Energy efficiency of the housing stock in Turkey: the links between energy efficiency and energy poverty

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Perspective on Energy Efficiency of the Housing Stock in the Policy Debate of Turkey Regarding Energy Poverty

Restricted access to energy has a negative impact on health, gender equality, education, poverty, and in general, on economic development in developing countries. Since energy poverty is – unofficially – defined in the literature in Turkey as the lack of access to clean, adequate and affordable energy sources as well as an issue of the lack of energy affordability as in most European countries, transitioning more fully to modern energy sources, investing in expanded grid-based electrification or in micro-size renewable energy sources are possible solutions to these problems (Erdogdu, 2020). On the other hand, poorer segments of the population are unable to afford sufficient energy due to high energy prices and the lack of insulation in buildings (YTONG, 2019). In this sense, the subject of energy efficiency is at the core of the problem of energy poverty. Therefore,

Turkey's steps to improving energy efficiency are worthy of consideration in developing strategies to reduce energy poverty across the population.

Turkey relies heavily on foreign energy sources and thus gives particular importance to securing long-term energy independence. Therefore, the country's energy policy promotes domestic energy sources and seeks to make use of Renewable Energy Sources (RES) potential in the country. By the end of 2018, Turkey is heavily dependent on foreign energy sources by approximately 73% (Chamber of Mechanical Engineers, 2020). Also, they reported that by the end of April 2020, 48.1% of total installed capacity came from renewable energy sources. In addition to these supply-related efforts, the Energy Efficiency Law (2007) guides Turkey's energy efficiency policy. The aim of this law is to increase efficiency in the use of energy resources, thus reducing the burden of energy costs on the economy and protecting the environment. With the help of energy efficiency policies and renewable energy sources, Turkey can become more energy self-sufficient. In this way, energy poverty in the country could also be reduced. Therefore, Energy Charter Secretariat recommended in 2014 that the Turkish government needed to put forward an energy efficiency policy roadmap for 2023 and beyond. The policy roadmap should establish high efficiency standards for new and existing buildings, with focus on the implementation of energy efficiency labelling schemes and of minimum energy performance standards, including construction characteristics and use of the buildings and home appliances (e.g. Arçelik's 4-year project on Market Transformation of Energy Efficient Household Appliances started in 2001) (Energy Charter Secretariat, 2014: 17, 79). Following these recommendations, Turkey put forward the National Energy Efficiency Action Plan (NEEAP) in 2018, although the country still has a long way to go (SHURA Energy Transition Center, 2019). Turkey also developed the National Climate Change Strategy of 2010-2023, which aimed to increase energy efficiency and reduce greenhouse gas emissions in buildings, industry, transport and energy sectors (Republic of Turkey Ministry of Energy and Natural Resources, 2018).

The Problem of Energy Efficiency in Turkey

These recent acts are preceded by earlier attention, including the ratification of the Energy Charter Treaty and the Energy Charter Protocol on Energy Efficiency and Related Environmental Aspects (PEEREA) in 2001. According to these agreements, Turkey committed itself to formulating and implementing policies for improving energy efficiency and reducing the negative environmental impacts of the energy cycle. PEEREA made cooperation among the large group of contracting

parties[1] possible (Energy Charter Secretariat, 2014). In addition, Turkey celebrates World Savings Day (Dunya Tasarruf Gunu) on October 31 each year so as to attract public attention to energy efficiency, among other modes of savings. These advances are quite notable in terms of raising awareness about efficient energy use, sustainable future and accordingly, reducing the problem of energy poverty (Enerji ve Çevre Bulletin, 2019; Erdoğdu, 2020).

Unfortunately, Turkey does not reap proportionate benefits from energy service systems, namely heating, cooling and lighting. According to governorship of Yalova provincial directorate for environment and urbanization (Yalova Valiligi Cevre ve Sehircilik Il Mudurlugu, 2018a), there are three basic reasons for this shortfall. The first one is that Turkish households pay very high energy prices especially for electricity and natural gas. The second one is that houses are equipped with energy-inefficient heating, cooling and lighting systems as well as energy-inefficient appliances The last one is that the architectural design and insulation of Turkey's residences are not made well to protect these residences against cold and heat or to take advantage of available light. All three of these conditions are logically correlated with energy poverty.

Insulation of buildings can be one of the solutions for tackling some of these issues. For instance, if the roof is well insulated, heat loss can be reduced up to 20% relative to no insulation. If exterior walls are well insulated, heat loss will be reduced up to 15% relative to no insulation. If windows and doors are well insulated, the heat loss will again be reduced up to 15% relative to no insulation (Yalova Valiligi Cevre ve Sehircilik Il Mudurlugu, 2018b). According to Enerji ve Çevre Bulletin (2019), improvements in use of building materials and of roof, window and wall thermal insulation applications may provide 50% reduction in energy consumption and fuel expenses. Furthermore, if precautions are taken to achieve good levels of airtightness, heat loss will be further reduced, (up to 10% relative to no insulation) adding up to 60% reduction in heat loss and in energy consumption and fuel expenses, in total (Yalova Valiligi Cevre ve Sehircilik Il Mudurlugu, 2018b, Enerji ve Çevre Bulletin, 2019). At that time, a joint project study was initiated with the support of British Council, Turkish Republic Ministry of

[1] Signatories and/or Contracting Parties to the PEEREA are Afghanistan, Albania, Armenia, Australia, Austria, Azerbaijan, Belarus, Belgium, Bosnia and Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, European Union and Euratom, Finland, France, Georgia, Germany, Greece, Hungary, Iceland, Ireland, Japan, Kazakhstan, Kyrgyzstan, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Mongolia, Montenegro, The Netherlands, North Macedonia, Norway, Poland, Portugal, Romania, Slovakia, Slovenia, Spain, Sweden, Switzerland, Tajikistan, Turkey, Turkmenistan, Ukraine, United Kingdom, and Uzbekistan. Source: https://www.energycharter.org/process/energy-charter-treaty-1994/energy-efficiency-protocol/ .

Environment and Urbanization and the British Embassy Welfare Fund; given this study, the aim of the governorship of Yalova (2018) was to inform building owners on the importance of Energy Performance Certificates, discussed further below. The Energy and Environment World Magazine (Enerji ve Cevre Bulletin) highlights that insulation of buildings is one of the most important precautions for being protected from the cold in winter. Since the presence of very high energy consumption and/or of leaky roofs, damp walls or rot in window frames at homes due to lack of insulation are considered to be indicators of energy poverty in Turkey in compliance with the EU Household Budget Surveys and/or EU-SILC data (TURKSTAT Income and Living Conditions Survey, 2019), it is expected that if these actions were applied, energy poverty could be reduced in Turkey.

Since Turkey is a developing country, its energy use is rapidly increasing because of increasing population, production and industrialization (Energy Charter Secretariat, 2014). It is worth noting that Turkey's aggregate demand for electricity increased from 122 TWh to 240 TWh between the years 2001 and 2013 (Bavbek, 2015: 1). According to the MURE database and TS 825 standards that were used to calculate heating energy needs of buildings, Turkey has lower stringency of energy-related building standards[2] compared to many EU countries (Aydın, 2018: 11-12). In addition, building standards in Turkey were not updated at all between 1980 and 2000. This led to lower energy efficiency for the buildings constructed between the years 1980 and 2000 compared to the period after 2000. The share of residential buildings constructed with low energy efficiency standards between 1980-2000 in the current dwelling stock is about 45%. Therefore, a significant amount of potential energy savings in the residential sector were lost in that period. If these dwellings were improved between 1980-2000, then almost half of its current dwelling stock could be more energy-efficient today (Aydın, 2018: 11). Furthermore, it is worth noting that the Bavbek (2015) gives some estimates on the country's potential for energy savings in the household sector in 2011. Estimations were originally made by the World Bank (Bavbek, 2015: 8). Therefore, it is crucial to bring the building up to much higher energy efficiency requirements and maximum emission limitations. Emissions reductions could be considered as a side-effect of higher building energy standards and it is essential to build new buildings sustainably so as to decrease energy demand and carbon emissions of the country and also to promote sustainable, environment-friendly buildings (Bavbek, 2015). These requirements are also in line with the goal of reducing energy poverty.

[2] "Maximum allowable U-value requirement" was used in the article as a proxy for the stringency of energy efficiency requirements of buildings. The main motivation of the implementation of U-value requirements in Northern European countries in 1960s was the the demand for thermal comfort (Aydın, 2018: 11)

Because renovation of homes in Turkey is relatively underdeveloped (particularly for multifamily apartment buildings) as a means of reducing heating and cooling use, it is necessary to develop programs to work with existing apartment management cooperatives and homeowner associations to help retrofit their buildings by improving access to appropriate financing, introducing incentives, and providing technical assistance (The World Bank, 2015). Turkish Standards Institution (TSI) brought into force minimum U-values (inversely related to thermal transmittance) required for improving the efficacy of heating in all buildings (newly constructed buildings and buildings to be amended) in four degree-day regions of Turkey in 2008 (Onur Enerji, 2018, Atmaca, 2016). Then, the number of degree-day regions were updated as five (5) in 2013 (Atmaca, 2016). If Turkey's energy standards are compared to those for developed countries by using U values, it is seen that the modelled annual amount of energy allowed to be spent for heating an area of one square meter is far above the amount spent by developed countries (Pelesen, 2020). For instance, while the annual energy amount spent for heating an area of one square meter in old buildings is 180 kWh/m^2 in many EU countries, but in Turkey's capital Ankara this amount is 311 kWh/m^2 for individual heating and 237 kWh/m^2 for central heating (Öztürk, 2018).

Therefore, compulsory energy audits, benchmarking, dissemination of information on energy efficiency measures are required to stimulate energy efficiency through a wide range of measures for the buildings and industry sectors (Energy Charter Secretariat, 2014: 17). According to the 2008 national regulation regarding energy performance in buildings (Information System of Regulations of the Presidency of the Turkish Republic, 2020), Energy Performance Certificates (EPC) are compulsory for all new buildings in Turkey, with the certificate valid for 10 years. In addition to this requirement for new buildings, existing buildings were originally scheduled to have that certificate by May 2017 (Energy Charter Secretariat, 2014: 76). The date for the requirement for Energy Performance Certificates in transactions of sales and lease of building was then deferred to 2020 (Republic of Turkey Ministry of Energy and Natural Resources). As of 1 January 2020, this regulation entered into force in Turkey (emlakkulisi.com, 2020).

Energy Performance Certificates include seven (7) energy classes for a building. These are categorized as A, B, C, D, E, F and G according to the building's primary modelled energy consumption depending on building characteristics(Ministry of Environment and Urbanisation, n.d.). Class A indicates a "most efficient" building (with lowest modelled energy consumption) and G indicates "least efficient" building (with highest modelled energy consumption) (Yiğit and Acarkan, 2016). If a building fully meets the required construction and insulation standards, then it receives a C rating. Also, it is compulsory for new buildings to have at least C class rating. In 2019, there were 873 000 buildings in total which had been

certified, however, certification is still required for more than 8 million buildings in the country. Istanbul ranks first in the number of buildings with an EPC. There are approximately 3 000 buildings with an A certificate, 272 000 buildings with a B certificate, and 677 000 with a C certificate in Turkey (Milliyet, 2020).

In general, there are some main differences between the EU legislation and Turkey's legislation in approach and regulation regarding energy efficiency in buildings. These differences are mostly related to the implementation of legislation. Three main factors likely account for the average education level of practitioners, lack of obeying the rules and the lack of effective mechanisms for ensuring implementation of legislation. One of the most notable difference between the Turkey's legislation and the EU countries' legislation is that EU's legislation on the relevant subject has a more dynamic nature, meaning that technical possibilities and changing needs can be transferred to the legislation more easily. In addition, since the Energy Efficiency Law(2007) was published many years ago in Turkey, the country needs to update this legislation as well as legislation for energy efficiency in buildings, by adopting a new perspective (Yüksekkaya, 2017: 52, 53).

Olga Rosca from the European Bank for Reconstruction and Development (Rosca, 2019) reported that Turkish families took out EBRD-led Turkish Residential Energy Efficiency Financing Facility (TuREEFF) mortgages and loans in order to either buy eco-friendly homes or equip their homes with energy-saving technologies. Some of households have benefited from these instruments indirectly such as by installing heating or cooling systems and/or windows. Thanks to this lending programme, which was put into practice in 2015, energy efficiency savings in excess of 29.3 GWh/year have been achieved, according to modelling studies.. All individuals who want to purchase energy-efficient domestic appliances and/or renewable energy equipment can benefit from the loan without specific targeting strategies (TuREEFF, 2020). More specific targeting on this subject could be quite helpful in terms of reducing energy poverty in the country. So, targeting loan programs to specific situations where energy poverty is likely to prevail could have additional social benefits. These situations particularly include , those who are precarious workers, farmers who use electric water pumps for irrigation, small scale enterprises, rural households, households who have to limit food costs along with other main spending items to be able to pay electricity bills, those who use illegal electricity, households who are disconnected from electricity supply as a result of arrears on electricity bills, etc. These people are particularly vulnerable to increases in the price of electricity (Erdoğdu, 2020). This is one way that energy efficiency policies can directly benefit address energy poverty in the country.

Research Perspective on Energy Efficiency of the Housing Stock in Turkey Regarding Energy Poverty

Although energy efficiency research is generally discussed in Turkey's literature independently of the topic of energy poverty, there are strong links between energy efficiency and energy poverty as specifically addressed in the seventh goal of sustainable development goals (SDG 7). Recent studies on energy efficiency in buildings generally focus on building insulation, green building certificate systems, photovoltaic applications and occupant behaviour in energy consumption. A study by Harputlugil and Harputlugil (2016) on the renovation of current social housing stock in Turkey argues that occupant behaviour is generally considered to be an important factor for determining energy consumption goals, and developing energy efficient strategies so as to improve current and new building stock. The study found that the most sensitive parameters on heating load and comfort levels during winter and summer are occupants' presence at home and their strategies for opening and closing windows. These occupant-related characteristics also have an impact on energy poverty levels since they may alleviate or aggravate the problem of energy poverty.

Building certificate systems are an important avenue to increasing public awareness for green buildings. In this sense, Bertiz et al. (2019) compare the national and international green building certificate systems because they may vary regarding each country. Although BREEAM and Green Star have similar evaluation criteria on the use of energy, water, pollution, novelty, materials, transportation, ecology, management, and land, BREEAM also has an evaluation criteria for waste while Green Star has an evaluation criteria for interior environmental quality. Apart from these certificate systems, Environmental Friendly Green Building Association (CEDBIK) in Turkey signed a memorandum of understanding with BRE Global and they are working together to adapt BREEAM according to Turkey's conditions. and can be an complementary solution for alleviating energy poverty along with other solutions such as reducing inequalities, government support for energy poor people, and energy sector regulations, etc.

Besides these studies, Uzun and Yeğin (2019) examine photovoltaic applications in energy-efficient buildings as a means of addressing the depletion of natural resources, and environmental problems in parallel to it. This study highlights the importance of solar energy for a sustainable future and suggests cooperation between industry and universities. However, these new technologies should also be supported by trade associations and local authorities in order to be adopted by architects and engineers. Göksel Özbalta and Yıldız (2019) examine the energy performance of double-skin façades (DSF) in hot and humid climate. It is known that the design of energy-efficient façade is really important in increasing energy

performance of current housing stock. Also, an improved building skin helps make the most of energy and reduce energy consumption and carbon emissions. The results showed that in implementations of double-skin façade, the choice of glass in buildings is very important in reducing cooling load. In another study, Alemdağ and Beyhan (2017:18) analysed energy efficient and sustainable architectural design patterns regarding their functionality, conceptuality, and technical aspects. They also pointed out positive and negative sides of using double skin facades. Some of its advantages are allowing for natural ventilation, heat, sound and night ventilation as well as enabling energy conservation and protecting buildings against external factors, etc. Its disadvantages are overheating of double skin façade cavity, possible reductions in the quantity of daylight, high construction costs, unbalanced air flow speed in façade cavity, possibility of fire, problems in mechanical air ventilation system and solar control elements (Alemdağ and Beyhan, 2017: 26).

Demircan (2020) highlights the importance of energy for improving life standards and leading a healthy life, also arguing that sustainable development is possible through a sustainable and high-quality energy supply. Since a major part of energy used in buildings goes to space heating and cooling, building insulation can add substantially reduce energy consumption and make these spaces more livable, thus tackling energy poverty on two levels. The author examines four uninsulated buildings through thermal camera in the province of Adapazarı and aims to detect heat leaks occurred in these buildings. At the end of the field study, he detected locations where heat leakages occurred in the buildings. This shows that it is important to follow procedures and principles stated in Turkish Standard 825 (TS 825) and that insulation should be performed by qualified workers in order for heat leakages not to occur in the future. It can be inferred that improving the quality of construction, including laying insulation, can help alleviate energy poverty problems in Turkey. Altun et al. (2020) examine the impact on building heating energy requirements, cost and carbon footprint of envelope insulation from a life-cycle perspective. The results showed that while insulation has a positive impact on annual heating energy, it also improves life-cycle cost and life-cycle greenhouse gas emissions.

References

Alemdağ, E. Beyhan, F. (2017). A Research on Construction Systems of Double Skin Facades. *GU J Sci, 30*(1), 17-30.

Altun, M., Meral Akgül, Ç., & Akcamete, A. (2020). Effect of envelope insulation on building heating energy requirement, cost and carbon footprint from a life cycle perspective. *GU J. Fac. Eng. Archit.*, *35* (1), 147-164.

Atmaca, U. (2016). TS 825 Binalarda Isı Yalıtım Kuralları Standardındaki Güncellemeler. *Tesisat Mühendisliği, 154,* 21-35. https://www.mmo.org.tr/sites/default/files/727e44224c40ad9_ek.pdf. [In Turkish]

Aydın, E. (2018). An Assessment of Residential Energy Efficiency in Turkey. Available at: https://pdfs.semanticscholar.org/148f/9625fb509fa1001941afe0392ad7334fbda5.pdf (Accessed 3 July 2020).

Bavbek, G. (2015). Opportunities for Improving Energy Efficiency in Turkey. EDAM Climate Action Paper Series 2015/3. Available at: https://edam.org.tr/wp-content/uploads/2015/08/EDAM_EnergyEfficiency_2015August.pdf (Accessed 3 July 2020).

Bertiz, D., Ekşi, I., Tokmak, M., Özbey, D., Ak, M., & Güneş, A. (2019). Yeşil Altyapı Açısından Uluslararası Ve Ulusal Yeşil Bina Sertifika Sistemlerinin Karşılaştırılması. *PEYZAJ*, *1* (2), 31-39. [In Turkish].

Chamber of Mechanical Engineers. (2020). Türkiye Enerji Görünümü 2020. https://enerji.mmo.org.tr/wp-content/uploads/2020/05/TurkiyeEnerjiSorunumuSunumu2020.pdf. [In Turkish]

Demircan, H. (2020). Detection of Heat Loss Occurring in Buildings By Thermal Camera Method (Adapazarı Example). *Sürdürülebilir Mühendislik Uygulamaları ve Teknolojik Gelişmeler Dergisi*, *3* (1), 26-31.

Emlakkulisi.com. (2020). Enerji kimlik belgesi zorunluluğu 1 Ocak itibariyle başladı! Available at: https://emlakkulisi.com/enerji-kimlik-belgesi-zorunlulugu-1-ocak-itibariyle-basladi/625187. (Accessed 26 December 2020). [In Turkish]

Enerji ve Cevre Bulletin. (2019). Türkiye'de 30.4 Milyar Dolarlık Enerji Verimliliği Sağlanabilir. Available at:http://www.enerji-dunyasi.com/yayin/902/turkiye-de-30-4-milyar-dolarlik-enerji-verimliligi-saglanabilir_25732.html#.Xv-DiigzZPY (Accessed 3 July 2020). [In Turkish]

Energy Charter Secretariat. (2014). In-Depth Energy Efficiency Policy Review of THE REPUBLIC OF TURKEY. Available at: https://www.energycharter.org/fileadmin/DocumentsMedia/IDEER/IDEER-Turkey_2014_en.pdf (Accessed 3 July 2020).

Erdogdu, S. (2020). DÜNYADA VE TÜRKİYE'DE ENERJİ YOKSULLUĞU ÜZERİNE. Available at: https://www.mmo.org.tr/sites/default/files/TEG-2020-3_EnerjiYoksullu%C4%9FuYoksunlu%C4%9Fu_Seyhan%20Erdo%C4%9Fdu.pdf. (Accessed 24 December 2020). [In Turkish]

Goksal Ozbalta, T., & Yıldız, Y. (2019). SICAK-NEMLİ İKLİMDE ÇİFT KABUK CEPHE ENERJİ PERFORMANSININ İNCELENMESİ. *METU Journal of the Faculty of Architecture*, *36* (1), 137-156. [In Turkish]

Harputlugil, G. U., & Harputlugil, T. (2016). Çevresel konfor ve enerji tasarrufu bağlamında konut kullanıcıları davranış profilleri üzerine bir araştırma. *Journal of the Faculty of Engineering and Architecture of Gazi University*, *31* (3), 695-708.

[In Turkish]Information System of Regulations of the Presidency of the Turkish Republic. (2008). Binalarda Enerji Performansı Yönetmeliği. Available at: https://www.mevzuat.gov.tr/mevzuat?MevzuatNo=13594&MevzuatTur=7&MevzuatTertip=5. (Accessed 26 December 2020). [In Turkish]

Milliyet. (2020). Enerji Kimlik Belgeli bina sayısı 1 milyona ulaştı. Available at: https://www.milliyet.com.tr/ekonomi/enerji-kimlik-belgeli-bina-sayisi-1-milyona-ulasti-6119065. (Accessed 27 December 2020). [In Turkish]

Ministry of Environment and Urbanisation. (n.d.). BİNALARDA ENERJİ KİMLİK BELGESİ (EKB) NEDİR? Available at: https://webdosya.csb.gov.tr/db/samsun/webmenu/webmenu4379.pdf. (Accessed 27 December 2020). [In Turkish]

Onur Enerji. (2018). Isı Yalıtım Ölçümü – Isıl Geçirgenlik (U-Değeri) Katsayısı. Available at: https://www.onurenerji.com.tr/olcumler/isi-yalitim-olcumu-isil-gecirgenlik-u-degeri-katsayisi/. (Accessed 26 December 2020). [In Turkish]

Öztürk, M. (2018). MERKEZİ ISITMA SİSTEMLERİNİN VE ISI ÖLÇÜM EKİPMANLARININ VERİMLİLİK POTANSİYELLERİ. Available at: http://www.cevresehirkutuphanesi.com/assets/files/slider_pdf/rBIoUNwdAe2D.pdf. (Accessed 26 December 2020). [In Turkish]

Pelesen, L. (2020). Energy Efficiency in Buildings Starts with Insulation. Available at: http://www.turkchem.net/energy-efficiency-in-buildings-starts-with-insulation.html (Accessed 3 July 2020).

Republic of Turkey Ministry of Energy and Natural Resources. (2018). National Energy Efficiency Action Plan (NEEAP): 2017-2023. Available at: http://www.yegm.gov.tr/document/20180102M1_2018_eng.pdf (Accessed 3 July 2020).

Rosca, O. (2019). Turkish families invest in energy efficient homes. Available at: https://www.ebrd.com/news/2019/turkish-families-invest-in-energy-efficient-homes.html (Accessed 3 July 2020).

SHURA Energy Transition Center. (2019). Enhancing Turkey's policy framework for energy efficiency of buildings, and recommendations for the way forward based on international experiences. Available at: https://www.buildup.eu/sites/default/files/content/shurabpie_buildings-energy-efficiency-policy.pdf. (Accessed 25 December 2020).

The World Bank. (2015). Republic of Turkey: Institutional Review of Energy Efficiency. Available at: https://www.esmap.org/sites/default/files/esmap-files/ACS12738revd.pdf (Accessed 3 July 2020).

TuREEFF. (2020). BİREYLERE ÖZEL KREDİLER: Kimler yararlanabilir? Available at: https://www.tureeff.org/page/kucuk_yatirimlar. (Accessed 26 December 2020). [In Turkish]

TURKSTAT. (2019). Konutun izolasyonundan dolayı ısınamama en çok karşılaşılan konut ve çevre problemi oldu. Press Release. Available at:

https://data.tuik.gov.tr/Bulten/Index?p=Gelir-ve-Yasam-Kosullari-Arastirmasi-2019-33820. (Accessed 27 December 2020). [In Turkish]

Uzun, T. & Yegin, M. (2019). Enerji Etkin Yapılarda Güneş Pili Uygulamaları [Conference paper]. Available at: https://www.researchgate.net/publication/339487439_ENERJI_ETKIN_YAPILARDA_GUNES_PILI_UYGULAMALARI (Accessed 5 July 2020). [In Turkish]

Yalova Valiligi Cevre ve Sehircilik Il Mudurlugu. (2018a). Konutlarda Enerji Tasarrufu. Available at: http://yalova.csb.gov.tr/konutlarda-enerji-tasarrufu-haber-229099 (Accessed 3 July 2020). [In Turkish]

Yalova Valiliği Çevre ve Şehircilik İl Müdürlüğü. (2018b). Binalarda Enerji Verimliliği. Available at: https://yalova.csb.gov.tr/binalarda-enerji-verimliligi-i-3561. (Accessed 27 December 2020). [In Turkish]

Yiğit, K. & Acarkan, B. (2016). Assessment of energy performance certificate systems: a case study for residential buildings in Turkey. *Turkish Journal of Electrical Engineering & Computer Sciences,* 24, 4839-4848. doi: https://doi.org/10.3906/elk-1407-87.

YTONG. (2019). Isı yalıtımı yetersiz evlerin faturaları kabarıyor. Available at: https://ytong.com.tr/haber-detay.asp?haberID=91. (Accessed 24 December 2020). [In Turkish]

Yüksekkaya, T. (2017). AB Binalarda Enerji Performansı Direktifi (EPBD) ile Binalarda Enerji Performansı Yönetmeliği Arasındaki Temel Farklılıklar ve Uyumu Zorlaştıran Nedenler. Türk Tesisat Mühendisleri Derneği Dergisi. https://www.ttmd.org.tr/PdfDosyalari/TTMD-Dergisi-108.pdf. (Accessed 27 March 2021). [In Turkish]