# Quantitative Relationship Between Domestic Energy Consumption and the Standard of Living in Hungary

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SUMMARY

*The changes in the energy consumption prices in the last few decades have caused a lot of trouble for the citizens. We can observe an undesirable tendency in energy prices indicated by the collective effect of several factors. This leads to difficulties for residents, because their income has not followed the rise of the energy prices. The problem is even worse regarding the fact that a significant part of residential use depends on fossil fuels. Only a small percentage of the citizenship can afford to supply their energy needs from new types of fuels. This paper attempts to determine a relationship between the population's standard of living and energy consumption in Hungary.*
*Keywords: energy consumption, renewable energy, standard of living.*
*Journal of Economic Literature (JEL) code: C10; I30; H31*

## INTRODUCTION

The standard of living of the population is influenced by many factors. Some of these factors can be measured by objective aspects and some of them just from a subjective point of view. Basically, the living standards are the projection of the economic development of a country. In Hungary we can demonstrate that the standard of living is lower in the economically and socially underdeveloped regions and the factors influencing living standards are different than in other regions with better conditions. The findings of my study showed that the different scientific methods do not use a uniform approach to examine the population's living standard and there is no generally accepted trend in research and analyses. Specialists in philosophy, economy, sociology, healthcare, etc. consider different aspects of the meaning of standard of living and about its quantification.

This paper is an integral part of an extensive research. The goal of this research is to examine the energy consumption of the population and to design a theoretical model based on the results. While creating the model I would like to take into consideration the population's opinion about their living standard, the composition of energy consumption, and the level of demand and acceptance of renewable energy resources. My question considers the aforementioned factors: Is there a basic correlation between the population's energy consumption, the indicators of living standard and the other indicators which have a direct or indirect connection with the standard of living? In this study there are of course factors that are subjectively chosen, because, as I mentioned before, the different scientific fields have not formed a consensus about the measurement of living standards.

### *The Energy Management of the Population*

The examination of the population's energy consumption is an essential part of the research. This topic is highlighted because in the last few decades the volume of energy consumption of the households has not changed significantly, but the structure of consumption has altered. Before the millennium most households' heaters were converted to use the gas grid due to the high state subsidy, comfort aspect, etc. Despite the fact that the gas prices rose after the millennium and the subsidies changed relevantly, the proportion of gas in energy consumption has not decreased, only increased.

There are several causes for this:

- the increase in gas supply of the settlements
- gas price subsidy system;
- increase in housing stock;
- decrease in population density;
- increase in average floor space.

Several factors have had a significant effect on the structure of residential energy consumption. These include the decrease in district heating, a rise in the electricity consumption, the internal change of solid-fuel consumption and the wide-ranged spread of alternative energy consumption (HCSO 2008).

*Table 1*
*Hungary's Energy Consumption in Petajoule*

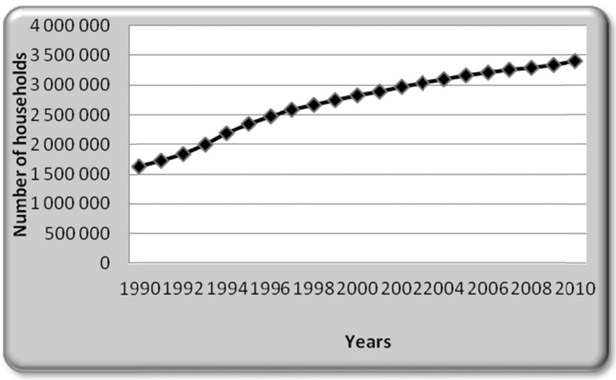
| Years | Industry except water and waste management | Building industry | Agroforestry and fishing | Transportation and warehousing | Population | Other sectors | Sum |
|---|---|---|---|---|---|---|---|
| 2000 | 368.0 | 8.8 | 38.7 | 48.3 | 400.6 | 190.7 | 1 055.1 |
| 2001 | 373.3 | 9.4 | 39.2 | 48.9 | 416.0 | 200.4 | 1 087.2 |
| 2002 | 369.6 | 9.4 | 38.0 | 48.6 | 402.3 | 198.9 | 1 066.8 |
| 2003 | 370.4 | 9.5 | 37.8 | 48.1 | 419.4 | 206.4 | 1 091.6 |
| 2004 | 372.5 | 9.6 | 38.0 | 48.2 | 410.3 | 209.5 | 1 088.1 |
| 2005 | 414.0 | 10.6 | 36.3 | 49.3 | 425.4 | 217.6 | 1 153.2 |
| 2006 | 421.3 | 10.7 | 35.9 | 50.3 | 415.8 | 218.0 | 1 152.0 |
| 2007 | 428.9 | 9.2 | 34.2 | 50.6 | 399.5 | 203.0 | 1 125.4 |
| 2008 | 426.7 | 9.0 | 35.1 | 50.5 | 402.5 | 202.5 | 1 126.3 |
| 2009 | 386.2 | 8.7 | 32.0 | 47.9 | 383.3 | 197.7 | 1 055.8 |
| 2010 | 410.2 | 8.0 | 31.0 | 48.0 | 390.9 | 196.9 | 1 085.0 |

Source: HCSO

Table 1 shows that the gas consumption has made up more than one-third of all energy consumption in every year in the last decade in Hungary. The energy demand of the population did not vary much. As an effect of the economic crisis (the changing energy prices and subsidy system, etc.) the energy consumption decreased by 10% from 2005 to 2010.

### *The Piped-gas (grid) Supply of the Households*

There was piped-gas supply available in 2,877 settlements in the year 2010, which means 91.2% coverage in Hungary. The gas supply since the change of political system is well demonstrated in Figure 1. Between 1990 and 2010 the number of gas consuming households increased by 3.74% in every year on the average.




Source: HCSO

*Figure 1. Piped Gas Consuming Households Between 1990 and 2010*

The amount of gas consumption did not increase parallel with the number of gas consuming households. In the examined period the actual consumption showed a hectic change, as shown in Figure 2. The usage reached its maximum in 2003 when the gas consumption per household was 1505 $m^3$. Consumption dropped progressively in the following years, so in 2010 it was just 1067.7 $m^3$ (HCSO, 2009).

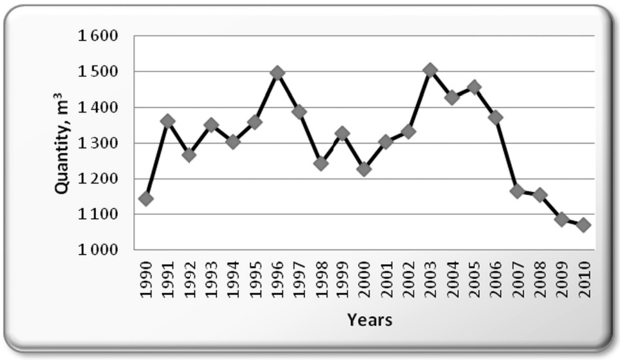


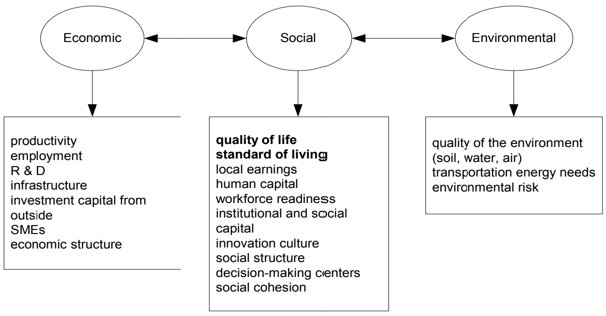

*Figure 2. Household Gas Consumption per Year in Hungary, m³*

### *Opportunities and Effects of Energy Resources*

The usage of traditional energy resources is becoming more and more costly for households so we have keep in mind the option of the utilization of renewable resources. A difficulty is that the redesign of energy production is a long process which is influenced by several other factors:

- ➢ safety of energy supply;
- ➢ diversification of energy supply;
- ➢ environmental aspects;
- ➢ ensuring social and economic cohesion (Nádudvari, 2007).

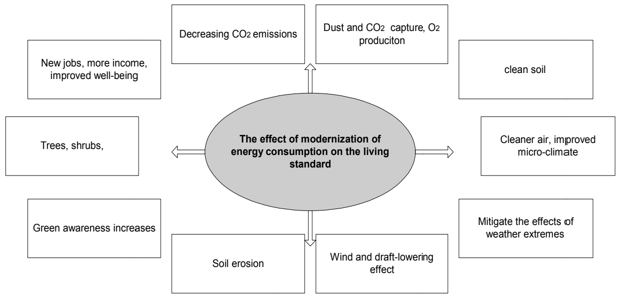
The successful transformation can lead to the creation of new local jobs, reducing the costs of the population, stimulating innovation, saving energy in the long term, etc.




Source: Lukács, 2010

*Figure 3. The Effects of the Use of Renewable Energies*

The impact of energy consumption on the standard of living (mainly caused by the environmental changes) is highly important in my study. Some of the factors can be quantified easily, but some elements are mainly subjective in the measurement of the standard of living.



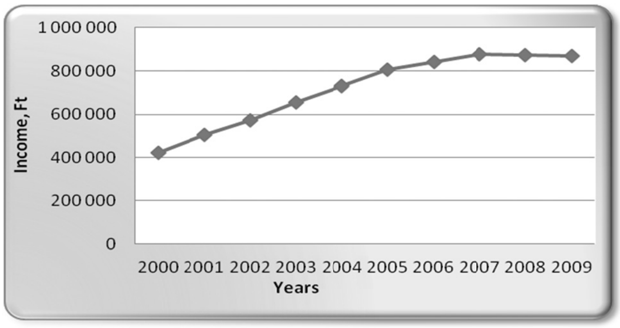

Source: Lukács, 2010

*Figure 4. The Effects of the Modernization of Energy Consumption on the Living Standard*

Naturally the investigation seems to be one-sided but as I mentioned before there is no agreement among different disciplines about the usable methodology. Every person ranks their needs for their standard of living (as important, less important, indifferent), but taking into theoretical consideration the opportunity of changing the habits of energy consumption, the model above is the most practical.

## CONSUMPTION AND FINANCIAL SITUATION OF THE HOUSEHOLDS

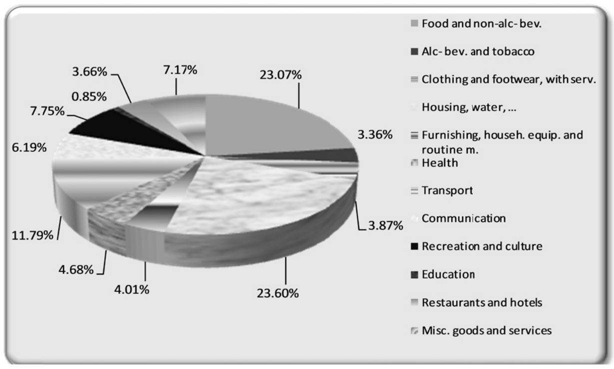
As the data of the Hungarian Central Statistical Office (KSH) show, the monthly net income per capita in Hungary in 2010 was 132,604 Ft, which varies over a wide range in the different sectors. If we examine the data of households given in Figure 5 the income value is more delusive, because many families have to meet their needs with less money than the average. After the millennium the average income increased till 2007 and after that we can see a dropping tendency.




Source: HCSO

*Figure 5. Average Annual Income of Hungarian Households per Capita*

The decline of the average income per capita did not result in the decrease of consumption; rather, the structure of consumption changed. The households gave up unnecessary expenditures (such as luxury, holiday travel, high value items, etc. source: HCSO).




Source: HCSO

*Figure 6. Annual Expenditure per Household, in % (2009)*

The households' highest expenditures in 2009 consist of food, overhead and household expenses (Figure 6). Of the total household expenditures, 23.6% are energy consumption and overhead. Within these costs the proportion of electricity, gas and other fuel consumption is about two thirds.

## THE RELATIONSHIP BETWEEN LIVING STANDARD AND ENERGY CONSUMPTION

The living standard of the population can be examined primarily by the income and labor status, through consumed goods and with other material indicators. Generally in international comparisons our basis can be the GDP per capita or the other indices derived from the national economy indicators. According to Bergh (2009), the usage of GDP to measure the standard of living has been questioned in the last decades, but nobody has stated unambiguously that it is useless, and no justified indices have been created either. Despite the theoretical and empirical criticism the role of GDP in economy, governance, politics and society remains significant (Bergh, 2009).

According to my research aim I have been seeking for the answer: What kind of stochastic relationship can there be between the chosen indicators qualifying and influencing the living standards and the most important energy consumption index?

### *Testing the Relation with Stochastic Analyzing Tools*

During the research I identified the "monthly average gas consumption per one household consumer" as dependent variable, but because of the decrease of heteroscedasticity I logarithmized the dependent variable (see later) and used it in that way for the analysis. The other indicators were involved as explanatory variables as the:

- Net average income (Ft – NET_INCOME)
- GDP per capita (1000 Ft – GDP)
- Gross investment per capita (Ft/capita – INVESTMENT)
- Activity rate (% - ACTIVITY_RATE)
- Environmental investment (million HUF-ENVIRONMENTAL)
- People per 100 housing (person– PEOPLE_PER_HOUSING)
- Regular average number of recipients of social assistance (person – SOCIAL_ASSISTANTE)
- Monthly electricity consumption per household (kWh/month – ELECTRICITY CONSUMPTION)
- Regular waste collection rate of housing (% - WASTE_RATE)

With the support of multiple regression analysis I tried to find the answer to my question: Using the data of the counties of Hungary in 2009, what kind of relationship can be found between the explanatory variables and the dependent variable? As a first step I created a correlation matrix which shows pairwise correlation coefficients. I discovered from the results that the monthly average gas consumption per household mostly correlates with:

- Net income - NET_INCOME;
- Gross investment per capita – INVSETMENT;
- Electricity consumption per household – ELECTRICITY_CONSUMPTION.

To investigate the nature of the relationship of the variables I used the Backward elimination process (Sajtos-Mitev, 2007). In this I involved all the variables into the model which can have logical coherence with the dependent variable. After conducting different tests, just those explanatory variables stayed in the optimal regression model which had a significant relationship with the dependent variable.

As the first step – with the support of SPSS 17.0 – the partial t-test for the parameters of the explanatory dependents are calculated (partial F-probe data is used to test the model):

$$t = \frac{\hat{\beta}_i}{\sigma(\hat{\beta}_i)} \qquad F = \frac{\hat{\beta}_i^2}{\sigma(\hat{\beta})^2}$$

I examined whether the dependent with the lowest „t” (or „F”) value is significant or not:

- if the values of the test function were higher than the function value according to the used significance level, the dependent variable is used in the model
- if the values of the test function were lower than the function value according to the used used significance level, the dependent variable is eliminated, because it has no explanatory power compared to the other variables (Ketskeméty-Izsó, 2005).

The table represented below shows step by step the application of the methodology and the results.

*Table 2*
*Optimal Regression Model*

| Model | Variables Entered | Variables Removed | Method |
|---|---|---|---|
| 1 | WASTE_RATE, ENVIRONMENTAL, SOCIAL_ASSISTANTE, INVESTMENT, ELECTRICITY CONSUMPTION, ACTIVITY_RATE, PEOPLE_PER_HOUSING, NET_INCOME[a] | . | Enter |
| 2 | . | ACTIVITY_RATE | Backward (criterion: Probability of F-to-remove >= 0.100). |
| 3 | . | SOCIAL_ASSISTANTE | Backward (criterion: Probability of F-to-remove >= 0.100). |
| 4 | . | PEOPLE_PER_HOUSING | Backward (criterion: Probability of F-to-remove >= 0.100). |
| 5 | . | ELECTRICITY CONSUMPTION | Backward (criterion: Probability of F-to-remove >= 0.100). |
| 6 | . | INVESTMENT | Backward (criterion: Probability of F-to-remove >= 0.100). |
| 7 | . | ENVIRONMENTAL | Backward (criterion: Probability of F-to-remove >= 0.100). |

a. All requested variables entered.

b. Dependent Variable: LOGGAS

It can be concluded from the Table 2 that the change in the “average monthly consumption of piped gas per household” is determined by the GDP per capita (NET_INCOME) and the regular waste collection rate of housing (WASTE_RATE). So I continued the analysis with these variables.

I tested the assumptions for linear regression models, and I found that the best-fitting model is heteroskedastic, therefore I logarithmized the dependent variable (LOGGAS), which also helped with the assumption of normal distribution (Figure 8). Now, we can observe on the scatterplot in Figure 7 that the variance of residuals is constant, which means the lack of heteroscedasticity after logarithmic differentiation.

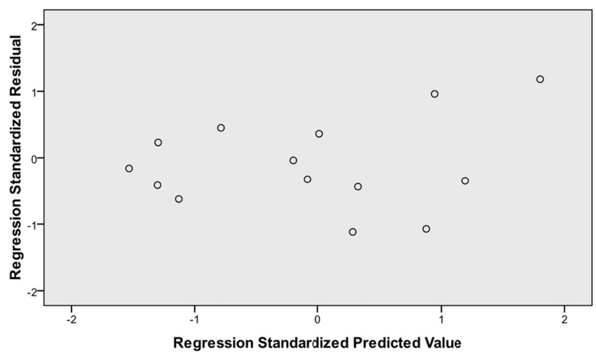



*Figure 7. The Standardized Error Terms According to the Standardized Estimates After Logarithmic Differentiation*

The distribution of residuals is shown by histogram in Figure 8. This shows that the error terms have normal distribution – since the average is close to zero – and the standard deviation is close to 1.

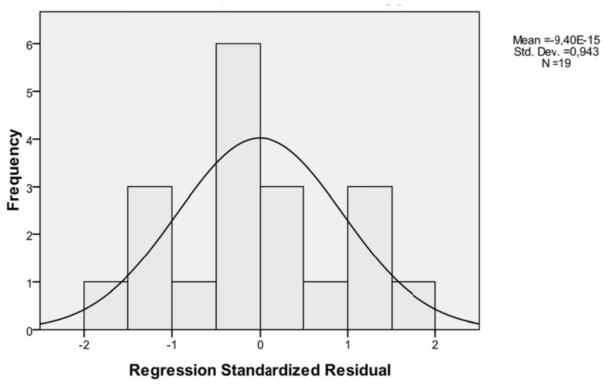



*Figure 8. The Standardized Distribution of Error Terms*

The applicability of the model is supported through the variance inflating factor VIF index of the two explanatory variables (Falus-Ollé, 2008). The results show no multicollinearity, because the VIF results are lower than the critical value of 5 (see Table 5 below). According to a Durbin-Watson test (Table 4), there is no autocorrelation in this model.

Since the assumptions are satisfied, I analyzed the best-fitting model. The test of the regression model was performed by F-test. The results are shown in the ANOVA table in Table 3. The optimal model can be considered as significant because the significance level is under 5% (Sig=0.7%).

*Table 3*
*ANOVA Table*

| Model | Sum of Squares | df | Mean Square | F | Sig. |
|---|---|---|---|---|---|
| Regression | .037 | 2 | .019 | 6.814 | .007g |
| Residual | .044 | 16 | .003 | | |
| Total | .081 | 18 | | | |

Table 4 shows that the value of the multiple correlation coefficient (R) is 0.678. This proves my conclusion (gained from the correlation matrix) that there is a strong relationship between the explanatory variables and the dependent variable, but it is a statistical relationship of just over moderate strength.

*Table 4*
*Model Summary*

| R | R Square | Adjusted R Square | Std. Error of the Estimate | Durbin-Watson |
|---|---|---|---|---|
| .678 | .460 | .392 | .05243 | 1.930 |

The table shows the multiple regression coefficient ($R^2$), which shows that 46% of the total standard deviation can be explained by the regression line. This means that the involved parameters of the model played a great role (46%) in the value of "monthly average gas consumption per one household consumer". This value is relatively low, so we can say that the fit of the regression line is not perfect to the data set. The further steps confirmed that more explanatory variables must be involved into the model for a wholly successful analysis.

As a last step I defined the optimal regression function. Results are shown in Table 5. While the variables chosen – net income and regular waste collection rate – may have an effect on the dependent variable – LOGGAS – the effect is not significant. Other variables with higher explanatory power are needed.

*Table 5*
*Estimation of Regression Coefficients*

| Model | Unstandardized Coefficients | | t | Sig. | Collinearity Statistics | |
|---|---|---|---|---|---|---|
| | B | Std. Error | | | Tolerance | VIF |
| (Constant) | 1.706 | .295 | 5.790 | .000 | | |
| NET_INCOME | 8.571E-6 | .000 | 3.620 | .002 | .823 | 1.216 |
| WASTE_RATE | -.007 | .003 | -2.180 | .045 | .823 | 1.216 |

# CONCLUSIONS

After the past decades it is obvious that the population's energy consumption habits must be transformed. Because of the effect of several economical, social, and environmental factors the costs of public access to energy (mostly by gas consumption) has increased significantly. In our country it is therefore an important objective to raise the share of renewable energy in the energy sector in the most cost-efficient way. The developments of the last decade give notice that households' energy consumption can be optimized, which can include tool modernization, the use of mixed-fuel-firing systems and the use of alternative energy resources. By utilizing these opportunities the direct and indirect improvement of the living standard of the population is possible.

My conclusion regarding the results is the significant need for further research, because the chosen variables may have effect on the dependent variable but it is not significant. As a sequel of this study I will try to involve more variables which can have a higher explanatory power and can comply with all the assumptions. With future research my goal is to examine more deeply the energy consumption habits of households based on the general regional data.

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