Investigation of pricing impact on the electrical energy consumption behavior of the household sector by a system dynamics approach

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Abstract
In this paper, a system dynamics model is developed to show how the changes in electricity price affect consumption pattern of the household sector in Iran. Electricity is a kind of commodity that is very difficult and expensive to be stored, if not impossible. It means that energy supply must always meet the demand. In addition, electricity supply capacity must be at least equal to the peak demand. Therefore, in non-peak hours, a portion of the capacity is not used. Peak shifting (shaving) is one of the demand-side load management techniques that can help such a problem. Moreover, subsidized electricity prices cause the power network to be overloaded in many hours of a day. This research has employed the system dynamics methodology, to analyze structure of consumption in household sector. First, the sector is divided into three income groups, including Low-income, Medium-income and High-income. Then, load pattern of each group is modeled by a bottom-up method, which is based on a fuzzy approach. The proposed model facilitates to investigate how different pricing and subsidizing scenarios can affect the consumption pattern to reshape it by shifting peak hours and/or reducing total consumption.

1- Introduction

Electric industry is one of the mother industries in each country, because today the production of all goods and the consumption of many are impossible without electric power. Utilizing many services like lighting, conditioning, freezing and much other services depends on electricity. Statistics in Iran show that household sector with 30% of consumption has the highest share among all other sectors.

Since electricity is considered as an essential commodity, government pays subsidy so that all groups of society can utilize it. Because of lack of appropriate substructures, it is not possible to pay direct subsidy to low-income groups. Therefore, government pays subsidy indirectly, which causes electricity price to be lower than its marginal cost, decreases sensitivity of the consumers, and consequently increases electricity consumption inappropriately. On the other hand, improper subsidy payment in present tariff system has caused high-income groups and high consuming householders get the most benefit of the subsidy.

In the referred study [RIEMP, 2005], the proposed tariff system satisfies the main goal of subsidy (utilization of electricity by low-income groups) and at the same time diminishes the inappropriate impacts of current tariff system. In other words, the proposed tariff system does not intend to delete subsidy but to make it more goal-oriented. If electricity tariff changes, it will affect the behavior of consumers. In this paper, the reaction of consumers to tariff change is studied.

Previous works in this field are mainly done by econometrics, in which historical data of consumption is used to compute the trend of demand in future [Asgari,1994], while we will study structural and behavioral changes in the household demand. Other works can also be found that study the overall demand for electricity in Iran based on the system approach [Shakouri, 2003], [Shakouri, 2006].

In this paper, the System Dynamics methodology is applied to study a much more efficient and effective tariff system in details, by which low-income groups can benefit subsidy more, and illogical consumption of electricity is prevented. Higher average price in recommended tariff system will cause structural change in demand. The system dynamics methodology helps to study this change by monitoring effect of price increase on the system. Demand of household sector, electricity expenditures of different income groups, load factor of household sector and income of electric power industry from household sector are some variables that show behavioral changes in the system. It is clear that such studies are not possible with aids of econometric models, which use historical data to predict future.

Moreover, previous system dynamic models of the electricity demand have used a simple function to show the relationship between demand, income and price [OleVogstad, 2000]. In the proposed short-run model, a new method based on Fuzzy Logic has been applied to model demand and consumption pattern of household sector, which helps to analyze the effects of recommended tariff system on short-term demand of this sector from an economic –but not social- view.

2- Electric industry features and the need for electricity tariff revision

Electric industry, due to its special conditions such as being capital intensive and economy of large scale, is monopolistic and governmental in many countries including Iran. Obviously, non-competitive market, where electricity pricing is influenced by the governmental policies decreases the efficiency. One of these policies is to provide social security by subsidizing. Such a policy, apart from causing loss for producer, has other disadvantages such as unclear preference of consumers, inefficient allocation of both resources and production factors, and economic instability. Moreover, non- needy groups will benefit the subsidy too.

The solution that is usually recommended for this problem is to pay direct subsidy to the low-income groups, so that they easily access electricity. In this manner, government should pay all or some part of the electricity market cost for normal consumption of a needy family. However, this needs to have accurate information about the status of incomes and expenditures and other social characteristics of families, such as the number of family members, their health conditions, etc., which is not practical. An alternative solution, we propose a more effective tariff system for short term.

In the present tariff of household sector, price of electricity is lower than the marginal cost. For example in 2002, average cost per KWh in household sector was 4.52 cents, but average price was 1.01 cents, which shows a gap of 3.51 cents between the sales price and the average cost. This gap has imposed about 1.335 Billion US$ of subsidy on government [Asgari,1994].

In the proposed tariff system, the amount of consumption is considered as a criterion for subsidy payment. In order to determine the price, electricity consumption has been divided into 4 intervals:

The first interval includes consumptions ranging from zero to 100 KWh per month, which shows the minimum level of consumption. This group gains the highest amount of subsidy.

The second interval is [100 – 250] KWh consumption per month, which is the normal consumption in household sector. If consumption exceeds normal consumption, it will be a sign of increase in electrical appliances or in the user financial power. Therefore, in this interval, the more electricity is consumed, the fewer subsidies are paid.

The third interval is [250 – 350] KWh per month, which shows the maximum consumption of a family. Subsidy payment for this amount of consumption is no longer permitted. Therefore, subsidy in this interval decreases into zero.

Finally, the fourth interval refers to consumptions more than 350 KWh per month. These consumers are charged by the total average price plus taxes (0.6% of average price). This tax is indeed the opportunity cost that is impose on industrial and agricultural sectors.

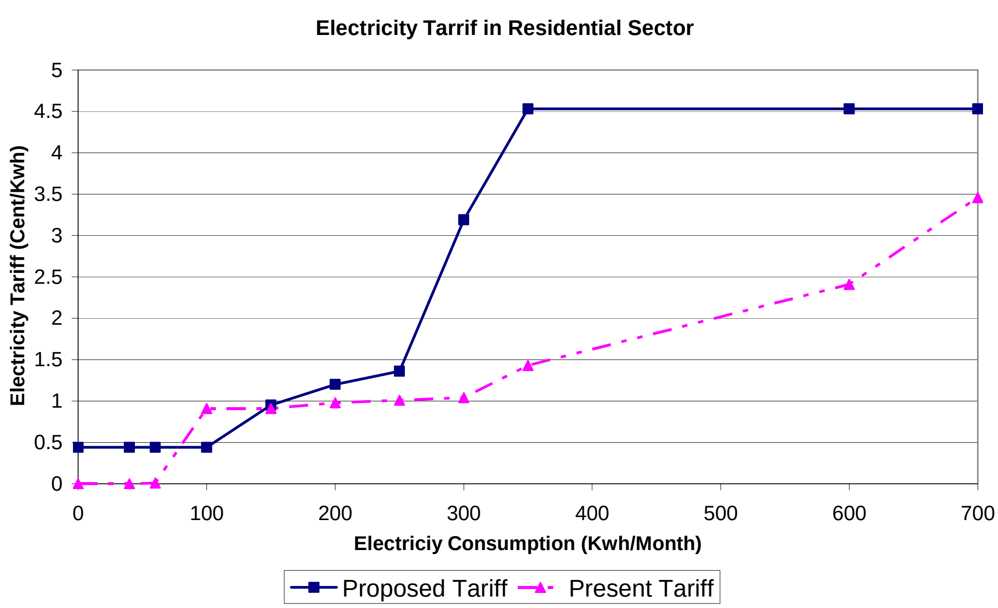

Figure 1: Pattern of the present and proposed tariff systems

If the recommended tariff is applied and no change occurs in consumption, 1.038 billion US$ is acquired through subsidy reduction. This amount can be used in investments of electric industry or in consumption management programs.

3- Impacts of the proposed tariff system on demand of household sector

In this section, a system dynamics model is presented, which is used to study the effects of recommended tariff system. This model helps to compare the behavior of electricity demand and other related indices of household sector in the present and recommended tariff systems. System dynamics is a methodology based on control theory and developed system, which is used to model managerial, social and economic systems [Forrester,1961], [Sterman,2000].

Based on this methodology, the dynamics of household demand has been described through non-linear differential equations, which include feedback loops and the state-flow structure.

In the following sections, first the cause-effect diagram of household sector demand will be explained to show dynamic structure of the system simply. Then details of the model are described for each element.

3-1- Cause-effect diagram of household sector demand

Figure 2 shows the effective factors on household demand with a simple structure.

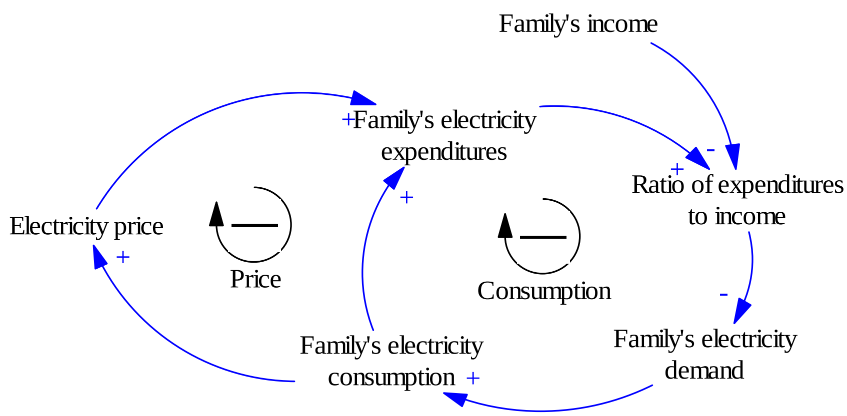

Figure 2: the cause and effect diagram of household electricity demand

According to figure 2, electricity demand, like other commodities is a function of price and income of the consumer. However, because of diversity of services and the extension of electricity network in different cities, it is influenced by other factors such as climate and cultural conditions. In addition to this, the demand structure of commodities like electricity that are used with other commodities, is affected by other factors such as the demand of their complementary commodities. Demand of complementary commodities of electricity (electrical appliances) is also influenced by their price, electricity price and the level of income.

According to recommended tariff system, electricity price is a function of consumption. Therefore, a negative loop is created in which the amount of household consumption is controlled by electricity price.

In the next section, variables of the model are exactly defined and the state-flow diagram is described in detail.

3-2- The state-flow diagram of electricity demand of household sector

The main variable of the model is electricity demand. Electricity demand results from the demand for services like lighting, conditioning, freezing, etc. Therefore, to study the precise structure of electricity demand, demand for electricity services is modeled first. This outlook both reveals the elements of demand load and also makes it possible to determine the consumption pattern of household sector [IME,1992]. Consumption pattern can be used to specify the hourly demand of household sector. Knowing the hourly demand, demand-side management policies can be reviewed and those policies are chosen which help to shift demand from peak load hours to low load hours.

As the need for electricity services change with different places and times, the demand for different end-uses in various climate regions and seasons should be cleared. To achieve this purpose, three regions: normal, hot1, hot2, and four seasons are considered, according to the groups assigned by the present tariffs.

The level of income is also one of the effective factors, which determines ability to use electricity or buy electrical appliances. To deal with this factor, based on a fuzzy approach, demand has been specified for three different income groups: high-income, middle-income and low-income families.

Finally, the average daily demand of different end-uses for each income group in each season and each region ($HDCED_{TIZS}$) is defined as a state variable (figure 10), where the subscripts T, I, Z, S refer to type of end-use, income group, zone (region) and season respectively.

The initial value of $HDCED_{TIZS}$ has been derived from the statistics. Although we have historical data of the total annual consumption of the household sector, unfortunately, there is no separately detailed statistics of the household consumption for different end-uses in each season, region and income group,. To come up with this problem, again using the fuzzy logics, the consumption pattern of electrical appliances for each income group, region and season is created first, and then the initial value of $HDCED_{TIZS}$ is generated based on the share of each end-use from the above consumption pattern and total annual consumption of the household sector.

In the next stage, demand must be specified for different hours of a day, so the time interval that each appliance uses during a day must be determined. Then by dividing the daily demand for each appliance by the time interval that it is used, the hourly demand is derived for each end-use. It is assumed that the probability distribution of daily demand in the consumption interval is even.

Moreover, demand for use of each appliance also depends on the climate condition of different seasons, which must be specified by another variable. Fortunately, VENSIM DSS software has provided the opportunity to define different subscripts for one variable, so different quantities can be assigned to one variable. The assignment of end-uses to different hours variable ($HADH_{th}$) and assignment of end-uses to different seasons ($HADS_{ts}$) has been defined. For $HADH_{th}$ two subscripts are considered to show the type of each appliance and each hour of 24 hours of a day respectively. The same method is used for the next variable ($HADS_{ts}$), meaning that if one appliance is used in each season, it will gain one, otherwise zero is assigned to it. Defining these variables, the hourly demand of household sector can be generated.

Now, monthly demand of a typical family of each income group in each season and region ($HMDF_{isz}$) can be

created., Then the demand of each income group in each region can be specified by the number of consumers (families) of each income group in each region, sum of which determines total annual demand of household sector. This variable can be used to verify the model. If this variable matches the real data of consumption, it shows that the computed parameters of the model are acceptable. Otherwise, the parameters should be changed until the demand generated by the model fits measured data.

After calculation of family demand, the effect of price change on demand should be included. As the electricity bill is delivered every two months, consumer consumes based on the attitude that he/she has about electricity expenditures and Attitude of consumer forms through time. Therefore, average of electricity expenditures of past months is used to model the reaction of consumer to changes in electricity price.

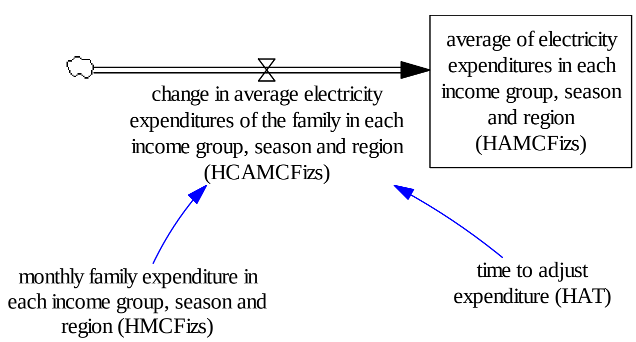

Figure 3: smooth function structure for getting average from family's electricity expenditures

The trend of variables $HAMCF_{izs}$, $HCAMCF_{izs}$ and $HMCF_{izs}$ is as follow:

$HAMCF_{izs}$ equals $HMCF_{izs}$ until t_0. Then, $HMCF_{izs}$ increases suddenly, but $HAMCF_{izs}$ increases slowly until equals $HMCF_{izs}$ again. The flow variable, $HCAMCF_{izs}$, grows up to its maximum value on t_0, and as the quantity of $HAMCF_{izs}$ is near $HMCF_{izs}$, it decreases and reaches to zero.

HAT is the time for consumer to understand the increase in electricity price and react. As electricity bill is delivered every 2.5 months on average, after realizing the change in electricity expenditures, consumer decides to change its consumption.

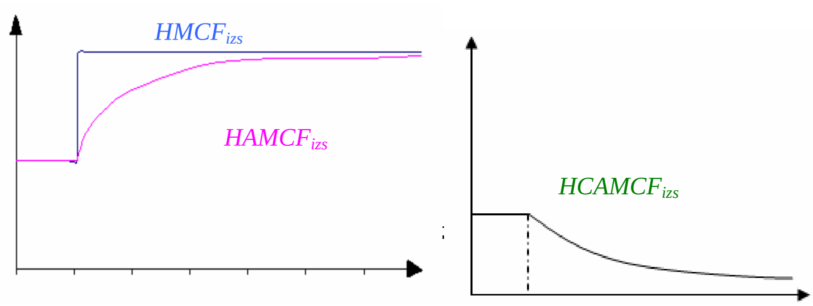

Figure 4: state and flow variables' changes

Expenditure change affects on demand through the price elasticity, which means how much the demand of one commodity will change if its price changes, and shows how consumer decides in reaction to price change. For calculation of elasticity, first demand function is computed by econometrics methods. Then, assuming other factors unchanged, the ratio of demand changes to price changes gives the price elasticity. In this model, total demand of one family was generated from the sum of demand for different electrical appliances, so the change in consumption of these appliances must be computed separately. As there is no separate statistics for different end-uses, the demand function for different end-uses cannot be created by econometrics. So a new methodology has been used to compute the price elasticity of different appliances (end-uses). In this method, consumer's behavior towards electricity price change cannot be traced accurately but approximately. For example, if price increases, consumption of more energy intensive appliances will decrease more or cheap and inefficient appliances will be replaced with more efficient quickly. To apply these concepts, fuzzy sets theory is used [George J.Kiler, 2001]. In this method, first factors effective in time of price change are determined. Then, an appropriate index is defined for each factor. The combined effect of these indices, gives the price elasticity for different end-uses. As no exact number can be assigned to these indices, using fuzzy sets theory, linguistic variables have been defined for each of the indices and the effect of indices on elasticity has been determined through word variables. The combination of linguistic variables of different indices creates relationships, which show the trend of consumer for changing the consumption of different end-uses. After all relationships from the combination of linguistic variables of different indices are specified, the general rule, which governs elasticity, is determined. In the following section, indices and their related linguistic variables are defined and then the relationships, which compute elasticity, are presented.

3-3- Price elasticity calculations for electrical appliances by fuzzy logic

Electricity consumption of electrical appliances is affected by two factors: the time interval of consumption and the appliance's power. Therefore, to change consumption, consumer changes either the time of consumption or the power of appliances. To show the tendency of consumer for changing the time of consumption, an index, the ratio of consumption to normal consumption is defined. In normal consumption, consumer has the highest utility. If one’s consumption is more than this amount, it will be a sign of inefficient usage of energy resources. Normal consumption is calculated for each of income groups. Power of electrical appliances in normal consumption pattern equals to average power that is used in each income group. If the ratio of consumption to normal consumption increases, it shows that consumer is utilizing more than he needs. As a result, price increase can cause consumption to decrease. Next index that is considered in change of appliances' power is the ratio of substitution cost of electrical appliances to family's income. Replacing efficient appliances with older ones, power demand will change. The more the ratio of price of one appliance to family's income is, the less it is possible for that family to replace the appliance with a more efficient one. According to this definition, the effect of this index on consumption change has been included by linguistic variables.

Present electricity tariff rises with consumption, meaning that by increase in consumption, tariff increases too. However, consumption does not decrease because ratio of price change to consumption change, i.e. the elasticity is less than one, which means by one percent increase in consumption, price increases less than one percent. As a result, not only the consumer is encouraged to reduce consumption, but also low utility increase cost creates a background for more consumption. This analysis is the same as the one that is made to show the elasticity of commodity demands to price or income. Therefore, the cost of consumption increase in the proposed tariff system is regulated more, and the ratio of price change to consumption change is used as an index to show how price increases if consumption increases too.

After determination of the effective indices on electricity consumption, it is also necessary to transfer elasticity and indices mentioned above into a fuzzy space. To achieve this purpose, first the change interval of each variable and then appropriate linguistic variables for each interval should be defined carefully.

To determine the elasticity change interval of each variable, a consumption pattern called “maximum consumption pattern” is defined, in which the maximum utilization of each income group is specified. For example, it is assumed that none of the group uses electrode-less or E-lamps and they gain their lighting service by 100 W incandescent bulbs. This consumption pattern helps to find the maximum elasticity of each electrical appliance to price in the proposed tariff system.

If price increases, it is assumed that the consumer, whose consumption is based on maximum consumption pattern, decides to reduce his consumption without losing his previous utility, and he will consume according to normal consumption pattern. In this case, the electricity price will be computed according to recommended tariff system. Introducing such a consumption pattern, maximum elasticity of consumption to price increase can be calculated for each of the electrical appliances. The same procedure is applied to find the change interval of consumption elasticity with respect to the price decrease. However, in this case, a minimum consumption pattern is introduced; elasticity is calculated using the minimum and normal consumption patterns. For each of above intervals, four linguistic variables (very low, low, high and very high) are defined due to each consumption decrease and increase. Some examples of “Maximum”, “Minimum” and “Normal” consumption patterns are presented in table 1. Similar categorization is used for other appliances too.

According to ratio of the Maximum consumption to the Normal consumption, the change interval of ratio of consumption to Normal consumption is defined between zero and ten. Four linguistic variables are also defined due to this interval: very low, low, high, very high.

As the price of electrical appliances changes in a broader interval, to determine the change interval of ratio of appliances' prices to income, the ratio of the most expensive appliance (refrigerator: 445 US$) to monthly income of lowest income group (111 US$) is considered as the upper bound of this index. Therefore, three linguistic variables: low, average, high, are defined in the interval of [0, 4].

Table 1: Maximum, Minimum and Normal consumption patterns for each income group (Wh)

Low income	Average income	High income	Low income	Average income	High income	Low income	Average income	High income	**Income groups**
Maximum consumption			Minimum consumption			Normal consumption			**Patterns**
2800	4200	7000	300	900	1500	0	0	0	**Bulb**
0	0	0	0	0	0	300	500	700	**E-lamp**
1200	0	2160	1200	1680	1680	1200	1680	2160	**Refrigerator**
0	960	1600	0	0	960	0	960	960	**Freezer**
350	525	2380	0	375	850	300	450	1020	**TV**
0	390	500	0	0	300	0	0	300	**Computer**
350	0	0	0	210	0	210	0	0	**Fan**
1750	1750	3500	0	1750	1750	1750	1750	1750	**Iron**
…	…	…	…	…	…	…	…	…	**…**
7850	16405	43745	1600	5015	11415	3885	8320	11795	**sum**
235.5	492.15	1312.35	48	150.45	342.45	116.55	249.6	353.85	**Monthly consumption**
19585	80593	552697	68	11865	41378	8275.05	49920	141540	**Monthly expenditure**

As if the index of ratio of price change to consumption change is less than one, consumer tends to increase consumption, and if it is more than one, consumer reduces its consumption, these two intervals are quite separate and do not overlap. For numbers between zero and one, two linguistic variables: very low, low, and for numbers between one and two, two other linguistic variables: high, very high, are defined.

After defining variables in the fuzzy sets, conditional relationships of indices and variable elasticity of each appliance's consumption are used to specify the general fuzzy rule, which is used to determine the elasticity. As an example, one of the relationships between indices and elasticity is stated as follow:

"**If** the ratio of consumption to normal consumption of one appliance is **very high**, **and** the ratio of its price to family's income is **very low**, **and** the ratio of price change to consumption change is **very high**, **then** elasticity towards consumption decrease is **very high**."

In this way, due to various combinations of defined linguistic variables, 48 relationships are formed for above indices. All these fuzzy rules together determine the elasticity of consumption for all appliances.

Results, which are obtained by the MatLab software, show that only the elasticity of the bulb is high and other appliances even in maximum consumption do not have so much elasticity. As a result, electrical appliances are categorized in three groups: lowly elastic, highly elastic and non-elastic. Non-elastic appliances are which their maximum elasticity is zero, like refrigerator, microwave oven, juice maker, etc. Lowly elastic appliances are which their maximum elasticity is less than one including all other appliances except bulb. Calculated elasticity via ratio of consumption to normal consumption is shown in figures 5 to 8, where elasticity is plotted as a function of ratio of consumption to the Normal consumption.

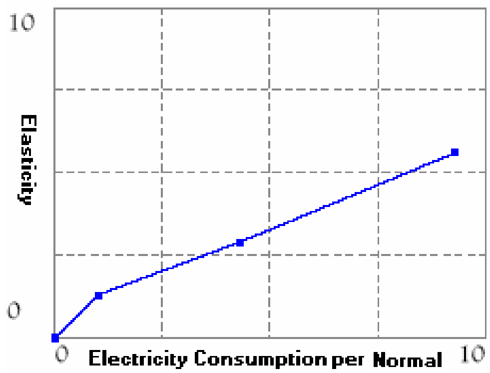

Figure 5: function of bulbs consumption reducing elasticity changes for low-income group

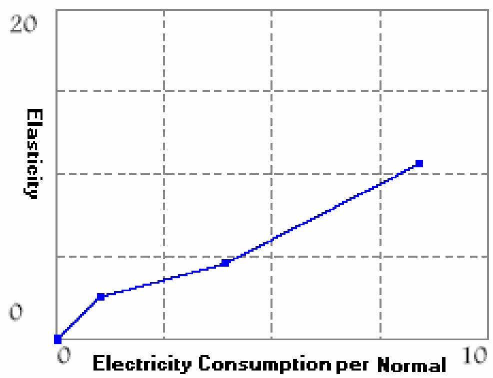

Figure 6: function of bulbs consumption reducing elasticity for average - income group

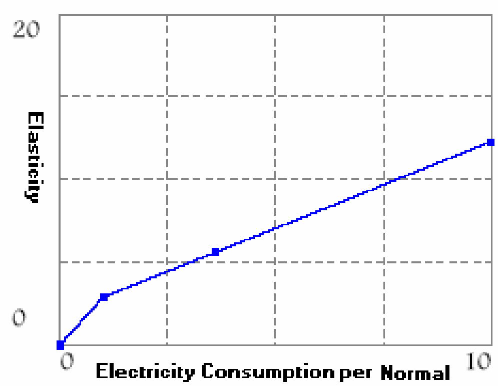

Figure 7: function of bulbs consumption reducing elasticity for high-income group

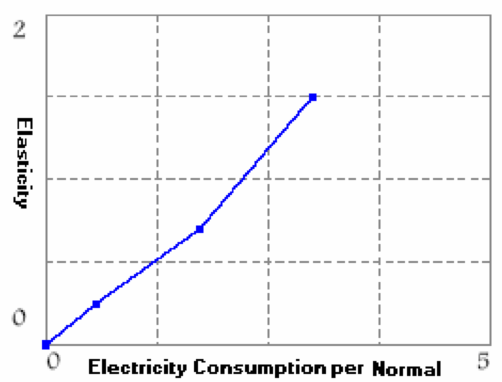

Figure 8: function of bulbs consumption reducing elasticity for low-elastic appliances

Now that the consumption elasticity of each appliance is determined, the state-flow diagram of the model is completed. This diagram is shown by figure 9.

4- Analyzing the effects of electricity tariff change

Electricity tariff change in household sector leads to change in family's expenditures. Increase in electricity expenditures cause the family to reduce its consumption. Then, changes in electricity consumption will change electric power industry's sales to household sector. In addition, changes in electricity tariff may also affect consumption pattern and as a result, load factor will change. As electricity generation costs are a function of load factor, change in consumption pattern will result in electricity costs change. To analyze the effects of change in electricity tariff, electricity demand, electricity expenditures and consumption pattern of household sector in addition to electric power sales is studied.

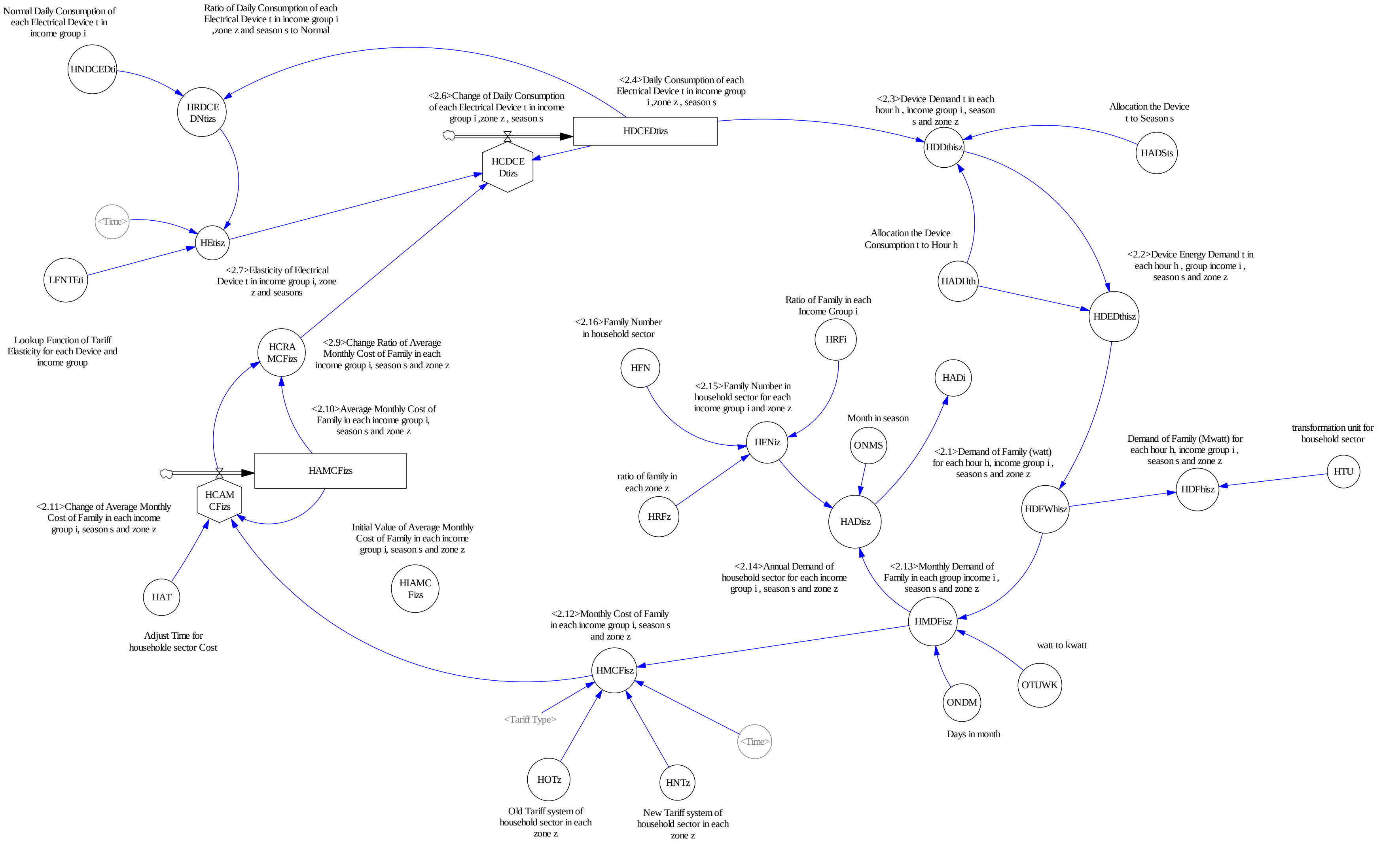

Figure 9: state-flow diagram of household electricity demand

4-1- electricity demand

Applying proposed tariff system, electricity demand of household sector reduces intensely in a way that after a year, demand will be less than that of the present system by 20%. However, after one year, because of population increase, electricity demand will increase again with a steady rate. This is shown in figure 10.

In 2002, the share of low-income, average-income and high-income groups out of $39.5*10^{12}$ KWh of electricity consumption, was 10.5, 35.5 and 54 percent respectively. In other words, high-income groups with 30 percent of society population have more than half the total consumption. It shows that consumption per capita is more in high-income groups and low-income groups use less than average consumption per capita.

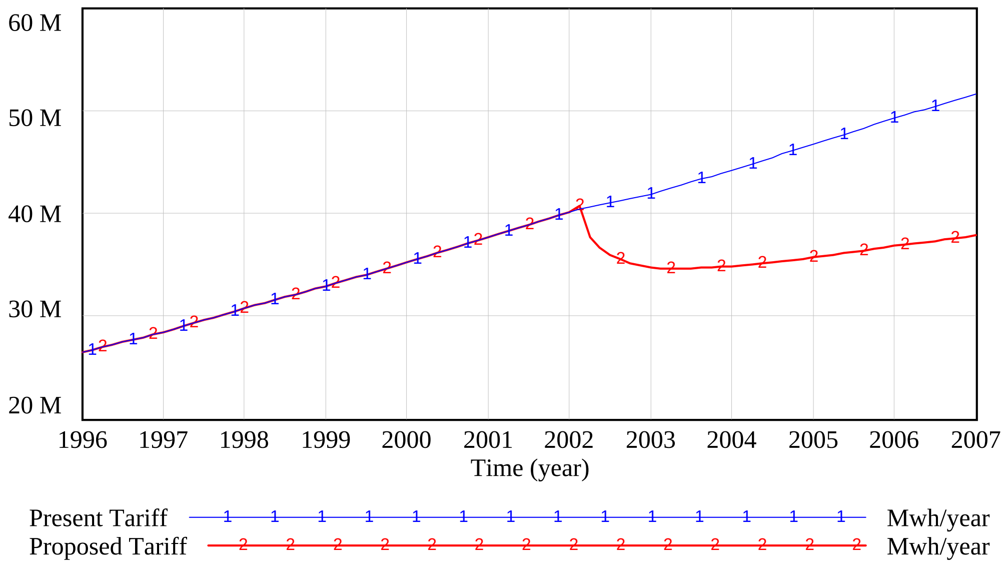

Figure 10: comparison of household electricity demand in two tariff systems

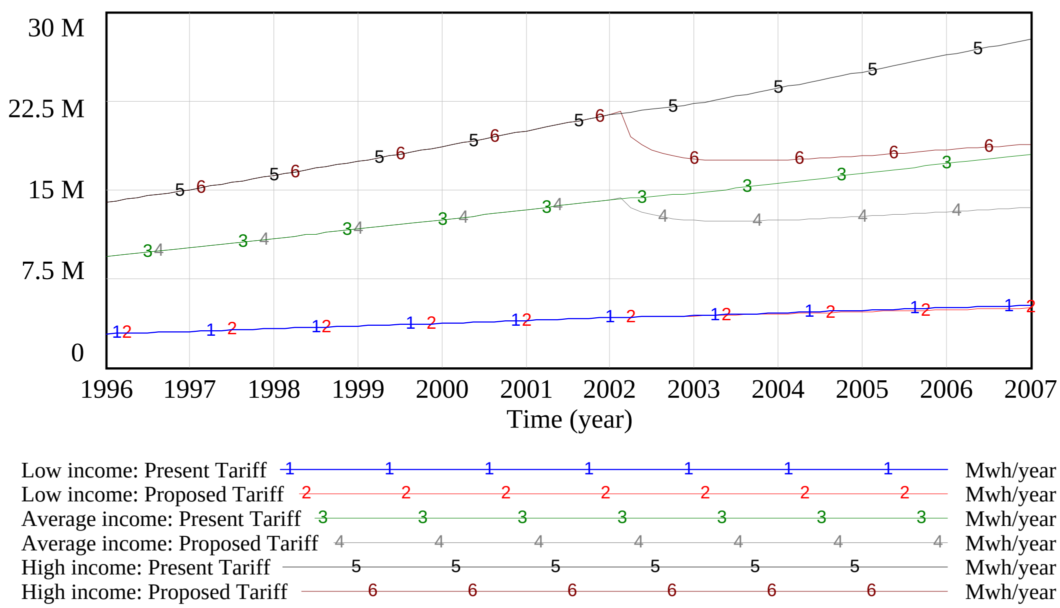

Figure 11: comparison of electricity demand of income groups in two tariff systems

According to figure 11, if the proposed tariff system was applied in 2002, electricity demand will decrease in average and high-income groups and will stay stable in low-income groups. However, the intensity of decrease will be more in high-income group.
Application of the proposed tariff system will decrease electricity demand of high and average income groups by 25 and 20 percent respectively in one year, but in the low-income group, electricity demand with one percent increase will rise to 112 KWh per month.
Electrical appliances are divided to three categories based on the amount of their elasticity to electricity price: highly elastic (lighting devices), non-elastic (refrigerator, slow cooker, microwave oven, juice maker, mincer and mixer) and lowly elastic appliances (other appliances). Lighting which is the most elastic use, had 26 percent of total consumption in summer and 34 percent in winter of 2002. If recommended tariff is applied in 2002, lighting consumption, these percents will change into 10 and 13 respectively. In other words, recommended tariff system causes lighting consumption to decrease significantly.

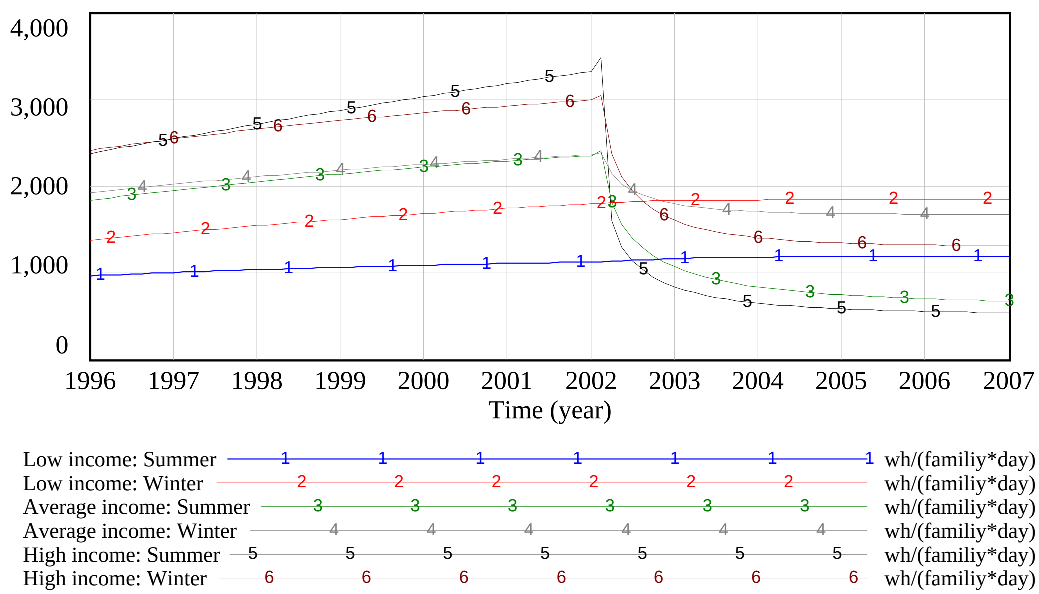

Figure 12: average lighting consumption of the income groups in winter and summer due to proposed tariff system

4-2- Electricity expenditure of various income groups

In the proposed tariff system, an increase in consumption leads to a tariff increase in a manner that for consumptions more than normal consumption (250 KWh per month for a typical average-income family) tariff increase is more intense. Consequently, those with high consumption are affected more in the new system.
In 2002, average monthly consumption of a typical family in high, average and low-income groups is 379, 250 and 111 KWh per month respectively. In new tariff system, electricity prices for the high-income group with consumption more than the maximum consumption (350 KWh per month) will not be subsidized. Therefore, electricity tariff will have a 250 percent increase for this group. Average-income group, who usually have normal consumption will benefit 50 percent subsidy, they only pay 50 percent of electricity marginal cost, and their tariff increases 27 percent. Finally, low-income group with minimum consumption will gain the most amount of subsidy: 90 percent of marginal cost.
Employing new system will change electricity expenditures of high, average and low-income groups from 5.33, 2.44 and 0.98 to 16.85, 5.52 and 0.75 US$ per month respectively. In fact, electricity expenditures in high and average income groups will rise 216 and 126 percent respectively. Intense increase in electricity expenditures cause consumers to lower their consumption, then after a while, electricity expenditures will lessen again, such that it will reach to 6.48 US$ in high-income group and 3.01 US$ for the average-income group. Because of low consumption in low-income group, electricity expenditure decreases by 23 percent. As electricity expenditures

decreases in this group, a tendency towards more consumption is created. Moreover, as a result, average electricity expenditures of this group will become 0.82 US$ after one year. See figure 13.

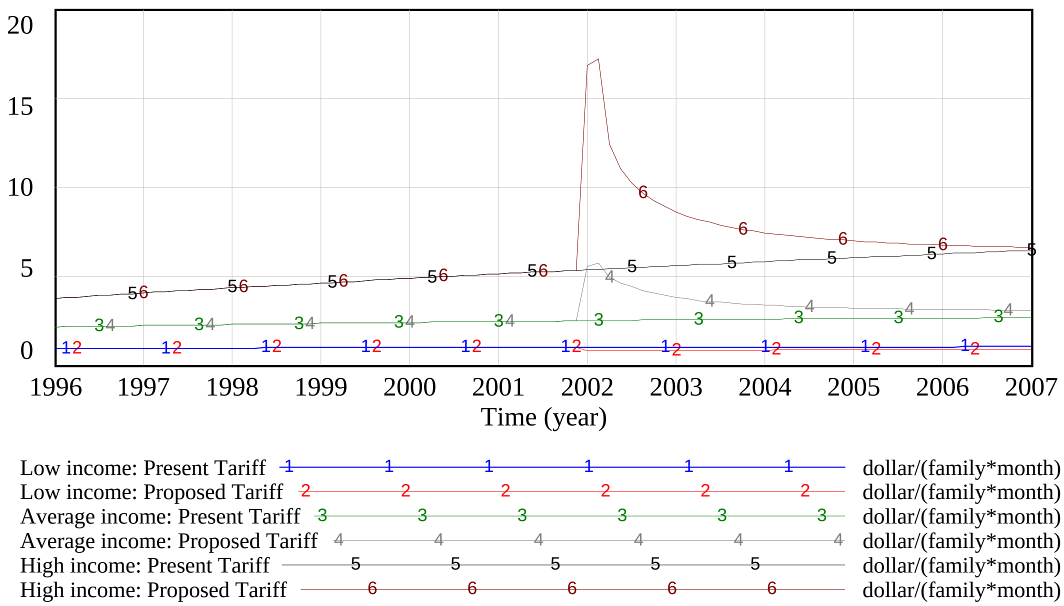

Figure 13: monthly electricity expenditures of different income groups

4-3- Electric power industry's income from household sector

In 2002, electric power industry's income from household sector is 421 million dollar in present tariff system, while if new tariff system is applied, this value will reach to 700 million dollar, which means 66% increase a few months. But as electricity demand in response to price increase decreases, income of electric power industry will reduce again and will reach to 549 million dollar up to 2007. This is shown by figure 14.

4-4- Consumption (demand) pattern of household sector

As electricity can not be saved like other commodities, it is a unique one. Therefore, generation must equal demand at each moment. Electricity generation should change with respect to different demands in different time intervals (hours, days of the week and seasons). To meet all demand, electric power industry's capacity at least should equal the maximum demand. Then, in some hours (low and average load hours), a certain percentage of the capacity will be unused. The more unused capacity exists, the more electricity generation costs are. Higher electricity costs mean higher marginal cost. Demand-side management techniques try to make the load curve as flat as possible. Load factor is an index that is used to show how much the pattern is flat. Load factor is the ratio of average electricity demand to the maximum demand. The higher the load factor is, the flatter the consumption pattern is.

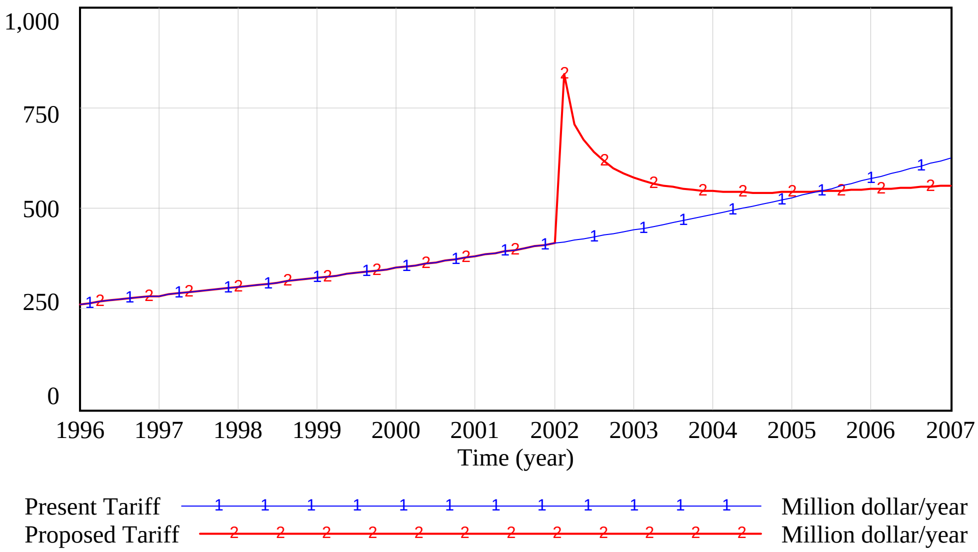

Figure 14: electric power industry's income from household sector

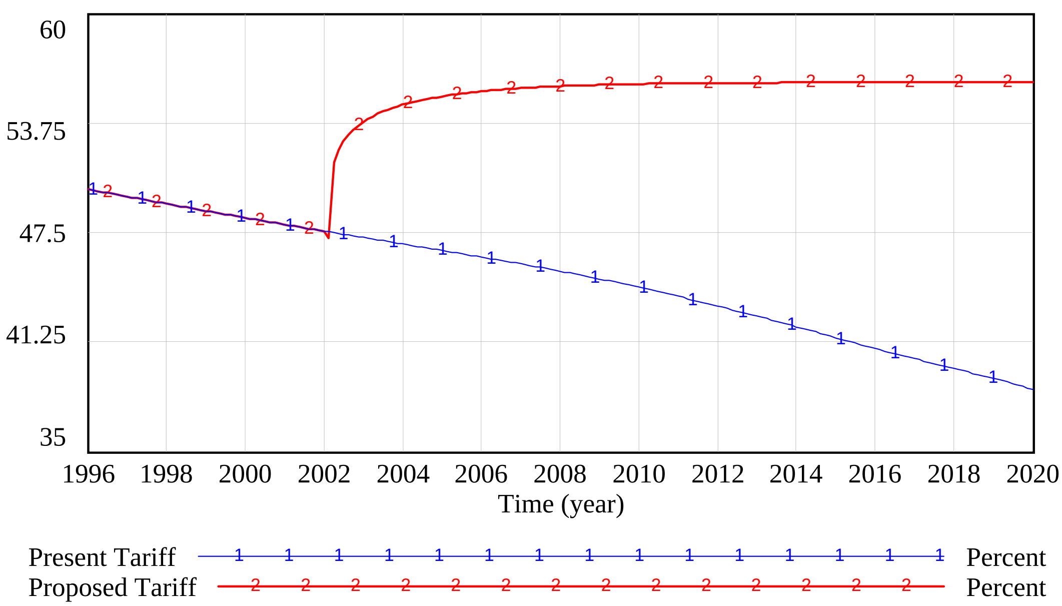

Figure 15: load factor of household electricity demand

As lighting services are used in peak load hours and they compose 25 to 35 percent of consumption in these hours, the amount of consumption in lighting services has got a great influence on load factor. In present system, tariff is increase rate is less than inflation rate. Therefore, not only does consumer decrease its consumption but it even uses more. Increase in consumption (especially in lighting services) causes load factor to decrease.

If new system is applied, electricity expenditures will rise and consumers will use less. As lighting has the highest elasticity, its consumption decrease will be the most and as a result, the load factor will increase from 47[1] percent in present system to 55 percent in new system.

[1] - This load factor belongs to the household sector, while the total Load Factor is about 65%.

5- Conclusion

In Iran, government pays subsidy for essential commodities so that all groups of society can benefit from a minimum level of welfare. Since necessary substructures for paying direct subsidy are not present, indirect subsidy is paid. In the electricity sector, improper design of electricity tariff system has increased the share of high-income groups from subsidy compared to the low-income ones. Low prices in this system have also caused consumers to consume more than they really need.

Simulation results show that in the new tariff system, since subsidy is not paid for consumptions more than the normal consumption, high-income groups with usually higher consumptions will benefit from less subsidy. Moreover, even if consumption of the low-income groups stays at the current level, the new system will cause their electricity expenditure to decrease slightly.

In addition, applying new tariff system will decrease energy consumption for lighting which has the highest elasticity with respect to the prices, and since their time of use coincides the peak time, load factor reduces significantly. Therefore, the proposed tariff system not only distributes subsidy more equitable, but also helps demand-side management, and causes costs of electric industry to decrease.

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