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Defining Nearly Zero-Energy Buildings (nZEB) for Turkey in terms of Boundary Conditions

* [1] Dr. **Gözde Gali Taşçı**
Istanbul Beykent University, Faculty of Engineering and Architecture, Istanbul, Turkey [1]
E-mail [1]: gozdetasci@beykent.edu.tr

Abstract
The European Union has presented that the building sector is responsible for 36% of greenhouse gas emissions due to energy consumption and 40% of all energy consumption. Within the framework of the EPBD directive followed to reduce fossil energy consumption in EU countries, the commission recommendation in 2016 (2016/1318) is to ensure that by 2020 all new buildings are nZEB. The current directive has further steps. In Turkey, the Regulation on Energy Performance in Buildings follows EPBD. However, the definition of nZEB in Turkey should be reviewed within its own boundaries. There are 5 different climatic regions in Turkey with different architectural characteristics. Therefore, different ways will have to be followed in terms of meeting the heating-cooling needs. This research deals with the boundary conditions that may be encountered while developing the nZEB definition for Turkey and proposes climatic definitions, additionally with a development in sectoral operation in building sector.
Keywords: nZEB; Energy Performance; Regulation; Green Building; Climatic Design.

1. Introduction

Global warming and its effects are drastically threatening the Earth and the living. This subject is currently a priority for humanity and nature(Amen, 2021, Aziz Amen, 2022, Amen et al., 2023, Amen & Nia, 2020). In fact, for a long time there have been important studies on this issue; however, not enough progress has been made in practice. At this point, buildings are now the key sector in order to reduce the fossil energy consumption and greenhouse gas emissions.

Formerly, the buildings were the third energy consumer following industry and transportation. However, latest research present that the consumption and emission rate are the highest in buildings. Figure 1 shows that the distribution of final energy consumption by sector in Turkey (National Energy Plan of Turkey, 2022). Additionally, according to amended directive EPBD (Energy Performance of Buildings Directive) 2018/844/EU (2018), buildings are responsible for approximately 36% of all CO_2 emissions in the European Union (EU). So, there is the same tendency about buildings also in EU.

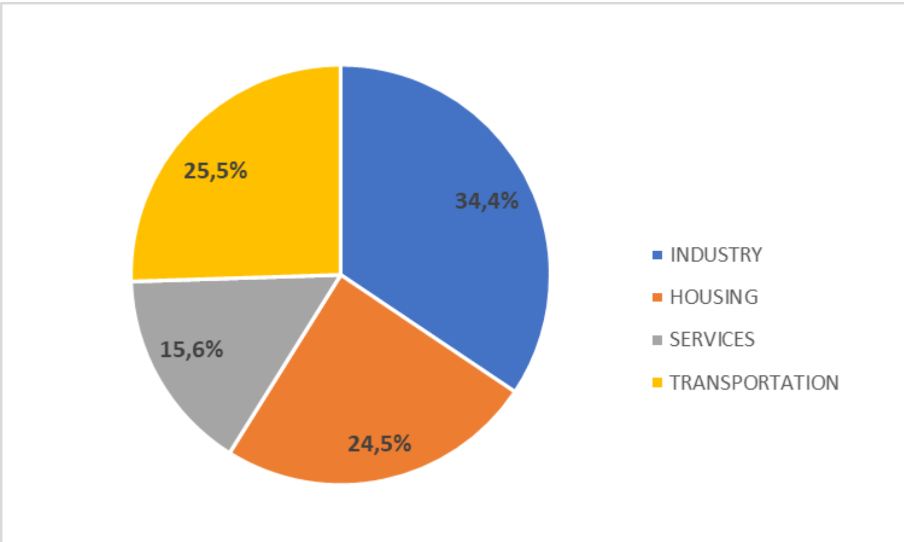

Figure 1. Distribution of Final Energy Consumption by Sectors (National Energy Plan of Turkey, 2022).

According to Energy Market Supervision Agency of Turkey (EPDK), yearly natural gas consumption is the highest in building sector with 35.85% in comparison to the other sectors as in Figure 2 (Natural Gas Market Sector Report, 2021). Also, according to National Energy Plan of Turkey (2022), yearly electricity consumption is the highest in building sector with 141.3 TWh which equals to 46.1% in 2020 as in Figure 3.

Therefore, reducing the energy consumption rate in building sector is the key point in order to reduce greenhouse gas emissions. For this reason, there are obligatory implementation studies in parallel to the regulations. Turkey follows the improvements in EU. The last amended directive EPBD 2018/844/EU (2018) recommends the renovation of national building stocks into a highly energy efficient and decarbonized building stock by 2050. In order to achieve this goal and facilitate the cost-effective transformation of existing buildings into nearly zero-energy buildings (nZEB) the directive presents 2030, 2040 and 2050 milestones. In this context, some revisions and additions were made to the amended Regulation on Energy Performance in Buildings (2022) in Turkey. As part of the innovations, the construction of new buildings as nZEB has become mandatory. While there is no clear explanation for existing buildings in the regulation, a 2053 Net Zero Emission target is specified for the building stock in the National Energy Plan of Turkey (2022).

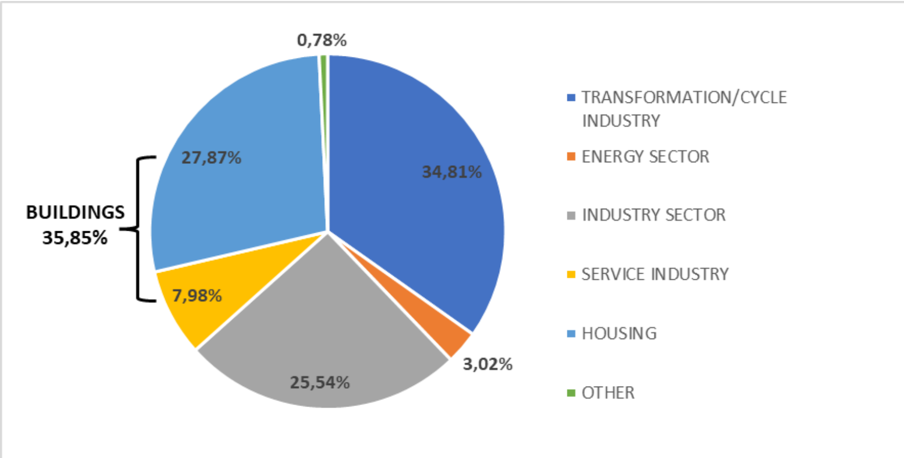

Figure 2. Natural Gas Sectoral Consumption Distribution (Natural Gas Market Sector Report, 2021).

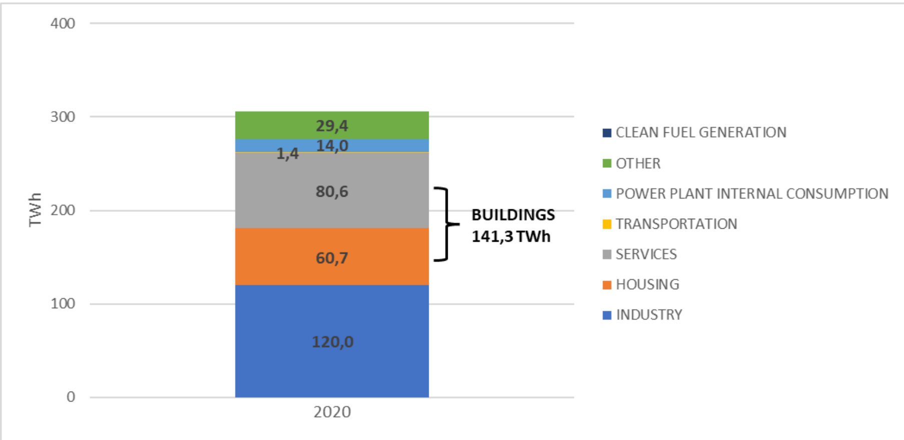

Figure 3. Electricity Consumption by Sector (National Energy Plan of Turkey, 2022).

Thus, it is very important to define what nZEB means and what are the boundaries to implement it in Turkey. In this way, new buildings and 2053 targets of Turkey could be clear and applicable. Within the scope of this study, the important points of the directives and regulations both in EU and Turkey have been compared and open-ended parts have been determined. Implementation of the directives and regulations have been analyzed through literature review and boundary conditions have been determined both for EU and Turkey. Finally, recommendations have been developed for Turkey according to climatic features and sectoral workflow.

2. Important Developments in Europe and Turkey

The most important document in EU is EPBD since it includes targets and general pathways for all EU countries. Turkey, which is on its way to join the EU, is following this directive and its amendments. In this context, the most important document in Turkey is the Regulation on Energy Performance in Buildings. In this section, comparisons will be made between these two legislations.

2.1. Legal Arrangements

Legal arrangements are the key points since they present the mandatory procedures and pathways for countries. As in Table 1, Turkey follows EPBD and improves the regulation and the plans. However, even if the goals are the same, there are time differences. Recently, however, there have been differences between the targets.

Table 1. Parallel regulations.

EU LEGISLATIONS	KEY POINTS	TR LEGISLATIONS	KEY POINTS
EPBD 2002/91/EC (2002)	- Energy performance certification - Framework for the calculation of energy performance of buildings - Design principles in terms of building energy performance	Energy Performance Regulation in Buildings (2008)	- Energy performance certification - Design principles in terms of building energy performance
EPBD 2010/31/EU (2010)	- 2020 target (reducing by 20 % the Union's energy consumption by 2020) - Nearly zero-energy buildings definition - Cost optimal level of energy performance. Net present value calculation. - Defining reference buildings.	Regulation on Amending the Energy Performance Regulation in Buildings (2010)	- BEP-TR software program for issuing energy performance certificates
EPBD 2018/844/EU (2018)	- 2050 nZEB target - 2030, 2040, 2050 milestones - National long-term renovation strategies - 2050 decarbonised national building stock target	Regulation on Amending the Energy Performance Regulation in Buildings (2022)	- nZEB target in new buildings

As seen in Table 1, there are parallel developments to EU in Turkey. However, some missing data creates difficulty to implement the regulation in Turkey. The last regulation, published in 2022, is the legally binding one. According to this regulation (Regulation on Amending the Energy Performance Regulation in Buildings, 2022), buildings with a total construction area of 2000 m² and above must be built as nZEB. This article binds new buildings. However, there is a large building stock that needs to be renovated. EPBD 2018/844/EU (2018) recommends to plan strategies for long-term renovations for each EU country considering this situation. Therefore, this missing part neglects to plan improvements of existing building stock in Turkey. Since Turkey follows EPBD, we can expect a similar article in the next regulation amendment in Turkey. For now, we can only see the 2053 net zero-emission target in the National Energy Plan of Turkey (2022).

2.2. Nearly Zero-Energy Building Definition

nZEB has been defined as; a building that has a very high energy performance, as determined in accordance with Annex I of EPBD 2010/31/EU (recast). The nearly zero or very low amount of energy required should be covered to a very significant extent by energy from renewable sources, including energy from renewable sources produced on-site or nearby in EPBD 2010/31/EU (2010).

In Turkey, it is defined as; a building with high energy performance and at the same time a certain amount of renewable energy use. In another article, the renewable energy use amount has been declared as 10% (Regulation on Amending the Energy Performance Regulation in Buildings, 2022).

These definitions are similar, only in Turkey there is a certain amount of renewable energy use has been designated. At this point, also the meaning of high energy performance building is very important in order to understand what nZEB really means. It is defined as; the energy performance of a building shall be determined on the basis of the calculated or actual annual energy that is consumed in order to meet the different needs associated with its typical use and shall reflect the heating energy needs and cooling energy needs (energy needed to avoid overheating) to maintain the envisaged temperature conditions of the building, and domestic hot water needs in EPBD 2010/31/EU (2010). There is no explanation of it in the Turkish regulation (Energy Performance Regulation in Buildings). So, this missing definition makes harder to built nZEB in Turkey since building sector specialists wouldn't know what they should implement in order to make a building with high energy performance. Therefore, it is very important to designate the framework of the key parameters of building nZEB in Turkey together with the definitions in accordance with the countries' related boundaries.

Additionally, as cooling energy is defined as "energy needed to avoid overheating" in parentheses, it creates conflict. Cooling energy need may mean for Nordic European countries only to eliminate overheating. However, the cooling

need for Southern European countries is definitely an issue that needs to be worked alone, just like the heating need. So, an inclusive "high energy performance building" definition is needed. The condition of Southern countries is also valid for Turkey since it is a Mediterranean country too.
Nevertheless, it is very important that the first step of nZEB has been taken in the regulation. Because our transition to this building typology is now mandatory. Greenhouse gas emissions, which are the main reason for global warming are mostly caused by fossil fuel consumption, and as explained above, the building sector ranks first in terms of emissions.

2.3. Energy Needs and Passive Design
Another important highlight in EPBD 2018/844/EU is reducing energy needs. The objective of the Directive is reducing the energy needed to meet the energy demand associated with the typical use of buildings. Therefore, in article 15 the Directive implies the importance of ensuring that measures to improve the energy performance of buildings shouldn't focus only on the building envelope but include all relevant elements and technical systems in a building, such as passive elements that participate in passive techniques aiming to reduce the energy needs for heating or cooling, the energy use for lighting and for ventilation and hence improve thermal and visual comfort (EPBD 2018/844/EU, 2018).
Therefore, it offers to imply passive measures first instead of technical installations. In this case, the architectural project part has a great responsibility. Since this part is where all design decisions are designated about building construction. The decisions are not only about building envelope but for example also about how the natural ventilation could be in depending on the location and direction of the building and the operable window layout.
Since architects are also the coordinators of the projects, ventilation, lighting, and air conditioning are related to their passive design decisions. Together with appropriate passive design, energy savings can be achieved by keeping the installation system capacities smaller, or electricity consumption can be reduced by choosing more efficient lighting elements in the lighting system.
Therefore, the key point in EPBD 2018/844/EU as "reducing energy need" is very important and it clearly ensures that the most important and priority task in reducing energy consumption is assigned to architects. In fact, we have known for a long time that passive measures to be taken in the architectural project will enable to make more efficient choices in the installation and electrical systems or prevent more costly additions to be made in order to ensure energy efficiency later. It has also been officially declared with EPBD 2018/844/EU.

3. Boundary Conditions of Implementing Legislations
There are two important legislations; EPBD is for EU and Energy Performance Regulation in Buildings for Turkey. In order to apply each to countries construction process the method should be clear. However, there are some missing statements in the definitions as mentioned in the sections above both for EU and Turkey. So, in the next amendments these issues should be clarified.

3.1. Boundary Conditions in EU
Implementing the general legislations is not only a problem for Turkey, but also in EU there are some boundary conditions especially since the Union is a multinational structure with different climatic characteristics and different management systems. According to literature review, in summary, 5 main topics can be counted. These are definitions, climatic conditions, thermal comfort definition differences, renewable energy production problem, construction quality (Attia et al., 2017).
The situation about definitions explained in the parts above. This condition prevents the determination of a common goal in the Union or the creation of its own plan for the common goal by each country according to the conditions of the country.
Climatic conditions are the focus of this paper. The climatic definitions constitute a limit as there are different climatic regions in EU, but most of the research are done for heating energy needs. Nordic European countries, which are highly advanced in building energy performance research and applications, mostly focus on the measures to be taken in accordance with their climatic regions and therefore to reduce the need for heating demand. However, in Southern European countries, it is absolutely necessary to reduce the need for cooling demand in order to solve the high energy consumption and greenhouse gas emissions problem. For example, German Passive House Standard has specified prescriptions such as; building orientation, compact form, good thermal insulation, energy efficient triple glazing and window frames, good sealing of the building envelope to air infiltration, passive preheating of fresh air introduced into the building during winter, heat recovery from exhaust air and its transfer to the fresh air introduced into the house, upper class domestic electric appliances (Badescu et al., 2015). As can be seen, all of these approaches are aimed at reducing the heating energy need. However, such a standard should be applicable throughout Europe or if it is as it is now it should be declared at the national level for Germany and countries with

similar climatic conditions. As a matter of fact, according to the studies conducted by Attia et al. (2017), heating load-based studies can cause overheating during the cooling period even in Northern countries. Therefore, active heating and cooling system is recommended when such passive house buildings are applied.

Thermal comfort definition is related to the climatic conditions. Since the climate characteristics and therefore the heating-cooling set point values to be taken as a basis will be different, the thermal comfort assessment should be defined according to the climatic regions. A common assessment cannot be made for the entire European Union. While a definition can be made for the Northern countries, the definition for the Southern countries is quite incomplete. At the same time, the criteria to be sought in order to provide thermal comfort could not be fully defined in Southern countries.

In renewable energy production problem, there are two points. The first one is in the nZEB definition, it is not specified how much of the energy need will be provided from renewable energy sources. This point is restricted in some countries. For example, it is stated as “10% of the remaining energy need” in Turkey. Since this limitation is not made, it is not known exactly how much renewable energy will be used to reach nZEB. However, countries can set limits themselves. The second issue is that the type of renewable energy to be used will vary according to the geographical, topographic and climatic characteristics of the countries. In this case, there will always be differences in terms of production amount and typology. The economic and technological development of the countries is also a very important determining criterion in the amount of production.

Construction quality is a very detailed subject, but we can only briefly describe it here. Depending on the technological, economic and social characteristics of the countries, the construction quality differs. Education is also very important in this regard. According to the studies, while Northern European countries give better quality results, there are generally more problems in Southern European countries (Attia et al., 2017). The most important reasons for this are the limited number of energy efficient building experts in the market and the lack of access to architects and engineers who are well-versed in new technologies and regulations.

As a result, there are some boundary conditions for applying the directives in the European Union. This problem can only be solved by the studies of the countries at the national level. Making generalizations causes different country conditions to be ignored and causes unrealistic targets to be determined. National remediation plans should be prepared for the decarbonization of building stocks.

3.2. Boundary Conditions in Turkey

Although Turkey takes into account the country's conditions in the Energy Performance in Buildings Regulation, which developed by following the EPBD, some restrictions are encountered in practice. These constraints are mostly due to the social and economic conditions of the country. Each is a boundary condition that can be overcome with detailed plans when worked on. However, as in Europe, there are no official studies on boundary conditions in Turkey yet. This topic is still at the research level. According to comparisons and research, 5 main boundary conditions can be counted for Turkey. These are education, construction workflow, climatic definitions, technology, official regulations. Within the scope of this paper construction workflow and climatic definitions will be focused on.

The development of the education is necessary for both experts and users. Architects and engineers who are experts in building energy efficiency should be trained. For this, university curriculum programs should be updated. For the correct use of the energy efficient buildings obtained, educational information should be given to all the public.

Technology is a key point for developments in the building industry. Technological development of the country belongs to the educational and economical level of the country.

Revisions should be made in the developed regulations by taking into account the country's boundary conditions. In order to solve the boundary conditions, national plans must be prepared, and applications must be checked.

There is a general operation in the building sector in Turkey. This process mostly includes the design and construction processes of buildings in accordance with certain standards. However, although the subject of building energy efficiency, which gained momentum especially in the 2000s, attracted the attention of the sector, it has been able to enter the process in the sector mostly at the level of voluntary certificates. This poses a serious obstacle to the implementation of the Regulation and reaching real nZEBs.

The boundary conditions in climatic conditions are quite similar to the EU, but since Turkey is a single country, it is an easier obstacle to overcome. The result can be reached by determining separate nZEB plans for the 5 climate zones in Turkey as climate sensitive nZEB definitions.

The last two boundary conditions will be discussed in more detail in the next section. In Turkey, as in the EU, the generalizations made in the regulation should be handled under the conditions of each climate zone, regional plan arrangements should be made, and applications should be checked on site. All boundary conditions can be improved over time depending on the initial regulation of the education.

4. Method Suggestion to Solve Construction Workflow and Climatic Boundary Conditions

Turkey is a very rich country in terms of climatic characteristics. It is very important to distinguish the differences between the climatic regions, in order to designate the necessary parameters to achieve nZEBs. The most useful scientific study on this subject is Zeren's (1959) associate professorship thesis. According to this study, there are 5 climate zones in Turkey as shown in Figure 4. The heating and cooling energy needs of these climatic regions are quite different from each other. Climatic features are defined in Table 2 according to the research of Koca (2006).

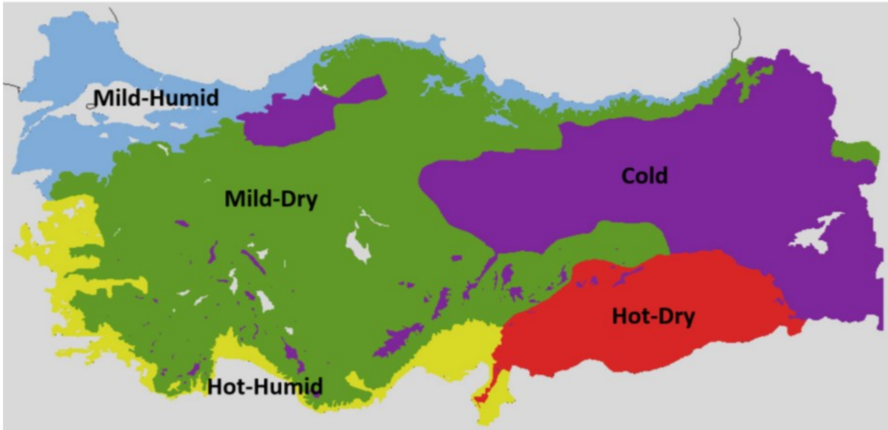

Figure 4. Climate Regions in Turkey (Zeren, 1959).

Table 2. Characteristics of the Climate Regions.

CLIMATE ZONE	CHARACTERISTICS
Cold Climate Zone	- Long and harsh winters, short and cool summers. - Average of maximum temperatures for months: 12.5 °C - Average of minimum temperatures for months: -2.2 °C - Average of sunny hours per day: 6.9 hours - Average wind speed: 10.0 kph
Hot-Humid Climate Zone	- Mild and rainy winters, hot and humid summers. Relative humidity problem. - Average of maximum temperatures for months: 24.7 °C - Average of minimum temperatures for months: 14.3 °C - Average of sunny hours per day: 7.9 hours - Average wind speed: 11.7 kph
Hot-Dry Climate Zone	- Mild winters, hot and dry summers. Difference in daily and annual temperature value. - Average of maximum temperatures for months: 22.9 °C - Average of minimum temperatures for months: 8.6 °C - Average of sunny hours per day: 7.8 hours - Average wind speed: 10.0 kph
Mild-Humid Climate Zone	- Relative humidity problem. - Average of maximum temperatures for months: 18.5 °C - Average of minimum temperatures for months: 12 °C - Average of sunny hours per day: 6.1 hours - Average wind speed: 16.4 kph
Mild-Dry Climate Zone	- Average of maximum temperatures for months: 17.1 °C - Average of minimum temperatures for months: 3.8 °C - Average of sunny hours per day: 6.9 hours - Average wind speed: 8.9 kph

As seen in Table 2, temperatures and wind speeds are quite different between climatic regions. The features to be sought in typical buildings according to climatic features are summarized in Table 3 according to vernacular housing research (Efe, 2009; Manioğlu, Koçlar Oral, 2010; Yılmaz, 2007). When the climatic features and characteristic building typologies are examined, a general nZEB construction method cannot be defined in Turkey in order to construct new buildings as nZEB, as it is generally stated in the energy performance regulation in buildings. If a general definition is made, it will be developed with passive measures to reduce heating energy, as in the EU, and in this case, it will not be possible to reach nZEB in regions with hot and humid climate characteristics. Even overheating problem may be encountered, as in the example of Passive House (Badescu et al., 2015). For example, in the cold climate zone with an annual average temperature of -2.2-12.5 °C, passive measures such as the preference of compact forms, minimum external surface areas, low transparency rate, good thermal insulation as in the Passive

House standard are appropriate to reach nZEBs, while in the hot humid climate zone with an annual average temperature of 14.3-24.7 °C, reverse passive applications such as light facade systems, transparency ratios and layouts that will provide cross ventilation will enable to reach nZEBs. For this reason, the method of reaching nZEBs for each climate zone in Turkey should be created as separate plans, as recommended for the EU.

Table 3. Vernacular housing characteristics.

CLIMATE ZONE	CHARACTERISTICS
Cold Climate Zone	- Compact forms - Massive walls for thermal mass - Good heat insulation on building envelope - Multi-layered glasses
Hot-Humid Climate Zone	- External walls with low heat storage capacity - Cross ventilation through windows, wide openings - Light-weight construction - Pitched roofs for raining - Shading
Hot-Dry Climate Zone	- Massive walls for thermal mass - Courtyard settlement - Flat roofs
Mild-Humid Climate Zone	- Enough heat insulation on building envelope - Cross ventilation through windows, average size openings - Pitched roofs for raining
Mild-Dry Climate Zone	- Enough heat insulation on building envelope - Average size openings

When all these data are examined, nZEB steps can be determined for both existing and new buildings. Although the Regulation does not focus on existing buildings, it will be reflected in Turkey in the future, as the EPBD is focused as explained in the sections above. In this context, the first passive measures that can be implemented simply to achieve nZEB in existing buildings are sufficient heat insulation of the building envelope, airtight window frames, control of thermal bridges, appropriate glazing selection in terms of U value, SHGC and Tvis.

For new buildings, there are generally known passive design parameters that are definitely considered, such as site selection, location, building direction, surroundings, building form, optical and thermophysical characteristics of the building envelope, solar control and natural ventilation systems. In addition to these, suggestions have been prepared to reduce the heating/cooling energy need by passive methods in each climatic region with the climatic characteristics and data obtained from vernacular houses. These recommendations are included in Table 4. Unlike the vernacular housing examples in Table 3, these suggestions are both adaptable to current construction techniques and applicable to all building typologies.

Table 4. Suggested passive measures for new buildings.

COMMON FEATURES	COLD CLIMATE ZONE	HOT-HUMID CLIMATE ZONE	HOT-DRY CLIMATE ZONE	MILD-HUMID CLIMATE ZONE	MILD-DRY CLIMATE ZONE
- Balanced transparency ratio - Sufficient heat insulation thickness - Airtight window frames - Appropriate glazing selection	- South direction - Compact forms - Limited openings - External shading device use such as shutters as insulation	- Prevailing wind direction - Wide openings -Lightweight walls - Internal shading devices - External shading devices such as shutters in order to obtain wind - Energy efficient lighting fixtures -Daylight automation system - Night ventilation - Natural cross ventilation with plenty of windows - Energy efficient appliances	- South direction - High thermal mass for high time lag through the external walls - Small openings through thick walls in order to increase air velocity and decrease thermal gain - Courtyard possibilities - External shading devices both for the external openings and courtyard/balcony/porch	- Prevailing wind direction - Cross ventilation with limited openings	- South direction - Thick walls for time lag (thermal mass)

The suggestions in Table 4 are open to improvement. Together with Table 2, it is intended to reveal the climatic differences and, accordingly, the differences in the requirements of building typologies in the regions. Passive measures are important, as the priority in achieving nZEB is to reduce building heating and cooling energy needs. A proposed flow diagram, which summarizes the steps to be followed in order to carry out such a study, is given in Figure 5. This diagram is only a suggestion and is open for improvement. It may constitute a preliminary research for a national study in this context.

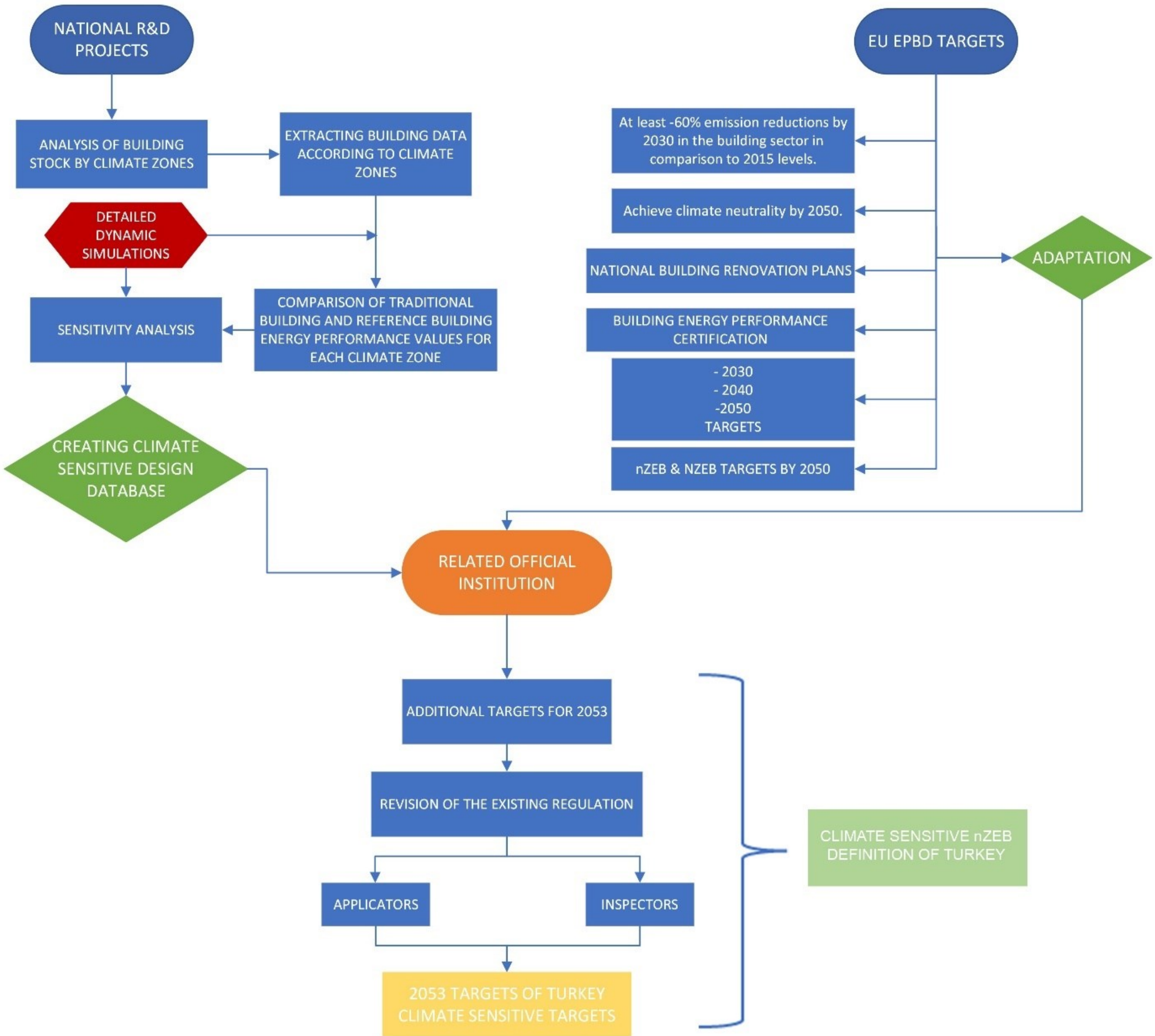

Figure 5. Climate Sensitive nZEB Definitions Flowchart.

According to the proposed flow diagram, national R&D projects will be the key part to achieve climate sensitive nZEB definitions. So, its development is the most important part in this diagram. In order to create a database, analyzing the existing building stock and distinguishing the building typologies according to the climate regions should be the first step. At this stage, reference building definitions will also be obtained according to building typologies. In this regard, the study of Yılmaz et al. (2015) which was previously conducted for the definition of reference residential buildings throughout Turkey, can be used. However, in this study, reference buildings should be separated not only according to the building typology, but also according to the climatic region in which they are located. Thus, even if there is a building typology with the same activity for each climate zone, there may be differences in terms of envelope and interior layout between the zones. However, it can be predicted that these differences may be less in existing buildings. After all, the aim is to develop such proposals at the last stage. After that, the existing energy performance of the reference buildings should be designated by using detailed dynamic simulation tools. After this stage, the passive system parameters, as in Table 4, should be applied to the reference buildings in accordance with the climate zone and retested with detailed dynamic simulation tools. In this application, all parameters should not be tested simultaneously, but individually and in various combinations. The results obtained should be compared with the reference building results obtained in the first case. Afterwards, sensitivity analyzes should be made and existing building improvement suggestions and new building application proposals that can be applied according to climate zones should be prepared as a database to reach the climate-sensitive nZEB. In order for this database to be easily accessible, it can be considered to be in a user-friendly web environment. This stage is not sufficient to impose an application requirement in the building sector. Therefore, on the other hand, targets should be determined in order to adapt to the developments in the EPBD. The methods to achieve climate-sensitive nZEB obtained in one side, legal processes and targets in the other side should be brought together with the current regulation in Turkey. As in the building energy certification before, the climate-sensitive nZEB database should be introduced by the regulation, the targets should be set, and accordingly, the use of the method in the database should be made mandatory.

As suggested in this diagram, EU projects are being carried out in the EU, especially in Southern European countries, in terms of reaching nZEBs. For example, the Passive-On project is one of them. The main aim of the project is to spread the Passive House concept further, especially in Southern Europe. The project presents the problem of household energy use in Southern regions not only of providing warm houses in winter but also, and in some cases more importantly of providing cool houses in summer. This condition is similar in certain climate zones in Turkey. Even as a result in the project, a software has been developed by Passivhaus Institute in Germany in order to calculate cooling loads and evaluate passive cooling solutions (EERG, 2007).

It is obvious that focusing on climatic definitions is a must in our country. Compared to countries with similar climatic conditions throughout the country, more complex methods should be developed for the target of nearly zero energy buildings in Turkey because of climatic variations. Passive measures that take into account the need for cooling energy should also be developed in climatic conditions where temperature and humidity are also intense. Reducing the heating energy need has been studied more and standards have been produced. Access to methods that reduce the need for cooling energy is more difficult. While access to applications that can reduce the need for heating energy in the market is quite practical, methods to reduce the need for cooling energy may require more cost or options integrated into the design in the building.

Obtaining climatic definitions is not enough alone. One of the most important problems today is that nZEB cannot find a place in the workflow in the building industry. The basis of the workflow problem is that the building energy efficiency field is not sufficiently included in the vocational trainings in the building sector. The process in education is reflected in practice. Therefore, the subject of building energy efficiency is trying to be engaged later in the workflow. However, the lack of experts in the sector and the lack of awareness of the vital importance of this subject cause energy efficiency practices not to be implemented in every project. Even the studies for obtaining the most popular voluntary certificates in the sector are carried out after the project design process.

A standard workflow diagram of the building sector is shown schematically in Figure 6. As can be seen there is no place for energy efficiency experts in this flow. It is only if one of the voluntary green building certifications is to be obtained that energy efficiency experts are added to the process after most of the initial design decisions have been made. Mostly, it is not to give direction to the design, but to evaluate the design.

As in the diagram, architects are the coordinators of the construction workflow. It is usually the architects who take the project and manage the process by distributing it to subcontractors. At this point, design decisions, application projects, building materials selection and interior space decisions belong to the architects. Structural features of the building are solved with static engineers. Heating-cooling-ventilation projects are solved with mechanical engineers and system decisions are made. All electrical installation and lighting system decisions are made with electrical engineers. In this context, architects are also involved in the layout, size and element selections in all projects. The design process guides the results of the building's thermal comfort conditions and lighting and ventilation systems from the beginning. At this point, the lack of involvement of building energy efficiency experts in the process makes it difficult to achieve the nZEB target.

A similar situation is experienced in Southern European countries. Within the scope of the EPBD's 2050 targets, EU projects are carried out in order to eliminate this boundary condition and to achieve the nZEB target. For example, the Passive-On project includes steps in this regard as well. It envisages the development of a design guideline that can be used by architects and designers so that the Passive House concept can be implemented in Southern European countries. The Design Guidelines for architects and designers (particularly small studios) has developed for developing cost effective, relatively low investment cost, all season Passive Houses in both heating load and cooling load climates. The Guidelines are targeted at small architectural studios, typical of Italy, Spain, and Portugal which have few resources for developing innovative designs and tend to stick with old proven solutions that is similar to most of the offices in Turkey (EERG, 2007).

The goal is a complete overhaul of the existing building stock for conversion to nZEBs and the new buildings to be built entirely as nZEBs. In this case, instead of working with energy efficiency experts only on projects with a specific purpose, the entire workflow needs to be reorganized so that building energy efficiency experts are integrated. The method proposal that can be followed for this purpose is given in Figure 7.

Figure 6. Construction Sector Operation Diagram.

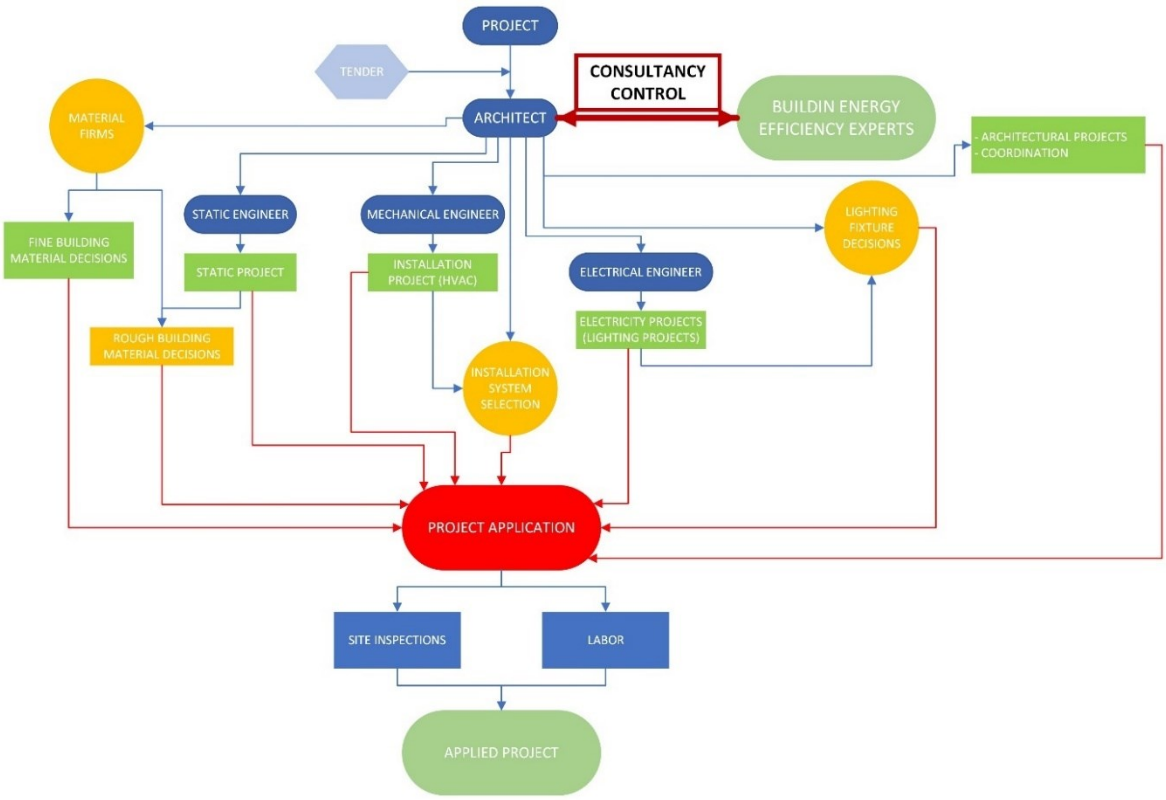

Figure 7. Construction Sector Proposed Operation Diagram.

It is very important that building energy efficiency experts are involved in the preliminary project stage where passive system decisions are made. Thus, heating, cooling, ventilation and lighting needs are reduced by passive methods, allowing smaller capacities and efficient choices in system selection. Then, all material and element selections should be continued with building energy efficiency experts and experts should be involved in the implementation of the project as controllers.
Another important part to solve this boundary condition is to educate the construction sector experts in order to give them the awareness of the importance of reaching nZEB and decarbonization targets. For example, another EU project SouthZEB in EU is just for this reason. The targeted group of this project is building professionals, decision makers, property owners, and vocational training. Its aim is fostering the energy efficiency of the building sector through the adoption of nZEB concepts in new or existing buildings, the project develops training modules targeted towards specific professionals (engineers, architects, municipality technicians and decision makers) in Southern European countries (Greece, Cyprus, Southern Italy and Portugal) (IEE, 2017).
In this case, we can say that Southern Europe and Turkey are very similar in terms of boundary conditions to reaching legislative targets. In this context, in order to exceeding boundary conditions, the ways followed and the projects carried out in EU can be followed as following the targets.

5. Conclusion

Global warming and its consequences pose a serious threat. Within the scope of the research, buildings are in the first place in the consumption of fossil fuels, which causes the formation of greenhouse gas emissions that cause global warming. For this reason, studies to improve building energy performance are more important than ever.
In order to ensure energy efficiency in the building sector, sanctions should be introduced. This can only be possible with legal practices such as regulations. In this context, the EPBD in the EU presents important targets and gives explanations for these targets. Despite this, implementation difficulties are experienced in the EU, especially in Southern European countries, and the targets cannot be achieved in a timely manner. Thus, the building sector has taken precedence over other sectors in terms of energy consumption and the targets have been postponed to the following years.
A similar situation is also valid for Turkey. Turkey, which regulates its current regulations by following the EPBD, both follows the EU behind, and the targets cannot be reached due to the implementation difficulties and control deficiencies. Thus, the targets are also postponed in Turkey. In this direction, it is important to determine the boundary conditions that cause difficulties in implementation and to solve these boundaries first. All of the boundary conditions determined within the scope of the study can be solved by planning. Education is at the top of all boundaries. Education will raise awareness of energy consumption both in the building sector and among users, and will prevent to construct and use of building typologies other than energy efficient solutions. However, it will take many years to achieve such a widespread level of education. Therefore, a start should be made with the inclusion of energy efficiency in the basic field courses in the vocational education of the entire building sector, while separate studies should be conducted for other boundary conditions.
Within the scope of the studies, the target of conversion of existing and new buildings to nZEBs is very important as it will significantly reduce fossil fuel consumption. The aim of nZEBs is primarily to reduce the energy need of the building with passive methods, and then to meet the remaining energy need from renewable energy sources. Thus, it is thought that a building typology with very high energy performance will be achieved. This target is also essential for the decarbonization of the building stock, as it will also reduce greenhouse gas emissions. The elimination of boundary conditions for these purposes is urgent.
In order to solve the boundary conditions, first of all, the missing definitions in the directives and regulations should be arranged in accordance with the country conditions with a team of experts. Then, taking into account the climate zones in Turkey and the fundamental differences between them, the steps to reach nZEBs, namely passive parameters to reduce building energy needs, should be regulated separately for each climate zone. A general method recommendation for the whole country is not correct. In such a case, the climatic zones in need of cooling are ignored and the nZEB target cannot be achieved. The intensity of the cooling need in Turkey should not be ignored. In this direction, it is imperative that passive cooling methods are developed and recommended to reduce the need for cooling energy in hot climate regions. Planning to be organized in this area should be presented to the building sector as a design and implementation method. For such a purpose, the method proposal presented in this study may facilitate the development of climate-sensitive nZEB definitions.
Transformation in the sectoral operation is essential for the transformation of the building stock and the provision of new building applications. In the current situation, the building energy efficiency issue is not included in the design and construction process due to the deficiencies in education. However, in voluntary cases it is included later in the flow and often gives little direction to the project. However, the subject should be included in the flow from the preliminary project stage. Decisions regarding the passive system parameters to be taken at the preliminary project

stage are very important in order to reduce the heating and cooling energy needs. Afterwards, energy efficiency experts should guide the decisions to be made at every stage of the project. After all design decisions, material and system selections are made in this direction, there will be a significant reduction in energy need. It is very important that energy efficiency experts follow the application during the construction process too. When the workflow in the building sector in Turkey comes to this order, it will be possible to achieve the nZEB and decarbonization targets.
In order to increase the energy performance in buildings and to reach the targets, it is a priority to solve the boundary conditions, which are also stated in this study. Thus, it will be possible to improve the problems caused by buildings in the field of global warming.

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Conflict of Interests
The authors declare no conflict of interest.

References
Attia, S., et al. (2017). Overview and Future Challenges of Nearly Zero Energy Buildings (nZEB) design in Southern Europe. Energy and Buildings, 155, 439-458, ISSN 0378-7788. https://doi.org/10.1016/j.enbuild.2017.09.043
Amen, M. A. (2021). The Assessment of Cities Physical Complexity through Urban Energy Consumption. Civil Engineering and Architecture, 9(7), 2517–2527. https://doi.org/10.13189/cea.2021.090735
Aziz Amen, M. (2022). The effects of buildings' physical characteristics on urban network centrality. Ain Shams Engineering Journal, 13(6), 101765. https://doi.org/10.1016/j.asej.2022.101765
Amen, M. A., Afara, A., & Nia, H. A. (2023). Exploring the Link between Street Layout Centrality and Walkability for Sustainable Tourism in Historical Urban Areas. Urban Science, 7(2), 67. https://doi.org/10.3390/urbansci7020067
Amen, M. A., & Nia, H. A. (2020). The Effect of Centrality Values in Urban Gentrification Development: A Case Study of Erbil City. Civil Engineering and Architecture, 8(5), 916–928. https://doi.org/10.13189/cea.2020.080519
Badescu, V., Rotar, N., Udrea, I. (2015). Considerations Concerning the Feasibility of the German Passivhaus Concept in Southern Hemisphere. *Energy Efficiency*, 8, 919-949. https://doi.org/10.1007/s12053-015-9332-8
EERG (end-use Efficiency Research Group of Politecnico di Milano), (2007). The Passive-On Project. https://www.eerg.it/passive-on.org/en/index.php Retrieved: 08.05.2023
Efe, A. (2009). Pasif Güneş Evlerinde Bina Kabuğu Sistemi Tasarımı [Design of Building Envelope System for Passive Solar Houses]. Istanbul Technical University Institute of Science, Istanbul.
Energy Performance Regulation in Buildings (2008). Official Gazette of the Presidency of the Republic of Turkey, T.R. Ministry of Public Works and Housing, No.: 27075. https://www.resmigazete.gov.tr/eskiler/2008/12/20081205-9.htm Retrieved: 10.05.2023
EPBD 2002/91/EC Directive 2002/91/EC of the European Parliament and of the Council of 16 December 2002 on the Energy Performance of Buildings (2002). Official Journal of the European Union, Document 32002L0091. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32002L0091 Retrieved: 03.05.2023
EPBD 2010/31/EU Directive 2010/31/EU of the European Parliament and of the Council of 19 May 2010 on the Energy Performance of Buildings (Recast) (2010). Official Journal of the European Union, Document 32010L0031. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32010L0031 Retrieved: 03.05.2023
EPBD 2018/844/EU Directive (EU) 2018/844 of the European Parliament and of the Council of 30 May 2018 Amending Directive 2010/31/EU on the Energy Performance of Buildings and Directive 2012/27/EU on Energy Efficiency (2018). Official Journal of the European Union, Document 32018L0844. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.156.01.0075.01.ENG Retrieved: 03.05.2023
IEE (Intelligent Energy Europe), (2017). SouthZEB: nZEB Training in the Southern EU Countries – Maintaining Building Traditions. Coordination of University of Patras, Greece. https://www.best.at/en/international-projects/projects/current-projects/southzeb/ Retrieved: 05.05.2023
Koca, Ö. (2006). Sıcak Kuru ve Sıcak Nemli İklim Bölgelerinde Enerji Etkin Yerleşme ve Bina Tasarım İlkelerinin Belirlenmesine Yönelik Yaklaşım [An Approach of Determination of Energy Efficient Settlement and Building Design Principles in Hot Dry and Hot Humid Regions]. Istanbul Technical University Institute of Science, Istanbul.

Manioğlu, G., Koçlar Oral, G. (2010). Ekolojik Yaklaşımda İklimle Dengeli Cephe Tasarımı [Climate Balanced Facade Design in Ecological Approach], 5. Ulusal Çatı ve Cephe Sempozyumu [5th National Roof and Facade Symposium], Dokuz Eylul University Faculty of Architecture, Izmir.

National Energy Plan of Turkey [Türkiye Ulusal Enerji Planı] (2022). T.R. Ministry of Energy and Natural Resources https://enerji.gov.tr/Media/Dizin/EIGM/tr/Raporlar/TUEP/T%C3%BCrkiye_Ulusal_Enerji_Plan%C4%B1.pdf Retrieved: 03.05.2023

Natural Gas Market 2021 Sector Report (2021). Energy Market Supervision Agency of Turkey (EPDK). https://www.epdk.gov.tr/Detay/Icerik/3-0-94/dogal-gazyillik-sektor-raporu Retrieved: 05.05.2023

Regulation on Amending the Energy Performance Regulation in Buildings (2010). Official Gazette of the Presidency of the Republic of Turkey, T.R. Ministry of Public Works and Housing, No.: 27539. https://www.resmigazete.gov.tr/eskiler/2010/04/20100401-5.htm Retrieved: 03.05.2023

Regulation on Amending the Energy Performance Regulation in Buildings (2022). Official Gazette of the Presidency of the Republic of Turkey, T.R. Ministry of Environment, Urbanism and Climate Change, No.: 31755. https://www.resmigazete.gov.tr/eskiler/2022/02/20220219-2.htm Retrieved: 03.05.2023

Yılmaz, Z. (2007). Evaluation of Energy Efficient Design Strategies for Different Climatic Zones: Comparison Of Thermal Performance of Buildings in Temperate-Humid And Hot-Dry Climate. *Energy and Buildings,* 39, 306-316. doi:10.1016/j.enbuild.2006.08.004

Yılmaz, A.Z., Ashrafian, T., Ganiç, N., Gali, G., Akgüç, A. (2015). Binalarda Maliyet Optimum Enerji Verimliliği Seviyesi için Türkiye Koşullarına Uygun Yöntemin ve Referans Binaların Belirlenmesi [Determination of Turkish Reference Residential Buildings and National Method for Defining Cost Optimum Energy Efficiency Level of Buildings]. Scientific and Technological Research Council of Turkey (TUBITAK). Project Code, 1001.

Zeren, L. (1959). Mimaride Güneş Kontrolü. Istanbul Technical University Faculty of Architecture, Istanbul.