POTENTIALS OF FUEL SWITCHING (HEATING SYSTEMS) IN MONTENEGRO

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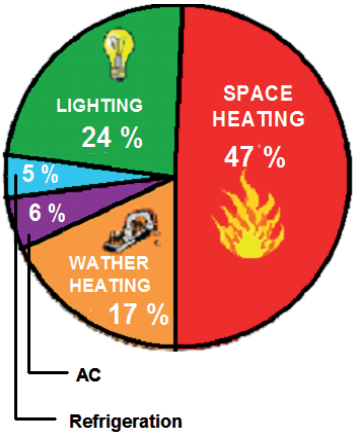
ABSTRACT:
In this paper the potentials of fuel switching in Montenegro is analyzed. Six different fuels or source of energy are compared using the local price and tariffs. Also, the use of different fuels for heating is analyzed in climate conditions of Montenegro.

Key words: *fuel swithing heating system Montenegro local*

1. INTRODUCTION



The ability to maintain desired temperatures is one of the most important accomplishments of modern technology. Keeping objects comfortable uses a lot of energy (chart right). In one Europe home, almost half of the average home's energy consumption is used for space heating Chart right). Another 17 percent is used for water heating, 6 percent for cooling space, and 5 percent for refrigeration. It is obvious that main energy consumption is related to process of heating space and water, ~64 %. Of cause, in Mediterranean parts of Montenegro, energy for cooling is increased, reducing in the same time percentage of heating. Up to now, in Montenegro was not defined clear energy

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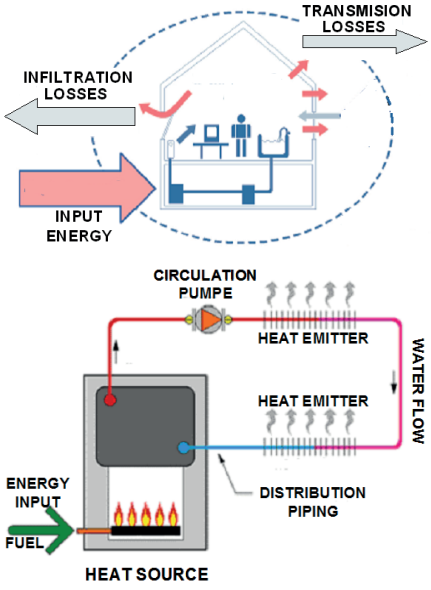
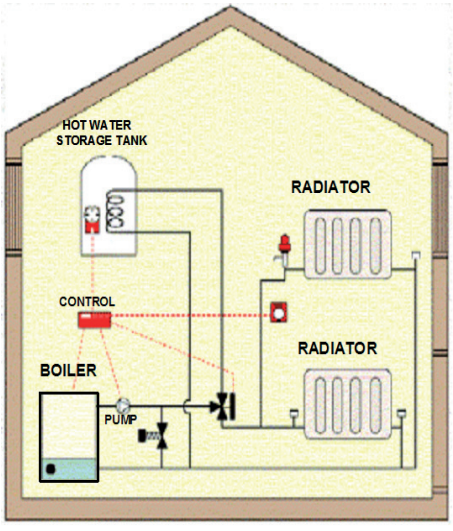
policy with respect to this problem, so many users or investors have a problem to make a decision: which source of energy select for a heating ? In the text follow, it will be considered this problem in the light of economical and ecological requests, emphasized in the last time by Global Warming Problem.

2. HEATING DEMANDS OF BUILDINGS

During the winter, the object is losing energy (heat) throw its envelope. The basic structure of these losses is defined by Transmission and Infiltration losses. There are many types of heating installation, but basic concept is shown at picture. Heating installation have many parts, but the "heart" of every such a system is the "Heat Source". Right or wrong choice of fuel as the heat source, will produce dramatic consequences for the life time of installation in economical as well as ecological meaning. Also, for water heating, electrical heaters are dominantly in use.

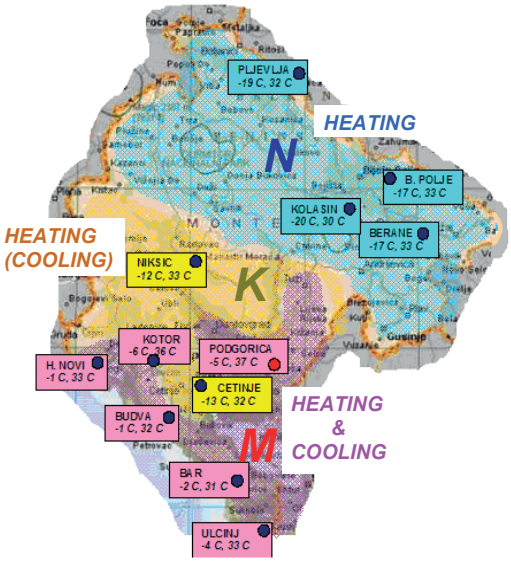




3. MONTENEGRO CLIMATE CONDITIONS

Climate of Montenegro could be divided into three climate regions: Mediterranean-*M* (pink), Continental Middle-*K* (brown) and Continental North-*N* (blue). The first one (*M*) requires both heating and cooling; in the second one (*K*) the heating is priority, although sometimes cooling is required. And the third one

(*N*) requires heating as absolute priority. On the map, the winter and summer design temperatures are given, below the city names. A concept of "Degree Day" (*DD*) is used to estimate the required energy for heating. By definition, one heating degree day occurs for each degree the daily mean temperature is below 20 degrees Celsius. In table below, Degree Day (*DD*), design temperature difference ($DT\ [^0C]=t_{Inside}-t_{Outside}$) and value (*DD/DT*) for several cities in Montenegro are given.



Location	$DT\ ^0C$	*DD*	DD/DT
Bar	22	1167	**53**
Berane	37	3093	**84**
B. Polje	37	3132	**85**
Budva	21	1142	**54**
Cetinje	33	2830	**86**
H. Novi	21	1113	**53**
Kolašin	40	3698	**93**
Kotor	26	1200	**46**
Nikšić	32	2717	**85**
Pljevlja	39	3323	**85**
Podgorica	25	1618	**65**
Ulcinj	24	1301	**54**

4. TYPES OF FUELS USED IN HEATING PROCESS

- **Coal**

The lignite from Pljevlja is dominantly present on Montenegro coal market. Its Heating Value is H_d= *3.3 - 4.2 kWh/kg.* It is delivered to small consumers by the price *~50 Eu / t.* Main difficulties in exploitations are related to problems with manipulation, delivering, store and control of the process. Average efficiency of process energy conversion to heat is $\eta \approx 0.65$.

- **Wood-Logs**

Wood fuel in the form of logs is one simplest, cheapest methods of producing fuel ready for use by the consumer. As most of the weight of freshly felled timber is due to its moisture content (35-60 %), it is preferable to buy the fuel by volume than weight. Relatively low density of energy produces the problems with storage, manipulation and control. Average Heat value is approximately H_d *[kWh/kg]* $\approx$ *4.4 kWh/kg (2000 kWh/m*^{3}*)*, and efficiency of wood heater is $\eta \approx 0.6$. Local price of that fuel is *~100 Eu / t*.

- **Wood-Pellets**

Although almost unknown in Montenegro, the use of wood pellets as source of heating energy is well established in countries such Sweden, Austria, Denmark and North America. A large proportion of pellets have up to now been produced from compressed sawdust from the wood processing industries - typically furniture-making. This has two main implications: first, the sawdust generally comes from seasoned wood, so already has a lower moisture content than freshly harvested wood and needs less (or no) drying. The main advantage over other wood fuels is their energy density ($H_d \approx$ *5 kWh / kg, 3100 kWh/m*^{3}). Price of that fuel is different from place to place, but on world market can be found as *200 Eu / t.* Because in Montenegro exists a few wood

processing industries, the production of that fuel has the chance. Efficiency of energy conversion is $\eta \approx 0.8$.

- **Heating Oil**

Heating oil is a petroleum product used as a fuel. Heating oil is popular as source of energy for heating. But current instabilities in the market and tightened regulations over the storage of domestic and commercial oil, new installations may increase in price. Heating oil can have a devastating effect on the environment, and all too frequently spills and leaks allow it to wreak havoc with ground, rivers and wildlife. Under the new regulations, tanks must have secondary containment to try and stem oil leaks. Heat value of this fuel *is* H_d*=10 kWh / kg* and price on the local market is *740 Eu/t.* Average efficiency of boiler is $\eta \approx 0.8$.

- **LPG**

Most consumers know Liquid Petroleum Gas (*LPG*) as mixture of butane and propane. These liquids are removed from oil and gas during the refining process. *LPG* offers a full range of options from gas heating, living flame fires and cookers to water heaters and cooling equipment. Its easy storage has allowed *LPG* to diversify its use beyond natural gas in many areas. There are three options available when it comes to *LPG* installation - Central bulk storage tanks, bulk tanks and single (or multi) cylinder installations. Both kinds of bulk tanks can be situated below ground. Underground installations are popular - all that remain visible are the tank covers and, because *LPG* readily vaporizes, there is less risk of underground tanks causing groundwater and soil contamination. From the aspect of regulation, Montenegro follows European practice in general. So we expect in nearest future *LPG* regulation as it is in Europe. Running costs for all fuels are notoriously difficult to calculate, but although *LPG* is not cheep fuel it has many advantages over other fuels. For space and water heating in buildings that, *LPG* is the only viable alternative to natural gas. Unfortunately, there isn't any plan to build pipeline for coming natural gas in Montenegro in near future because the economical reasons. In every case, it is possible to design *LPG* installation compatible with natural gas application. In this moment, we have in Montenegro two independent suppliers of *LGP*: INA and Energogas. Both of its supply consumers by *LPG* with the price *720 Eu/t* , but if it is delivered in cylinders (capacity *10 kg*) the price is higher, *1 Eu/kg*. Usually,

the best time for consumers to be supplied with this fuel is summer, because the price on *LPG* market goes down up to *10 %*. Heat value of that fuel is $H_d = 12$ *kWh/kg*, and conversion efficiency is $\eta \approx 0.85$.

- **Electricity**

There are a number of electricity heating solutions such as boiler-fired central heating, space heating and the more frugal night storage heating. Installing electricity as power source is not too costly, but on other side, it is, conditionally speaking, very costly way of heating. In a fact, in Montenegro, up to now the price of electricity was low, so many people use it as basic source of heating energy. But today, the globalization of the electrical energy market makes the price is increasing. Also, it is however, the only fuel that operates on a peak/off peak system. Using peak electricity can result in massive fuel bills. Like all fuels, electricity has it's good points and bad points. While it is obviously supported by an unbeatable array of household equipment, there is no escaping the fact that running an entire object solely with electric power is an expensive business. In this moment, we can count with the price *10 Cents Eu / kWh* and as it is known, the efficiency of electric energy conversion to heat is $\eta \approx 1$.

5. ECOLOGICAL ASPECT

Global warming problem defined CO_2 emission as one of the basic criteria for estimation the fuel environment impact.

Carbon emissions of coal are, however, higher than given off by oil or gas. The smoke is of course carried away by chimney flue - releasing them into the atmosphere. On a positive note, medical research shows that burning solid fuel can reduce risk of hay fever, asthma and eczema.

Wood emit carbon dioxide when they are burnt, also. But, the amount released is equal to the carbon absorbed when the tree was growing, so the process is essentially carbon neutral. This is the theory. The newest investigations, considering the time lag, indices that the situation is much more complex than we assume earlier.

The fact that new regulations have had to be bought into force to combat oil pollution tells its own story. Heating oil can have a devastating effect on the environment, and all too frequently spills and leaks allow it to wreak havoc with ground, rivers and wildlife.

Under the new regulations, the tanks must have secondary containment to try and stem oil leaks. Non-compliance with any new rules could see oil users hit by law sanctions if pollution occurs.

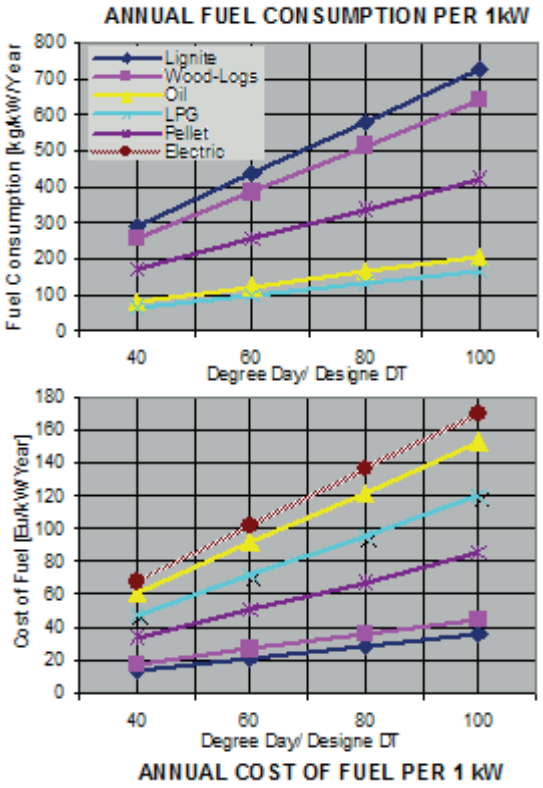
Nobody simply cannot argue against *LPG*'s safety record. Since it was first used, *LPG*'s reputation has never once suffered from a single pollution incident. While oil is responsible for many environmental pollution episodes every year, no soil or water-course has ever been contaminated by *LPG*. Of course, *LPG* is a highly flammable substance. However the expertise and level of care that has been prominent within the industry ever since it's origins ensure that *LPG* remains one of the safest fuels available today. *LPG* also finds favor in some regulation documents, where it is shown to be among the cleanest fuels in terms of carbon dioxide emissions.

Fuel Emission of CO_2	[*kWh/ kg*]
Coal	*0.34*
Light Oil	*0.28*
NG - Natural Gas	*0.20*
LPG – Liq. Petroleum Gas	*0.20*
Biomass	*0*
Electricity (from NG)	*~ 0.5*

The only black mark against electricity in terms of safety and the environment is carbon dioxide emissions: heating with electricity gives off more carbon dioxide than any other fuel.

6. FUEL CONSUMPTION DURING THE HEATING SEASON

It is obvious that fuel consumption for all heating season (*F [kg/yea*r]) depends on total heating energy ($\dot{Q}_H$ *[kW]*) needed to compensate the all heating losses of building, climate conditions defined by Degree Day (*DD)*, design temperature difference ($DT\,^0C$) for specific location of object, heating value of fuel (H_d *[kWh / kg]*) and efficiency (η) of process conversion of fuel energy to heat . Having this in mind, it is possible to calculate fuel consumption for one year (the heating season). On the Chart below, annual fuel consumption per *1 kW* of installing heating power (*kg/kW/Year*) and appropriate cost of it (*Eu/kW/Year*), as function of value of Degree Day over Design Temperature Difference *(DD/DT),* are shown. All calculations are based on the data, given at the tables, previously presented.



Example

Estimate the fuel (Heating Oil, *LPG* and Electricity) yearly consumption cost for every *kW* of installed heating power, for the object located at Kolašin (*DD/DT=93*) and Podgorica (*DD/DT=65*).

Eu/ kW/Year	*Heat_Oil*	*LPG*	*Electric*
Kolašin	*140*	*110*	*155*
Podgorica	*100*	*80*	*110*

7. ECONOMICS OF HEATING SYSTEMS

Choice of a heating system is not simply a matter of cost, but running and appliance costs usually influence the decision. Table below compares the running cost of different types of heating appliances. Small differences in the cost of 'useful energy' shown in the table should be ignored, because fuel prices and appliance efficiency can vary sufficiently to change the relative costs. The table shows that *LPG* has the minimal running cost, comparing to heating oil and electricity.

Energy supply	*Price*	*Energy content*	*Efficiency of use*	*Eu Cents/kWh useful energy*
Coal	*50 Eu/t*	*3.8 kWh/kg*	*65%*	*2*
Wood-Logs	*100 Eu/t*	*4.4 kWh/kg*	*60%*	*3.8*
Wood-Pellets	*200 Eu/t*	*5 kWh/kg*	*80%*	*5*
Heating Oil	*740 Eu/t*	*10.4 kWh/kg*	*80%*	*8.9*
LPG	*720 Eu/t*	*12 kWh/kg*	*85%*	*7*
Electricity	*0.1 Eu/kWh*	*1 kWh*	*100%*	*10*

Running costs of various heating options based on local 2007 fuel/electricity costs.

8. LITERATURE

[1] SMEDA, *Small and Medium sized Enterprizes,* Tech Brief 2007, Podgorica

POTENCIJAL VEZAN ZA IZBOR GORIVA U GREJNIM SISTEMIMA U CRNOJ GORI

SAŽETAK:
U ovom radu je analiziran potencijal koji sa sobom nosi proces izbora goriva za primjenu u grejnim sistemima u Crnoj Gori. Six different fuels or source of energy are compared using the local price and tariffs. Also, the use of different fuels for heating is analyzed in climate conditions of Montenegro.
Upoređivano je šest različitih vrsta goriva prisutnih u Crnoj Gori, vodeći računa o lokalnim cijenama i različitim klimatskim uslovima.