

The Energy Intensity of Office/Showroom Buildings *An Analytical Approach*

The energy aspect is the prime consideration of this paper, being linked to the wider investigation into the energy demands of office/showroom buildings. This paper looks into subjects dealing with the effects of energy-use and the data gathered will assist building personnel to produce energy-efficient and cost-effective design solutions through practical supporting guidance on how to plan energy use and make use of energy-saving measures.

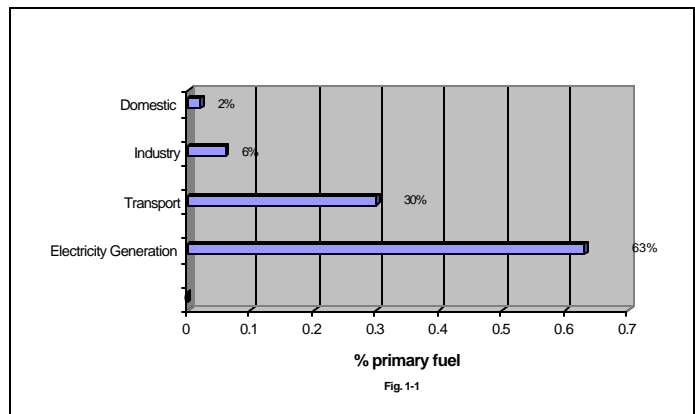
1 INTRODUCTION

Energy efficiency is not a new criterion of design, for the context of building has always been defined by climate and material limitations. [1] Many examples of ancient architecture have special design features that provide comfortable living conditions, without the expenditure of conventional energy sources. Unfortunately, the last 50-75 years have seen planners 'surrender' to a wave of optimism, extensively using and often abusing prefabricated and industrialised elements. The most obvious shortcomings were the almost complete absence of any rapport with the environment, of any analysis, integration, study or enhancement of the natural elements, particularly of sunlight and its correct utilisation.

1.1 Trends in Energy Use in the Local Scenario

Energy utilisation in the Maltese Islands is characterised by a total dependence on imported fossil fuels, low efficiency utilisation and a lack of diffusion of alternative sources. From recorded information, it is clear that there has been an increasing consumption of primary energy sources from 1.1 toe in 1980 to 2.1 toe in 1995, i.e. almost a doubling consumption over a period of 15 years. [2]

Fossil fuel is utilised in four main sectors locally: electricity generation, transport, industry and domestic. The percentage distribution of the primary energy used is shown in figure 1-1.



It is clear that electricity generation consumes the greatest amount of primary energy, approximately two thirds of all the local fossil fuels imported.

Although the heating and cooling of buildings consume the least energy when compared to other consumptions namely in power and transport, the building sector being a very sensitive one, is prone to significant increases in energy consumption with further improved standards of living, given the changing climatic conditions and the present poor performance of local buildings. [2] This situation has given rise to a steep increase in the installation of air conditioning systems. Energy conservation measures can mean substantial savings of energy without any loss of comfort. The setting up of standards indicating the energy rating of a type of building, through building legislation, provides one of the most effective ways of introducing such measures in new buildings.

1.2 Conclusion

The whole objective behind the analysis carried out in this study is to provide technical guidance on the energy rating of heavy consumer buildings such as commercial buildings, in order to help reduce primary fossil fuels used in this sector. The number of showroom/office buildings developed during the past few years has been substantial locally. This can be seen from the data gathered by the Strategic Projects Monitoring Database, Planning Authority with regards office buildings, shown in table 1-1 below.

Table 1-1. *Number of approved office projects*¹

Office Approvals	1993	1994	1995	1996	1997
Projects approved	20	40	46	83	69
Floor space approved (m ²)	16,515	36,591	29,058	27,871	19,715

A desk study carried out as part of the Commerce and Industry Subject Study indicated that in early 1997, the number of showrooms in the main locations were as tabulated in table 1-2.

Table 1-2. *Number of showrooms in main locations up to 1997*

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38	29	28	27	25	22	20

It will be of great help to the developers of these building types to get to know about passive measures that they can adopt in order to reduce the energy consumption. This will not only be of benefit to the local environment, but in the long-term will also have a positive effect on the economics of the company itself.

2 DESIGN DATA

Human beings are very sensitive to heat energy fluctuations. To make up for the resulting discomfort in buildings, various heating/cooling systems are being adopted. The amount of energy consumed when using these systems is largely dependent on the threshold value of temperature chosen for a 'comfortable' living.

The whole process of these heating/cooling systems is based on heat exchange between the external and the internal environment through the fabric of the building enclosure. In order to carry out a fairly accurate analysis of the energy intensity of an office/ showroom building, it was essential to gather and compile all the data required (external and internal to the building itself) for identifying the major culprits of energy flow. This data is being represented under two sections:

- one dealing with external energy gains through climatic factors,
- the other dealing with internal energy gains through the use of electrical appliances, lighting equipment and human occupancy.

2.1 Conclusion

If the local situation, regarding energy consumption in the building sector, is to make considerable improvements, efficient tools must be developed to provide simple methods of analysis.

Owners should be provided with all the technical documentation regarding the different types of plant and appliances incorporated in the respective buildings. Only in this way can accurate analysis of energy use in buildings be achieved.

Once such information is made available, the public becomes more aware of energy use and there is a high probability that substantial reductions in energy consumption in the local building sector will follow. This may truly yield significant reductions of primary energy use, improving not only the local energy scenario, but on a much larger scale, the global energy scenario.

3 HEAT EXCHANGE PROCESSES

One important measure of the success of a building design is the extent to which comfortable internal conditions can be economically maintained. Calculations of heat exchange processes occurring in the case-study building, together with data regarding the building's electricity consumption, were evaluated to establish the energy load of the building, clearly identifying those factors that are attributing to its energy consumption.

3.1 Physical characteristics of the building

¹ Structure Plan Review, Monitoring Report 1996 – 1997: *Monitoring Report: 1996 - 1997, Planning Authority, January 1999, pg. 40.*

Heat is transferred through and inside a building in three different ways, by conduction, convection, and radiation. Another important concept of heat flow is the thermal transmittance or U-value which depends on the air-to-air resistance.

Detailed information about the physical properties of those building elements directly involved with the heat exchange processes taking place, namely the ceiling, flooring, inner & outer walls, and apertures, was gathered, in order to establish the thermal mass of each of these elements.

3.2 Conclusion

The case-study building made use of 'comfort air-conditioning' in order to supply comfortable conditions for people through controlled inside temperatures, humidity and cleanliness of the air. In order to make an estimate of the amount of the electrical energy consumed by such a system, a comparison method was adopted.

From the whole analysis carried out, one could conclude that the designer should treat the various design factors in the order of priority indicated in table 3-1.

Table 3-1. *Priority Criteria considered in Building Design*

<i>Criteria considered in building design</i>	<i>% effect on energy load of building</i>
1. Solar gains	20.7
2. Thermal mass	20.1
3. Lighting	17.7
4. Building fabric	5.4
5. Electrical appliances	5.1
6. Air infiltration	3.3
7. Human occupancy	1.1

4 APPLICATIONS OF PASSIVE MEASURES

To reduce the energy intensity of the building, the thermal load caused by the above mentioned criteria should be reduced. The objective of the whole analytical approach of this study was to examine design solutions that allow coupling of the building to the environment leading to low-energy use and improved comfort, with a consequent reduction in electrical energy consumption.

The main strategic features of the low-energy design proposed in this analysis:

- improved glazing system on the façade and provision of external shading devices
- high efficient lighting equipment
- increased thermal mass
- good insulation of back concrete wall, and
- improved efficiency of heating/cooling system

have indicated that substantial savings can be achieved for the case-study building.

However, each of these individual strategies in isolation is not very effective. The optimum results are achieved through the correct combination of all these systems.

5 CONCLUSIONS

In the broadest use of the term, any action on energy conservation involves an economic decision. In other words, any conservation measure implies the consumption of some resources in order to reduce the consumption of some other. This action is a worthwhile undertaking if the cost of the consumed resources is less than the cost of the resources conserved.

In order to complete the whole analytical study, a comparative analysis was carried out (comparing one proposal with another) reducing the above mentioned variables to mere constants (allowing for values that represent the local scenario as much as possible). Results should be compared with those of other solutions, so that one might be in a position to evaluate the feasibility of a particular solution. From an economic point of view, the optimum strategy is to keep the capital in an alternative investment until the appropriate time for action is reached. [3] This situation may be prompted through incentives set out by the government, the private sector and lending institutions encouraging the use of energy conservation.

5.1 Results and discussions

The results of the most practical measures presented in this analysis are summarised in table 5-1 with the cost of implementation and the corresponding savings in energy. This table also indicates the payback periods and rate of return on investment on each of the different proposals. The order of feasibility for the various systems investigated in this study is presented in table 5-2.

Table 5-1 *Payback Periods and Return on Investments*

Proposed Scheme	Cost (LM)	Saving (LM)	Simple Payback Period, F (years)	Actual payback period, y (years)	Simple rate of return on investment, R (%)
Lighting	3021	133	22.7	22.6	4.4
Glazing	2748	233	11.8	12.0	8.5
Shading Device	3000	429	7.0	7.1	14.3
Exposed soffit mesh	4810	4	1300.0	546.4	0.1
Insulation Option 1	732	74	9.9	10.1	10.1
Insulation Option 2	630	59	10.6	10.8	9.4

Table 5-2 *The Order of Feasibility*

Order of feasibility	Energy-saving commodity				
	Efficient lighting scheme	Efficient glazing system for the facade	Shading device for the facade	exposed meshed soffit	Insulation of back wall
					Op-tion 1
1			X		
2					X
3					
4		X			
5	X				
6				X	

A variation of back wall construction has been considered. The insulation system adopted with option 2 made use of weather-proof insulation boards directly applied on existing wall, whilst that adopted with option 1 made use of aluminium cladding with an air gap in between and insulation resting against existing wall.

The following comments ensue from the feasibility study carried out above:

- From the analysis, the shading device scheme has come out ahead. It would take only 7 years, at the current electricity cost profile, before the savings began to break even with the capital charge. This result should be enough evidence why shading devices should be incorporated with large glazing facades.
- The fact that the exposed mesh soffit provides such a low rate of return indicates that through our local massive construction there is little or no gain in increasing the thermal mass.
- Table 5-2 rates the proposed lighting scheme in the 5th place. This is no reason why lighting should not be made as energy-effective as possible, particularly since it is responsible for con-

sequential energy consumption by the air-conditioning plant.

6 RECOMMENDATIONS

In order to analyse critical data about a building and its immediate environment, accurate tools and measurements are required. Further studies, locally, should emphasise on:

- Detailed derivation of more theoretically based models, which more fully define the assumptions and limitations of the complete model.
- Increased sophisticated computer programs for information processing regarding local weather factors and thermal characteristics of walls and windows in local building construction.
- Detailed analyses of energy-use in different building types based on floor area, type, location and orientation.

It is vital that after sufficient scientific investigation manageable codes of practices should be set up so that the architect may evaluate the thermal performance of buildings according to a set of clear cut rules without any cumbersome analysis.

7 REFERENCES

- [1] Energy-Efficient Buildings, edited by Walter F. Wagner, JR., AIA.
- [2] *Energy, Climate and Buildings in Malta* by Mario Fsadni and A.A.M. Sayigh.
- [3] Energy Conservation and Energy management in Buildings, edited by A.F.C. Sheratt (1976): *Economic aspects of energy conservation*, by D. Fisk and S. J. Leach, pg. 164-165.