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Energy conservation in airconditioning

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ENERGY CONSERVATION IN AIRCONDITIONING

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The human being has always desired to protect himself from extreme cold and hot climates which depended largely on the part of the world he inhabitated or on the time of the year. He has therefore always tried to create comfort condition around him, according to the resources available, by moving from the flat land to caves, or designing insulation through tents or mud houses.

As the life progressed new developments were adopted. From spraying water on the ground, wet mats evolved and these were subsequently hung in front of open doors and windows to achieve a crude form of evaporative air cooling.

Effective heating, ventilating and air conditioning (HVAC) started only about a century ago, the central heating in winter and mechanical refrigeration for summer cooling began to be common only in the last 50 years or so.

At the time of partition of the Indian subcontinent air conditioning as we know today was very rarely used but with the passage of time more wide application was witnessed. Even in houses, air conditioning started replacing ceiling fans very quickly, but the use of air conditioners on mass scale mainly introduced in houses by Pakistanis working abroad bringing air conditioners from the Middle East. This accelerated both the commercial import and the local assembly of window type air conditioners. Local assembly is estimated at the rate of about 20,000 per year. Adding to these the units imported over the past 10 years, we can safely assume that over 2,00,000 window units are working on the WAPDA system.

From Table-1 it can be noticed that for an energy input of about 2.4 KW of a 1-1/2 ton unit, the total electrical consumption in one month will be of the order of 115 million kWh. The assumption for this huge electricity consumption is an average working of only 8 hours per day. The total energy bill for the full season of 6 months, therefore, will be about 1/2 a billion rupees calculated @ Rs. 0.70 per kWh average on the Tariff A-1 for domestic consumers.

TABLE —1

ENERGY CONSUMPTION OF AIRCONDITIONING UNIT

One window unit capacity	1.5 Tons
One Window unit input	2.4 KW
Monthly running period @ 8 hrs/day	240 Hours
Monthly energy consumption 2.4 x 240	576 kWh
Monthly energy consumption for 200,000 units @ 576 kWh	115 Million kWh
Monthly energy bill @ Rs. 0.70/kWh	Rs. 80.6 Million
6 Months seasonal energy consumption	690 million kWh or Rs. 0.48 billion

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Result : About 700 million kWh of electrical energy is consumed for six months of cooling only through window type airconditioners.

With the advent of high rise buildings the new capital, and development of trade and finance institutions, central airconditioning was also very rapidly adopted. Since the early sixties and now in the eighties no new buildings is conceived without central airconditioning. For the large consumption of energy associated with such buildings, the Architect can play an important role in lowering the energy inputs for which methods are now available which must be considered by the designers at the very outset. This measures can also be evolved in retrofits for existing buildings, and overall energy consumption can be considerably reduced.

To assess the energy consumption in a building to be airconditioned, let us analyses the factors involved. The airconditioning system actually is a function of the heat transfer, and the three aspects to be considered for heat transfer into the building or vice-versa, are:

a. Surface Area — A Sq. Ft.
b. Thermal Conductivity — U BTU/Hr/Sft/F^{O}
c. Temperature difference — Δ T F^{O}

The quantity of heat is an inter-relation of these three aspects and can be expressed by the simple equation:

$$Q = A \times U \times \Delta T.$$

The decrease in any of these factors ruduces the rate of heat transfer. The objective is to reduce Q for a given building and this can be accomplished by making A, or U or Δ T as small as possible. The area for heat transfer can be reduced by minimizing the peripheral surface area. The only building discussed in the Holy "Quran" is the KHANA-E-KABA which has a square shape and I believe that this reference is a clear directive for economical and efficient buildings. Let us analyse and compare two buildings to be airconditioned, one square and the other rectangular, both having an equal covered area of say 10,000 Sq. Ft. The square building is of 100 ft. x 100 ft with a perimeter of external walls of 400 Rft. The rectangular building is of 200 ft x 50 ft and a perimeter of 500 Rft. It will be noticed from the following comparison that the heat load of the square building is about 18.5% lesser than that of the rectangular building of the same area as indicated in Table-II.

TABLE – II
SUMMER COOLING LOAD COMPARISON

S.No.	DESCRIPTION	SQUARE BUILDING (A) BTU/HR	RECTANGULAR BUILDING (B) BTU/HR
1.	Solar Heat Gain By Conduction		
	West Wall	132126	264252
	South Wall	132126	66063
	East Wall	177327	354654
	North Wall	125172	62586
	Roof	183600	183600
	Glass	120000	150000
2.	Solar Heat Gain by Radiation Through Glass	108455	191100
3.	Electrical load & Lighting Load	68200	68200
4.	Occupant Sensible Heat	23000	23000
5.	Occupant Latent Heat	12000	12000
6.	Ventilation air load	192375	192375
	Ventilation sensible load	9180	9180
	Ventilation latent load	10880	10880
		1294441	1587890
7.	Safety Factor @ 10%	129444	158789
8.	Total load (BTU/HR)	1423885	1746679

Result : The air conditioning capacity in square building is 18.5% less than in rectangular building.

Thermal conductivity (U) is the inverse of the thermal resistant between the inside and outside surfaces of the building structure e.g. walls, roof etc. In order to reduce U, many techniques are available which should be adopted by the Architect by detailing the insulation of the building structure, which would be high heat resistant building materials i.e. insulation in order to achieve lower thermal conductivity. Let us analyse two buildings, both having 9" thick walls, one with insulation and the other without insulation. It is assumed that both walls have a 1/2" inch plaster on the internal and external surfaces.

Similarly let us also analyse the building roof with normal brick tiles, over mud & plaster, and RCC slab - one with insulation and the other uninsulated. By assigning the standard thermal resistance values, it will be noticed in Table-III that the transmission coefficient of insulated roof is 50% lower than the un-insulated structure.

TABLE — III

COMPARISON OF THERMAL COEFFICIENT (U)

STRUCTURAL MEMBER	CONSTRUCTION	THERMAL RESISTANCE (Rt) WITHOUT INSULATION	WITH INSULATION
WALL	1. Outside Surface	0.25	0.25
	2. External Plaster 1/2"	0.10	0.10
	3. Brick 9"	1.80	1.80
	4. Insulation 1"	—	3.57
	5. Internal Plaster 1/2"	0.10	0.10
	6. Inside Surface	0.68	0.68
	TOTAL RESISTANCE Rt.	2.93	6.50
	U = 1/Rt.	0.34	0.15
ROOF	1. Outside Surface	0.25	0.25
	2. Brick tile 1—1/2"	0.3	0.3
	3. Insulation 1"	—	3.57
	4. Mud & Plaster 3"	1.27	1.27
	5. RCC Slab 6"	0.91	0.91
	6. Inside Surface	0.92	0.92
	TOTAL RESISTANCE Rt.	3.65	7.22
	U = 1/Rt	0.274	0.138

Result : The transmission coefficient of un-insulated walls is 56% less and roof is 50% less than insulated structures, i.e. 10. 12% saving in plant size.

The outside and inside temperature difference ΔT is to be selected by the designer, being the range between the ambient temperature existing outside and the comfort temperature desired inside . Keeping in view the local conditions, the initial capital outlay and the energy crisis, some degree of compromise should be made from standard design range adopted in developed countries. For evaluating the total heat load for air conditioning building, following aspects should be considered:

a. The inside temperature in summer should be selected between 78°—80° F and in winter 68°—72° F instead of 75°+2° F recommended by ASHRAE. This will reduce the electricity consumption by about 5%.

b. Similar compromise is recommended for humidity condition e.g. the prescribed outdoor temperature for Lahore of 109° F DB and 83° F WB should be reduced to 105° F DB and 82° F WB respectively.

The above two considerations will considerably reduce the running cost due to lower plant capacity and more electricity saving.

In the light of the above discussions some useful suggestions are given for energy conservation.

RESIDENTIAL APPLICATION

i. All external walls and the roof should be properly insulated with high thermal resistance material like Glass Wool (Thermopore), Polyurithene, Tiles and Hollow Walls. The maximum heat transfer per sq.ft is from the roof which should be given more attention.

ii. All windows should be covered with heavy curtains or venetian blinds and should preferably be made of wood, as steel or aluminium windows have more heat transfer. Windows should be air tight.

iii. Door closers should be used having rubber or felt sealing under it to keep exfilteration of cooled air to a minimum.

iv. The thermostat should be adjusted at $78^{o}-80^{o}$ F temperature. This is a slightly higher room temperature, but should be acceptable in order to reduce the electricity consumption.

v. Ceiling fans should not operate when the air conditioner is working. For proper air circulation the window units should be installed at 5 ft from the floor and the grill direction should be slightly upwards as shown in Sketch No. 1. Direct draft is anyway harmful for health.

vi. The location for window air conditioner should be selected carefully, so as to provide free air circulation.

vii. A shade should be provided to protect the air conditioner from direct sun radiation.

viii. The air conditoning unit should be serviced periodically, particularly the filter which should be cleaned twice a week.

COMMERCIAL/OFFICE BUILDINGS

i. Use high thermal resistance material in external walls, roof etc.

ii. Avoid excessive use of exterior glass. The heat transfer through glass is 5–6 times more than that through walls. Furthermore, the heat transfer through glass is by radiation as well as by conduction.

iii. Use internal shading devices, e.g. heavy curtains, venetian blinds, roller shades inside the window overhangs or side reveals etc to minimize the heat transfer through glass.

iv. Use double window glazing if possible. The heat transfer through double glass can be reduced by about 12%. A reflective coating over glass can reflect the radiation by about 30%.

v. Use window sash with a tight seal to control air leakage through cracks. As mentioned earlier, wooden frames are better than metal frames because 17% more heat transfer takes place through metal.

vi. The building should be oriented for minimizing solar heat gain in summer and maximizing it in winter.

HEATING/COOLING SYSTEM

Following important points should be considered before selecting the system:

i. Examine the possible use of a total energy system compared with conventional system.

ii. Use recovery devices to heat or cool the air used for ventilation. The air to be exhausted from the system should be routed through corridors and toilets to get maximum advantages before exhausting it to the atmosphere directly.

iii. Use refrigeration condenser water for producing any hot water requirements in Kitchen etc if Water Cooled units are being used. Also, the waste heat of the boilers could be used for co-generation etc if Absorption Chillers are being used.

iv. Compare the energy consumption of heat pump with separate system for heating and cooling.

v. Examine the possibility of a solar energy collector system for heating services, hot water or even for space heating.

vi. Use multiple equipment so that some equipment can be turned off at part load. The equipment operating then will be closer to full load, at which it will be most efficient.

CONTROL SYSTEMS

Considerable energy conservation can be achieved through selection of proper automatic controls. The automatic controls for any airconditioning system can be compared in importance and function with the brain and nervous system of a human being without which the body would be useless, regardless of how healthy it may be. The airconditioning controls must function properly otherwise the air conditioning system will not produce satisfactory conditions. Following points should be considered while selecting the controls for an air conditioning system:

i. Use temperature control system for supply air. Temperature control devices sense and measure the temperature of the outside and return air, and adjust the dampers to provide the air mixture propertion which will produce the most economical cooling.

ii. Use automatic time switch devices to start and stop the equipment according to need. Use night and weekend temperature setback for unoccupied space.

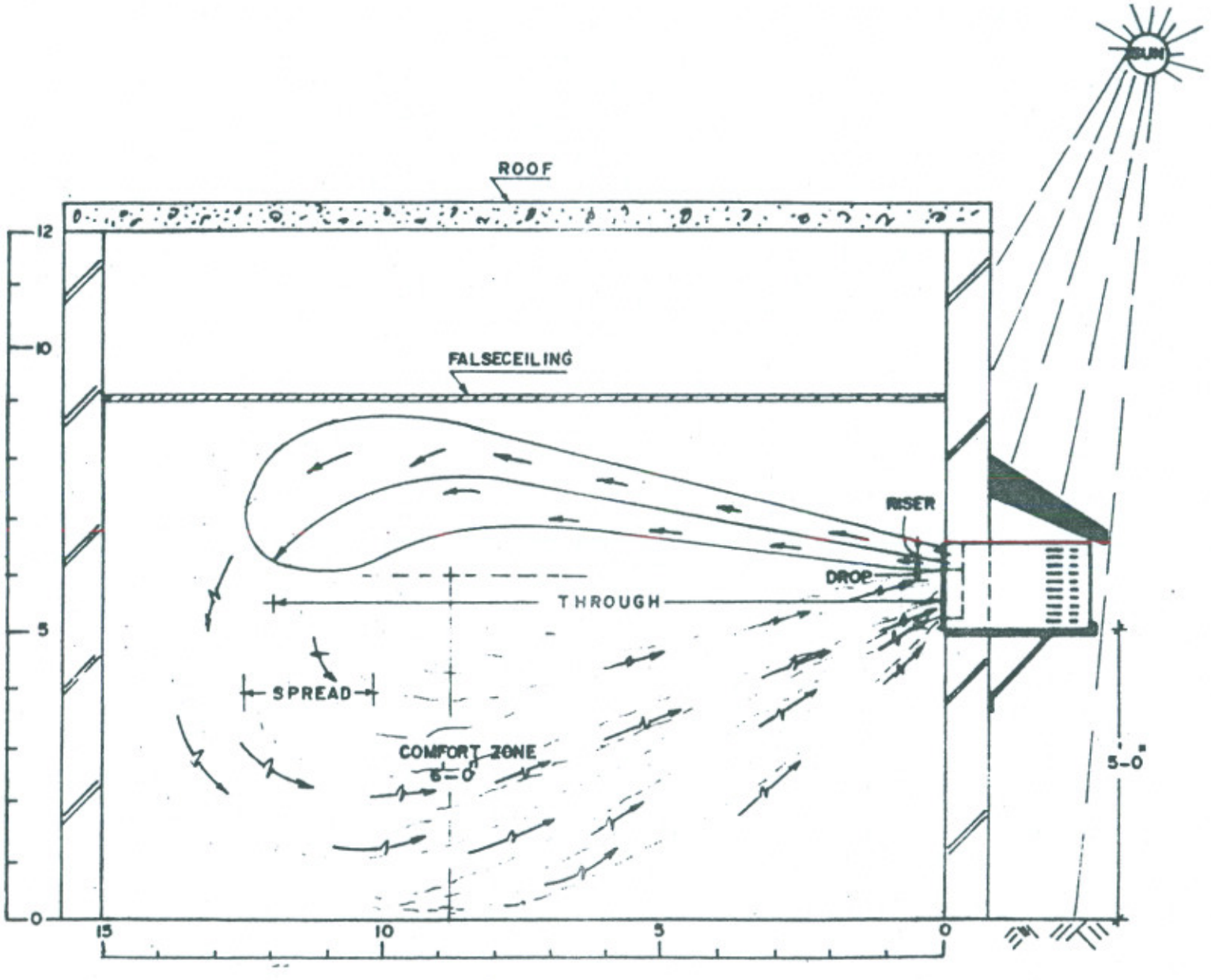
iii. Investigate the possible use of a central computerized control system designed to provide the most efficient operation at all times.

CONCLUSIONS

1. The load shedding has disturbed our entire life pattern. There is tremendous loss of production in the industrial sector and with it the associated price hike. The western world adopted ways and means for energy conservation soon after the Arab oil embargo in 1973, thereby reducing their oil import bill. As a result, now in 1986 the oil shortage is not a problem for them anymore. We must learn from their experience and adopt devices especially developed for energy conservation. Any saving in our major energy consuming industries would make available to WAPDA sufficient gas/oil for thermal generation.

2. The window units in the country consume an estimated 700 million kWh in one season, and by simply adjusting their thermostal a saving of upto 5% i.e. about 35 million kWh is possible. This saving can be further increased if other recommendation are also adopted.

3. For larger air conditioning plants the very building orientation can result in a saving of 18.5% and an additional 10.12% in air conditioning capacity by providing suitable insulation (transmission coefficient). All these factors have to be properly assessed for the type of building under consideration so that overall energy conservation in air conditioning load may be possible.



25°

GRILL ANGLE

SKETCH NO: 1

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