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Case Study

Comparative Study of Energy Role in Urban Morphology with an Emphasis on the Formation of Spatial Structure (Case Studies: Tehran and Berlin)

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ABSTRACT: Today, topics related to climate change and energy have found a special place in urban studies. Both issues complement each other, because less energy consumption, especially non-renewable energy, can produce fewer greenhouse gases and, on a larger scale, reduce their impact on climate change. In this regard, the main purpose of the present study is to extract an optimal thermal energy model based on urban morphology that can help to analyze comparatively the urban typo morphology in the most appropriate way and provide policies for observing the basic concepts. This study is analytical descriptive research and in terms of purpose is applied research. Library research, data extraction from the database, and data creation by relevant software were used to collect data. Then, using dimensions and indicators extracted, figure-ground maps with certain measures were provided. Finally, out of 25 different types of building configurations recognized in Berlin and Tehran, five common Morpho-type were selected to be simulated and evaluated by using purification technique According to the results, the typo-morphological samples selected from each city had different behavior as to the amount of thermal energy and the configurations with higher density indicated better energy efficiency. Average building height, building density, and surface area-to-volume ratio were recognized as good criteria for thermal energy efficiency and had a positive correlation with thermal energy demand. As the main result of the study, some policies are presented.

Keywords: Energy; Urban morphology; Thermal energy; Building density

RUNNING TITLE: Role of Energy in Urban Morphology

INTRODUCTION

Climate change and energy have been the most important issues considered when doing urban studies in developed countries (Keirstead, et al., 2012) Today, cities are responsible for emitting more than 70% of greenhouse gases (Protocol G. H. G, 2015) Although cities cover 2% of the biosphere surface (Hui,2001) their inhabitants consume 60 to 80% of the global energies (Grubler, et al., 2012) As this issue intensifies, energy efficiency turns into a key factor in urban development (Mitchell, 2005) and governments make every effort to reduce greenhouse gas emissions (Ward, 2008) The necessity and importance of attention to energy and its efficiency is felt in Iran like all over the world. Recent statistics released in Iran also indicate a significant increase in urbanization, leading to more use of energy resources (Issazadeh and Mehranfar,2010) and due to the limited energy resources and the need to protect the available resources, energy efficiency should be improved in cities (AGECC UN,2010) Urban energy is consumed in five main sectors of industry, transport, building, service, and agriculture.

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The maximum energy consumption in third world countries occurs in the sector of transport and building, among which buildings account for the highest amount of energy consumption (approximately 40%) and greenhouse gas emissions (UN, 2020) (Gul, Patidar,2015) The buildings can play the most significant role in reducing (about 29% by 2030) greenhouse gas emissions (Mohanty UN, 2011). According to the United Nations, the urban form has a direct impact on energy consumption (Marique and Reiter, 2012) In fact, the urban form and design with such characteristics as density, land-use mix, and public transport network affect energy consumption (Van Wee, 2002; Pan, et al., 2009; Ferguson, 2014; Owens, 2005) Important factors affecting energy consumption in buildings are density, diversity, design, and other statistical characteristics. Hence, the concept of energy in the buildings as clusters in urban texture depends on the concept of morphology. Therefore, the type of buildings as cells of this concept determines the degree of energy efficiency.

Morphology and Typo-morphology

Urban morphology is the study of urban form over time (Stanilov and Scheer, 2004) It is defined as the analysis of how residential elements are erected and expanded (Norberg-Schulz, 2019) as well as the study of the formation of human settlements and the process of their formation and transformation (Moudon,1989) According to Madanipour (Sadeghi, and Li, 2019) urban morphology is the systematic study of the form, map, structure, and functions of the diverse urban textures, their origins, and the patterns of their evolutions over time. Urban morphology includes three main schools: British, Italian or Muratorian, and French. Each of these school's centers around certain features of urban morphology. Saverio Muratori had an analytical look at the structure of Italian cities, leading to a typological approach to morphology. In this approach, the urban form is explained by the detailed classification of buildings and open spaces based on their types. It is referred to as typo-morphology (Moudon,1994). In addition to the four components of urban morphology (Conzen,1960) the six elements of urban texture (Kropf,2009) and other elements presented by Trache (2001), land use occupation, the ratio of the total residential area to the area of land, and building height have been presented by Radberge (1996) as the main parameters used for the typology of urban blocks. He considered a set of buildings surrounded by the streets as the unit of the analysis of urban blocks. The Spacemate diagram has also provided by Pont and Haupt (2009), which analyzes the relationships between the four indicators of land use occupation, open spaces, number of floors, and building density (Zaker Haghighi, et al., 2010). The Concept of Energy in the Spatial Structure of Urban Morphology Regarding the relationship between buildings and their surrounding environment, each building changes the climate around it. The changes, called urban micro climate, take place under the influence of factors such as geometry, city section, form, height, and size of buildings, the orientation of streets and buildings, and the surface of open spaces (Bahraini,2010). Based on their effects on climatic factors around and above them, including temperature, relative humidity, wind speed and direction, and sunlight, urban built elements create an artificial climate that always interacts with each other (Nasrollahi, 2014). Therefore, considering its effects on climatic factors, urban morphology affects directly or indirectly the change of energy consumption in cities, especially thermal energy, and the buildings cannot be considered as an independent unit without taking into account their location and conditions on the urban scale (Adolphe, 2001). In fact, the most important concept related to energy in cities is to achieve its sustainable form, which stems from optimal energy efficiency. The main step taken in the present research has been to explain the concept of energy in the spatial structure that requires the explanation of "energy stability in urban morphology". Reviewing the basic concepts, (Alberti, 2010) argued that the mechanism of urban planning and system is similar to that of the energy system and include determining the location of habitats in a Geo-morphological context, determining the infrastructure according to the available technology, and managing human behaviors according to the local culture. (Fig.1)

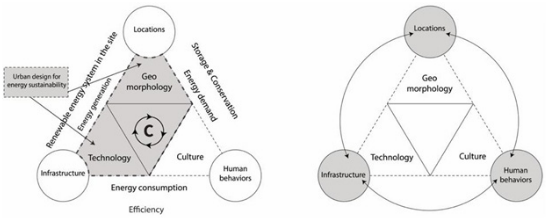

Fig 1: Conceptual model of urban design in relation to energy sustainability; the relationship between urban system, planning, energy system, and energy sustainability

Accordingly, urban morphological design and planning are considered based on the structure, context, and form in relation to culture and human behavior. The relationship between sustainable energy development, energy system, planning, and urban morphology can be explained by a framework. It can be said that the spatial configuration of elements in an urban area has a significant impact on ecosystem dynamics. Generally, it can be argued from a morphological point of view that urban development affects directly an urban settlement configuration, the main indicators of which are the types of buildings, patterns of streets, and blocks forming it. In fact, various configurations of urban textures and their forms require various energy consumption and conservation options and energy generation capacities. Spatial structure and land use patterns directly affect energy flows (such as redistribution of solar radiation) and the energy needed for human activities depends indirectly on the spatial configuration of the urban settlement. In other words, spatial structure plays a vital role in the future of energy. Therefore, by physically changing the configuration (structure, patterns, forms) of urban settlements and improving the energy flows, settlements with higher energy efficiency can be designed and planned. Accordingly, using the indicators recognized, the conceptual model of energy efficiency in urban settlements on a medium scale is presented in Fig. 2.

Review of Literature Regarding the concept of energy in cities, especially the relationship between energy consumption and urban spatial structure, many studies have been conducted with various approaches in recent years, most of which have been focused on large-scale

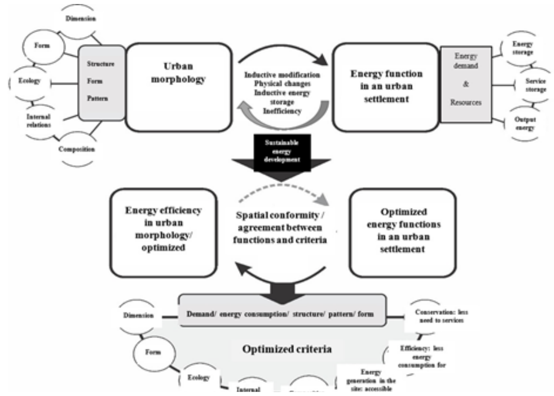

Fig 2: Conceptual model of research, urban design for energy efficiency; extraction of optimized criteria for operationalization of indicators

samples and the mechanism of patterns forming urban texture. Most of these studies have been conducted using experimental research methods to explain the given mechanism while there has been sometimes a systemic approach as well.

The comparison of similar or different mechanisms using a purely scientific method can be seen rarely. However, it is possible to refer to some relevant research conducted previously in this field. In a study entitled "a supporting method for selecting cost-optimal energy retrofit policies for residential buildings at the urban scale"(Chiara Delmastro, et al., 2016) considered energy retrofit policies in urban textures while focusing on building energy performances. They presented an approach that can support different stakeholders in selecting specific strategies and policies to form low carbon cities (López-González, et al., 2016). Investigated the environmental and energy impact of the EPBD in residential buildings with a case study of La Rioja in Spain. They discussed the concept and importance of energy in the cities and the energy efficiency resulting from the form of urban textures and provided scenarios for energy recovery. In another study entitled "Solar energy and urban morphology: Scenarios for increasing the renewable energy potential of neighborhoods in London", (Sarralde, et al., 2015) (considered the concept of energy in both fields of urban planning and design. They focused mainly on the relationships between urban morphology and environmental sustainability and presented analytical models and scenarios for the optimization of energy efficiency. In other studies, entitled " Energy-efficient city: A model for urban planning" and "Solar urban planning: a parametric approach" by (Amado, and Poggi, 2014) models for supporting energy-efficient cities and guidelines for urban planning have been presented. Finally, among foreign research, (Morganti and Salvati, 2017) have conducted a study entitled "Urban morphology indicators for solar energy analysis" with an approach similar to that of the current research. However, it focused on a large scale in terms of the depth and method of analysis. Among Iranian research, Mirmoghtadaee, et al. (2017) conducted a study entitled "A comparative study on the role of energy efficiency in urban planning system of Iran and Germany" and Jahromi and Barakpour (2016) assessed energy efficiency at the urban scale. These studies considered the concept of energy and presented different models by investigating the principles and nature of energy efficiency. In other parallel studies entitled "Typo-morphological evaluation of new residential urban textures to optimize primary energy consumption" and" Analytical framework for the typo-morphological study of urban texture from energy efficiency perspective", (Mortezai, et al., 2017) investigated the relationship between energy efficiency and the form of urban textures while focusing on the design of new residential textures. Generally, in the above-mentioned studies, especially who worked in Iran, the concept of energy has been considered on the macro-scales while medium and micro scales in urban morphology that have the greatest impact on the formation of urban textures have been ignored. Quantitative research methods have rarely been used to evaluate extracted models and the conceptual model of the research that includes relevant indicators and parameters has been presented considering all the intervening parameters, reducing the certainty of the results. Accordingly, there has been an attempt in the present study to adopt an innovative approach and present conceptual models to evaluate exactly the concept of energy in relation to urban morphology of spatial structures. To achieve these objectives, the research survey was conducted in Tehran and Berlin cities in two different countries, Iran and Germany in 2020.

MATERIALS AND METHODS

Data collection

This study has been applied research in terms of purpose and an analytical-descriptive one in terms of structure. Due to the lack of research conducted on the concept of energy in relation to urban morphology as one of the branches studying the urban spatial structures, the present research has had an exploratory approach by formulating a conceptual model. To collect data, library research, data extraction from Bing Maps Platform in Berlin and Tehran, data creation by ArcGIS software, and Google Sketch-up software for 3D design were used. Then, based on the purposes presented in the form of a conceptual model, the concept of energy in relation to urban morphology was considered so that using dimensions and indicators extracted, figure-ground maps with certain measures were provided. Finally, out of 25 different types of building configuration in Berlin and Tehran, five common types were selected to be simulated and compared. In the two mentioned cities, two real and ideal samples of urban areas with the scale of 500×500 were selected as similar upstream isolated urban textures.

According to the characteristics of the urban textures, each typo-morphology in both cities was redesigned and simulated using the "purification" technique. In two stages of research, all climatic parameters of both cities were comprehensively considered, and according to the conceptual model of the study, urban morphological indicators (extracted from the morphological elements presented in the section of the theoretical framework)that affect the amount of thermal energy in various typo-morphology were investigated.

Accordingly, the dependent variable was considered to be the amount of thermal energy while the heat demand was selected as the principal dependent variable according to the research approach. Independent variables included such morphological indicators as building, block, and network. To ensure convergence and avoid the convexity of evaluations, some quantitative changes were ignored.

Analytical framework

According to the mentioned indicators, to achieve the purposes of the research, the indicators considered being evaluated as pairs of elements included height, building density, surface area-to-volume ratio, land use occupation, block structure, and enclosure, width, and orientation of passages. It should be noted that the intervening factors such as climatic parameters, human behavior, materials, insulation, facade details, age of the building, quality of buildings, and openings surface area were considered to be similar in all building types (Fig. 3). It should be explained that in the current research, due to the type of research, its purposes, and lack of space, only quantitative evaluations have been conducted and qualitative evaluations related to the pattern of passages or human behavior can be addressed in future research.

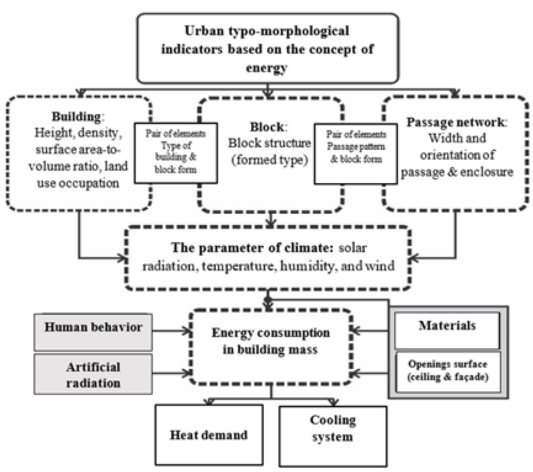

Fig 3: Conceptual model of research

By examining real samples, using simulation software, and modeling the type of energy mechanism used and the rate of reflection or absorption of building surfaces, the ideal sample was determined as the best representative of energy consumption. Finally, according to the type of evaluations and modeling, the relationship between variables and effective parameters, such as outdoor temperature, was tried to investigate the effect of energy, especially solar energy as thermal energy, on the formation of different urban typo-morphologies. Additionally, based on the results of evaluations and modeling, policies for designing and planning energy in urban morphologies were presented.

Case studies

In this research, Iran and Germany, which have significant differences in terms of energy efficiency indicators, were selected to be studied. Compared to Germany, Iran has different climates and micro climates, and each of the countries includes different lifestyles and ways of consuming energy. Iran's economy is based on the export of fossil fuels and the relatively low price of these resources, while Germany is an importer of fossil energy so that the cost of energy is much higher in this country than in Iran. Due to the experiences gained from the world wars in Germany, optimal energy consumption has been institutionalized in this country.

Lack of access to renewable energy generation and consumption technology in Iran and the economy based on industry and export of goods in Germany have led to fundamental differences in the pattern of energy generation and consumption in these two countries.

The relative success of Germany in the field of energy efficiency compared to Iran has made the country a model and the conditions in Iran to be analyzed in comparison with this country. Accordingly, Berlin and Tehran (Fig. 4, Fig. 5) were selected to be studied for the following reasons:

• The cities should be large enough to have a large variety of building types

• The cities should have a variety of topographic configurations

•The cities must have diverse cultures and building styles

• There should be accessible and valuable data and information about the cities that are worth studying.

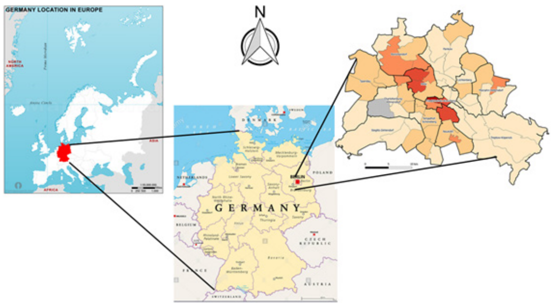

Fig 4: The location of Berlin in Germany and in the world

Fig 5: The location of Tehran in Iran and in the world

In the first stage, the mentioned cities (Fig. 6, Fig. 7) were scanned initially in terms of types of residential buildings and morphology and were classified based on building composition, architectural style, and urban neighborhoods. In the second stage, according to the considered basics and concepts, the final typologies were selected using Street View software, Microsoft Bing Maps Platform, and satellite images. Version February 26, 2021 submitted to Journal Not Specified 7 of 17 Out of 25 different samples extracted, five typo-morphological samples with a scale of 500×500 were selected as homogeneous upstream isolated urban textures. For Berlin, the urban typo-morphologies including discrete, row, sheet, apartments, and compact block buildings with identifiers of DH, RH, SH, AB, and CUB were selected. For Tehran, urban typo-morphologies including high-rise apartments, modern apartments, discrete, sheet, and compact block buildings with the identifiers of HRA, MA, DH, SH, and CUB were selected. Fig. 8 and Fig. 9 represents the type of each typo-morphology according to the urban population density.

Fig 6, Fig 7: Picture of selected samples in the two cities of Berlin and Tehran in order

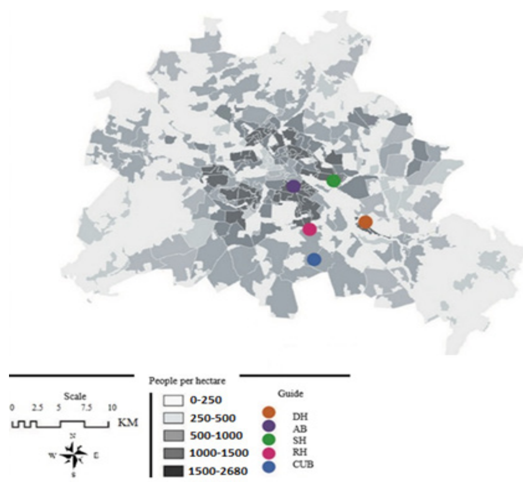

Fig 8: Morphological and density maps of Berlin

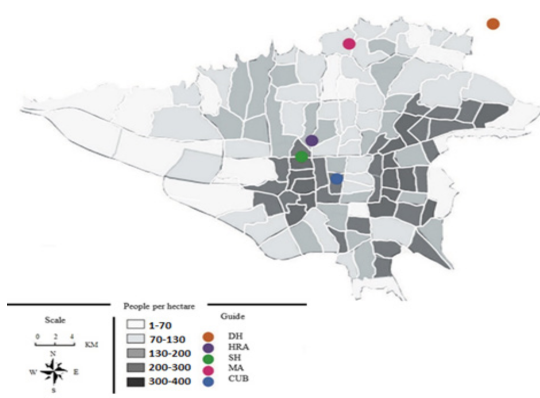

Fig 9: Morphological and density maps of Tehran

RESULT AND DISCOTION

Descriptive statistics and factor analysis for variables entering the analysis

According to the five typo-morphologies presented above for Berlin and Tehran, it was necessary to present figure-ground maps of the relevant buildings, as one of the main basic maps for morphology, with the same scale to conduct evaluations. It should be explained that the type of buildings and the shape and form of each plate can be distinguished in the blocks forming these types of maps and the relationship between mass and space can be easily understood (Fig. 10, Fig. 11).

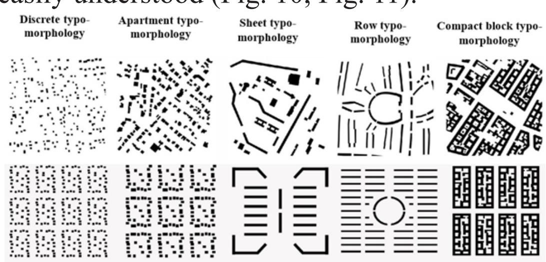

Fig 10: Top: Real typo-morphologies; bottom: Ideal typo-morphologies of Berlin, figure-ground maps

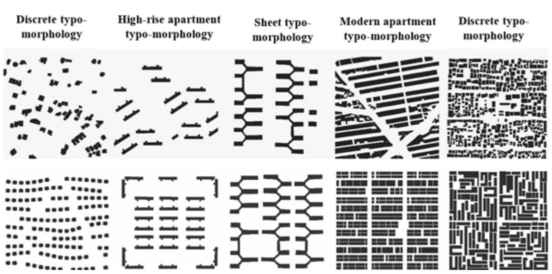

Fig 11: Top: Real typo-morphologies; bottom: Ideal typo-morphologies of Tehran, figure-ground maps.

For Berlin it includes: Discrete, Apartment, Sheet, Row and Compact block typo-morphology and for Tehran: Discrete, High-rise apartment, Sheet, Modern apartment and Compact block.

Quantitative values to describe the urban form of typo-morphological samples include average height, land-use occupation, passage surface, surface area-to-volume ratio, and floor area for each sample, which were calculated as follows. The radar charts can show obvious differences between the available conditions. It can be seen that there are many differences between typo-morphological samples for both cities (Fig. 12, Fig. 13).

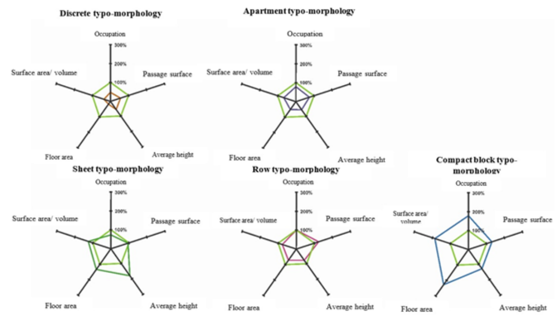

Fig 12: Radar charts, comparison of numerical values of real typo-morphological samples of Berlin

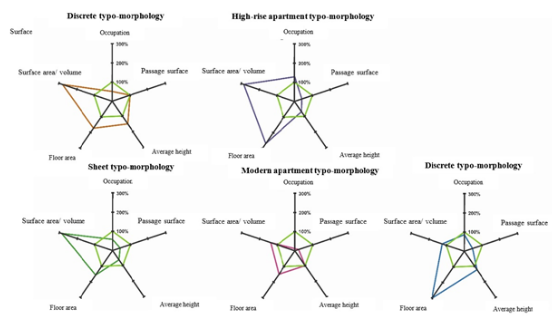

Fig 13: Radar charts, comparison of numerical values of real typo-morphological samples of Tehran.

The relationships between the typo-morphological indicators of each sample indicated a very large difference between each typo-morphology. The results showed that the differences between the typo-morphologies were on a medium scale. Generally, the indicators of land use occupation and average height had a positive correlation with density, while having a negative correlation with surface are-to-volume ratio. Both average height and surface area-to-volume ratio indicated a critical density, which can be further investigated. All typo-morphologies were studied exclusively in relevant samples. All

typo-morphologies were investigated using the Space mate diagram provided by Pont and Haupt(2009) to consider the relationship between density and typo-morphology in an urban texture. The key relationships between the four elements of urban form that indicate the urban spatial structure were also examined as follows. Key Relationships Different typo-morphologies were compared in terms of the indicators of building density, land-use occupation, average height, and surface area-to-volume ratio. For all samples, density was considered as the control variable. In general, it is quite clear that land-use occupation and height were positively correlated with density, while surface-to-volume ratio was negatively correlated. For both variables of height and surface area-to-volume ratio, it seems that when there is a density crisis that more increase in density causes a very large decrease in these variables. After examining and analyzing the variables using the Space mate diagram, the key relationships between the elements of the urban form can be determined clearly. Density and Building Type in both selected cities and all typo-morphological samples, discrete morphology included the lowest building density (0.1 to 0.9), of which Berlin was no exception. Modern apartment typo-morphology included the highest building density (2.5) in Tehran (Fig. 14).

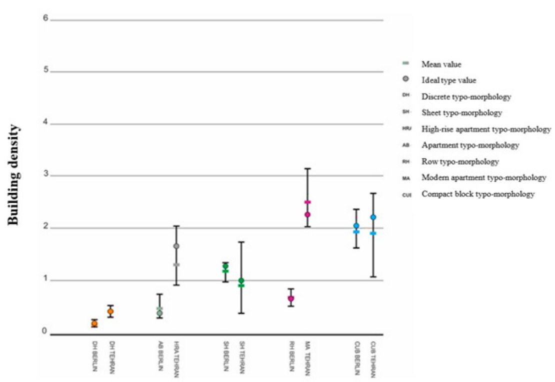

Fig 14: Density and typo-morphology, the amount of energy demand in each typo-morphology of Berlin and Tehran

Density and Surface Area-to-Volume Ratio The surface area-to-volume ratio represents the ratio of the total area of all building surfaces to its volume. In this study, there was a negative correlation between this variable and density in both cities so that a building density of 1.5 to 2.5 could be seen. It seems that the main reason for this is that more lighting in the building is needed as the density increases. It should be acknowledged that Berlin enjoys justice and equality in this regard, while the conditions are completely different for Tehran (Fig.15).

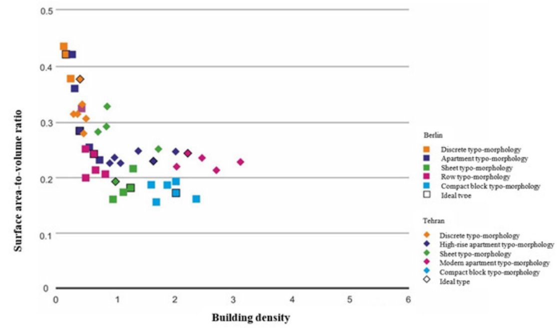

Fig 15: Surface area-to-volume ratio and density

Density and Average Height of the Building There was a positive correlation between the two variables of average height and density in both cities so that a building density of 1 to 1.5 could be seen. On the other hand, a rapid increase in height and density could be recognized, especially in the high-rise apartment and sheet morphologies (Fig.16).

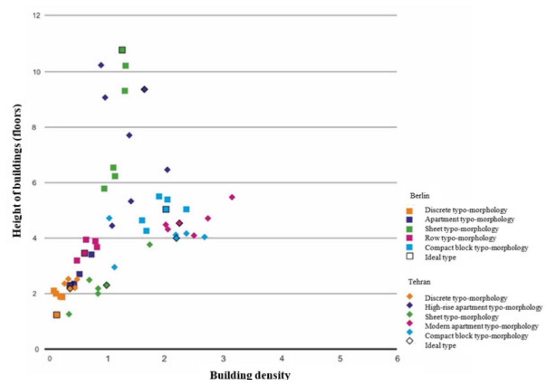

Fig 16: Density and the average height of the building.

Density and Land-use Occupation There was a positive correlation between the two variables of land-use occupation and density in both cities. A general relationship could be seen in the typo-morphological patterns of this variable. This issue could be recognized clearly in the sheet typo-morphology in Berlin. There was a building density of 3.2 and a land-use occupation below 0.6 in Tehran (Fig.17).

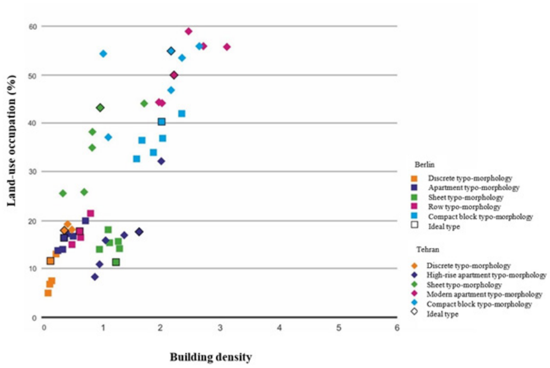

Fig 17: Density and land-use occupation.

Space mate Diagram: The comprehensive visualization of the key relationships of the variables can be seen in this diagram. (Figure S13). In addition to the mentioned variables, the open space ratio, which indicates the relationship between the unbuilt area and gross density, has also been represented in this diagram. The diagram clearly shows the conditions of two discrete and compact typo-morphologies as two common typo-morphologies. As indicated above, the urban typo-morphological blocks had typically a density below 0.5, a land-use occupation below 30 percentages, a height of two floors, and an open space index above 1. Compact urban blocks included two clusters. The first cluster had a density of about 2, a land-use occupation of 30 percentages, a height of between 4 and 6 floors, while in the second cluster, a high density could be seen only in some typo-morphologies.

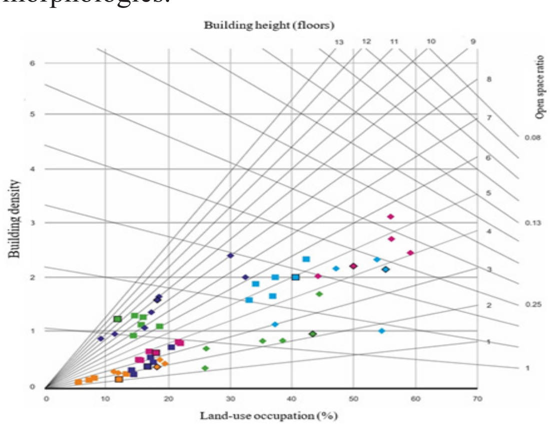

Fig 18: Space mate diagram, a three-dimensional representation of the key
321 relationships between the studied variables.

This issue is specific to historical locations in Berlin, which include mostly an average height of 7 to 9 floors. The modern urban form, including the sheet and high-rise apartment typo-morphologies, involved a combination of low land-use occupation and density, higher building height, and lower open space ratio (Fig.18).

To evaluate the behavior of the mentioned typo-morphologies in terms of energy while focusing on solar energy, especially the concept of heat demand in various types of buildings in Berlin and Tehran, it is necessary to study the issue of heat in the building mass. In this research, a temperature of at least 19 °C was considered as a thermal comfort temperature, variables such as insulation, climatic conditions, and

social preferences were considered stable, other technical differences were ignored, and the physical dimension of the buildings and the layout of the urban texture considered within the boundaries of isolated urban blocks were given priority. Using this approach, the mechanism of energy consumption in a typo-morphology in relation to the spatial configuration of the urban structure can be understood than other approaches. The heat demand model is based on the top-down engineering models in this research (wan, and Ugursal, 2009).

Heat demand modeling for each typo-morphology was done in two stages. In the first stage, all the separate parameters, including the climatic conditions, were assumed to be fixed. Then, using simulation, the amount of heat energy received and the amount of surface heat loss were modeled. Additionally, in both samples, the indoor thermal energy demand per year was calculated. In the next stage, the effects of insulation and the amount of UV exposure were assessed considering other factors. The thermal energy was assessed using a GIS-based model and all calculations were included in the simulation software. Clearly, all urban morphological factors, including light reflection, the spatial and physical dimensions of buildings, and the environmental context, have affected the result. However, considering the monthly temperature below 26 °C, the assessments focused on the amount of heat demand. In this part of the assessments, the outside temperature was the main variable, which was considered as the average annual outside temperature. In short, to calculate it, relevant formulas such as Heating Degree Hours (HDH) and Heating Degree Days (HDD) were used. The initial heat demand was also calculated by the formula (DH) , the amount of heat loss by (Ltot) , and the heat energy received by (Gtot) . The amount of heat transfers and lower heating value was finally calculated using the formulas (LHT) and (LHV) . As a result, by taking into account all the calculations and considering the final formula, i.e. (Gsun) to calculate the amount of solar energy received, all typo-morphologies in both cities were evaluated and simulated. Then, the heat demand was calculated and simulated on the square meter in the real and ideal typo-morphologies of both cities and was showed using colorful heat maps. The obvious difference between the discrete typo-morphologies and lower-density typo-morphologies could be seen, indicating that both form and size play an important role in this regard (Fig.19).

Fig 19: Initial heat demand in both real and ideal typo-morphologies.

By purifying the physical proportions and spatial arrangement of the buildings in real typo-morphologies, the ideal typo-morphologies that presented the optimal conditions were obtained. For example, the homogeneous typo-morphologies such as discrete ones indicated results similar to that of real samples. The modern typo- morphologies such as the sheet ones were closely related to the real samples.

CONCLUSION

Distribution of Buildings with Different Heat Demand

Finally, the heat demand in both cities was obtained. The results for the real samples showed the dominant rate of the heat demand of 50-150 kWh. Berlin demonstrated such a distribution less than Tehran (Fig.20 and Fig.21).

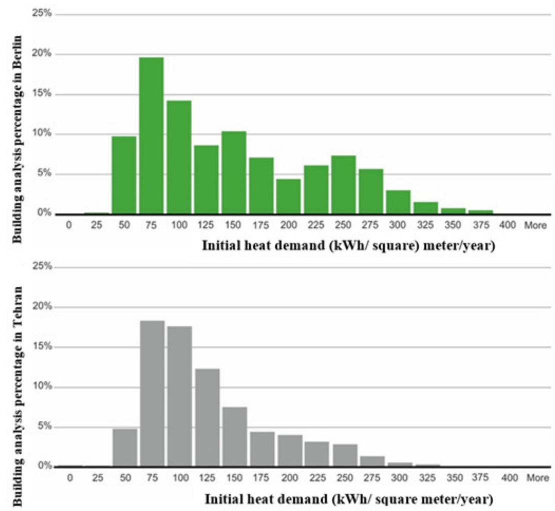

Fig 20, Fig 21: Initial heat demand in both real and ideal samples

Urban Morphology and Heat Demand: As the main result of the research, the key relationships were examined and considered finally from the morphological perspective, while all four main variables were evaluated in relation to the heat demand. It can be said that the typo-morphologies in each city have different behavior in terms of the amount of heat demand. Higher density configurations have better energy efficiency. The ratio between the lowest and highest heat demand in samples makes this issue clear. Average building height, building density, and surface area-to-volume ratio can be considered as good criteria for thermal energy efficiency and have a significant correlation with heat demand. Finally, data relationships and correlations of typo-morphological variables with heat demand can be presented as the main results (Fig.22, Fig.23, Fig.24 and Fig.25)

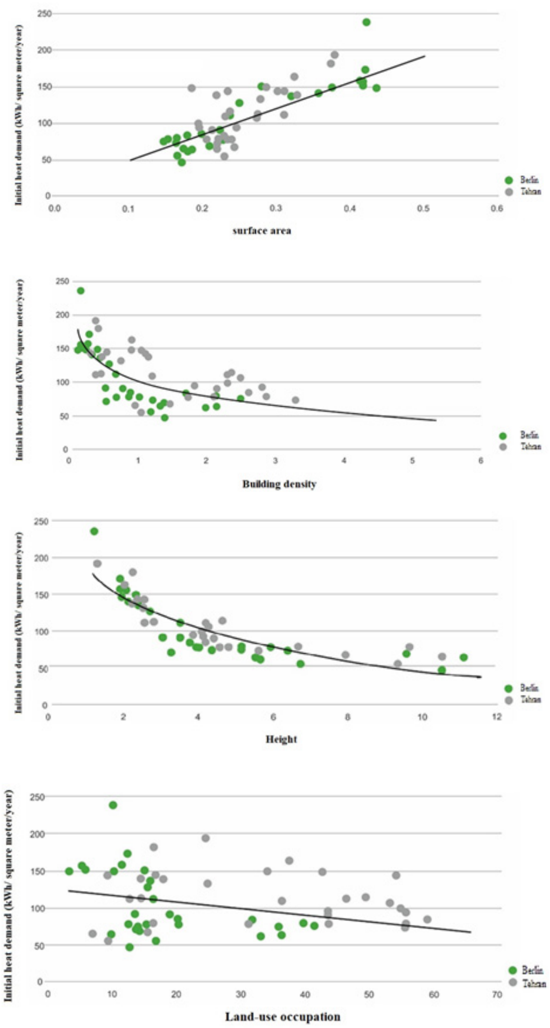

Fig 22, Fig 23, Fig 24, Fig 25: Data relationships and correlations of morphological variables with Heat demand

As can be seen, the three main variables of density, height, and land-use occupation had a negative correlation. The four diagrams above show the outline of typo- morphological samples in terms of head demand while providing a better approach to evaluation and more accurate results regarding the samples. Clearly, density had a strong correlation with heat demand in both cities, according to which the reasons

for creating modern typo-morphologies and the behavior of urban blocks can be understood better. In general, the type of policies adopted in relation to urban planning in both cities can be considered as a basic principle affecting the behavior of the cities with regard to energy so that the building types are the only main actors in this area. In comparison with Berlin, Tehran with its specific typo-morphologies experience a serious crisis in its modern approach to technology so that the concept of density is often considered for revenue generation in organizations and institutions, but energy as the fuel and the driving force of civilization has been completely abandoned in this approach. Considering the type of urban textures in Tehran and Berlin, policies adopted in relation to the type of spatial configuration and the arrangement of urban texture resulting from the activities of urban planners determine the importance of paying attention to energy as a main issue in the metropolitan economy. Therefore, to promote urban planning based on energy efficiency, some policies can be adopted according to the results obtained from the present study, some of which include: - Giving priority to medium density than high density in urban typo-morphologies. - Avoiding overlapping and increasing discrete typo-morphologies, especially in an urban texture where there are other options. - Considering the height of buildings as a morphological criterion in the discussion of heat demand - Providing minimum standard density of 1 - Providing a surface area-to-volume ratio of at least 0. 2-Conducting basic studies on solar radiation to do urban planning. Recommendations for Future Research: In future research, additional assessments that address the demand for cooling energy, elevation, and orientation can be made, the scale of the study can be increased to study more samples, and micro climates and population density and behavior can also be considered.

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