factors can be categorized as follows:

**Urban density**

Rapid population growth brings with it, a growing need for built-up area which is one of main problems of the cities. Most of the time, this need is proved with high-rise buildings or compact settings, instead of expanding the boundaries. This brings the term of "urban density" which is used in urban planning and urban design to refer to the number of people inhabiting in a given urbanized area [Sokido and Bhaduri, 2013]. The urban density can affect the total energy demand of a city with different ways and these effects are complex and conflicting [Givoni, 1998]. Density sometimes can bring the benefits but it also creates extra loads and undesirable conditions. It affects the thermal performance, the natural lighting and ventilation possibilities of the buildings and these effects can either be positive or negative according to dominant climatic condition. On the other hand, the density supports to the district energy systems and besides that, the infrastructure facilities are shorter so it reduces also the energy requirement for pumping. Controversially, the energy requirement for pumping on the vertical direction is getting higher in the high-rise cities [Eicker et al., 2010]. The effect of density on heating, cooling and lighting energy demand of the areas is different and their influences are changing according to climatic conditions.

**Characteristics of built environment**

Physical properties of buildings and technologies in the building sector have a significant effect on the energy consumption. Insulation properties, windows type and area, the efficiency of technical appliances in buildings such as elevators, escalators, HVAC systems' equipments are profiled the building for evaluation of its energy. Building envelope, this is interface between outdoor environment and indoor conditions, works as a thermal barrier and serves a function in regulating a comfortable indoor temperatures. It plays a crucial role for reducing the need for heating and cooling of building. Moreover the placement of windows and doors, the size and location in the envelope has a significant role on the control of energy losses. Buildings should always be contemplated in the conjunction with their surroundings. In order to manage the use energy of the built environment in a sustainable way and to minimize harmful emissions, the performance of the city scale must be considered. Building energy condition can be characterized with urban pattern, building stock properties and also infrastructure possibilities. In the terms of shading and reflection, lighting and thermal energy loads are influenced by the architectural form of the urban structures and the neighborhood relationship.

**Possible renewable energy source applications**

Buildings are integrated into networks of overriding technical infrastructures which are water supply, drainage, sewerage, water disposal, electricity system, heating and cooling networks and transportation. The development of more sustainable cities critically depends on a style of urban infrastructure condition that encourages more efficient patterns of resource consumption. District heating or cooling in combination with energy efficiency measures in buildings account for approximately one third of the reduction of emissions [Särnholm et al., 2009]. Therefore, efficient supply system and integration of renewable energy technologies to the network are crucial for sustainable cities. On the other hand renewable energy integration is more meaningful solution at urban scale. Indivual building renewable energy integration is not factual answer for efficiency and feasibility. Renewable energy application on the urban area or district, which is directly connected to the grid so it eliminates transmission loss on the other hand it doesn't use any other land for application, has better energy performance than the individual applications. Solar PV or solar heating system integration on the roof has high potential with easy application. Façade integration has not easy for the underperformance of panels caused by the inequable shading. Wind tirbunes are not easy to implement to the urban district for the reason that it is affected from location of the building, wind direction, heights of surrounding buildings, other roof-top structures and so on.
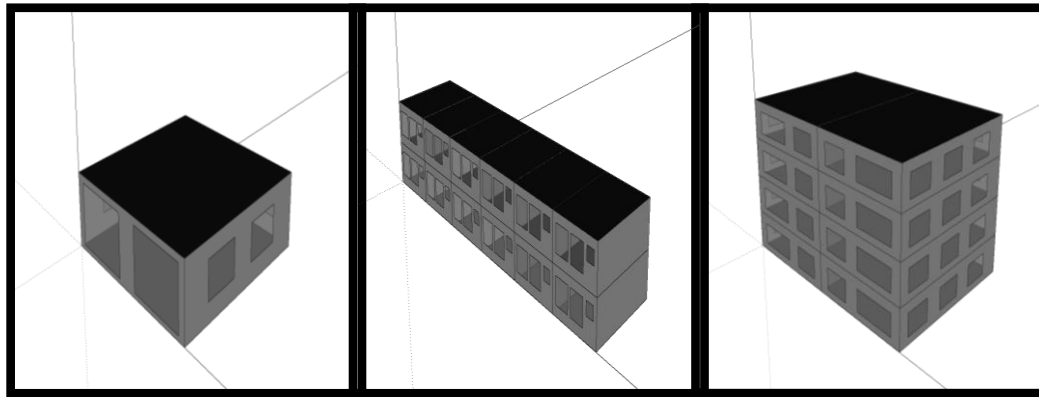
| Building type | One storey house | Row houses | Apartment block |
|---|---|---|---|
| Floor area | 10.5mx10.5m | 7m x10m | 20mx14m |
| Height | 3.5m | 7m | 10.8 m |
| Building unit | 1 house- | 6 houses | 1 block- |

**Figure 1**        (a) Energy plus model of one storey house (b) Row houses and (c) Apartment block

## METHODOLOGY FOR PARAMETRICAL ANALYSIS

In the urban transformation projects, especially used for residential areas, highrise apartment form is used for restructuring the land in the furtherance of scalling up the recreation and green area opportunity. In order to limit the complexities related with real urban areas, the archetype was defined according to common typologies for transformation projects and this simplified type is used for energy performance simulations. There is not any survey for common building typology in Turkey but the German building stock was explored on the basis of energy demand properties and main residential building typologies defined by Institute for Housing and Environment-Germany (IWU, 2003). According to this research one storey, row houses and apartment blocks take into account for possible former building types of urban transformation area **as shown in Figure1.** According to profesionel point of view similar building forms are commonly used also in Turkey.

The apartment block with 10 storeys is chosen for possible new building form for urban transformation projects in Turkey and Germany. Floor area of the building is 24,4m*24,4m and height of it is 30m. Glazed area on the façade is 35% of the full façade area. Three dimensional urban quarter simulation was done for generic urban form **as shown in Figure 2.** The representative urban quarter constitutes of 9 generic building blocks and the distance between the buildings varies according to site density. The major orientation for the site design is the South. To see the total energy demand of the building, heating and cooling analysis including the annual electricity consumption with daylight responsive control was calculated in the Energyplus simulation program (simulation methodology has been described detailedly in the paper Kesten et al., 2011). Ankara and Stuttgart Energyplus weather data is used for the simulations.
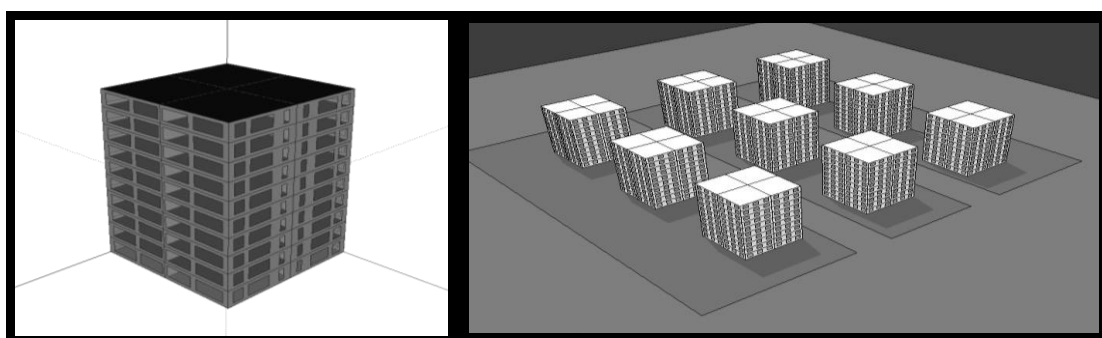


**Figure 2**        (a) Energy plus model of urban quarter and (b) Energy plus model of urban quarter according site density.

**Table 1. U-values (W/m²K) of building envelope according to construction year and building energy standards (LE: Low energy standard, PH: Passive house standard)**

| Building Component | ANKARA | | | STUTTGART | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 1984 | 2000 | 2008 | 1948 | 1968 | 1978 | 1983 | 1994 | 2000 | 2007 | 2009 | LE1 | LE2 | PH |
| Exterior walls | 1.2 | 0.5 | 0.5 | 1.7 | 1.4 | 1.03 | 0.8 | 0.6 | 0.5 | 0.3 | 0.24 | 0.23 | 0.15 | 0.13 |
| Floor | 0.75 | 0.45 | 0.45 | 0.8 | 0.8 | 1 | 0.8 | 0.6 | 0.5 | 0.3 | 0.24 | 0.3 | 0.26 | 0.19 |
| Roof | 0.47 | 0.3 | 0.3 | 0.8 | 0.8 | 0.6 | 0.5 | 0.3 | 0.3 | 0.3 | 0.24 | 0.25 | 0.19 | 0.15 |
| Windows | 2.7 | 2.6 | 2.4 | 5.89 | 2.72 | 2.72 | 2.72 | 1.93 | 1.82 | 1.73 | 1.3 | 1.2 | 0.9 | 0.8 |

Occupation of the flats was simulated for an identical family scenario, consisting of 4 family members who are not home during the day except on weekends. The usage time of the appliances was configured according to the statistical data. Every house has television, computer, washing machine, dishwasher, oven, and fridge. The usage was determined as the average time taken from the German household statistic (Gruber and Schlomann., 2005)The EN ISO 13791 was taken as an input for internal gains from occupants. The lighting was defined as 13 W/m$^2$ and 40% of this is the convective gains. The heating set point was defined as 20°C and cooling set point was defined as 26°C. The heating system was shut down end of April to the end of October and while the cooling was operational for the duration of this time. The properties of building envelope are defined according to national standarts of the countries **as shown in in Table 1.** Simulation has been validated with measured data and it has been described detailedly in the paper Tereci et al., 2010. In the transformation project areas it is assumed that the former buildings in Germany can have been built before 1994 standards. Because of the unplanned development after 1980 in Turkey, the energy values of former buildings can be the worse than this results. But 1984 building standards are taken into account for building envelope which can be the best energy performance case for urban transformation project.

## PARAMETRICAL ANALYSIS RESULTS

The heating, cooling, electricity and hot water useful energy demands for possible former building types were simulated without considering the effects of obstructions. These results are **presented in Table 2** and serve as a baseline for comparison. In the cold climatic condition like Stuttgart and Ankara, heating demand especially for residential houses is very important indicator for energy performance of the building.

Heating and cooling demand of the building types in different dense areas were evaluated to get an understanding of the site density effect. **Figure 3 shows** the heating and cooling demand of the former building types located in the centre of an urban block with function of site density densities which were constructed in 1984. Without any shading effect the heating consumption of one storey house is 106.5 kWh/m$^2$ while depending on the shading of the area the heating consumption can be 12% higher in Ankara climatic condition. The energy demand of apartment block is less by compare with one family house and row houses for both climatic conditions. Site density is affected less in Stuttgart by 8% for one family houses. Especially for cooling loads site density was highly affected in Ankara conditions and coillings loads decrease nearly 50% for all type of buildings.

**Table 2. Dynamic simulation results of former reference buildings (construction year 1984) without surrounding obstructions**

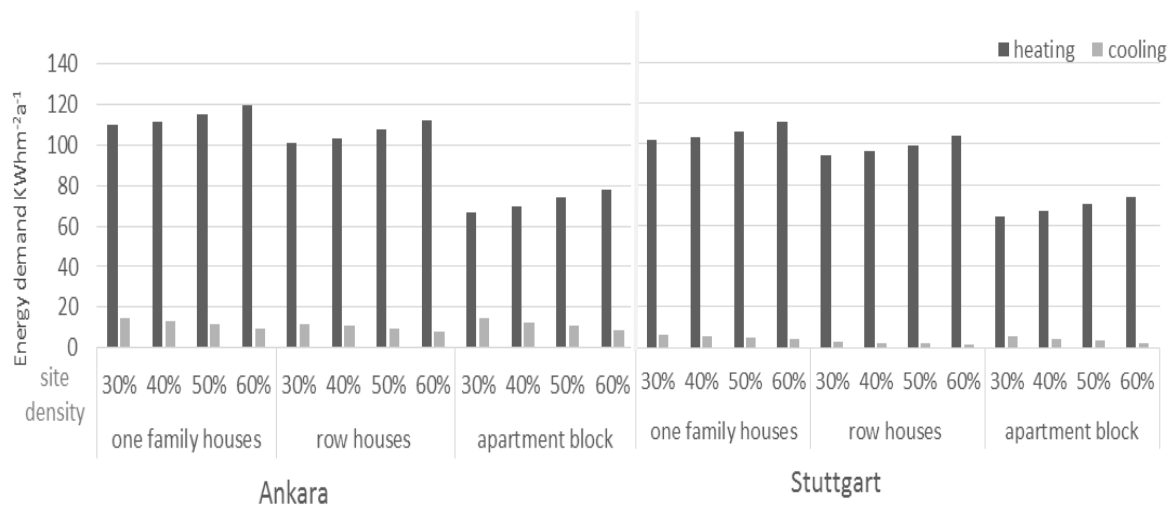| Reference Buildings | Ankara | | | Stuttgart | | |
|---|---|---|---|---|---|---|
| | Heating | Cooling | Electricity | Heating | Cooling | Electricity |
| One Family House | 106.53 | 19.44 | 30 | 101.53 | 6.03 | 33 |
| Row Houses | 98.63 | 15.38 | 18 | 94.01 | 2.82 | 19 |
| Apartment Block | 61.82 | 19.2 | 21 | 62.77 | 6.87 | 23 |

**Figure 3**　　　　Heating and cooling energy demand of building types with site density

As mentioned before, physical properties of buildings have a significant effect on the energy consumption so the building envelope properties according to energy standards or codes are profiled the building for evaluation of its energy. To understand the effect of energy standards on the buildings, reference buildings are simulated according to different construction years. **Figure 4 presents** the energy demand of eleven versions of apartment block according to different energy standards in Germany since 1948. The passive standard buildings show the heating demand without heat recovery from exhausted ventilation air. Similar trend is observed for one family house and row houses. It is not possible to mention or calculate for Turkey another building envelope properties because of the lack of the energy standards. We can assumed that the buildings which were built before 1984 are in the worse than these conditions and Germany example can have an idea about the effect of thermal properties of envelope. According to results, building standards in 1994 has given a jump for the energy performance of buildings and we can say that for urban transformation project for both countries, the energy performance of the site can be enhance at least 30% for the buildings constructed in the year before 1994.

It is also important to decide for new construction area density for urban transformation project. Therefore ten storeys apartment block which is constructed with current energy standards (Turkey 2008, Germany 2009) was evaluated according to site density and the results are presented **in Figure 5**. The heating consumption of the blocks is 53 kWh/m$^2$ and cooling demand is 10 kWh/m$^2$ in Stuttgart. The heating consumption of the blocks is 55 kWh/m$^2$ and cooling demand is 16 kWh/m$^2$ in Ankara. Depending on the shading on the site, the heating demand can be 25% higher more and the cooling demand can be 40 % less than the building without shading.
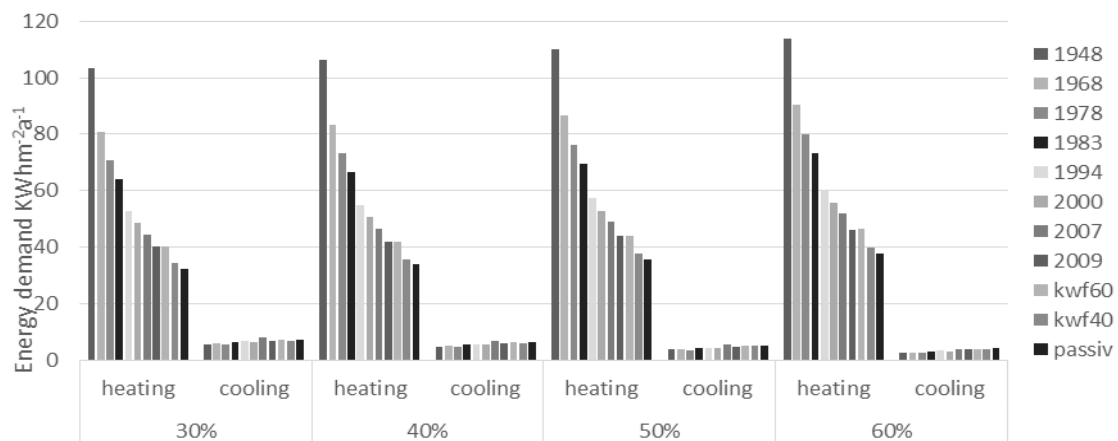


**Figure 4**　　　　Heating and cooling demands of the ten storey apartment block in Germany with different site densities and envelope properties.
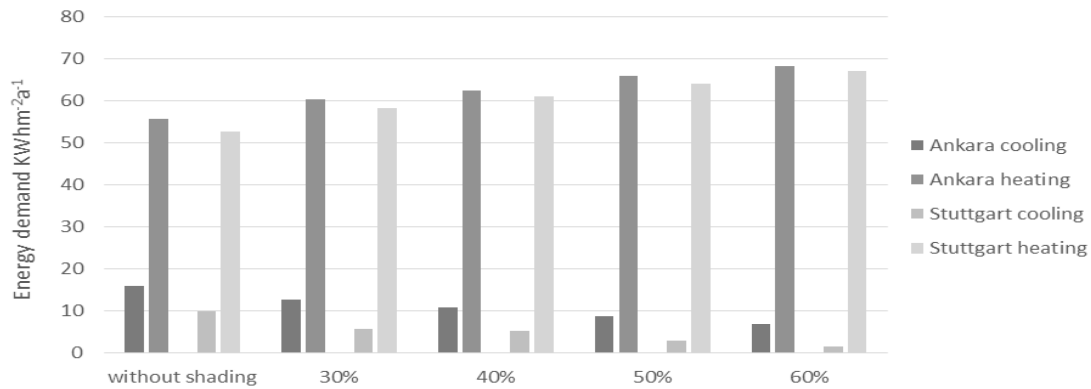
**Figure 5**  Heating and cooling demands of the ten storey apartment block constructed with current energy standards for Ankara and Stuttgart climatic conditions within different site density.

According to the reference building results, it is not easy to compare the site energy performance. Therefore the site performance of the new and former buildings was evaluated according to the same size urban districts and equal densities. Depending on the building typology chosen, the number of buildings, and therefore the number of housing units and their occupancy will vary. For each building type, the heating and cooling demand of the whole site was simulated at a density of 40% for Stuttgart. These figures are presented **in Table 3.** The average heating demand of ten storeys apartment block for urban transformation project is 60 kWh/m$^2$ while the average heating demand of one family house is 105 kWh/m$^2$, row houses' is 98 kWh/m$^2$ and apartment block with 4 storeys' is 68 kWh/m$^2$. The urban transformation project can reduce the heating demand up to 43% and it has the similar positive effect on the cooling demand of the site. In Ankara, the average heating demand of ten storeys apartment block for urban transformation project is 58 kWh/m$^2$ while the average heating demand of one family house is 114 kWh/m$^2$, row houses' is 105 kWh/m$^2$ and apartment block with 4 storeys' is 72 kWh/m$^2$. Reduction on the heating demand by urban transformation project can be 50% and also cooling demand reduction can be seen up to 28%.

In this study, supply scenario an electric heat pump with a COP of 4.0 was chosen as a standard heating system solution, covering 80% of the heat demand, supplemented by a gas condensing burner with 96% efficiency. Cooling was provided by an electric chiller with a COP of 3.0. Also, auxiliary electrical energy for pumping as well as delivery distribution losses of 10% of the heating and cooling demand was added. According to the $CO_2$ emission factor for natural gas was 0.202 t $CO_2$/MWh and for electricity 0.539 t $CO_2$/MWh, per capita $CO_2$ emissions is calculated. The lowest primary energy demand is ten storey apartment block for urban transformation project but lowest per capita $CO_2$ is the old apartment blocks.

**Table 3.  Heating and cooling energy demands of an urban area with 40% site density for different building types**

| | Number of buildings | Flats | Conditioned floor area/m$^2$ | Total heating energy demand/ MWh | Total cooling energy demand/ MWh | Average primary energy demand (kWh/m2) | $CO_2$ emission /t $CO_2$ | $CO_2$ emission per capita/t $CO_2$ cap−1 |
|---|---|---|---|---|---|---|---|---|
| **One family house** | 88 | 88 | 8800 | 926 | 61 | 115.5 | 176 | 0.5 |
| **Row houses** | 21 | 147 | 20580 | 2010 | 596 | 107.5 | 378 | 0.64 |
| **Apartment block** | 31 | 372 | 34720 | 2353 | 202 | 87 | 494 | 0.33 |
| **Apartment block (urban transformation)** | 14 | 560 | 83342 | 5034 | 283 | 79 | 1291 | 0.58 |

In the urban transformation project to add some renewable energy sources to the site is easier than the implemention to former buildings by reason of orientation, construction conditions, shading and etc. It is possible to add some district heating system for both cities and also this system can be combined with cogeneration plant, geothermal heating or central solar heating system in the urban transformation project. These systems can reduce high amount of carbon emissions and burning fossil fuels. For determining the performance of a PV system for the buildings in Ankara and Stuttgart, it was considered that the whole roof area of the buildings would be used for a free standing PV-installation with a tilt angle of 25°. PV-fields with for this example chosen 44 Sunpower SPR-305-WHT panels each, oriented to South. Each PV field was arranged to 4 strings of 11 PV-panels each which are connected to one inverter. The total collector fields and two inverters with a nominal power of 29.34 kW and a power ratio of 1.18. The average energy yield of the system is 34.2 MWh/a for Stuttgart and 48 MWh/a for Ankara. It is possible the produce 25% -35% of the consumed electricity with these installations.

**CONCLUSION**

The total energy consumption of the cities is crucially influenced by urban design decisions. This study shows that the site density and physical properties of buildings have significant effects on the site energy performance so this kind of evaluation should be made before the design of refurbishment of old settlements area. It is difficult to make the recommendations for all cities since they have unique characteristic and context but according to building standards and density decisions can provide big key for energy management of the cities. There is notable connection between energy demand and the urban site planning. Definitely instantaneous energy demand of the city is highly affected from the energy usage behavior of citizens and operation of the system but statistic mode of energy consumption may give design criteria for energy management decisions. Hovewer in addition to that, the climatic conditions and the population of the area, building typology and the density should be analysed carefully before the urban transformation projects.Detailed dynamic thermal simulations show that 10-20% heating and cooling demand may be saved by an energy aware site planning.

Beside that, renewable energy applications should be integrated in the urban planning process at the beginning in order to maximise the use so the urban transformation projects also have a big potential for integrating the renewable sources. According to this study, there is a big potential to save more than 30% of the energy used with renewable energy integration. This study covers only project site decision for urban transformation projects but better renewable energy integration can be done with district planning.

**REFERENCES**

Beatley, T. Manning, K. 1997. The ecology of place: planning for environment, economy, and community, ISBN-10: 1559634782 , Island Press

Eicker, U. Tereci, A.Kesten, D. 2010.Energy Performance of Buildings in Urban Areas Energy Performance of Buildings in Urban Areas. SET2010 - 9th Int. Conf. on Sustainable Energy Techn.

Givoni, B. 1998. Climate Considerations in Building and Urban Design. Chap. 8: Urban design effects on the urban climate. Van Nostrand Reinhold, USA.

Gruber E. , Schlomann B., 2005.The current and future electricity demand of appliances in German Households. Fraunhofer Institute for Systems and Innovation Research

Horwood, C. 2007. Overview: Tomorrow's Crises Today, Cities of darkness / cities of life. UN-HABITAT, Tomorrow's Crises Today -The humanitarian impact of urbanization. Malta

IWU-Institut Wohnen Und Umwelt GmbH.2003. Gebaeudetypologie Deutschland, A Method to Quantify the Energy Performance in Urban Quarters.

Kesten, D. Tereci, A. Strzalka, A. Eicker, U.2011. A method to quantify the energy performance in urban quarters. HVAC&R Research 18 (1–2) 100–111.

Särnholm,E. Jarnehammar A. Hagberg, L. Oman, A. Ekvall, E. 2009. Sustainable cities' energy demand and supply for heating and cooling. ISBN 978-91-7381-033-3.

Sokido D. L., Bhaduri S. 2013. Urban Density and Spatial Quality of Urban Spaces in Built Environment ,International Journal of Innovative Research & Studies,vol 2-7, ISSN 2319-9725

Tereci A., Kesten D, Eicker U.,2010. The impact of the urban form on heating, cooling and lighting demand of cities. ICSU 2010, Hong Kong

Thorns D.C. 2002. The Transformation of Cities Urban Theory and Urban Life, Palgrave Macmillan, ISBN 0–333–74596–5.

UnitedNations. 2008. World urbanization prospects the 2007 revision. United Nations, New York