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ORIGINAL ARTICLE

Methodology for estimation of the annual electricity consumption of a typical bank with multiple branches

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Abstract In the digital age, banks adopt energy-efficient, sustainable, and environmentally friendly methods. Such organizations with hundreds of branches and thousands of employees not only provide considerable energy efficiency opportunities but also offer significant possibilities with climate change-related investments. In order to manage, control, and mitigate electricity consumption, in-depth knowledge is required, since the banking operations heavily depend on electricity. It is a challenging but necessary step to calculate the electricity consumption of a sizeable banking organization consisting of different units, varying dimensions, and characteristics. The aim of this study is to develop a model for estimating the electricity consumption of the banks based on a few main research questions. A novel model is proposed to calculate the annual electricity consumption of banking organizations to contribute to the sustainability literature and best practice area on efficient use of natural resources. The model was developed using the field data from a major Turkish bank. In the model, nominal bank electricity consumption is proposed from a base month concept, representing the month with no heating and cooling. The breakdown of electricity consumption sources can easily be monitored for energy management by using the model. For the validation of the model, the total electricity consumption of five Turkish banks is calculated. The model results are in good agreement with the respective sustainability reports within 12% certainty. The validity and accuracy of the model are also tested for a Spanish bank that operates in ten countries and is one of the few bank conglomerates with an annual electricity consumption figure given in sustainability reports. The annual electricity consumption was estimated within 6.6% certainty. Thus, the annual electricity consumption of a bank can be estimated within an acceptable range using the number of branches, employees, and ATMs, supported by some reasonable assumptions.

Keywords Energy management in banking sector · Electricity consumption model · Nominal bank electricity consumption · Sustainability · Carbon footprint

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Introduction

The realization of a new worldwide consensus regarding the reduction of global warming has been the main reason for organizing the 2015 Paris Climate Conference. COP21, also known as the 2015 Paris Climate Conference, creates a universal climate regime in which all 195 countries, including Turkey, voluntarily agreed to participate. It is also significant that all parties submit their own plans to combat climate change by way of Intended Nationally Declared Contributions (INDC) as opposed to an enforced reduction target. In order to reach a common goal, countries have agreed to convene

every 5 years and to set more ambitious targets in line with scientific facts. While offering various opportunities, the agreement concerns not only the energy and transport sectors but all sectors across the board. Each country must take responsibility for decreasing greenhouse gases related to every sector. Thus, in addition to the manufacturing sector, the service sector has gained importance in terms of greenhouse gases (GHG) emissions. Increasing demand for energy leads to higher levels of greenhouse gas emissions, which has been described as the primary cause of global warming and many climate change-related problems. These concerns prompted greater efforts among countries and international organizations to balance energy generation with energy demand while considering environmental impacts (Esmaeil et al. 2019). The banking sector has a unique dual role in this context. Banks vary from a couple of branches to thousands of branches; hence, each of them is unique, and in general, they are usually large organizations. Along with their sizeable energy consumption figures, they can affect the climate change-related projects by providing and administering investing and lending choices to the other sectors. Especially of interest are energy investments that can affect the environment.

Due to the increasing and critical danger of global warming, it is inevitable to take necessary precautions. Therefore, some organizations have been founded specifically to draw attention and direct the countries and corporations for this upcoming critical issue where the results could not have been estimated before. These organizations, which are governmental, inter-governmental, or non-governmental, provide scientific, technical, and socio-economic information for the evaluation and prevention of climate change. Not only they provide information, they also support their activities by forming guidelines for preventing climate change and measurement of carbon emissions. The World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) have jointly developed a protocol called Greenhouse Gas Protocol. According to this protocol, the GHG emissions are categorized into three scopes (World Business Council for Sustainable Development,, and World Resources Institute 2001):

- Scope 1: Direct emissions from the equipment and processes owned or directly controlled by the company
- Scope 2: Indirect emissions that are energy-related and emanating mainly from electricity or district heating purchased from third parties
- Scope 3: Indirect emissions which are related to a company's activities but from sources not owned or controlled by the company

It is appropriate to emphasize the importance of this research and the novelties in this paragraph briefly. Due to the lack of sufficient academic literature in this area, the main purpose of this paper is to add value to the literature regarding sustainability leading to the efficient use of natural resources. The novel model proposed in this paper calculates the electricity usage of a typical bank branch. Additionally, one can calculate the Scope 2 carbon footprint of a typical bank by using this data. Hence, the focus of this study is to estimate the electricity consumption of a bank. In order to control and mitigate electricity consumption, one must have in-depth knowledge about electricity consuming equipment. Once the consumption figures are known about these elements, the priorities for lowering the total consumption can easily be determined. Thus, by using the proposed model, the breakdown of electricity consumption figures can easily be monitored for energy management.

Banks have electricity consumption values reflected in sustainability reports. However, mostly, these figures are based on the billing information instead of the actual consumption figures in kWh (Yurtsever and Firat 2019). In addition, the breakdown of the individual equipment consuming electricity is not known, and thus, it will not be clear where the mitigations will be conducted in energy management. Since there is no such calculation procedure, a simple methodology has been developed for the banks to calculate their electricity consumption and also determine the priorities they have to give for lowering their total consumption. The research questions of this study are stated as below:

•The main research question is stated based upon the purpose of this study that "Can the electricity consumption of the banks be estimated using a model?" In other words, "Is it possible to develop an original model for this purpose?"

•The second question is, "Is it still possible to calculate the base electricity consumption even though there is little data and information about the bank?" If the number of employees, branches, and ATMs are known only, can the base electricity consumption, except

heating and cooling consumptions, be estimated for a bank?

•The third question is "When we have knowledge on the breakdown of the electricity consumption sources of the bank branches, will it be more convenient to monitor and audit their energy management?"

•The last question is "Which sources such as lighting, computers etc. are important and the most contributor in the sense of electricity consumption amount?"

Banking sector and electricity consumption in Turkey

The measurement of carbon emissions in the service sector has become a crucial and complicated task. Although carbon emission calculations have become popular, there has been a considerable gap in the literature for the service sector, especially the banking sector. Electricity consumption by the banks constitutes a major percentage of the GHG emissions and thus deserves a much closer look. This is true in almost all countries.

It is important to understand the situation of the banks in Turkey. There are no regional and local banks in Turkey. All are national banks and have a sizeable number of branches distributed all over the country. A list of the top six banks by size of assets according to the report of the Banks Association of Turkey by June 2018 is given in Table 1 (The Banks Association of Turkey 2018a). The numbers of branches and employees for these banks are also shown in this table. All these banks have a minimum of 800 branches and at least 14,000 employees.

According to the Banks Association of Turkey, there were 47 banks in Turkey with a total of 10,505 branches and 193,343 employees as of September 2018 (The Banks Association of Turkey 2018b). Of the ten major banks in Turkey, seven of them publish their annual sustainability reports on the scope basis and have them available on their web sites. However, one of the banks reported the general directorate building alone. Thus, it was not taken into consideration. From this point on, five major banks will be investigated.

When the sustainability reports of the Turkish banks are examined, it is found that all banks report their total annual electricity consumption. The summary of which bank reports cover what type of buildings in terms of GHG emissions, amount of GHG emissions, and electricity consumption in 2017 and 2018 can be seen in Table 2 (Ziraat Bank 2019) (Yapı Kredi Bank 2019) (Garanti Bank 2019) (Akbank 2019) (Halkbank 2019). The data presented in Table 2 demonstrate some significant reduction in electricity consumption in each bank. This improvement, published by the major banks in their annual sustainability reports, signifies the importance of GHG emission calculations. In the light of the identified electricity consumption figures, the sources of the problems were better addressed, and the necessary steps have been taken. It is evident that such GHG emissions and control applications performed better in the initial years due to the wider opportunities for progress. Reductions in yearly electricity consumption are based on the major potential for the savings and the quality of the reports getting more efficient every year.

It should be mentioned here that none of the sustainability reports provides an accurate country-specific carbon emission multiplier. In a recent study, the carbon emission per kWh of the energy consumed is calculated approximately 0.6 kg of CO_2-e/kWh, including transmission and distribution losses for Turkey (Yurtsever 2019). Utilizing this factor for preliminary evaluations demonstrates that a significant portion of the GHG emissions from the banks is due to the annual electricity consumption (Table 3). Close inspection of Table 3 shows no agreement between all the five banks which essentially do the same type of work, and also, one of the banks which did not report Scope 3 emissions must have an error in reporting the total GHG emissions. It should also be assumed that if the banks have used a smaller multiplier for the kg of carbon equivalent emission values for kWh consumed, then their GHG emissions should also go up.

Also shown in Table 3 is the number of equivalent households that the banks' electricity consumption represents for the years in question. According to the Turkish Statistical Institute (TSI), the amount of electricity produced in Turkey is around 297,000 GWh, and households have a share of 21.8% of net electricity consumption for the year 2017 (TUIK 2018a). There are around 23 million households by the year 2018, according to the TSI (TUIK 2018b). Thus, the average annual electricity consumption is approximately 2,000 kWh per household. Using this figure, we can find the number of households consuming similar electricity.

A comparison of electricity consumption figures for the years 2017 and 2018 can be seen in Table 4. It should be noted that all the major banks report approximately a 10% decrease in annual electricity consumption.

Table 1 Top six banks according to total assets in Turkey, September 2018

	Name of the bank	Ownership	Total assets (million TL)	Number of branches	Number of employees
1	Türkiye Cumhuriyeti Ziraat Bankası A.Ş.	Public	551,994	1,830	24,559
2	Türkiye İş Bankası A.Ş.	Private	444,334	1,357	24,570
3	Türkiye Garanti Bankası A.Ş.	Private	410,777	936	18,338
4	Akbank T.A.Ş.	Private	392,457	780	13,367
5	Yapı ve Kredi Bankası A.Ş.	Private	390,170	867	18,088
6	Türkiye Halk Bankası A.Ş.	Public	387,323	987	21,530

All of the sustainability reports are evaluated in detail. In the 2018 report of Ziraat Bank, instead of providing the actual energy consumption figures, the electricity consumption values were calculated from the electricity costs. On the other hand, the electricity consumption values for 2017 were the actual consumption figures. From 2017 to 2018, a 13% decline in the electricity figures appears to be a considerable achievement. Nonetheless, it is not mentioned in detail. Because of the inconsistencies mentioned above, especially for Ziraat Bank, the validity of the 2018 figures is questionable.

According to the 2018 report of TUIK, Turkey's GHG emissions for 2016 amount to 496.1 Mt CO_2e (TUIK 2018). Thus, the banking sector will have a share of approximately 1.5% of the GHG emissions of Turkey. Similarly, according to the Turkish Electricity Transmission Corporation (TEİAS), the amount of electricity produced in Turkey by the end of 2017 is over 297,000 GWh (297,277,500,000 kWh) (TEIAS 2017a, 2017b). Thus, the banking sector will have a share of approximately 0.39% of the electricity consumption of Turkey. Although electricity consumption may seem small as three thousandths, it should be noted that this is important when considering the households. On the other hand, emissions accounted for 1.5%. Therefore, the carbon footprints of banks are significant.

In this study, an estimation and calculation model of the electricity usage for the banking sector is developed originally and then applied by using real-world data. As a result of the literature and applied studies, there is no such method found available. In this manner, this developed equational model is likely to be considered as the first and unique method in this area. Thus, in this study, the proposed model calculates the electricity usage of a typical bank branch. By using these data, the Scope 2 carbon footprint of a typical bank can be calculated. Thus, the electricity consumption of a bank branch is the focus of this study.

Table 2 Amount of GHG emissions and electricity consumption of the five leading Turkish banks

Name of the bank	Year	Electricity consumption (kWh)	Amount of GHG emissions (tons CO_2-e)				All the buildings including branches	Administrative buildings excluding branches
			Scope 1	Scope 2	Scope 3	Total		
Ziraat Bank	2017	105,899,015	33,429	54,234	*N/A*	**87,663**	x	
	2018	92,460,676	29,015	46,842	*N/A*	**75,857**	x	
Garanti Bank	2017	114,479,000	11,835	58,628	2,494	**72,957**	x	
	2018	107,182,000	12,933	61,260	3,111	**77,304**	x	
Halk Bank	2017	68,608,534	14,919	30,912	34,069	**79,900**	x	
	2018	64,959,337	13,971	30,169	29,445	**73,585**	x	
Akbank	2017	78,840,278	7,515	36,115	3,753	**47,383**	x	
	2018	70,240,556	6,970	33,153	*N/A*	**40,123**	x	
Yapı Kredi Bank	2017	109,459,722	15,975	54,183	15,520	**85,678**		x
	2018	93,377,778	14,665	46,218	13,666	**74,549**		x

Table 3 Percentage of bank GHG emissions stemming from annual electricity consumption for the five leading Turkish banks

Name of the bank	2018 electricity consumption (kWh)	Total GHG emissions from electricity consumption (approx.) (tons CO_2-e)	Total GHG emissions (reported) (tons CO_2-e)	% total GHG emissions from annual electricity consumption (%)	Number of equivalent households consuming the same amount of electricity
Ziraat Bank*	92,460,676	55,476	75,857	73	46,230
Garanti Bank	107,182,000	64,309	77,304	83	53,591
Halk Bank	64,959,337	38,976	73,585	53	32,480
Akbank*	70,240,556	42,144	40,123	105	35,120
Yapı Kredi Bank**	93,377,778	56,027	74,549	75	46,689
Total of five banks	**428,220,347**	**256,932**	**341,418**	**75**	**214,110**

**Scope 3 is not reported*

***Emissions from general directorate and other service buildings excluding branches*

Methodology

As a result of the literature review, in order to calculate the carbon footprint of a corporation, it is important to know its energy usage and personnel travel data (World Business Council for Sustainable Development,, and World Resources Institute 2001). For the banking sector, total energy consuming components can be summarized as the electronic infrastructure including computers, printers, and information screens, lighting, security cameras, advertisements, and company logos, climate control of the premises, and many other electrical devices together with the fuel consumption for heating and number of personnel (Yurtsever and Firat 2019). For example, the climate zones in a country play an important role in energy usage and the distribution of energy consumption throughout the year. A base month in electricity consumption in which there is no heating and cooling, or the values are negligible, is defined in this study and called "nominal bank electricity consumption." The components of the nominal bank electricity consumption are given in Table 5, and the details are given from section *Electrical and electronic equipment used by bank employees* to *Extra electricity consumption when bank branch occupies the whole building*. It should be emphasized that the nominal bank electricity consumption does not include electric

Table 4 Comparison of electricity consumption of the top five banks

Name of the bank	2018		2017		Change in electricity consumption (%)
	Number of branches	Electricity consumption (kWh)	Number of branches	Electricity consumption (kWh)	
Ziraat Bank	1,830	92,460,676	1,823	105,899,015	−13
Garanti Bank	936	107,182,000	948	114,479,000	−6
Halk Bank	987	64,959,337	963	68,608,534	−5
Akbank	780	70,240,556	801	78,840,278	−11
Yapı Kredi Bank	867	93,377,778	866	109,459,722	−15

heating, air conditioning, or ventilation. However, all the sustainability reports do include electricity consumed for these processes. For this reason, the Results and discussion section include these consumptions. The data on these consumptions were collected from various bank branches and suppliers.

In domestic and international banks, the annual total electricity consumption was presented in their sustainability reports. Previous studies demonstrated that the breakdown of the consumption provides better insight identifying the source of the problem and more suitable for comparison in future works (Yurtsever 2019). In order to examine the distribution of electricity consumption, observations and surveys were carried out in banks, and it was concluded that the energy consumption items in Table 5 are indeed to be the basic components.

It is important to mention that the information used through sections *Electrical and electronic equipment used by bank employees* to *Extra electricity consumption when bank branch occupies the whole building* is collected from the face-to-face interviews with technical personnel, managers, employees, and self-observations as a framework of research methodology for this study. In addition, it is assumed that in a typical month, there are 22 working days and 8 weekends, which are non-working days. Thus, the equations derived by the authors in this research are based upon the collected data and information from the exploratory data analysis (EDA) combining with the main opinions extracted from the mentioned research methodologies above.

Table 5 Components of the nominal bank electricity consumption of a typical bank

Electrical and electronic equipment used by bank employees	Per employee
Electricity consumption required lighting	Per area
Electricity consumption by ATMs	Per number of ATMs
Electricity consumption for advertisement/logos	Per lighted 15 m^2 of advertisement pane
Electricity consumption by the network system	Per employee
Other electricity consumption	-
Extra electricity consumption for a standalone building used as a bank branch if the whole building is used by the bank only	-

Electrical and electronic equipment used by bank employees

The electrical and electronic equipment used by bank employees in a typical branch includes desktop, laptop, printer, passbook printer, money counting machine, and company desk telephone. In light of the interviews and self-observations, it is accepted that each bank employee is given one PC (desktop or laptop). Additionally, one printer, one money counting machine, and one passbook printer are allotted for every four employees of the branch.

According to a study conducted in 2014 (Desroches et al. 2014), the average on-power and standby power of desktop and laptop computers are 50 W and 1.6 W, respectively. Similarly, the average power information for printers, money counting machines, and passbook printers is obtained from various manufacturers (MoneyCounting, n.d.) (Epson, n.d.) (HP, n.d.).

The monthly electricity consumption of the printer, money counting machine, and passbook printer per employee is calculated. The calculation is based on the assumption that a computer is in power mode for 10 h and in standby mode for 14 h on a typical working day. Additionally, computers are in standby mode for 24 h a day on weekends, which are considered as non-working days. In a typical branch, the printer is used for an average of ½ h per day, the passbook printer runs an average of ½ working hours per day, and the money counting machine is used for an average of 1 h per day. The remaining hours on working days and the weekends, all of them remain on standby. Thus, the monthly electricity consumption of the electrical and electronic equipment and infrastructure used by the bank employees is calculated as 18 kWh/month per employee.

Electricity consumption required for lighting

In a bank branch, the average illumination for normal working conditions is taken as 250 lux (Erkin 2012). In order to maintain 250 lux illumination, the power densities of fluorescent, incandescent, and halogen lamps are 4.17 W/m^2, 16.67 W/m^2, and 12.5 W/m^2, respectively (Rapid Tables, n.d.).

Electricity consumption required for lighting can be grouped under indoor lighting and security lighting headings. It is assumed that the floor where the customer is usually found, the ground floor ($\frac{A}{n}$), is illuminated by

fluorescent lamps for 9 h where the branch area is indicated as A (m^2) and the number of floors is indicated by n. Then, the electricity consumption for the ground floor is given by Equation 1. Even though the approximate operating hours for a typical branch is 8 h, 9 h of illumination is taken into consideration since the employees continue to work during lunch break or after the bank closes:

$$\frac{\frac{A}{n} \times 9\ \mathrm{h} \times 22\ \mathrm{d} \times 4.17 \frac{\mathrm{W}}{\mathrm{m}^2}}{1000} = 0.826 \times \frac{\mathrm{A}}{\mathrm{n}} \quad {}^{\mathrm{kWh}}/_{\mathrm{month}} \tag{1}$$

In addition, if the branch is not a single floor ($n \neq 1$), partial (about 25%) lighting is applied on the other floors. The calculation of the electricity consumption of the partial lighting is calculated using Equation 2:

$$\left(\frac{\left(A - \frac{A}{n} \right) \times 9\ \mathrm{h} \times 22\ \mathrm{d} \times 4.17 \frac{\mathrm{W}}{\mathrm{m}^2}}{1000} \right) \times 0.25$$

$$= 0.207 \times \left(A - \frac{A}{n} \right) \quad {}^{\mathrm{kWh}}/_{\mathrm{month}} \tag{2}$$

In the light of the observations, in Turkey, approximately 25 m^2 of a branch is illuminated with halogen type lamps for 24 h. Thus, the average monthly consumption of indoor security lighting is calculated as 225 kWh/month.

Therefore, using the above-mentioned information and Equations 1 and 2, the electricity consumption required for indoor lighting is calculated as in Equation 3:

$$\left[0.826 \times \frac{A}{n} \right] + \left[0.207 \times \left(A - \frac{\mathrm{A}}{n} \right) \right] + 225 \quad {}^{\mathrm{kWh}}/_{\mathrm{month}} \tag{3}$$

Electricity consumption by ATMs

According to the information through an interview with the NCR Company, a large ATM supplier, the average on-power mode of a typical ATM is 672 W, whereas standby power is 240 W. It has been learned from the interviews with NCR company and various bank employees that an ATM is actively running for an average of 6 h and is in standby mode for an average of 18 h. In addition, every ATM has security lighting at night. It is assumed that approximately 1 m^2 of each ATM is illuminated with a halogen lamp for 12 h. The ATM's considered here are the ones reachable from outside the branch and illuminated by a halogen lamp. Thus, in this equation, the power density of a halogen lamp, which is 12.5 W/m^2, is used. The monthly electricity consumption of a single ATM is calculated as 254.5 kWh/month.

Electricity consumption for advertising/lighting

The electricity consumption of the illuminated bank logo used for advertising purposes on the branch building has also been calculated. It was reported that 15 m^2 lighted sign (LED) consumes 3,285 kWh energy annually when it is on for 10 h a day (LightWorld 2014). It is observed that the signs are utilized 14 h a day in winter months and 10 h in summer months, thus, annually, on average, 12 hours a day. From this perspective, the monthly electricity consumption of 1 m^2 LED sign is calculated as 21.9 ${}^{\mathrm{kWh}}/_{m^2-\mathrm{month}}$.

Assuming there is a 14-m-long and 0.5-m-wide sign on a facade, the total area for the sign is 7 m^2. Thus, the monthly electricity consumption is 153.3 kWh/month for the 7 m^2 sign. By using this information, the monthly electricity consumption of the LED sign per meter is calculated as ${}^{11\ \mathrm{kWh}}/_{\mathrm{meter-month}}$.

Accordingly, one should know the length of the lighted sign (LLS) to calculate the electricity consumption for advertising. If this information is not available, then the total area (m^2) of the branch (A), the number of floors (n), and the number of facades where the sign will be placed (n_f) should be known. The annual electricity consumption of advertising lighted sign (EALS) is given in Equation 4. It should be noted that the investigated banks for the study construct their logo in 50 cm width. If other width sizes are used, then a correction will be needed by using the width of the lighted sign (WLS), which is also shown in Equation 4. Otherwise, WLS can be taken as 50 cm:

$$\mathrm{EALS} = \begin{cases} 11 \times \frac{\mathrm{WLS\ (m)}}{0.5\ \mathrm{m}} \times \ \mathrm{LLS}, & \text{if LLS (m) is known} \\ \sqrt{\frac{\mathrm{A}}{\mathrm{n}}} \times \frac{\mathrm{WLS\ (m)}}{0.5\ \mathrm{m}} \times \mathrm{n_f} \times 11, & \text{if LLS (m) is not known} \end{cases} \tag{4}$$

Electricity consumption of the network system

As Internet usage increases, the importance of infrastructure and data increases. Thus, the network system

and the infrastructure, which include devices like WAN/LAN routers, switches, servers, and firewalls, have significant electricity consumption. Power information has been obtained from supplier companies for those devices. In addition, as a result of the interview conducted with the technical personnel of the network and security equipment supplier of the banks, it was learned that the network hardware infrastructure is dependent on the branch size and therefore proportional to the number of employees. Considering the foregoing, the monthly electricity consumption of the network system (ENS) according to the number of employees is given in Table 6.

Other electricity consumptions

There are other sources of electricity consumption such as queue machines and info displays, security cameras and alarm systems, water dispensers, refrigerators or similar kitchen appliances, and lighting of WCs. In a typical branch, the sum of the electricity consumption of those is calculated as 267.6 kWh/month, for which the details are given below.

Queue machines and info displays If a 50-inch LED TV operates continuously 4 h a day and every day of the year; the annual electricity consumption is 60 kWh/year (Enerji Atlası 2016). According to this information, if the info displays in the banks are on 24 h a day (30 days), the annual electricity consumption is 360 kWh/year. Based on the interviews and personal visits to branches, it was seen that there were 4 screens in a branch approximately. Hence, the monthly electricity consumption of the info displays and queue machines for a typical branch is calculated as 120 kWh/month.

Security cameras and alarm system An interview was held with the technical supervisor of the banks' network and security equipment supplier. The technically responsible person stated that the average power of a typical camera was 5 watts for day and night use, and the camera recording box has an average of 8.3 W. In addition, an average of 10 security cameras is used in a typical branch. By using the above-mentioned information, the monthly electricity consumption of 10 security cameras is calculated as 36 kwh/month. In addition, the monthly electricity consumption of the recording box is calculated as 6.0 kWh/month. Accordingly, for security cameras and recording box, the monthly electricity consumption is found as 42 kWh/month.

Table 6 Monthly electricity consumption of the network system (ENS)

Number of employees	ENS (kWh/month)
1–11	1,000
12–18	1,500
19–28	2,000
29 and over	3,000

Water dispenser A typical water dispenser consumes 3.5 kWh in 24 h (1 day) (Uğur Soğutma, n.d.). Assuming there is one water dispenser in a branch, the water dispenser has a consumption of 77 kWh/month in 22 working days.

Refrigerator or similar durable kitchen appliances If a refrigerator has a power of 30 watts (Enerji Bes, n.d.), then it consumes 0.72 kWh of electricity per 24 hours. Thus, a typical refrigerator consumption is approximately 22 kWh/month.

The lighting of WCs The average number of bank employees is 18 in Turkey. Assuming that the total number of toilets in a bank is around 4 m^2 and that one staff uses the WC for 15 min a day on average, the lighting of the toilet is in use for about $15 \times 18 = 270$ min, which is 4.5 h a day. If a 4 m^2 area of the toilet is enlightened with an incandescent bulb, the monthly electricity consumption of the toilet is calculated as 6.60 kWh/month.

Extra electricity consumption when bank branch occupies the whole building

If the whole building is used by the bank, which means that a bank operates in the whole building, then extra electricity consumption for the branch will occur. The building can have a boiler room and elevator or escalator inside.

The power of the booster pumps and other electrical appliances in the boiler room is determined as approximately 3 kW by interviewing the mechanical engineering department. The average monthly electricity consumption per boiler room can be calculated as 198 kWh/month if the boiler room operates approximately 3 h a day and 22 days in a month.

It is assumed that the elevator works no more than 4 h a day. The power of one elevator motor is approximately 10 kW (Mitsubishi Electric, n.d.). In this case, the monthly electricity consumption for a single elevator can be calculated as 880 kWh/month.

To sum up, all the information given through sections *Electrical and electronic equipment used by bank employees* to *Extra electricity consumption when bank branch occupies the whole building*, the equation for calculating the nominal electricity consumption (ELC_b) of a typical branch is derived as in Equation 5. The constant 225 is taken from Equation 3, and the other constant, 267.6, is taken from section *Other electricity consumptions*. It should be noted for the equation given in Equation 5, and the assumptions were used, as shown in Table 7.

The Equations 1–4 are combined together with the information mentioned in sections *Electrical and electronic equipment used by bank employees* through *Extra electricity consumption when bank branch occupies the whole building* and simplified in order to find out Equation 5, which gives the annual nominal electricity consumption of a branch:

$$ELC_b = \left[0.826 \times \frac{A}{n}\right] + \left[0.207 \times \left(A - \frac{A}{n}\right)\right] + 225 + (18 \times NOE) + (254.5 \times N_{ATM}) + EALS + 267.6 + ENS + (198 \times NOBR) + (880 \times NOL) \quad (5)$$

where:

ELC_b is the annual nominal electrical consumption of a branch $\left(\frac{\text{kWh}}{\text{month}}\right)$.

A is the area of the branch (m^2).

n is the number of floors of the branch.

NOE is the number of employees.

N_{ATM} is the number of ATMs inside or attached to the branch.

EALS is the annual electricity consumption for advertising lighted sign (kWh) :

$$EALS = \begin{cases} 11 \times \frac{WLS\ (m)}{0.5\ m} \times LLS, & \text{if LLS (m) is known} \\ \sqrt{\frac{A}{n}} \times \frac{WLS\ (m)}{0.5\ m} \times n_f \times 11, & \text{if LLS (m) is not known} \end{cases}$$

where:

LLS is the length of the lighted sign.

Table 7 Assumptions of the model

Name	On power (hour/day)	Standby power (hour day)
PC	10 h/working day	14 h/working day
		24 h/weekend
Money counting machine	1 h/working day	23 h/working day
		24 h/weekend
Passbook printer	½ h/working day	23.5 h/working day
		24 h/weekend
Printer	½ h/working day	23.5 h/working day
		24 h/weekend
ATM	6 h/day	18 h/day
Info displays	24 h a day	-
Boiler room	3 h a day Not operational in weekends	-
Elevator	4 h a day Not operational in weekends	-
Others		
One PC		Per one employee
One printer, one money counting machine, and one passbook printer		Per every four employees of the branch
Lighting		9 h for ground floor
		About 25% lighting on the other floors
		With fluorescent lamps
Security lighting		25 m^2 for 24 h
		With halogen type lamps
ATM Lighting		1 m^2 of ATM for 12 h
		With a halogen lamp
Lighted bank logo		Utilized 14 h a day in winter months
		10 h in the summer months
		On average, for a year 12 h a day
Info displays per branch		4 screens
Number of security cameras		An average of 10
Number of water dispenser		1
Number of refrigerators		1
Area of WCs		Around 4 m^2
Usage of WC		Is 4.5 h a day for a typical branch
Lighting of WC		With the incandescent

WLS is the width of the lighted sign.

n_f is the number of facades where the sign is placed

ENS is the monthly electricity consumption of network system : $\left(\frac{\text{kWh}}{\text{month}}\right)$

$$\text{ENS} = \begin{cases} 1,000, & 1 \le \text{NOE} \le 11 \\ 1,500, & 12 \le \text{NOE} \le 18 \\ 2,000, & 19 \le \text{NOE} \le 28 \\ 3,000, & \text{NOE} \ge 29 \end{cases}$$

where:

NOBR is the number of boiler room.

NOL is the number of lifts (elevators).

A bank does not just consist of branches. In addition to the branches, there are also buildings such as the general directorate, regional headquarters, and other administrative buildings, and the employees working in these buildings constitute a significant portion of the bank. In order to include these buildings, the methodology assumes a new variable, the number of equivalent branches (NEB), for the banks. It is common practice not to give the distribution of the employees of international banks to the branches and general directorates. However, this distribution must be known to calculate the number of equivalent branches. Table 8 shows the number of employees and the percentages of the employees in branches and the general directorate for each of the five banks considered in this study. It is interesting to note that the public banks have less percentage of the employees working under the general directorate. In the same table, the figures of the employee per branch (NOE_B) are taken into consideration to calculate the number of equivalent branches, as shown in Equation 6. The number of employees per branch is interchangeable; thus, it is a suitable parameter to calculate NEB, which is an integer number:

$$\text{NEB} = \frac{\text{NOE}_{general\ directorate}}{\text{NOE}_\text{B}} \tag{6}$$

where:

$\text{NOE}_{\text{general directorate}}$ is number of employees of the general directorate.

NOE_B is the number of employees per branch.

Naturally, the bank electricity parameters for the equivalent branches will differ from the normal branches. The list of the parameters used for bank branches and equivalent branches are shown in Table 9.

As discussed above, sustainability reports include all types of electricity consumption, including heating, cooling, outside ATMs, and administrative buildings. The total annual electricity consumption (TEC_b) of a typical bank branch can be calculated by using Equation 7a and 7b. Equation 7a is the branches that do not use electricity for heating purposes, whereas Equation 7b is for the branches which use electricity for heating purposes:

$$TEC_b = \text{Branch Base Electricity Consumption} + \text{Equivalent Branch Electricity Consumption} + \text{Electricity Consumption of Outside ATMS} + \text{Electricity Consumption from Cooling} + \tag{7a}$$

$$TEC_b = \text{Branch Base Electricity Consumption} + \text{Equivalent Branch Electricity Consumption} + \text{Electricity Consumption of Outside ATMS} + \text{Electricity Consumption from Cooling} + \text{Electricity Consumption from Heating} \tag{7b}$$

For ease of calculation, bank heating and cooling are divided among branches and equivalent branches. The electricity consumption for the heating purposes of a typical bank branch is calculated from Bank G's sample data. Accordingly, there are 31 bank branches in zone 1, which use electricity for heating purposes. The average value of HDD for these branch locations is 750, and the electricity consumption per HDD is calculated from the data as 12 kWh/HDD. Thus, the annual electricity consumption for the heating purposes of a typical bank branch is 9,000 kWh/year. Similarly, by employing CDD values, the annual electricity consumption for the cooling purposes of a typical bank branch is found to be 9,350 kWh/year in Turkey (Yurtsever 2019). It should be noted that this consumption figure also includes natural infiltration which is embedded in the total

Table 8 Distribution of bank employees among general directorate building and branches of the five largest Turkish banks

Name of the bank	Ownership	Percentage of employees in general directorate building	$NOE_{general\ directorate}$	Number of employees in the branches	Number of branches	NOE_B	NEB	Total number of branches (including NEBs)
Ziraat Bank	Public	0.21	5,157	19,402	1,778	11	469	2,299
Garanti Bank	Private	0.31*	5,685	12,653	930	14	406	1,342
Akbank	Private	0.34	4,545	8,822	782	11	413	1,193
Yapı Kredi Bank	Private	0.31*	5,607	12,481	867	14	401	1,268
Halk Bank	Public	0.18	3,875	17,655	987	18	215	1,202

Not given in the report, thus the average of the private banks is taken

heat transfer coefficient of the branch building. Thus, electricity consumptions from heating and cooling operations of branches and equivalent branches are demonstrated as in Equations 8 and 9, respectively. In these equations, P_{BH} and P_{BC} represent the percentage of bank branches heated or cooled by electrical energy, respectively. In addition, NEB is the number of equivalent branches, and NOB is the number of branches:

$$\textit{Annual Electricity Consumption for Heating and Cooling Operations of the Branches}: (\mathrm{NOB} \times P_{BH} \times 9000) + (\mathrm{NOB} \times P_{BC} \times 9350) \tag{8}$$

$$\textit{Annual Electricity Consumption for Cooling Operations of the Equivalent Branches}: (\mathrm{NEB} \times 0.8 \times 9350) \tag{9}$$

It should be noted that for the equivalent branches, it is assumed that none of them is using electricity for heating purposes. Additionally, as calculated from various banks' available data, the total area of the administrative buildings divided by the total area of the branches for any particular bank is 0.8. This value is added as a multiplier to Equation 9. Substituting Equations 5, 6, 8, and 9, and using the parameters given in Table 9, Equations 7a and 7b can be written as Equation 10 for the total annual electricity consumption of a bank:

$$\begin{aligned} TEC = \Big(NOB \times \Big[\Big(7.43 \times \frac{A}{n}\Big) + (2.48 \times \mathrm{A}) + (216 \times NOE_B) + (3,054 \times N_{ATM}) + \\ (12 \times EALS) + (12 \times ENS) + (9,000 \times P_{BH}) + (9,350 \times P_{BC}) + (10,560 \times P_{BL}) \\ + (2,376 \times P_{BB}) + 5,911.2\ ]) + (6,108 \times N_{OATM}) + (12 \times EALS \times \mathrm{NOAB}) \\ + \Big(NEB \times \Big[\Big(5.94 \times \frac{A}{n}\Big) + (1.99 \times \mathrm{A}) + (216 \times NOE_B) + (12 \times ENS) + 26,327\Big]\Big) \end{aligned} \tag{10}$$

Table 9 List of parameters for the normal branches and equivalent branches

Parameters	Normal branches	Equivalent branches
Electrical and electronic equipment Used by bank employees	Same, section Electrical and electronic equipment used by bank employees	
Electricity consumption required for lighting	Section Electricity consumption required for lighting	Multiply the figure found in section Electricity consumption required for lighting by 0.8
Electricity consumption by ATMs (by the branch)	Section Electricity consumption by ATMs	Calculate the number of outside ATMs (off the branches) and after calculating the electricity of those ATMs, double it.
Electricity consumption for advertising/lighting	Section Electricity consumption for advertising/lighting	Multiply section Electricity consumption for advertising/lighting by not NEB but NOAB Where: Number of administrative buildings, NOAB = NEB/20 The number of facades where the sign will be placed, n_f is 4
Electricity consumption of the network system	Same, section Electricity consumption of the network system	
Other electricity consumptions	Same, section Other electricity consumptions	
Extra electricity consumption when bank occupies whole building	Section Extra electricity consumption when bank branch occupies the whole building Percent of the branches owned by the bank	Section Extra electricity consumption when bank branch occupies the whole building All NEB has one lift and one boiler room.

where:

TEC is the total annual electricity consumption.
NOB is the number of branches.

NEB is the number of equivalent branches.

NOAB is the number of administrative buildings.

NOE_B is the number of employee per branch.

$NOE_{general\ directorate}$ is the number of employees of the general directorate :

$$NEB = \left\lceil \frac{NOE_{general\ directorate}}{NOE_B} \right\rceil$$

$$NOAB = \left\lceil \frac{NEB}{20} \right\rceil$$

where:

A is the area of each branch (m^2).

n is the number of floors of each branch.

N_{ATM} is the number of ATMs inside or detached to the branch.

N_{OATM} is the number of ATMs outside or off the branch.

P_{BH} is the percentage of branches which uses electricity for heating.

P_{BC} is the percentage of branches which uses electricity for cooling.

P_{BB} is the percentage of branches with boiler room.

P_{BL} is the percentage of branches with lifts/escalators.

EALS is the annual electricity consumption for advertising lighted sign (kWh) :

$$EALS = \begin{cases} 11 \times \frac{WLS\ (m)}{0.5\ m} \times \quad LLS, & \text{if LLS (m) is known} \\ \sqrt{\frac{A}{n}} \times \frac{WLS\ (m)}{0.5\ m} \quad \times n_f \times 11, & \text{if LLS (m) is not known} \end{cases}$$

where:

LLS is the length of the lighted sign.

WLS is the width of the lighted sign.

n_f is the number of facades where the sign is placed

ENS is the monthly electricity consumption of network system $\left(\frac{kWh}{month}\right)$

$$ENS = \begin{cases} 1,000, & 1 \le NOE \le 11 \\ 1,500, & 12 \le NOE \le 18 \\ 2,000, & 19 \le NOE \le 28 \\ 3,000, & NOE \ge 29 \end{cases}$$

Application of the proposed method

One of the leading banks in terms of number and distribution of branches over the country was chosen to test the electricity consumption model developed above, and for the ease of identification, the bank is identified as Bank G to keep its name anonymous.

Bank G has provided monthly electricity and fuel consumption data for 134 branches among different climate zones. Additionally, for those branches, they have given additional information on total branch area, number of floors, number of employees, solid waste data, and annual cargo and mail load. Besides the branches, similar information has also been provided for other buildings, including the general directorate building and other multi-story buildings owned and operated by Bank G. The distribution of the branch numbers for Bank G is given in Table 10.

Heating zones are taken from the Turkish State Meteorological Service (TSE, 2013). Heating zone 1 represents part of the Aegean and Mediterranean Region, the warmest region in Turkey, and heating zone 4, on the other hand, represents the coldest region of the country, which corresponds to East and North-East Anatolia. As it is seen from Table 10, the data provided by Bank G covers all the heating zones and regions of the country. A base month electricity consumption in which there is no heating and cooling related consumption is taken into consideration in this study.

Sample branch calculation

A branch was chosen from heating zone 1 to calculate the ELC_b, monthly nominal electrical consumption of a branch. The branch parameters are given in Table 11. The result is given in the last row, which is 3,099 kWh/month.

By using Equation 8 and the calculated annual ELC_b, the total electricity of the sample branch and comparison with the actual value are given in Table 12. This branch uses electricity for heating purposes. Instead of average values for heating or cooling, actual calculated values are used and shown in Table 12.

In Table 13, the difference between the actual and the calculated monthly bank electricity consumption of a branch in different zones for Bank G can be seen. The bank branches chosen were representative of their zones with a varying number of employees and areas.

A concept called "base month" is needed to form the basis of the study and model the electricity consumption characteristic accurately. In a base month, electricity consumption on heating and/or cooling is zero or negligible. Thus, it provides the basic electricity consumption figure for a typical month, independent of heating and cooling activities. In this study, the base month electricity consumption is taken into consideration to find out the average actual electricity consumption. Thus, the calculated nominal electricity consumption and average actual electricity consumption can be compared. Table 13 shows that among the chosen sample branches, the maximum error is around 2.8%.

Results and discussion

The results and discussions are given based upon categorization of the findings as follows: (i) Bank G, (ii) top five Turkish banks, and (iii) Bank Santander (international bank).

Bank G results and discussions

In order to apply the proposed model, a Turkish Bank, called Bank G, which is one of the leading banks in terms of the number and distribution of branches all over the country, was contacted. They have provided monthly electricity and fuel consumption data, among others, for 134 branches for different heating zones.

Information on the heating zone, number of employees, total branch area, number of floors, and number of ATMs are primary variables. Additionally, whether the building is a single-tenant or a multi-tenant building is important to determine who operates the boiler room. In Turkey, if a building is single-tenant, then the responsibility of operating the boiler room and the elevator lies with the tenant. The elevator within the branch is always operated by the bank.

As shown in the Application section, there are a total of 12 parameters needed for testing the model. Of these 12 parameters, 4 were given by Bank G. For the other 8 parameters, default values were employed. Table 14 gives the data needed and those that were provided by Bank G and calculated or assumed by the model.

Where needed, the street view function of Google Maps is used to determine whether the whole building is used by the bank only. If the whole building is occupied by Bank G only, then it is assumed that there is a bank-

Table 10 Distribution of the branch numbers for Bank G

	1st heating zone	2nd heating zone	3rd heating zone	4th heating zone	Total
Total	33	34	34	33	134

operated boiler room, which should be considered in the electricity consumption calculations.

Thus, by using Equation 5, the nominal electricity consumption for each branch of Bank G is calculated. The calculated monthly average nominal electricity consumption of the branches in each zone is given in Table 15.

The result given in Table 15 indicates that regardless of what heating zone the bank branch office is in, the average nominal electricity consumption is 3,397 KWh for heating zones, and the maximum error is less than 3%.

Equation 7a and Equation 7b is examined for the branches of Bank G. It is seen that the electricity consumption of a branch is a function of the number of employees, electronic network system, lighting, advertisement, number of ATMs, electricity for heating, electricity for cooling, lifts, and boiler rooms if any. The number of ATMs within the branch depends on the existence of ATMs nearby the branch; thus, it is not a true branch variable. When the importance of the variables is examined, electronic network system and number of employees have the highest influence on the electricity consumption with a 39.4% and 21.1%, respectively. However, ENS parameter is also employee dependent. But this dependence is expected to diminish as online banking increases. Electricity consumption for heating and cooling is a strong function of HDD and CDD. Remembering the fact that electricity heating is only employed in Region 1 in Turkey, its percentage becomes 3.9% whereas cooling is 8.6 %.

Top five Turkish banks results and discussions

The developed methodology is applied to the five major Turkish Banks. The 2018 figures taken from the sustainability reports to test the results of the methodology developed are shown in Table 16.

For the parameters that could not be found in the sustainability reports, some assumptions had to be made to run the model. The assumptions are based on the information given by Bank G and based on some observations are given in Table 17.

Table 11 Parameters of the sample branch

Zone	1
A: area of the branch (m^2)	393
NOE: number of employees	15
n: number of floors of the branch	2
NOATM: number of ATMs	2
NOBR: number of boiler rooms	0
NOL: number of lifts (elevators)	0
ENS : monthly electricity consumption of network system $\left(\frac{\text{kWh}}{\text{month}}\right)$	1500
n_f: number of facades where the sign will be placed	1
Length of the lighted bank logo and sign	LLS = $\sqrt{\frac{393}{2}}$ m
Width of the lighted bank logo and sign	WLS = 0.5 m
Single or multiple tenants in the building where the branch is located	Multiple

$$\text{ELC}_b = \left[0.826 \times \tfrac{393}{2}\right] + \left[0.207 \times \left(393 - \tfrac{393}{2}\right)\right] + 225 + (18 \times 15) + (254.5 \times 2) + \left(\sqrt{\tfrac{393}{2}} \times \tfrac{0.5}{0.5} \times 1 \times 11\right) + 267.6 + 1500 + (198 \times 0) + (880 \times 0) = \mathbf{3,099\ kWh}$$

Table 12 Sample branch electricity consumption calculation for Bank G

Annual nominal electricity consumption (kWh)	37,188
Annual electricity consumption from heating (kWh)	10,076
Annual electricity consumption from cooling (kWh)	8,184
Calculated annual electricity consumption (kWh)	55,448
Actual annual electricity consumption (kWh)	49,999
Difference (%)	10,9

By utilizing the information given above, and by using Equation 10, the total electricity consumption of each of the five Turkish banks is calculated. The results and comparison with the actual values for these banks are given in Table 18.

Once the parameters given in Table 14 are known for any branch by the bank, monthly and annual electricity consumption can easily be calculated from Equation 10. The total bank electricity consumption can then be derived by calculating it for all the branches and equivalent branches.

However, not all the banks have the relevant information and data on their branches. In addition, in order to estimate the consumption of electricity for foreign banks, it is impossible for the authors to obtain all data needed for the mentioned bank group. Most of the bank groups on an international scale, including the ones in Turkey, only have information on the total number of branches, the total number of employees, and the total number of ATMs in their sustainability report. Table 19 shows the parameters needed to make a reasonable assumption on the total electricity consumption. The bank has to provide three mandatory parameters. The rest of the parameters can be given by the bank, or default values can be used.

Starting from this fact, a simple estimation model has been developed, taking the averages obtained from the five leading Turkish banks that could be applicable to the international banks because they all employ the same or similar electronic infrastructure. In order to overcome these difficulties, a simple estimation, Equation 11, has been developed:

$$\begin{aligned} TEC = \Big(NOB \times \Big[18,440 + (216 \times NOE_B) + (12 \times ENS) + (9,000 \times P_{BH}) + (9,350 \times P_{BC}) \\ + (10,560 \times P_{BL}) + (2,376 \times P_{BB})\ \Big]) + (6,108 \times N_{OATM}) + (2,156 \times \mathrm{NOAB}) \\ + (NEB \times [28,963 + (216 \times NOE_B) + (12 \times ENS)\ ]) \end{aligned} \tag{11}$$

where:

TEC is the total annual electricity consumption.

NOB is the number of branches.

NEB is the number of equivalent branches.

NOAB is the number of administrative buildings.

NOE_B is the number of employee per branch.

$\mathrm{NOE}_{\text{general directorate}}$ is the number of employees of the general directorate :

$$\mathrm{NEB} = \left\lceil \frac{NOE_{general\ directorate}}{NOE_B} \right\rceil$$

$$\mathrm{NOAB} = \left\lceil \frac{NEB}{20} \right\rceil$$

N_{OATM} is the number of ATMs outside or off the branch.

Table 13 Electricity consumption of the sample branches

Heating zone	Average actual electricity consumption (kWh)	Average calculated electricity consumption (kWh)	Difference (%)
Zone 1	3,187	3,099	−2.76
Zone 2	2,431	2,427	−0.15
Zone 3	3,254	3,243	−0.35
Zone 4	6,642	6,829	2.82

Table 14 Data availability for applying the model

Variable or input	Variable used/employed
Number of branch offices	Given
Number of employees working in branch offices	Given
Number of floors (n)	Given
Total floor area (A)	Given
Number of facades where the sign will be placed	Some taken from the Google maps/earth web site. Others, default value = 1 side sign
Length of the lighted bank logo and sign (assumed there is uniformity among all the lighted bank logo and signs of the bank in every branch)	Some taken from the bank web site Others, default value LLS = $\sqrt{\frac{A}{n}}$ used
Width of the lighted bank logo and sign	WLS = 0.5 m
Monthly electricity consumption of the network system (ENS)	Table 6
Number of ATMs of each branch	Most branches: given Few branches: default = 2
Single or multiple tenants in the building where the branch is located	To be given or inputted by the bank
Number of lifts	If the number of floors is 4 or above, there is at least one lift
Existence of the boiler room	If the branch is single-tenant one, then there is one boiler room

P_{BH} is the percentage of branches which uses electricity for heating.

P_{BC} is the percentage of branches which uses electricity for cooling.

P_{BB} is the percentage of branches with boiler room.

P_{BL} is the percentage of branches with lifts/escalators.

ENS is the monthly electricity consumption of network system $\left(\frac{\text{kWh}}{\text{month :}}\right)$

$$\text{ENS} = \begin{cases} 1,000, & 1 \leq \text{NOE} \leq 11 \\ 1,500, & 12 \leq \text{NOE} \leq 18 \\ 2,000, & 19 \leq \text{NOE} \leq 28 \\ 3,000, & \text{NOE} \geq 29 \end{cases}$$

Table 15 The calculated monthly average nominal electricity consumption of the branches for Bank G

Heating zone	Number of branches	Average monthly nominal electricity consumption (kWh/month)
1st heating zone	33	3,308
2nd heating zone	34	3,412
3rd heating zone	34	3,493
4th heating zone	33	3,373
Average		**3,397**

Bank Santander (international bank) results and discussion

In order to figure out if the model applies to the banks other than in Turkey, the report of the Bank Santander is examined. Bank Santander is a Spanish bank with a wide spread of branches that is almost 2 times the total of the branches of the top five Turkish banks. It is a large bank that is spread all over the world and has the electricity figures in its sustainability report. The assumptions in Table 19 are considered to apply the model to Bank Santander. The values taken from the Bank Santander report and the calculated electricity are given in Table 20 (Santander UK Group Holdings 2019).

Bank Santander Group is one of the few bank conglomerates with a total annual electricity consumption figure given in their sustainability reports. By using the proposed model, the annual electricity consumption was estimated within 6.6% certainty. In addition, for the five leading banks in Turkey, as can be seen from Table 18, the model predicts the annual electricity consumption of

Table 16 Variables of the five largest Turkish banks from the sustainability reports, 2018

Name of the bank	Number of branches	Number of employees	Sustainability report electricity consumption (kWh)	Total ATM number	General directorate employee percentage (%)
Ziraat Bank	1,830	24,559	92,460,676	7,311	0.21
Garanti Bank	936	18,338	107,182,000	5,258	0.31*
Akbank	780	13,367	70,240,556	4,900	0.34
Yapı Kredi Bank	867	18,088	93,377,778	4,330	0.31*
Halk Bank	987	21,530	64,959,337	4,023	0.18

**Not given in the report, thus the average of the private banks is taken*

five banks by around 12% error with little available data information. Thus, if one knows the total number of branches, the total number of employees, and the total ATM Number of any bank, without knowing other parameters and with some reasonable assumptions as shown in Table 19, the total electricity of the bank can be easily estimated within an acceptable range.

Conclusion

In this study, a general methodology is proposed to calculate the electricity consumption of a bank with multiple branches based upon main research questions. The nominal bank electricity consumption concept is introduced for bank branches. The method also introduces an equivalent bank branch concept for buildings owned by the bank, such as headquarters, regional quarters, and call centers. Essentially, the work carried out in the other buildings in terms of infrastructure and employee profiles is similar and interchangeable to work carried out in bank branches. Using this new approach, the calculation of the bank's energy consumption is simplified because the buildings in question can be treated as equivalent branches. Thus, this developed model calculates and estimates the total annual electricity consumption of a bank. The validity and accuracy of the model are tested against national and international banks by using their sustainability reports.

It can be seen from Table 18 the proposed model predicts the annual electricity consumption within ± 12% range with minimum information available for the bank or branch. As the available data increases, the error decreases, as can be seen from Table 15. The results obtained seem applicable not only to banks in Turkey but other countries as well. Bank Santander has

Table 17 Estimated parameters for Turkish banks that variable or input values are not given in the sustainability report

Variable or input name	Parameter type	Proposed estimated values	Standard deviation	Confidence interval (%95)
Area of each branch, m^2 (A)	Arithmetic mean	800 m^2 for public banks 600 m^2 for private banks	50 for public banks 40 for private banks	791–809 for public banks 593–607 for private banks
Number of floors of each branch (n)	Mode*	3	-	-
Number of ATMs inside or next to the branches (NOATM)	Mode*	2	-	-
Number of facades where the lighted sign will be placed (n_f)	Mode*	1	-	-
Percentage of branches with lifts/escalators (P_{BL})	Proportion	15%	3.91	%9–%21
Percentage of branches with boiler room (P_{BB})	Proportion	15%	3.91	%9–%21
Percentage of branches which uses electricity for cooling (P_{BC})	Population proportion	100%	-	-
Percentage of branches which uses electricity for heating (P_{BH})	Proportion	20%	4.38	%13.3–%26.7

**Mode is used because there are only limited integer values (1,2,3)*

Table 18 Comparison of the calculated and actual electricity consumptions of the five Turkish banks, 2018

Name of the bank	Actual electricity consumption (from the banks' reports) (kWh)	Calculated electricity (kWh)	Difference (%)
Ziraat Bank	106,668,584*	123,546,088	15.8
Garanti Bank	107,182,000	90,060,979	−16.0
Akbank	70,240,556	74,055,3533	5.4
Yapı Kredi Bank	93,377,778	81,379,988	−12.8
Halk Bank	64,959,337	74,525,907	14.7

**Assumed by using bank's 2017 consumption values and 2018 addition to branches and employees*

a better prediction percentage than Turkish banks. It is believed that one of the reasons for this is the presence of a detailed sustainability report. It should also be remembered that electricity data represents the most reliable heating option among all the fuel types. Electricity cannot be stored like most solid and liquid fuels, and consumption figures and tariffs are always readily available.

Being able to identify the energy consumed for heating and cooling purposes easily results in determining and prioritizing energy savings, which would, in turn, lower greenhouse gas emissions. Especially in new branch openings, energy consumption for cooling purposes can easily be achieved by primary building directions and the availability of natural and man-made shades.

Overall the extracted results from this research can be summarized under the three main categories as below:

- A novel model development: A model that calculates and estimates the total annual electricity consumption of banks is developed for the first time in the literature upon the first research question. Nominal bank electricity consumption concept is introduced for bank branches. The number of equivalent branches (NEB), which represents bank administrative buildings, is introduced.
- Validation: The validity and accuracy of the model are tested against sustainability reports of the national and international banks. By applying the proposed model, the annual electricity consumption was estimated within ± 6.6% interval for Bank Santander Group, which is a Spanish bank with a wide spread

Table 19 Annual electricity consumption estimation variable or input

To be Provided by the bank (mandatory)				
Total number of employees				
Total number of branches				
Total number of ATMs				
Estimation variables or inputs if not provided by the bank				
Variable or input name	**Parameter type**	**Proposed estimated values**	**Standard deviation**	**Confidence interval (%95)**
Percentage of employees in general directorate	Proportion	31%	5.07	%23.2–38.8
Area of each branch, m^2 (A)	Mean	800 m^2	50	791–809
Number of floors of each branch (n)	Mode	3	-	-
Number of ATMs inside or next to the branches (N_{ATM})	Mode	2	-	-
Number of facades where the lighted sign will be placed (n_f)	Mode	1	-	-
Percentage of branches with lifts/escalators (P_{BL})	Proportion	30%	5.02	%22.3–37.7
Percentage of branches with boiler room (P_{BB})	Proportion	30%	5.02	%22.3–37.7
Percentage of branches which uses electricity for cooling (P_{BC})	Population proportion	100%	-	-
Percentage of branches which uses electricity for heating (P_{BH})	Proportion	20%	4.38	%13.3–%26.7

**Mode is used because there are only limited integer values (1, 2, 3)*

Table 20 Parameters of Bank Santander from the sustainability report, 2017

Total number of branches	Total number of employees	Sustainability report electricity consumption (kWh)	Total ATM number	General directorate employee percentage	Total calculated electricity (kWh)	Difference of the electricity (%)
13,217	202,713	1,019,000,000	38,503	0.31*	952,233,526	−6.6

**Not given in the report*

of branches that is almost 2 times the total of the branches of the top five Turkish banks. The model predicts the annual electricity consumption of five leading banks in Turkey by around ± 12% interval with the little available data information.

- Claim of the applicability: Upon the second research question, by knowing the information on the total number of branches, the total number of employees, and the total ATM number of any bank, without knowing other parameters and with some reasonable assumptions, the total electricity of the bank can be easily estimated within an acceptable range. The reasonable assumptions are given for ease of calculations and can be modified according to parameters deemed important by the bank. By using these assumptions with little available data information, the time can be saved on the data collection and the processing time as well.

Thus, for answering the third and fourth research questions, an original methodology supported by clear and simple calculations has been developed for the banks to calculate their electricity consumption and also determine the priorities they have to give for lowering their total consumption. In addition, the proposed methodology can be revised and applied to other companies in the service sector easily. In conclusion, the carbon emission evaluation of service sector companies is composed of complex inputs.

A user-friendly mathematical model is proposed in this paper. This model allows a bank to make an estimated electricity calculation even before opening a new branch. Also, this model gives a strong tool for the banks to prepare their sustainability reports quickly and in a fully accurate manner.

In this research, the authors have faced some limitations which are declared as below:

- Research modeling stage: There is no such model in the literature in order to make benchmarking for all the stages of this research.
- Data collection stage: Banks are only using the bill content; the breakdown of the electricity consumption items is not recorded. Banks are tending not sharing information except contents of the public reports, according to general legal arrangements.
- Model developing stage: Determining the variables and factors that affect the amount of electricity consumption in the banking sector due to no available sector research studies on this topic.
- Findings and conclusions cannot be benchmarked with the literature due to the lack of similar comparative research.

For further studies, this developed method, which is validated by applying the real-world data, can easily be modified for different sectors, especially for the managerial and office buildings. In addition, the energy consumption for heating and cooling purposes can be modeled in future studies and aggregated by this newly proposed model.

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Declarations

Conflict of interest The authors declare no competing interests.

References

Akbank. (2019). *2018 Sustainability report.* Istanbul. Retrieved June 2019, from https://www.akbank.com/tr-tr/Yatirimciiliskileri/Documents/2018_Akbank_Surdurulebilirlik_Raporu.pdf

Desroches, L.-B., Fuchs, H., Greenblatt, J., Pratt, S., Willem, H., Claybaugh , E., … Young, S. (2014). *Computer usage and national energy consumption: Results from a field-metering study.* Berkeley: Lawrence Berkeley National Laboratory. Retrieved June 2018, from http://eta-publications.lbl.gov/sites/default/files/computers_lbnl_report_v4.pdf

Enerji Atlası. (2016, October). *Dünya'nın En Az Elektrik Tüketen Televizyonları, 2016*. Retrieved September 2018, from Enerji Atlası: http://www.enerjiatlasi.com/haber/dunya-nin-en-az-elektrik-tuketen-televizyonlari-2016

Erkin, E. (2012). *A methodology to calculate lighting energy saving potentials in the office buildings (doctoral dissertation).* Retrieved from Council of Higher Education Thesis Center Database (Accession No. 333048)

Esmaeil, K., Alshitawi, M., & Almasri, R. (2019). Analysis of energy consumption pattern in Saudi Arabia's residential buildings with specific reference to Qassim region. *Energy Efficiency., 12*, 2123–2145. https://doi.org/10.1007/s12053-019-09806-x.

Garanti Bank. (2019). *2018 Sustainability report.* Istanbul. Retrieved June 2019, from https://www.garantibbvainvestorrelations.com/tr/images/pdf/GBFR17_TR_KAP.pdf

Halkbank. (2019). *2018 Sustainability report.* Istanbul. Retrieved June 2019, from http://mediaservice.halkbank.com.tr/media/document/Halkbank/Biz/Surdurulebilirlik/raporlarveetkinlikler/2018SRTurFinal.pdf

LightWorld. (2014, May). *İTO Reklam Grubu*. Retrieved September 2018, from LightWorld: http://www.lightworld.com.tr/ito-reklam-grubu-kampanya-baslatti

Santander UK Group Holdings. (2019). *2018 Sustainability report. Istanbul. Retrieved June 2019.* London. Retrieved July 2019, from https://www.santandersustainability.co.uk/sites/default/files/Sustainability_Report_2018_SantanderUK_0.pdf

TEIAS. (2017a). *The distribution of gross electricity generation by primary energy resources and the electric utilities In Turkey*. Retrieved October 2018, from Turkish Electricity Transmission Corporation: http://www.teias.gov.tr/sites/default/files/2017-10/69.xls

TEIAS. (2017b). *Turkey's gross electricity production by production companies*. Retrieved August 2019, from http://www.teias.gov.tr/sites/default/files/2018-11/39_0.docx

The Banks Association of Turkey. (2018a, June). *Assets of banks*. Retrieved August 2018, from The Banks Association of Turkey: https://www.tbb.org.tr/Content/Upload/istatistikiraporlar/ekler/1023/Aktif_Buyuklugune_Gore_Banka_Siralamasi.xls

The Banks Association of Turkey. (2018b). *Information on bank numbers*. Retrieved October 19, 2018, from The Banks Association of Turkey: https://www.tbb.org.tr/modules/banka-bilgileri/banka_sube_bilgileri.asp

TSE. (2013). *TS825: Thermal insulation requirements for buildings*. Turkish Standards Institution.

TUIK. (2018, April). *Greenhouse gas statistics, 2016*. Retrieved March 2019, from http://www.tuik.gov.tr/PreHaberBultenleri.do?id=27675

TUIK. (2018a). *Distribution of net electricity consumption by sectors*. Retrieved August 2019, from http://www.tuik.gov.tr/PreIstatistikTablo.do?istab_id=1579

TUIK. (2018b, May). *Families through statistics*. Retrieved August 2019, from http://www.tuik.gov.tr/PreHaberBultenleri.do?id=30726

World Business Council for Sustainable Development, & World Resources Institute. (2001). *The greenhouse gas protocol: A corporate accounting and reporting standard.* World Resources Inst.

Yapı Kredi Bank. (2019). *2018 Sustainability report.* Istanbul. Retrieved June 2019, from https://assets.yapikredi.com.tr/WebSite/_assets/pdf/arsiv/surdurulebilirlik/SurdurulebilirlikRaporu2018-Final.pdf?v7

Yurtsever, Ö. (2019). Carbon emission modelling and assessment of the Turkish banking sector. (Doctoral dissertation).

Yurtsever, Ö., & Firat, S. U. (2019). An evaluation on carbon footprint indicators in Turkey located banks and worldwide banks. *International Journal of Business Analytics (IJBAN), 6*, 74–95. https://doi.org/10.4018/IJBAN.2019100106.

Ziraat Bank. (2019). *2018 Sustainability report.* Ankara. Retrieved June 2019, from https://www.ziraatbank.com.tr/tr/Bankamiz-ZB/surdurulebilirlik/Documents/SurdurulebilirlikRaporu2018.pdf.