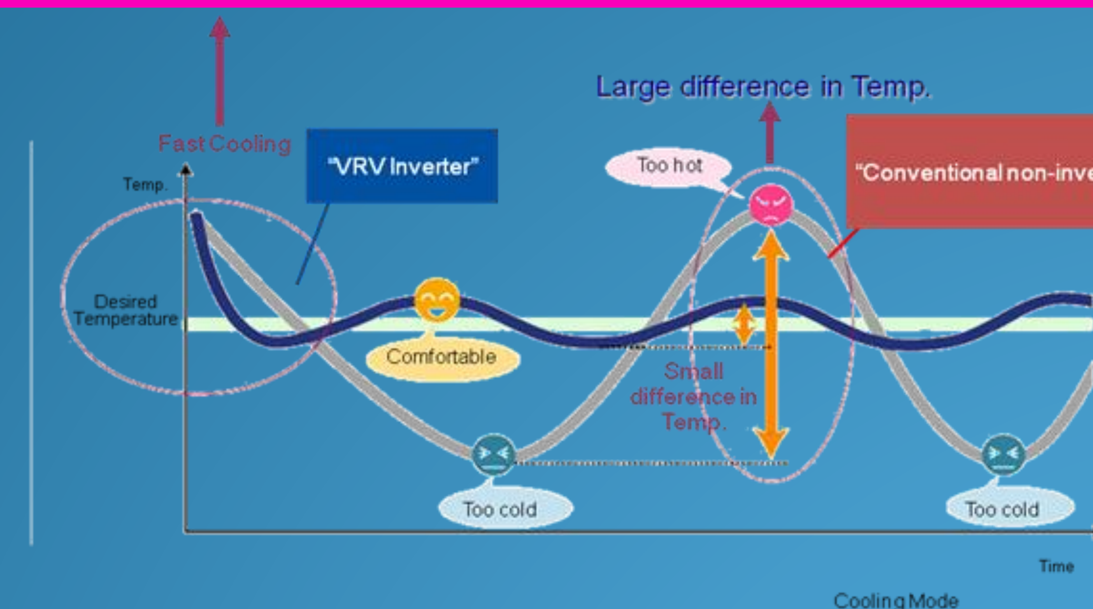
The main system consists of a water cooled chiller, three 20-tons air handlers, one 30-tons air handler, two pumps and a cooling tower. The secondary system consists of three separate direct expansion splits. These two were treated as one "global" system. The main electricity consumption corresponds to the chiller; however, the other equipments also request a lot of energy to operate.

MAIN OBJECTIVE

Optimization of the A/C system of the office area while introducing the energy saving concept as the main parameter.

VRV SYSTEM

When analyzing different possible systems to recommend, the Variable Refrigerant Volume (VRV) was the best option. VRV is a split system where one or many units (typically up to 64) can be connected to a single circuit. It has an inverter compressor that operates as a variable frequency drive. It varies its frequency, which it's also proportional to the velocity of the compressor. With electronic expansion valves on each of the indoor units and the velocity of the compressor being varied, the refrigerant can also be varied. By first analyzing the cooling demand on each of the areas, and varying the refrigerant as required, this system provides better energy savings and performance in general.



METHODOLOGY

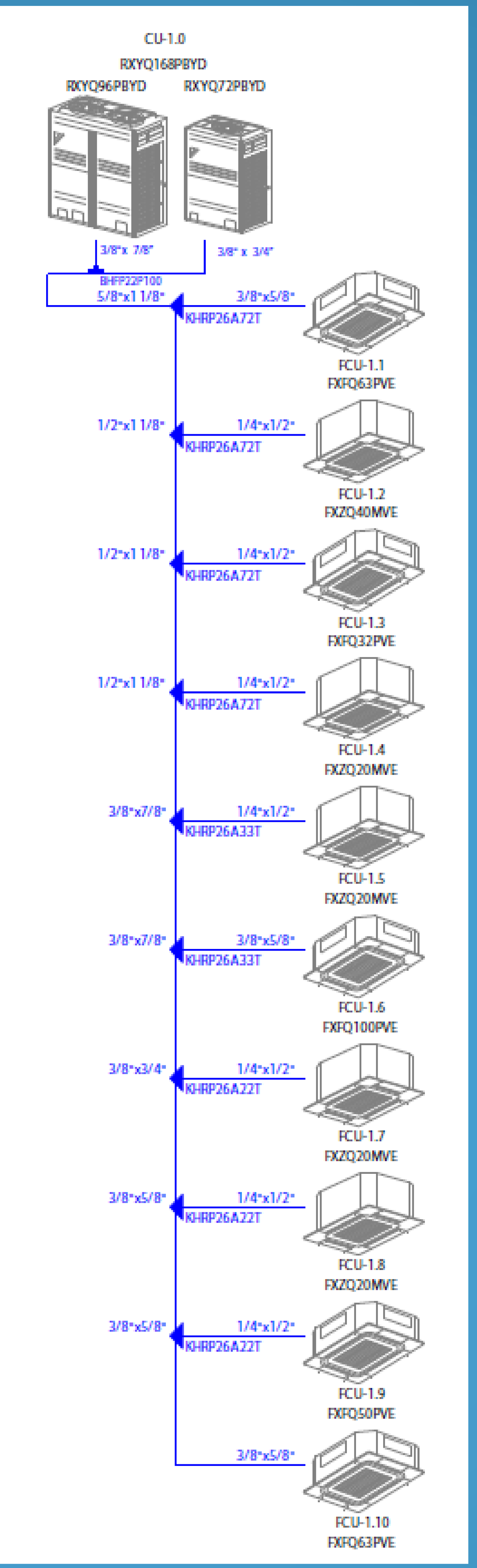
Mechanical and electrical conditions analysis for the present air conditioning system was made. Electrical consumption was measured with ammeters. No data logging device was available, so current measure was made and single and three phase power calculations were completed. It is important to mention that measuring the amperage is a good technique, but it lacks exactitude. With data logging systems, energy consumption calculations will be more precise because it takes more parameters into consideration; such as peak currents, compressor off time and exact hours of operation.

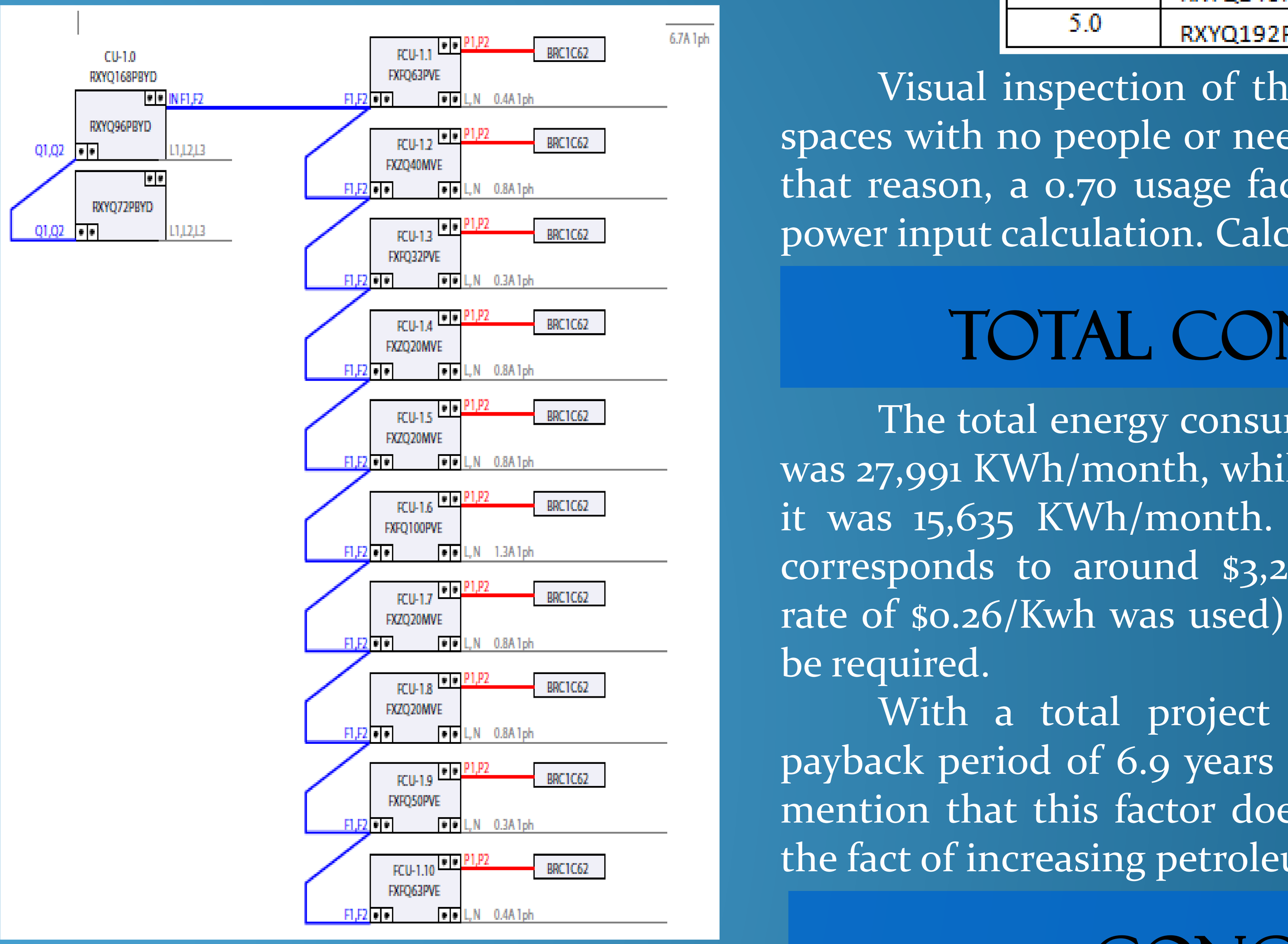
After consumption was established, design recommendations were made, and final design established. A simple economic analysis was required in order to establish the viability of the project; main pro parameter being energy saving and main con parameter being initial cost.

SYSTEM DESCRIPTION

The new design consists of 94.85 tons. Big main ducts were not considered. New system is designed with individual cassettes and smaller duct type evaporators. These types of indoor units provide the user with more flexibility in terms of temperature, air distribution and on-or-off capability per area.

Present ductwork: and common return air at the air handlers room:





ANALYSIS & CALCULATIONS

Actual equipments power input:

Type	Current (A)	Voltage (V)	Phases	Input (KW)
Chiller	50.0	480	3	41.57
Chiller Pump	23.5	480	3	19.54
Cooling Tower Pump	25.4	480	3	21.13
Cooling Tower Fan	14.9	480	3	12.39
AHU #1	12.0	208	3	4.32
AHU #2	10.5	208	3	3.78
AHU #3	11.0	208	3	3.96
AHU #4	16.0	208	3	5.76
Conference Room CU	31.4	208	1	6.53
RD 17 Conf. Room AHU	5.4	208	1	1.12
Office 1 CU	18.1	208	1	3.76
Office 1 AHU	2.0	208	1	0.42
Office 2 CU	12.6	208	1	2.62
			Total	127.23

Proposed equipments power input was calculated by using their rated IEER value (IEER is a useful tool and it is a parameter certified by AHRI Standard 1230):

CU	Model	IEER (Btu/Wh)	Cap. (Btu/hr)	Input (KW)
1.0	RXYQ168PBYD	19.00	168,000	8.8
2.0	RXYQ240PBYD	16.00	240,000	15.0
3.0	RXYQ240PBYD	16.00	240,000	15.0
4.0	RXYQ240PBYD	16.00	240,000	15.0
5.0	RXYQ192PBYD	17.75	192,000	10.8

Visual inspection of the office was made and several spaces with no people or need of cooling were noticed. For that reason, a 0.70 usage factor was used for indoor units power input calculation. Calculated value was 4.459 KW.

TOTAL CONSUMPTION

The total energy consumption for present equipment was 27,991 KWh/month, while for the proposed equipment it was 15,635 KWh/month. This consumption reduction corresponds to around $3,200 monthly savings (average rate of $0.26/Kwh was used). Around 45% less energy will be required.

With a total project cost of around $265,000, a payback period of 6.9 years is expected. It is important to mention that this factor does not take into consideration the fact of increasing petroleum cost.

CONCLUSION

Calculations showed a considerable amount of savings that can be achieved with the VRV system. Not only the monetary savings need to be considered here, mechanical and electrical conditions of the chiller system also showed that A/C system must be replaced or modified soon. If more energy efficient technologies are present today, residential, commercial and industrial sites must consider these options. Home owners, tenants and companies in general can save important amounts of money if they implement these inverter systems.

They will be also helping the environment, while reducing air pollutants. Carbon dioxide, nitrogen oxide, ozone, nitrogen dioxide and hydrocarbons are just some of them .

With around 45% less energy used in the A/C proportion of this office building, it is technically recommended to proceed with the project. However, financially speaking, total payback of 6.9 years is not an attractive number to proceed with the project; manufacturing plants typically seek a period of less than 2.5 years. Payback period is also high mainly because of installation cost. Since this is an area in operation, installation is complicated and more costly.

Just one mechanical contractor and one manufacturer were used for design, quoting and payback calculation. Main recommendation will be to analyze the possibility of using another contractor and another equipment manufacturer. Costs could be again established and payback period compared.