Energy-conscious urban planning and development-lessons from a case-study

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1- SYNOPSIS

Demand-Side Management has been used for a long time as an efficient strategy for the transformation of the energy market, that should be used in urban development in general.

2 - ABSTRACT

During the last fifteen to twenty years, DSM -- with this or other designation -- has made an invaluable contribution to sustainable development, allowing growth to be simultaneous with environment protection. The theory and practice behind DSM is actually fundamental to the Market Transformation concept, which relies on the action of both regulators, economic agents and consumers to achieve an energy efficient economy through education, technology replacements and adequate building and energy management. Utilities' attitudes towards energy efficiency promotion are adapting to market liberalisation. This is the reason why the well-known DSM designation tends to be avoided by utilities' people. Nevertheless it is necessary to keep energy efficiency as a key concept for action. The paper uses the EXPO'98 case as an example of a project in this direction. Namely, it emphasises the importance of local authorities in environmentally sustainable development. The paper tries to make a four-fold contribution: give a brief view of present market conditions that influence the attitudes of governments and energy suppliers towards energy efficiency -- at large and at the EXPO'98 level; present a summary of the main orientations that provide the background for the sustainable development of the urban space at the EXPO'98 site, from the points of view of energy and the environment; discuss some opportunities for energy savings and for influencing the rate of energy use according to the DSM portfolio of measures; point out some key issues of possible guidelines for future terms of reference regarding artificial lighting, whose necessity is justified as it has been largely overlooked in favour of thermal energy services.

3 - INTRODUCTION

The concept of demand-side management (DSM) has been introduced in the USA, more specifically in the electricity industry, in the mid-eighties. It has been originally defined as the planning, implementation and monitoring of a set of programmes and actions carried out by electric utilities to influence energy demand in order to modify electric load curves in a way which is advantageous to the utilities. Changes in load curves must decrease electric systems running costs - both production and delivery costs -, and also allow for deferring or even avoiding some investments in supply-side capacity expansion. Thus, DSM has been driven by strict economic reasons. Energy efficiency was a privileged instrument for DSM implementation, as will be seen. Hence, in societal terms, this was a typical win-win situation, as consumers would also benefit from cheaper energy services, as overall efficiency would increase.

DSM has been a major breakthrough that led to a great deal of innovation, both at business management and at technological development, and also to huge environmental benefits. Yet, a great number of DSM tools already existed previously to the concept, and had been in use by many utilities, namely those tools related to remote load control, known as load management (LM). But LM aims predominantly at influencing power use - the amount of energy used by unit of time at specific times. Energy efficiency was actually a newcomer to the business, brought by DSM to the portfolio of utility management options.

There are six main objectives defined in the context of DSM, known as: peak clipping, valley filling, load shifting, flexible load curve, strategic conservation and strategic load growth. Apart from strategic load growth (SLG), all other options require that the utility's system is under pressure and requires either capacity expansion or load relief. Cost-benefit analysis will dictate which options to adopt. In many cases utilities have opted for DSM in order to avoid or postpone important financial stresses.

In general, DSM implementation options may be classified into several different broad categories: customer education, direct customer contact, trade ally co-operation, advertising and promotion, alternative pricing, direct incentives. Some measures pin-pointed in the text below are examples of some of them.

3.1. Problems facing utility-driven DSM

Influencing the way electric energy is used has become an effective means of complementing supply-side options with the purpose of increasing overall systems efficiency. Determining the appropriate mix of supply-side and demand-side resources became the goal of the so-called integrated resource planning (IRP), allegedly leading to a global least-cost approach. Several difficulties had to be tackled with to solve the problem of cost-benefit evaluation of demand-side options. A standard approach has been designed for the purpose, which has only recently been adapted to the European specificities through an initiative of the European Commission, in 1996.

DSM has been recognised as an ally to environment conservation as it leads normally to lower overall consumption growth and contributes to using available resources in a more rational way -- the portfolio of DSM even includes fuel replacement options. Huge savings, both financial, energy and environmental have been claimed, namely in the USA, as due to the massive adoption of DSM programs by utilities, bounded by strict regulatory constraints. The trend towards highly regulated DSM and IRP in the USA, actually forcing utilities to adopt certain decisions though with the guarantee of financial compensation, shows in itself that these instruments have been considered of high societal value. DSM has been identified since the infancy of the concept as a privileged tool for utilities to contribute to the societal goal of environment protection -- besides being profitable on its own in many cases. In view of this advantage, in some countries regulations have been issued and accompanying procedures implemented that sought to maintain economic advantage for the utilities while promoting energy efficiency on the demand side. Losses of revenues had to be compensated in some way, which is not possible, in strict economic terms, in a competitive environment.

But it should be noted that when utilities use demand-side options, they can not take for granted that costs are recovered in the desired time span -- namely because estimates may be wrong, either relative to customer participation, occurrence of free-riders, unexpected behaviour of participants, or programmes' imperfections, etc. Hence some claims have been made that the true costs of saved energy are not so low as stated when compared to investments in new capacity -- in many cases they would have shown to be actually higher. In what concerns strategic load growth (SLG) in particular, it will be cost-effective when previous supply-side investments need recovery conditions which are not likely to exist without promoting energy consumption growth. But this promotion will assume SLG nature (efficient end-uses are mandatory, by definition of SLG) only if regulations impose it. Otherwise there will be plain load growth, eventually with some free-riders adopting conservative measures. Hence, all the implications and constraints of each DSM action must be carefully anticipated in order to take decisions in as much an informed way as possible.

The present trend towards energy market liberalisation brings about some concerns, as for instance on how to prevent utilities from keeping the old perspective of selling kilowatt-hours instead of energy services. Some authors express fears that DSM may be in danger when confronted with plain market rules taking into account that regulation has been indispensable to make it work up to now where it has been successful.

3.2. DSM from a broader perspective

European Union (EU) has been very active in recent years issuing directives on environment protection, some of which are mandatory to member-states. Obviously, energy efficiency plays a major role in EU policy for the environment and there are several financing schemes in the field of non-nuclear energies aiming at energy efficiency improvement. It is clear that a strong influence may be, and has actually been, exerted by governments towards improving the energy efficiency of national economies and reducing harmful environmental impacts of energy use. As a matter of fact, the present trend towards a liberalised energy market brings an accrued responsibility to governments in two main issues: appropriate regulation and consumer education through key information delivery. Only appropriate regulatory frameworks can put in place adequate stimuli directed at various economic agents - energy and equipment suppliers, energy service providers, consumers - for promoting energy efficient technologies and practice.

If energy prices are driven by sales volume criteria alone, there is a narrow margin to be explored in utility-driven energy efficiency: either an energy supplier is occasionally confronted with capacity shortage and decides, to his own interest, to manage demand instead of investing in capacity expansion - provided that he has a franchise market - or, in a competitive context, provides technical advice to customers in order to retain them, which may include improvements in energy end-use efficiency to decrease energy service costs. Hence, national and local authorities intervention may assume several eligible forms like price regulation, legislation to influence building and systems design, incentive programmes to investment in energy efficiency at large, training programmes for designers and technical staff, consumer education, appliance labelling, even building labelling.

The concept of demand-side management may, under these assumptions, be easily generalised. It may be driven by other agents besides energy suppliers -- namely governments and municipal authorities -- and may be understood broadly as a framework of actions and programmes aiming at energy efficiency improvement at the demand side. Ultimately, to comply with environmental protection.

4 - ENERGY CONSCIOUS URBAN PLANNING - THE EXPO'98 CASE-STUDY

4.1 General issues

EXPO'98 has been the last world exhibition of the 20th century. The event has been used as a strong motive for rehabilitating a degraded area of the city of Lisbon, at its East end. Authorities have decided to follow a unified approach, where the exhibition would be integrated in a broader urban plan. Many of the buildings, exception made to the majority of the national pavilions, should be permanent and fully usable after the end of the event. Moreover, a much broader area than the one strictly needed for the exhibition should be harmoniously planned to integrate the exhibition remaining equipment (buildings and surroundings), allowing at the same time a planned development of a new city region, with all kinds of activities and residential areas. The exhibition buildings have been, naturally, the first to be built according to this big plan. However, several residential areas are presently in course of development. The site remains very active after the official exhibition end.

The plan defined a total intervention area of 3 300 000 m^2 . Planned building areas are listed below:

Residential	1 215 000 m^2
Hotels	42 000 m^2
Offices and Public Administration	462 000 m^2
Shops	146 000 m^2
Light Industry	19 500 m^2
Urban Equipment	114 000 m^2
Railway Station (intermodal system)	32 000 m^2
EXPO'98 Pavilions	200 000 m^2

The number of planned dwellings for the mid-term is 12 000, for a total resident population of 25 000 persons. 15 000 persons are expected to work in this new urban area of the city.

4.2. Objectives and strategy

Since the very beginning, the urban project of the 1998 World Exhibition, EXPO'98, has been viewed with an integrated approach to rational use of natural resources. From the point of view of energy, this implied the consideration of a paradigm that may be expressed in the four terms expressed in figure 1 below.

This paradigm is applicable to virtually any system where people live or work, that is to say, to an industrial facility, to an urban area, to a building of any size. According to the perspective on DSM presented above, the company in charge of the site of EXPO'98 assumed itself as an active agent in the promotion of energy efficiency at the demand side. The regulatory and legal framework within which it has been created favoured this attitude, as it had equivalent prerogatives to a municipal authority.

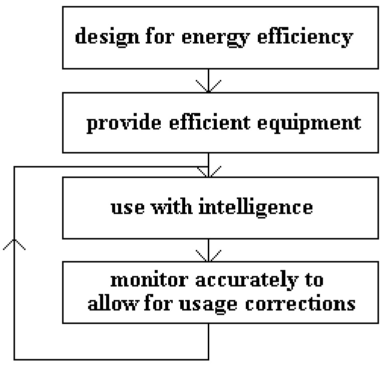

Figure 1 *: Paradigm of efficient use of energy from a perspective of systems life-cycle*

At the start of the project a set of objectives has been stated, in the framework of a Global Strategy for Energy and the Environment, and the corresponding strategic actions have been delineated and implemented. The objectives may be briefly referred:

- plan the new urban area in such a way that it will be comfortable, both in interior and exterior spaces;
- consider this "city" as a single energy system, managing supply options and supply-demand interactions in the most efficient way possible;
- define DSM strategies in order to influence both urban and building design, avoiding high peak energy demands and unnecessarily high consumption levels;
- implement monitoring of the whole urban energy system as an essential support to an adequate urban management;
- assess environmental benefits of the strategies adopted both locally and from a wider perspective;
- disseminate results at national and European levels.

The actions supporting this strategy may also be summarised in the following topics:

- perform climatic research on the area;
- provide designers with accurate data on the existent natural conditions;
- define general guidelines for urban planning;
- define terms of reference for the thermal characteristics of buildings and HVAC systems;
- provide consultancy support to building designers;
- propose the implementation of a district heating and cooling (DHC) system for the whole urban area;
- create an observatory of energy supply and demand.

4.3. Paradigm and practice

The first term of the above mentioned paradigm of efficiency at the demand side is very well illustrated at the EXPO'98 urban level by two components: the urban design approach used and the terms of reference for buildings.

Urban planning has been informed by a study where solar radiation distribution on the site and on the buildings has been anticipated for several configurations, and the effects and interactions among variables such as building heights, vegetation and wind have been experimented for different seasons in order to evaluate possible design outcomes in terms of exterior comfort conditions.

The terms of reference for buildings establish maximum limits for building energy needs. The limit values are 50% of those in the Portuguese regulations for the building considered as a passive system and 60% of those generally applicable to active systems (HVAC). Hence, designers are compelled to conceive buildings and associated systems in a way that the results are well above the current efficiency standards.

Further actions have been put forward trying to foster the application of the terms of reference, through the provision of support to building designers. Consultancy has played an important role in the design of several main buildings of the EXPO'98 site. The solutions adopted represent in most cases examples that have already been used to illustrate the real possibility of implementing very efficient buildings. Here, not only the first term of the paradigm is fulfilled but also partly the second because, as a rule, active equipment for the various energy services within the buildings are highly efficient.

The most common solutions adopted fall into some categories that illustrate the kind of possibilities there are to comply with the terms of reference.

- natural ventilation through stack effect
- mechanical displacement ventilation
- integral insulation of the building envelope
- heating and cooling sources from the DHC networks, avoiding boilers and chillers
- heat recovery
- variable speed drives for pumping and ventilation loads
- night ventilation and free cooling
- daylight use through appropriate fenestration, up-lights and shading devices
- efficient technologies for artificial lighting
- energy management systems

Several recent buildings act as examples for future efficient designs.

Efficiency and environment protection is also informed by options at the supply-side, as the district heating and cooling networks exemplify. It consists of an urban distribution network of hot water and a similar one of chilled water, fed by a gas-fired co-generation system complemented by an absorption chiller and a chilled water storage tank. The networks allow for a clean and efficient alternative to individual HVAC plants distributed among buildings, as they potentially avoid the use of local systems for heat and cold generation.

The monitoring phase of the urban site, which is based on an agreement among the various energy suppliers and energy service providers involved, closes the loop of efficiency management. With appropriate data collection, organisation and processing, the so-called Observatory has the potential to become a key instrument to demonstrate the effectiveness of many solutions implemented but also to timely correct management procedures and eventual technology malfunctions.

4.4. A prospect of increasing awareness

The above stated paradigm of efficiency is not a novelty. Appropriately adapted, it suits to almost any reality where management seeks to use resources in a rational way. EXPO'98 is not only an integrated approach to environmentally and energy conscious urban design. It is mainly the demonstration of the feasibility of this type of approach.

DSM opportunities

Experience shows that in countries where liberalisation is more advanced, utilities show a natural tendency towards maximising profits and, hence, to promote energy sales. This is clearly at odds with energy efficiency promotion and led to the abandonment or, in the best cases, to a strong decrease of DSM utility-driven initiatives.

A broader content has been proposed above for DSM, which enlarges the list of actors with an active potential role in the promotion of energy efficiency: authorities, utilities, consumers, energy service companies, equipment manufacturers. Though traditionally utilities play a major role in DSM, the initiatives of local, regional or national authorities in general will have to be intensified.

Nevertheless, regulation will have to be adapted to the prevailing market conditions at every moment in the future. It is definitely different to issue regulations in conditions of franchise market to some energy types of supply or to do it when suppliers of the same energy form compete with each other for customers. Namely, energy price is strongly influenced by the form of market organisation. Hence, a good regulation today may become obsolete tomorrow and accrued difficulties may arise.

However, as long as franchise markets prevail, competition will exist among suppliers of alternative forms of final energy for the same end-uses (e.g. electricity and gas for water heating in washing applications). This may play a positive role in the dissemination of the most efficient and environmentally benign technologies, provided that consumers are well informed.

The list of opportunities below has been organised according to what seems to be the most likely situation of the energy market in the short- and mid-term in Portugal and in the urban area of EXPO'98 in particular. Uncertainty cannot be eliminated. In the working perspective used, franchise market organisation is assumed for the supply of electricity, gas, hot and chilled water. This eliminates, for the time being, the difficulties identified above, associated to competition among suppliers of the same energy form.

Categories of DSM measures and impact on emissions
The objectives of DSM in its conceptual formulation have been referred before as: peak clipping, valley filling, load shifting, flexible load curve, strategic conservation and strategic load growth. It should be retained that this list informs a definition of DSM where the main objective is modifying the shape of the load diagram seen by utilities. It is possible to classify the six so-called DSM objectives in two broad categories.

The former four objectives are directed towards the modification of consumption rates (power values, in the case of electricity), either in amplitude or in time of occurrence, or both - they clearly modify the shape of load curves and avoid peak coincidence among loads, especially during the day (on-peak periods).

The latter two objectives have effect on the value of energy consumption in general and not explicitly on consumption rates -- however, as long as they have influence on end-use equipment, they also end up influencing consumption rates indirectly.

Any of the two aspects -- consumption and consumption rate modification -- may have the contribution of local energy conversion systems (local to the end-users premises) dedicated to provide energy services. Henceforth this type of option will be referred to as dispersed generation, leading to either electric or thermal energy production coupled to end-uses.

Thus, three main categories of measures will be used to organise the list: measures influencing rate of consumption, or power, measures influencing energy consumption and measures promoting dispersed generation.

If the two latter have obvious influence in the total amount of emissions due to electricity generation, the first has an influence that depends on the characteristics of the generation system. As, in general, externalities are not used as a criterion for scheduling generators for servicing the electric systems load, dispatch decisions are mostly based on strict economic and reliability criteria. DSM measures affecting rate of consumption tend to raise load factor -- rise power demand during the night and lower it during the day. If, for instance, base load generators are mainly coal-fired, CO_2 emissions might even rise, depending on the generation mix that is usually in place during the day (it may or may not pollute more, on average, than coal-fired plants alone). Hence, DSM measures affecting rate of consumption usually are beneficial because energy conversion efficiency of base load plants is higher, but a careful assessment of the possible total emissions variations must be performed before launching actions with potential strong load shifting effects.

4.5 Measures influencing rate of consumption
Under this category of measures two main issues can be potentially considered: remote control of end-use equipment by utilities -- the so-called load management (LM); tariff systems based on time-of-use (TOU) rates. They correspond to the classical two main forms of DSM -- direct control of equipment and indirect influence on consumers behaviour through prices. Naturally, the latter should be complemented with others, one of them being quite obvious in general: promote energy storage at customers premises.

LM allows utilities an effective control of their load diagram. Equipment normally under control consists of electric water heaters and HVAC, which have high time constants. Hence, quality of service is not much at stake because of short duration shedding actions. In the particular case of the EXPO'98 site, the DHC system will probably be used extensively for heating and air conditioning of the majority of the buildings in the site - the majority presently at the design stage. This is expected to have a dramatic influence on the total power installed for HVAC systems, reducing the potential interest of LM. More important than this particular technical issue is the lack of motivation for LM in the area. As a matter of fact, LM is used in circumstances where supply capacity is not abundant and is subjected to stress especially at times of peak demand. This is clearly not the situation of electric supply systems at the EXPO'98, and will not be for the next several years.

Telemetering
Any energy supplier is virtually interested in knowing, to the best detail possible, the structure and the characteristics of its customers loads. This allows for a detailed assessment of the supply systems operation, for extensive load research and for the definition of management strategies leading to minimum operating costs -- which may be achieved through DSM actions, particularly well justified in the presence of telemetering facilities. Technological solutions to telemetering exist already as stabilised products, and are evolving. Bi-directional communications support is needed -- for interrogation and reply of remote terminal equipment -- that opens prospects for other uses, such as special energy rates, as will be seen in the following section. The most used transmission medium is the electric network itself, through power line carrier technology, although telephone lines are also used to a smaller extent.

According to a recent UNIPEDE (Union Internationale des Producteurs et Distributeurs d'Energie Electrique) study, by the year 2000 about 1 million of customers served by its associated utilities will have their consumption metered with apparatus that include bi-directional communication facilities. The main advantages of bi-directional communications, as identified by utilities, are the capability of performing remote meter reading, of applying multirate tariffs and of remotely modifying contractual parameters. Besides, in some cases electric utilities are offering telemetering services to other utilities -- gas and water distribution companies and district heating companies. Telemetering could be a very useful source of information for the EXPO'98 Observatory, especially if this integrated perspective was used, providing data on consumption of all forms of final energy at the site.

Energy pricing options
Cost of supply is not constant for any type of energy delivery, be it electricity, gas or heated water. Variations of demand per unit time within a given period of time cause variable operating conditions that correspond to variable system running cost. The causes for variations are different among energy forms but variations always exist. Tariff systems with multirate structure are, in general, an adequate response to variable costs of supply, as they correspond to pass on to consumers an approximate image of supply cost variations -- they are usually based on long term previsions of marginal cost of delivery. In the electricity business multirate tariffs are already traditional, at least to certain customer classes. The same does not apply with the same extension to other utilities, mainly because of technical and management difficulties. The alternative is the so-called flat rate, meaning a constant price, independent of cost of supply variations.

Multirate tariffs potentially lead to a reaction of demand, that depends on its actual elasticity with price, which is in principle beneficial to both sides -- supplier and consumers. These tend to see positively the possibility of controlling more effectively their bills. Indirectly, demand reaction will induce variations on the level of emissions. Theoretically there is a reciprocal influence between prices and demand level, depending on elasticity, which corresponds in general to an efficient use of supply resources.

Dynamic pricing schemes require adequate technology, that harmoniously suits also telemetering needs. Hence, if telemetering in itself is attractive enough for utilities, dynamic prices represent only a marginal technological demand. In point of fact, the bi-directional communication capability of telemetering systems is adequate for broadcasting the price signal associated to dynamic pricing. The additional requirement is due to the fact that the consumer must have some means of responding automatically to price signal levels. Terminal metering equipment must then have two additional functions: appropriate interactivity for setting parameters and power interfaces for connecting and disconnecting loads / consuming devices according to the parameters and the price value -- configuring the well-known "smart meters".

With a much smaller penetration than telemetering equipment, smart meters have though a field application history of more than ten years, which turn them into a viable option for price induced consumer behavioural changes.

Telemetering in itself has the accrued advantage of allowing an accurate assessment of price elasticity of demand, whatever the final energy form considered. Adequate tariff rate adjustments are thus possible, for the benefit of suppliers and consumers, who both may use available resources more rationally and, hence, for the benefit of society at large.

For example, multirate tariff options presently available in the Portuguese tariff system of electricity allow an acceptable approach to price induced DSM, although not so efficient as dynamic pricing. The possibility may be considered of conveying new contracts of electricity supply to low-voltage consumers with small contractual power, by default to a two-block rate option, unless the consumer explicitly prefers the flat rate option. This approach demands that consumers can be well informed, requiring adequately prepared utility personnel for interfacing with clients. The lack of tradition of multiblock rates for the other forms of energy is surely a barrier to implementation of similar approaches. However, if integrated telemetering will be available, it will be possible to assess their feasibility after some time.

It is obvious that flat rate options are attractive to utilities especially in situations of franchise market, privately owned supplier companies and enough available capacity in view of present and forecast demand levels. They are the best option for the supplier that wishes to rapidly recover its investment on assets but are certainly in opposition to DSM and to emissions containment. Hence, price induced DSM success depends heavily on suppliers' attitudes towards this issue, ultimately on regulatory frameworks.

Energy storage
The existence of a DHC system at the EXPO'98 site apparently would discourage the adoption of energy storage systems (ESS) in buildings, as heat and cold will be constantly available everywhere. Nevertheless, the expected good thermal inertia of buildings designed according to the terms of reference turns them into good candidates to the inclusion of thermal energy storage. This opens the possibility of competition between the DHC network operator and equipment manufacturers/suppliers (or an agreement between equipment suppliers and an energy supplier other than the operator of the DHC system) that manage to install efficient enough ESS to be competitive. Presently, electricity being the only energy source with foreseeable multiblock rates, represents the most apparent candidate for feeding ESS in buildings.

Combining energy storage with efficient equipment options may lead to the use of reversible heat pump as the heat or cold source to storage containers. The possible combination with solar active systems will be referred later.

The advantages of ESS at end-users' premises for the electric distribution utility in EXPO'98 may not be evident, at least in the short-term, because there are no constraints of supply capacity that could otherwise make the utility welcome a demand reduction during on-peak hours, hence stimulating final users to adopt ESS.

4.6. Measures influencing energy consumption

Efficiency vs. reduction of energy consumption
A previous consideration must be made here on the possible attenuation of expected effects of efficiency improvement on energy consumption. It is not uncommon, especially in the residential sector, that the pattern of use of efficient equipment adopted during a DSM campaign tends to follow implicitly a cost levelling criterion -- i.e., an increased use of the energy service provided as compared to the "normal" situation with standard equipment, up to where the total cost approximately equals that of using the standard equipment the usual way. This is to enhance the need for consumer education, though the actual value that a consumer gives to a saved kWh depends on its income. It is not unlikely that some free-riders use extensively, but also loosely, efficient equipment. Here, probably more than education, some level of automation is recommendable to ensure that waste is not generated with high efficiency devices.

Both strategic conservation and strategic load growth are based on the promotion of efficient equipment. Provided that some influence can be exerted upon energy suppliers, it is possible that their market strategies do not rely on plain load growth stimulation. In those cases where there is competition for market shares among different energy suppliers a positive approach is more easily followed -- strategic load growth is then a likely marketing strategy.

Strategic conservation measures
Bearing in mind the discussions in previous sections, it may be said that the measures already taken to influence building and systems design at the EXPO'98 site provide an advanced starting point for further DSM:

building orientation, thermal characteristics and passive systems, along with efficient solutions for active ambient conditioning systems, all add to an effective limitation on energy consumption when compared to conventional designs. Hence, exploring the remaining energy saving potential must be accomplished according to the main categories of intervention: artificial lighting, automation, fluid movement and other equipment. DSM requires here the forms of advertising and promotion and trade ally co-operation -- through contacts with designers -- and also consumer education.

Artificial lighting
This type of load may assume a high relative importance in buildings in the context of high efficiency building design aiming at thermal comfort. General orientations exist in order to influence design at the EXPO'98 site. In the form presented, however, they can only play an indicative role in spite of the careful consideration of energy efficiency issues in the whole project. There is clearly a need of some more precise and quantitative indications for efficient artificial lighting systems design in buildings.

Guidelines for energy efficient lighting at the design stage should consider some key issues that have been used already in some regulations: area power densities, main criteria to be used for lighting control, indicative automation requirements, maintenance implications, heat recovery possibilities. A method similar to the complete building method used in California seems an adequate approach, where whole building lighting power densities could be specified in Watt/m^2, as it seems more appropriate to projects of entire buildings. In this way designers have freedom of choosing lighting solutions for particular applications and individual spaces, the only limitation being a global figure that depends on the building floor area.

A possible set of power density values may be proposed, as in the following table 1.

Table 1: Recommended power densities for lighting in buildings

Type of use	Watt/m^2
General commercial and industrial work buildings	9
Industrial and commercial storage buildings	6
Hospitals, medical buildings and clinics	10
Office buildings	11
Auditorium and convention centres, religious worship	14
Restaurants	10
Retail and wholesale stores	14
Schools	11
Theatres	12
Hotels	10
All others (including residential)	9

Estimates of savings for the whole EXPO'98 urban area, in the mid-term, based on the above figures, on the total estimated built area and on estimated annual building occupancy hours, amount to approximately 8900 MWh/year in lighting alone, without including savings in cooling loads due to the reduction of internal gains during the cooling season or extra savings due to some degree of automation, and excluding urban equipment.

As this is a typical end-use which is specific to electricity, local authorities must play an essential role, besides influencing design activities, next to residential consumers, by encouraging them to use energy efficient lamps and systems. Compact fluorescent lamps (CFL) must be actively promoted even, if necessary, without the utility's co-operation, which will not feel the pressure of competition from other energy forms in this particular end-use.

Control functions design and building automation
In a building designed and equipped according to energy efficiency concerns, including passive solar solutions and efficient active devices, there is a margin still available for efficiency gains, related to the way that active systems are planned to be used and the way they are actually used. From the strict point of view of rational use of energy, the provision of adequate control functions or devices is mainly useful for increasing the possibility of avoiding waste due to ill-informed design, human negligence or lack of awareness. It allows energy services to be provided at adequate levels with minimum consumption.

Two different aspects must be taken into consideration: the design, location and ease of use of manual controls, and systems automation. There is a high diversity of solutions to building automation (including home automation) needs. A number of system types exists for the residential market, for example, that use different communications media and provide a great variety of functions, from energy management to security, fire detection, remote control, etc.. Many available systems use dedicated conductors for supporting communications, although a number of them also may use the power lines for the same purpose, avoiding the existence of a specific communications network. Hence, any recommendation for building designers in this area must include the need of a dedicated network of conductors in new buildings, to allow the future installation of energy management systems -- or building, or home automation systems at large -- if they are not an integral part of the initial design.

Some home appliance manufacturers are including or considering the inclusion of energy consumption self-metering capabilities into appliances, together with communication capabilities. This allows for the possible integration of such appliances in the context of sub-metering and automated energy management functions and/or systems. If the building design does not take this possibility into account a very effective potential for energy management may be wasted.

Fluid movement loads
Water pumps and ventilation fans represent important loads in most buildings, associated to HVAC systems. There are three main aspects that, once adequately considered, contribute to a high efficiency of energy use in these applications: type of motors used in pumps and fans, type of motor drives and automatic control.

Automatic control -- provided by energy management systems (EMS) -- can restrain the use of pumps and fans to the periods when they are strictly necessary -- a small period of running time avoided everyday, for the usual rated power values amounts to big savings on a yearly basis. Besides, the total number of pumps in operation at a given time depends on the loading of the zone to be conditioned, which can be assessed by an EMS.
Variable speed drives (VSD) allow the continuous control of pump speed and hence of flow rate with much less energy consumption than if flow control is implemented through throttle valves. Besides, VSD are easily integrated in EMS that can take advantage of the smoothness of control offered by VSD. Operating cost of pumping and ventilation systems can be minimised with appropriate combination of plant loading, switch-on time, water temperature or air temperature and water flow rate or air flow rate. Also, hammer effects in the water systems and power surges on start-up are negative phenomena which are avoided with VSD.

High efficiency motors can represent big savings when subject to long running times, as is the case for HVAC applications. And they have also a better behaviour when controlled through VSD than their "as usual" counterparts.

Other opportunities
Two further directions should be seriously considered in promoting energy efficiency, both having to do with consumer education and trade-ally co-operation.

Appliance labelling is presently mandatory for some domestic equipment, and other appliances will soon follow. On one hand, active marketing of the advantages of high efficiency appliances should be targeted to consumers at large. On the other hand, in those cases where some appliances are an integral part of the dwellings or apartments for sale, anticipated influence should be exerted on builders in order to ensure the appliances to be installed are efficient enough for them to use this fact as a marketing argument. Consideration may be given to the definition of lower bounds to efficiency of these appliances as a detail of a possible building "eco-labelling" programme.

Systems must be maintained for a great number of reasons. Essentially, because the service they provide may be at stake after some time of operation if they are not adequately maintained. But, as a general rule, even while they keep on providing the service they have been designed for, efficiency will drop increasingly with time. This happens with passive solar devices, with artificial lighting systems, with electric motors, with HVAC systems, with active solar systems, etc. It is not the purpose of this text to provide a best practice manual for systems maintenance. However, this issue is of such a great importance that it should also be one of the mandatory ones to consider in campaigns of consumer education, specially directed at energy managers of buildings and organisations. Sustainability of investments in efficiency depend on it to a large extent. It requires advice not only at technical level but also at organisational level, including maintenance management.

Dispersed generation
Dispersed utilisation of thermal solar active systems in buildings at the EXPO'98 site is strongly conditioned by the existence of the DHC network. When designing each building, every possible configuration and function of an active system must be carefully assessed against the possibility of using the DHC fluids. The table below lists some of the possible options.

Table 2: Some possible options of thermal active solar systems use

Technology options	Type of use	Special requirements
Solar collectors with gas firing support	Water heating, space heating	
Solar collectors with electrical resistance support	Water heating, space heating	May require storage to take advantage of low electricity night rates
Solar collectors with heat pump support	Water heating, space heating	Better with storage to take advantage of low electricity night rates
Solar collectors combined with absorption chiller for heating and cooling, with heat pump support	Water heating, space heating and cooling	Better with storage to take advantage of low electricity night rates

Similar considerations may be made on the possibility of using small-scale co-generation systems in buildings, for local heat generation and some degree of autonomous electricity supply. Also producing cold by means of absorption chillers or even compressor chillers driven by part of the generated electricity may be assessed at design stage.

Photovoltaic (PV) panels are also a possibility of partially satisfying buildings' electricity demand. Solutions to integrate these devices in architectural design exist for some years and is not limited to vertical façade elements. In particular, when shading devices are planned for South façades, they can provide mechanical support to PV panels. Though limitations to output efficiency due to non-optimal panel tilt also apply, they are not necessarily so important as when using vertical mounting because, when using shading devices as support, horizontal mounting is not mandatory. Care should be taken when designing the systems to coexist with supply from the electricity distribution grid. Preferably, design and implementation should be assisted by the local electricity distributor. Due to the present costs of this technology, only if some incentives are found in the funding programmes available, cost-benefit life-cycle analysis will possibly recommend its implementation.

The role of strategic load growth
Because of the present state of regulations (and mid-term expectable evolution), final energy suppliers at the EXPO'98 -- namely supplying electricity, gas, hot and chilled water -- will face no competition from others supplying the same form of energy in the near future. Hence, competition for supplying the same energy services will be the only form available. In an urban area which is expanding, it is natural that this form of competition exists, namely because each supplier will try to expand its business as much as possible. Examples of this may show for instance with the gas supplier promoting washing machines with independent hot water inlet, on the basis of a lower energy service cost, when the consumers use gas to heat water, or with the electricity supplier promoting induction heating as a safer, more reliable and more efficient alternative to conventional cooking appliances.

From a consumer point of view, cost of supply depends on the final energy price and on the end-use equipment efficiency. If choice is available for both factors -- some uses demand a specific energy form and thus choice is only applicable to efficiency -- consumers have a wider decision domain. They must be well informed to take the right decision.

When a supplier cannot beat a competitor through energy unit price, it will tend to beat him through end-use accrued efficiency. Alliances between energy suppliers and equipment manufacturers may arise. Strategic load growth can be of great importance in this process. The local authority's role must be of intensively educating consumers to give them unbiased decision support, not leaving them subject only to commercially-oriented information. Most of the times this will prove to be in the interest of environment protection in both the short- and long-term.

However, co-operative efforts among suppliers should also be encouraged to the greatest extent possible by the local authority. It is not unlikely that publicly visible co-operation is judged by suppliers to be beneficial in the mid-term because it improves their public image. The success of the Observatory for Energy depends also on it.

A second aspect is also potentially beneficial from an environmental perspective: competition between dispersed and centralised generation/supply. From what has been said before, there are options of decentralised generation, namely solar applications, that are even more environmentally benign than the already high standard centralised solutions available at the EXPO'98 site. This opens the possibility of new actors coming into scene: dispersed generation equipment suppliers, either of renewable energy or of small co-generation systems suited for buildings. This possibility should at least not be discouraged. If the present orientation of providing consultancy to building designers keeps on being applied in the future, it should extend its scope to all apparently relevant applications, namely those of integrating dispersed generation systems into buildings.

5 - CONCLUSION

The EXPO'98 site is equivalent to a small town built on purpose. Thus, it has been possible to plan it according to an energy conscious perspective, from the layout of the streets and open spaces, to building orientation, defining also strict rules for the quality of the buildings, in order to make them comfortable and energy efficient. The overall approach makes the EXPO'98 site a good example of environmentally concerned urban development. In the paper some possible ways of applying demand-side management strategies to such an already efficient urban system are discussed, in the framework of the present liberalisation of the Portuguese energy market, taking into account the roles of the various possible agents.

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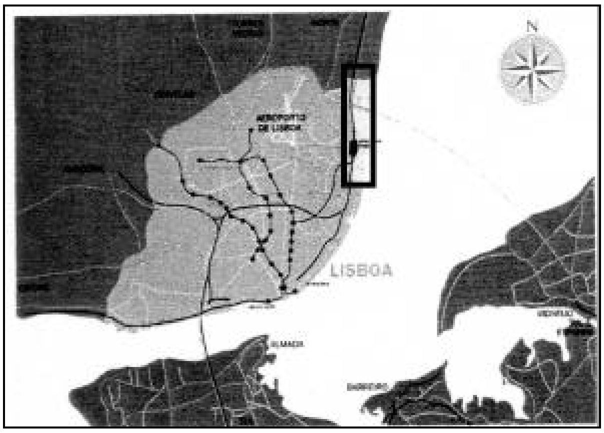

Figure 2 *: The city of Lisbon and the EXPO'98 area marked with an outline.*