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RESEARCH ARTICLE

Determination of the energy consumption of the public building by using BIN method

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Abstract

Energy consumption is particularly relevant to the three-sector concept, including the industrial, service, and agricultural sectors. Consequently, energy consumption in the building and construction sectors has become one of the most pressing global concerns. As the world population grows, the energy demand of buildings, particularly energy consumption in the public buildings has been increasing rapidly. Various methods have been applied to manage energy consumption in public buildings. The correct application of these methods has been shown to facilitate the rapid detection of energy consumption in public buildings and the acquisition of more detailed consumption data. As demonstrated by this study, the BIN Method, which is based on meteorological data, has been used to determine energy consumption in buildings with accuracy comparable to accual values. In this study, the energy consumption of a building owned by the Istanbul/Beykoz Municipality was determined using the BIN method. To apply the BIN method, Dry Air Thermometer (DAT) temperature data, expressed as Typical Meteorological Year (TMY) values, were used; these values were derived from 25 years of meteorological data at the Istanbul Göztepe station. The required energy consumption for the heating and cooling of the municipal administrative building has been calculated using the BIN method. A comparison was made between the values obtained using the BIN method and the actual invoice values. The results of the present study indicate that energy consumption in public buildings can be reliably estimated using the BIN method and that annual energy demand can be determined efficiently.

Keywords: Energy, heating, cooling, building, energy consumption, BIN method

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1. Introduction

As human needs continue to rise, global energy consumption has reached critical levels. The scarcity of accessible energy resources, coupled with growing demand, has led to a steady increase in the unit cost of energy. This trend poses significant challenges, particularly for countries that rely heavily on external energy sources, and directly impacts their economic stability and future energy security. Energy, defined as the capacity to perform work, is a fundamental component of human life and development. As the global population expands, energy demand and consumption continue to escalate at an unprecedented rate. This ongoing trend highlights the urgent need for comprehensive and sustainable energy management strategies that can effectively address the complex interrelationships among sustainability, economic growth, and energy security. The building sector is one of the most energy-consuming sectors, along with agriculture, transportation, and industry. Swan L. U. and Ugursal V. I. (2009) mentioned that the residential sector has been identified as a significant source of energy expenditure for many reasons, including the materials used for the external layers of the building, changes in climate and the behaviours of end-users. Both top-down and bottom-up approaches have been used to define energy consumption. Most researchers have sought ways to reduce energy consumption. In the building sectors, increasing the energy consumption has been affected by the change of the climate, the unit cost of the energy, the increase demands of the energy and the difficulty of energy supply chains [1-3].

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This study aims to improve thermal comfort and reduce energy costs in public buildings. The building sectors, particularly public buildings, offers greater potential to improve energy performance than other sectors. Public buildings include a wide range of facilities, such as police stations, immigration offices, health care centers, municipal buildings, fire stations, public hostels, sports centers, lodging facilities, and public housing buildings. The energy requirements of these building categories are contingent upon their essential functions. Most public buildings in Turkey are designed to account for the prevailing climatic and meteorological conditions. In climatic contexts, energy is utilised in two distinct ways: first, to elevate the ambient temperature during winter months for heating the environment and second, to reduce the ambient tempertaure during summer months for cooling the surrondings [4-6].

The calculation of the energy consumption of a building depends upon the heating the cooling loads. In this study, the BIN method was used to calculate the energy required for heating and cooling. The BIN method is an analytical approach for assessing a building's energy consumption. The bin method is also a calculation technique used to estimate the amount of energy required for heating and cooling buildings. It is a straightforward steady-state technique. This method has predicated on the calculation of the interval of temperature differences and the temporal interval. When calculating a building's heat transfer, the structural design, the thicknesses of the outer layer, walls, columns, and beams, the foundation and the ceiling should also be determined. [7-9].

Ekmekçi I. and Pusat Ş. (2017) calculated the BIN weather data of Turkey and mentioned about BIN weather data for different climates of Turkey. The energy consumption of the public building was calculated using the BIN method. To calculate energy consumption, it is necessary to determine the energy consumed by the HVAC system for heating and cooling loads, such as radiators, fans, air conditioning, hot water systems, chiller groups and boilers used in the building. The BIN method has been used in conjunction with the bin data from the specified year, in order to ascertain the frequency with which the average temperature corresponds to the time interval [10].

Climate data collected hourly have been used to determine energy consumption at hourly, daily, weekly, monthly, and yearly intervals, rather than relying on the average daily outdoor temperature. In the context of BIN methods, the evaluation of energy consumption has been achieved through the discrete utilisation of temperature and time interval as independent variables and used separately to evaluate energy consumption [11].

Despite the widespread use of energy-consumption methods in developed countries, notably the degree-day and BIN methods, these approaches remain underutilised in Turkey. In recent years, these methods have been studied independently, and getting the appropriate amount of the values [12].

In this study, the energy consumption of the building sectors was defined using BIN methods. The values of the BIN data for Istanbul have been applied in a public building (a municipal building), and the required amount of heating capacity in the winter would be estimated.

2. BIN method

The energy consumption the point of issue appears to be one of the most important factors in human life. Both energy consumption and energy demand have been increasing rapidly. In many countries, energy consumption has a significant impact on national economic performance and industrial development. In the 1970s, following the global crisis, both developed and developing countries made a concerted effort to explore novel approaches to energy management and identify potential renewable energy sources. In the majority of countries, the construction sector, which encompasses commercial, residential, and industrial buildings, has consumed approximately 40% of total energy consumption [13].

Increasing thermal comfort aims to improve the quality of life of building occupants. Energy production in Turkey is limited. Consequently, an ongoing research and development programme aims to identify alternative energy sources and ways to reduce energy consumption in buildings. In the contemporary era, the majority of newly constructed buildings are designed in accordance with conditions that are climate change-proof, thereby ensuring resilience to extreme weather events other methods [14-15].

In this study, temperature was determined over one-month and one year periods using the BIN method. The outside air temperature ($T_{o,i}$), the interval of temperature(BIN), and the BIN data of the time taken ($N_{bin,i}$) were verified. The amount of energy will be determined from the temperature obtained over the elapsed hour. The total energy consumption has been obtained by collecting energy consumption of all the interval of temperature differences differences [16-19].

The heating temperature was generally 18°C. As shown in the Equation 1 below;

$$Q_{bin,i} = \pm\ N_{bin,i}\ \left(\sum U.A/\eta\ \right)*\left(T_{bp}\ -\ T_{0,i}\right) \quad (1)$$

Where, ∑ U.A (W/°C) is total heat transfer coefficient of the building, positive (+) sign is for heating and negative (-) sign is for cooling. η is the efficiency of the heating of cooling system's coefficient, $N_{bin,i}$ (h)is duration of the number of times taken determining the interval of temperature changes, $T_{o,i}$, midpoint of the interval of the temperature, and T_b is the balance point temperature of the value of outdoor temperature which heating or cooling needed above or below etc. [20].

Where n refers to the total number of the interval of temperature. The total $N_{bin,i}$ values has been shown in Table 1.

Table 1. Monthly total N_{bin} values for Istanbul (h/month)

Month	Time Interval(h)	Temperature Bin(°C)																			
		-6/-4	-4/-2	-2/0	0/2	2/4	4/6	6/8	8/10	10/12	12/14	14/16	16/18	18/20	20/22	22/24	24/26	26/28	28/30	30/32	32/34
January	0-2	1	8	4	10	10	11	5	5	0	0	0	0	0	0	0	0	0	0	0	0
	2-4	1	6	5	12	9	8	5	9	0	0	0	0	0	0	0	0	0	0	0	0
	4-6	3	4	5	9	9	7	10	7	3	0	0	0	0	0	0	0	0	0	0	0
	6-8	3	11	5	7	5	9	6	8	5	7	0	0	0	0	0	0	0	0	0	0
	8-10	1	6	4	7	5	6	8	5	9	12	0	0	0	0	0	0	0	0	0	0
	10-12	0	4	4	8	4	6	8	10	15	10	2	0	0	0	0	0	0	0	0	0
	12-14	0	4	3	7	1	8	10	10	15	6	5	0	0	0	0	0	0	0	0	0
	14-16	0	4	5	8	0	7	14	6	9	5	0	0	0	0	0	0	0	0	0	0
	16-18	1	3	7	12	1	9	14	7	12	16	0	0	0	0	0	0	0	0	0	0
	18-20	2	3	8	3	2	10	10	9	12	9	0	0	0	0	0	0	0	0	0	0
	20-22	0	6	5	5	7	9	3	8	4	6	0	0	0	0	0	0	0	0	0	0
	22-24	2	9	4	5	7	7	3	6	5	0	0	0	0	0	0	0	0	0	0	0
	Total	14	68	59	93	60	97	96	90	89	71	7	0	0	0	0	0	0	0	0	0
February	0-2	1	2	4	10	10	11	4	5	0	0	0	0	0	0	0	0	0	0	0	0
	2-4	1	2	5	12	8	8	5	10	0	0	0	0	0	0	0	0	0	0	0	0
	4-6	1	2	5	12	8	8	9	6	3	0	0	0	0	0	0	0	0	0	0	0
	6-8	0	0	5	10	5	9	5	9	5	9	0	0	0	0	0	0	0	0	0	0
	8-10	0	0	4	8	0	7	7	5	10	10	2	0	0	0	0	0	0	0	0	0
	10-12	0	0	4	8	0	7	7	10	15	7	11	1	0	0	0	0	0	0	0	0
	12-14	0	0	3	8	0	10	10	12	12	3	15	4	0	0	0	0	0	0	0	0
	14-16	0	0	5	8	0	7	13	10	7	1	5	0	0	0	0	0	0	0	0	0
	16-18	0	0	7	7	0	10	12	10	5	14	0	0	0	0	0	0	0	0	0	0
	18-20	0	0	8	8	0	10	10	9	5	6	0	0	0	0	0	0	0	0	0	0
	20-22	0	0	10	9	4	7	3	7	3	8	0	0	0	0	0	0	0	0	0	0
	22-24	0	0	5	8	5	4	2	6	5	0	0	0	0	0	0	0	0	0	0	0
	Total	3	6	65	108	40	98	87	99	70	58	33	5	0	0	0	0	0	0	0	0
March	0-2	0	0	0	5	3	19	11	13	4	2	0	0	0	0	0	0	0	0	0	0
	2-4	0	0	0	3	12	29	13	9	10	0	0	0	0	0	0	0	0	0	0	0
	4-6	0	0	0	3	16	21	14	8	5	0	0	0	0	0	0	0	0	0	0	0
	6-8	0	0	0	3	11	15	15	9	10	7	0	0	0	0	0	0	0	0	0	0
	8-10	0	0	0	2	10	16	14	10	4	9	3	0	0	0	0	0	0	0	0	0
	10-12	0	0	0	0	5	16	10	6	0	0	6	1	0	0	0	0	0	0	0	0
	12-14	0	0	0	0	1	21	8	0	0	0	6	1	0	0	0	0	0	0	0	0
	14-16	0	0	0	0	37	15	0	0	0	0	5	0	0	0	0	0	0	0	0	0
	16-18	0	0	0	0	23	15	1	0	0	4	0	0	0	0	0	0	0	0	0	0
	18-20	0	0	0	2	21	17	4	2	0	7	0	0	0	0	0	0	0	0	0	0
	20-22	0	0	0	8	10	31	10	11	10	7	0	0	0	0	0	0	0	0	0	0
	22-24	0	0	0	8	10	24	16	16	10	1	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	34	159	239	116	84	53	37	20	2	0	0	0	0	0	0	0	0
April	0-2	0	0	0	1	2	10	14	24	10	20	6	2	0	0	0	0	0	0	0	0
	2-4	0	0	0	3	11	6	17	12	10	15	6	6	0	0	0	0	0	0	0	0
	4-6	0	0	0	3	10	8	15	11	14	5	4	7	3	0	0	0	0	0	0	0
	6-8	0	0	0	0	7	8	22	9	10	0	6	4	10	0	0	0	0	0	0	0
	8-10	0	0	0	0	0	6	18	13	6	0	6	3	1	0	0	0	0	0	0	0
	10-12	0	0	0	0	0	8	13	11	1	0	0	1	0	2	1	0	0	0	0	0
	12-14	0	0	0	0	0	0	6	16	5	0	0	1	0	15	2	1	0	0	0	0
	14-16	0	0	0	0	0	0	5	20	4	0	0	1	0	2	1	0	0	0	0	0
	16-18	0	0	0	0	0	6	8	10	3	0	0	0	0	0	0	0	0	0	0	0
	18-20	0	0	0	0	0	7	5	12	3	0	0	0	0	0	0	0	0	0	0	0
	20-22	0	0	0	0	7	15	15	15	13	4	0	0	0	0	0	0	0	0	0	0
	22-24	0	0	0	1	6	14	20	20	10	5	20	1	0	0	0	0	0	0	0	0
	Total	0	0	0	8	43	88	158	173	89	49	48	26	14	19	4	1	0	0	0	0
May	0-2	0	0	0	0	0	0	0	0	6	20	10	12	10	9	0	0	0	0	0	0
	2-4	0	0	0	0	0	0	0	0	5	20	10	11	10	9	0	0	0	0	0	0
	4-6	0	0	0	0	0	0	0	0	3	35	11	14	14	6	0	0	0	0	0	0
	6-8	0	0	0	0	0	0	0	0	0	10	15	10	10	4	3	0	0	0	0	0
	8-10	0	0	0	0	0	0	0	1	0	5	15	10	10	3	8	0	0	0	0	0
	10-12	0	0	0	0	0	0	0	0	0	10	13	7	10	4	6	0	0	0	0	0
	12-14	0	0	0	0	0	0	0	0	0	15	10	7	3	10	6	12	3	1	0	0
	14-16	0	0	0	0	0	0	0	0	0	13	20	12	1	4	7	4	0	0	0	0
	16-18	0	0	0	0	0	0	0	5	0	5	33	5	4	2	1	0	0	0	0	0
	18-20	0	0	0	0	0	0	0	0	0	10	20	7	7	0	12	0	0	0	0	0
	20-22	0	0	0	0	0	0	0	0	0	13	33	8	15	0	0	0	0	0	0	0
	22-24	0	0	0	0	0	0	0	0	0	18	21	10	18	0	0	0	0	0	0	0
	Total	0	0	0	0	0	0	0	6	14	174	211	113	112	51	43	16	3	1	0	0
June	0-2	0	0	0	0	0	0	0	0	11	11	10	12	14	12	10	0	0	0	0	0
	2-4	0	0	0	0	0	0	0	0	1	4	10	12	16	10	6	0	0	0	0	0
	4-6	0	0	0	0	0	0	0	0	0	0	12	10	15	10	6	0	0	0	0	0
	6-8	0	0	0	0	0	0	0	0	0	0	0	12	10	10	7	6	0	0	0	0
	8-10	0	0	0	0	0	0	0	0	0	0	0	15	10	8	10	10	10	4	0	0
	10-12	0	0	0	0	0	0	0	0	0	0	0	10	10	8	6	18	15	5	1	1
	12-14	0	0	0	0	0	0	0	0	0	0	0	7	3	0	7	5	15	12	3	0
	14-16	0	0	0	0	0	0	0	0	0	0	0	10	1	10	7	10	10	12	1	1
	16-18	0	0	0	0	0	0	0	0	0	0	0	10	4	17	2	13	24	0	2	0
	18-20	0	0	0	0	0	0	0	0	0	0	0	4	10	20	14	12	1	2	1	0
	20-22	0	0	0	0	0	0	0	0	0	0	0	0	15	16	15	0	0	0	0	0
	22-24	0	0	0	0	0	0	0	0	0	0	0	10	14	13	9	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	12	15	32	112	122	134	99	74	75	35	8	2

Table 1. Continued

Month	Time Interval(h)	Temperature Bin(°C)																				
		-6/-4	-4/-2	-2/0	0/2	2/4	4/6	6/8	8/10	10/12	12/14	14/16	16/18	18/20	20/22	22/24	24/26	26/28	28/30	30/32	32/34
July	0-2	0	0	0	0	0	0	0	0	0	0	0	2	10	12	20	2	0	0	0	0
	2-4	0	0	0	0	0	0	0	0	0	0	0	0	10	11	10	0	0	0	0	0
	4-6	0	0	0	0	0	0	0	0	0	0	0	0	5	14	10	0	0	0	0	0
	6-8	0	0	0	0	0	0	0	0	0	0	0	0	0	10	33	17	4	0	0	0
	8-10	0	0	0	0	0	0	0	0	0	0	0	0	0	8	22	36	17	0	0	0
	10-12	0	0	0	0	0	0	0	0	0	0	0	0	0	8	12	9	26	14	0	0
	12-14	0	0	0	0	0	0	0	0	0	0	0	0	0	0	13	8	20	22	4	0
	14-16	0	0	0	0	0	0	0	0	0	0	0	0	0	10	14	16	44	25	1	0
	16-18	0	0	0	0	0	0	0	0	0	0	0	0	0	17	15	14	40	6	0	0
	18-20	0	0	0	0	0	0	0	0	0	0	0	0	0	23	15	21	2	1	0	0
	20-22	0	0	0	0	0	0	0	0	0	0	0	0	0	9	24	9	0	2	0	0
	22-24	0	0	0	0	0	0	0	0	0	0	0	0	0	21	22	2	2	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	0	2	25	143	210	134	155	70	5	0
August	0-2	0	0	0	0	0	0	0	0	0	0	6	15	19	20	3	0	0	0	0	0
	2-4	0	0	0	0	0	0	0	0	0	0	2	12	24	20	7	0	0	0	0	0
	4-6	0	0	0	0	0	0	0	0	0	0	0	6	20	14	9	0	0	0	0	0
	6-8	0	0	0	0	0	0	0	0	0	0	0	5	15	10	12	9	0	0	0	0
	8-10	0	0	0	0	0	0	0	0	0	0	0	5	21	8	9	13	10	0	0	0
	10-12	0	0	0	0	0	0	0	0	0	0	0	1	20	7	8	19	20	3	0	0
	12-14	0	0	0	0	0	0	0	0	0	0	0	0	15	2	10	4	15	6	0	0
	14-16	0	0	0	0	0	0	0	0	0	0	0	0	15	5	11	10	10	3	0	0
	16-18	0	0	0	0	0	0	0	0	0	0	0	0	22	19	12	21	2	0	0	0
	18-20	0	0	0	0	0	0	0	0	0	0	0	0	23	20	15	10	1	0	0	0
	20-22	0	0	0	0	0	0	0	0	0	0	0	0	15	41	21	0	0	0	0	0
	22-24	0	0	0	0	0	0	0	0	0	0	0	5	3	26	10	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	0	0	8	49	212	192	127	86	58	12	0	0
September	0-2	0	0	0	0	0	0	0	0	6	19	10	10	10	16	2	0	0	0	0	0
	2-4	0	0	0	0	0	0	0	0	4	21	9	10	10	14	2	0	0	0	0	0
	4-6	0	0	0	0	0	0	0	0	5	10	13	13	10	14	5	0	0	0	0	0
	6-8	0	0	0	0	0	0	0	0	8	2	13	18	8	10	12	7	0	0	0	0
	8-10	0	0	0	0	0	0	0	0	0	2	8	9	8	8	3	11	0	0	0	0
	10-12	0	0	0	0	0	0	0	0	0	0	2	6	10	6	3	10	2	3	0	0
	12-14	0	0	0	0	0	0	0	0	0	0	0	8	15	6	7	8	16	6	1	0
	14-16	0	0	0	0	0	0	0	0	0	0	0	5	15	6	7	10	2	3	0	0
	16-18	0	0	0	0	0	0	0	0	0	3	0	10	13	1	6	16	0	0	0	0
	18-20	0	0	0	0	0	0	0	0	0	5	0	15	10	0	1	10	0	0	0	0
	20-22	0	0	0	0	0	0	0	0	0	6	0	16	10	0	10	0	0	0	0	0
	22-24	0	0	0	0	0	0	0	0	4	8	21	13	18	17	10	0	0	0	0	0
	Total	0	0	0	0	0	0	0	0	27	76	76	133	137	98	68	72	20	12	1	0
October	0-2	0	0	0	0	0	0	9	10	17	10	3	4	1	10	0	0	0	0	0	0
	2-4	0	0	0	0	0	0	8	10	20	40	0	4	6	8	0	0	0	0	0	0
	4-6	0	0	0	0	0	0	8	7	17	35	0	8	5	10	2	0	0	0	0	0
	6-8	0	0	0	0	0	0	5	9	24	2	6	4	3	2	2	0	0	0	0	0
	8-10	0	0	0	0	0	0	0	7	10	8	6	5	6	8	1	0	0	0	0	0
	10-12	0	0	0	0	0	0	0	3	5	10	2	10	5	5	5	0	0	0	0	0
	12-14	0	0	0	0	0	0	0	26	3	5	2	5	8	12	7	4	0	0	0	0
	14-16	0	0	0	0	0	0	0	13	3	7	2	5	8	5	5	2	0	0	0	0
	16-18	0	0	0	0	0	0	0	9	10	5	4	9	7	0	3	0	0	0	0	0
	18-20	0	0	0	0	0	0	0	4	5	10	0	17	10	0	0	0	0	0	0	0
	20-22	0	0	0	0	0	0	6	10	16	13	0	7	5	0	0	0	0	0	0	0
	22-24	0	0	0	0	0	0	2	10	10	33	0	6	3	3	0	0	0	0	0	0
	Toplam	0	0	0	0	0	0	38	118	140	178	25	84	67	63	25	6	0	0	0	0
November	0-2	0	0	0	5	8	16	6	8	0	0	0	0	0	0	0	0	0	0	0	0
	2-4	0	0	0	3	7	9	5	9	0	0	0	0	0	0	0	0	0	0	0	0
	4-6	0	0	0	3	6	8	9	7	3	0	0	0	0	0	0	0	0	0	0	0
	6-8	0	0	0	3	9	7	4	9	10	5	3	0	0	0	0	0	0	0	0	0
	8-10	0	0	0	3	7	10	5	7	15	6	6	0	3	0	0	0	0	0	0	0
	10-12	0	0	0	6	12	8	6	10	10	10	6	9	5	0	0	0	0	0	0	0
	12-14	0	0	0	6	8	15	10	7	6	10	8	10	8	1	0	0	0	0	0	0
	14-16	0	0	0	5	3	19	8	2	10	26	12	10	3	0	0	0	0	0	0	0
	16-18	0	0	0	3	1	10	8	2	15	7	14	10	0	0	0	0	0	0	0	0
	18-20	0	0	0	3	2	14	10	7	15	6	0	2	0	0	0	0	0	0	0	0
	20-22	0	0	0	8	7	8	3	9	10	6	0	2	0	0	0	0	0	0	0	0
	22-24	0	0	0	8	9	11	3	9	5	0	0	0	0	0	0	0	0	0	0	0
	Total	0	0	0	56	79	135	77	86	99	76	49	43	19	1	0	0	0	0	0	0
December	0-2	0	0	3	10	10	18	4	7	0	0	0	0	0	0	0	0	0	0	0	0
	2-4	0	1	4	12	7	9	5	8	0	0	0	0	0	0	0	0	0	0	0	0
	4-6	0	1	4	20	8	9	9	7	3	0	0	0	0	0	0	0	0	0	0	0
	6-8	0	0	4	20	8	8	6	9	10	5	2	0	0	0	0	0	0	0	0	0
	8-10	0	0	4	15	13	9	7	7	10	5	2	0	2	0	0	0	0	0	0	0
	10-12	0	0	3	7	12	7	9	10	12	8	6	4	1	0	0	0	0	0	0	0
	12-14	0	0	2	10	10	9	10	10	6	17	4	4	2	0	0	0	0	0	0	0
	14-16	0	0	3	1	6	13	13	5	12	5	3	0	0	0	0	0	0	0	0	0
	16-18	0	0	7	2	2	10	13	5	5	4	4	0	0	0	0	0	0	0	0	0
	18-20	0	0	3	12	9	10	10	9	5	6	0	0	0	0	0	0	0	0	0	0
	20-22	0	0	2	6	8	10	3	6	5	5	0	0	0	0	0	0	0	0	0	0
	22-24	0	0	4	11	11	12	3	8	5	0	0	0	0	0	0	0	0	0	0	0
	Toplam	0	2	43	126	104	124	92	91	73	55	21	8	5	0	0	0	0	0	0	0

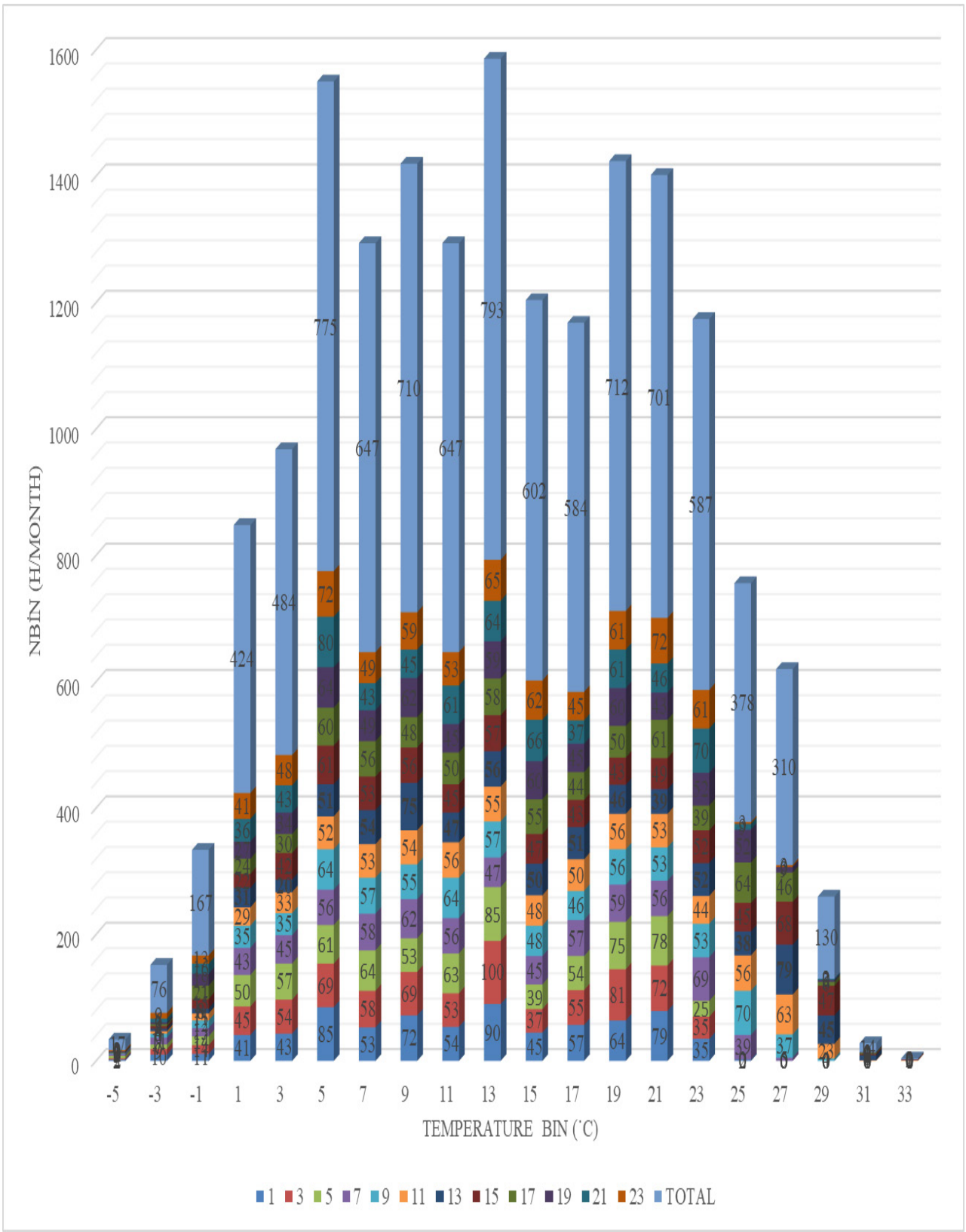

Figure 1. The value of the Bin data effected on the periods of time within the day

For the total energy consumption of the interval of the temperature, the value of the total Qbin,i would be calculated above the Equation 2 and

$$Q_{tot} = \sum Q_{bin,\ i} \quad (2)$$

The Fuel consumption would be calculated as Equation 3 as follows,

$$F_{tot} = \frac{Q_{tot}}{H} \quad (3)$$

In this study, the dry bulb temperature ranging from -6°C to 34°C was utilised to generate the BIN data for Istanbul. Subsequently, the BIN data for the designated period (N_{bin}) was determined by dividing the entire day into 12 equal segments. Receiving the data 25 years from 1983 to 2008 from State Meteorological Affairs, the value of the BIN data has been calculated by using the value of hourly of the dry-bulb temperature of total 25 years periods.

In Table 1, the value of the BIN data of Istanbul has been given monthly as seperately for receiving the dry-bulb teperature. As illustrated in Table 1, the lowest recorded temperature of -6°C (-6°C/-4°C) occurred after a duration of three hours in January.

As demonstrated in Figure 1, the mean total time spent at temperatures of between -6°C and -4°C in January is 14 hours. Then, the highest temperature of 33°C has been obtained 2 times in June. In this table, the times of repeated temperature have been studied easily as below. The lowest temperature of -6°C has been seen 3 hours in January, it means -6°C was repeated 3 times in this month. The average temperature of -5°C has been recorded on approximately 14 occasions, with 11 of these occurring in January and 3 in February. Furthermore, the average temperature of -4°C has been recorded on 36 occasions, 33 of which were in January and 3 in February. Subsequently, the temperature of -3°C was replicated on approximately 40 occasions, 35 of which occurred in January, three in February and a further two in December. As demonstrated by the calculation above, it can be deduced that January is likely to be the coldest month in Turkey.

Moreover, it is evident that the months of February and December experience lower temperatures in comparison to other months in Turkey. The winter period extends from November to April, while the summer months are from May to October. During the summer months, the highest temperatures can reach approximately 33°C. The maximum temperature, ranging between 32°C and 34°C, has been documented on two occasions in June. Then, the temperature at 29°C repeated as 37 times, 10 times in June, 20 times in July and 7 times in September.

Although most of the people know that the hottest month is August in Turkey. As demonstrated in Table 1, the temperature of 31°C was recorded on four occasions in June, and the temperature of 30°C was recorded ten times, including four times in June, five times in July and once in September. Subsequently, the temperature was recorded at 29°C on 37 occasions, 10 times in June, 20 times in July and 7 times in September. Despite the prevailing perception that August is the hottest month in Turkey, the findings of this study, based on the BIN data, indicate that June is indeed the month with the highest temperatures [21].

As illustrated in Table 2, the values of the bin data for yearly are already given. The maximum total number of the BIN data for the designed period (N_{bin}) for the year was determined to be 793 hours in 13°C, within the interval of (12°C/14°C). In Figure 2, the value of monthly N_{bin} changes of Istanbul has already been shown. N_{bin} of winter and summer would be seen from this Figure 2. As illustrated in Figure 2, the summer season is depicted on the left side of the figure, while the winter season is represented on the right. According to the Table 2, the total number of days in both summer and winter has been calculated. As demonstrated in Table 2, the number of instances of action on the average temperature ranging from -6 to 34°C has been calculated for a 12-month period. Furthermore, the mean hours in a day can be determined from BIN data and as shown in Table 2.

Table 2. Yearly total N_{bin} (h/year) for 12 separate time periods of day for Istanbul

Time Interval(h)	Time Interval(h)	Temperature Bin(°C)																				
		-5	-3	-1	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33
1	0-2	2	10	11	41	43	85	53	72	54	90	45	57	64	79	35	2	0	0	0	0
3	2-4	2	9	14	45	54	69	58	69	53	100	37	55	81	72	35	0	0	0	0	0
5	4-6	4	7	14	50	57	61	64	53	63	85	39	54	75	78	25	0	0	0	0	0
7	6-8	3	11	13	43	45	56	58	62	56	47	45	57	59	56	69	39	5	0	0	0
9	8-10	1	6	12	35	35	64	57	55	64	57	48	46	56	53	53	70	37	4	0	0
11	10-12	0	4	11	29	33	52	53	54	56	55	48	50	56	53	44	56	63	23	1	1
13	12-14	0	4	8	31	20	51	54	75	47	56	50	51	46	39	52	38	79	45	8	0
15	14-16	0	4	15	22	42	61	53	56	45	57	47	43	43	49	52	45	68	47	2	1
17	16-18	1	3	21	24	30	60	56	48	50	58	55	44	50	61	39	64	46	6	2	0
19	18-20	2	3	19	27	34	64	49	62	45	59	60	45	60	43	52	52	9	3	1	0
21	20-22	0	6	16	36	43	80	43	45	61	64	66	37	61	46	70	9	0	2	0	0
23	22-24	2	9	13	41	48	72	49	59	53	65	62	45	61	72	61	3	3	0	0	0
Total	Total	17	76	167	424	484	775	647	710	647	793	602	584	712	701	587	378	310	130	14	2

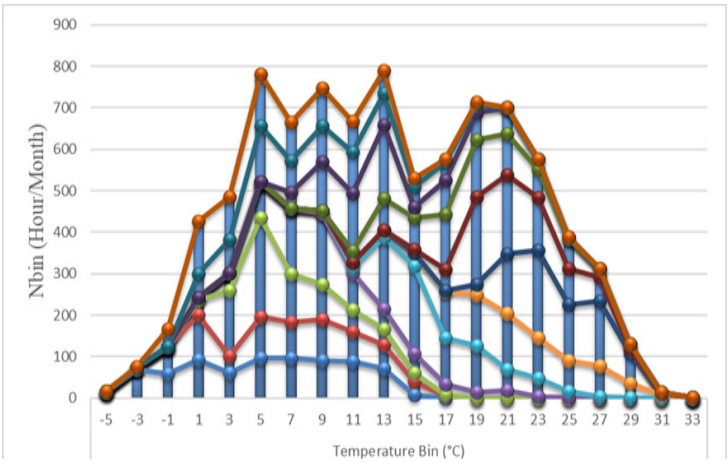

Figure 2. Yearly total Nbin value (h/year) for 12 separated period of the day of İstanbul

The winter period is defined as the months of November to April, whereas summer extends from May to October. As demonstrated in Figure 2, the values of the bin data have been affected by the time of day. The temperature values for all periods of time are displayed in Figure 2. With regard to the data presented in Table 2, the temperature range of -6°C to 34°C has repeated as follows. The interval of the temperature between -6°C to -4°C has repeated 17 hours, the interval of the temperature between -4°C to -2°C has repeated 76 hours, the interval of the temperature between -2°C to 0°C has repeated 167 hours, the interval of the temperature between 0°C to 2°C has repeated 424 hours, the interval of the temperature between 2°C to 4°C has repeated 484 hours, the interval of the temperature between 4°C to 6°C has repeated 775 hours, the interval of the temperature between 6°C to 8°C has repeated 647 hours, the interval of the temperature between 8°C to 10°C has repeated 710 hours, the interval of the temperature between 10°C to 12°C has repeated 647 hours, the interval of the temperature between 12°C to 14°C has repeated 793 hours, the interval of the temperature between 14°C to 16°C has repeated 602 hours, the interval of the temperature between 16°C to 18°C has repeated 584 hours, the interval of the temperature between 18°C to 20°C has repeated 712 hours, the interval of the temperature between 20°C to 22°C has repeated 701 hours, the interval of the temperature between 22°C to 24°C has repeated 587 hours, the interval of the temperature between 24°C to 26°C has repeated 378 hours, the interval of the temperature between 26°C to 28°C has repeated 310 hours, the interval of the temperature between 28°C to 30°C has repeated 130 hours, the interval of the temperature between 30°C to 32°C has repeated 14 hours and the interval of the temperature between 32°C to 34°C has repeated 2 hours, has been calculated in Table 2. The total number of times that the same temperature was recorded at 1 am has been calculated about 743 times, at 3 am has repeated about 753 times, at 5 am repeated about 729 times, at 7 am, the same temperature repeated about 724 times, at 9 am the temperature repeated about 753 times, at 11 am repeated about 742, at 13 pm the temperature repeated about 754 times, at 15 pm, the same temperature repeated about 752 times, at 17 pm, the same temperature repeated about 718 times, at 19 pm, repeated about 689 times, at 21 pm, 685 times repeated, at 23 pm the same temperature repeated 718 times and respectively as shown in Figure 3.

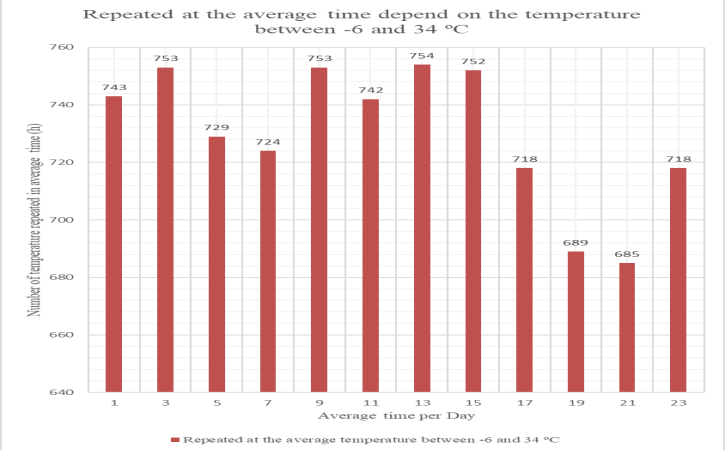

Figure 3. Repeated at the average temperature between -6 and 34 °C per day

The minimum repeated times of 685 have been seen in 21 pm and the maximum repeated times of 754 hours have been seen in 13 pm. At 17 pm and 23 pm, the same temperature repeated as 718 hours. Moreover, at 3 am and 9 am the same temperature repeated as 753 hours have been seen in Figure 3.

As demonstrated in Figure 4, the number of repeated BIN temperatures has been calculated. The average Bin temperature between -6°C and 34°C has been calculated in the duration of repeated hours per day. The average temperature of -5°C has been repeated about 17 times per year and every one time is the equivalent of one hour. Then, the average temperature of -3°C has been repeated as 76 times per year, the average temperature of -1°C has been repeated as 167 times, 1°C has been repeated about 11°C repeated about 647 times in each, 9°C repeated about 710 times, 13°C repeated about 793 times, 15°C repeated about 602 times, 17°C repeated about 584 times, 19°C repeated about 712 times, 21°C repeated about 701 times, 23°C repeated about 587 times, 25°C repeated about 378 times, 27°C repeated about 310 times, 29°C repeated about 130 times, 31°C repeated about 14 times and 33°C was repeated in 2 times and respectively as shown in Figure 4.

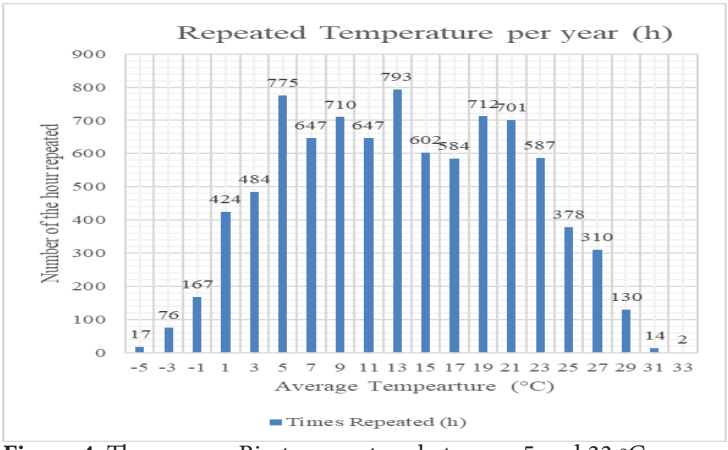

Figure 4. The average Bin temperature between -5 and 33 °C per year

424 times, 3°C repeated about 484 times, 5°C has been repeated about 775 times, then, both 7°C and In this study, at an average temperature of 13°C has indicated that the maximum repeated temperature per year which has been about 793 hours. It has been observed that the average temperature of 33°C was the highest temperature recorded throughout the year and this temperature was repeated only twice. It was determined that it has been the least repeated temperature in the year. In this study, bin data of İstanbul has been obtained from 25 years of the result of TMY (Typical Meteorological Year) has been used and the relationship between bin temperature and the duration of repeated temperature has been observed. Following the calculation of N_{bin}, its application in public buildings enables the estimation of energy consumption and future energy The values obtained can be utilised to determine the energy demand for heating and cooling purposes. Consequently, the energy requirement can be estimated. The values of N_{bin} , which are determined at hourly and temperature interval points, facilitate the straightforward calculation of a building's energy consumption. The total energy consumption for the winter period has been calculated as the total N_{bin} from November to April. The required energy for heating has been calculated as illustrated in Figure 5.

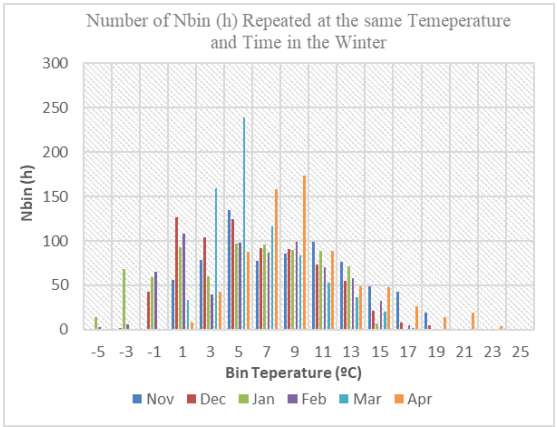

Figure 5. Total Nbin from November to April

Otherwise, The total energy consumption for the summer period has been calculated as the total N_{bin} from May to October. The required energy for cooling has been calculated as illustrated in Figure 6.

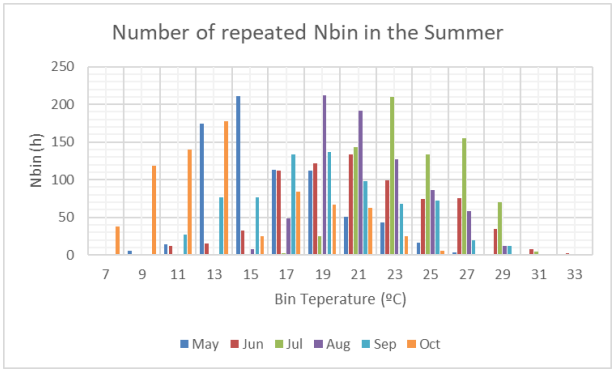

Figure 6. Total Nbin from May to October

3. Determination of annual heating and cooling loads for a public building (Beykoz municipal building)

The wall materials of public buildings in Turkey change depending on the geographical location. The Municipal Building (Beykoz Municipal Building) was constructed in 2011 in Beykoz, in Istanbul. The total floor area of the building is approximately 10,735 m², length is 69 m, width is about 55m and the height is about 14m. The total number of employees in 2023 was 561. In terms of its structural design, the building comprises four storeys, such as the ground floor, the subterranean level, the first floor, and the second floor, respectively. The composition of the outer wall of the Beykoz municipality building is as follows: firstly an outer layer of aerated concrete measuring 60 x 25 x 15 cm, secondly a layer of rock wool about 5 cm thickness, glass wool also about 10 cm thickness (at the roof) and finally insulated paints about 1 cm thick on the outer walls and 1 cm thick plaster paint was used on the interior facade [22].

The specification of the physical and thermal values of the public building has already been delineated in Table 3. [33].

Table 3. Physical and thermal specifications of the public building [33]

Construction Material	Area(m²)	U(W/m²°C)	UA(W/°C)
Outer Layer(Wall)1	3.314	0,3	994
Beam and Colon(Wall)2	1.760	0,35	616
Outer layer(Glass Wall)3	744	2,4	1.786
Ceiling	300	0,4	120
Base	200	0,4	80
Window(Doble Glasses)	1.100	2,12	2.332
Total	7.418	5,97	
		Ktop = ∑UA	5.928

In this public building, certain layers of the external structure (wall) consist entirely of glass and the windows have double-glazed panes. In accordance with the provisions stipulated in TS 825, this building has been categorised within the class of A, which denotes the presence of effective insulation. With regard to the calculation of energy consumption, the requisite natural gas consumption for heating purposes has been determined [23].

There are many different types of insulation materials to reduce energy consumption of the public buildings. In this municipal building rock wool and glass wool have been used as insulation materials. The usage of the thickness of the insulation material has been changed depend on region of the location of the building and thickness of the outer wall. The properties of insulation material used in Beykoz municipal building as follows; both glass wool and rock wool are natural insulation and heat insulation materials. The properties of glass wool which has been used in the roof deck, the value temperature coefficient has been about 0.040W/mK, The material has been demonstrated to exhibit a high level of thermal stability, with a temperature range of -50°C to +250°C. This material has been characterised by its resilience to exposure to moisture, water, and humidity. As for the rock wool that has been used in the outer wall, the thermal conductivity declaration value at 10°C has been determined to be between 0.035 and 0.040 W/mK.

The resistance factor, μ, for water vapour diffusion is therefore equal to one. Depending on the type of the product, temperature of the rock wool has been the range of -50/+650°C. and melting temperature less than 1000°C [25-29].

It is hypothesised that the coefficient of heating value for natural gas as a fuel is 0.92, and that the balance point of temperature for heating is 18°C.

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Calculations of the energy consumption of the public building by using BIN method

First of all, the value of N_{bin} has been calculated from Table 2, and the total value is 8.760 h.

The total amount of heat transfer coefficient (ΣU*A) is 17.510 W/°C.

The value of η assumed as 0,92. T_b=18°C and $T_{o,i}$ =13°C receiving from Table 2.

By using Equation 1;

$Q_{bin,i}$ = 8.760* 5.928/0,92 (18-13) kWh

The calculation of annual heating energy for the public building is presented in Table 4, with data broken down according to different intervals of time and temperature. The total amount of the energy required for heating in the winter as show in Table 4.

As demonstrated in Equation 1 and Equation 2 above; the total energy required for the heating of this public building has been calculated as follows:

Q_{tot} = 319.139 kWh (for heating) ,

In the case of natural gas, the assumption of a low calorific value has been 34.534 kJ/m³. The fuel consumption has also been calculated using Equation 3.

F_{tot} = (319.139 / 34.534,5) *3.600 = 33.268 m^3

Total energy consumption in the winter has been calculated at about 319.139 kWh. In winter, the minimum temperature of -6°C has been reached in Istanbul.

The interval of the temperature of -6°C to -4°C has been seen in the frequency of 17 times(17 hours),which are 14 times(14 hours) in January and 3 times(3 hours)in February. The required amount of the fuel as natural gas per year would be about 33.268 m^3. The average maximum outside temperature is 19°C in the winter. In this study, the reference temperature for the heating could be assumed as 18°C.

The energy consumption of the public building(Beykoz municipal building)at the average bin temperature of -5°C has been calculated 2.132 kWh, at -3°C has been calculated 8.705 kWh, at -1°C has been calculated 17.308 kWh, at 1°C has been calculated 39.313 kWh, at 3°C has been calculated 39.596 kWh, at 5°C has been calculated 54.950 kWh, at 7°C has been calculated 45.860 kWh, at 9°C has been calculated 41.176 kWh, at 11°C has been calculated 29.186 kWh, at 13°C has been calculated 25.549 kWh, at 15°C has been calculated 11.639 kWh and at 17°C has been calculated 3.725 kWh. In the winter, the highest energy consumption has been obtained about 54.950 kWh at 5°C and the lowest energy consumption has been obtained about 2.132 kWh at -5°C.

The annual energy consumption could be calculated by the addition of the total energy consumption of the winter and summer [24].

The energy consumption of the public building for heating as shown in Figure 7.

Although the hottest month known as August, the highest BIN temperature of 33°C reached as the frequency of 2 times in June.

In the summer, the temperature varies from 15°C to 33°C. From the calculation of the energy consumption, we can assume that the hottest month in Istanbul is August. The total annual energy con-

sumption is the addition of Q_{tot} (Heating) = 319.139 kWh (energy consumption in the winter) and Q_{tot} (Cooling) = 37.055 kWh (energy consumption in the summer).

Total annual energy consumption = 356.194 kWh

The calculation of annual cooling energy for the public building is presented in Table 5, with data broken down according to different intervals of time and temperature. The total amount of the energy required for cooling in the summer as show in Table 5.

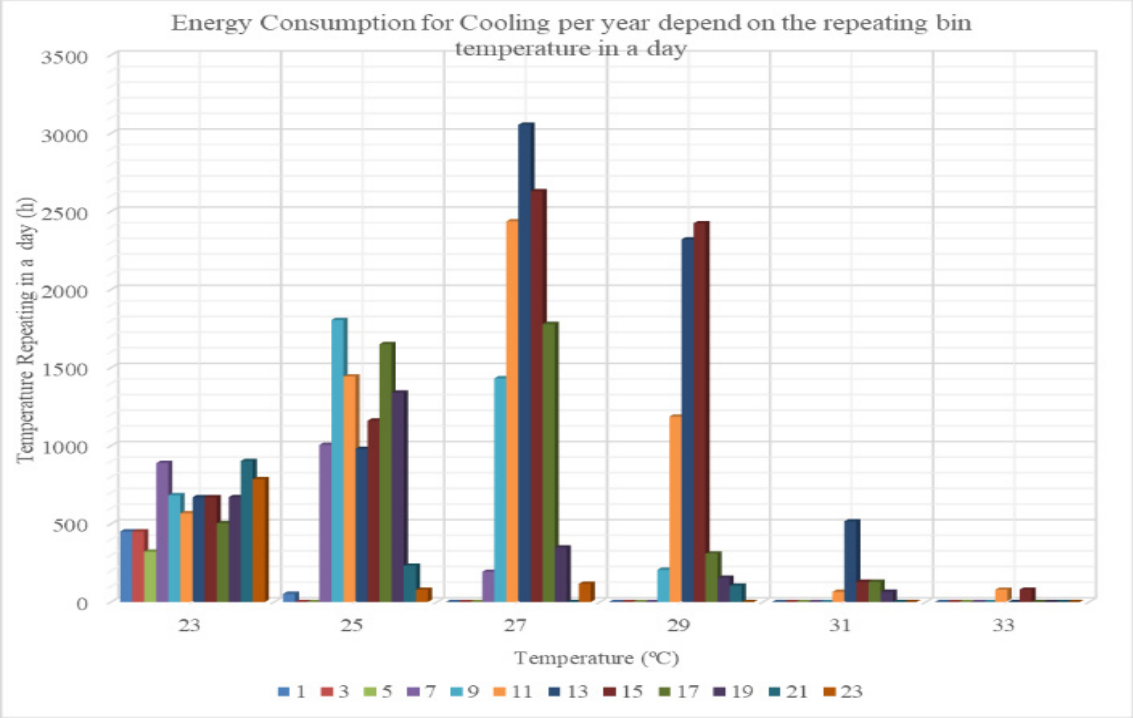

Figure 8. Calculation of Energy consumption for cooling in the summer by using BIN method

The energy consumption of the public building(Beykoz municipal building)in the summer, at the average bin temperature of 23°C has been calculated 7.565 kWh, at 25°C has been calculated 9.744 kWh, at 27°C has been calculated 11.986 kWh, at 29°C has been calculated 6.702 kWh, at 31°C has been calculated 902 kWh and at 33°C has been calculated 156 kWh.

For cooling, the calculation of the amount of the required energy has been shown in Table 5 and the energy consumption of the public building for cooling, in the summer as shown in Figure 8 as follows.

Total annual energy consumption = 356.194 kWh and the total energy consumption for heating in winter is 319.139 kWh.

The maximum energy consumption during the winter period is approximately 31.010 kWh, which is evident during the 2-4 am time interval.

It can be hypothesised that the 1 am time point corresponds to the peak energy consumption. The temporal pattern of energy consumption for heating purposes during the winter period is analysed. The findings indicate that the period of time between 12-14 pm (corresponding to noon) experiences the lowest energy consumption, with an average of 22.758 kWh recorded. This analysis suggests that the energy consumption is at its lowest at 13 pm.

4. Energy consumption of Beykoz municipal building by using the invoice of natural gas and electric energy

In this study, the energy consumption of Beykoz Municipal Building over a period of three years, specifically in 2021, 2022, and 2023, has been the subject of evaluation in Table 6 below.

The total energy consumption for heating in the winter for a period of three years has been obtained from the invoices of natural gas for the Beykoz municipal building, amounting to approximately 140.675 m^3. The average natural gas consumption has calculated to be 46.892 m^3, equivalent to 494.707 kWh.

Comparing the energy consumption for heating by using the bin method with the invoice of natural gas of the Beykoz Municipal Building by using the bin method, the total energy consumption for heating in the winter has been calculated to be about 319.139 kWh at the temperature between -6°C and 19°C.

Table 4. The amount of the required energy for heating in the public building

Time Interval(h)	Temperature Bin(°C)																			
	-5	-3	-1	1	3	5	7	9	11	13	15	17	19	21	23	25	27	29	31	33
1	251	1145	1140	3802	3518	6027	3757	4175	2436	2900	870	367	0	0	0	0	0	0	0	0
3	251	1031	1451	4172	4418	4892	4111	4001	2391	3222	715	355	0	0	0	0	0	0	0	0
5	502	802	1451	4635	4663	4325	4536	3074	2842	2739	754	348	0	0	0	0	0	0	0	0
7	376	1260	1347	3987	3681	3971	4111	3595	2526	1514	870	367	0	0	0	0	0	0	0	0
9	125	687	1244	3245	2864	4538	4040	3190	2887	1836	928	297	0	0	0	0	0	0	0	0
11	0	458	1140	2689	2699	3687	3757	3132	2526	1772	928	322	0	0	0	0	0	0	0	0
13	0	458	829	2875	1636	3616	3826	4350	2120	1804	967	277	0	0	0	0	0	0	0	0
15	0	458	1555	2040	3436	4325	3757	3248	2030	1836	909	284	0	0	0	0	0	0	0	0
17	125	344	2176	2225	2454	4254	3970	2784	2255	1869	1063	290	0	0	0	0	0	0	0	0
19	251	344	1969	2503	2782	4538	3474	3595	2030	1901	1160	290	0	0	0	0	0	0	0	0
21	0	687	1659	3338	3518	5672	3048	2610	2752	2061	1276	238	0	0	0	0	0	0	0	0
23	251	1031	1347	3802	3927	5105	3473	3422	2391	2095	1199	290	0	0	0	0	0	0	0	0
Total	2132	8705	17308	39313	39596	54950	45860	41176	29186	25549	11639	3725	0	0	0	0	0	0	0	0

This study utilised comprehensive invoice data concerning natural gas consumption. The average natural gas consumption has been determined to be about 494.707 kWh, encompassing utilisation for culinary purposes, domestic hot water provision, and other essential functions. Just only average of 64.5% of the energy consumption is used for heating per year. The amount of energy consumption for heating in the municipal building is about 319.090 kWh for heating. During the winter, from the month of November to April, all the energy consumption of heating, just only 16% of natural gas has been used for cooking and hot water, and 84% of the energy consumption is for completely using for heating of the building.

An analysis of the detailed invoices for natural gas and electrical energy consumption reveals slight discrepancies between the results

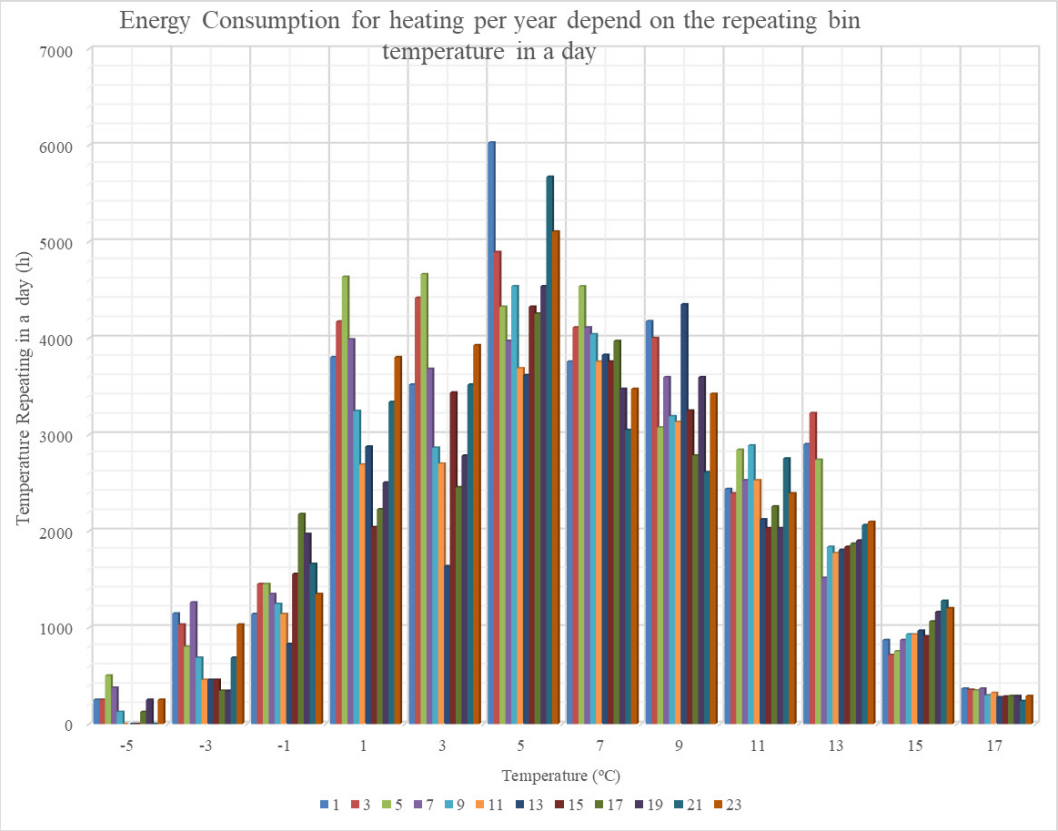

Figure 7. Energy consumption for heating in the winter

Table 5. The amount of the required energy for Cooling in the public building

Time Interval(h)	Temperature Bin(°C)											
	11	13	15	17	19	21	23	25	27	29	31	33
1	0	0	0	0	0	0	451	52	0	0	0	0
3	0	0	0	0	0	0	451	0	0	0	0	0
5	0	0	0	0	0	0	322	0	0	0	0	0
7	0	0	0	0	0	0	889	1.005	193	0	0	0
9	0	0	0	0	0	0	683	1.804	1.431	206	0	0
11	0	0	0	0	0	0	567	1.443	2.436	1.186	64	78
13	0	0	0	0	0	0	670	980	3.054	2.320	516	0
15	0	0	0	0	0	0	670	1.160	2.629	2.423	129	78
17	0	0	0	0	0	0	503	1.650	1.779	309	129	0
19	0	0	0	0	0	0	671	1.340	348	155	64	0
21	0	0	0	0	0	0	902	232	0	103	0	0
23	0	0	0	0	0	0	786	78	116	0	0	0
Total	0	0	0	0	0	0	7.565	9.744	11.986	6.702	902	156

obtained using Bin methods and the actual figures. The energy consumption of natural gas and electricity for the years 2021, 2022, and 2023 has been presented in Table 6.

The HVAC system is utilised for the purpose of cooling the municipal building during the summer months. The detailed calculation of the energy consumption for cooling the municipality building has been carried out. This calculation has been conducted in accordance with the ventilation and air conditioning devices that were installed within the building. This municipal building has been equipped with the centralized cooling system that incorporates a range of air conditioning solutions, including split air conditioners, advanced cassette-type air conditioners and evaporative air coolers, thereby ensuring a comfortable indoor environment.

Table 6. Average Energy Consumption of three years between 2021 to 2023

Year	**The Amount of Naturel Gas Consumption(m^3)**	**The Amount of Electrical Energy Consumption(kWh)**
2021	41.641,00	957.945,14
2022	43.817,00	1.354.607,00
2023	55.217,00	1.933.374,37
Total	140.675,00	4.245.926,51

In this building, there are total 140 items of wall-type split air conditioners are available, however, only 78 items of the air conditioner have been occupied. The capacity of the each of these equipment has been 4,2 kW and the energy consumptions of these equipments during the summer period has been calculated as 314.496 kWh. Moreover, the building is equipped with 40 air conditioning units of the cassette variety. Each of these units possesses a cooling capacity of 14 kW. The energy consumption of these 40 items during the summer has been calculated as 537.600 kWh. Afterwards, the energy consumptions of other 30 items with the cooling capacity of 4,5 kW have been calculated as 129.600 kWh. Later, the energy consumptions of the 30 items with 12,5 kW of outdoor units have been calculated about 360.000 kWh. Following extensive research and analysis, the energy consumption of the ventilation systems with a capacity of 200 kW has been calculated. The results indicate that the energy consumption is approximately 96,000 kW. The total energy consumption of HVAC system has been calculated about 1.437.696 kWh, which is the equivalent of the 3 years of average electrical energy consumption of Beykoz municipal building [30-32].

5. Comparison of the energy consumption for heating

A comparison has been made of the amount of energy consumed for heating in the public building (Beykoz Municipality Main Building), the 3-year average invoice value and the values found by applying the BIN method. First the amount of the values is getting from 3 years of the actual invoices of the public building, as shown in Table 7. All the invoice data from 2021 to 2023 has been determined as follows.

In 2021, the amount of energy consumption by using natural gas in the winter has been calculated as 41.641,00 m^3, which is the equivalent of 439.321,55 kWh, and electrical energy consumption has been calculated as 957.945,14 kWh, where the energy consumption has been the lowest year due to the times of covid-19. In 2022, the amount of energy consumption by using natural gas has been calculated as 43.817,00 m^3, which is the equivalent of 462.269,35 kWh, and electrical energy using about 1.354.607,00 kWh. In 2023, the amount of the energy consumption by using natural gas in the win-

Table 7. Energy consumption between 3 years (according to the invoice of natural gas and electrical energy)

Months	The Amount of Naturel gas Consumption(m^3), in 2021	The Amount of Electrical Energy Consumption(kWh),in 2021	The Amount of Naturel gas Consumption(m^3),in 2022	The Amount of Electrical Energy Consumption(kWh),in 2022	The Amount of Naturel gas Consumption(m^3),in 2023	The Amount of Electrical Energy Consumption(kWh),in 2023
January	8.396,00	62.103,96	7.279,00	116.400,00	5.868,00	230.792,00
February	4.507,00	51.670,84	8.928,00	73.500,00	6.450,00	165.886,00
March	5.965,00	62.005,01	7.698,00	59.700,00	7.402,00	142.472,00
April	5.937,00	82.673,34	4.930,00	78.000,00	7.176,00	153.212,34
May	3.735,00	86.242,44	4.370,00	87.800,00	6.255,00	102.045,55
June	2.044,00	90.940,67	1.392,00	139.200,00	2.883,00	89.000,38
July	1.246,00	103.341,68	735	173.500,00	2.464,00	222.736,17
August	705	99.208,01	597	159.700,00	2.285,00	230.528,21
September	620	93.745,56	780	137.800,00	2.313,00	160.667,29
October	1.574,00	60.683,76	878	123.509,00	2.029,00	133.218,45
November	3.459,00	72.189,24	1.891,00	97.239,00	3.035,00	163.211,48
December	3.453,00	93.140,64	4.339,00	108.259,00	7.057,00	139.604,50
Total	41.641,00	957.945,14	43.817,00	1.354.607,00	55.217,00	1.933.374,37

ter has been calculated as 55.217,00 m^3 where the amount of the energy consumption by using natural gas about 582.539,35 kWh and electrical energy consumption about 1.933.374,37 kWh.

In Table 6, the average energy consumption of the public building (Beykoz Municipal Building) has been calculated, and the average energy consumption of the municipal building between 2021 and 2023 has been calculated as about 46.891,66 m^3, where the natural gas consumption has been the equivalent of 494.707,12 kWh. Then, the total energy consumption of the electrical energy has been calculated, and the average electrical energy consumption between 3 years, which is from the year of 2021 to 2023, has been calculated. The amount of electrical energy consumption has been about 1.435.308,83 kWh per year. In this study, the energy consumption of the public building for heating in the winter has been compared. The energy consumption between November to April has already been calculated for heating and has shown in Table 8.

In our calculation acoording to the Table 8, recieving the data from the acual invoice of natural gas consumption of Beykoz municipal building from the month of November to April has been calculated as 364.924,50 kWh. It is important to note that the value of this invoice is indicative of the total energy consumption values that will be applied to heating between November and April. These values represent the three-year average for the months of November to April of the average 3 years from 2021 to 2023. All amount the energy consumption of the Beykoz Municipal Building for heating, just 85% of the energy consumption has used for heating of the building and the other 15 % has used for cooking, hot water and any other purposes. Moreover, the total energy consumption of the public building for heating can be referred 305.624,27 kWh, in the winter which is from the month of November to April. Then, the amount of the values of energy consumption receiving after the calculation from BIN Method, there are 305.516,20 kWh using for the heating at the temperature between -6 °C and 18°C.

According to the detailed invoice of the average 3 years (from 2021 to 2023), the energy consumption can be compared as in the following Table 8. In this study, we have mentioned before, just the energy consumption for heating has been studied. In the invoice detailed, the energy consumption in November has been about 29.487,25 kWh including hot water and using in the kitchen. Just only 24.695,57 kWh of energy has been used for heating of the building. But the calculation of the amount of the energy consumption in November, by using BIN method, the energy consumption has been 43.160,17 kWh and respectively as shown in Table 8. Whereas, the energy consumption of the building in April 53.140,40 kWh has been calculated from the invoice detailed, 39.860,74 kWh has been calculated by using BIN method.

Comparing both the energy consumption for heating by using BIN Method and accual values of the invoice of the public building, there has been not much difference. There has been only 108 kWh difference and energy consumption by using Bin method has been more efficiently than any other method.

6. Conclusion

This study focused on analyzing heating energy consumption in public buildings, considering Turkey's reliance on external energy sources and increasing energy consumption. Specifically, the main building of Beykoz Municipality, one of 68 public buildings directly

Table 8. Physical and thermal specifications of the public building

Months	The amount of the average energy consumption (kWh) , between 2021 to 2023 in the winter(from actual invoice)	The amount of the average energy consumption(kWh), between 2021 to 2023 only heating in the winter(from actual invoice)	The amount of the energy consumption(kWh)for heating by using BIN Method
November	29.487,25	24.695,57	43.160,17
December	52.218,98	43.733,40	56.440,72
January	75.759,55	63.448,62	60.370,74
February	69.928,92	58.565,47	50.141,22
March	74.078,58	62.040,81	55.542,61
April	63.451,22	53.140,40	39.860,74
Total	364.924,50	305.624,27	305.516,20

managed by the municipality in the Beykoz district, a significant contributor to the Marmara region's economy, was examined.

Analyses revealed that the BIN data method is an effective tool for quickly and accurately performing energy consumption simulations for public buildings. Using Istanbul's BIN data (ranging from -6°C to 34°C with 2-hour differences across 12 distinct time periods)and considering the building's total heat loss coefficient(ΣU^*A = 5.928 W/°C):

- The total annual heating energy consumption for the Beykoz Municipality main building was determined to be 319,239 kWh.
- For the winter months(November to April),the total heating energy consumption calculated using the BIN method was 305,516.20 kWh.
- Similarly, an analysis of three years of invoice data(2021-2023)showed that natural gas consumption solely for heating during the winter months(November to April)was approximately 305,624.27 kWh. Invoice data indicated that 85% of total consumption was for heating, while 15% was for hot water, cooking, and other purposes.

Most importantly, a negligible disparity was found between the energy consumption values calculated using the BIN method and actual invoice values. This clearly demonstrates the reliability of the BIN method in accurately estimating energy consumption in public buildings.

When examining heat loss dynamics during winter months, it was determined that maximum heat loss occurred between 02:00-04:00 AM(approximately 31,010 kWh),while minimum heat loss was observed around 13:00 PM(22,758 kWh).

In light of these findings, efficient energy use is a fundamental requirement to reduce energy costs in public buildings. Energy saving potential is influenced by factors such as geographical location, building structures, insulation, and architectural design. The BIN method, with its ability to quickly calculate energy consumption based on building characteristics and types, offers a valuable tool for energy efficiency studies.

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