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TECHNOLOGICAL ADVANCEMENT IN THE EFFICIENT USE OF WOOD AS ENERGY SOURCE

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ABSTRACT: During the last decade, Albania has faced a steady increase in the energy demand. This results in rising environmental problems due to the additional use of fossil fuels, and the need for the new power plants construction sites. According to INSTAT (2012), Albania has a population of 2.8 million inhabitants, where 46.5 % of inhabitants is living in rural areas. Firewood is the main source used by rural families for heating and cooking. On average, at the national level one family in rural areas use 5 m^3 of wood fuel for cooking and heating. Existing residential buildings in rural areas use fireplaces and stoves, with a low energy efficiency causing problems in terms of indoor air quality and firewood consumption.

This paper focuses on the importance of using new environmental friendly technologies – such as boilers and thermo-stoves – at the household level especially in Albanian rural areas. According to the economic analysis carried out in this paper, the use of energy efficient technologies (boilers and thermal-stoves) could reduce the expenditures for timber purchase about 50-78% and indoor and outdoor CO_2 emissions of 0.18-0.25 tonne $year^{-1}family^{-1}$. In order to develop a sustainable energy system in Albania, there is a urgent need to undertake some measures in the residential sector (improving energy efficiency) and in the use of renewable energy.

Keywords: firewood**,** energy saving, thermal generators, energy efficiency.

1 INTRODUCTION

Albania is a small country situated in the western Balkan peninsula, with an overall area of 28748 square kilometre and a forest cover of 1.5 million ha [2]. As in many developing countries, the incidence of poverty is highest in rural areas, where most of population depends on agriculture, livestock and forestry. The last population census conducted on 2011, showed that resident population in Albania was 2.821 million where 53.5 % live in the urban areas and 46.5 % lived in rural areas. The number of private households is 722 262 of which 56.7 per cent were located in urban areas and 43.3 per cent in rural areas. Heating systems in Albania dwellings consist mainly of separate equipment like stoves (e.g. owned by 63.3 percent of the households), air conditioners, electric heaters, while central heating systems within the building were owned only by 3.2 per cent of households [5].

In rural areas firewood continued to be the main type of heating meeting 57.5 percent of the households, followed by gas 20.8 percent and by electricity with 15.4 per cent. In comparison with 2001, the use of firewood has been decreased by 12.3 percent, while is increased by 14.9 percent the number of households using gas. In urban areas, the distribution of households by main type of energy used for heating was more balanced. Thirty six percent of households are heated with wood, 24.0 percent with electricity and 31.3 per cent with gas [5]. Firewood remain an important source of energy at national level providing about 208 ktoe or 14 percent of energy demands [1]. Various studies has shown that firewood consumption at the national level ranged from 1.5 million m^3 to 1.7 million m^3 [3], if the fuel wood consumed in schools, kindergarden and other institutions is considered.

One of the critical issues in using firewood in Albania is the use of low efficiency thermal generators like chimney and stoves, not only in rural areas but also in some urban areas. Their use likely is increasing the firewood consumption and indoor air pollution. Indoor and outdoor wood-smoke emissions by firewood burning can be reduced by using efficient (and well maintained) appliances and well-seasoned (e.g. dry) wood. Nowadays the modern furnaces (boilers) has shown an increasing efficiency in wood burning and reducing the wood consumption.

The new European Union Renewables Directives has set a mandatory target for Albania of 36% till to 2020, for increasing the proportion of energy from renewable sources in the energy, transport and heat [6]. Achievement of this manadatory target could require a radical policy about how the required volumes of Renewable Energy Sources (RES) will be sourced from domestic resources. One of the possible directions of this policy concerning RES is the sustainable and efficient use of current forest resources as well as of efficient thermal technologies. The recognition of the impact that high efficiency thermal generators have on wood consumption and monoxide carbon releasing in the atmosphere was the objective of this study.

2 THERMAL EFFICIENCY OF TRADITIONAL AND MODERN GENERATORS

Thermal generators are divided in two categories:

- Conventional thermal generators (fireplaces and stoves), and
- Modern thermal generators(thermal generators and wood boilers).

These devices varies in burning efficiency and their power (Table I).

Table I: Thermal generators and their energy efficiency

Nr	Thermal generator	Energy efficiency (%)	Thermal generator power (kW)
1	Chimney	15-20	1-3
2	Stoves	40-65	3-12
3	Thermo stoves	60-80	7-10
4	Wood boiler	Over 90	10-1000

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Some of the characteristics of these thermal generators used at rural areas in Albania are as follows.

Figure 1: Traditional fireplaces used in rural areas in Albania *(Source: Toromani & Çollaku, 2009)*

2.1 Fireplace

The chimney is an ancient traditional thermal generator. It is impossible to arrange the primary and secondary air flux in order to improve the exchange or the diffusion of heat. A considerable amount of heat is diffused out of the dwelling through the chimney tubes. This type of generator is less efficient, because only 15-20% of the energy produced from wood is used for heating or cooking. This type of generator needs also a special service of maintenance in order to remove the ash produced after combustion. This appliance is widespread mainly in the northern part of Albania and it is one of the thermal generators used not only for cooking but also for heating (Fig. 1).

Figure 2: Stoves traded in the local market which are used from households in rural areas

2.2 Stoves

Stoves used at households are constructed from metallic and ceramic material and are quite different from fireplaces, because the wood combustion takes place in a closed room which in the front side is composed of metal or glass. In this thermal generator it is possible to arrange the flux of primary air. The heat released by wood fuel is absorbed from the stove and it is diffused in the room environment. There are a lot of stove models in the market. The efficiency of this thermal generator is 40-65%. Stoves have a power of about 3-12 kW depending on the amount of wood fuel and on the efficiency. For their installation the house needs kin and a levelled pavement. These thermal generators (e.g. Fig. 2) are mainly used in rural areas in the central and southern part of Albania.

2.3 Thermo-stoves

Thermo-stoves (Fig. 3) have a higher efficiency compared to normal stoves. The hot air is collected and sent in the heat diffuser where, within metallic tubes, it passes through the thermal vector and it is diffused in the dwelling rooms. The combustion is controlled through an air arrangement and, in more sophisticated models, through secondary air. The efficiency of this thermal generator is 60-80%, compared to wood energy content. They use mainly firewood and pellets. The stoves with pellets that are sold in Albania have a power of 7-10 kW with a price 144 000-219 000 ALL. They consume 0.7-1.5 kg/hour of pellets. The CO_2 emitted from these stoves range from 0.013% (7 kW) to 0.015% (10 kW). They are constructed according to the European Standards EN 14785: 2006.

Figure 3: Thermo-stoves using pellet

2.2 Wood boilers

Wood boilers are the most sophisticated thermal generators (Fig. 4). They warm the environment through sanitary water that is circulated through the radiator located in the dwelling rooms. This type of generator has higher efficiency than other generators. They are able to control the primary and secondary air flux because they contain a lambda stylet and a system of dust circulation into the burning room. They have an efficiency about 90% of wood energy content, with a power ranging from 10 to 1000 kW.

Figure 4: Boiler with wood *(Source: Mori et al., 2007)*

3 ESTIMATION OF THE THERMAL GENERATOR POWER

In order to estimate the power of a thermal generator, the following variables must be taken into account:

- The volume of dwelling for heating
- The type of windows (single or double glasses)
- The structure of building
- The minimal outdoor temperature of the area and the temperature that should be reached through the thermal generator
- The distribution of thermal demand per year and the maximal amount of energy produced

The thermal generator power is estimated with the following formula [6]:

$$Q=E \times S \times F_{tm} \times F_{te}$$

where:

- Q is the maximal power of the thermal generator (kW)
- E is the specific thermal demand (FTS) (W/m^2)
- S is the area of the dwelling (m^2)
- F_{tm} is the correction factor applied basing to the minimal temperature of the area
- F_{te} is the correction factor based on the type of building

The thermal specific demands depends on: type of the building, thermal isolation, rooms height and glass type of windows (Table II).

Table II: Thermal specific demand for various buildings (W/m^2)

Type of building	Thermal isolation	Type of glass	Room height	FTS (W/m^2)
Old	partial	Double	>2.5m	130
Old	partial	Double	<2.5m	110
New	yes	Double	<2.5m	90
New	yes	Triple	<2.5m	70

(Source: Mori et al., 2007)

Thus we have calculated the power of a boiler for heating in a typical residential dwelling in Albania rural areas with such characteristics: average housing area 180 m^2; partly thermal isolation; old building with rooms height over 2.5 m; outdoor minimal temperature -6 ° C (F_{tm}=0.76). The maximal power of boiler for heating will be:

$Q = E \times S \times F_{tm} \times F_{te} = 130\ W/m^2 \times 180 m^2 \times 0.76 \times 1 =$

17784 W=17.8 kW

This energy is equivalent with the power of 6 fireplaces, 2 stoves and 1 furnace (boiler).

4 ESTIMATION OF ECONOMIC AND ENVIRONMENTAL BENEFITS FROM EFFICIENT THERMAL GENERATORS

Firewood is one of the most important renewable energy sources for inhabitants in rural areas which is used in various thermal generators with different energy efficiency. The use of firewood has a lot of advantages from both the economical and environmental point of view. For that reason, we have investigated and assessed the economic (wood saving) and environmental benefits (CO_2 emission reduction) of above-mentioned thermal generators which use wood as fuel.

Table III: Economic and environmental benefits of various thermal generators

Type of generator	Fireplace (n=7)	Stoves (n=5)	Therm. stoves (n=2)	Boilers (n=1)
Efficiency %	20	40	65	90
Energy demand per family (kWh yr^{-1})	26 700	26 700	26 700	26 700
Quantity of wood (kg $family^{-1}$)	33 375	16 687	10 269	7 417
Production of coppice (t ha^{-1})	14.8	14.8	14.8	14.8
Forest Area (ha $family^{-1}$ yr^{1})	2.25	1.13	0.69	0.5
Forest Area at national level (ha yr^{-1})	943 870	474 480	289 726	209 947
Expenditures for same level of energy (ALL yr^{-1})	92 340	46 375	28318	20 520
Money saving (ALL)	0	45 965 49.8%	64 02 69%	71 820 78%
Quantity of CO_2 emissions (t yr^{-1} $family^{-1}$)	0.81	0.41	0.251	0.181

(Source: Toromani & Çollaku, 2009)

The heating of an old building with an area of 180 m^2 (power of generator 17.8 kW) with 1 500 hour of work $year^{-1}$, requires 26 700 kWh yr^{-1}. In case of use of seasoned wood as fuel wood, which own an energy

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content of 4 kWh kg^{-1}, one family needs 6 675 kg (or 6.675 tons fuel wood). Let's take into account four types of thermal generators using fuel wood as raw material with various energy efficiency. The most common firewood used in rural areas in Albanian is originated by oak species. According to the last Albanian National Forest Inventory [2], the average volume of coppice forests is 22.8 m^3 ha^{-1} with a production of 14.8 t ha^{-1} (22.8 × 650 kg =14 820 kg). The cycle of production for coppice forests is considered to be 30 years. Based on the above- mentioned data we have calculated the economic and environmental benefits for various thermal generators (Table III).

This analysis reveals clearly the economical benefits in terms of forest area and money saving for timber purchase and consumed at family and national level. The use of modern and efficient thermal generators like: thermal-stoves and wood boilers, reduce the money expenditures from 69 to 78 percent for each family in rural areas. On the other hand the use of such modern devices has a great impact on the reduction of firewood consumption ranged from 69 to 76 percent compared with firewood used in fireplaces. These estimations also put lights on the importance of the usage of efficient thermal generators for reduction of CO_2 emissions release and improvement of indoor air quality at dwelling level.

5 CONCLUSION ABOUT BIOMASS ENERGY USAGE IN ALBANIA

The study conducted on the energy efficiency and the role of thermal generators on firewood consumption, environmental protection and indoor air quality life has attained the following findings:

- Firewood is the main source for heating in Albanian, especially in rural areas
- Low energy efficiency generators consume more fire wood than most efficient technologies.
- The coppice forest area production in Albania doesn't cover the demand for firewood at national level in rural areas. The estimated forest area (943840 ha) needed for meeting the firewood demands is much higher than coppice forest area (623799 ha) in Albania [2]. Taking into account the distribution of coppice forests and the population density in some villages it can be said that coppice forest resources in some areas do not meet the demands for fuel wood.
- As result of technology improvement the rural families save about 70% of their budget for the same amount of energy production.
- The use of efficient technologies at household level will improve indoor air quality creating a friendly environment family members.
- The carbon dioxide emissions released as result of high energy efficiency thermal generators is reduced 69-78% compare with traditional appliances.

6 RECOMMENDATIONS

Some of the recommendations drawn based on the findings of the study were:

- The improvement of technology for wood burning at household level should be a priority in order to promote energy, biomass, and financial savings.
- Beside wood burning technology improvement another opportunity to save energy is the improvement of the thermal isolation of houses and windows (e.g. double glasses not only in new but also in old buildings).
- Governmental and non governmental agencies should undertake initiatives and support the use of new technologies for wood burning in rural areas.
- Government should support the construction of "passive houses" with 15 kWh per square meter for heating as main type of dwellings for energy saving.

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