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Early energy simulation of urban plans and building forms

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Abstract

Cities play a major role in more efficient use of energy sources, deployment of renewables, energy efficiency and successful implementation of climate policies. Energy planning in cities and energy performance assessment of new settlements is a new research area that needs efforts from various disciplines. This study introduces a method for energy performance assessment of a new development area in the planning phase. Energy performance of an urban plan designed for a development area of Milas is assesssed by using several building parameters. Obtained results showed that building parameters, urban forms can cause significant energy reductions and the building parameters and urban forms that perform better can be proposed to urban planners, architects, and construction engineers. This study clearly underlines the importance of early energy performance assessment of settlements, neighborhoods and urban areas.

Keywords
Energy planning, Energy simulation, Urban energy performance, Urban form.

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1. Introduction

Today 50 % of earth' s population is living in cities and this number is expected to rise to 70 % in 2050. Major economic and social drivers behind this rapid urbanization is that cities offer oppurtinities to people such as employment, education, security and social services. While cities offer such oppurtinities they demand high amount of energy to perform such activities. Nearly 2/3 of global energy consumption and 70 % of greenhouse gas emissions occur in cities.

Cities will play a major role in more efficient use of energy sources, deployment of renewables, energy efficiency and successful implementation of climate policies.

Cities in Turkey developed inadequately from perspective of different disciplines. Unresistant structures to earthquake, inadequate infrastructure, transportation, water supply, energy losses are causing degradation in life quality and economic losses in urban areas. All these factors should be considered in urban regeneration policies. Energy saving measures that are taken into account in urban level rather than building level will be more effective and efficient.

Energy efficiency measures are not being taken into account in urban planning practice for various reasons. Lack if interest is not one of them but lack off assessment tools and difficulties to access data are major ones.

In order to assess energy performance of a settlement, to evaluate effects of alternative plans and to make improvements in energy performance of a neighborhood, data is needed from a variety of resources and speacilists from different disciplines must use a variety of tools to perform such tasks. Such processes must be simplified to a level that actors of planning hierarchy can evalute them without difficulty (Ianni and Sanchez de Leon, 2013).

There is a need for development of new energy models that will guide planning of energy policies in urban level. The value created by the developed models will be measured by the level of information that they can give to designers and political decision makers.

Thermophysical properties of building materials, efficiency of energy supply systems, occupant activities, building morphology and urban form are major factors that effect energy consumption. While urban form can effect energy consumption of buildings with it's physical properties, urban form can indirectly effect use of energy supply systems (solar systems, urban energy systems).

Energy systems in buildings can be replaced and occupant behaviours can change in shorter term while urban form can have a longer lasting effect on energy consumption in a positive and negative way. Secondly it can be deemed that energy systems and occupant behaviour do not act independently from urban form and urban form can lead better system performance and occupant behaviour. Building energy system' s performance is related occupant behaviour but compact urban forms are not effected by occupant behaviour (Wener and Carmalt, 2006).

Neighborhood scale energy studies are limited and less developed methodologically in comparison to building scale and regional scale studies. Neighborhood scale studies are important because they take into account urban form and energy consumption interaction.

2. Parameters affecting energy efficiency

2.1. Environment (climate)

Climate affects environmental and energy performance of buildings and it affects occupant's comfort. Climate can be analysed in two broad categories: macro climate and micro climate. Macro climate defines the climatic characteristics of a region or zone. Temperature, humidity, average rainfall, wind direction and speed, solar radiation atmospheric pollution are important climate parameters. Micro climate is the surrounding climate of buildings. Neighbouring buildings (shading, wind patterns), terrain (slopes, valleys, hills) can create different micro climates. Also buildings can have different climates on their facades. Facades facing prevailing wind direction, north and south have different micro climates.

2.2. Orientation of building

Orientation of buildings directly affect the solar gains of buildings and indirectly affect heat gains and losses of buildings. Depending on the sun's path successful orientation rotates the building to minimize energy loads and maximize free energy from the sun and wind. Rooms should also be located to take best advantage of the sun depending on their daily uses.

2.3. Planning of settlement area

Analysing the settlement area and locating the buildings in the most suitable location is another important step. Passive solar building design utilizes natural resources. Positioning of buildings and setback distances are critical design parameters. For a good solar passive design best site for a building is where access to daylight is minimised in summer and maximised in winter. Depending on the prevailing wind directions site must be planned to provide protection from winter winds to reduce heating needs and site must be planned to maximise natural ventilation in summer. Topography, neighbouring buildings, vegetation have a crucial affect on solar radiation, wind direction and speed.

2.4. Building form

Building form impacts energy consumption because compact forms minimise heat transfer. Cubic form minimise heat transfer but a rectangular form is better for a passive solar building. A rectangular form with longer sides facing north and south may allow for greater solar gains if north facade properly insulated. Positioning of building elements according to sun reduce heating and cooling loads of buildings. Also inner rooms must be placed to provide the better zoning configuration (Bayraktar and Yılmaz, 2007).

2.5. Building envelope

The building envelope is the interface between the interior of the building and the outdoor environment, including the walls, roof, and foundation. By acting as a thermal barrier, the building envelope plays an important role in regulating interior temperatures and helps determine the amount of energy required to maintain thermal comfort. Minimizing heat transfer through the building envelope is crucial for reducing the need for space heating and cooling. In cold climates, the building envelope can reduce the amount of energy required for heating; in hot climates, the building envelope can reduce the amount of energy required for cooling. Building envelope is an important element in design of passive solar building. Elements of envelope also affect occupant's thermal and visual comfort (Bayraktar and Yılmaz, 2007).

2.5.1. Opaque components

Walls, roof, floors, ceilings... are opaque components of a building. Increased insulation level is the most common way of reducing heat transfer in cold climates. This method can also be used to reduce overheating in warm climates. Climate characteristics should be taken into account for the insulation for a good passive solar building. After minimisation of heat transfer, heating and cooling demand met with passive techniques. Heat loss of a building is related to inner and outer temperature, area of component and U value. Color of the opaque is another parameter that affects it's thermal behaviour. Optical parameters (reflectivity, emissivity,..) are a function of opaque element' s surface color.

2.5.2. Fenestrations

Fenestration systems transmit more than 80 % of solar radiation and they play an important role in passive solar design but in the meantime because of their high U-values they are less resistant to heat transfer. Optical characteristics (emissivity, transmittance, reflectance) of window glasses may cause overheating because they transmit short-wave radiation but they keep long wave radiation inside the building.

Location and size of fenestration systems also have big impact on energy consumption. For passive heating bigger portion of fenestration systems must be placed on southern facades. Fenestration systems facing east and west must be minimised regarding the natural lighting requirements because they have little solar gain in winter and they result overheating in summer (Bayraktar and Yılmaz, 2007).

2.5.3. Passive control devices

The use of sun control and shading devices is an important aspect of many energy-efficient building design strategies. In particular, buildings that employ passive solar heating or daylighting often depend on well-designed sun control and shading devices. During cooling seasons, external window shading is an excellent way to prevent unwanted solar heat gain from entering a conditioned space. Shading can be provided by natural landscaping or by building elements such as awnings, overhangs, and trellises. Some shading devices can also function as reflectors, called light shelves, which bounce natural light for daylighting deep into building interiors. The design of effective shading devices will depend on the solar orientation of a particular building facade.

Another passive control system is natural ventilation supplied by openings on building envelope. Natural ventilation systems rely on pressure differences to move fresh air through buildings. Pressure differences can be caused by wind or the buoyancy effect created by temperature differences or differences in humidity. In either case, the amount of ventilation will depend critically on the size and placement of openings in the building.

3. Study area Milas

Milas is a historical settlement area which still has a traditional and historical urban structure. For the study, a design for development area of Milas is used. The design for new development has references from urban character of Milas. Urban blocks of conservation area have a closed form, a mix of attached and detached buildings with 2-3 storeys. Also widenings and narrowings of streets create a sense of motion and surprise effect. Characteristics urban forms of Milas were used in the new design.

3.1. Milas climate

The coastal areas of Turkey bordering the Aegean Sea and the Mediterranean Sea have a hot-summer Mediterranean climate, with hot, dry summers and mild to cool, wet winters. Milas has an average temperature of 6.4°C in January and an average temperature of 26.8°C in July. Annual average temperature for Milas is 16.3°C.

3.1.1. Microclimate

Topography is a main factor that affect microclimate. Milas is surrounded with mountians from east, west, south and north. Milas is on an alluvial plain with mounds to the east of Sodra mountain. There is slope to the north with 30 % inclination. The old city center with dense traditional urban form has an inclination between 5-15 %.

3.1.2. Heating and cooling degree days of Milas

According heating and cooling degree days data of Milas heating is most needed in November, December, January, February and March. Cooling is mostly needed in June, July, August and September. Passive strategies should be planned to cover most of supply heating and cooling needs in cold and warm months.

3.2. Site selection and orientation

Location and topography of city is suitable for hot and dry climates. Milas is placed on a plain and mountains to the north, south, east and west provide shelter to city. The hill to the south blocks the wind that mostly blow from south in winter and the mountain to the north acts as a barrier to the cold north winds. The wind that mostly blow from north in summer is advantegeous for passive cooling. Topography of Milas provide advantage for passive cooling and heating which give Milas a high ranking in site selection and orientation (Meşe, 2014).

3.3. Urban form

Traditional settlement area of Milas has a compact urban form that prevent overheating in summer and overcooling in winter. Such an urban form also reduce heating and cooling energy needs (Meşe, 2014).

3.4. Urban form and solar envelope

In hot climates row houses elongated along the east-west axis provide the best shading of the critical east and west walls. Mostly building blocks in Milas developed along the east-west direction. These attached buildings provide shading to each other thus reduce cooling loads in summer. Building blocks along north-south axis are less dense then east-west oriented building blocks and these blocks have dead ends along east-west direction that allow south facing structures. North-south oriented building blocks allow sun from south thus they provide passive heating in winter (Meşe, 2014).

Figure 1. Plan of Milas development area.

3.5. Street orientation

In hot dry climates streets should be designed to provide maximum shading to pedestrians and buildings should have minimum solar radiation (Givoni, 1998).

Street width and orientation affect urban microclimate by blocking sun and changing wind direction. In case of contradiction, sun effects should be the primary design factor. For pedestrian comfort east-west oriented streets offer best solution (Olgyay, 1992).

4. Energy performance assessment of Milas plan

4.1. Simulation parameters and building forms

In the study energy performance of the new urban development is evaluated with respect to chosen building parameters and energy performance of chosen building forms are compared. Four building parameters that affect energy loads are chosen. These are insulation thickness-window type, infiltration rate, ventilation type and shading. There are 438 buildings and ten building forms which were chosen during design of new development area. The method in this study is in the following order: planning of new settlement, design of building forms, 3D modelling of settlement, evaluation of building parameters, access to climate data, energy simulation of new development and evaluation of simulation outputs.

The new development area has ten different building forms in it' s design. It is expected that these ten different forms will have different energy because of their form.

For building parameters, three values are chosen for insulation thickness – window type and infiltration rate. For conditioning and ventilation one case is cooling and mech. vent. is on for other case only natural ventilation is available. Shading is on for one case and shading is off for the other case.

In total there are 36 combinations for all values of parameters. For all combinations energy simulation is run for total energy demand, heating demand and cooling demand.

4.2. Simulation program

EnergyPlus program is used for simulation of total energy, heating cooling loads of buildings.The EnergyPlus program is a collection of many program modules that work together to calculate the energy required for heating and cooling a building using a variety of systems and energy sources. It does this by simulating the building and associated energy systems when they are exposed to different environmental and operating conditions. The core of the simulation is a model of the building that is based on fundamental heat balance principles. EnergyPlus implements detailed building physics algorithms for heat transfer—radiation, convection, and conduction—air and moisture transfer, light distribution, and water flows. EnergyPlus integrated solution manager manages the surface and air heat balance modules and acts as an interface between the heat balance and the building systems simulation manager. The surface heat balance module simulates inside and outside surface heat balance; interconnections between heat balances and boundary conditions; and conduction, convection, radiation, and mass transfer (water vapor) effects. The air mass

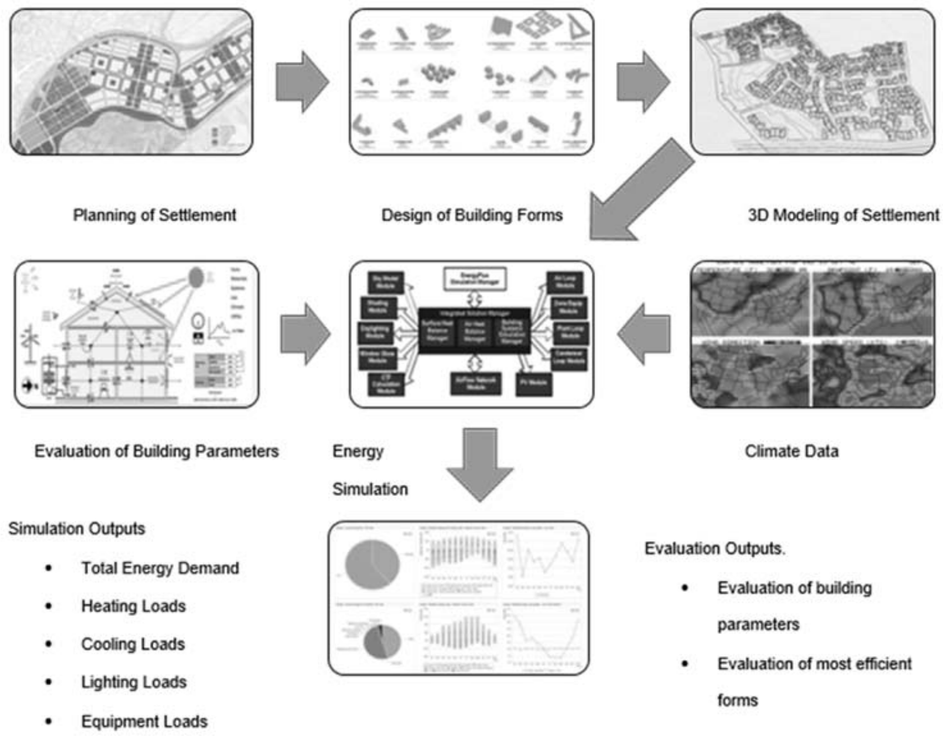

Figure 2. *Method of the study.*

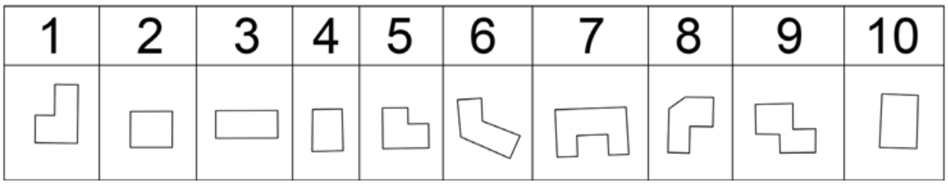

Figure 3. *Building forms.*

balance module deals with various mass streams, such as ventilation air, exhaust air, and infiltration. Integrated structure of EnergyPlus program produces more accurate results (Eskin, 2009). Simulation Manager, heat and mass balance simulation, building systems simulation are main components of EnergyPlus program (Aktacır et al., 2011).

4.3. Simulation results

Energy simulations results for all combinations are evaluated with SPSS program. Total energy demand, heating demand and cooling demand graphs are drawn for building forms.

Building form have a greater effect on cooling energy demand. Building form 6 have highest cooling energy demand (61.98 kWh/m²) and building form 10 have the lowest cooling energy demand (50.73 kWh/m²). There is a 11.25 kWh/m² (22.17 %) difference between the minimum and maximum values. For heating energy demand

Table 1. *Building parameters.*

Insulation Thickness	0 cm	4 cm	10 cm
Wall U-value (W/mK)	1.41	0.44	0.22
Window Type	Single	Double	Triple
Infiltration Rate	0.2 ach	0.5 ach	1.1 ach
Conditioning/Ventilation	Cooling/ Mech. Vent.		Natural Ventilation
Shading	Shading On		Shading Off

Table 2. *Building forms energy demand.*

Form	Form 1	Form 2	Form 3	Form 4	Form 5	Form 6	Form 7	Form 8	Form 9	Form 10
Heating Avg.	61.56	59.96	60.67	62.07	63.32	62.33	63.60	60.68	63.94	58.75
Cooling Avg.	60.22	52.66	53.73	54.92	60.26	61.98	58.55	61.14	57.64	50.73
Heat. + Cool.	121.78	112.63	114.40	116.99	123.58	124.31	122.15	121.82	121.59	109.47

Table 3. *Infiltration rate effect on building form energy demand.*

Form	Form 1	Form 2	Form 3	Form 4	Form 5	Form 6	Form 7	Form 8	Form 9	Form 10
HEATING										
I.R. 0.2 ach	42.15	39.94	41.03	42.10	43.90	42.91	43.89	41.39	44.18	38.51
I.R. 0.5 ach	56.23	54.43	55.31	56.69	58.01	56.96	58.25	55.70	58.60	53.28
I.R. 1.1 ach	86.31	85.52	85.67	87.43	88.06	87.11	88.67	84.96	89.06	84.45
COOLING										
I.R. 0.2 ach	62.89	55.18	56.20	57.63	63.01	65.09	61.33	64.38	60.47	53.06
I.R. 0.5 ach	60.23	52.56	53.38	54.67	60.22	62.12	58.46	60.85	57.52	50.45
I.R. 1.1 ach	57.53	50.25	51.61	52.45	57.55	58.74	55.85	58.19	54.93	48.66
Heat.+Cool .										
I.R. 0.2 ach	105.04	95.12	97.23	99.73	106.90	108.00	105.21	105.77	104.65	91.57
I.R. 0.5 ach	116.46	106.98	108.70	111.36	118.22	119.08	116.72	116.56	116.11	103.73
I.R. 1.1 ach	143.84	135.77	137.29	139.88	145.61	145.85	144.52	143.15	143.99	133.12

Table 4. *Insulation and window type effect on building form energy demand.*

Form	Form 1	Form 2	Form 3	Form 4	Form 5	Form 6	Form 7	Form 8	Form 9	Form 10
Heating										
No Ins Sgl W.	107.70	103.79	105.39	107.41	110.41	108.88	110.70	106.45	111.14	101.51
4cm Ins Dbl W.	45.72	44.83	45.26	46.62	47.30	46.33	47.57	44.83	47.90	44.08
8cm Ins Trp W.	31.28	31.26	31.37	32.18	32.26	31.77	32.53	30.77	32.80	30.65
Cooling										
No Ins Sgl W.	57.09	49.88	51.28	52.31	57.36	58.69	55.59	58.00	54.74	48.18
4cm Ins Dbl W.	62.88	54.85	55.66	56.92	62.60	64.81	61.00	63.50	59.97	52.65
8cm Ins Trp W.	60.68	53.27	54.26	55.54	60.80	62.45	59.04	61.91	58.21	51.35
Heat.+Cool.										
No Ins Sgl W.	164.78	153.67	156.67	159.72	167.77	167.57	166.29	164.45	165.87	149.69
4cm Ins Dbl W.	108.59	99.68	100.92	103.53	109.91	111.14	108.58	108.34	107.87	96.73
8cm Ins Trp W.	91.97	84.53	85.62	87.72	93.06	94.22	91.57	92.69	91.01	82.00

there is 5.19 kWh/m^2 (8.8 %) difference between maximum and minimum values. Building form 9 has highest heating energy demand and building form 10 has minimum heating energy demand.

Infiltration rate has a bigger impact on heating energy demand. Average heating energy demand is 42 kWh/m^2 for 0.2 ach infiltration rate. Increasing infiltration rate increase heating energy demand and heating energy demand doubles as we increase infiltration rate to 1.1 ach (86.72 kWh/m^2). With increasing infiltration rate heating energy demand differences between building forms decrease. For 0.2 ach the difference between maximum and minimum heating energy demand of building forms is 14.7 %. As we increase infiltration rate to 1.1 ach this difference decreases to 5.4 %. Increase in infiltration rate has a lesser effect on average cooling energy demand (9 %).

Increasing infiltration rate slightly decreases cooling energy demand. For 0.2 ach average cooling energy demand is 59.92 kWh/m^2 and for 1.1 ach average cooling energy demand is 54.58 kWh/m^2 (9 % decrease).

Insulation and window type have a greater effect on heating energy demand. If there is no insulation and if we use single window, average heating energy demand is 107,34 kWh/m^2. Using 4 cm insulation and double windows decrease average heating energy demand 46,04 kW/m^2 (57 %). Increasing insulation from 4 cm to 8 cm and using triple windows decrease average heating energy demand to 31.69 kWh/m^2 (31.17 %). Increasing insulation thickness and using more layered windows increase average cooling energy demand from 54.31 kWh/m^2 to 59.48 kWh/m^2 (9.5 %). But a further increase in insulation thickness and window layers decrease average cooling energy from 59.48 kWh/m^2 to 57.75 kWh/m^2 (2.9 %).

Shading reduces average cooling energy demand from 69.18 kWh/m^2 to 45.18 kWh/m^2 (35 %). There is an 23 % difference between in maximum and minimum cooling energy demand when there is no shading. This difference is 21 % when shading is applied.

In all forms buildings have highest energy demand in case of no insulation, single window, 1.1 infiltration rate, mechanical ventilation and no shading. Buildings have minimum energy demand with 8 cm insulation, triple window, 0.2 (ach) infiltration rate, with shading and natural ventilation. Building form 10 has the minimum energy demand. In consecutive order building form 10, building form 2 and building form 3 have minimum energy demand. Building forms 5, 6, 7 and 9 have highest energy demand in consecutive order.

Average total energy demand when cooling and mechanical ventilation is available is 152.08 kWh/m². If cooling and ventilation is done by natural ventilation average total energy demand is 94.62 kWh/m². There is a 37.8 % decrease in average total energy demand. Differences between energy demand of building forms vary with values of building parameters. In case of no insulation-single window, mechanical ventilation, energy demand of building forms have maximum difference. If buildings have 8 cm insulation-triple window, and natural ventilation, differences between energy demand of buildings are minimum. Increase in insulation thickness and increase in window layers, reduce total energy demand and it also decrease differences in total energy demand between different building forms.

In all forms buildings have highest heating energy demand in case of no insulation, single window, 1.1 infiltration rate, and with shading. In this case average heating energy demand differences between building forms are maximum. Buildings have minimum average heating energy demand with 8 cm insulation, triple window, 0.2 (ach) infiltration rate and with no shading. In this case average heating

Table 5. *Shading effect on building form energy demand.*

Form	Form 1	Form 2	Form 3	Form 4	Form 5	Form 6	Form 7	Form 8	Form 9	Form 10
Heating										
No-Shading	56.85	55.88	56.21	57.61	58.56	57.48	59.05	55.65	59.38	54.76
Shading	66.28	64.04	65.14	66.53	68.08	67.17	68.15	65.72	68.51	62.73
Cooling										
No-Shading	73.05	63.77	64.87	66.30	72.94	75.34	70.64	74.12	69.51	61.26
Shading	47.38	41.56	42.59	43.54	47.58	48.63	46.45	48.16	45.77	40.19
Heat. + Cool.										
No-Shading	129.90	119.65	121.08	123.91	131.50	132.82	129.70	129.77	128.89	116.02
Shading	113.66	105.60	107.73	110.07	115.66	115.80	114.60	113.87	114.28	102.92

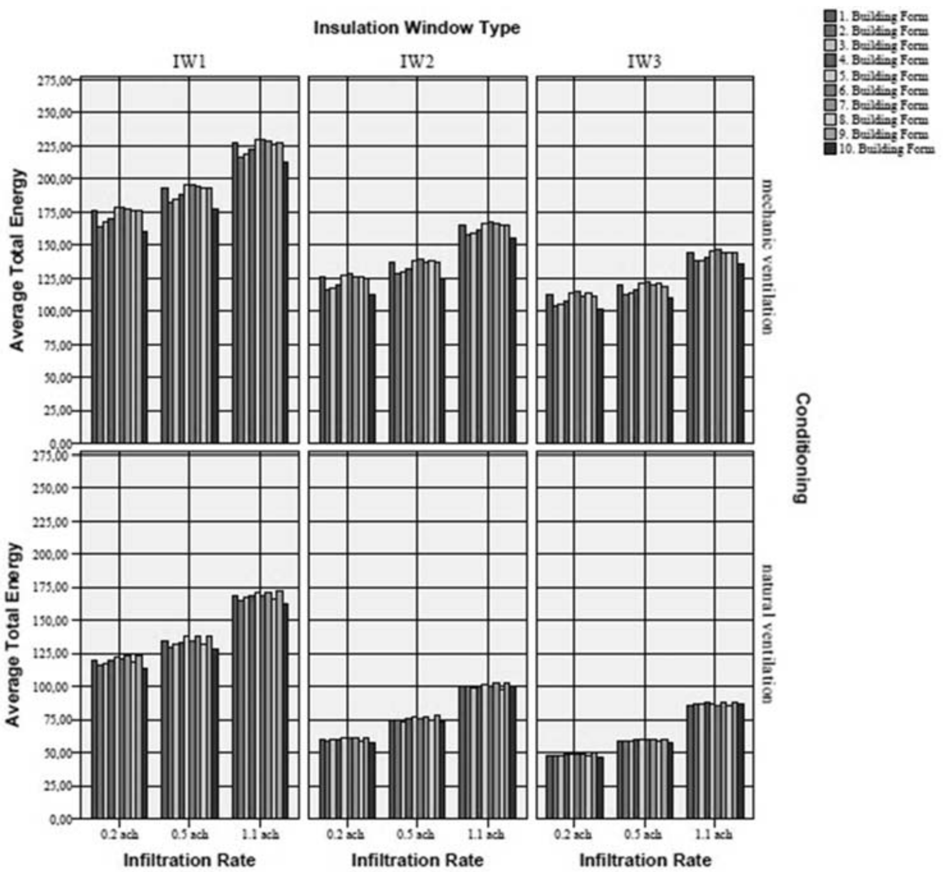

Figure 4. *Building parameters, building forms, average total energy demand.*

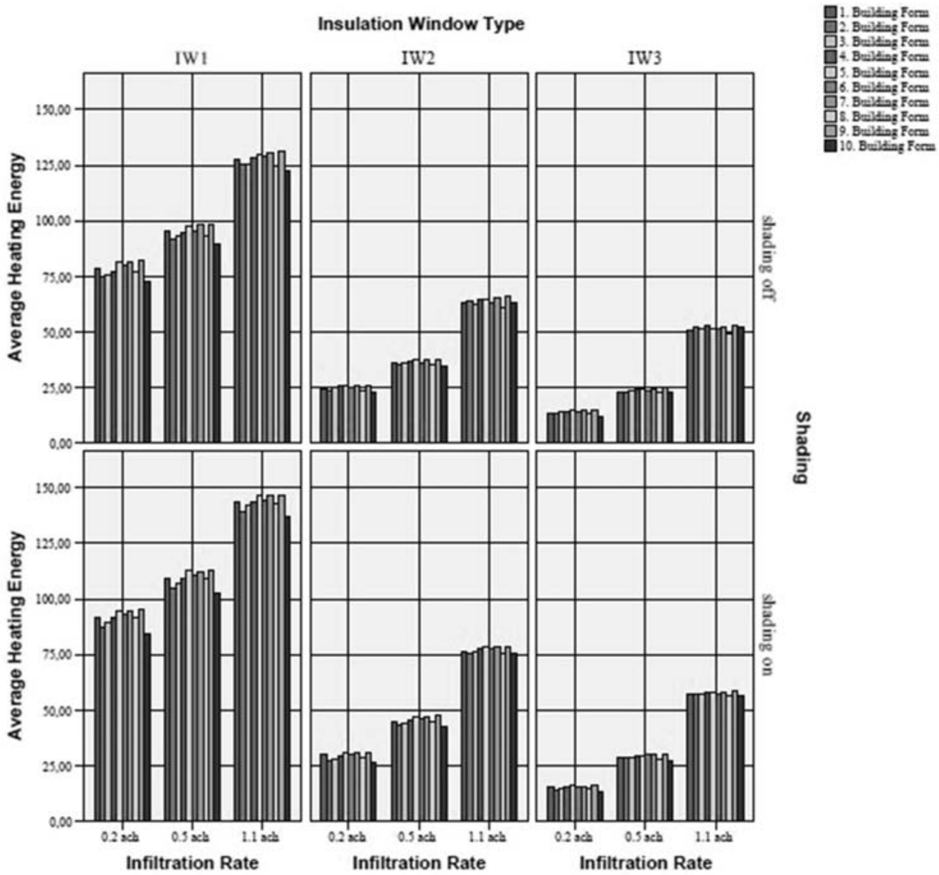

Figure 5. *Building parameters, building forms, average heating energy demand.*

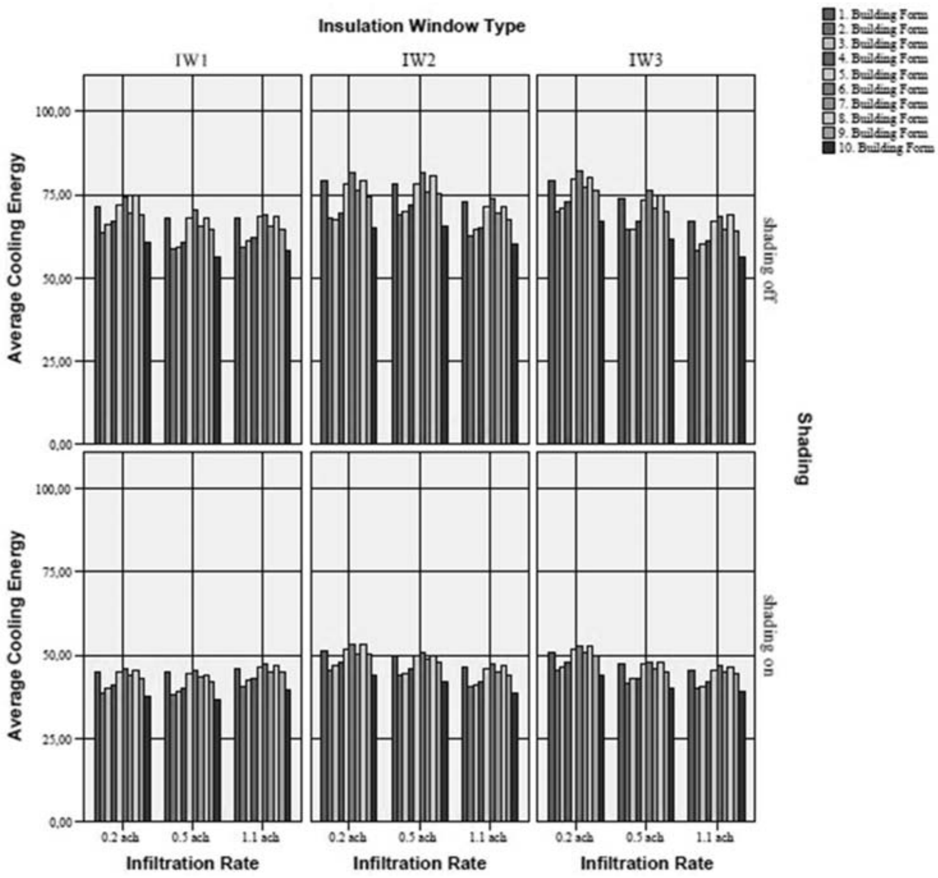

Figure 6. *Building parameters, building forms, average cooling energy demand.*

Table 6. *Simulation results of all combinations.*

Building Parameters	Avg. Energy	Total Energy	Avg. Heat. Energy	T. Heat. Energy	Avg. Cool. Energy	T. Cool. Energy
IW1_TL1_HV1_LS1	177.20	22,540,031.42	75.74	9633827.87	68.08	8659619.45
IW1_TL1_HV1_LS2	165.57	21,061,216.28	90.09	11459800.95	43.94	5589477.72
IW1_TL1_HV2_LS1	113.38	14,422,488.83	79.95	10170198.96	0.00	0.00
IW1_TL1_HV2_LS2	125.25	15,932,779.61	91.85	11683460.31	0.00	0.00
IW1_TL2_HV1_LS1	192.93	24,542,055.56	96.42	12265308.55	63.08	8024189.48
IW1_TL2_HV1_LS2	184.96	23,527,977.00	110.13	14009373.50	41.40	5266687.22
IW1_TL2_HV2_LS1	126.25	16,060,069.34	92.86	11811876.22	0.00	0.00
IW1_TL2_HV2_LS2	141.01	17,936,557.85	107.58	13684433.93	0.00	0.00
IW1_TL3_HV1_LS1	227.62	28,954,753.09	130.39	16585673.93	63.82	8118010.39
IW1_TL3_HV1_LS2	218.45	27,787,402.62	141.28	17971141.39	43.78	5569125.98
IW1_TL3_HV2_LS1	158.16	20,118,537.94	124.75	15868457.35	0.00	0.00
IW1_TL3_HV2_LS2	178.23	22,671,212.51	144.79	18417590.39	0.00	0.00
IW2_TL1_HV1_LS1	132.04	16,796,282.79	25.65	3262799.58	72.92	9275529.65
IW2_TL1_HV1_LS2	111.24	14,150,056.81	29.07	3698292.37	48.73	6199182.33
IW2_TL1_HV2_LS1	57.64	7,331,688.29	24.22	3080585.81	0.00	0.00
IW2_TL1_HV2_LS2	62.58	7,960,710.04	29.15	3708613.55	0.00	0.00
IW2_TL2_HV1_LS1	143.12	18,205,505.83	36.04	4584862.14	73.63	9366389.52
IW2_TL2_HV1_LS2	123.83	15,751,106.78	43.57	5542893.16	46.82	5956156.06
IW2_TL2_HV2_LS1	70.26	8,937,408.03	36.83	4685238.62	0.00	0.00
IW2_TL2_HV2_LS2	80.11	10,190,004.53	46.69	5939043.37	0.00	0.00
IW2_TL3_HV1_LS1	168.65	21,453,175.32	67.93	8641041.12	67.28	8559279.18
IW2_TL3_HV1_LS2	156.38	19,892,674.76	79.72	10140750.31	43.22	5498091.66
IW2_TL3_HV2_LS1	93.32	11,871,004.62	59.89	7618663.21	0.00	0.00
IW2_TL3_HV2_LS2	107.78	13,710,451.23	74.36	9458843.53	0.00	0.00
IW3_TL1_HV1_LS1	120.86	15,374,231.05	12.75	1621974.81	74.66	9498118.22
IW3_TL1_HV1_LS2	96.85	12,320,096.51	14.79	1880823.63	48.66	6190060.72
IW3_TL1_HV2_LS1	48.09	6,117,127.64	14.61	1857991.32	0.00	0.00
IW3_TL1_HV2_LS2	48.43	6,160,578.56	15.00	1907880.90	0.00	0.00
IW3_TL2_HV1_LS1	126.51	16,092,307.02	24.19	3076658.96	68.92	8767904.61
IW3_TL2_HV1_LS2	107.54	13,678,980.99	29.68	3775081.07	44.41	5649231.04
IW3_TL2_HV2_LS1	56.61	7,201,533.25	23.18	2948944.66	0.00	0.00
IW3_TL2_HV2_LS2	61.68	7,845,567.45	28.22	3589516.03	0.00	0.00
IW3_TL3_HV1_LS1	149.35	18,998,151.38	53.05	6748562.97	62.84	17449134.21
IW3_TL3_HV1_LS2	134.35	17,089,817.19	57.93	7368318.33	42.97	11506661.97
IW3_TL3_HV2_LS1	84.09	10,696,980.41	50.65	6443147.43	0.00	0.00
IW3_TL3_HV2_LS2	90.32	11,489,456.38	56.92	7240951.73	0.00	0.00

* IW Insulation-Window, TL Infiltration Rate, HV Ventilation, LS Shading

energy demand differences between building forms are minimum. Increase of insulation thickness, usage of more layered windows, decrease of infiltration rate reduce average heating energy demand differences between building forms. Building forms 9, 5 and 6 has maximum average heating energy demand and building forms 10, 2 and 3 have minimum average heating energy demand. in consecutive order.

In all forms buildings have highest average cooling energy demand in case of 4 cm insulation, double window, and with no shading. In this case average cooling energy demand differences between building forms are maximum. Buildings have minimum average cooling energy demand with 0 cm insulation, single window, and with shading. In this case average cooling energy demand differences between building forms are minimum. Infiltration rate have little effect on average cooling energy demand. Building forms 6, 8, 1 and 5 have maximum average cooling energy demand and building forms 10, 2 and 3 have minimum average cooling energy demand in consecutive order.

5. Conclusion

In the early design phase of new settlements when decisions are being made about roads, building forms; solar gains, energy performance of buildings should be investigated. Such early assessments can provide advisory results for other disciplines that are going to take part in the design and construction of new settlements. Also energy performance evaluations in earlier phases of urban planning are likely to be more efficient than later phase interventions. Therefore incorporation of energy performance evaluations into urban planning practice is still being investigated and debated.

In this study, energy performance of a new development area which has references to traditional form of Milas is simulated with various building parameters. For every paramater value total energy demand, total heating energy demand and total cooling energy demand are calculated. Simulation results showed effects of building parameters and building forms on energy demand. Depending on values of the building parameters new development area's maximum simulated energy demand is 28.954.533 kWh and it' s minimum simulated energy demand is 6.117.128 kWh. For total heating energy demand maximum simulated value is 18.417.590 kWh and minimum value is 1.621.975 kWh. For total cooling energy demand maximum and minimum values are 9.498.118 kWh and 5.266.687 kWh respectively. Differences between maximum and minimum values show how much building parameters can effect affect energy performance of a newly planned settlement. Also building forms used in the design of urban plan affect energy demand considerably. For average heating energy demand there is a 8.8 % change between most energy efficient and least energy efficient building forms. For cooling energy demand this value is 22 %. For heating and cooling demand there is a 13.5 % change between most energy efficient and least energy efficient building forms.

This study is limited to chosen building parameter values, building forms and as a future work, the study can be expanded to evaluate the impact of a broader range of parameters in urban settlements. Urban heat island effects which account urban morphology have direct effects on weather data. Integration of urban heat island effects may generate more accurate energy simulation results, as a future study.

As a conclusion, this study is aimed to show the potential for energy savings In the planning phase of new developments. It is possible to evaluate energy performance of neighborhoods and make recommendations about values of building parameters and building forms.

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