SOCIAL, ECONOMIC AND ENVIRONMENTAL IMPACTS OF THE WOOD BIOMASS USE IN CYPRUS HOUSEHOLDS

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ABSTRACT: In many island communities of Europe, wood biomass is considered one of the most important sources of energy for heating and cooking, especially for the mountainous and rural ones. The aim of this paper is to determine comprehensively the wood biomass quantities consumed in the mountain areas of Cyprus; additionally the origin of biomass, the implications of the uncontrolled use and overexploitation of wood biomass as well as the evaluation of the social and economic impacts. The planned actions involve the identification of the quantities and the origin of wood biomass consumed in the mountainous communities of Cyprus (more than 40) with the analysis of data collected through a structured questionnaire and a dedicated field research. Also, measurements of the variation of air quality (CO2, CO, NOx, PM2.5, PM10, TPM) was carried out, between winter and summer months for both indoor and outdoor air quality in mountain households. Comparable measurements were performed in houses that use energy efficient fireplaces in order to record any changes/improvement in air quality. This study is financed by the Cyprus Research Promotion Foundation.
Keywords: biomass, socio-economic impact, wood biomass, emissions, environmental impact

1 INTRODUCTION

In Cyprus, like in many island communities in Europe, wood biomass is used for heating and cooking in the residential sector, especially in mountainous and rural communities, mainly in the form of firewood [1]. It’s a practice that it’s performed for many years in Cyprus mainly by residents with low income.

In 2009, the Cyprus Energy Agency [2] conducted a research study which shows that the majority of the households use firewood for heating and cooking and most of them are using timber from their own resources. More specific, it scopes to examine and to quantify the social, environmental and economic impact of using wood biomass for heating which will help the authorities to develop appropriate policies and to take the necessary measures.

2 PURPOSE OF THE WORK

The research project «Potential, Origin and Utilization of Wood Biomass in Cyprus», which is supported by the Research Promotion Foundation of Cyprus, aims to identify the social, economic and environmental impacts (positives or negatives) from the utilized of bioenergy and particular the use of solid biomass in Cyprus [3]. More specific, it scopes to identify:

- the energy sources used by households in mountainous communities
- the most common technologies and practices for heating, water heating and cooking
- the wood biomass penetration; also types, quantities and origin of the biomass used, as well as the citizens’ attitudes and perceptions
- the air quality in relation to a number of factors; to quantify types and amounts of indoor air pollutants as a result of biomass fuel use, especially where traditional fireplaces or stoves are used
- the potential technological and/or economical benefits from increased use of wood biomass for heating
- the effects of existing practices on the wood biomass market and the labor market, as well as the impact of relevant policies.

The emissions from traditional fireplaces and stoves over time become significant and worthy of recording. Traditional fireplaces generally pollute the surrounding environment compared to the energy efficient fireplaces where the combustion is complete and therefore CO is committed for the final production of CO2.

There is obviously a need for in depth studies to examine and to quantify the social, environmental and economic impact of using wood biomass for heating which will help the authorities to develop appropriate policies and to take the necessary measures.
The replacement of the traditional fireplaces with new energy efficient fireplaces (efficiency up to 75-80%) that are available nowadays in the market will significantly contribute to wood biomass savings as well as to the improvement of the indoor and outdoor air quality, meeting also the efficiency requirements of the new RES Directive 2009/28/EC. Furthermore, with the replacement of the traditional fireplaces with the energy efficient fireplaces, approximately 4.5 tons of wood per year per fireplace is saved in each permanent household.

Table 1: Emission factors for residential wood combustion (g/kg dry wood) [4,5,6].

<table>
<thead>
<tr>
<th>Emission</th>
<th>Pellet stoves</th>
<th>Wood stoves [g/kg dry wood]</th>
<th>Residential fireplaces</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Conventional</td>
<td>Non-catalytic</td>
</tr>
<tr>
<td>PM₁₀</td>
<td>ND</td>
<td>13.8</td>
<td>8.8</td>
</tr>
<tr>
<td>CO</td>
<td>ND</td>
<td>104.5</td>
<td>63.7</td>
</tr>
<tr>
<td>NOₓ</td>
<td>6.25</td>
<td>1.26</td>
<td>ND</td>
</tr>
<tr>
<td>SO₂</td>
<td>0.18</td>
<td>0.18</td>
<td>0.18</td>
</tr>
<tr>
<td>CO₂</td>
<td>1337</td>
<td>ND</td>
<td>ND</td>
</tr>
<tr>
<td>CH₄</td>
<td>ND</td>
<td>13.6</td>
<td>7.3</td>
</tr>
</tbody>
</table>

So far there has been no comprehensive research to explore all aspects of exploitation of wood biomass in mountain communities in Cyprus (heating, cooking), which has negative consequences, like forest and agriculture vegetation destruction, the risk on human health from the emissions of dangerous air pollutants etc.

In addition there has been no detailed study that explores either the impact of new policies for promoting renewable energy (e.g. national subsidy/grant for the installation energy efficient fireplaces) or the social and economic aspects of wood biomass utilization.

3 METHODOLOGY

Due to the climatic conditions of Cyprus, the activities of the project took place in selected mountainous communities of Cyprus that extensively use wood biomass during most of the year to cover their household energy needs, such as space and water heating and cooking. In total, 41 communities were investigated with an altitude of over 500 m, and total population of 19,755. For the purpose of this project the following actions were carried out:

- The quantities and the origin of wood biomass consumed in the mountainous areas of Cyprus were investigated, with the analysis of data collected through a structured questionnaire and a dedicated field research.
- The social and environmental aspects of using biomass in the mountainous areas of Cyprus were gathered by trained researchers through door to door interviews and statistically analyzed.
- Measurement of the air quality variation between winter and summer months (CO₂, CO, NOₓ, PM₂.₅, PM₁₀, TPM) both indoor and outdoor in selected mountain households. Relevant measurements performed in houses where energy efficient fireplaces are used in order to evaluate any changes/improvement in air quality.

A total of 514 door-to-door questionnaires were completed during summer in order to obtain information related with origin of biomass, the building stock typology and moreover air quality measurements in 514 households were respectively completed (in-and outdoor). During winter only air quality measurements were performed to selected households that utilize exclusively wood biomass for heating, water heating and cooking. A total of 156 households were measured both in- and outdoor (their location is indicated on the map below with colored dots; the color of the dots represent the four major districts of Cyprus where the above actions were implemented).

Figure 1: Selected mountainous communities, involved in the field research.

3.1 Field Research

One of the aims of the project is the identification of wood biomass quantities, which are consumed in the mountain areas of Cyprus and the classification of the origin of this biomass (forest, agriculture areas, nature protection areas etc). For this reason a specific questionnaire was developed and completed by trained researchers through door to door interviews in 41 communities with altitude over the 500 m. The number of completed questionnaires (door to door) reaches up to 514.

For the survey a structured questionnaire has been designed by the Technical University of Crete. The questionnaire’s main sections are:

a) General information of the household (concerns the type, location, use etc),
b) Energy data of the household (types of fuels, systems, technologies, consumption, source, etc), with overview of the main energy sources in the household (space heating - fireplaces, stove, biomass stove, biomass boiler, biomass use other than space heating)
c) Environmental issues - quality data (concerns knowledge, attitudes, practises and interviewee profile)
d) Identification data
3.2 Measurements of air quality variation

On site experimental measurements were conducted concerning the variation of air quality during winter and summer months. The concentration of CO\(_2\), CO, NO\(_x\), PM\(_{2.5}\), PM\(_{10}\), and TPM were measured. This action applied in selected mountain households both indoor and outdoor and a total of 1340 measurements were recorded. Relevant measures performed in houses that use energy efficient fireplaces. The number of measurements on air quality was equal to the percentage of questionnaires that were completed in each community i.e. 12 completed questionnaires have respectively 12 indoor/outdoor air measurements. Therefore important comparative measurements of the variation of the air quality in two periods and between biomass combustion technologies defined. The Department Environmental Management of Cyprus University of Technology provided all the necessary portable equipment for the successful accomplishment of the mentioned measurements:

- CO\(_2\): Extech CO 250 Indoor Air Quality Meter
- CO: Extech Carbon Monoxide Meter
- NO\(_x\): DUVAS
- PM\(_{2.5}\), PM\(_{10}\), and TPM: Aerocet-531 Mass Particle Counter/Dust Monitor

The visits to the communities for the completion of the questionnaires and the measurement of the air quality started from May 2011 - August 2011 when summer measurements were performed and continued from January 2012 - April 2012 when the winter air measurements were completed.

4 RESULTS

The utilization of the wood biomass for heating and cooking is a practice that is performed in the mountainous communities in Cyprus mostly from the economically disadvantaged residents with limited budget to procure other fuel types.

The populations of the 41 communities/municipalities are mainly pensioners/employees with low educational background (some only primary school graduates) and of low annual income (less than 20,000 €). Furthermore, the majority of the houses were built during 1980’s, with no energy efficient improvements and space heating is achieved with a combination of a traditional fireplace and a boiler. The period that the wood biomass is utilized for both water and space heating is 5-6 months each year.

The analysis of the collected data has shown that approximately 35% of the surveyed households utilize traditional fireplace as main heating system (Fig. 2) and 48% of them utilize wood biomass originating from their own properties, mainly from agriculture residues (Fig. 3).

![Figure 2: Basic Heating System in the Cyprus mountainous communities](image)

![Figure 3: Biomass supply source in the Cyprus mountainous communities](image)

In summer, as well as in winter, the CO concentrations were detected low both inside and outside of houses. High concentrations of CO\(_2\) and NO\(_x\) were observed during summer due to the high temperatures in Cyprus, however the concentrations do not exceed the allowed limits set by the European Union.

Also, in summer period, there were recorded not too high concentrations of CO\(_2\) and NO\(_x\) in the indoor compared to outdoor. The main reason is that the residences are using mainly LPG for cooking.

Concerning the suspended particles in the air PM\(_{10}\), high concentrations were observed during the winter period indoor and outdoor (Figs 4, 5). The European Union has set a limit of 40 \(\mu\)g/m\(^3\) per year. During the winter the measurements have shown that the average of these particles inside the households exceeded the limit. Since the majority of the surveyed households utilize traditional fireplace as main heating system, this increase of PM\(_{10}\) may be due to the continuous and all - day combustion of wood biomass for heating.

The PM\(_{2.5}\) concentrations which are considered as the most hazardous for human health have shown a slight increase indoor and outdoor of the households, still below the EU limit – 25\(\mu\)g/m\(^3\) per year.

The comparison between traditional and energy efficiency fireplaces has shown that the traditional ones emit higher concentrations of CO\(_2\) and CO in- and out-
The maximum PM$_{2.5}$ was detected in households that utilize wood burning stoves as the main heating system. These systems are usually old in age and technology. Regarding the two types of fireplace, the traditional fireplace emits higher emissions of PM$_{2.5}$ compared to energy fireplace (Table II).

The energy fireplaces, due to their mechanism, they do not produced NO, on the contrary the traditional fireplace emits an average of 10 ppb within the space of the heated room and in some extend to the house depending on the layout.

Table II: Air pollutants concentrations in the surveyed households use wood biomass for heating (indoor).

<table>
<thead>
<tr>
<th></th>
<th>CO (ppm)</th>
<th>CO$_2$ (ppm)</th>
<th>NO (ppb)</th>
<th>NO$_2$ (ppb)</th>
<th>PM$_{2.5}$ (μg/m$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Traditional Fireplace</td>
<td>0.8</td>
<td>556.3</td>
<td>10.1</td>
<td>26.4</td>
<td>8.2</td>
</tr>
<tr>
<td>Energy Efficient Fireplace</td>
<td>0.1</td>
<td>455</td>
<td>0</td>
<td>24.9</td>
<td>6.3</td>
</tr>
<tr>
<td>Wood Burning Stoves</td>
<td>1.4</td>
<td>747.3</td>
<td>32.2</td>
<td>33.3</td>
<td>20.4</td>
</tr>
<tr>
<td>Wood Burning Boilers</td>
<td>0</td>
<td>677.6</td>
<td>2.8</td>
<td>19.5</td>
<td>3.8</td>
</tr>
</tbody>
</table>

5 CONCLUSIONS

Wood biomass is traditionally an essential energy source for heating and cooking, especially for the mountainous and rural communities in European islands. Although the extended use of wood biomass may lead to a number of social and environmental risks - air pollution, health problems due to the emissions from the burning procedure, overexploitation of forests.

The results of this survey have shown that approximately 35% of the survey households utilize traditional fireplace as main heating systems, which have low efficiency (up to 25%), resulting to large quantities of wood biomass consumed annually.

Through the analysis of the measurements of the air quality high PM$_{10}$ concentrations were recorded during the winter compared to summer both indoor and outdoor of the surveyed households. The combustion of wood biomass with traditional fireplaces or wood stoves is increasing the pollution of air with particulate matter.

As expected the comparison between traditional and energy efficiency fireplaces has shown that the traditional ones emit higher concentrations of air pollutants. Also high concentrations of air pollutants were detected in households that utilize old heating systems like wood stoves. However, in mountain areas of Cyprus there is no use of efficient systems for heating. On the other hand, the residents of the semi - mountain and mountain households utilize old systems with ignorance to new efficient systems.

The household income appears to affect the choice of the heating system, since the majority of the residents who are engaged with agricultural activities or are pensioners, utilize mainly traditional fireplace. In general, the utilization of the wood biomass for heating and cooking is a common practice in the mountainous communities in Cyprus mostly by the economically disadvantaged residents who don’t have enough financial resources to obtain other types of fuels.
6 REFERENCES


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For more information you may visit the web:
www.cea.org.cy/biomass/

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8 LOGO SPACE

www.cea.org.cy

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www.resel.tuc.gr

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