An Investigation into Electricity Subsidy Dynamics by a System Dynamics Approach

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Abstract

After the Islamic Revolution in 1979, Iran had to face another challenge: the war against Iraq. This challenge forced the government to help people by granting subsidy to essential goods such as bread, drugs and different kinds of energy - especially electric power which is one of the major industries in every country. This policy helped people have an easier life during the war, but as the famous law of supply – demand tells us, the lower the price of any good, the higher demand for that good is predicted and this low price of energy made Iran one of the most and worst energy consumers in the world. This high rate of consumption will cause lots of problems such as lack of electricity and financial pressure on the government. In this paper, a system dynamics model is developed to simulate the situations of Iran's electric power industry since 15 years ago, assuming the effect of people's pressure on the government and the pressure of the government to decrease subsidy. The main model is built on two positive and negative loops and the results are compared with the real statistics. Then, two policies are applied to the model: education and increasing the price.

Keywords: Electric power, Subsidy, Electricity price, Consumption, Model

Introduction

Nowadays, Iran is dedicating 11 percent of its GDP to energy subsidy and people are addicted to consume all kinds of energy, more and more. This problem caused Iran's *electricity industry* to have a disastrous decade since 1997.

In Iran, electricity consumers are divided into five sectors: household, industrial, agricultural, trade and public. Each sector has a different tariff of subsidy, but in all of them, the prices are much lower than the real prices and the consumption is much more than standard. In this paper we are going to build a model for electricity consumption of household sector considering people's and government's impact on decrease or increase in electricity price.

The main concerns produced by the policy of granting subsidy to electricity are:

Pressure on Government: Paying over 3.5 billion dollar of subsidy, results in a pressure on the government, inability of investment in construction parts, infrastructures and other parts. Statistics show that this process has had an increasing rate and it needs urgent consideration.

Increase in Consumption: The consumption of electric power in different parts is proved to be much more than the average in other developing countries and has caused severe problems. It is a consequence of low price of electricity (as a result of price-demand rule). As you can see in figure (1), consumption per capita is continuously increasing:

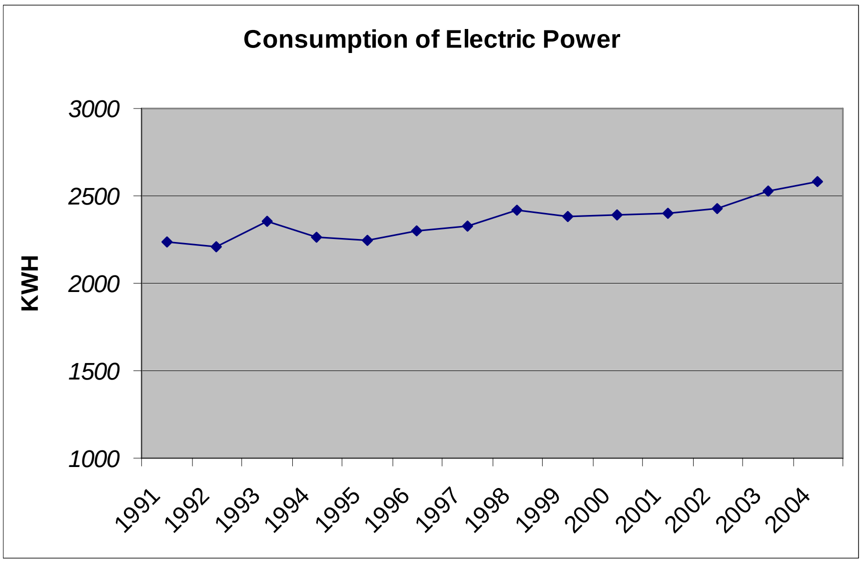

Figure (1): Diagram of Electricity Consumption per capita from 1991 to 2004

Social Justice: People with higher incomes consume more electricity than low-income people and as a result, much subsidy is devoted to high-income people, which is against the main purpose of granting subsidy to electricity. However, electricity power management is trying to solve this problem via step functions in pricing, though there is a hiatus to eligible conditions.

Blackout: Blackout, which is a result of consumption rate becoming more than production rate in consumption peak hours, ad side from its detriment for household and industrial electric equipment, damages power plants.

Dynamic hypothesis and cause-effect diagrams

One of the major loops that exist in this system is "*Government Pressure to Increase Electricity Price*". It says when electricity is supplied with a price lower than its actual price, the resulting pressure causes government to raise the price up to its real value. The cause-effect diagram of this loop is shown in Figure 2.

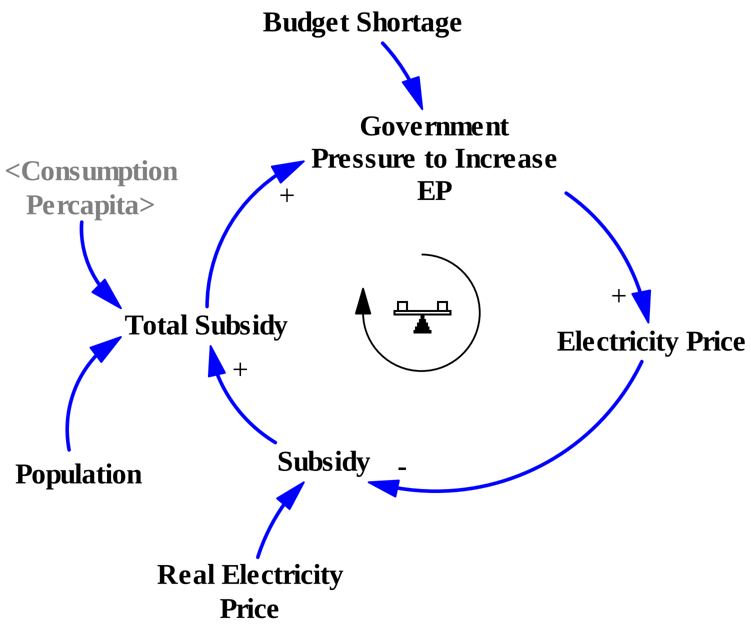

Figure 2: Cause-effect diagram of government pressure to increase electricity price.

But this is not what we are facing in reality. As you see in Figure 3, there is no sensible change in electricity price since 1997. So this is the question: although there is a deterrent loop which should decrease amount of subsidy, why does it not happen?

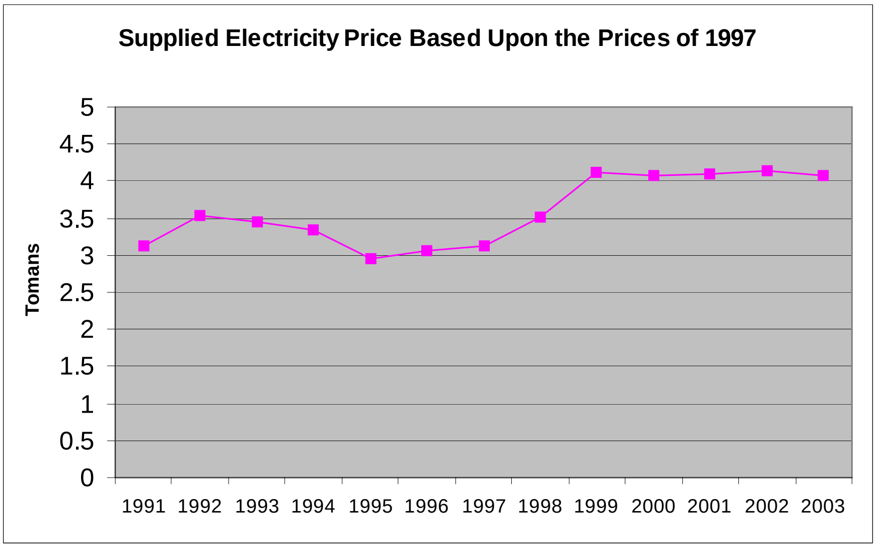

Figure 3: Supplied Electricity Price Based Upon the Prices of 1997.

There should be other loops which cause the price to decrease or stay unchanged. One of the major loops which cause this is “*People Pressure to decrease Electricity Price*” which is a result of the increase in families’ electricity cost. This increase comes about when either electricity price or family consumption rate increases because of the low price of electricity (related to real price). This causes people to increase their pressure on government to lower the price. The cause-effect diagram of this loop is shown in figure 4.

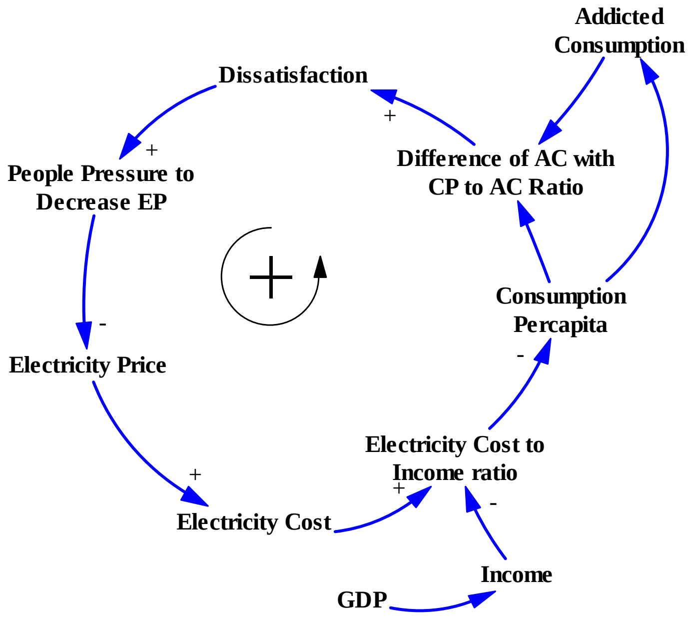

Figure 4: Cause-effect diagram of people pressure to decrease electricity price.

So the dynamic hypothesis can be stated as below:
An **increase** in amount of subsidy causes a **decrease** in the ratio of family's electricity cost to family's income which causes **more** consumption per capita. This causes people to become addicted to **higher** consumption rates which causes the pressure on government to **increase** or stay the same and then, a **decrease** in electricity price as a result of this pressure. But this cycle cannot continue forever because of the deterrent loop. In this case, an **increase** in the amount of subsidy **increases** the pressure on government and causes the electricity price to **increase**. Cause-effect diagram of the whole system can be seen in figure 5.

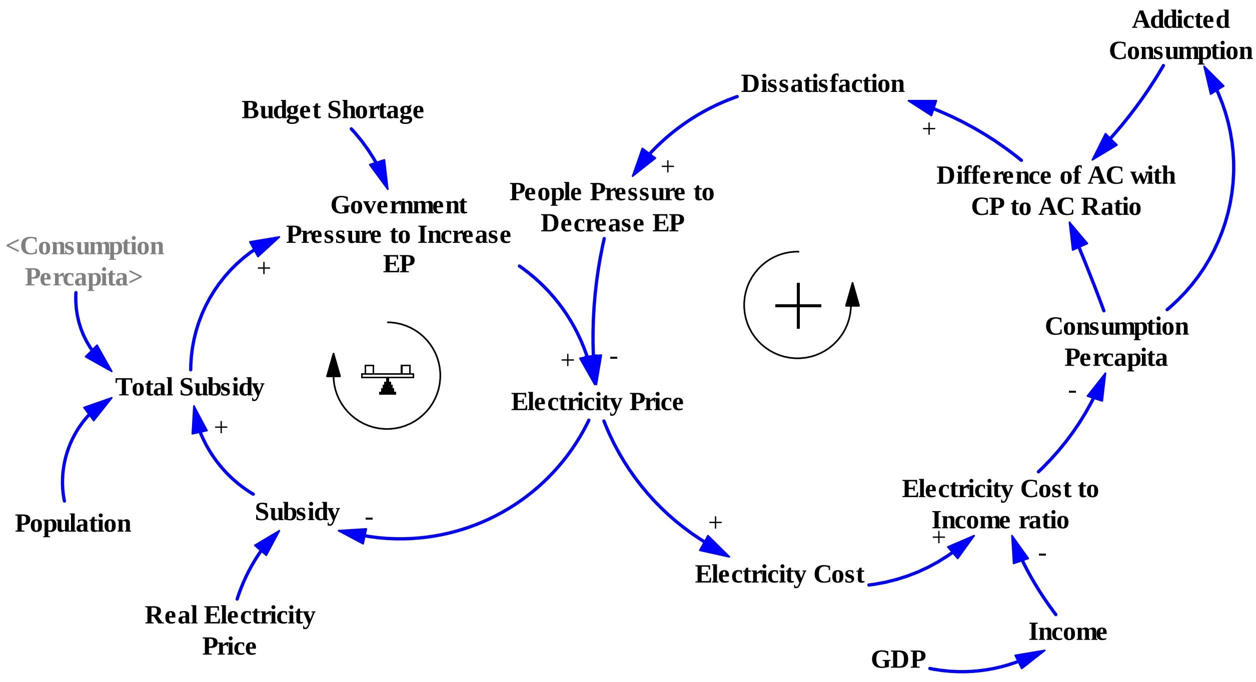

Figure 5: Cause-effect diagram of whole system

Flow diagrams and model description

There upon**,** we have 2 major loops for this model:

1. First loop which makes electricity price decrease and subsidy increase and will become active when electricity is supplied with a price lower than its real price so the ratio of family's electricity cost to family's income increases and more consumption is caused. With increase in consumption, family electricity cost increases and so does people's pressure on government to lower the price.
   Flow diagram of this loop is shown in figure 6. In this diagram, "*Consumption Per capita*" is the amount of electricity that each family consume per year which depends on the ratio of family's electricity cost to family's income and will become "*Actual Consumption Per Capita*" after some delay. This delay is not equal for increasing and decreasing situations because increase in consumption takes place sooner. Also, "*Addicted Consumption*" is the consumption rate that has become vogue in 5 years and whenever the consumption rate becomes less than this rate, people's discontent increases and causes their pressure on government to increase as well.

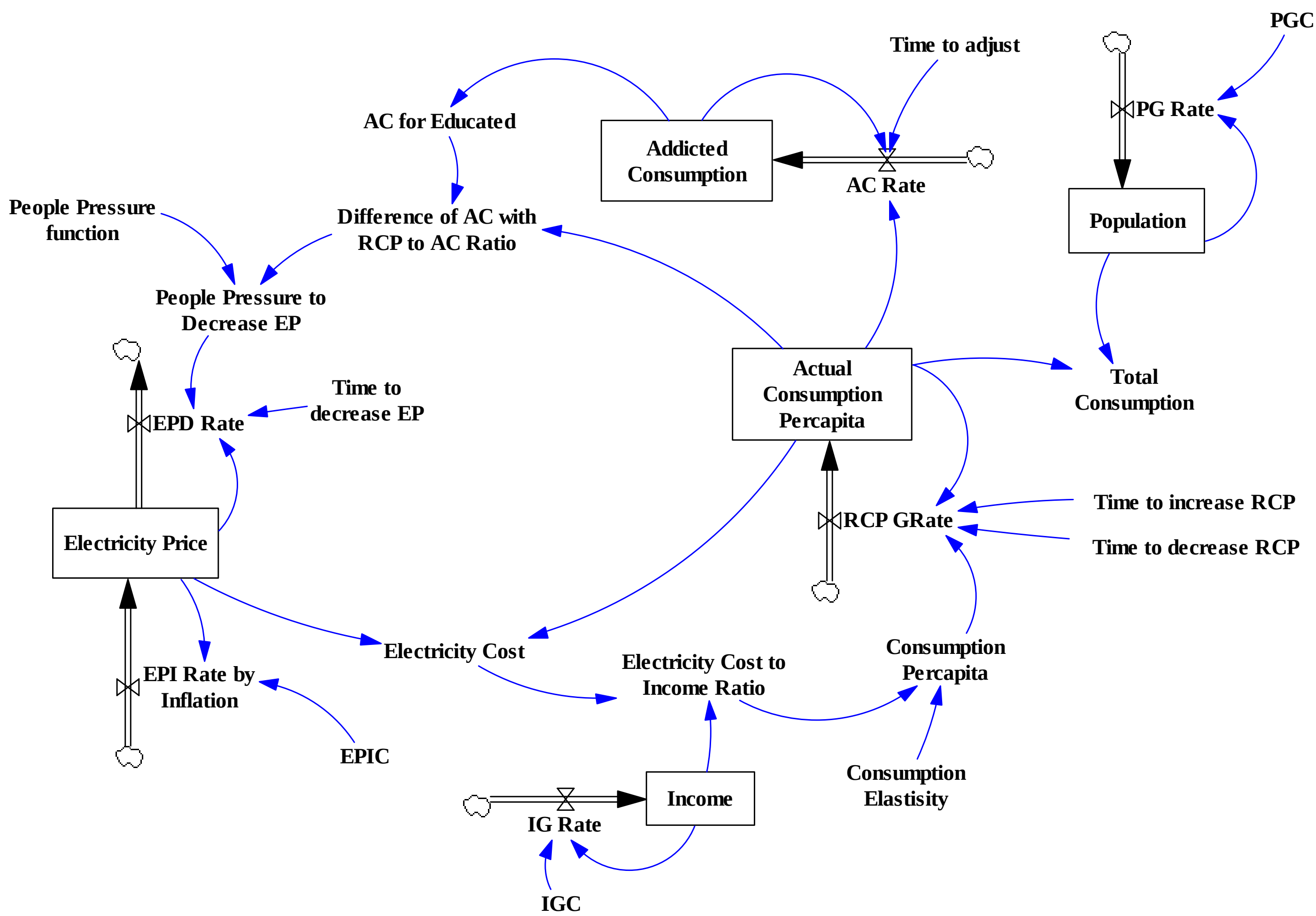

Figure 6: Flow diagram of people pressure to decrease electricity price

2. The second loop becomes active when the total amount of subsidy exceeds a certain limit and the government is facing budget shortage. In this case, the government pressure increases to raise the price. After activation of this loop, the first loop is still active for a while, but gently loses its effect because people's addiction to consumption becomes less and so the discontent will disappear gradually.
   Diagram of this loop is shown is figure 7. In this diagram, "*subsidy*" is the difference between the "*Real Electricity Price*" and "*Electricity Price*" and when the ratio of this difference to budget shortage increases, government's pressure to raise the price also increases.
   At last we have the flow diagram of figure 8 for this system.

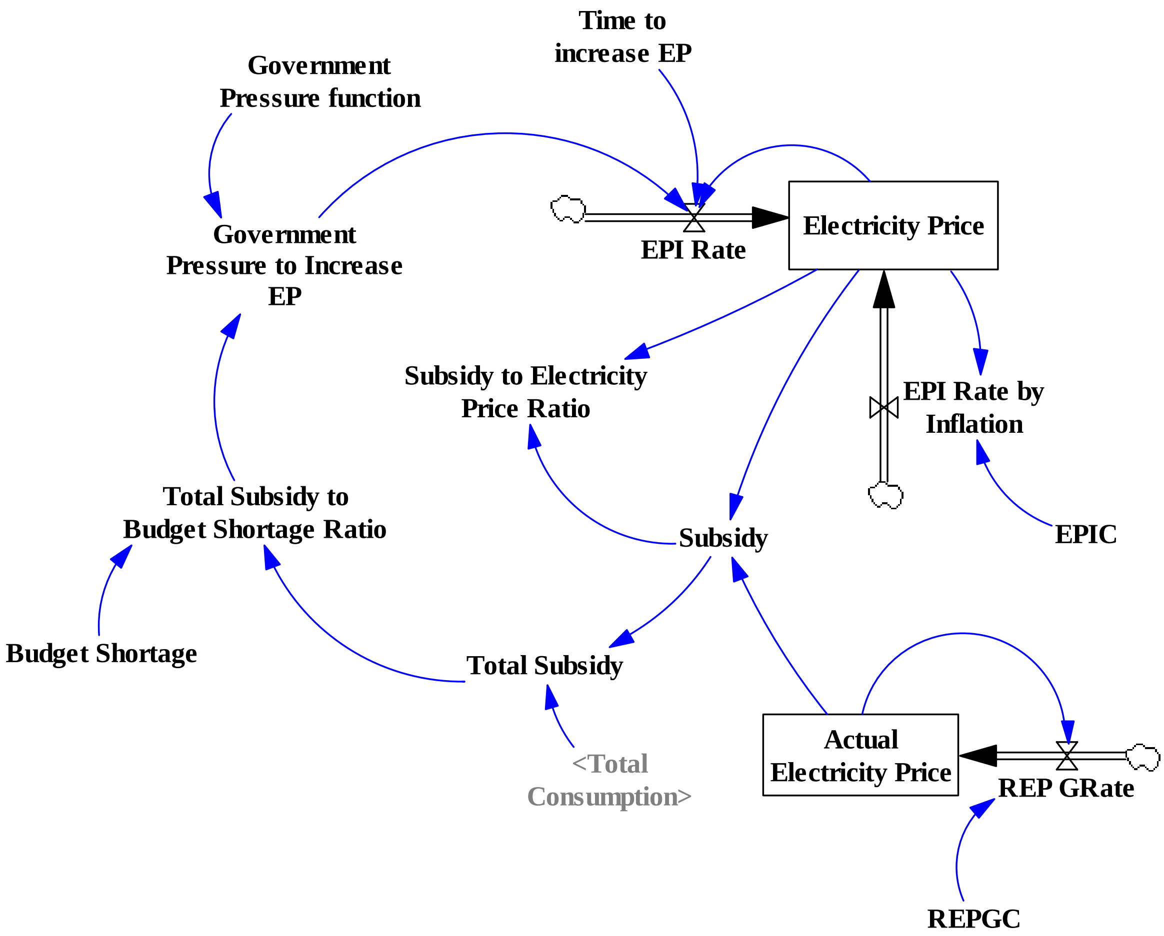

Figure 7: Flow diagram of government pressure to decrease electricity price

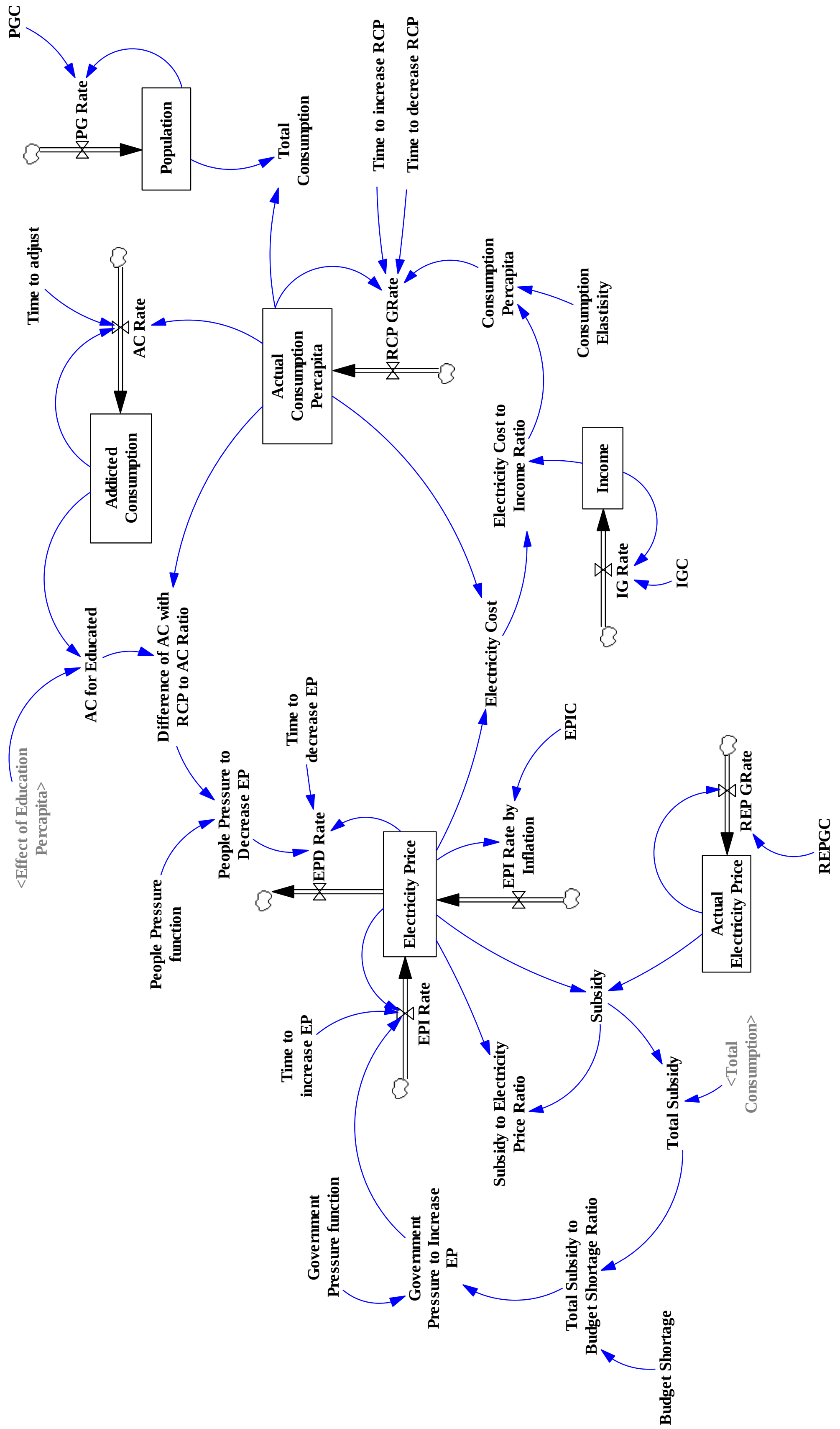

Figure 8: Flow diagram of system

Simulation and results

After simulating this model, the diagrams of Consumption per Capita (Shown in figure 9), Total Consumption (Shown in figure 10), Total Subsidy (Shown in figure 11) and Electricity Price (Shown in figure 12) are as follows:

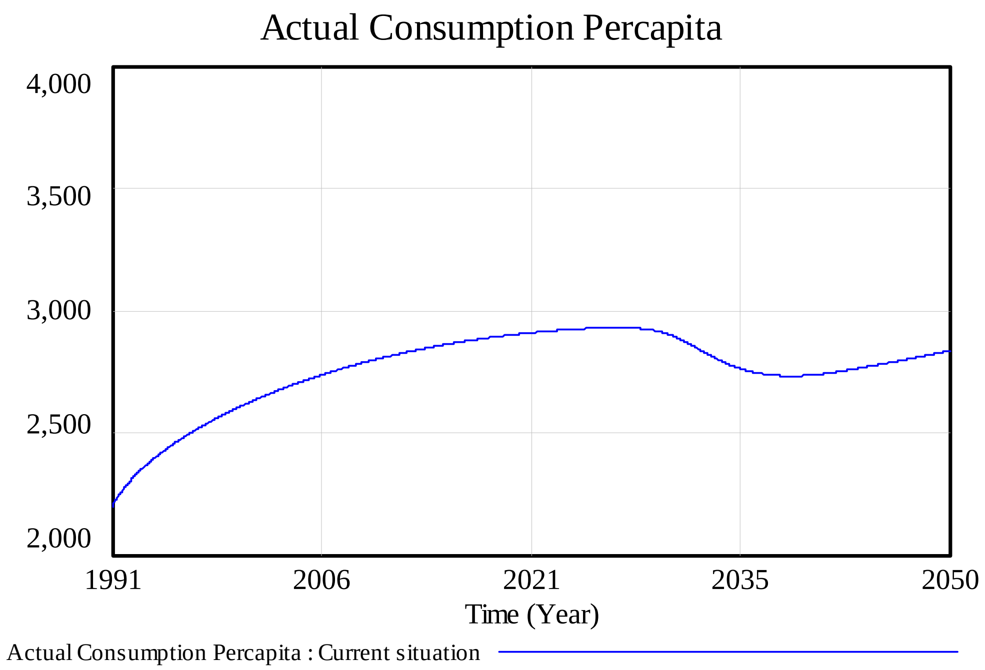

Figure 9: Actual Consumption Per Capita

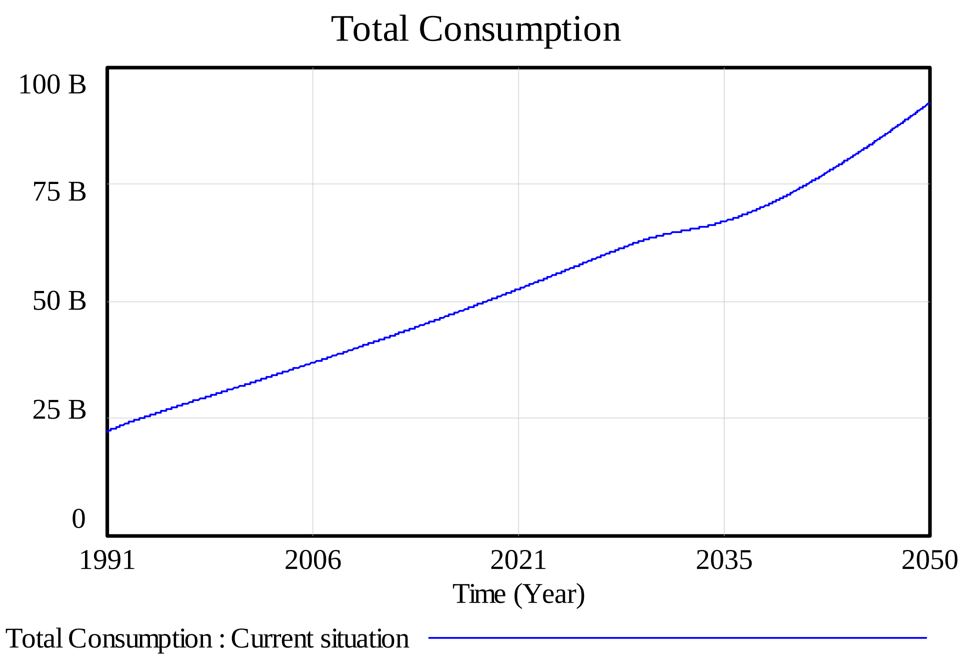

Figure 10: Total Consumption

So the devoted subsidy increases until government cannot undertake this huge amount of money and tries to raise the price. At last the electricity price becomes equal to the real price.

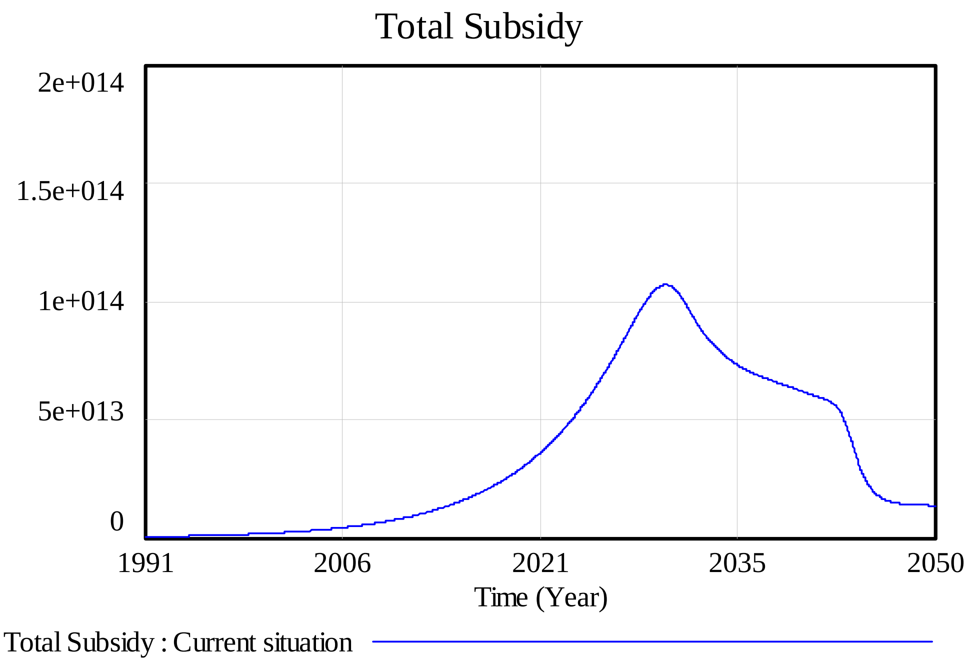

Figure 11: Total Subsidy

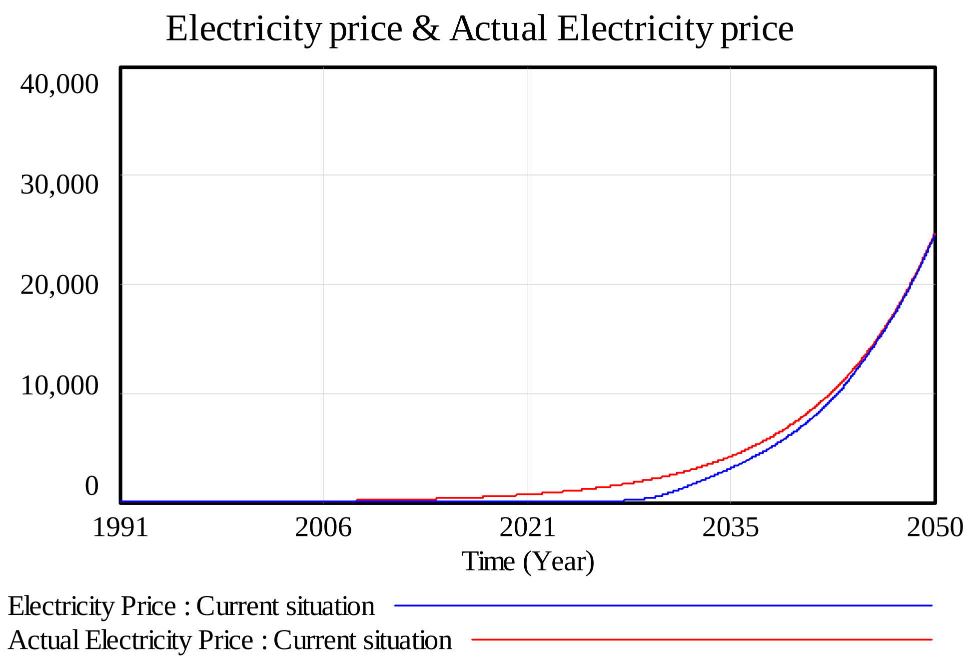

Figure 12: Comparison between electricity price and actual electricity price

Policies

We need to give some solutions which reduce the pressure on government and cause people's addicted consumption to decrease. One of the methods that governments use to reduce people's consumption is to "*Educate*" them. This education is performed by investment on publicity in order to encourage people to consume less or to use products which consume less than their counterparts

Using this method, consumption decreases and people's pressure on government will be reduced as well as financial pressure.

The flow diagram of this part is shown in figure 13. In this diagram, "*Educated People*" are those who are affected by advertisement and consume less. This stock has 2 incoming rates: one of them depends on government's publicity and the other on the communication of educated people with uneducated ones.

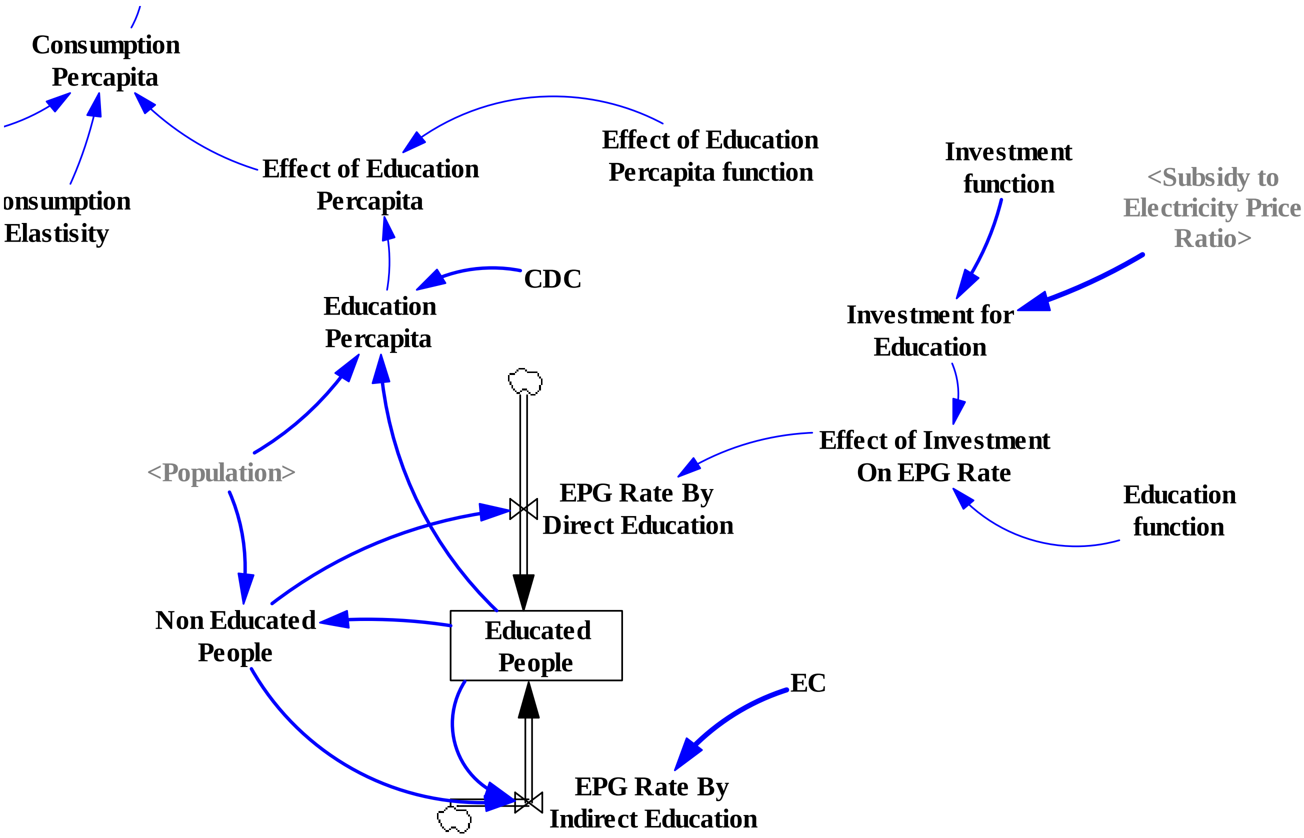

Figure 13: Flow diagram of Education to decrease consumption

Simulating the model with this additional part shows that Consumption Per Capita - shown in figure 14 - will decrease but total subsidy - shown in figure 15 - still increases with population. So this solution causes consumption per capita to decrease and also reduces the pressure on government but does not eliminate it. Thus, we need another solution.

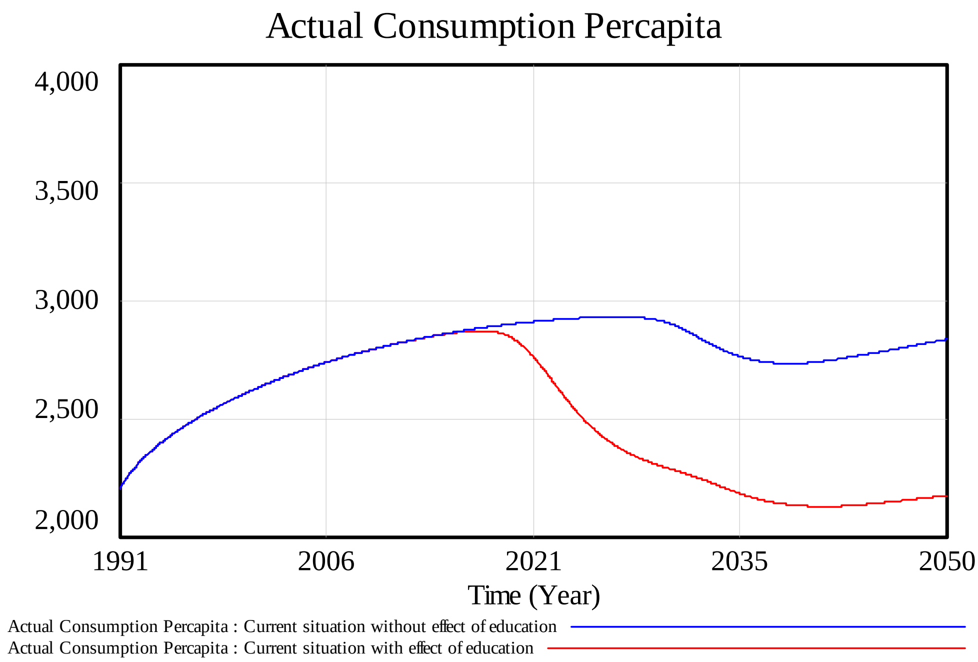

Figure 14: Comparison of consumption per capita in 2 cases: with and without education

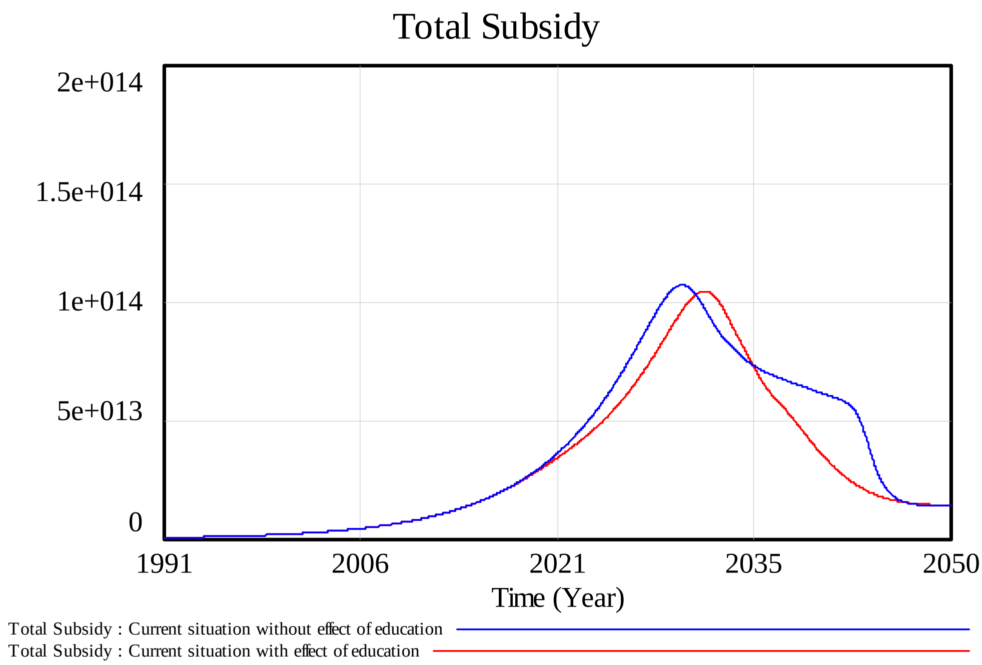

Figure 15: Total subsidy in 2 cases: with and without education

Another solution is to raise the price gently until the electricity price becomes equal to the real price. This way the pressure on government caused by the large amount of subsidy will be reduced and also the consumption per capita does not increase (because of the higher price). In this situation, the behaviour of Consumption Per Capita will be similar to Figure 16 and that of total subsidy will be similar to figure 17.

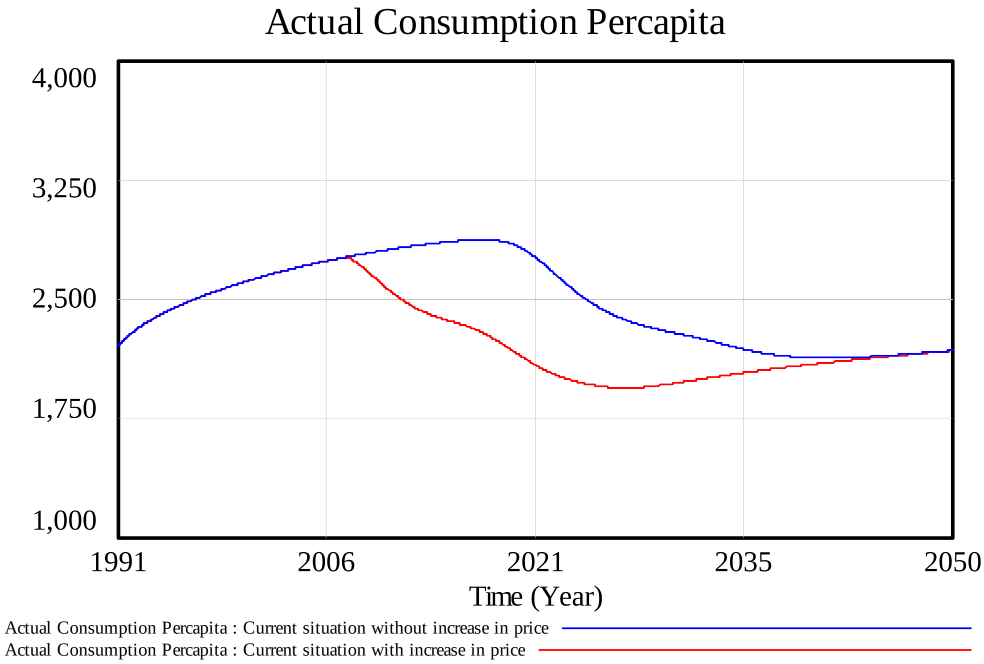

Figure 16: Comparison of consumption per capita in 2 cases: with and without increasing in price

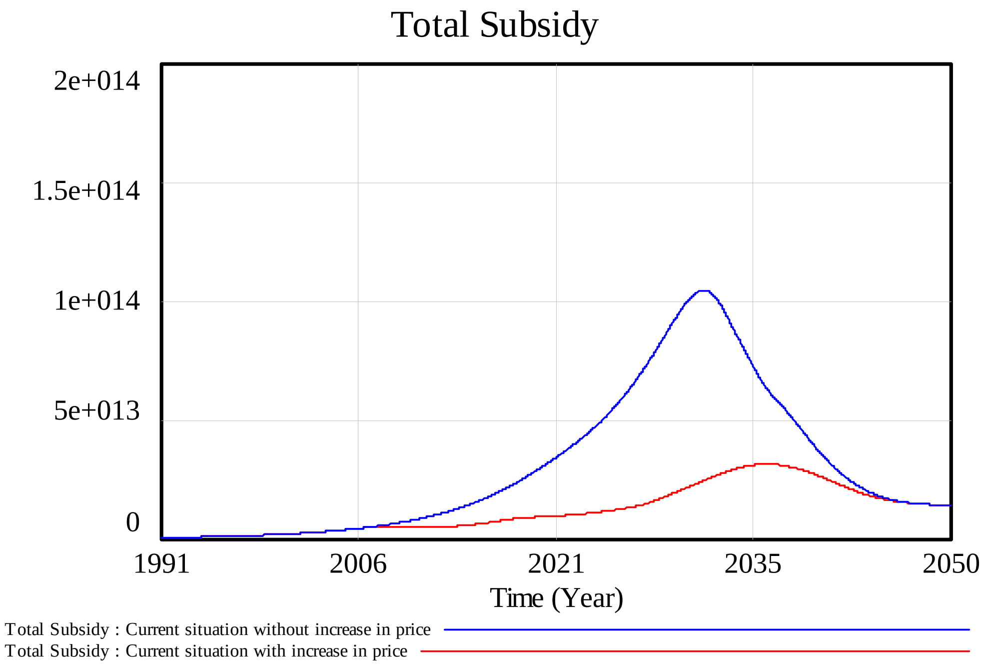

Figure 16: Total subsidy in 2 cases: with and without increasing in price

As mentioned before, total subsidy decreases noticeably. In this situation, consumption per capita will be equal to the previous situation finally, but the difference is lower pressure on government.

Conclusion

As Iranian power minister said in January 2007, the electric power industry of Iran will be bankrupted, if the price of electricity is not changed rapidly. This statement is proved in the model of this paper. Also, electricity consumption per capita has been increasing during last ten years and its rate is the same as the rate in our model. Similarity between the price of electricity in the model and what is shown by statistics is another reason that the model simulates the real situation quite accurate. It seems that Iran's government has only two ways to control this destroying situation: first, to change "*consumption culture*" of the people by education and second, to "*force*" people to decrease consumption by increasing the price of the electricity. In this model both policies were implemented, separately and together. The results showed that although education is very important and can help decrease consumption and financial pressure on the government, but this is not the final solution and the government should increase the price too. To control people's pressure on government, this increase should have a very smooth rate and simultaneously, the policy of education should be applied.

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