Elektrikli ev aletleri kullanim tercihinin enerji tarifelerine göre hanelerin enerji faturalari üzerine etkisinin incelenmesi

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Öne Çıkanlar

• Türkiye pazarında mevcut olan elektrikli ev aletleri dâhil edildi.
• Türkiye'de uygulanan elektrik tarifeleri dikkate alındı.
• Elektrikli ev aletlerinin en ekonomik ve en pahalı kullanım alışkanlıkları arasındaki net maliyet farkları hesaplandı.
• Üç zamanlı ve tek zamanlı enerji tarifeleri arasındaki maliyet farkı karşılaştırıldı.

Amaç: Bu çalışmada, elektrikli ev aletleri kullanım tercihlerinin üç zamanlı ve tek zamanlı elektrik tarifelerine göre hanelerin enerji faturaları üzerindeki etkileri incelenmiştir.

Metot: Hanelerdeki eşyaların kullanım süreleri için anket hazırlanmış ve elde edilen veriler göz önünde bulundurularak, iki farklı senaryo hazırlanmıştır. Senaryolarda, elektrik tüketiminin aynı miktarda olduğu ancak elektrikli eşyaların gün içindeki kullanım zamanlarının farklı olduğu düşünülerek enerji tüketim tabloları oluşturulmuştur. Tablolarda en düşük elektrik faturası için kullanım alışkanlıklarının nasıl olması gerektiği, üç zamanlı tarifenin bilinçli ve uygunsuz kullanılması durumlarında faturaya nasıl yansıyacağı incelenmiştir.

Sonuç: Bazı elektrikli eşyalar az kullanılsa dahi elektrik gücünün yüksek olması nedeniyle çok fazla enerji tüketebilir. Araştırma kapsamında belirlenen senaryolara göre, üç zamanlı tarifenin bilinçli kullanımıyla minimum ücretin ödeneceği (440 ₺), bilinçsiz kullanımıyla ise en yüksek ücretin ödeneceği tespit edilmiştir (515 ₺). İki kullanıcının faturaları arasında %17 fark bulunmaktadır. Tek seferlik tarife, üç zamanlı tarifeyi bilinçsizce kullanan bir haneye göre daha ekonomiktir. Sabit tüketim alışkanlığı olan kullanıcılar için tek seferlik tarifenin daha uygun olduğu belirlenmiştir. Ayrıca tüketicilerin tarife değişikliği yapmadan önce elektrikli ev eşyası kullanım alışkanlıklarını (zaman ve süre) kaydedip değerlendirmelerinin, eğer sabit bir tüketim alışkanlığı varsa tek zamanlı tarifeyi kullanmalarının daha uygun olduğu belirlendi.

Anahtar Kelimeler

Elektrikli ev aletleri, Elektrik tarifeleri, Enerji faturası, Tarife yönetimi, Elektrikli eşyalar, Doğru tarife seçimi

Impact of Household Electric Appliance Utilization Preferences on Energy Costs under Varied Tariffs: An In-depth Analysis

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Highlights:

- The electric appliances existing in Turkish market are included.
- Turkish electric tariffs are considered.
- Net cost differences between best and unconscious electric consumption are calculated.
- The difference between three time and single time energy tariffs are compared

Abstract

In this study, the impact of preferences in using electrical appliances on household energy bills were investigated, taking into account both three-time and single-time electricity tariffs. A survey involving 50 households to assess the usage patterns of various household items was conducted. Based on the survey data, two distinct usage scenarios for electrical items were developed. These scenarios incorporated tables detailing energy consumption, assuming consistent overall electricity usage but varying usage patterns throughout the day. Our findings indicate that, with mindful energy consumption under a three-time tariff, households can potentially reduce their energy bills by 76 ₺ (approximately 17%) compared to less conscious consumers.

1. Introduction

Electricity consumption forms the basis of the energy needs of modern societies. Electricity consumption increases proportionally with the increase in human population and developing technology [1]. Both individually and socially management of consumption is of great importance. Energy consumption increases especially at certain times of the day and it becomes difficult for suppliers to meet the demand during peak hours [2-4]. Electricity tariffs have been created to reduce this density. Electricity tariffs are an important tool that shapes energy consumption habits

with the pricing models they offer to consumers. They can help consumers optimize their energy costs and direct them towards more sustainable energy use. In this context, three-time and single-time electricity tariffs attract particular attention. While single-time tariffs offer a traditional approach where energy prices are fixed for all hours of the day, three-time tariffs encourage balancing of energy use by pricing higher during peak consumption hours and more attractively at other times. In this paper, the features, advantages and disadvantages of these two different tariff models are discussed in basis of economics and it is investigated to determine which tariff will be more suitable and economical for consumers in which situations.

There are satisfactory amount of studies on energy tariffs and on the description of energy tariffs [5] and the selection of the right tariff, creating household scenarios with different energy consumption [6]. Also, energy labels and energy consumption scenarios of electrical items are studied [7], and the labels are examined in detail [8]. There are also scientific studies that develop their own algorithms to compare electricity tariffs.[9].Energy bills of a university building for different tariffs were calculated [10]. The consumption may vary depending on items and people's habits [11]. Additionally, the research on energy classification in white appliances enables the examination of energy labeling [12]. The energy efficiency of devices used in residential buildings should be taken into account not only in active operating situations, but also in passive situations [13]. Research on the energy efficiency of electrical devices used in offices provides important data to understand the energy use of offices [14]. The research on household electricity consumption and energy efficiency provides important data on electrical household items and energy efficiency [15].

In Europe, household items meet approximately 30% of the total electricity demand of the final residential energy consumption [16]. Population growth and technological developments cause the average per capita electricity consumption to increase [17]. This increases the use of electrical energy in buildings day by day [18]. In Turkey, in a household with an average monthly consumption expenditure of 12,159 ₺ [19], the price paid can be reduced by conscious use of the electricity tariff. A survey shows that respondents expect approximately 50% savings in the cost of washing and drying clothes [20]. However, the savings achieved depend on the activities and level of awareness.

Unlike the literature, we examined a proportion between the conscious use of the three-time tariff and the positive consumer economy in our research. In the three-time tariff scenarios we have prepared, it has been researched that energy costs can be reduced by ensuring optimal load distribution without changing net consumption.

Table 1. Survey questions

	QUESTIONS	YES / NO	TIME (Hour)
1	Do you have a dishwasher in your household? How many hours do you use it per week?		
2	Do you have a refrigerator in your household?		
3	Do you have a deep freezer in your household?		
4	Do you have a television in your household? How many hours a day do you watch?		
5	Do you have a dryer in your household? How many hours does it work a week?		
6	Do you have a washing machine in your household? How many hours does it work a week?		
7	Do you have a vacuum cleaner in your household? How many hours does it work a week?		
8	Do you have an iron in your household? How many hours does it work a week?		
9	Do you have contact grill in your household? How many hours does it work a week?		
10	Do you have a mixer in your household? How many hours does it work a week?		
11	Do you have an oven in your household? How many hours does it work a week?		
12	Do you have an electric water heater in your household? How many hours does it work a week?		
13	Do you have a microwave oven in your household? How many hours does it work a week?		
14	Do you have a hair dryer in your household? How many hours does it work a week?		
15	Do you have a combi boiler in your household? How many hours does it work a week?		
16	Do you have air conditioning in your home? How many hours does it work a week?		
17	Do you have a kettle in your household? How many hours does it work a day?		
18	Do you have a coffee machine in your household? How many hours does it work a week?		
19	Do you have a computer in your household? How many hours does it work a day?		
20	Do you have chargers in your household? How many hours does it work a day?		
21	Do you have a blender in your household? How many hours does it work a week?		
22	Do you have an aspirator in your household? How many hours does it work a week?		
23	Do you have a ventilator in your household? How many hours does it work a week?		
24	Do you have an iron in your household? How many hours does it work a week?		

2. Material and Method

In this research, a survey was conducted covering 50 households to obtain data such as the operation time of electrical items, daily usage amounts, and the rate of presence of electrical items in the household. The survey questions are given in Table 1.

Within the scope of the research, different consumption scenarios were developed and the effect of consumption habits on the energy

bill was investigated. Two scenarios were created to determine whether it would be more economical for households to choose single or three-time tariffs.

In the scenarios, it is assumed that the monthly electricity consumption of the households does not change, only the electricity consumption hours change. In Scenario 1, consumption intensity is less in the day and nighttime interval and more in the peak time interval. In Scenario 2, the consumption intensity in the peak time period is distributed between day and nighttime periods. The tariffs used in the calculations are explained, taking into account the scenarios and sales prices of electricity distribution companies.

Three Time Tariff

Three-time electricity scale refers to a pricing model prepared for situations where electricity consumption occurs at different time periods during the day. In this tariff, a higher unit price is applied during peak consumption hours and a lower unit price is applied during low consumption periods. It divides the day into three time periods: day, peak and night, and different prices are applied.

Daytime Tariff (06:00 – 17:00)
Peak Tariff (17:00 – 22:00)
Night Tariff (22:00 – 06:00) [21]

Single Time Tariff

Single-time electricity tariff is a scale where the price remains constant throughout the day for the consumption. The amount of electricity consumed for each hour of the day is billed at the same price.

Table 2. Residential tariff price distribution announced by Energy Market Ragulatory Authority (1st October 2023) [22]

Single time	1.778 ₺/kWh
Daytime (three-time tariff)	1.03 ₺/kWh
Peak (three-time tariff)	2.729 ₺/kWh
Night (three-time tariff)	1.063 ₺/kWh

Daily consumption in single-time tariff is calculated with Equation (1).

$$T_g = \sum(P \times t) \tag{1}$$

Here, T_g is the daily energy consumption (kWh), P is the rated power (label power) of the items (kW), t is the average daily usage time of the items (h). Monthly total energy consumption (kWh) was calculated with equation (2).

$$T_a = T_g \times d \tag{2}$$

d refers to the number of days in the month. Consumption cost (₺) for single-time tariff is calculated with equation (3).

$$TF_{single} = T_a \times E_f \tag{3}$$

E_f, refers to the single-time residential electricity price (₺/kWh). The peak cost of daily energy consumption of the three-time tariff is calculated with equation (4).

$$PF = \Sigma(T_{g\,peak}) \times P_f \tag{4}$$

$T_{g\,peak}$ refers to the energy consumption at daily peak time interval (kWh), P_f refers to the peak tariff consumption price (₺/kWh). Daytime cost of daily energy consumption was calculated with equation (5).

$$MF = \Sigma(T_{g\,daytime}) \times M_f \tag{5}$$

$T_{g\,daytime}$ refers to the daily energy consumption during daytime interval (kWh), M_f refers to the day tariff energy consumption price (₺/kWh). The night cost of daily energy
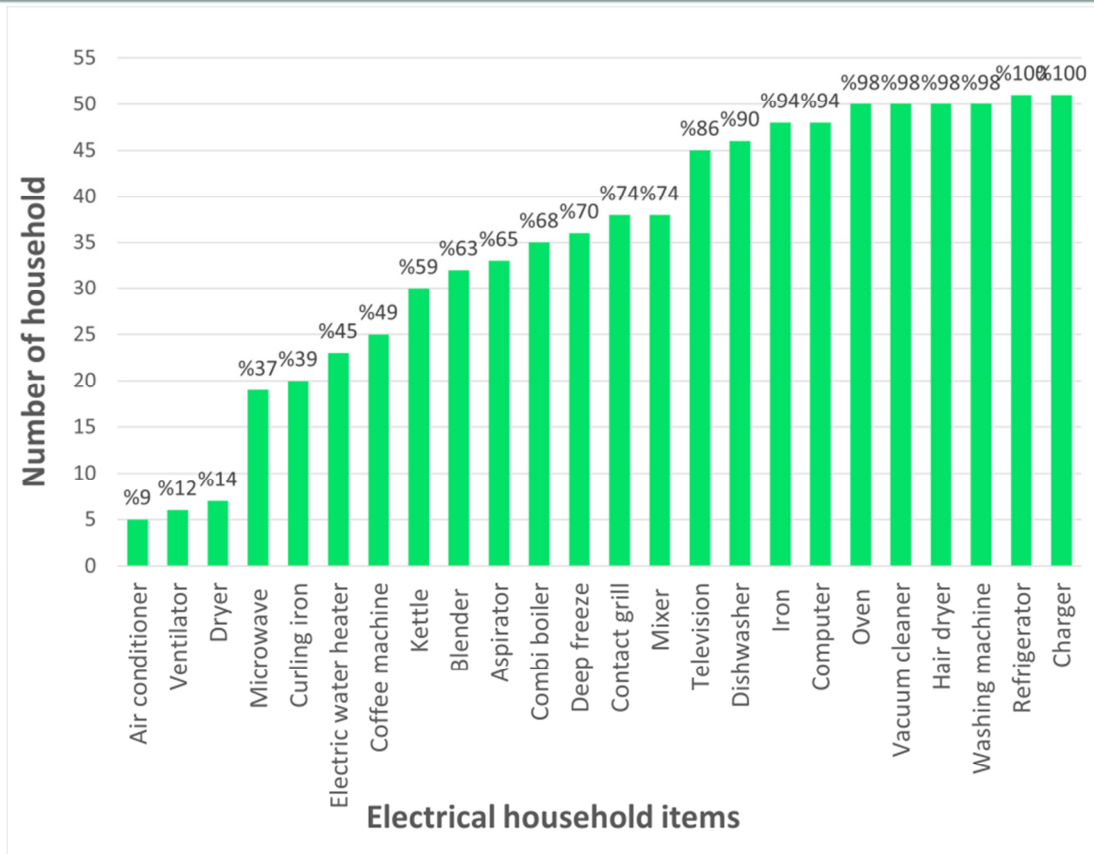
Figure 1. Usage Rates of Electrical Items in Houses

consumption (₺) was calculated with equation (6).

$$NF = \Sigma(T_{g \text{ night}}) \times N_f \qquad (6)$$

$T_{g \text{ night}}$ refers to the energy consumption amount at nighttime interval (kWh), N_f refers to the Night tariff consumption price (₺/kWh). The total daily energy consumption cost of the three-time tariff (₺) was calculated by equation (7).

$$TGF = PF + MF + NF \qquad (7)$$

Monthly three-time energy consumption cost (₺) is calculated by equation (8).

$$AF = TGF \times d \qquad (8)$$

3. Results and Discussion

In this paper, a research to examine the impact of electricity tariffs on households was conducted, based on the survey that is given in Table 1. In the research, electrical household items, rates such as usage rates in households, ratio of usage times, and energy consumption ratio were examined.

Figure 1 shows the number and proportion of electrical items in the surveyed households. The availability of basic household items such as refrigerators, washing machines, dishwashers and ovens is high. However, the rates of electrical items such as dryers, air conditioners, fans and coffee machines, which are used preferentially or whose work can be performed in a different way, are low. The number of items that consume electricity in
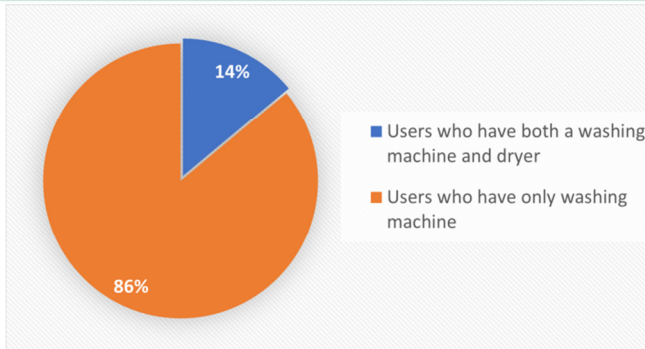
Figure 2. Comparison of Dryer Usages in Households

the household varies. This change creates differences in electricity consumption between households. While in some households there is a difference in the number of items (air conditioning or not), in some households there are items that serve the same

function but have different operating principles (combi-electric water heater). Although the work done by the items is the same, the electricity consumption values and the consumption value in the household vary due to the different working principles of electrical items.

According to the survey in Figure 2, there are 43 households that use only a washing machine and 7 households that use both a washing machine and a dryer. While in 43 households the laundry is dried using natural resources such as wind and sun (86%), in 7 households the laundry is dried in the dryer (14%). This increases electricity consumption in houses.
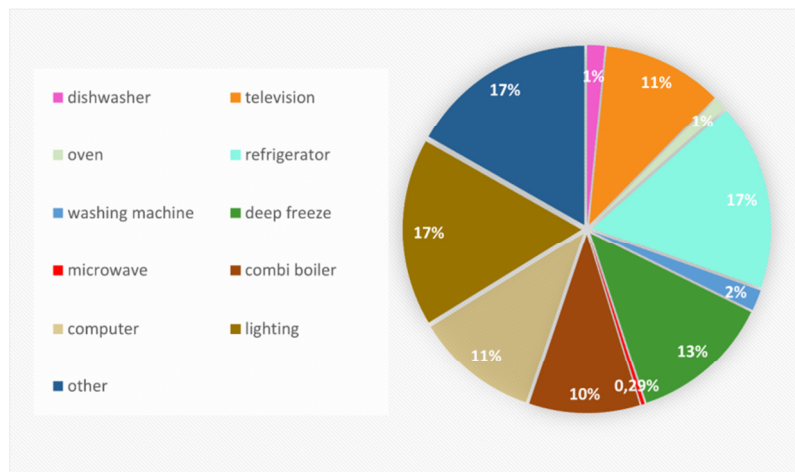
Figure 3. Average Weekly Usage Time of Household Electrical Items
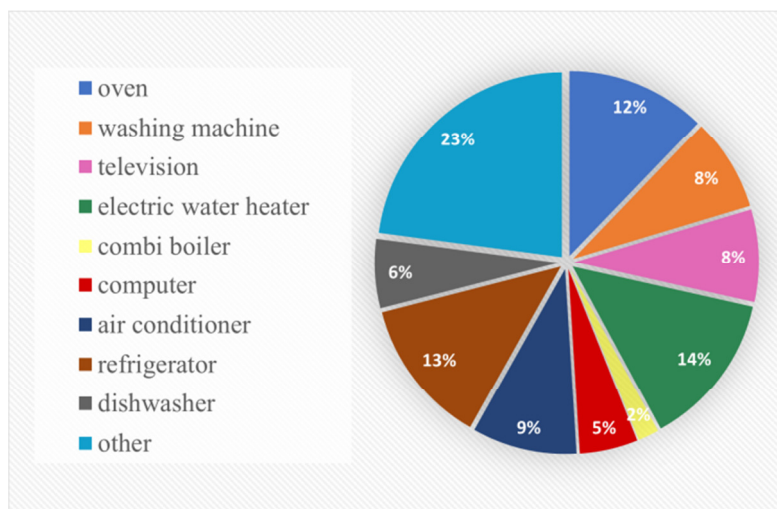
Figure 4. Energy Consumption Rates of Electrical Household Items

Table 3. Scenario 1 Operating hours and power consumption of electrical household items during the daytime, peak and night periods.

Household items	Start time	End time	Operation time (h)	Rated power (kW)	Number of operating days per month	Power consumed per mounth (kWh)	Working hour per day	Peak time	Operation hour per night
Oven	16:30	18:30	2	1,20	20	36,00	0,5	1,5	0
Washing machine	20:00	23:00	3	0,80	10	24,00	0	2	1
Television	15:00	01:00	10	0,08	30	24,00	2	5	3
Computer	16:00	02:00	10	0,15	15	5,00	1	5	4
4x10w led lighting	17:00	02:00	9	0,04	30	10,80	0	5	4
Dishwasher	00:00	02:00	2	0,90	10	18,00	0	0	2
Refrigerator	00:00	23:59	8	0,02	30	5,04	3	2	3
Hair dryer	07:45	08:00	0,25	1,30	20	6,50	0,15	0	0
Vacuum cleaner	13:00	13:30	0,5	0,70	15	5,25	0,5	0	0
Deep freeze	00:00	23:59	6	0,02	30	3,60	2	2	2
Iron	23:45	00:00	0,25	1,00	10	2,50	0	0	0,25
Contact Grill	08:00	08:20	0,33	1,10	10	3,63	0,33	0	0
Modem	00:00	23:59	6,5	0,01	30	2,34	2	2,5	2
Electric water heater	06:00	07:00	1	2,00	20	40,00	0	0	1
Microwave	20:00	20:30	0,5	0,35	12	2,10	0	0,5	0
Combi boiler	00:00	23:59	4,5	0,04	30	5,40	2	1,5	1
HVAC	11:30	12:15	0,75	1,80	20	27,00	0,75	0	0
Charger	00:00	23:59	5	0,03	30	4,50	1	3	1
Coffee machine	17:00	17:30	0,5	0,80	25	10,00	0	0,5	0
Blender	19:45	20:00	0,25	0,30	10	0,75	0	0,25	0
Aspirator	20:00	20:20	0,33	0,03	24	0,24	0	0,33	0
Curling iron	08:00	08:10	0,15	0,04	15	0,08	0,15	0	0
Dryer	23:00	23:45	0,75	1,30	10	9,75	0	0	0,7

Table 4. Pricing of electrical items energy consumption according to three-time tariff (₺)

Household items	Daytime	Peak	Night	Three-time tariff total
Oven	21,64	98,26	0	119,90
Washing machine	0,00	43,67	8,50	52,17
Television	8,66	32,75	7,65	49,06
Computer	4,06	30,71	9,57	44,33
4x10w led lighting	0,00	16,38	5,10	21,48
Dishwasher	0,00	0,00	19,13	19,13
Refrigerator	3,41	3,44	2,14	8,98
Hair dryer	7,80	0,00	0,00	7,80
Vacuum cleaner	9,47	0,00	0,00	9,47
Deep freeze	2,16	3,71	1,28	7,15
Iron	0,00	0,00	2,66	2,66
Contact Grill	7,26	0,00	0,00	7,26
Modem	1,30	2,46	0,77	4,52
Electric water heater	0,00	0,00	42,52	42,52
Microwave	0,00	6,49	0,00	6,49
Combi boiler	4,33	4,91	1,28	10,52
HVAC	48,69	0,00	0,00	48,69
Charger	1,62	7,37	0,96	9,95
Coffee machine	0,00	30,90	0,00	30,90
Blender	0,00	2,05	0,00	2,05
Aspirator	0,00	0,73	0,00	0,73
Curling iron	0,14	0,00	0,00	0,14
Dryer	0,00	0,00	10,36	10,36
			Total	516,28

Table 5. Scenario 2 Working hours and power consumption of electrical household items during the day, peak and night periods.

Household items	Start time	End time	Operation time (h)	Rated power (kW)	Number of operating days per month	Power consumed per mounth (kWh)	Working hour per day	Peak time	Operation hour per night
Oven	10:00	12:00	2	1.2	20	36	2	0	0
Washing machine	00:00	3:00	3	0.8	10	24	0	0	3
Television	11:00	21:00	10	0.08	30	24	7	3	0
Computer	10:00	20:00	10	0.15	15	5	7	3	0
4x10w led lighting	17:00	2:00	9	0.04	30	10.8	0	5	4
Dishwasher	00:00	2:00	2	0.9	10	18	0	0	2
Refrigerator	00:00	23:59	8	0.021	30	5.04	3	2	3
Hair dryer	07:45	8:00	0.25	1.3	20	6.5	0.15	0	0
Vacuum cleaner	13:00	13:30	0.5	0.7	15	5.25	0.5	0	0
Deep freeze	00:00	23:59	6	0.02	30	3.6	2	2	2
Iron	23:45	0:00	0.25	1	10	2.5	0	0	0.25
Contact Grill	08:00	8:20	0.33	1.1	10	3.63	0.33	0	0
Modem	00:00	23:59	6.5	0.012	30	2.34	2	2.5	2
Electric Water Heater	06:00	7:00	1	2	20	40	0	0	1
Microwave	08:00	8:30	0.5	0.35	12	2.1	0.5	0	0
Combi Boiler	00:00	23:59	4.5	0.04	30	5.4	2	1.5	1
HVAC	11:30	12:15	0.75	1.8	20	27	0.75	0	0
Charger	00:00	23:59	5	0.03	30	4.5	2	1	2
Coffee Maker	09:00	9:30	0.5	0.8	25	10	0.5	0	0
Blender	19:45	20:00	0.25	0.3	10	0.75	0	0.25	0
Aspirator	22:40	23:00	0.33	0.03	24	0.24	0	0.33	0
Curling iron	08:00	8:10	0.15	0.035	15	0.08	0.15	0	0
Dryer	23:00	23:45	0.75	1.3	10	9.75	0	0	0.75

Table 6. Pricing and proportional distribution of energy consumption of electrical household items according to three-time tariff

Household items	Daytime	Ratio (%)	Peak	Peak percent (%)	Night	Night percent (%)	Three-time tariff total
Oven	86,57	34,16	0,00	0,00	0,00	0,00	86,57
Washing machine	0,00	0,00	0,00	0,00	25,51	22,67	25,51
Television	30,30	11,96	19,65	26,67	0,00	0,00	49,95
Computer	28,40	11,21	18,42	25,00	0,00	0,00	46,83
4x10 w led lighting	0,00	0,00	16,38	22,22	5,10	4,53	21,48
Dishwasher	0,00	0,00	0,00	0,00	19,13	17,00	19,13
Refrigerator	3,41	1,35	3,44	4,67	2,01	1,79	8,86
Hair dryer	7,03	2,78	0,00	0,00	0,00	0,00	7,03
Vacuum cleaner	9,47	3,74	0,00	0,00	0,00	0,00	9,47
Deepfreeze	2,16	0,85	3,28	4,44	1,28	1,13	6,72
Iron	0,00	0,00	0,00	0,00	2,66	2,36	2,66
Contact Grill	6,55	2,58	0,00	0,00	0,00	0,00	6,55
Modem	1,30	0,51	2,46	3,33	0,77	0,68	4,52
Electric Water Heater	0,00	0,00	0,00	0,00	42,52	37,79	42,52
Microwave	3,79	1,49	0,00	0,00	0,00	0,00	3,79
Combi	4,33	1,71	4,91	6,67	1,28	1,13	10,52
HVAC	48,69	19,21	0,00	0,00	0,00	0,00	48,69
Charger	3,25	1,28	2,46	3,33	1,91	1,70	7,62
Coffee Maker	18,03	7,12	0,00	0,00	0,00	0,00	18,03
Blender	0,00	0,00	2,05	2,78	0,00	0,00	2,05
Aspirator	0,00	0,00	0,65	0,88	0,00	0,00	0,65
Curling iron	0,14	0,06	0,00	0,00	0,00	0,00	0,14
Dryer	0,00	0,00	0,00	0,00	10,36	9,21	10,36
Total	253,42	100%	73,69	%100	112,53	%100	439,64

Figure 3 shows the average weekly operation times and rates of electrical household items. The maximum usage time for lighting is 56 hours per week (17%). The minimum average microwave time is 57 minutes (0.29%). Electrical items whose working hours cannot be interfered with during the day have the longest working hours.

Figure 4 shows the energy consumed during the day (kWh), taking into account the average energy consumption values

and working hours declared by companies producing electrical goods [21].

Table 5 shows the economic energy consumption scenario of the three-time tariff. Assuming that the inefficient usage in the peak zone in Scenario 1 was distributed to day and night tariffs in Scenario 2, the difference between the two scenarios was examined.

Since constantly operating items such as refrigerators and freezers cannot be intervened, the time intervals during which they operate have not been changed. Since

the energy cost during daytime and night hours is lower than peak hours, the bill amount also decreases with the change. If a single-time tariff is used, the consumption fee is 464.61 ₺, and if a three-time tariff is used, the consumption fee decreases by 24.97 ₺ and becomes 439.64 ₺. It has been observed that a household that can manage the usage hours of electrical items correctly pays a lower bill compared to the first scenario and a single-time tariff.

In Figure 5, the economical and inefficient usage cost of the three-time tariff is compared with the single-time tariff. The bill in single-time tariff does not change in two household too. However, the three-time tariff is the highest bill in the first household due to inefficient use, while it is the lowest bill in the second household. There is approximately 76 ₺ difference between these two users. This decrease in the three-time tariff cost is inversely proportional to the awareness of the household. It shows that raising consumers' awareness about electricity tariffs is very important. This fee decreases with household awareness increases. It has been determined that there will be an increase in the fees resulting from unconscious consumption.

The conscious households bill will be reduced because they use electrical items outside of peak hours during the daytime. If an unconscious household chooses the three-time tariff despite actively using peak hours, it will cause economic damage. While the best results are achieved with the correct use of the three-time tariff; the worst results are encountered when used incorrectly. It shows that it is more

economical to use a single-time tariff in households that do not have time management.
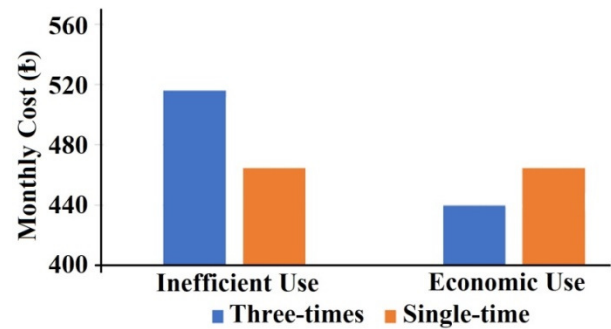
Figure 5. Comparison of conscious and unconscious three-time tariff fee with single-time tariff fee

1. Conclusions

In this research, it was observed that the rate of availability of basic items such as refrigerators, washing machines and ovens in the household rate is high. However, the rate of availability of items are low in the household such as coffee machines, air conditioners, fans and dryers, which are used preferentially or can be performed in a different way, are low in the household. The energy consumed by electrical items depends on their usage time and electrical power.

Although an electrical item is used less, it can consume a lot of energy due to its high electrical power. According to the scenarios determined within the scope of the research, it shows that the minimum fee will be paid by conscious use of the three-time tariff (440 ₺), and the highest fee will be paid by the unconscious use of the three-time tariff (515 ₺). There is a 17% difference between the two users' bills. The single-time tariff is more

economical comparing with a household that uses the three-time tariff unconsciously.

Three-time tariff can provide cost advantage during the peak energy consumption hours during the day. However, it seems that a single-time tariff is more suitable for users with a fixed consumption habit. It has been determined that it is more appropriate for consumers to record and evaluate their usage habits of electrical home items before changing the tariff, and if they have a fixed consumption habit, it is more appropriate to use the single-term tariff.

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