International Journal of
Sustainable Energy Planning and Management

Evaluation of the heating share of household electricity consumption using statistical analysis: a case study of Tirana, Albania

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ABSTRACT

Albania's residential sector represents a large share of the country's energy consumption, especially of electric power. Other important characteristics of the sector include a fast growing energy demand and a high level of energy losses, which challenge the possibility of sustainable development. The electricity losses, being 29–52 % of total electricity supplied, consist of both technical and nontechnical losses (theft and unpaid electricity). A large share of the electricity demand is used for heating purposes – a demand that could potentially be met in a more energy-efficient manner. However, the precise portion of electricity used to meet heat needs is unknown. The main objective of this article is thus to determine the share of electricity used for heating in the largest Albanian city.

Based on a sample of households in Tirana, a statistical model is established and applied to perform a regression analysis to derive an estimation of household electricity demand. The heating share of the domestic electricity consumption is then quantified using additional information validated by actual measurements. The distribution of the electricity consumption data is better understood through an analysis of heat-related electricity consumption. Additionally, the monthly relative share of household electricity consumption reveals the number of households with electricity demand above the monthly 300 kWh limit established by the Albanian Energy Regulatory Authority, which, if exceeded, triggers a higher electricity tariff. During 2011, 67% of the sample's households resulted with higher monthly average electricity consumption than this limit, with a slight reduction to 64 % in 2012. It is suggested that household electricity consumption will continue to grow in the near future, due to rising incomes and changing climatic conditions that are influencing the amount of heat used by Albanians, who rely primarily on electricity to heat their homes. This situation has been impacted by the high system losses and high migration rate from rural to urban areas, including emigration abroad, and distorted energy prices. In Tirana County, only 31% of the households use wood for heating, usually due to a lack of electricity.

Keywords:

household energy consumption; regression analysis; heating energy policy.

URL:
dx.doi.org/10.5278/ijsepm.2015.5.2

INTRODUCTION

Albania, a small European country with 2.831 million inhabitants [1], is making every effort to develop its democracy and free market economy. Working towards these goals has not been without its challenges, and the country has faced many barriers and difficulties that

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have affected and influenced this transition. The energy sector is greatly affected by this transition, so it is important to understand the larger Albanian context as it pertains to the complex energy sector.

To better understand Albania's energy situation, it is useful to examine certain economic and energy indicators for the country and the region. Two of these are shown in Figures 1 and 2. These graphs reflect the fact that Albania is a poor country even relative to neighbouring countries, and that it consumes less electricity per capita than its neighbouring countries. However, the figures also reveal that both of these indicators have grown annually since 2006.

The electricity consumption of the residential sector relative to total electricity consumption in Albania is similar to the average of the 27 countries in the EU [8], while in absolute terms (per capita electricity consumption) the Albanian residential sector consumes less power than other EU countries. For instance, among neighbouring countries, the average consumption of the residential sector as a portion of total electricity consumption is 34% for Greece, 48% for Macedonia and 53% for Serbia [9]. The nontechnical losses level explains the difference seen in Albania.

The specific energy sources that comprise the Albanian energy consumption are shown in detail in Figure 3, which reflects a fairly constant ratio of the various energy sources over the past decade [3]. During these past ten years, oil has remained the dominant source of energy, while natural gas has played a very minor role, only representing 0.2% of Total Final Energy Consumption in 2012. National electricity generation has been dominated by hydro power in recent years. Since 1990 until now, Albania has been a net importer of electricity, with the exception of 2010. The net import of electricity for 2011 through 2012 was 42% of total final electricity consumption.

Figure 3 presents the national balance of the final energy consumption by the primary energy sources. The electricity share includes electricity production by hydro power.

To understand which sectors are using energy in Albania, a breakdown of energy consumption by sector in 2012 is shown in Figure 4.

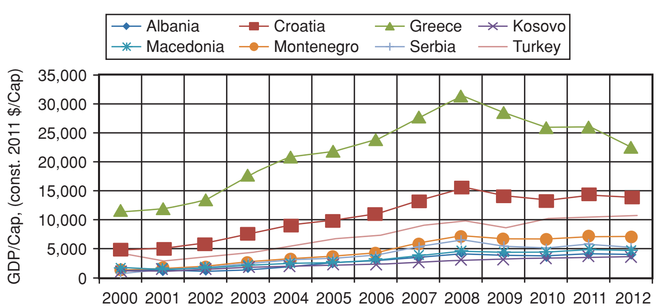

Figure 1: Comparison of GDP/capita for eight selected Balkan countries [2].

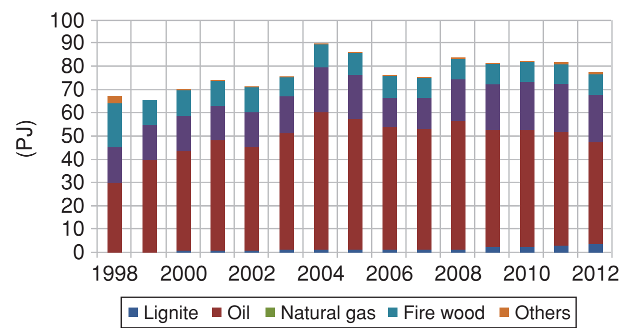

Figure 3: Albanian annual final energy consumption [3].

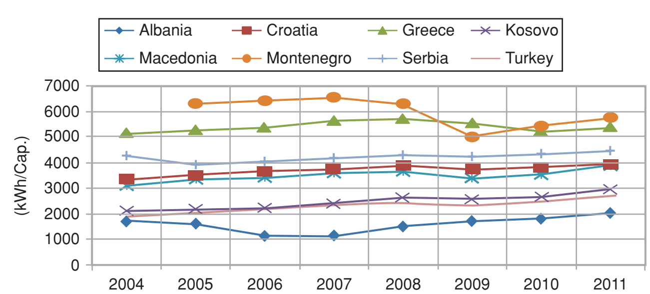

Figure 2: Comparison of per capita electricity consumption for eight selected Balkan countries [2].

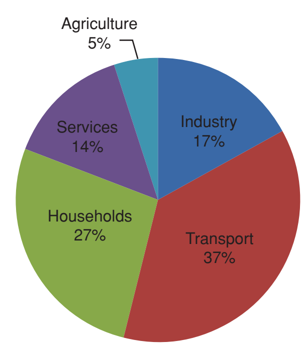

Figure 4: Distribution of primary energy supply on demand sectors in Albania 2012 [4].

As seen in Figure 4, households represent the second largest energy-consuming sector in the country, underscoring the importance of understanding residential energy-use characteristics. In general households in Albania do not have access to a natural gas network, which greatly influences household energy consumption as other types of energy resources are used instead. Electricity is a main source (see next paragraph) while the other energy sources used in Albanian households include wood and propane, but their use is largely limited to rural areas. While propane/LPG is used mainly for cooking purposes, especially in urban areas, wood is used for heating purposes and in industrial thermal processes. The contribution of wood in total energy consumption is estimated to be 10.28%.

The 2012 Albanian electricity production and consumption can be seen in Figure 5. Households in Albania were responsible for 54% of the electricity demand[2], reflecting the heavy reliance on electricity as household energy sources. This was confirmed in a 2011 census [6] of Albanian households, which are indeed responsible for the majority of the nearly 8 TWh of electricity supplied annually [5].

The service sector ranks second with 23% of electricity consumption, followed by the industrial sector with 20%. The agricultural sector only accounts for 1% of consumed electricity [7].

One notable characteristic of Albania's electricity use is the major electricity losses, which amounted to 41% of the total electricity production in 2012 [8]. The electrical losses are due to:

- Technical losses in the high voltage (transmission) network or in the low voltage (distribution) network, due to losses in transformers and power lines;
- Nontechnical losses, which include: non-payment, theft, etc.

The majority of these losses occur in the residential sector.

The losses have remained constant or increased over the years, and no reductions in losses have been seen in spite of the privatisation of the distribution network. Although there is not an annual breakdown for electric power losses, it is accepted that technical electricity losses are 18–20 % [12] – thus; non-technical losses exceed technical losses. This situation of extensive losses has persisted for years, due mainly to the political and economic situation in the country.

In Albania, the success of a transition to a sustainable economy depends greatly on improving the energy sector, and electricity in particular. Two critical indicators reflect the immense need for improvement in the Albanian electricity sector: the mean electricity price in Albania is higher than in some regional countries [10] as shown in the Figure 6; and in certain years Albanians have experienced significant electricity shortages, power failures, and planned power cut offs, up to an average of 3.4 hours/day in 2007 [12].

A better understanding of how electricity is used in Albania, and where improvements could be made, is necessary. The main objective of this article is to help build a better understanding of Albanian electricity use. Based on statistical analyses, this article examines how much electricity is used by households, and how that electricity is used within homes, focusing specifically on heating and domestic hot water use. While the sample

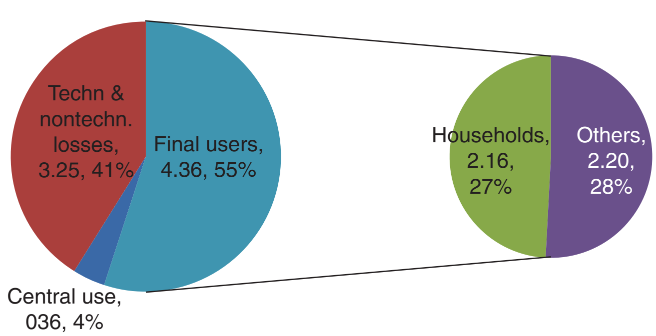

Figure 5: Distribution of the Albanian electricity consumption for 2012. Amounts in percent and TWh. Total production is 7.97 TWh. Central use is on power stations [8].

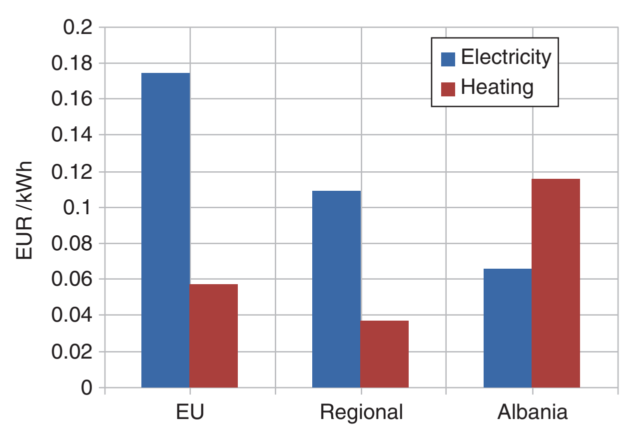

Figure 6: Average electricity and heat prices in 2012 in the EU, Balkan region, and Albania [10].

[2] In 2012, households consumed 2.16 GWh of electricity (paid) plus an estimated 1.95 TWh (unpaid/theft) out of total ex works supply of 4.36 TWh + 3.25 TWh (See Figure 5)

and analyses are derived from data on Tirana, the results are certainly valuable for the country as a whole. Additionally, the methodology used is applicable to other countries as well.

THE SAMPLE

To analyse electricity consumption in Tirana, a sample of 72 urban households was constructed. Monthly electricity consumption was measured for each household, and a calculation of the mean monthly and annual energy consumption was developed over a two-year time period: 2011 - 2012. The sample's households were chosen at random, without impacting individual consumer behaviours. Only households that used electricity exclusively and paid for their own energy use were chosen. During the study period, household electricity prices remained constant. All the sample units were dwellings that lacked insulation, had single-pane glass windows, and were constructed between 1980 and 2010. The average number of dwellers per sample unit was 3.4. For geographical diversity, the sample units were chosen from ten of the in total eleven Municipality Units [13]. The sample did not include units from Municipality Unit 11, owing to its rapid and chaotic development, high informality, high levels of migration, and low rates of employment. It was thus not viewed as a "typical" Municipality Unit of the city.

All of the sample data was reviewed in detail prior to being used in the larger statistical analyses. Two units of the 2011 sample were rejected after being analyzed in detail. One of the rejected units had monthly electricity consumption of zero kWh, while the other had monthly electricity consumption that was not within the realm of expected values. Upon verification, it was revealed that the electricity was used for other purposes. The final valid sample size was reduced to 70 household units for 2011. During the data validation process, specific attention was paid to ensure that the entire sample unit regularly paid their monthly electricity bills. In Table 1 the sample households are shown, distributed by their monthly average electricity consumption in each year.

In both sample years, more households fell into the 300-550 kWh per month consumption category than any other category. Figure 7 shows which of the four categories of monthly electricity consumption during the study period was most prevalent in the sample. The inner ring shows 2011 categorization, while the outer ring shows 2012 categorization.

The first two categories (of smaller consumption) increased by 1% and 2% in 2012 compared with 2011. Meanwhile, the third category saw a reduction of 3% from 2011 to 2012. The fourth category remained almost unchanged. This indicates that the sample household units shifted slightly to the categories of lower average monthly electricity consumption from 2011 to 2012. This is a result of declining incomes caused from the effects of the regional crisis, which were more pronounced in households with lower incomes.

To determine how much electricity was used for different purposes within the sample units, a regression analysis was applied to the sample. This analysis took

Table 1. Nr. of sample households, distributed by monthly electricity consumption, 2011:2012

Month	Distribution (kWh)							
	0–100		100–300		300–550		>550	
Years	'11	'12	'11	'12	'11	'12	'11	'12
January	1	2	11	12	30	27	28	31
February	2	2	17	13	30	30	21	27
March	1	3	19	18	30	29	20	22
April	1	3	19	26	36	33	14	10
May	3	4	21	25	35	27	11	16
June	4	4	25	27	32	35	9	6
July	2	5	27	34	34	26	7	7
August	4	5	33	37	26	24	7	6
September	2	2	30	31	31	31	7	8
October	4	8	17	20	33	32	16	12
November	4	2	16	17	30	34	20	19
December	3	2	10	14	29	33	28	23

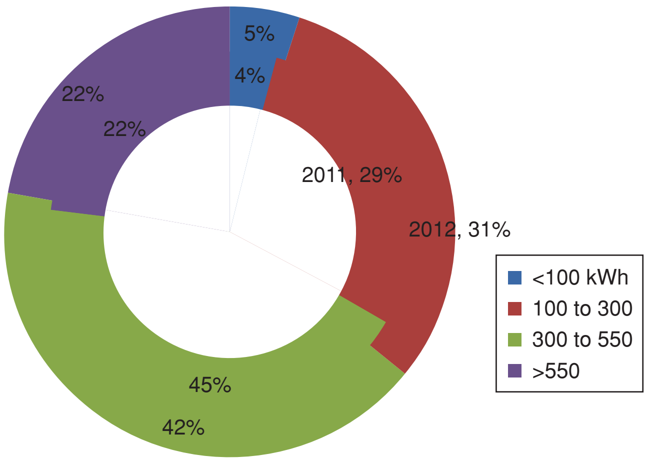

Figure 7: Relative frequencies of monthly electricity consumption by category, 2011:2012.

into account the three major uses of electricity, examining 1) space heating; 2) domestic hot water (DHW); and 3) lighting and other appliance and service-related uses, such as refrigerators, electronic devices, cooking uses, washing machines, and miscellaneous uses. Of the three major uses identified, the first two were determined to be the most important and the most in need of analysis.

The share of total household electricity consumption attributable to space heating was evaluated using data on hot domestic water consumption and additional analysis of the monthly average electricity consumption collected in the sample. Basic electric power meters were used to measure the electricity used for domestic hot water. The electricity used for lighting was derived by applying an accepted percentage to the total monthly consumption, while the electricity used for the refrigeration, appliances, and services mix was analysed as a constant based on consumption for May, a month in which there would be no electricity use for either heating or cooling.

THE MODEL

In general, household energy consumption is well studied. Emphasis on the energy use of individual households often focuses on efforts to reduce individual household consumption, and policies and programs that can reduce greenhouse gas emissions associated with household energy consumption. Despite the long history of household-level consumption analysis, households are complex energy users, and different cities, regions, and countries require different models to reflect and analyse energy consumption factors that are unique to certain regions or people.

New models are also needed in order to assess the impact of energy efficiency and renewable energy programs and the adoption of related technologies suitable for residential applications. Different models rely on different techniques and inputs, and different assumptions and scopes. Of course each model has its strengths, weaknesses, and explicit purposes, yielding results with varying relevance and applicability to different household sectors. A good analysis of these various models is given in [14].

For household energy consumption, income and price elasticity have been studied very well. Household energy consumption is viewed as a function of seven so-called energy functions: space heating, water heating, lighting, refrigeration, cooking, cleaning, and other services [15]. Demand derived from each of these functions is determined by a set of driving factors. Considering the electricity price as an important driver for energy policy, one study [16] has shown the influence of energy prices on domestic electricity demand elasticity. The main objective of the paper [17] is to show electricity end uses and the influence of low income family on their consumption. Other studies have included the other factors. Based on these studies, it is accepted than the energy consumption for heating is proportional with heating degree days (HDD) [18]. The other factors that influence energy consumption are: the number of occupants, home characteristics, energy efficiencies, etc [19].

Some recent studies take into account the critical influence of human behaviour, and some focus on energy consumption within urban households due to high levels of energy consumption, as discussed in [20,21]. A rather different treatment of household energy consumption is explored in [22], where the "neural network" method was shown as capable of accurately modelling residential end use energy consumption. Importantly, most studies have been converging on a model that finds household energy consumption to be highly dependent on household incomes, energy prices, home size, and local urbanization rates [23]. In this case the function of energy consumption is generally expressed by:

$$\ln E_t = a_0 + a_1 \cdot \ln I_t + a_2 \cdot \ln P_t + a_3 \cdot U_t + \varepsilon_t \qquad (1)$$

where: E_t is the residential electricity consumption, in kWh per capita; I_t is the real income per capita in EUR, generally found as GDP per capita; P_t is the real electricity price in EURO/ kWh; and U_t is the urbanisation rate (in percentage of total population residing in urban areas); coefficients a_1, a_2, a_3 are the constants, being respectively $a_1>0$, $a_2<0$, $a_3>0$; ε_t is residual.

The above model and others like this analyze the household energy consumption from an economic point of view, determining the energy burden for each family. Economic models depend primarily on the relevant factors given in equation (1), but also on other parameters, such as weather conditions, number of new buildings, equipment, and building ownership (using historical data, *etc*). However, these models do not consider all the influencing factors, because the factors not only affect the energy consumption of residential buildings significantly, but they also interact and interconnect with each other. The proposed model [24] is based on total of 19 selected indicators, analyzing the correlations between the known energy consumption and each indicator.

Technical models are related to all the energy appliances. In this context the household energy consumption is expressed as the sum of final energy consumed by this household for energy use services: space heating, water heating, lighting, refrigeration, cooking, cleaning and other services. From these functions, some of them are less important, especially concerning their variations. The results [25] show that four of them need to be monitored and viewed as the most important factors. Apart from the energy used for space heating, the energy used for DHW is one of the most important energy functions as it has been analyzed in detail through Residential End Use Model (REUM) [26]. A general linear model with two variables is used to analyze the electricity for space and water heating [27]. The household energy consumed by refrigeration can be accepted as constant because compressor technology has had a great effect on the performance and economy of domestic refrigerators [28]. Although the lighting energy usage in residential dwellings is a function of more variables, as shown in study [29], its relative annual variation is small. For this reason it can be considered as constant as well, in addition to the rest of the so called energy factors. Assessing energy consumption in households, by relying on this technical model, will help analyze and predict energy demand; increase energy efficiency; increase the use of renewable energy, and also determine the maximum electricity demand.

Drawing from the economic model, and based on the model described in [14], this study's proposed model has the following basic form:

$$E_t = E_h + E_{h,w} + E_l + E_{mx} + \varepsilon_t \tag{2}$$

In equation (2): E_t is the monthly average electricity consumption during the year; E_h is the electricity used for heating; $E_{h,w}$ is the electricity used for DHW; E_l is the electricity used for lighting in the household; and E_{mx} is the electricity used for other appliances in the household. The model is a linear equation, yielding an average monthly electricity consumption expressed in kWh. It does not consider variations in monthly energy consumption attributable to the other appliances. Hence the fourth term in equation (2) is accepted as constant. In equation (2), the first three variables are proportionally dependent on heating degree days (HDD), which are implicated in the electricity consumption. In matrix form, equation (2) can be expressed in this form:

$$\begin{pmatrix} E_1 \\ E_2 \\ \dots \\ E_{12} \end{pmatrix} = \begin{pmatrix} Y_{1,1} & Y_{1,2} & Y_{1,3} \\ Y_{2,1} & Y_{2,2} & Y_{2,3} \\ \dots\dots & \dots\dots & \dots\dots \\ Y_{12,1} & Y_{12,2} & Y_{12,3} \end{pmatrix} \cdot \begin{pmatrix} 1 \\ 1 \\ 1 \end{pmatrix} + \begin{pmatrix} C_1 \\ C_2 \\ \dots \\ C_{12} \end{pmatrix} + \begin{pmatrix} \varepsilon_1 \\ \varepsilon_2 \\ \dots \\ \varepsilon_{12} \end{pmatrix} \tag{3}$$

In the equation (3), E_i denotes total average monthly electricity consumption; $Y_{i,1}$ denotes electricity consumed for heating; $Y_{i,2}$ denotes electricity consumed for DHW; and $Y_{i,3}$ denotes electricity consumed for lighting. The remaining terms are considered to be constants. The last term is the residual value and its value is set 0. Index **i** denotes the respective month, ranging from i=1 for January to i = 12 for December; **j** is used for components of monthly electricity consumption, with j = 1 for heating, j = 2 for DHW and j = 3 for lighting ones.

This model takes into account the weight of the factors mentioned before, including electricity used for DHW, which is determined by analysing real-time measurements of the energy consumption made at the inlet of electric supply for the boiler. So ($Y_{i,2}$), representing electricity attributable to DHW, is developed by elaborating on the data shown from the measurements. For electricity attributable to lighting, ($Y_{i,3}$), the energy consumption is developed by using a pre-defined share of the total household consumption, which is 10%. The proposed model is better to use when electricity is mainly used for space heating and DHW as well.

The weather-related values for the constant column (C_i) are determined by monthly consumption data, where the HDD and cooling degree days (CDD) are equal to 0. According to equation (2), by measuring the electricity consumption for DHW and accepting the value for lighting and for the service mix, the average monthly electricity consumption used for household space heating can be determined.

THE RESULTS

The sample and focus area of Tirana County has household electricity consumption that mirrors that of the country as a whole, representing 34.3% [30] of Albania's total electricity consumption. This again underscores the importance of focusing on electricity use in this sector. Prior statistical analyses performed for this function, as well as for the other functions, have demonstrated the difference between average and median as estimators. Based on the regression analyses of the sample under this study, the average and the median of the monthly electricity consumption were derived. While the analyses and conclusions were based on the average estimator, the median was also taken into account. For both study years, the median values were lower than the average values for the monthly electricity consumption. Using the derived average and median values for the sample units in this study, a histogram was developed, right asymmetric, reflecting the fact that the median value is lower than the average.

Aiming to more clearly understand the electric energy consumption in an average household, more attention is paid to the average than the median. The resulting findings reflecting the average monthly electric energy consumption are shown in the following Figure 8.

Figure 8 shows the monthly average electricity consumption for one household within the sample of the Tirana urban area, during years 2011 and 2012. The average annual electricity consumption for one household from the sample can be seen in Figure 9.

The Figure 9 shows an increase of 7% in the average annual electricity consumption from 2011 to 2012 for the selected sample. The 7% increase in electricity consumption can be explained mainly due to the rising quality of life and from the noted variations in the number of HDD. The annual number of HDD is dependent upon

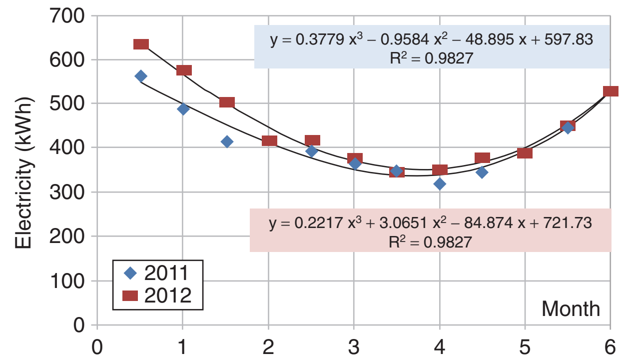

Figure 8: The monthly average electricity consumption for a household, 2011 and 2012.

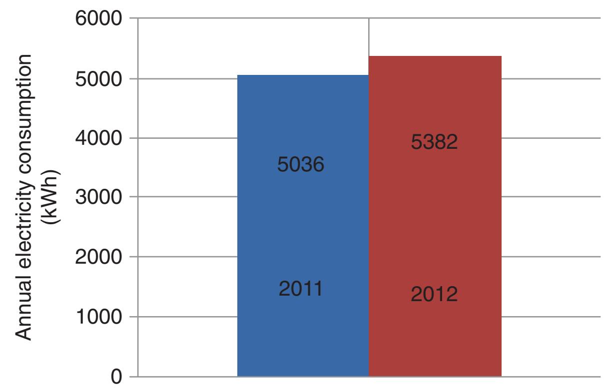

Figure 9: Sample's average annual electricity consumption for a single household, 2011–2012.

average monthly temperatures, which directly influence household heat-related electricity consumption. The HDD values and definition for the Tirana district (Ura Tabakeve station) are based on the international standards, mainly from the EU, referring to the standard temperature of 15 degrees Celsius. The variation of the HDD and CDD for a 10 year period is taken into account. Referring to equation (2), the monthly average temperature is the variable for the two first elements E_h and $E_{h,w}$, as well. Additionally, reflecting the warming and changing Tirana weather climatic conditions, annual household total energy consumption has begun to be influenced by the number of CDD as well. There is no reliable data on the use of air conditioners in apartments for cooling purposes, but a qualitative assessment can be made if the data reflects an average change of electric power demands in the Albanian power system. Based on the data it seems that the power on the summer-time period has not been reduced, but has in fact increased. If the average power rate in August compared with June 2007 was 0.88, in 2012 this ratio reached in 1.094, based on annual reports of the ERE. A similar analysis can be done to observe the average monthly consumption values for the sample. This trend will likely be more evident in the near future, when heat pump systems begin to dominate many households and other factors change heating and cooling choices.

A goal of this work was to understand how much electricity consumption within a household might be contributable to heating activities. Analysing just the average annual electricity consumption for a household, even if normalized per square meter, would not reveal a full picture of heat-related energy use. Such an indicator would not be useful because electricity attributable to space heating is not apparent and is a factor of many variables in addition to just a household's energy use.

By using equation (2) it is possible to determine the electrical energy consumption attributable to space heating uses. The two other equations, addressing DHW and lighting respectively, are needed.

Households in the sample have electric boiler systems that provide DHW. The energy consumption in households attributable to DHW varies within each month and within each annual period. A representative variation in monthly electricity consumption by one DHW system can be seen in Figure 8. The data are based on measurements taken during monitoring activities in the sample households. The period of the DHW electricity energy measurements was from December 2010 to March 2013. As can be seen, less electricity is used to produce hot water in the warmer summer months than in cooler and colder ones. One important factor to consider in DHW use is water supply. The household sector of Tirana does not yet have access to an uninterrupted fresh water supply. Hence DHW system tanks hold 24 hours worth of water to ensure satisfactory supply. They are cold-water tanks with capacity ranges of 0.5-5 m^3, which discharge to indoor electric boilers. However, the model does not consider the influence of solar radiation on the fresh water temperature in the tank. Fresh water temperature is thus assumed to be constant. The parabolic equation, given in Figure 10, shows that DHW electricity consumption depends on the outside temperature and human behaviour.

The electricity consumption in households attributable to lighting varies each month during the annual period. This variation is given in Figure 11, and is probably best explained by the increased hours of sunlight during the summer and adjacent months.

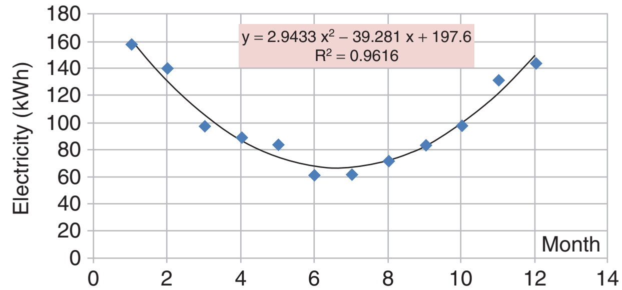

Figure 10: Average monthly electricity consumption by DHW system (one unit, 2012).

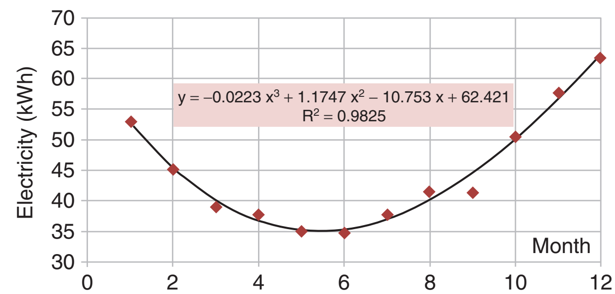

Figure 11: Average monthly electricity consumption attributable to lighting (one unit, 2012).

By comparing the annual electricity consumption for single households in absolute terms, it is evident that electricity used for DHW is the single biggest use within a household, confirming its important role in any analysis of the residential sector. In this specific case, energy attributable to cooling during the summer months is not considered. Therefore, for Tirana and its specific climate, electrical energy attributable to DHW is the main variable in household electricity consumption, and comparable to the amount of electricity consumption attributable to heating. The variation range between maximum and minimum of this component, in absolute terms is 96.4 kWh in 2012. A different discussion could be done concerning the peak power demand, where the space heating and cooling are determining factors.

The calculation to derive electricity consumption attributable to DHW for one family during the 2012 heating season is given in equation (4) below:

$$\frac{E_{h,w}}{E_t} = 0.0004 \cdot x^3 - 0.0033 \cdot x^2 - 0.82 \cdot x + 0.2801 \quad (4)$$

Equation (4) expresses $E_{h,w}$ in relative terms. It is obtained by dividing the DHW monthly electricity consumption by the average monthly electricity consumption for a single household. As in other cases the "x" refers to the month. It is interesting to notice that the polynomial exponent is greater than 1. This reflects the fact that energy consumption for DHW cannot be considered a constant and instead depends on the outside air temperature and human behaviour.

By turning our attention specifically to the 2012 heating season, and considering the existing model, it is possible to determine the electricity used for heating and its share for a single household in Tirana. Figure 12 presents the average monthly electrical energy used for heating during the 2012 heating season. In this Figure 1 stands for November, 2 for December, etc., until 5 for March.

The heating season for Tirana spans 5 months (from November until March), and the estimated function for the heating-related electricity is applicable only for this heating period. The presence of a maximum is acceptable and in line with the climatic conditions of Tirana city. The estimation of the electric energy used for seasonal heating by a single household is 1,164 kWh, calculated by adding together the average heating-related electricity consumption for the five relevant months. As a measure of a household's total annual electric energy consumption, the share of the electricity attributable to heating was 21.63% for a single household unit in Tirana during 2012. A breakdown of the annual average electricity consumption for a single household in relative and absolute terms is given in Figure 13.

In relative terms, the electric energy used to heat a single unit in the urban Tirana area can be expressed by the estimated regression function:

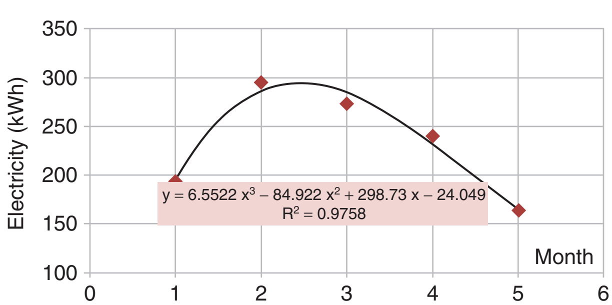

Figure 12: Average monthly electricity attributable to heating only (one unit, 2012).

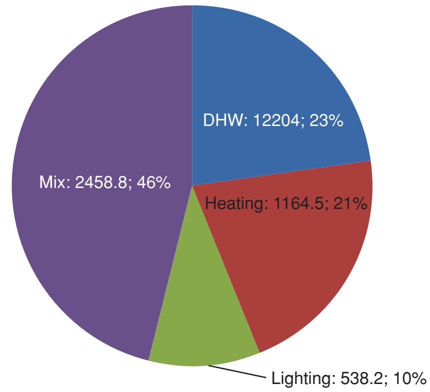

Figure 13: The breakdown of absolute and relative annual average electricity consumption for single household, 2012 (in kWh and in %).

$$\frac{E_h}{E_t} = 0.0006 \cdot x^3 - 0.0358 \cdot x^2 - 0.202 \cdot x + 0.1985 \qquad (5)$$

Equation (5) expresses E_h in relative terms. It is obtained by dividing the monthly electricity consumption for every month during the heating period, by the respective average monthly consumption of electricity for a single household. It is a trendline, yielding a $R^2 = 0.9994$. The high value of R^2 shows that the cubic model expressed in function (5) explains 99.94 (%) of the observed variation in $\frac{E_h}{E_t}$.

The extent to which the points in the sample shown in Figures 9, 10, and 11 deviate from the estimated line, suggest a very small value for the estimate of the variance σ^2 of the random error term.

There are several caveats and considerations to remember when considering these proposed functions. While Figure 12 does not reflect that intra-month variation of electric power supplied to heating systems during the heating season, it is still important information for the demand- side management (DSM) programs and efforts. As discussed in other cases such as [31], the monthly results derived can be used to help predict the impact of DSM programming in the residential sector in the first Albanian climatic zone, where Tirana is placed. Equations (4), (5) can be used for the other cities aiming to determine the share of the heating and/or DHW electricity consumption, if total monthly electricity consumption information is known.

Due to the sample households' location within the Albanian climatic zone, and as a result of other factors, household-scale heat pumps are expected to dominate future heating infrastructure investments. Assuming fast penetration of these heat pump systems, the previously described model would be useful for future energy planning. On the other hand, annual increases in electric energy demand have also been influenced by an increase in cooling demand. While cooling demand has not been an important factor in this study or in analyses of electricity use in the past, its importance will increase in the near future. Considering the electricity use profiles of the sample in this study, a combination of a heat pump and a solar thermal system, combined with household thermal insulation, would be an optimal and energy-efficient system design. Many countries in Europe offer examples of how to sustainably meet individual buildings' heating needs. In particular, district heating systems could potentially offer sustainable solutions for both space heating and domestic hot water [32].

CONCLUSIONS

Using a statistical model and an analysis of actual electricity consumption at the household level, an analysis of its findings yields some important conclusions that could influence energy policy design and future research relevant to electricity consumption patterns in the Albanian climatic zone. These include:

1. The annual electric energy consumed by one household in the urban Tirana area during 2012 is estimated to be 5,382 kWh, with a relative growth of 6.86% over 2011 consumption. This year-over-year rise is perhaps explained by an improving quality of life and changing climatic conditions and resulting human behaviour.
2. The proposed model can be used to undertake future energy research and to understand the influence of economic conditions on electricity consumption and vice versa. This model can help inform scenarios designed to model the impact of DSM programs, as it adequately considers the electricity consumption attributable to the operation of household-scale heat pumps. Penetration of heat pumps with the average value of COP 2-3, will help reduce peak power demand in winter, but it is expected to increase annual energy consumption by 10% and power demand in summer as well.
3. On average, the electric energy used for heating during the 2012 heating season in Tirana represented 21.63% of a household's total annual electric energy consumption.
4. The results of the model show that electric energy used for domestic hot water is the largest single electricity use among households, representing the biggest share, at 22.7%, of total electricity consumption. This suggests that the impact of higher penetration of solar panels for domestic hot water would make a very measurable impact on net domestic electricity consumption.

A policy and technical approach that considers how to more sustainably address three critical areas of energy use in Albania will be more likely to see success and increase the sustainability of Albania's energy use than an approach that fails to address these issues. These three areas are:

a. Sustainably meeting space heating needs,
b. Sustainably meeting domestic hot water energy needs, and
c. Giving priority attention to improving individual building insulation.

Albania's energy challenges can be viewed as opportunities to respond to the country's changing economic and climatic conditions with smart choices that provide Albanians with reliable and sustainable energy services.

NOMENCLATURE ABREVIATIONS

EU:	European Union
GDP:	Gross Domestic Product
Cap.:	Capita
toe:	tonne oil equivalent
HDD:	Heating Degree Days
CDD:	Cooling Degree Days
DHW:	Domestic Hot Water
DSM:	Demand Side Management
COP:	Coefficient Of Performance

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