

# ENERGY EFFICIENT SYSTEMS IN STATIONS OF DELHI METRO

Delhi Metro Rail Corporation is the biggest consumer of electricity in the state of Delhi. Its traction system is completely electricity driven. In addition to traction, electricity is required for signalling, communication, Air-conditioning and lighting etc. In the underground section of metro which covers 10 stations in line 2 spreading from Vishva vidyalaya to Central Secretariat and 3 stations in line 3 from Rajiv Chowk the Mandi House, Air-conditioning and lighting are approximately 50% of the total electricity consumption. The efforts of energy saving other than rolling stock, telecommunication and signalling system is discussed in this paper.

## **1. ENERGY EFFICIENT AIR-CONDITIONING SYSTEM IN UNDERGROUND STATIONS**

### **⌘ Ventilation and Air-Conditioning**

- ◆ After considering the various factors following ambient conditions were assumed:

Summer            43 degree C (DBT)                    28 degree C (WBT)

Monsoon           35 degree C (DBT)                    29 degree C (WBT)

The above temperatures are selected on the basis of available metrological data which reveals that 1% design conditions for summer are 43 degree C (DBT) and 28.1 degree C (WBT). This implying that these temperatures are exceeded only 1% of time in three months of summer i.e. April, May and June. With similar considerations Monsoon temperatures with 1% design conditions are 35 degree C (DBT) and 29 degree C (WBT).

- ◆ The energy efficiency aspects have been taken care of while designing the environment control system of Delhi Metro Rail Corporation. Following design criteria has been adopted in the stations:

Design Temperature :            29 degree centigrade.

RH                                    :            65%

The designing of ECS system is done in such a way that it not only provide reasonable degree of comfort to the commuters but a lot of energy saving as well.

### **⌘ Consideration of sub soil temperature**

Another reason which has contributed to the selection of above mentioned design temperature is sub soil temperature. In case of difference in temperature between conditioned air and sub soil heat transfer shall take place. The greater the differential between tunnel air temperature (Which varies) and sub soil temperature (Which has stabilized) the greater the flow of heat will occur, thus reducing the required cooling effect of ventilation air during the summer.

Sub soil temperature measurement for a full year at three different depth through probes are obtained and the results indicate the temperature to be around 29 degree C.

⌘ **Consideration of Thermal Shock**

Inside temperature of the metro trains are kept at the level of 25 degree C. On the other hand outside temperature reaches to 45 degree centigrade. Such a sudden change may cause thermal shock to the commuters. To avoid such conditions, the various areas of stations are divided into various temperature zones. Different temperatures are maintained platform, concourse and surface levels. This consideration not only gives hygienic conditions to commuters but also saves energy.

⌘ **Winter air-conditioning**

In winter instead of heating, free cooling has been restores to. The heat released by various equipments will be adequate to maintain acceptable conditions inside the subway.

Hence there is considerable energy saving on VAC system during the winter season.

⌘ **Selection of Energy Efficient VAC Equipments**

Air conditioning equipment includes cooling sources, air handling and air cooling apparatus, filters and an air distribution system i.e. Chillers, Air handling Units, Cooling tower, pumps and Duct work. In Delhi Metro, these equipments have been selected on the various factors such as efficiency, energy consumption, space requirement, noise levels and maintenance cost etc.

The specific power consumption (KW/TR) of various type of compressors is as given below:

	Reciprocating	Centrifugal	Screw
Sp. power consumption (KW/TR)	0.7 – 0.9	0.63	0.65

- ◆ Among them Screw type Chillers has been considered best due to their excellent performance in part load operation. The AC plants, like most of the other electrical equipments operates between 50% to 75% of its capacity most of the time. Hence screw type compressors were selected by DMRC for its VAC requirements.
- ◆ Water based Cooling Tower has been selected instead of Air cooled Cooling Tower since Water based Cooling Tower consume 0.73 kwh/tonne, Air cooled Cooling Tower consume 1.1 kwh/tonne.

### **Quantification of Energy Saved:**

- ◆ Each underground station has been provided with air conditioning of 639 tonnes capacity. Total capacity at 10 stations (Line-2) is 10395 tonnes of Air conditioning. The estimated energy consumption for 16 hours working cycle/day for 10395 tonnes air conditioning load is 4,00,00,000 kwh/annum. If reciprocating chillers with air cooling tower selected the estimated energy consumption would have been 5,00,00,000 kwh/annum. Thus the choice of energy efficient equipment has been resulted in estimated savings of 25% kwh p.a.

### **⌘ Operating Strategies**

Judicious mix of demand and effective control & monitoring of the chillers results in optimal utilization of the designed capacities.

#### **Following operating strategies have been adopted in DMRC:**

- ◆ The air conditioning of the underground stations is controlled through Building Management System having the features of running the system in automatic logic control, open/closed loop, Enthalpy and Timetable control to ensure the air-conditioning system is optimally utilized.
- ◆ The air conditioning system of stations is kept off during the non-summer period.
- ◆ Starting / closing timings of the chillers are reviewed regularly according to temperature and peak traffic hours.
- ◆ In the morning hours the Air-conditioning systems of the stations are started in open mode to drive out the stale air and take in the low temperature air from the atmosphere and run in Closed mode to re-circulate the air with 10% fresh air.
- ◆ The chillers are run on auto logic mode depending upon the enthalpy of load and time table control through BMS.
- ◆ More number of chillers are run to cater the load (more energy efficient mode) rather than running the less numbers of chillers at full load.

#### **Following guide lines worth mention here to operate AC plant at best of its efficiency.**

- ◆ Best heat transfer in condenser tubes of chiller system can be achieved by keeping scale formation at lowest level. By operating water softening plant efficiently the scale formation can be minimized and plant efficiency can be maximized.
- ◆ In general designed chilled water temperature drop across the chiller is 5 deg C. If it is less, attention is required.

- ◆ With 1 deg C rise in evaporator temperature in refrigerating system there is 3% increase in power consumption.
- ◆ With 0.55 deg C reduction in temperature of water returning from cooling tower compressor power reduction is 3%.
- ◆ 0.8mm scale build up on condenser tubes can increase energy consumption by 35%. Therefore the most critical items to be considered during operation of AC plant is water quality.

## **2. ENERGY EFFICIENT AUXILIARY SYSTEM AT STATIONS**

Though, the air conditioning in any system consumes the major part of Electricity, the other auxiliary measures cannot be neglected. Delhi Metro has considered various aspects during the designing of auxiliary system at stations. Such as selection of various equipments like lifts, Escalators, energy efficient lighting sources with automatic timers. While constructing the building provision of natural light with minimum heat trapping inside the station to maintain the lux level as well as the temperature inside the air-conditioned building.

**Energy conservation measures to save energy in lighting of the stations:**

### **⌘ Selection of Equipments**

- ◆ No incandescent lamps are used any where in Delhi Metro. Instead, around 17000 T-8, 80-NG tube lights with 93 Lumen/w efficacy & CFL's been provided in underground stations and around 53000, T-8 tube lights with 67 lumen/w efficacy have been provided on Elevated stations.
- ◆ CFLs are 13 % more efficient due to electronic ballast.
- ◆ Apart of this Electronic ballast have been provided, which saves 6w energy/tube.
- ◆ DMRC used the Variable Voltage Variable Frequency (VVVF) control drive system in Lifts & Escalators, which matches the power requirements with actual load.
- ◆ The Escalators have been provided with idling speed of 0.2m/sec against the normal operating speed of 0.5m/sec or 0.65m/sec. This has resulted in estimated energy saving of 1%.

### **⌘ Designing considerations**

- ◆ Provision of sky lights at Kashmiri Gate, Rajeev Chowk, Barakhamba stations etc.
- ◆ 25% lights are provided in each of the 4 circuits in underground stations, making it easy to put off every 4<sup>th</sup> light.

- ◆ Dimming circuits on Barakhamba - Dawarka line has been provided in platform lighting of Elevated stations.

⌘ **Operating Strategies to save energy in lighting of the stations**

- ◆ All lights near entrances are well controlled with either the digital timer or through the natural light intensity. Especially the parking lights are automatically controlled by natural light intensity.
- ◆ Regular cleaning of lights.

**3. FURTHER IMPROVEMENTS PLANS**

⌘ **Tunnel light in underground section**

Initially, tunnel lights were kept ON during revenue as well as non-revenue hours. This lighting circuit was also associated with other equipments. A separate wiring has been done for these equipments. Now tunnel lights are kept OFF during revenue hours.

⌘ **Recent developments to save energy in lighting of the stations**

◆ **Implementation of SUN FILM**

Sun films have been provided recently at Rajeev Chowk dome area. This has reduced solar heat gain on ECS system.

◆ **Implementation of UVC Emitters**

- Energy Efficient UV-C emitters are being implemented in Delhi Metro on experimental basis. UV-C Emitters are placed inside the AHUs of Rajeev Chowk ECS system to reduce algae growth on cooling coils which enables better heat transfer between chilled water and circulating air.
- It works on the principle of the Ultra violet energy generated in the 260 nanometer frequency, curbs the growth of all types of bacteria, mould and even the tiniest viruses, which are far too small to be captured by regular air filters. By altering the DNA structure of these micro-organisms, the UV-C Emitters ensure the breath clean and sterile air at all times. Apart of it, also provides better system working and low electricity bills.

**Benefits of UV-C Emitters**

- Continuously cleans coils, drain pans, plenums and ducts, reducing or eliminating costly cleaning programs.
- Lowers the HVAC energy cost by improving heat transfer and increase net cooling capacity.

- Produces no Ozone or secondary contaminants, and thus ensure that building occupants, equipments and furnishing are not affected.
- Kills or inactivates surface and airborne micro-organisms that trigger ailments and also eliminates associated odors.
- Prevents spread of infectious disease caused by bacteria. Hence provides Hygienic atmosphere for commuters.

◆ **Use of Solar Energy**

At PTCK & KB Metro Stations solar energy has been used to light the auxiliary station lights as well as the parking lights

◆ **Energy Saving by Using T-5 Tubes**

Recently, on experiment basis DMRC is going to replace all existing 36Watt tube light with 24 Watt T-5 tube lights at one station. This work shall be done on ESCO model. The firm shall supply and install the energy efficient tube lights. Payment shall be made from saving achieved in this process.

**Features of T-5 Energy Efficient Tube light System**

- It gives up to 50% energy saving compared to a normal 40W lamp with electromagnetic ballast.
- Improves power factor to better than 0.9, resulting in reduction in maximum demand.
- Gives much higher rated lamp life of 18000 Burning Hours (BH) and a much higher average rated ballast life of 5000 BH.
- Gives higher Color Rendering Index (CRI) of 85, closest to natural light.
- Gives better color distinction and much better visual comfort.
- Reduction in heat load on air-conditioning.

**4. CREATING AWARENESS AMONG STAFF**

It is well known fact that no target can be achieved unless it is whole heartedly supported by staff. Organizing seminars with employees participation, distributing leaf lets, rewards for good work are the tools to achieve targets in real sense.

**Following activities were carried out:**

- O&M department has organized a seminar on Energy conservation at training school Shastri Park train depot on 14.12.07.

- Officers & staff both presented their papers. They have discovered many unexploited fields where energy savings can be achieved just by simple but effective methods.
- O&M has also invited PCRA (Petroleum Conservation and Research Association) to organize quiz programme drawing competition at DMRC's residential colonies at Shastri Park and Najafgarh.

## **5. FURTHER SCOPE IN ENERGY SAVINGS**

- ◆ Extensive use of solar lights for external lighting, parking lights of metro stations.
- ◆ Use of LED based light source which have highest efficacy among all the known light sources.
- ◆ Carrying out energy audit to explore the fields where further savings can be done.
- ◆ In future phases of DMRC, to provide best quality of water to AC plants, RO system is being installed. Also it is planned to phase out water softening of existing system with RO based water purification technology for better results and energy efficiency.

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