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ECONOMIC IMPACT OF EXERGY EFFICIENT BUILDING BLOCK DESIGN

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Abstract

Even after the end of 20th century, the details of connection between energy – especially energy production- and the environment were not fully understood. The population growth in last thirty years, undeniable climate changes and the starvation of non-renewable energy source reserves leaves no room for doubt, however: energy and environment share a strong and significant connection. This perspective is especially important in the world of economics, considering the cost of energy for end users.

This study covers the economic impact and gain of applying exergy efficient planning to a building block. The study hereby undertakes a case study to show that an efficient planning can help save energy, and thus money. The existing blocks of the chosen case had 2% energy efficiency, while the designs proposed in the study have 10-11%. The findings in this study show that an 8 % improvement in the exergy efficiency of the building block results in 780.05TL saving for a single housing. This sums up to 54.603,49TL for the building block annually.

Keywords: *Exergy efficient planning, economy, energy conservation, energy*

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Introduction

In order to better understand the scope of energy usage in construction and usage of structures, the literature data on varying sectors energy usage were inspected and the following information was gathered: 51% of total energy production is used in industry, 20% in transportation, and 18 % in residential and 12% in commercial sectors (EIA 2013). When details of the construction sector were investigated, it was found that 50% of the total energy consumption and 42% of the total water consumption are utilized in the construction and usage period of the buildings. Considering the relationship with nature as well, though, it is worth to keep in mind that, 50% of the greenhouse gases, 40% of the water pollution and 24% of the air pollution arise from the activities in the built environment (Edwards 2001). Another interesting detail is that the heating of the houses take up 81% of the residential energy demand (Tokuç 2005). Highlighting this, the numbers above show that the amount of energy used in residential areas cannot be underestimated and any increase in efficiency in a given area would greatly contribute to the energy sector. This improvement would also lead to a decrease in the total energy cost and the amount of emissions. Various studies in the literature point out that, buildings densely use energy, and they use various energy sources. Energy in buildings is mostly used for heating, cooling and lighting purposes. Oftentimes this energy is obtained from nonrenewable sources. Yet still, buildings, building blocks and neighborhoods should minimize energy demand while optimizing comfort properties. This can be achieved by considering energy efficiency during the design phase. For example, utilization of renewable sources must not be underestimated in the design strategies. Due to all of these, increase in energy efficiency must be considered in a higher priority in construction sector, especially considering that built environments are amongst the largest energy consumers. Such studies can also aid the efforts to decrease greenhouse gases (CSB 2011).

From the energy efficiency point of view, the different properties of the spatial structures at different scales are important. The fundamentals exercised during planning and decision making for local energy efficiency plans are also effective for decisions at the regional scale. Besides the properties like orientation and microclimate at the local scale, wider spatial properties are, however, also relevant and important at a regional scale. At small scales, direct forward changes bring considerable improvements, like adjusting the orientation of the building for the sake of energy savings, which does not even increase the cost of the construction. For comprehensive energy effectiveness on the regional scale, climatic and microclimatic properties of the urban area have to be considered with great care due to the loads arising from the small (or house) scale by heating and cooling.

At all levels of land use planning decisions, the usage of energy has to be taken into account and the planners have to develop solutions about efficient use of energy. The land-use patterns directly affect energy consumption and influence the energy systems. This holds true for small scales, like the houses, to the largest scales, like the country itself. No matter what the scale is, however, it is crucial to understand the significance of the energy-efficient planning's contribution to energy conservation.

This study aims to find out the amount of savings by utilization of an exergy efficient planning for a building block. Exergy analysis is defined as a powerful tool for understanding the true characteristics of a system from the perspective of energy by investigating the true potential of its source. This study will hopefully offer the exergy and urban planning contexts as a new point of view for the decision makers as the economic perspective of the energy efficiency is also underlined.

Case Area

Mavişehir settlement is located on the boundary of Karşıyaka Municipality to the north of Izmir Bay (Figure 1). The case area is defined as a mass housing area with high-rise blocks according to the

Metropolitan Master Plan of Izmir. The area, totaling 270 ha, is surrounded by Atakent housing units to the east, by old Gediz river bed to the west, by a mass housing area that was previously a squatter housing area to the northeast by Izmir-Manisa-Ankara railway triage area to the north, and by Izmir Bay to the south (Figure 2). Mavişehir mass housing area is formed by three sub- regions which were constructed in three stages (Mavişehir I, II and III) with subsidies of the Housing Credit Bank. In addition to the housing units, the projects also includes social and leisure facilities such as sports areas, green areas, parking areas, playgrounds, education and commercial areas. With having a gas central heating system, double glazed windows, sun blinds, decorative coated doors, and double bathrooms; each accommodation in Mavişehir is a luxury residential high-rise apartment and villa (Özçelik 1998, Koç 2001, Aydoğan 2005).

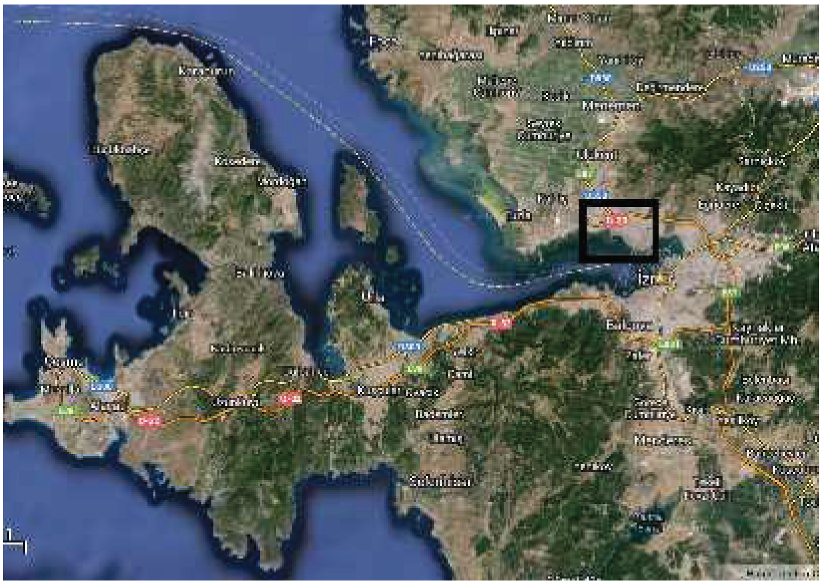

Figure 1 Location of Mavişehir in Izmir Bay (Source: Google 2013)

Figure 2. View of Mavişehir Project (Source: Google 2013)

Exergy efficient urban area plan

Parameters and factors rely on the site and building design and are important from the points of view energy conservation and climatic comfort. These effects can be investigated under two groups: physical environment parameters, and design and construction parameters. Investigated physical design parameters are topography, climate, solar radiation, temperature, humidity, and wind. Investigated design parameters are layout effects on the built-up area, orientation, location, building form, distance between buildings, building envelope and insulation, and natural ventilation. The design parameters of the energy efficient perspective for İzmir are tabulated in Table 1.

Table 1. Design and planning parameters of hot-humid climate regions

Cities	Adana, Antalya, Aydın, Denizli, Hatay, **Izmir**, Manisa, Mersin, Muğla, Osmaniye
Aim	The general aim is to avoid overheating

	and radiation in hot periods and increase ventilation and humidity losses.
Settlement Pattern	Higher sections of the hills must be selected to increase the cooling effects of the winds.
	Separate and scattered formation must be selected with a preference for shadowed, short streets.
	Necessary spacing must be supplied between the buildings to ease the winds cooling effect
	To increase the ventilation effect of the wind buildings must be placed in a dislocated way
	Open spaces must be designed in the path of the winds for sake of a well ventilation
	Layout design must be in a way that the wind corridors must be maintained.
Building Design	Scattered buildings must be designed with lower density and a north-east building orientation
	Shadow protection must be applied on the roof and higher storey buildings placed in south east and west.
	North facades must be maximized and west facades must be minimized for the sake of cooling in the nights
	Necessary arrangements must be applied to ease the penetration of the ventilation through the building
Orientation	5°-10° from south through east
	3° from south through east is optimum.

	Good orientation is from 10° southwest to -19° south east, acceptable orientation is 19° from southwest to -30° southeast
Open Space	Public spaces must be shaded
	Elements that may cause an increase in evaporation must be avoided
Planting	Use of water elements is preferred
	Wide branched, long body trees must be used for sustaining a well wind corridor. Grass and shaded places must be formed around the buildings in the hot season
	Short plants and shrubs must be avoided near the buildings since they block the ventilation
Form	East and west facades must be minimized for sake of decreasing radiation
	Optimum building ratio 1:1,7 and 1,3 in east and west direction.
Facades and Openings	Openings and windows must be maximized in the direction of ventilation for a better cooling performance
	On the other hand, to decrease the solar radiation the windows and openings must be minimized in the solar orientation.
Materials and Colors	Light colors must be preferred for solar radiation Materials that have resistance to humidity must be selected along with a good insulation property

(Source: This table is formed by compiled studies; Olgyay 1973, Ayan 1985, Owens 1986, Givoni 1998, Tokuç 2005, Karaca 2008 and Ovalı 2009)

The housing block consists of 70 separate buildings, each with 32 housing units, resulting in a grand total of 2240 units. Various infrastructures like playgrounds, green areas, sports area, parking area, and social, cultural and educational areas were also considered and evaluated within the frame of the study (Figure 3). Due to the increased height of the buildings, the distance between them could also be kept higher. This helps to obtain a low number of buildings in a given area, and as the number of floors is also high, total number of housing units actually increases. The general and detailed 3D models of the eight-floor plans are shown in Figure 4. Like the four-floor plan, eight-floor plan also shows that the distance between buildings and their orientation has a positive effect on the shadow effect, where with the design, shadows of the buildings are not blocking the other buildings' solar gain.

Figure 3. Site plan of the new alternative (Mert, 2014)

In the site plans 80% of the buildings are shadow free but 10 % of the buildings have 5 SEF and 10 % have 3 SEF. From the Table 2 it is seen that increasing shadow effect increases the exergy load values for all type of plans. This is an expected situation since the decrease in the solar gain increases the need for energy in the building. On the other hand, it is seen that with decreasing SEF the efficiency values increase too. This situation is the result of positive effect of the solar gain in building area regarding the efficiency.

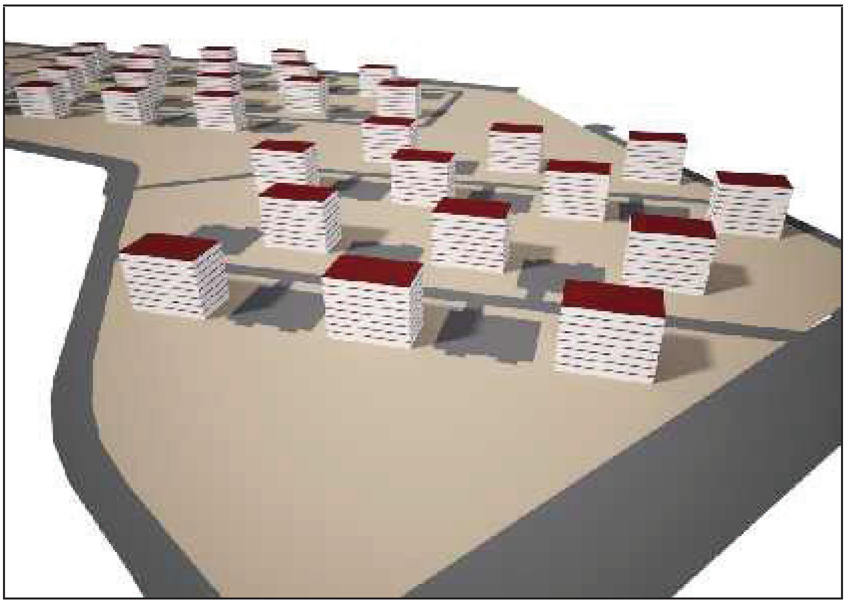

Figure 4. Site model of eight-storey buildings alternative (Mert, 2014)

The exergy efficiency values are about 10.9% and the exergy by fuel values changes from 3438 kW to 3456 kW. The exergy load per housing unit results are 108 to 107.43 kW annually.

Table 2. The results for a building in new plan

SEF	Exergy Load Summer [W]	Exergy Load Winter [W]	Exergy by Fuel [W]	Exergy Efficiency [%]	Exergy Flexibility Factor [%]
5	9794	5435.2	3456.8	10.916	28.54
3	9816	5431.1	3449.4	10.965	28.46
0	9848	5424.9	3438.1	10.998	28.33

The total money saved is shown in shown in Table 3. The investigation covers the amount of money saved in a year for a single

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housing unit, for a building and for the whole site. It is evident that every housing unit saves 780.05 TL in a year by the effect of the energy efficient design, while the value near 25.000 TL for a building and 54.603 TL for the site as a whole. The amount of money saved is considerably high for every Turkish family. When the effects of such a saving are thought in city or country scales, the values will reach to an extremely significant level. Moreover, since sustainability has increased and energy usage is decreased, a reduction in greenhouse emission will also be achieved along with the monetary gains; another benefit for an energy importing country.

The planners and decision makers of urban planning authorities should consider such savings and decrease in the foreign trade deficit. The governmental bodies will clearly respond to this issue if the case, method and result is identified and explained in details.

Table 3. The annual saving by energy efficient design

	Per Housing [TL]	Per Building [TL]	Site Total [TL]
Existing Plan	854,73	27.351,36	59.831,10
New Plan	74,68	2.389,76	5.227,61
Saving	780,05	24.961,60	54.603,49

Conclusion

The exergy efficient urban area planning is investigated from economic point of view in this study. The results of the exergy efficient design showed us that 8-11% exergy efficient increment for the housing units are achieved.

The investigated physical design parameters are topography, climate, solar radiation, temperature, humidity, and wind. Investigated design parameters are; layout effects on the built-up area, orientation, location, building form, distance between buildings, building envelope and insulation, and natural ventilation.

The results show us that the amount of saving is high enough to take attention of every family in Turkey. The total amount of yearly money conservation reaches up to 25000TL per building.

The impact of the energy and economic gain of the exergy efficient design will take too much attention from the government and local administration when the foreign trade deficit and budget equality is taken into account especially in countries that import energy as Turkey in this case.

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