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Investigation of Housing Projects for Rural Areas in Terms of Sustainability Criteria with Revit-The Case of Kayseri

İbrahim Bektaş *
Aysun Özköse**

Abstract

To realize sustainable rural development, it aims to contribute to constructing rural dwellings that are sensitive to climate change and resistant to disasters, where resources are used efficiently. The study was carried out in five parts. In the first part, the study area was determined. Secondly, information about the subject was collected. The third part is the field study, and the architectural features of the old and new houses in the study area were determined. In the fourth chapter, the rural housing projects designed by TOKİ, the Ministry of Environment, Urbanization, and Climate Change, and Mimar Sinan Fine Arts University and the selected residences in the study area were modeled in the Revit program and analyzed based on the sustainability criteria. Finally, in the last section, the conclusions and recommendations are presented. It has been found that the housing projects prepared for the rural area are in a disadvantageous position in terms of solar orientation and daylight benefit compared to the residences in the study area and an advantageous situation in terms of energy consumption. This study is limited to examining the determined rural housing in terms of solar utilization and energy consumption characteristics of ecological sustainability. This study's findings indicate that sustainability analyses be made at the design stage of all buildings, especially rural residences. At this point, making these analyzes mandatory for obtaining construction permits may help increase energy-efficient construction. In the literature review, no study was found on examining rural houses according to the sustainability criteria with the Revit Program.

Keywords:
Kayseri, revit, rural settlement, sustainable rural development, Yamula Dam.

* Department of Architecture and Urban Planning, Tomarza Mustafa Akıncıoğlu Vocational School, Kayseri University, Kayseri, Turkey. (*Corresponding author*)
Email: ibrahim.bektas@kayseri.edu.tr

** Department of Architecture Başak Cengiz Faculty of Architecture, Karabük University, Karabük, Turkey.
Email: aysunozkose@karabuk.edu.tr

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INTRODUCTION

Climate change, precipitation regime changes, population increase, and low soil productivity have caused financial problems in rural areas. Furthermore, as stated in the Republic of Turkey's Eleventh Development Plan (2019-2023), Special Commission Report on Rural Development, agricultural mechanization, structural problems in agriculture, and the fact that cities offer better opportunities in fields such as education, health, and employment increase migration from rural to urban areas (Ministry of Development, 2018).

New residential areas are being created in Turkey for rural areas damaged by various reasons, such as landslides, earthquakes, and dam construction. In addition, various institutions and organizations have developed housing projects according to the local texture, the region's people's needs, living conditions, and habits.

The concept of "Sustainable Development" has emerged due to the need to preserve development activities instead of continuing but not damaging the environment. The achievement of sustainable development, especially sustainable rural development, is possible through creating residential areas and spaces that align with nature and reflect the spirit and characteristics of its location. Therefore, from this point on, rural housing projects created by different institutions in our country are within the scope of the study.

LITERATURE REVIEW and ORIGINAL VALUE OF WORK

Various studies related to sustainable development, rural development, rural housing, and rural settlements are covered within the scope of the study. However, among the studies in the literature, the following current studies were chosen as the most closely related to this study's subject.

İner (2013) aimed to build sustainable rural housing by focusing on determining sustainability criteria in rural houses. The situation analysis was carried out by evaluating the rural dwellings within the borders of Edirne province based on physical, socio-cultural, and psychological criteria. The survey study tried to determine the people's age, gender, education, occupation and income status, feelings, and expectations about the rural area and housing.

Kara (2014) looked at eight different ecovillages, four of which were in countries other than Turkey and four of which were in Turkey. She looked at why the settlements were built, how they had been used in the past, the types of people who lived there, the proposed solutions for ecological sustainability, social sustainability, economic sustainability, and a comparison of exemplary buildings. So, she argued that the idea of an ecovillage is a good way to come up with comprehensive and flexible solutions. Furthermore, she stated that ecovillages develop ways to reduce the environmental footprint and end income and living level inequality. She also made suggestions for how these villages could be spread.

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Feridonzadeh et al. (2019), in their study, aimed to determine the standards for the formation of rural houses in the cold and mountainous regions of Ardabil province. Their study randomly determined that 27 of 176 settlements were located between 1500-2150 meters above sea level. From each of these villages, ten people between the ages of 20-65 have chosen a total of 270 people. Then, a survey of 50 questions was conducted on the participants to determine the characteristics of their houses. He classified the responses according to the 4-point Likert scale and analyzed them in SPSS and AMOS 18 software. As a result, he reported that the construction conditions, climate, economic conditions, scale, and traditional conditions effectively shaped the houses.

There are many studies on the sustainability of rural dwellings in the literature. In these studies, rural houses were examined in terms of design, socio-cultural, structural, and ecological features. These studies used methods such as questionnaires, interviews, and comparisons. When this study is compared to previous studies, there are three major differences. The first case is the absence of any study on rural settlements in the Yamula Dam region of Kocasinan District of Kayseri Province, which was determined as the study area. Second, while the current studies looked at the houses in terms of their design and planning decisions, this study focused on analyzing and comparing the houses in the first settlement areas under the dam, the houses built in the new settlement area, and the housing projects made by different institutions in terms of how well they use energy and daylight. Thirdly, the methods used to determine a sustainable construction strategy by creating a sustainable rural housing example in the current literature are to create a synthesis using existing references and evaluate the information obtained through questionnaires. Finally, in this study, residences were tested in a virtual environment with BIM (Building Information Modeling) based Revit program to determine sustainable performance values , and their sustainability performances were measured. This study, which was carried out in line with the three situations described above, might positively contribute to the literature in addition to other studies. As a result, it aims to contribute to sustainable rural housing development.

AIM SCOPE AND METHOD

In order to create a sustainable environment, sustainable structures must be built. Buildings should be planned with sustainability in mind, including how they use water, and energy, manage waste, recycle, and use local materials. Since each of these factors is a broad subject of study, in this study, rural housing is discussed in terms of benefiting from the sun, which is one of the natural resources, and energy management. Answers were sought in this direction to the questions of how long the residences determined within the scope of the study can benefit from daylight, what the quality of daylight in the interiors is, how much energy they consume, and in total for heating, cooling, and lighting, and how much of this consumed energy can be met from renewable sources.

This research was carried out in five stages to create an energy-efficient rural house (Figure 1). The area where the fieldwork will be conducted was determined in the first stage. In this context, rural settlement areas located on the edge of Yamula Dam in the Kocasinan district of Kayseri province were determined as the areas to be surveyed. In this region, the rural settlements of Taşhan, Çevril, Kuşçu, and Mollahacı were submerged by the dam, and the rural settlement of Obruk was destroyed due to landslides. Due to these situations, new settlement areas are planned in the regions. However, the fact that the new settlement area planning was different from the first settlements in that it was an urban design rather than a rural one, and many buildings in the rural area could not be included in the new plans. Therefore, the new houses were built in different shapes, and the architectural features of the first settlement were effective in selecting this region.

In the second stage, rural housing projects carried out by different institutions and organizations were investigated. At the end of the research, housing projects designed by the Ministry of Environment, Urbanization, and Climate Change, Mimar Sinan Fine Arts University, and TOKİ were reached.

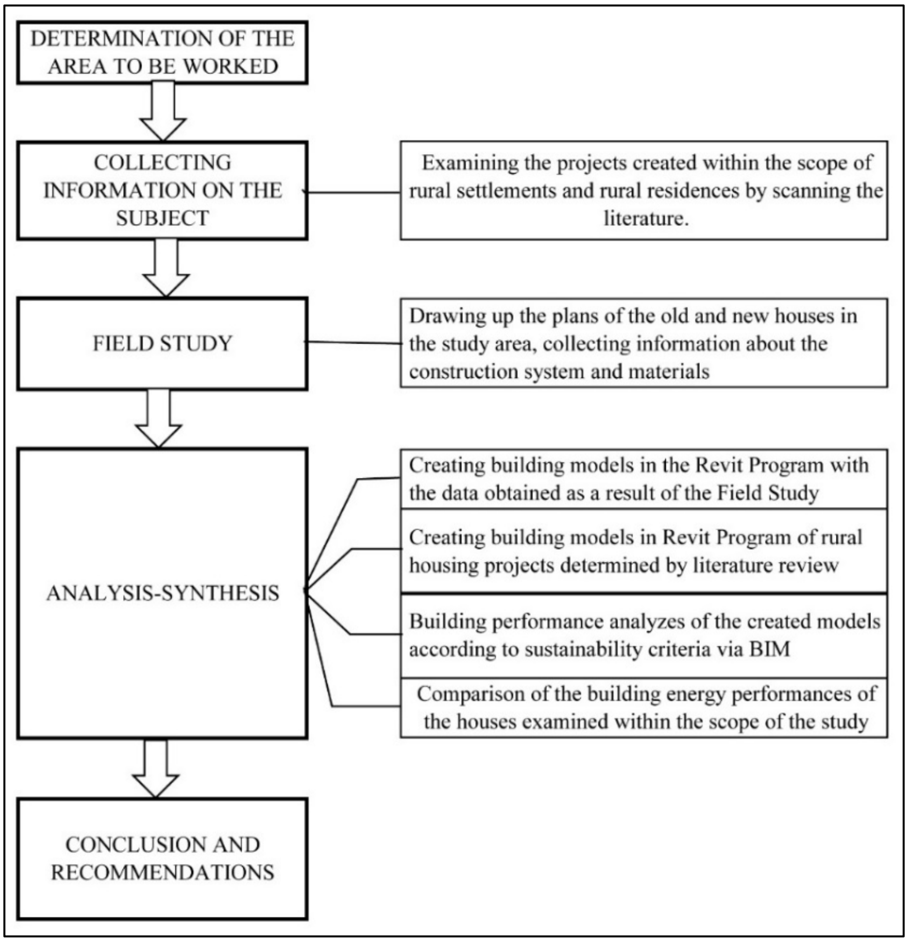

Figure 1. Work method

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In the third stage, fieldwork was carried out. In this section, the houses to be analyzed are determined. These houses were analyzed in terms of sun orientation, daylight saving, and energy consumption in the Revit Program. There are 14 rural settlements in the study area (Figure 2). Since the first settlement area of four of these rural areas was flooded and one was destroyed due to landslides, there is no old building. In both settlements, there are no old buildings due to the demolition of old buildings and the construction of new buildings. Seven old buildings were identified in the remaining seven settlements. However, the architectural features of only three old structures, which do not pose a security risk, have walls, doors, windows, floors, and roofs, and are allowed by the owner, could be determined. However, the architectural features of the three old buildings and the three new buildings allowed by the owner in the same settlement area were determined to make a better comparison. With the data obtained, the plans and sections of the structures were prepared in the AutoCAD program.

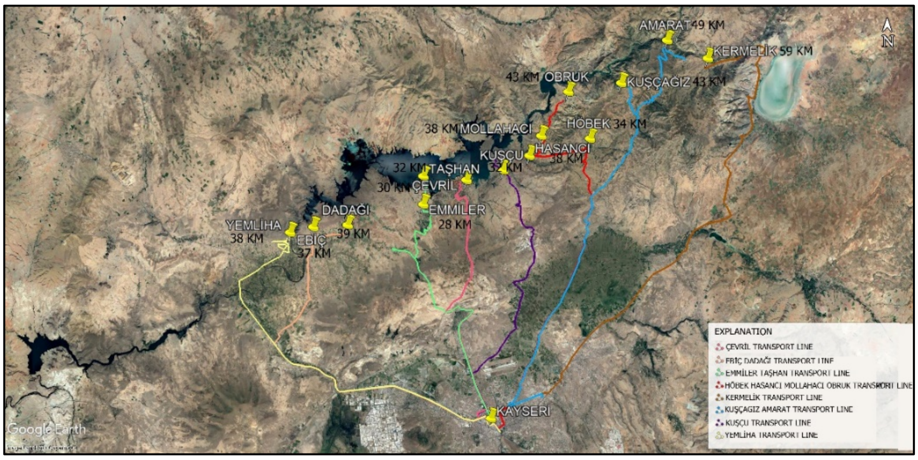

Figure 2. Rural settlements in the study area. (Google Earth, 2022)

The architectural features determined in the fourth chapter are analyzed in terms of daylight and energy consumption characteristics of ecological sustainability whether the objectives of the sustainable buildings created to reduce the damage to the environment can be realized or not can be determined by the analyzes made by considering the environmental conditions before the construction.

One of the methods used to measure sustainable performance targets is software programs. One software is the Building Information Modeling (BIM) based Revit program. Sustainability analyzes can be made by entering data on physical environmental conditions in the Revit program (Figure 3). From these analyses, regional daylight exposure times and daylight lux values can be measured indoors by analyzing sun orientation and daylight exposure. With solar energy analysis, regions where solar panels can be placed can be determined, and the amount of energy that can be produced can be calculated. With the wind analysis, the wind resistance of the building can be measured. Finally, the energy analysis can calculate the heating, cooling, and lighting energy amounts, and the total energy consumption amount can be determined (Ofluoğlu, 2016).

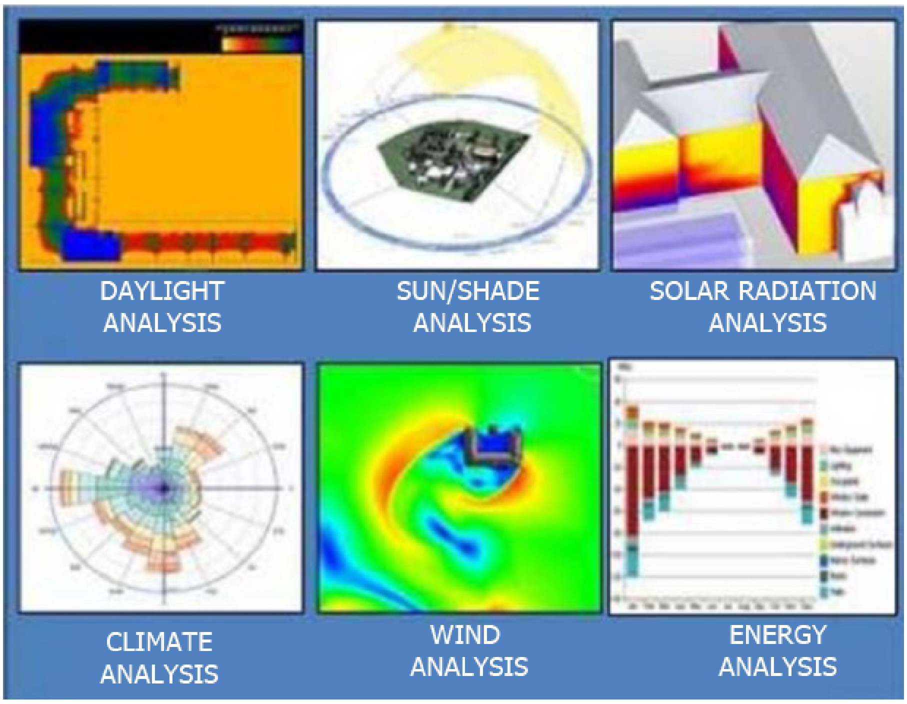

Figure 3. Analyzes in revit program revit (Ofluoğlu, 2016).

These analyses, which can be done in a digital environment, allow the targeted performances to be measured. Thanks to the data obtained from the analysis, it is possible to improve the design and eliminate the deficiencies by making interventions in the early stages of the design. In addition, problems such as problems, disruptions, and additional costs that may occur in the construction and use of buildings can be intervened by determining compliance with sustainability (Ofluoğlu, 2016).

Revit Program was used to analyze the structures determined due to these features. For this, the building plans prepared in AutoCAD were modeled in the Revit program and analyzed by creating the region's climatic conditions. In the last section, the results obtained are compared.

HOUSING INVESTIGATION IN THE SCOPE OF THE STUDY

This section provides information about rural housing projects created by the people, institutions, and organizations covered in this study. Furthermore, old, and new houses are also examined in the study field.

Realized Housing Projects in the Context of Rural Development Examined within the Scope of this Study

For various reasons, migration from rural areas to cities causes problems such as decreased production, rising unemployment in urban areas, and the spread of irregular slum areas. These problems, especially those of high-level governments, local administrations, and people who migrate from rural areas to the city with livelihood concerns become the whole country's problems. For this reason, rural development is one of the most important issues of all time. Therefore, various studies are carried out in Turkey to develop these areas. Since the proclamation of the Republic, housing projects for rural areas have been carried out by

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different individuals and institutions. However, the 1940s were one of the periods in which most projects were produced in this field. In addition to the Ideal Republic Village project (İnan, 1978), which was created with the support of Atatürk in these years, there are rural settlement and housing projects prepared by Abidin Mortaş (Mortaş, 1940), Behçet Ünsal (Ünsal, 1940), and Burhan Arif Ongun (Ongun, 1935).

These are examples of projects prepared for rural areas in the Republic's early years. From the 1940s until the 2000s, there were no projects for the countryside. Since those years, the countryside has come up again, and projects have started to be prepared. One of these projects is the Tarımköy project, which TOKİ built. In addition to housing (Figure 4), a residential area consisting of schools, mosques, barns, and health clinics is also created (TOKİ, 25.07.2021).

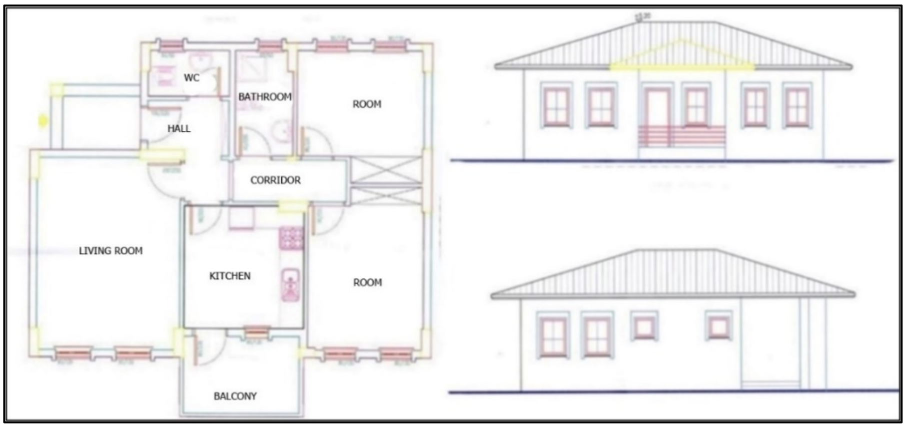

Figure 4. Kayseri Felahiye Doburcalı Tarımköy floor plan and views (Municipality of Felahiye 25.07.2021)

The other project for the countryside is the "Regional Texture and Architectural Features in the Countryside" project prepared by the Ministry of Public Works and Housing at Mimar Sinan Fine Arts University. Within the scope of the project, work was carried out for Kayseri in 2008 and Balikesir in 2010. In the study carried out in Kayseri, the villages of Kocasinan district, Çevril, Karahöyük, Tashan, and Melikgazi district, Bağpınar were selected as the working area. Project results are collected in six books. In the first book, environmental data, building materials, building elements, construction systems, units that make up rural housing, and sustainable regional architecture are discussed in the formation of rural architecture (Çorapçıoğlu et al., 2008a). The second book contains the methods used to investigate the local architectural identity and how to write the results reports (Çorapçıoğlu et al., 2008b). In the third book, information about natural and environmental information of the countryside, socio-cultural data, building materials, building elements, construction systems, rural housing departments, and settlement types are given (Çorapçıoğlu et al., 2008c). Finally, in the sixth book, idling projects and photographs of the houses in the workplace are included (Çorapçıoğlu et al., 2008d). Six different housing types were developed at the end of the study (Figure 5).

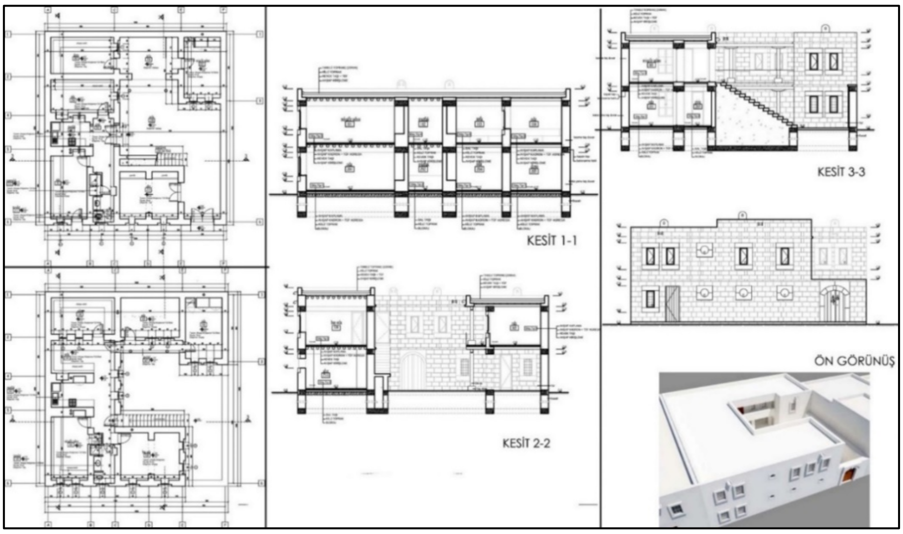

Figure 5. Local texture and architectural features in rural area project type 4C floor plans sections and views (Çorapçıoğlu et al., 2008e).

Another project related to construction in the countryside, "Housing Projects suitable for local architectural features" was carried out by the General Directorate of Building Works of the Ministry of Environment, Urbanization and Climate Change. The project aims to make new structures in rural settlements according to the local texture, the needs of the region's people, living conditions, and habits. Therefore, it was aimed to avoid constructing silhouette-disturbing structures in rural areas in favor of constructing structures appropriate for the tissue (Oruç et al., 2020). In line with the project, housing projects were carried out with the contributions of different architectural companies (Figure 6).

Figure 6. Housing projects suitable for local architectural features Kayseri type 3A Floor plans sections and views (Ministry of Environment, Urbanization and Climate Change, 25.07.2021)

Rural Housing Investigation in The Scope of This Study

New settlements have been created for the rural settlements of Taşhan, Çevril, Kuşçu, and Mollahacı, whose settlements are in the Kocasinan district of Kayseri province, which was flooded by the Yamula dam, and Obruk, whose settlement area was moved due to landslides. In addition, the former residences and new dwellings in the Höbek, Hasanci, and Emmiler regions in the vicinity have been examined as part of the study to ensure rural sustainability in these areas.

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Looking at the old and new houses examined in the Höbek settlement (Figure 7), there is no garden or courtyard in front of the building in the old residence. The ground floor consists of a barn, haystack, and home-pantry units, while the entrance and room units are placed on the upper floor to correspond to the top of the haystack (Figure 8). It was determined that the ground floor was made of rubble stone, and the upper floor was made of wood carcass filling materials with the local name "iskidas." Ground floor wall thickness varies between 70-90 cm. The wall thickness of the upper floor is 20 cm. When looking at the upper cover of the ground floor, the barn and the house-pantry section consist of round wooden beams, frequently arranged oak branches, and thick clay soil, which are thrown in the opposite direction on the thick round beam called "hezen." There is a room section above the haystack section. On the floor, there is a thick wooden beam in the center of the room, parallel to the short side at the bottom. On this beam, there are wooden beams placed in the opposite direction, coating boards, clay soil, and finally, lean concrete. The doors were created by hammering pieces of wood on the wooden lata with thick nails called pins. A locking system also opens with large keys locked in padlocks. The window sizes are small, and there are guillotine windows on the upper floor (Figure 9).

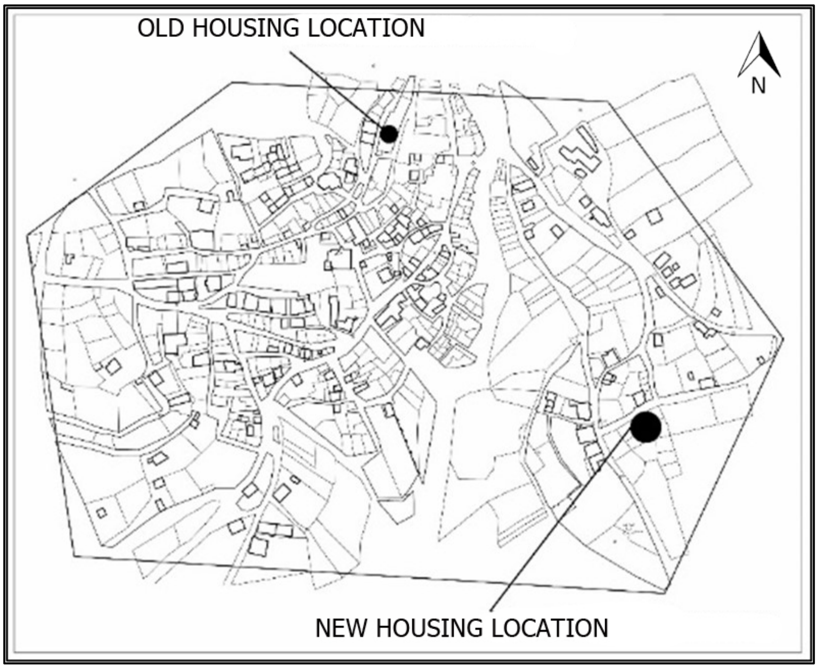

Figure 7. The location of the new and old house investigated in Höbek (Kayseri Cadastre Directorate, 2019)

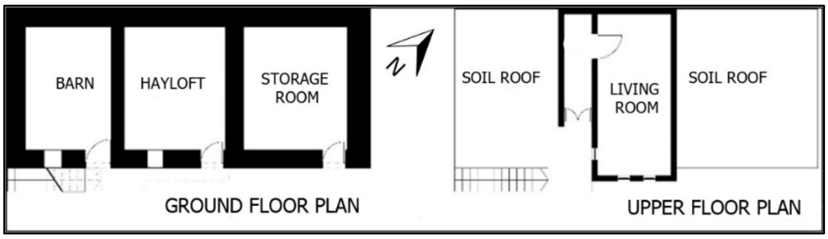

Figure 8. Plan of the old house investigated in Höbek.

Figure 9. The old house investigated in Höbek.

When we look at the newly built house in the Höbek settlement, it is seen that the ground floor, which is two stories, is used as a warehouse, garage, barn, and repair maintenance area, and the upper floor is used as a living area (Figure 10). The structure was built as masonry, and the exterior walls of the ground floor are made of 50 cm stone interior walls and 20 cm of brick. The top cover is hollow block flooring, and pumice concrete is the filling material. The upper floor is made of 20 cm of brick, and the ceiling flooring has a roof on a reinforced concrete plaque. The garage section is added and has a 50 cm stone wall, and the top cover is a trapeze sheet covering the steel carcass. The structure has no thermal insulation, and the exterior is painted on plaster. The flooring is lean concrete on a compacted floor. The living room and bedrooms upstairs have laminate flooring, while the kitchen has a ceramic finish with wet areas. The windows are PVC (polyvinyl chloride), and the doors are wooden (Figure 11).

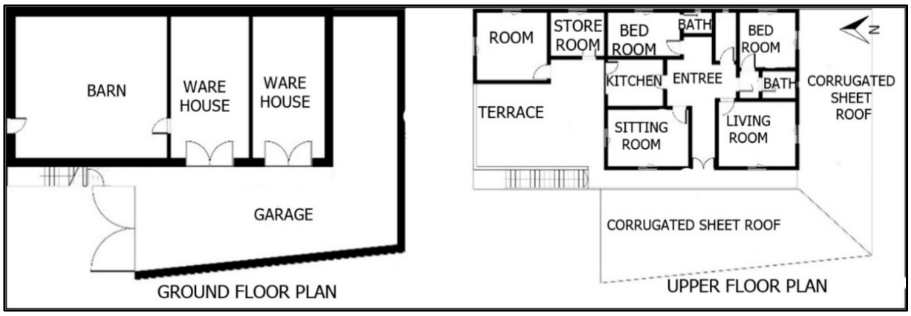

Figure 10. Plan of the new housing investigated in Höbek.

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Figure 11. New housing investigated in Höbek.

Looking at the old and new houses (Figure 12) examined in the Hasancı settlement; the old residence, in a single story, has been made of rubble stone. When the building plan is examined, the house consists of rooms, tandoors, a pantry, and cattle units, and there is no garden or courtyard in front of the building (Figure 13). The wall thickness varies between 70-90 cm. Looking at the upper cover, the round wooden beam, which is thrown in the opposite direction on the thick round beam called hezen, consists of oak branches that are frequently arranged and, finally, thick clay soil (Figure 14).

Figure 12. The location of the new and old house investigated in Hasancı (Kayseri Cadastre Directorate, 2019)

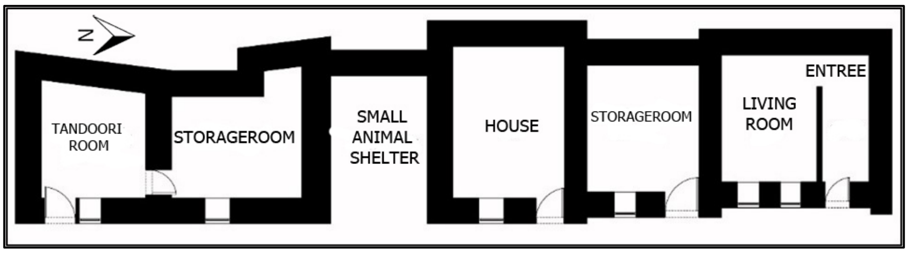

Figure 13. Plan of the old house investigated in Hasancı.

Figure 14. The old house investigated in Hasancı.

When we look at the newly built house in the Hasancı settlement, it is seen that the ground floor has two stories. The ground floor is used as a warehouse and garage, while the upper floor is used as a living space (Figure 15). The ground floor of the building is a framed structure, and the upper floor is a masonry system. All the walls in the building are made of 20 cm pumice material. The ground floor slab is made of lean concrete on a compressed floor; the ground floor ceiling is 20 cm pumice and 10 cm concrete hollow block, and the upper floor ceiling slab is a 12 cm reinforced concrete slab. It is a fringed structure and has a crushed roof. New materials are used in the structure, with no thermal insulation and only rough plaster. Upstairs, the living room and bedrooms are laminate floorings, while the kitchen is a ceramic finish with wet volumes. The windows are PVC, and the doors are wooden (Figure 16).

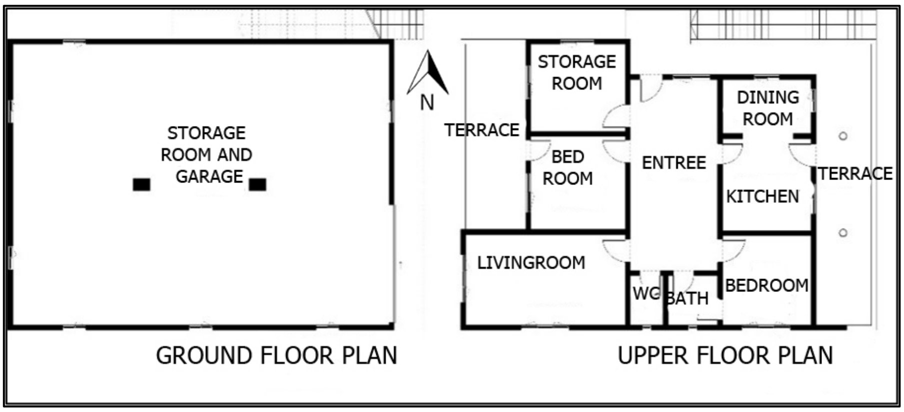

Figure 15. Plan of the new housing investigated in Hasancı.

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Figure 16. New housing investigated in Hasancı.

Looking at the old and new houses examined in the Emmiler settlement (Figure 17), the old residence is on two floors. When the building plan is examined, the lower floor is a barn, and the upper floor consists of living space. The living area is entered via a stone staircase from the road (Figure 18). The walls are made of cut stone, and the thickness is 70 cm on the lower floor and 35 cm on the upper floor. The barn and the living area flooring consist of wooden beams, branch pieces on the hezen, and concrete on the ground. The roof was added to the structure, which did not have a roof in its first form. Windows and door sizes are small (Figure 19).

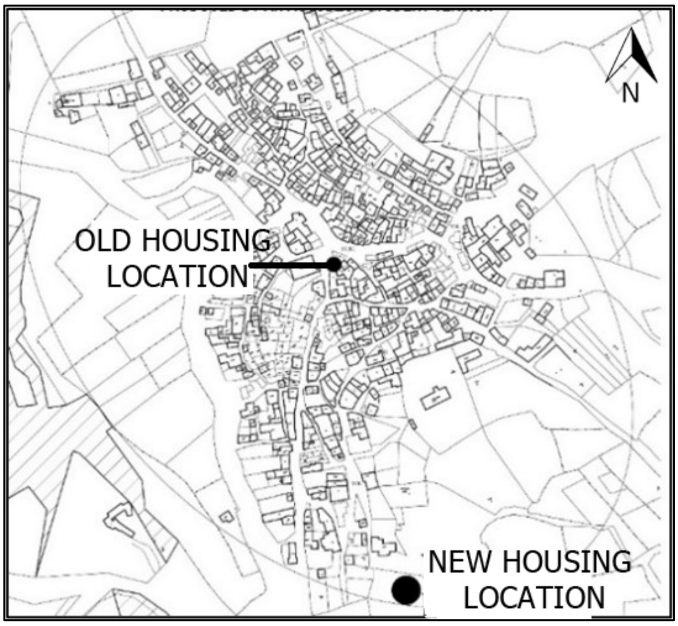

Figure 17. The location of the new and old house investigated in Emmiler (Kayseri Cadastre Directorate, 2019)

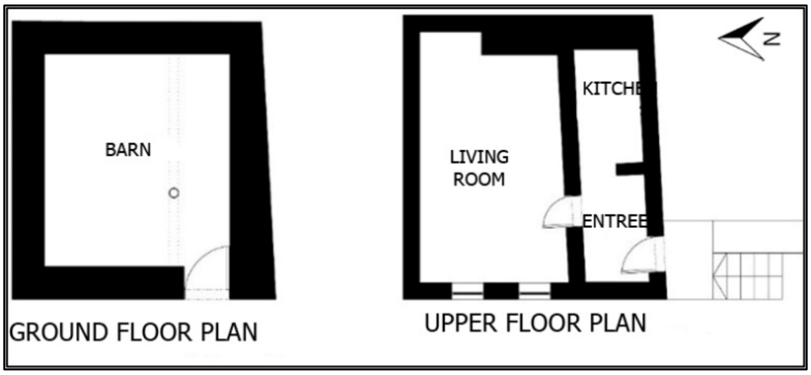

Figure 18. Plan of the old house investigated in Emmiler.

Figure 19. The old house investigated in Emmiler.

When we look at the newly built house in Emmiler settlement, the building consists of a basement and ground floor. While the basement is a warehouse, the upper floor consists of a living area (Figure 20). However, a semi-open tandoori area (where phyllo, tomato paste, and molasses are cooked) and a closed unit for woodland next to it; greenhouses are in the garden. The walls are made of 20 cm of pumice concrete. There is no thermal insulation, and the exterior is painted on plaster. The flooring is lean concrete on a compressed floor, the living room and bedrooms have laminate flooring, and the kitchen and wet areas are ceramic coated. The upper cover of the living area is a crushed roof on the cladding board on wooden beams with rectangular sections and is covered with Marseille-type tile. The windows are PVC, and the doors are wooden (Figure 21).

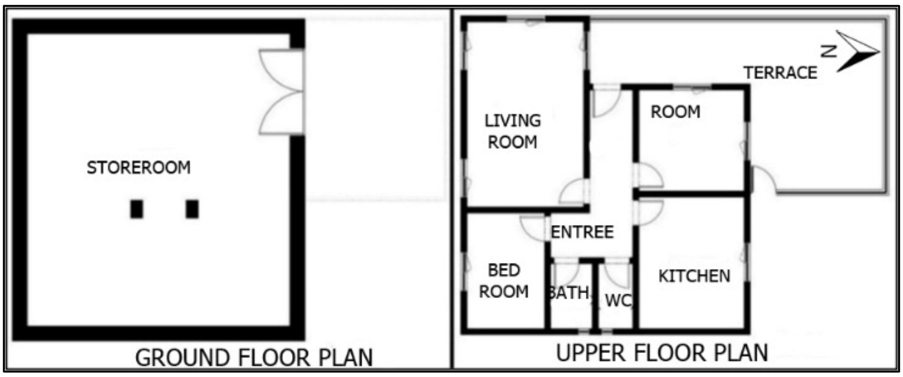

Figure 20. T Plan of the new housing investigated in Emmiler.he old house investigated in Emmiler.

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Figure 21. New housing investigated in Emmiler.

FINDINGS

Within the scope of the study, old and new residents in the rural settlements of Höbek, Hasancı, and Emmiler with the Tarımköy housing project prepared by TOKİ, the Type No. 4C housing project, one of the types of housing in the Rural Area Regional Architectural Identity Project prepared by Mimar Sinan Fine Arts University, and the Type 3A project prepared by the Ministry of Environment, Urbanization, and Climate Change were analyzed in the Revit program. Analyses carried out within this scope include analysis of solar orientation, daylight acquisition, and energy consumption.

Sun Orientation and Daylight Reception Analysis

The study included nine projects assessed based on the sun's position, the sunbathing time of the venues, and the lux value of the daylight received by the venues based on space size. According to the six project locations examined in the field of study, the type projects are positioned to face south so that the main living spaces can get more light (Figure 22). Furthermore, direct daylight retrieval times (Figure 23) and direct daylight lux values (Figure 24) were calculated depending on the sun orientation analysis.

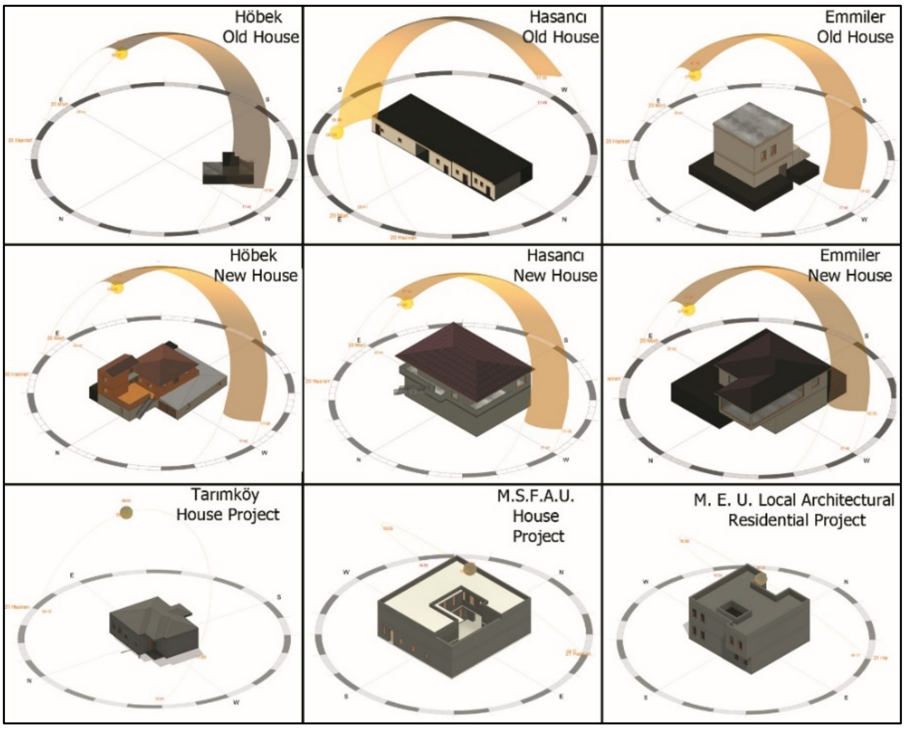

Figure 22. Land session and sun orientation of selected houses.

When looking at Figure 21, the façades of the old houses in Höbek and Hasancı looks at sunrise, Emmiler looks at sunset, and the long façades of the buildings are in the north-south direction and look in the east and west directions. When looking at the façade openings, it can be seen that all the windows and doors are on the eastern façade, and the western façade has no openings. In this case, daylight at the appropriate temperature in summer is used by taking it into the house, and coolness is created by avoiding high-temperature daylight. In the winter, thanks to the western façade being deaf or covered with soil, heat is gained by storing high-temperature daylight and giving the temperature to the interior when there is no sun. In the new housing in the workplace, the frontlines look west or north. Thanks to the presence of windows or doors on all fronts, daylight enters the interior all day. This situation provides an advantage in terms of saving the energy required for lighting by ensuring that the illumination times of the interior spaces are long both in summer and winter. On the other hand, the large number of openings causes the interior spaces to warm up more in the summer. The heat bridge areas increase in the winter, thus increasing the energy required to create the ideal ambient conditions. Thus, the sun is both benefited and adversely affected.

In the Tarımköy and Ministry of Environment, Urbanization and Climate Change housing projects, the eastern and western fronts are deaf and only receive light from the northern and southern fronts. In the Mimar Sinan Fine Arts University housing project, light is taken from the southern and eastern fronts, and other fronts are deaf. It is observed that the sun is largely not considered in type projects.

When looking at the direct daylight periods depicted in Figure 22, the lower floor of the old residence in the Höbek region is in the range of 0-1

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hours, and the upper floor is in the range of 0-3 hours, while the lower floor of the new dwelling is 0-2 and the upper floor is in the range of 0-3 hours. While the old residence in the Hasancı region is in the range of 0-0 hours, the lower floor of the new residence is 0-3, and the upper floor is 0-5 hours. When looking at the Emmiler area, the lower floor of the old residence is 0-3 upper floor in the range of 0-2 hours, while the lower floor of the new dwelling is 0-0, and the upper floor is in the range of 0-5 hours.

In the Tarımköy housing project, a small area in front of the hall window and a large room receives light for up to 3 hours, while all the rest of the places receive direct daylight in the range of 0-1 hours. When looking at the Mimar Sinan Fine Arts University Type No. 4C housing project, the courtyard receives direct daylight for up to 5 hours, while all indoor spaces receive direct daylight from 0-1 hour. A very small area in the bathroom with the south-facing room on the ground floor receives direct daylight for up to 2 hours in the Regional Architecture Type 3A housing project, while a small area in front of the window of the mansion room and south-facing room on the upper floor receives direct daylight for up to 2 hours. All other venues appear to receive direct daylight in 0-1 hours.

Figure 23. Direct daylight time analysis of selected houses.

Looking at the lux values detailed in Figure 23, the lower and upper floors of the old residence in the Höbek region and the upper floor of the new residence receive 0-6000 lux daylight, while the lower floor of the new residence receives daylight in the range of 0-63 lux. Looking at the lux values in the Hasancı region, the old residence receives 1-619 lux daylight, while the lower floor of the new residence is 4-6000, and the upper floor is in the range of 0-6000 lux. When looking at the Emmiler

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area, the lower floor of the old residence is 0-814, the upper floor is 0-157 lux, while the lower floor of the new dwelling is 0-2, and the upper floor is in the range of 2-6000 lux.

It is identified that the rest of these rooms, where 107-6000 lux light can be obtained up to the middle parts of the hall and large room spaces of the Tarımköy housing project, and all other places in the residence are illuminated in the range of 0-107 lux. When looking at the Mimar Sinan Fine Arts University Type No 4C housing project, the only indoor room with a light value of 107-6000 lux is the room next to the kitchen. Located in the southwest direction, the rooms, barn, and guest rooms in the northeast are secondary bright spaces, and the lux value rises to 1291 lux in front of the windows and 5382 lux in front of the door in the barn. Upstairs, sofa, kitchen, and headroom spaces are the brightest spaces, receiving 6000 lux in light on window sides, while the rest have over 107 lux in light. The other bright space on this floor is in the courtyard, where it can receive up to 646 lux. All other venues receive light of 0-107 lux. On the other hand, in the Local Architectural Type 3A residential project, the headroom on the ground floor and most of the other south-facing room gets light in the range of 107-1291 lux, while the kitchen and most of the other north-facing rooms get light in the range of 107-646 lux. The areas corresponding to these places on the upper floor receive the same light value. As a result, these rooms, together with the corridor, panty, and wet volume units, which are placed in the middle and away from the window, have a light of 0-107 lux.

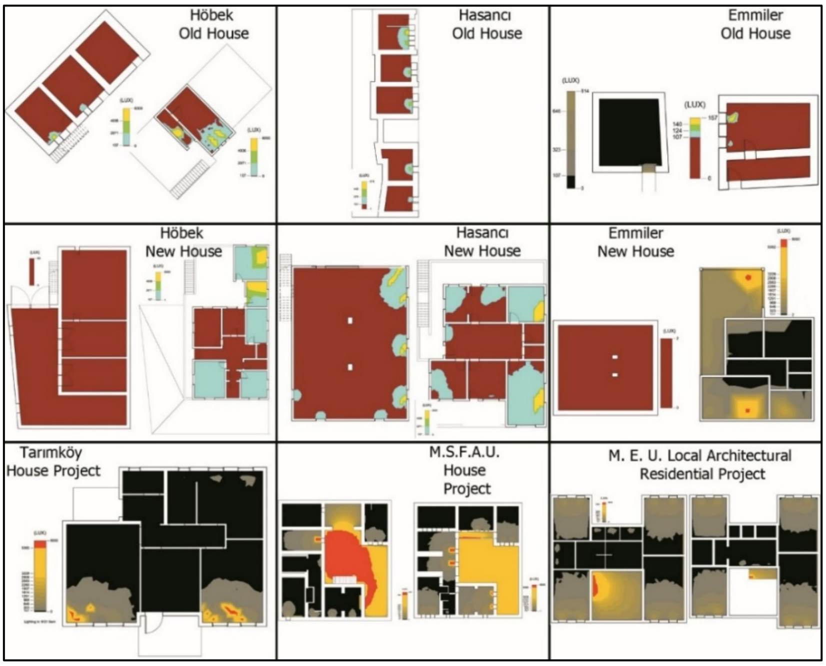

Figure 24. Lux value analysis of selected houses

Solar and Energy Consumption Analysis

In this section, the energy needs consumed in total are calculated in Table 1 in the Revit program of the selected houses to use electricity for heating, cooling, lighting, and various domestic appliances. The amount of energy consumption per sqm is also calculated in this table.

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Table 1. Annual energy consumption analysis-kwh

	Heating	Cooling	Lighting	Various domestic Appliances	Calculated	Area (sqm)	Energy per sqm
Höbek Old House	5.903	13.989	2.631	2.631	**25.154**	**113**	**222,6**
Höbek New House	16.542	199.119	10.147	13.189	**238.997**	**532**	**449,24**
Hasancı Old House	10.350	4.789	3.431	3.431	**22.001**	**140**	**157,15**
Hasancı New House	9.644	81.447	13.825	13.825	**118.741**	**350**	**339,26**
Emmiler Old House	7.050	3.556	1.936	2.519	**15.061**	**68**	**221,49**
Emmiler New House	11.858	17.297	7.100	7.100	**43.355**	**207**	**209.44**
Tarımköy House Project	8.706	1.586	1.694	1.694	**13.680**	**80**	**171**
MSFAU House Project	20.292	11.194	6.981	6.981	**45.448**	**336**	**135,26**
M. E. U. Local Architectural Residential Project	17.361	13.308	4.856	6.314	**41.839**	**226**	**185,13**

The energy obtained using renewable energy sources is clean, does not harm the environment, and contributes greatly to the family budget. Therefore, meeting the energy used in buildings in these ways will greatly contribute to ecological and economic sustainability. Based on this situation, if solar energy panels are placed on the roofs of the houses, the ratio of the produced energy to the consumed energy is calculated and shown in Table 2. Then, the annual electricity consumption amounts required for the cooling, lighting, and equipment shown in Table 1 are multiplied by 0.693408 (Kayseri Elektrik Perakende Satış A.Ş., 25.07.2021), which is the energy consumption cost of the KEPSAŞ company that distributes electricity in Kayseri province, and the annual electricity consumption cost excluding taxes are calculated in the first stage of this calculation. In the second stage, the number of 280 W Polycrystalline solar panels with dimensions of 165x100 cm, widely used for small-scale residences that can be placed on roofs, has been determined. Finally, the amount of electricity that can be produced annually was calculated by multiplying the number of panels determined at the end of this process by 280 W, the electricity generating power of the panel, and 1.588 KWh/sqm-year (GNS Solar, 25.07.2021), which is the Kayseri radiation value. Then, the annual electricity production amount and the energy consumption cost of KEPSAŞ company are multiplied, and the consumption cost corresponding to the produced amount is determined. In the last step, the ratio of the consumption price corresponding to the amount produced to meet the annual electricity consumption has been calculated and shown.

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Table 2. Electricity consumption and production costs, consumption coverage ratio

	Heating	Cooling	Lighting	Various domestic Appliances	Calculated	Area (sqm)	Energy per sqm
Höbek Old House	5.903	13.989	2.631	2.631	**25.154**	**113**	**222,6**
Höbek New House	16.542	199.119	10.147	13.189	**238.997**	**532**	**449,24**
Hasancı Old House	10.350	4.789	3.431	3.431	**22.001**	**140**	**157,15**
Hasancı New House	9.644	81.447	13.825	13.825	**118.741**	**350**	**339,26**
Emmiler Old House	7.050	3.556	1.936	2.519	**15.061**	**68**	**221,49**
Emmiler New House	11.858	17.297	7.100	7.100	**43.355**	**207**	**209.44**
Tarımköy House Project	8.706	1.586	1.694	1.694	**13.680**	**80**	**171**
MSFAU House Project	20.292	11.194	6.981	6.981	**45.448**	**336**	**135,26**
M. E. U. Local Architectural Residential Project	17.361	13.308	4.856	6.314	**41.839**	**226**	**185,13**

As shown in Table 1, the annual energy consumption of old houses in the region is between 15,000-25,000 kwh, while the energy consumption of new houses is between 43,000-239,000 kwh. In this case, it is reported that new houses consume between 1.72 and 15.93 times more energy than old houses. When looking at type projects, the annual energy requirements are in the range of 13.000-45.500 kwh, and the minimum energy requirement is in the Tarımköy project. Compared to these projects and old housing projects, the MSGSU Housing Project and Ç.Ş.B. Regional Architectural Housing Project consume 0.66 to 2.01 times more energy than old houses. In comparison, the Agriculture Village Project consumes 0.1-0.84 times less energy. When we examine the amount of energy consumption per square meter, it is generally observed that type projects consume 0.15-0.65 times less energy than old houses and 0.13-2.32 times less energy than new houses.

As detailed in Table 2, the annual energy generation potential of old houses is between 8,000-36,000 kwh, while in new houses, it is between 29,000-51,000 kwh, and in type projects, it is between 13,000-27,000 kwh. In light of this data, in Table 3, the annual electricity consumption amount in old houses is very comfortably met. In contrast, houses other than Emmi can meet the annual electricity consumption of 15% - 45% in new houses. When looking at type projects, the Local architectural housing project can meet 89% of its annual energy consumption, while other projects can produce more than they need.

CONCLUSIONS AND RECOMMENDATIONS

Within the scope of the study, one old and new housing in Höbek, Hasancı, and Emmiler regions in the Kayseri Kocasinan district and the Tarımköy Housing Project prepared by TOKİ, Type No 4C Housing Project, one of the types of housing in the Rural Area Regional Architectural Identity Project prepared by Mimar Sinan Fine Arts University, and Type 3A project from Type Housing Projects suitable for

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regional architectural features prepared by the Ministry of Environment, Urbanization and Climate Change, have been examined by subjecting sustainability analysis to rural housing projects through the BIM-based Revit program. With these analyses, answers were sought for the questions of the duration of daylight use, quality of daylight indoors, heating, cooling, lighting specifically, and in total, how much energy consumption and how much of the consumed energy can be met from renewable energies in rural housing.

In terms of benefiting from daylight, it is discovered that the new houses in the region are more advantageous than the other houses, the old houses are in second place, and public projects are in last place. When considering the variables that contributed to the construction of this situation, the placement of the new houses on the land and their orientation to the sun, wide window sizes, and the high number of windows in space stand out. When we look over the old houses, the small size and number of windows, the high wall thickness, the light from only one direction, and the smaller interior dimensions compared to the new houses cause less sunlight than new houses. When we examine public projects, the positioning of the land so that important places can receive more daylight, the long interior dimensions, the lack of size and number of windows to meet this length, and the high number of deaf façades cause the least benefit from the sun.

In terms of energy, new residences consume the most energy in total energy consumption, while public projects are in the second place and old residences are in the last place. In the context of energy consumption per square meter, public projects consume the least energy, while old houses are in the second place and new houses are in the last place. In public projects, it is observed that the project prepared by Mimar Sinan Fine Arts University is the least energy-consuming structure in terms of energy consumption per square meter among other public projects.

The fact that the areas of the old houses are small, the façade openings are few, the number of deaf façades is high, the walls are made of stone material, and the thickness is high has ensured the total amount of energy consumption is low. In terms of public projects, it is believed that the thermal insulation of Tarımköy and Regional Architectural Housing reduces total energy usage. Aside from the fact that the total area of the residence prepared by Mimar Sinan Fine Arts University is larger than other public projects, and the amount of energy per square meter is low despite the lack of thermal insulation, the introverted design, the low number of deaf façades, and the local material, stone material, all contributed. On the other hand, when looking at the new houses, it is thought that the lack of thermal insulation, the presence of window openings on each façade, the low wall thickness, and the low heat holding capacity of the wall materials increase the amount of energy consumption.

When a general evaluation is made, while new houses are advantageous in terms of daylight use, they are disadvantageous in terms

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of energy consumption. On the other hand, while public projects are disadvantageous in terms of daylight use, they are advantageous in energy consumption. Then again, the old houses are in an intermediate position in both respects.

Another unique situation in rural areas is that people build their buildings without having a project prepared or necessary permits. However, per the Building Inspection Law, buildings under 500 sqm in rural areas are not subject to building inspection. Therefore, the project, building inspection, and building construction fees are high enough to affect the individual budget.

From this point of view, preparing a project and obtaining a license should be obligatory by reducing all fee prices for buildings built in rural areas. Furthermore, during the project phase, sustainability analyzes should be made mandatory in the design of all buildings, especially rural residences, and missing points should be identified and improved. In addition, the state should provide project support services, and original designs should be made by determining the needs of people instead of typical projects.

Today, rural areas are served by the Rural Services Directorates within the municipalities. Therefore, these units should be given project and construction site control procedures for all construction in rural areas, and inspections should be increased. In this way, controlled and sustainable construction can occur.

In the design of rural houses, wide openings should be included on all façades so that the sun can be benefited most, and heat-saving glasses should be preferred in the windows. Energy-saving materials should be used in the entire structure. The use of solar energy panels should be encouraged and made compulsory for obtaining licenses and building occupancy permits.

With the propositions made, it is thought that resources can be supported more effectively in a better environment. The study is expected to contribute to sustainability by serving as the foundation for future studies.

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Resume

İbrahim Bektaş received his undergraduate degree from Erciyes University, Faculty of Architecture, and his graduate degree from Karabük University, Institute of Science, Architecture Department. He works as a lecturer at Kayseri University Tomarza Mustafa Akıncıoğlu Vocational School.

Aysun Özköse works as a Professor at the Başak Cengiz Faculty of Architecture at Karabük University.

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