

Biomass consumption in residential sector of Ukraine in 2007–2016

Viacheslav Antonenko^{1,*} and Sofia Levinska²

¹ Researcher, PhD student, Institute of Engineering Thermophysics of NASU, 03058 2a Marii Kapnist str., Ukraine

² Lead engineer, Master's degree, Scientific engineering center "Biomass", 03058 2a Marii Kapnist str., Ukraine

Abstract. Residential sector plays a decisive role in the bioenergy sector growth in Ukraine. Larger half of biomass used by households comes from so-called self-production, which is problematic for the statistical monitoring. State Statistics do not publish detailed fuel mix reports on regional level. In this article we are providing a detailed data on fuel mix used by the households at regional level during 2007–2016 and determine the biofuel self-production amount. The facilities that are direct emission sources and are the final fuel consumers, including individual heating/hot water boilers/stoves out of district heating system and individual cookers are considered in detail.

1. Introduction

According to the International Energy Agency, in preventing the global temperature increasing on the Earth more than to 2°C, concerning to the preindustrial period, the most important role in reducing CO₂ emissions in the period up to the 2050 will be playing energy efficiency (40%) and renewable energy (30%). Determination of the biofuel self-production amount in households at regional level concerns both and that's why is actual nowadays.

According to the Energy Strategy of Ukraine until 2035 [1], Ukraine is going to reduce fossil fuels consumption and increase the share of renewable energy sources in the total primary energy production from 4,4% (in 2017) to 25% (in 2035). In recent years, biomass sector has accounted for about 80% of renewable energy in the country and is based mainly on utilization of woody biomass in heat generation: wood logs and wood pellets mostly for population and district heating, wood chips and residues mostly for industrial purposes, public heating and power production [2]. However, the Ukrainian corn stover has relatively high ash melting temperature defusing requirements for the boiler additional systems and steel quality. As a result, the Ukrainian corn stover potentially may be used within wood-fired boilers [3,4].

2. Objectives of the project

In recent years, a biomass consumption in Ukraine shows a rapid growth. Analysis of similar data for the period of 2010–2016 shows that the average growth rate of the bioenergy sector in Ukraine is 35% per year by the indicator of the "total supply of primary energy from biofuels and waste". For example, the total supply of primary energy from biofuels and waste was 3,046 ktOE in 2017 (against 2832 ktOE in 2016) [5]. And residential sector plays a decisive role in this growth: the final biofuel consumption of households was 1,506 ktOE in 2016 (against 1,097 ktOE in 2015). Larger half of biomass used by households comes from so-called self-production, which is problematic for the statistical monitoring. Furthermore, there are large differences between regions in the fuel mix. However, the State Statistics do not publish detailed fuel mix reports on regional level. The differences are related to mix of causes e.g. gas pipe network availability, coal and peat deposits, forest cover, population density, urbanization level, income level etc.

Therefore, the objective of the present paper is to provide a detailed data on fuel mix used by the households at regional level during 2007–2016 and to determine the biofuel self-production amount. The present study is focused on the facilities that are direct emission sources and are the final fuel consumers. That include individual heating/hot water boilers/stoves out of district heating system and individual cookers.

^{1*} Corresponding author: viacheslavon@gmail.com

3. Methodology

The main data source of the present study is the State Statistics of Ukraine. The statistical office collects and process data on the gross final energy consumption. The monitoring covers 41 different fuel types and refinery products. These fuels are divided into 4 groups: coal (including peat); oil refinery products; natural gas; biofuel and waste.

The required data on specific fuel consumption in different subsectors on regional level can be found in statistical reports available by Request for Information only, namely:

- Report on Remains and Usage of Energy [6] (hereinafter, - 4-MTP) and
- Households Living Conditions Survey [7] (hereinafter, - HLCS).

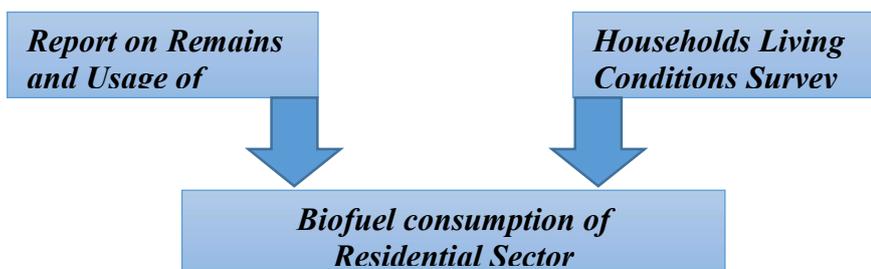


Fig. 1. Data Flow Diagram

The Statistical Survey by Form 4-MTP applies to business entities of all types of economic activity, regardless of size, organizational and legal forms of management and subordination, which use and have in the balances energy materials and products of oil refining [8,9]. All indicators are based on the data of the primary documentation and accounting. The 4-MTP include data on the volumes of fuel sold to population by enterprises and organizations to satisfy their household needs. However, in reality population (residential sector) utilize more biofuels and wastes than reflected in standard 4-MTP statistical form. The substantial portion of this biofuels is coming from so-called “self-production” or “self-procurement” performed by the households themselves. The fuel self-production volumes are based on data from the HLCS.

3.1 Self-production Methodology Extensive Description

In rural settlements many people are searching for cheap and available firewood due to poverty. Many of them are involved in self-production of firewood. In order to estimate the self-production amount the State Statistics uses specific mathematical model developed on the basis of statistical sampling.

The HLCS is based on generally accepted international standards and corresponds to the current socio-demographic and economic situation in Ukraine [10].

The methodological foundations for the sample formation are given in the documents [11,12]. The HLCS is carried out on a separate network of respondents (non-institutional (private) households). The volume of the annual sample of households for the survey in 2014–2018 is 13,029 households.

3.2 Extrapolation (dissemination) on the general population

For the dissemination to the entire population of Ukraine (except temporarily occupied Autonomous Republic of Crimea and Sevastopol) the statistical weights are used. The statistical weights are taking into account the probabilities of including the households into the sample and the actual level of participation in the survey, coordination of the survey results with external data, including the data of demographic statistics (number, sex and age structure of the population, according to social statistics on the number and placement of the population, etc.).

3.3 Data Quality

In the analysis of the quality of The HLCS data, the replicate method of balanced repeat replications (BRR) is implemented, which is calculated in the standard WesVarPC program package [13].

Relative standard error (RSE) is often used as an indicator of data suitability.

- $RSE \leq 5\%$ - then the score is considered reliable;
- $5\% < RSE \leq 10\%$ - evaluation is suitable for quantitative analysis, but its reliability not high enough;
- $10\% < RSE \leq 25\%$ - the assessment is suitable only for qualitative analysis and should be used with caution.

In general, for the regional level, the accuracy of the assessments of the indicators under consideration is satisfactory. For 13 regions out of 26 regions (which comprise 60% of population and 50% of territory), the relative standard error of the sampling does not exceed 5% (for all indicators), that is, the estimates are reliable. In other regions, the relative standard error of sampling for all indicators does not exceed 10%. In general, survey data can be used for statistical analysis at the regional level.

4. Results and discussion

4.1 Standard statistics

Household natural gas consumption shows a stable pattern, explained by the price of gas for households in real terms being almost constant from 2008 until 2013. However, between 2013 and 2016, total gas, coal and oil consumption decreased dramatically (See Fig. 2).



Fig. 2. Residential Fuel Mix of Ukraine 2007–2016

The key drivers of this decrease are the loss of control over 46.2 th. m² of the country’s territory (7%), 6 million people (13%) and 20% of GDP. At the same time, households experienced a 119% weighted average USD increase in the tariffs for natural gas while simultaneously experiencing a decline of average per capita income of almost 50% [14]. As a result, the hitherto relatively constant Ukrainian household consumption of natural gas has declined in 2016 by some 31% (from the 2013 level) (-4,228 ktoe), coal consumption shows 62% decline (-456 ktoe).

Since natural gas prices for households raised (up to 70% of the market level), a large share of gas consumers are no longer able to pay bills with new price of natural gas. Therefore, biomass-to-energy utilization became one of the economically reasonable alternative for heat supply of households. The biomass consumption pattern supports the judgement. While consumption of other fuel types show decrease in 2014–2016, the biomass consumption of households increased by 51% for mentioned period (+500 ktoe) regardless military action and statistical data gap (See Fig. 3). Thus, the share of biomass in total final fuel consumption of households increased from 8.1% in 2014 to 13.5% by the end of 2016 (excluding district heating and electricity).

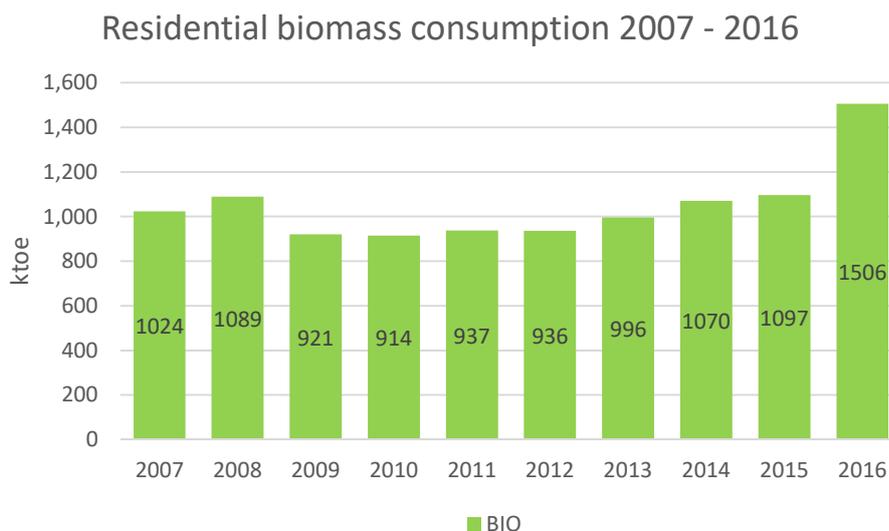


Fig. 3. Residential Biomass Consumption of Ukraine

4.2 Self-production

Along with firewood, a self-production of peat and coal takes place. However, according to data of previous observations the dominant fuel type is woody biomass (own expert judgment suggests that >95% of total self-production comes from biomass). Thus, self-production of the coal and peat may be neglected.

Since 2009, the biomass self-production demonstrates dramatic growth from 555 to 1,145 ktoe/yr corresponding to 62% - 76% of total biomass consumption of the residential sector (**Fig. 4**).

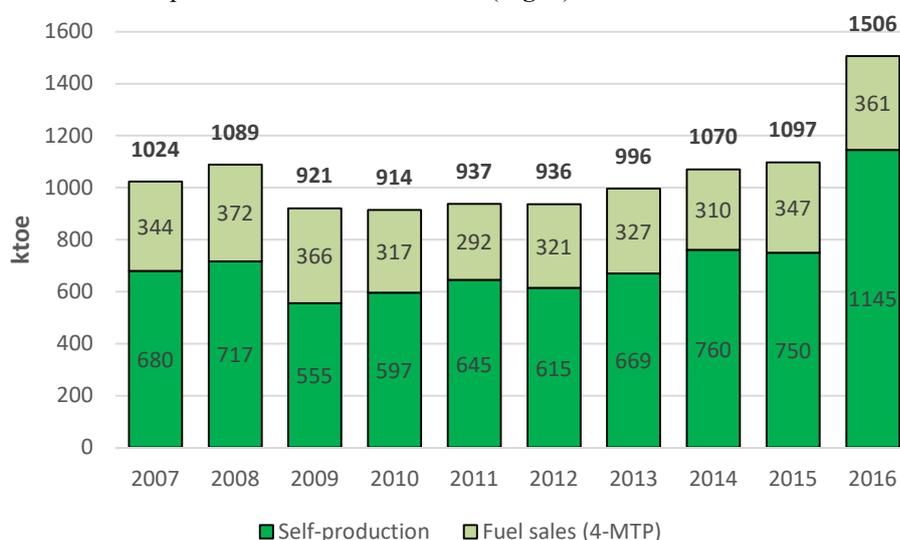


Fig. 4. Final biofuel consumption by households 2005-2016

Noteworthy, that in 2016 a considerable growth of self-production (+70%) coincided with gas consumption drop (-31%) comparatively to 2013 despite the data gap from occupied Donbass and Crimea.

Despite the biomass growth, natural gas remains the most common fuel for each region. However, biomass covers remarkable share in some forest-rich regions: Chernivtsi (32%), Chernihiv (29%), Zhytomyr (28%), Rivne (21%) etc. (**Fig. 5**). On the other hand, the coal mining regions show high coal consumption rates: Luhansk (34%), Donetsk (19%).

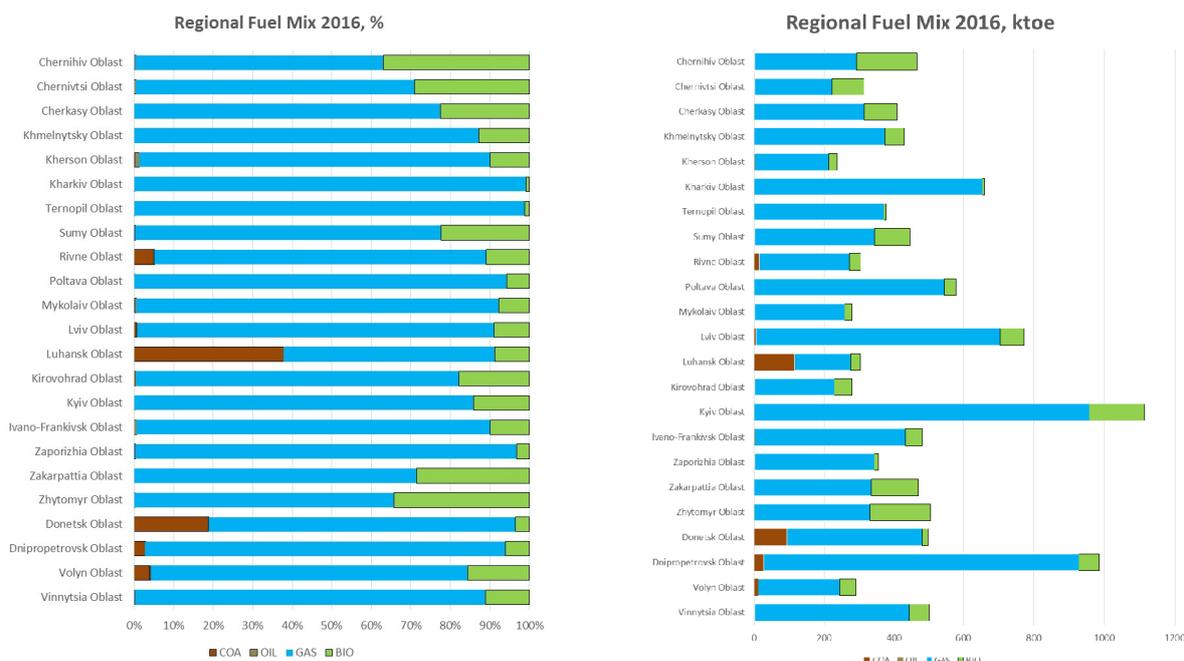


Fig. 5. Regional Fuel Mix*

* Biofuel breakdown is based only on 4-MTP "Fuel Sales" regional distribution factors. Assume the biomass self-production is around 70% (differs each year) of every region due to no details on the regional level.

At the same time, 6 regions: Zhytomyr, Kyiv, Sumy, Cherkasy, Chernivtsi, Chernihiv consume more than 52% of biofuel in residential sector of the country.

5. Conclusions

The paper gives a detailed review on fuel final use in the residential sector of Ukraine during 2007–2016 years at the regional level based on official statistical reporting. It gives a clear picture of Residential Sector final energy consumption record for the period 2007–2016 with deep breakdown by the fuel type on regional level.

The study shows that a self-produced biofuel is a main biomass source for residential sector of Ukraine. Biofuel self-production reached a menacing level providing 76% of total biofuel consumption of households. And this activity is illegal and problematic for control and monitoring. Therefore, a stricter control of biofuel procurement and trade may be needed.

References

1. International Energy Agency World Energy Outlook Special Report 2015: Energy and Climate Change
2. National Renewable Action Plan till 2020 in force since 1 October 2014 (Decree of Cabinet of Ministers # 902-r)
3. V.O. Antonenko, V.I. Zubenko, O.V. Epik, Fuel Properties of Ukrainian Corn Stover, *Industrial Heat Engineering* **40**, No3 // ISSN 0204-3602 <https://doi.org/10.31472/ihe.3.2018.11> (2018)
4. V. O. Antonenko, Fuel Properties and Fertilization Cost of Ukrainian Corn Stover, *Proceedings of CYSENI 2017*, May 25-26, Kaunas, Lithuania. ISSN 1822-7554 (2017)
5. State Statistics Service of Ukraine <http://www.ukrstat.gov.ua/>
6. Report on Remains and Usage of Energy And Oil Recycling Products (Form 4-MTP (Annual), Table 3), State Statistics of Ukraine. Confidential.
7. Households Living Conditions Survey, State Statistics of Ukraine. Confidential
8. Instruction on filling in the form of state statistical observation № 4-mtp "Report on the residual and use of energy materials and products of oil refining", approved by the order of the State Statistics Committee of 15.09.2008 number 331 and registered with the Ministry of Justice of Ukraine 10.10.2008 for № 959/15650 .
9. Methodological Provisions From The Organization Of Public Statistics Observations On Use Fuel And Energy. Approved Order of the State Committee Statistics of Ukraine 03.10.2011 number 250.
10. Expenditure And Resources of Households Of Ukraine in 2015 Year. Methodological Explanations. State Statistics
11. Methodological Provisions on Statistics. Volume 2. State Committee of Statistics of Ukraine. - K. : ICC of the State Statistics Committee of Ukraine, 2006. - p. 456-483, p. 497-525.

12. Methodology For The Formation Of Sample Communities For Conducting Sample Surveys Of The Population (Households) In 2014-2018: Living Conditions Of Households, Economic Activity Of The Population And Agricultural Activity Of The Population In Rural Areas. State Statistics Service of Ukraine. - K. : 2013. - 204 p.
13. Methodological Position To Preparation Of Standard Reports On The Quality Of Government Sample Surveys Of The Population (Households), Approved By The Order Of The State Statistics Committee Dated 05.06.2008 No. 178 (With Amendments Approved By The Order State Statistics Service As Of 01.01.2017 № 107)
14. The Ukrainian residential gas sector: a market untapped ISBN 978-1-78467-060-3.
<https://www.oxfordenergy.org/wpcms/wp-content/uploads/2016/07/The-Ukrainian-residential-gas-sector-a-market-untapped-NG-109.pdf>