

Smarter Stoves Partnership

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Alternative biomass heating devices
for domestic use in the Western Balkans

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ALTERNATIVE BIOMASS HEATING SOURCES FOR DOMESTIC USE IN THE WESTERN BALKANS

1. Western Balkans heating systems market analysis

Until recently, the heating systems market in the Western Balkans used to be traditionally dominated by solid fuel appliances, but in the last decade the circumstances changed dramatically; firstly with the introduction of pellet stoves and boilers and more recently with the whole range of alternative heating sources slowly being introduced in the households. Yet, due to financial constraints the majority of the Western Balkan population are facing, old solid fuel heating systems are still present in large numbers and continue to represent a challenge to human health and ecology.

In tables below, market analysis for all Western Balkans countries is shown:

Solid fuel stoves include wood and coal fueled air and hydro stoves.

Pellet stoves include pellet fueled air and hydro stoves. Air stoves transfer heat via radiating hot air in the room where the stove is installed. Hydro stoves have boilers inside and transfer heat via water through the central heating system and also via radiating hot air in the room where the stove is installed.

Solid fuel and pellet boilers transfer all the heat via water through central heating system.

Market of Albania

Solid fuel stoves manufacturer	Estimated annual sales volume (pcs)	Market share in %	Average retail price (EUR)	Total (EUR)	Already selling product that meet Eco design YES/NO
Alfa plam Serbia	2.500	20,50	310	775.000	NO
Mbs Serbia	852	6,98	240	204.480	
Plamen Croatia	664	5,44	400	265.600	
Rekor Turkey	500	4,10	270	135.000	
Jakšan Turkey	3.038	24,90	100	303.800	
Priti Bulgaria	1.600	13,10	170	272.000	
Luks Energij Bulgaria	815	6,70	105	85.575	
Hosheven Turkey	845	6,90	220	185.900	
The others:	1.391	11,40	240	333.840	
Total:	12.205	100		2.561.195	

Pellet stoves manufacturer	Estimated annual sales volume (pcs)	Market share in %	Average retail price (EUR)	Total (EUR)	Already selling product that meet Eco design YES/NO
Alfa plam Serbia	20	9,10	750- 820		There are only pellet boilers with Eco design, but on this market there are no buyers interested in it. As far as this market is concerned, air pellet stoves are mainly sold.
Mbs Serbia	0	0			
The others:	200	90,90			
Total:	220	100		cca 200.000 EUR	

Gas boilers	Estimated annual sales volume (pcs)	Average price	
there is no information on the sale of gas boilers			

Electric boilers	Estimated annual sales volume (pcs)	Market share in %	Average retail price (EUR)	Total estimated value (EUR)	Price of electricity for households
Bosch	30	37,50	850	25.500	0,1 EUR/kwh
Vaillant	50	62,50	900	45.000	
Total:	80	100		70.500	

Market of Bosnia and Herzegovina

Solid fuel stoves manufacturer	Estimated annual sales volume/p cs	Market share in %	Average retail price (EUR)	Total value (EUR)	Already sell products that meet Eco design
Alfa plam Serbia	21.000	70,70	330	6.930.000	NO
Mbs Serbia	6.000	20,20	270	1.620.000	
PlamenCroatia	1.700	5,70	390	663.000	
Other producers	1.000	3,40	300	300.000	
Total:	29.700	100		9.513.000	

Pellet boiler manufacturer	Estimated annual sales volume/p cs	Market share in %	Average retail price (EUR)	Total value (EUR)	Already sell products that meet Eco design
Alfa plam Serbia	200	2,60	1.300	260.000	only products that are certified as pellet boilers meet Eco design standard
Mbs Serbia	40	0,50	1.250	50.000	
Termo Flux BiH	5.000	64,60	1.400	7.000.000	
Kenda BIH	1.000	12,90	1.250	1.250.000	
Lafat BiH	1.000	12,90	1.300	1.300.000	
Centrometal Croatia	400	5,20	1.500	600.000	
Other producers	100	1,30	1.100	110.000	
Total:	7.740	100	9.100	10.570.000	

Inverter air conditioning, manufacturer	Estimated annual sales volume/pcs	Average retail price (EUR)	Total value (EUR)	there are no informations about how many of these devices are used to heat the households
origin of goods mainly from China	20.000	400	8.000.000	

Gas boilers	Estimated annual sales volume/pcs	Average retail price (EUR)	Total value (EUR)	The price of gas connection
Vaillant , Bosch	3.000	700	2.100.000	There is a state subsidy for gas connection in the amount of up to 500 eur.

Electric boilers	Estimated annual sales volume/pcs	Average retail price (EUR)	Total value (EUR)	The price of electricity for households
Vaillant, Bosch	1.000	450	450.000	0.050EUR/kW+17%PDV

Market of Montenegro

Solid fuel stoves manufacturer	Estimated annual sales volume/pcs	Market share in %	Average retail price (EUR)	Total value (EUR)	Already sell products that meet Eco design YES/NO
Alfa plam Serbia	3.000	50	380	1.140.000	NO
Mbs Serbia	1.300	21,70	240	312.000	
Plamen Croatia	800	13,30	520	416.000	
Timsistem Serbia	300	5	200	60.000	
Bella Thalia Trgoprodukt, Serbia	300	5	180	54.000	
Blist Serbia	300	5	150	45.000	
Total:	6.000	100		2.027.000	

Pellet stoves manufacturer	Estimated annual sales volume/pcs	Market share in %	Average retail price (EUR)	Total value (EUR)	Already sell products that meet Eco design YES/NO
Alfa plam Serbia	800	47,30	1.700	1.360.000	only products that are certified as pellet boilers meet Eco standard
Mbs Serbia	10	0,60	1.400	14.000	
Tim Sistem Serbia	50	3	1.400	70.000	
Centrometal Croatia	500	30	1.800	900.000	
Kepo Serbia	20	1,20	1.700	34.000	
Termofulx BIH	50	3	1.700	85.000	
Karmek one Italy	100	5,40	1.800	180.000	
ABC Serbia	30	1,80	1.500	45.000	
Radijator Serbia	30	1,80	1.800	54.000	
Stilmetal BIH	100	5,90	1.800	180.000	
Total:	1.690	100		2.922.000	

Inverter air conditioning, manufacturer	Estimated annual sales volume/pcs	Market share in %	Average retail price (EUR)	Total value (EUR)	
Beko	1.000	9,70	340	340.000	there is no information about how many of these devices are used to heat the households
Hisense	1.000	9,70	320	320.000	
Azuri	300	2,90	330	99.000	
Bergen	200	1,90	330	66.000	
Gree	3.000	29,10	360	1.080.000	
LG	1.000	9,70	700	700.000	
Samsung	500	4,80	700	350.000	
Toshiba	800	7,80	600	480.000	
Fujitsu	500	4,80	800	400.000	
Vivax	2.000	19,40	340	680.000	
Total:	10.300	100		4.515.000	

Gas boilers	Estimated annual sales volume/p cs	Average price	The price of gas connection
there is no sale of these products in Montenegro			/

Electric boilers	Estimated annual sales volume/pcs	Average retail price (EUR)	Total value (EUR)	The price of electricity for households
Vaillant , Bosch	50	450	22.500	0,103 EUR/kwh

Market of Kosovo*

Solid fuel stoves manufacturer	Estimated annual sales volume/ pcs/	Market share in %	Average retail price (EUR)	Total (EUR)	Already sell products that meet Eco design YES/NO
Alfa plam Serbia	7.500	48,90	310	2.325.000	NO
MBS Serbia	6.000	39,10	240	1.440.000	
Plamen Croatia	500	3,30	410	205.000	
Hoseven Turkey	600	3,90	230	138.000	
Pryti Bulgaria	400	2,60	180	72.000	
Jaksan Turkey	350	2,30	100	35.000	
Total:	15.350	100		4.215.000	

Pellet stoves manufacturer	Estimated annual sales volume/pcs/	Average retail price (EUR)	Total (EUR)	Already sell products that meet Eco design YES/NO
Enrad, Gnjilane, Kosovo		600-1.000		NO
Termoflux BIH		800-1500		NO
Biodom Slovenia		1.800-2.300		YES
Biodom Slovenia		1400-1800		YES
Burnit Bulgaria		600-1000		NO
Alfa plam Serbia		800-2400		YES
Total:	500		500000	

Gas boilers	Estimated annual sales volume	Average price	The price of the gas connection
there is no gas connection on this market			

Electric boilers	Estimated annual sales volume/pcs/	Market share in %	Average price of the device (EUR)	Total value (EUR)	The price of the electricity for households EUR
Vaillant	8.000	51,60	900	7.200.000	0,06 €
Jakova/ Producer from Djakovica/	2.000	12,90	500	1.000.000	
Bosch	5.000	32,30	850	4.250.000	
Ekopan	500	3,20	700	350.000	
Total:	15.500	100		12.800.000	

Market of North Macedonia

Solid fuel stove manufacturer	Estimated annual sales volume/ pcs/	Market share in %	Total (EUR)	Average retail price (EUR)	Already sell products that meet Eco design	
Alfa plam Serbia	5.000	42,20	1.900.000,00	310	NO	
Mbs Serbia	900	7,60	200.000	220		
PlamenCroatia	1.000	8,40	400.000	380		
Priety Bulgaria	1.000	8,40	150.000	150		
Skladova tehnika Bulgaria	700	5,90	100.000	140		
Trgoprodukt Serbia	1.000	8,40	100.000	100		
Blist Serbia	400	3,40	70.000	150		
Centrometal - etaz Croatia	50	0,40	50.000	1.100		
Hrovat Slovenia	600	5,10	100.000	150		
Solid fuel stove boiler of other manufacturers	1.200	10,10	300.000	250		
Total:	11.850	100	3.370.000,00			

Pellet stoves manufacturer	Estimated annual sales volume/ pcs/	Market share in %	Total (EUR)	Average price (EUR)	Already sell products that meet Eco design	
Alfa plam Serbia	900	16,10	882.000	980	only products that are certified as pellet boilers meet Eco standard	
Mbs Serbia	200	3,60	140.000	700		
Termo flux BIH	500	9,00	1.000.000	2.000		
Eko Spar North Macedonia	1.100	19,70	880.000	800		
Bauger-Lafat BIH	250	4,50	250.000	1.000		
Mareli Bulgaria	700	12,50	525.000	750		
Diekotek. North Macedonia	400	7,20	360.000	900		
Centrometal	100	1,80	130.000	1.300		
Kepo Serbia	130	2,30	156.000	1.200		
Feroli Italy	70	1,20	140.000	2.000		
Blist serbia	50	0,90	40.000	800		
Priety Bulgaria	50	0,90	40.000	800		
ST - Lafat BIH	70	1,20	49.000	700		
Fabigio - Lafat BIH	60	1,10	42.000	700		
Milkus North Macedonia	500	9,00	400.000	800		
The others:	500	9,00	500.000			
Total:	5.580	100	5.534.000,00			

Inverter air conditioning, manufacturer	Estimated annual sales volume/ pcs/	Total (EUR)	Average price (EUR)	Remark
Panasonic, Daikin, Samsung, Hisense, Gree, Tesla, Haier, Mitsubishi, Vivax, Toshiba	40.000	20.000.000	600	There is no information about how many of these devices are used to heat the households. It was sold 5.000 pcs through the program air conditioning for the wood cookers. There is similar sales forecast for this year .

Gas boilers	Estimated annual sales volume/ pcs/	Total (EUR)	Average price (EUR)	The price of the gas connection (EUR)
Vaillant Bosh	70		conventional boilers 650 EUR	1.000
Bosch	30		condensing boilers 1.000 EUR	
total:	100	100.000		

Electric boilers	Estimated annual sales volume/ pcs/	Total (EUR)	Average price of the device (EUR)	The price of the electricity for households (EUR)
Vaillant, Bosh and others	7.000	3.150.000	350-600	0,08

Market of Serbia

Solid fuel stoves, cookers, and boilers	Estimated annual sales volume/ pcs/	Market share in %	Total EUR	Average retail price EUR	Already sell products that meet Eco design
Alfa plam Serbia	28.000	49,60	10.080.000,00	360	NO
MBS Serbia	25.000	44,30	5.500.000,00	220	
Megal Serbia	150	0,30	120.000	800	
Blist Serbia	650	1,10	110.500	170	
Plamen Croatia	400	0,70	192.000	480	
Radijator Serbia	250	0,44	212.500	850	
Timsistem Serbia	500	0,90	175.000	350	
Solid fuel stoves, cookers and boilers of other manufacturers	1.500	2,70	375.000	250	
Total:	56.450	100	16.765.000,00		

Pellet stoves, cookers and boilers manufacturer	Estimated annual sales volume/ pcs/	Market share in %	Total EUR	Average price EUR	Already sell products that meet Eco design
Alfa plam Serbia	9.000	54,90	12.600.000	1.400	only products that are certified as pellet boilers meet Eco standard
MBS Serbia	500	3,00	600.000	1.200	
Termo flux BIH	1.500	9,00	2.400.000	1.600	
Eko Spar North Macedonia	600	3,70	660.000	1.100	
Bauger-Lafat BIH	700	4,30	700.000	1.000	
Mareli Bulgaria	2.000	12,20	2.000.000	1.000	
Kepo Serbia	1.600	9,80	2.400.000	1.500	
Pellet stoves, cookers and boiler of other manufacturers	500	3,00	650.000	1.300	
Total:	16.400	100	22.010.000		

Gas boilers	Estimated annual sales volume/ pcs/	Total (EUR)	Average price (EUR)	The price of the gas connection
Vaillant, Bosh, Ariston etc.	15.000	12.000.000,00	conventional boilers 650 EUR condensing boilers 1000 EUR	average price 900 EUR

Electric boilers	Estimated annual sales volume/ pcs/	Total (EUR)	Average price of the device (EUR)	The average price of the electricity for households (EUR)
Vaillant, Bosh etc.	3.000	3.150.000	350-600	0,07 €

The data sources used for this analysis are explained below:

- Data from importers and wholesalers on the quantities they import and data on the quantities they sell on the markets
- Officially available information of producers on their websites, and portals of official government institutions to whom the final reports of the company are submitted
- Information collected from manufacturer's salespersons and merchandisers
- Information collected from other representatives of the manufacturers
- Available newspaper articles and data from the portal stating the results of market research on heating appliances, air-conditioning, heat pumps and gas boilers.

There is not even unofficial information about the black market, which does not mean that it does not exist. We estimate that it is not significant, and it has absolutely no impact on the estimated quantities given in this report.

2. Pellet stoves and boilers as alternative heating sources for domestic use

The majority of people in Balkan consider pellet appliances as the most direct replacement to solid fuel heating appliances. The pellet which is used as a fuel in the pellet appliances is usually made by the wood compound that also includes other organic materials such as corn husks or nut shells. Due to the automatized combustion process, pellet appliances are the cleanest of all solid fuel heating systems. Pellet fuel appliances are more convenient to operate than ordinary wood stoves or fireplaces, and have much higher combustion and heating efficiencies. As a consequence of this, they produce very little air pollution.

There are a many different types of pellet appliances, but they can be grouped in the following categories:

- Pellet air stoves where the heat is directly vented to the room via hot air
- Pellet hydro stoves that combine water and air heat transfer. Usually most of the heat is being released via the boiler integrated within the stove and some smaller amount of heat is being directly released into the room where the stove is installed.
- Pellet boilers – all the heat is released through the water installation
- Pellet cookers that have multifunctional use for heating and preparing food.

Pellet fuel appliances are available as freestanding stoves or fireplace inserts. They are suitable for homes as well as apartments or condominiums.

Comparing to the solid fuel appliances, there are following pros and cons of pellet appliances:

Pros:

- There is a specialized control unit integrated in all modern pellet appliances which controls the combustion process and provides automation, safety, great efficiency and reduce pollution.
- Pellet feeding, exhaust gas extraction, ignition and all other features are completely automated which make pellet appliances much more convenient to operate than ordinary wood stoves or fireplaces.
- All pellet fuel appliances have a fuel hopper to store the pellets until they are needed for burning which will last a day or more under normal operating conditions.
- Due to its functionality, energy efficiency in modern pellet appliances is usually higher than 90%. Automatized combustion enables reducing and controlling emission of CO, NOx, OGC and dust particles
- Most pellet appliance exteriors (except glass doors) stay relatively cool while operating, reducing the risk of accidental burns.

- It is possible to use a control unit and components powered by 24V DC. This system provides even less electric consumption, less noise and can be installed everywhere in the world without any modification due to different mains electricity. These systems are still rare due to their price being 20% higher than AC powered systems.

Cons:

- Due to the complexity of pellet appliances, there are more expensive components that can break down.
- Pellet appliances need to be cleaned by the homeowner on a weekly basis and by a professional on an annual basis.
- Pellet appliances require electricity to run fans, controls, and pellet feeders. Unless the stove has a back-up power supply, the loss of electric power results in no heat and possibly some smoke in the house.

3. Energy efficiency and emission standards for the pellet appliances

Currently there are a lot of different standards and regulations related to the pellet and solid fuel heating appliances. There are European standards, but also many countries have some additional requirements which usually contain some more restrictive limits for the emissions and the efficiency (In Germany there is a BImSchV, in France Flamme verte, in Italy Lombardia DGR5656, in Austria ART.15a BV-G, in the UK Ricardo/DEFRA and many others).

The following table represents European standards related to the pellet appliances with all requirements regarding the limits of emissions and efficiency.

Standard	Condition	CO	DUST	NOx	OGC	Efficiency
EN 303-5 (Class 5) Boilers	Manual load	700 mg/m ³ (10%O ₂)	60 mg/m ³ (10%O ₂)		30 mg/m ³ (10%O ₂)	87%+log(Pn)
	Automatic load	500 mg/m ³ (10%O ₂)	40 mg/m ³ (10%O ₂)		20 mg/m ³ (10%O ₂)	
EN 14785 Stoves and fireplaces	Nominal load	0,04 %Vol (13%O ₂) 500 mg/m ³ (13%O ₂)				75%
	Reduced load	0,06 %Vol (13%O ₂) 750 mg/m ³ (13%O ₂)				70%

The following table represents European standards related to the solid fuel appliances.

Standard	Condition	CO	DUST	NOx	OGC	Efficiency
EN 13229 Fireplaces	Closed door appliances	1% (13%O ₂)				30%
	Built-in fireplace	0,2% (13%O ₂)				75%
	Other appliances					30%
EN 13240 Stoves	Nominal load	1% (13%O ₂)				50%
EN12815 Wood cookers	Nominal load	1% (13%O ₂)				60%

A comparison between the two tables shows how much more restrictive are limits for pellet appliances compared to the solid fuel appliances.

Eco-design regulation brings even more restrictive limits for efficiency and emissions. Regulation 2015/1189 for the boilers has started being implemented since January 1st 2020. Regulation 2015/1185 for local space heaters is going to be implemented from January 1st 2022.

The following table represents Eco-design limits for the efficiency and emissions:

Regulation	Condition	CO	DUST	NOx	OGC	Efficiency	
Regulation 2015/118 5: local space heaters from 1/1/2022	Open fire appliances	2000 mg/m ³ (13%O ₂)	50 mg/m ³ (13%O ₂)	200 mg/m ³ (13%O ₂)	120 mg/m ³ (13%O ₂)	30% (seasonal efficiency)	
	Closed fire appliances (except pellet)	1500 mg/m ³ (13%O ₂)	40 mg/m ³ (13%O ₂)			65% (seasonal efficiency)	
			Pellet appliances			300 mg/m ³ (13%O ₂)	20 mg/m ³ (13%O ₂)
	Kitchens	1500 mg/m ³ (13%O ₂)	40 mg/m ³ (13%O ₂)			120 mg/m ³ (13%O ₂)	65% (seasonal efficiency)
Regulation 2015/118 9: boilers From 1/1/2020	Hand loaded boilers	700 mg/m ³ (10%O ₂) (seasonal)	60 mg/m ³ (10%O ₂) (seasonal)	Biomass: 200 mg/m ³ Fossil: 300 mg/m ³ (10%O ₂) (seasonal)	30 mg/m ³ (10%O ₂) (seasonal)	75% (seasonal efficiency; power ≤20kW)	
	Automatic loaded boilers	500 mg/m ³ (10%O ₂) (seasonal)	40 mg/m ³ (10%O ₂) (seasonal)		20 mg/m ³ (10%O ₂) (seasonal)	77% (seasonal efficiency; power >20kW)	

CO-carbon monoxide; NOx – nitrogen oxides; OGC – organic gaseous carbon; Dust – hard particles
Seasonal efficiency is a new way of measuring the true energy efficiency of heating over an entire year.

A new European standard EN16510 is already written, approved and is waiting to be officially introduced, probably at the beginning of the next year. This standard will include all solid fuel appliances, except the solid fuel boilers.

Even now there is a big gap that solid fuel appliances need to overcome in order to fulfill eco-design requirements. For example, the current standard which regulates solid fuel stoves, EN 13240 sets limits for CO emission at 10000 mg/m³ and 50% for efficiency. Dust, OGC and NOx were not measured at all. Compared to these limits, for the same group of solid fuel appliances, Eco-design requires CO lower than 1500 mg/m³ (almost 7 times more restrictive) and 75% efficiency. Eco-design also requires dust value to be lower than 40 mg/m³, NOx to be lower than 200 mg/m³ and OGC lower than 120 mg/m³. In the very near future emission limits will only get more restrictive and these circumstances strongly favor pellet appliances compared to solid fuel appliances. Automated combustion in pellet appliances provides great flexibility and programmability which enable much easier and faster development of new products. Combination of advanced electronic components and new materials could make pellet

appliances even cleaner and more efficient.

On the other hand, it is very challenging to customize solid fuel (wood) appliances in order to fulfill current Eco-design requirements, which resulted in many products being discontinued after many years of production. Most coal fueled appliances were being completely phased out even before Eco-design started being implemented due to the fact that emissions are even worse than in wood appliances. Since the combustion process in solid fuel appliances is mostly determined by its structure and exhaust gasses pathway, even the smallest improvements in combustion would require changes in construction of the stove. Very often, in order to improve combustion, it is necessary to completely redesign wood appliances, and this process takes as many resources as to develop a completely new one. Finally, there is much less chance to achieve declared performances of wood appliances in real conditions due to the fact that combustion process is not 100% controlled and it depends a lot on many variables that neither manufacturer nor final user can have influence on. According to the standard, the official testing period for wood stoves is usually 60 minutes and during this period a precise amount of dry wood is being burnt inside the combustion chamber under the controlled conditions such as constant draught in the chimney and precisely set quantity of primary air. These conditions can't be repeated in a customer's house because they will never put the same amount of wood for combustion and draught in the chimney and the moisture content in the logs can vary a lot. These variables have a great effect on stove's performances.

4. Fuel costs analysis

Burning pellets is the most advanced way to use biomass energy. Pellet is basically made from the wood industry residuals which are recycled in a specific technological process. Burning 1kg of pellet releases about 5kWh heating energy. Heating energy made by burning 2kg of pellet is equal to energy made by burning 1l of oil. Pellet is considered as an ecologically acceptable heating source due to the small amount of ash and CO₂ released through combustion.

The table below shows a prices of wood and pellet in Western Balkans:

Country	Price of 1 m ³ of firewood in the season (EUR)	Price of 1 m ³ of firewood out of the season (EUR)	Price of the 1t of pellet in the season (EUR)	Price of the 1t of pellet out of the season (EUR)
Albania	40	35	220	190
Bosnia and Herzegovina	45	40	175	140
Montenegro	40	35	180	140
Kosovo*	45	40	210	190
North Macedonia	65	60	200	185
Serbia	50	40	200	160

When pellet appliances first appeared in Western Balkans about 10 years ago, there was a big question mark about its price and availability. Pellet was not available in every place and it was usually purchased in a way that a group of users would buy it directly from the manufacturer. The only condition was that they must buy one full truck. When pellets first appeared it was approximately 30% more expensive than wood if we compare the quantity needed for heating the same area during one season. In the meantime, during the last 10 years, the situation changed almost completely and today many could argue that wood is even more expensive than pellet. Pellet production capacities increased drastically and Balkan countries are among the largest exporters of pellet.

The price of pellets was relatively stable in the last 5 years and varies only seasonally, in early spring it could be up to 30% lesser than during the winter. Depending on the distance from the location of the producer, the price of pellets usually is 150-170 EUR per 1 ton in early spring and up to 200-230 EUR per 1 ton in midwinter.

In order to enable pellet appliances to function in the best possible way, it is absolutely crucial to choose the right pellet. It is difficult to recognize pellet's quality visually, so the safest way is always to look for EN plus sign on a pellet bag. EN plus is a world certification scheme for wood pellets which should guarantee quality through controlled purchasing chain from producer to the distributor and to the final client. Quality pellets contain less humidity (less than 10%) and there is less quantity of ash during combustion which makes cleaning easier and less frequent. If there is a bigger quantity of ash during the combustion, this is a clear sign that the pellet contains wood crust or more humidity. Wood crust in pellets is especially problematic, because it could contain sand, mud or other dirt and exactly these materials cause the biggest problems in functionality of the pellet appliances.

On the other hand, the price of wood has continually increased in the last five years. Currently the wood is the cheapest in Serbia where the price of a cubic meter of wood is about 45-50 EUR. In some Balkan countries the price of a cubic meter of wood can go up to 70 EUR. It is important to know that the price of wood 10 years ago, when pellets first appeared, was about 35 EUR per 1m³ in Serbia. In the last 10 years the price of wood increased about 50% and this is the same trend in all Balkan countries. There are several reasons for price increase, like stricter control by government agencies, all the woodland with easier access is being cut and now it is more difficult to extract wood logs, increased salaries of the workers etc. General trend looks contradictory with wood prices going up on one side and pellet prices being stable on other especially because pellets are mainly made from wood. This trend is probably determined by competition and large demand in the pellet market and decreasing demand in the wood market.

It is important to understand that caloric values of different types of wood could vary a lot. Conifer wood is good for ignition but it should not be used for combustion due to the high content of resin which burns too fast for heating. Also burning conifer wood release a large quantity of smoke. The best suited type of wood fuels for heating appliances are beech, oak and acacia. These types of wood have a good caloric value and its

combustion is stable and gradual. The most used wood for heating in Western Balkans is beech and all prices mentioned above are related to beech wood. The prices of oak and especially acacia wood could be less than 20% but they are much less used than beech wood.

The price of pellet and the fact that it is produced locally are important advantages of pellet appliances compared to the other heating appliances which fuels (oil and gas) are imported and as such are more susceptible to the price fluctuations.

5. Replacement of solid fuel appliances with pellet appliances

At the beginning, mostly the younger people with innovative spirit were interested in pellet appliances, but just a few years were necessary for the pellet to start its expansion in the Western Balkans. For the manufacturers, pellet appliances started as additions to the standard solid fuel products, but very soon most of them had to make shifts and customize production capacities in order to fulfill increasing demand for pellet appliances. The biggest manufacturers in the Balkans had a long history in producing solid fuel devices. The initial know-how was mostly gained through some cooperation with Italian producers who pioneered the pellet program in Europe, and in terms of metal processing capacities were already present. Now there are several big manufacturers in the Western Balkans like Alfa plam, MBS, Centrometal, Termoflux, Radijator, ABC and others, with their own research and development and complete production cycle and also there are many small manufacturers who produce appliances through some joint projects with bigger companies. The local manufacturers provide a wide range of products which local buyers can afford and there is a strong competition among them which is also good for the final users.

As mentioned at the beginning, most people consider pellet appliances as a direct and more advanced replacement to the older wood appliances. There are several reasons for that:

- There is a strong tradition of having heating appliances that actually burn and make flames. A lot of people have the preconception that alternative heating sources like heat pumps are better suited for some warmer climate and not for the Balkans.
- Many people already had similar stoves, cookers and boilers and replacing them with pellet appliances which have the same functionality seems like a logical step.
- If you compare the quantity of the fuel necessary for the heating season, the price of pellets is almost equal to the price of wood. For example, 80m² area in the house or apartment with average thermal insulation will require about 2,5 t of pellet or 10 cubic meters of wood for one heating season. In Serbia, the average price of pellets is 200 EUR per 1t and the average price of wood is 45 EUR per

1m³. The reason for this is the fact that pellet stoves which fulfill eco-design requirements have very high efficiency, usually more than 90%. Wood also requires preparation through cutting which costs about 50 EUR for 10 m³ and drying because it is not possible to buy dry wood. If a user wants to have proper functionality of wood appliances, he must buy wood at least a few months in advance so the wood can be dry enough when the heating season starts. There is a price difference between pellet and wood appliances, but technological leverage of pellet appliances is so obvious to the final users that they are willing to pay for it.

- For the houses most people use a central heating system with a boiler. In case wood boiler or hydro stove are being replaced with its pellet counterparts, very small or even no modifications are needed in water installations and connections.

- New pellet technologies like remote control via smartphone application, automated cleaning systems which reduce final user involvement in cleaning and increased work autonomy make pellet appliances even more appealing to the general population.

Before making direct comparisons in retail prices of wood and pellet appliances, it is important to take into account that in the Balkans all pellet appliances are considered to be upmarket products and within wood appliances there are low cost models and upmarket models. The wood low cost models usually do not fulfill requirements of European standards and are specially produced for non EU markets. The following table shows the retail price comparison:

Type of appliances	Retail price in Serbia
Pellet air stove	650-1150 EUR
Pellet hydro stove	1.150-1.700 EUR
Pellet boiler 18kw-100kw	1.800-4.100 EUR
Pellet air cooker	980-1.100 EUR
Pellet hydro cooker	1.500-1.700 EUR
Upmarket wood air stove	Up to 1.100 EUR
Upmarket wood hydro stove	Up to 700 EUR
Wood boiler	1.000-1.700 EUR
Upmarket wood air cooker	Up to 850 EUR
Upmarket wood hydro cooker	Up to 1.200 EUR
Low cost wood air stove	120 EUR
Low cost wood hydro stove	300 EUR
Low cost wood air cooker	150 EUR
Low cost wood hydro cooker	420 EUR

Pellet appliances have a lot of components installed which use electrical energy. The electrical consumption of the pellet appliances at nominal power is usually about 100W (0,1kWH) which is insignificant for the household electrical consumption.

The maintenance of pellet appliances depends directly on regular cleaning and quality of pellet used for combustion. If the appliance is cleaned regularly and the quality of pellet is at least A2 class then it should not have any problems during its lifetime. This is especially important for appliances of older generations, before cleaning mechanisms were introduced. All electric and electronic components are under the factory's warranty as long as the whole appliance is. Many users have the impression that due to all automated systems, the stoves or boilers do not need to be cleaned regularly and this is the main cause of problems. Additional education is necessary in order to explain to users that even when appliances are automatized, they burn solid material and as a side effect there will always be some residuals (ash, dust, slag etc.) that need to be occasionally removed. The quantity of residuals is directly related to the quality of pellets.

Due to Covid-19 pandemic and all related problems, a whole industry is facing some new challenges which seriously affect the final consumer's decision to replace old heating appliances with new one. The large growth of sheet metal price on the market, along with other materials, has led to an increase in both production and sales prices of wood and pellet appliances by an average of 15% - 30% during 2021.

Inverter air-conditioners are more frequently mentioned as alternative types of heating for housing units. Unfortunately, there is no data on how many households are being heated only via inverters. It is obvious that there is a growing trend in sales of

inverter air-conditioners in Macedonia due to the subvention program they had for replacing wood stoves.

Some of the following suggestions should be kept in mind when defining a strategy for replacing old appliances with environmentally friendly appliances:

- Introduction of EU standards in the Western Balkans countries related with Eco-design standards - education of the population on the type of firewood to be used
- Timely informing customers about all announced public calls for the allocation of funds that enable the purchase of environmentally friendly devices under more favorable conditions - education of the population that there are wood stoves that comply with EU regulations and subsidies for the purchase of such devices that meet eco standards
- Prohibition of coal or any other fuel except firewood through manuals of stove manufacturer, use of coal or anything other than firewood (also under the prescribed conditions in terms of percentage of moisture)
- Additional subsidies for gas connections
- Subventions for procurement of heat pumps
- Legal changes of construction conditions for residential buildings in terms of targeting smart green buildings and houses, partially in reference of insulation and construction of adequately prescribed chimneys
- Defining the body that will put into operation the heating devices, which will also check the technical conditions for connection to the chimney and the compliance of the device with standards.
- Subventions and support for producers working to win products that comply with EU standards
- Support for manufacturers who are conquering new segments such as gas boilers, heat pumps - support for manufacturers of heating devices in terms of free professional assistance of professors from the Faculty of Mechanical and Electrical Engineering and other accredited institutions and laboratories in the Western Balkans in order to conquer new technologies that will enable the production of environmentally friendly devices
- Support for the construction of laboratories at the manufacturers of wood and pellet devices which would be able to perform all tests in accordance with relevant standards. There is one accredited laboratory in Serbia, Kvalitet Niš, which can perform official and preliminary tests. The price of one day of preliminary testing is 350 EUR. Joint laboratory for different manufacturers is not a realistic idea due to the fact that all of them want to keep the project hidden from the competitors until the product is officially launched in the market.

In the Western Balkans, expected lifespan of solid fuel appliances is between 15 and 25 years with adequate maintenance and service. In the Western Europe solid fuel appliances are replaced more often, every 5 to 8 years due to bigger purchasing power. During the lifespan of solid fuel cookers, periodically fire bricks inside of the combustion chamber have to be replaced because they get damaged from the wood logs. Depending on the way a user puts the wood logs in the burner, the fire bricks can last from one season up to many seasons if the wood logs are put carefully. The price of a complete set of fire bricks is between 15 and 25 EUR. If the replacement is performed

by a service man that usually costs another 15 EUR. This operation can be performed also by the user himself.

6. Estimation of costs associated with improved technologies

Currently the majority of people in the Western Balkans use individual space heaters for heating their homes. There are estimated more than three million devices used in the Western Balkans that do not fulfill Eco-design requirements and represent potential hazard to the natural environment and human health. There is a space for immediate action to improve heating practices across the Western Balkans, but considering the economic situation in the region, costs of action are crucial to estimate and take responsibility for. The costs can be grouped into two categories:

- Direct costs which affect final price of the products that fulfill eco-design requirements
- Indirect costs which are related to the energy efficiency of the house and long term effects of eco-design implementation

The manufacturer is initially responsible for direct costs of eco-design implementation, but these costs are later transferred to the final user through increased price of the final product. The most important direct costs are the following:

a. Research and development process

Research and development process could take a lot of time and working hours of engineers who work on the project as well as of qualified workers who are making prototype samples. The process could take from 3 months in case of some redesign up to 1 year in case of a completely new product. Estimated costs in working hours, used materials and tools are between 8000 and 40000 EUR.

b. New materials and components

Depending on the type of appliance and extent of modifications being made, it is necessary to introduce new materials. The biggest costs are related to the usage of tooling which is necessary for producing cast iron, aluminum, plastic and ceramic parts. These costs vary between 10000 EUR (for cast iron door) up to 100000 EUR (in case of tooling for producing complex metal parts).

c. New production technologies

New design requires new technologies for welding, bending, metal processing, painting and assembling. Developing technologies could take a lot of working hours of technologists, and sometimes workers have to be trained in case of some complex operations. These costs could vary between 5000 and 10000 EUR.

d. Certification costs

Every new product must be certified in an accredited laboratory at the notified body in accordance with the European Standards. The cost of certification is

4000 - 6000 EUR.

e. New improved production and quality procedures

Improving efficiency and performances of the heating appliances and reducing pollution in exhaust gasses always require significant improvement in the production process. This is especially related to the precision of metal processing and final assembly. Older non efficient appliances could have bigger tolerances between different parts of combustion chamber, but in order to fulfill eco-design requirements, the combustion chamber and appliance in general has to be perfectly assembled and sealed. This improvement increases the working hours needed for production and in this way directly affects the final price of products.

f. Final factory price of products

Due to all costs mentioned above, the final price of new appliances that fulfill eco-design requirements is 25% higher than the price of appliances that do not fulfill eco-design requirements. 3-5% percent of this price increase are related to the marketing and education costs.

Indirect costs are mostly related to the household where the heating appliance is installed. In order to achieve full potential of improved performances and efficiency in new products, it is necessary to fulfill some preconditions:

a. Thermal insulation of the house

Appropriate insulation materials and design adaptations for buildings will slow the transfer of heat through the enclosure to reduce heat loss and gain. This is a long term investment and government assistance is crucial in order to help people adapt old buildings due to high costs of insulation compared to the price of real estates. The price of this investment is minimum 5000 EUR but it can reach up to 20000 EUR in case all the windows and doors are being replaced. The price of one PVC window is about 130 EUR per 1m² and the price of windows with wooden frames is 40% more expensive. The price of thermal insulation with installation for a 100m² house is between 6000 and 8500 EUR. The price of the cheapest thermal insulation, graphite Styrofoam, is 20 EUR per 1m² and better quality rock wool is 30 EUR per 1m². New buildings should have thermal insulation thickness of at least 12cm. The 100m² house usually requires the same surface area to be insulated, which means that only the price of thermal insulation material is between 2000 and 3000 EUR plus costs of other materials, such as binder mixture and especially installation costs which are continually rising in last decade due to migration of qualified workers to the Western Europe. It is also necessary to make roof insulation. It is estimated that 300 000 houses in Serbia do not have any kind of thermal insulation and many old houses in rural parts of the Western Balkans are worth less than insulation for the houses.

b. New chimney

Old houses usually have old rectangular concrete chimneys which are in very bad shape after long term exploitation. New chimney is necessary in order to

achieve declared performances of the appliances and to extract and take out of house exhaust gasses in a proper way. The price of a new chimney is 1000-2000 EUR.

c. Fuel quality

There is a big problem with pellet quality in the Western Balkans. A reason for that is the fact that the whole pellet market is not regulated by government agencies; there are no clear standards nor regulations to regulate production of the pellet, and finally there are no government agencies that control the quality of pellets sold to the final user. Many customers are ready to pay more for pellets (100-200 EUR more per heating season) in order to be sure that the quality is good. This is another area where government assistance is needed.

7. Suitability of pellet in household or buildings

Pellet as a fuel is the most suitable for household use and for heating houses or apartments. Some storage place for pellets is needed and it is necessary to keep pellets dry. Pellet boilers are usually installed in technical rooms and pellets are usually stored either next to the boiler or in the room next to the technical room. Pellet air and hydro stoves are installed usually in the living room. The aesthetics of pellet stoves is very important and there are all kinds of different designs and materials used for so-called aesthetical parts like cast iron, aluminum, glass, ceramics etc. Final users can choose the model which is best suited for their needs. Pellet cookers are installed in the kitchen where they can be used for preparing food and for heating.

Control units installed in the pellet appliances provide important options like a connection of other heating systems to work with or without pellet appliances. Control units in the pellet appliances can manage functionality of the pellet boilers together with solar collectors, buffers, smart home systems etc. Various options for customization of heating systems enable final users to choose and set heating configuration which is the best suitable for their needs and the most economical for their environment.

Pellet boilers could be used also for heating larger buildings but these large industrial boilers are mostly made on a request by manufactures specialized in this type of boilers. Bigger output powers (more than 100kW) require different type of feeding and ignition systems which are more difficult to manage and control and possibly could compromise efficiency and emissions. Storage of pellets and maintenance of these systems could be also problematic considering the fact that they need to burn large amounts of pellets. These boilers do not exclusively use pellets as a fuel but can also use other types of biomass due to its feeding and igniting systems. Generally practicality of these types of boilers could be an issue and it should be installed in combination with another heating source.

8. Other alternative heating sources for domestic use

There are several other alternative heating sources which could replace solid fuel appliances to some extent, but these heating sources also have some serious limitations that prevent its widespread use.

a. **Gas appliances** (stoves and boilers)

Gas boiler can represent a much cleaner, more efficient and more user friendly alternative to the solid fuel boiler. The price of a gas boiler is similar to the price of a wood boiler with the same output power, but the user has to pay for the gas connection and when taking into account gas connection costs, the price is similar to the price of a pellet boiler with the same output power. Gas heating appliances have many advantages comparing to the solid fuel heating appliances:

- Compact dimensions
- Easy maintenance and no need for cleaning by user
- High efficiency and small emission of pollution
- They are suitable for homes, apartments and even large buildings or factories - They are more convenient to operate than wood or pellet boilers

There are also some serious drawbacks which are preventing expansion of gas boilers in western Balkans:

- Natural gas is still not available to the majority of people in Western Balkans. Only some areas in Serbia do have access to natural gas and the rest of the region will not get access in a near future.
- The price of natural gas is not stable. It depends on the global situation and the fluctuations of global price are occurring on regular basis.
- Natural gas cannot be purchased in a free market but only from a state owned company that has exclusive rights for gas distribution.

The table below shows retail prices of gas boilers in Western Balkans:

Manufacturer	Type of boiler	Price (EUR)
Proterm /B brend Vaillant/	24-28kw conventional boilers-heating and hot water preparation	520-650
Bosch	24-28kw conventional boilers-heating and hot water preparation	730-870
Vaillant	20-32kw conventional boilers -heating and hot water preparation	1 100-1.450
Habitat /Romstal/	25-35kw conventional boilers -heating and hot water preparation	520-800
Vaillant	20-28kw conventional boilers, only for heating	980-1.100
Proterm /B brendVaillant/	24-25kw condensing boilers - heating and hot water preparation	900-1.100
Bosch	24-28kw condensing boilers - heating and hot water preparation	900-1.200
Vaillant	20-25kw condensing boilers - heating and hot water preparation	1 300-1.600
Habitat /Romstal/	25-35kw condensing boilers- heating and hot water preparation	850-1.200
Vaillant	24kw condensing boiler, only for heating	1.100

b. Heat pumps

Heat pumps are transferring thermal energy from a cooler space to a warmer space using the refrigeration cycle, being the opposite direction in which heat transfer would take place without the application of external power. Heat pumps include air source heat pumps, ground source heat pumps, water source heat pumps and exhaust air heat pumps.

Air source heat pumps are relatively easy and inexpensive to install and have therefore historically been the most widely used heat pump type. They can operate in heating and cooling mode, but usually are better suited for areas with mild winters because at temperatures below around 0 °C an air-source heat pump may achieve a COP (coefficient of performance) of 2.5 and this leads to bigger electricity consumption and bill. Air source heat pumps are more expensive than pellet boilers even though its output power is comparable to pellet air stoves.

Ground source heat pumps or so-called geothermal heat pumps rely on consistent underground temperatures to efficiently heat home during the winter. Depending on the home's location, the temperature underground is between 7°C and 21°C throughout the entire year-often warmer than winter surface temperatures. The warmer underground temperature makes geothermal pumps more efficient than air source heat pumps. The price of a geothermal heating system is higher than a comparable air source system due to installation which involves drilling a hole in the ground or placing heat-transferring coils in a nearby body of water. Geothermal system will need at least 10 years to cover the cost difference. This is the reason why many people in the Western Balkans are very hesitant to this solution.

A water-source heat pump works in a similar manner to a ground-source heat pump, other than that it takes heat from a body of water rather than the ground. The body of water needs to be large enough to be able to withstand the cooling effect of the unit without freezing. Installation of this system also requires a great cost which can be covered only after 5 to 10 years. System maintenance could be also problematic since underground waters in the Western Balkans consist of many minerals and chemicals that could potentially damage heating systems and regular maintenance and protective measures are necessary.

Table below shows the prices of different types of heat pumps in Serbia:

Manufacturer	Model	Type	Power heating/cooling	Price (EUR)
Alfa Clima	AK TP 40WW	Water source	2,84/2,17	2.420
	AK TP 160WW		10,8/8,47	6.240
Galletti	MCW 018HS		19,2/17,3	6.195
Bosch	Compress 6000AW 5 Electro	Air source	6,4/4,12	5.873
	Compress 6000AW 13s Electro		15,2/8,86	7.356
Viessmann	Vitocal 200-S		6/6	5.050
	Vitocal 200-S		13/13	7.915
Ferroli	Omnia Split		6/6	3.510
	Omnia split 16T	16/16	5.932	
	HMW	Water source	45/45	15.534
Samsung	EHS Split Inverter A2W	Water source	6/6	4.271
			16/16	7.000
Gree	Split DC Inverter Versati II		9/8,5	3.305

c. Solar heating

There are two forms of solar heating: active and passive. Passive solar heating relies on solar gain, where solar heat passes through windows and/or skylights and provides heat for the home. The heat can be retained with an absorber and thermal mass. In a home, the absorber is simply a floor covering, such as tile, and the thermal mass is the floor underneath (and/or walls) that retain heat (cement or masonry). Passive solar heating can work as a supplement to standard heating systems. Installing skylights and south-facing windows can improve solar gain and, in turn, lower heating costs.

Active solar heating is less common and is also usually used as a supplement to standard central heating. A solar collector uses the sun's heat to warm liquid, or sometimes air. The heated material is then stored or transferred directly to the living area, either with a blower or a radiant heat system. Generally solar heating has a much bigger potential as a

supplement to standard heating systems especially during the spring and fall than being used as a main heating system during the winter.

d. Inverter air conditioning units

Inverter AC units are some of the most efficient products when it comes to energy consumption, because they use less energy – when compared the heat they produce against other electrical energy-powered heating devices. A 12 AC, for example, consumes 1,2 kW, but gives out 3,5 kW when cooling or heating. When heating, all AC units are able to function properly in the weather up to minus 5 degrees Celsius. However, when buying AC intended for heating – inverter devices should be chosen. The reason is simple: inverter AC units can function even with the outside temperature reaching minus 15 degrees Celsius. The inverter technology is made so that the compressor functioning is adjusted to the reached temperature. At first, it worked with full capacity. Later, as it's approaching the set temperature, work intensity, consumption and RPM are decreasing, saving a significant amount of energy when compared to traditional AC units that work with full capacity all the time. This way, inverter AC saves energy, at the same time not allowing significant deviations from the set temperature. AC units do not have any electrical heaters inside, as the rest of heating devices do. They use the effect of compressed gas, which is one of the reasons they are quite energy efficient.

There are several benefits in usage of inverter AC units for heating:

- Inverter AC unit's price starts at around 500 EUR so it is the cheapest way of heating when compared to other electrical heating devices, gas, coal, woods, district city heating and oil;
- A customer manages an AC by using a remote control and he can also program it turning on or off;
- There is no ash or dust which means there is no need for cleaning;
- It does not occupy a lot of space in the apartment;
- It starts heating immediately after being turned on – there is no need to heat up the furnace or accumulate energy overnight.

There are also some drawbacks which can't be ignored:

- Inverter AC unit's efficiency directly depends on the energy efficiency of the building or apartment where it is installed. Unfortunately, in Western Balkans energy efficiency in the buildings is still not adequate and this could lead to the bigger electricity consumption of inverter AC units.
- Even though the climate is getting warmer, in the Western Balkans there are many areas with harsh winters with many days with temperatures below zero Celsius degrees. In these conditions the efficiency of the AC unit is much lower and the electricity consumption is much higher which could get heating costs too high for the average household.
- Electricity in the Western Balkans is not obtained in a free market and it is a social category provided by state owned companies. The downside of this system is the fact that higher consumption of electricity activates penalties which increase the price of kWh. In

other words there is a policy to destimulate people from higher electricity consumption.

9. Summary

The effects of climate changes and global warming are present everywhere and can be seen even in the Western Balkans region. Global warming is being driven by human-induced emissions of greenhouse gasses of which more than 55% is CO₂. At the moment when there are more than 8 billion people on Earth, it is not acceptable anymore to buy heating appliances only in accordance with our own needs and without considering its global effect on the environment. The protection of forests and other plants is top priority because they are producing oxygen and through photosynthesis removing CO₂ from the atmosphere. Forests are crucial also due to other positive effects like absorbing many other dangerous particles produced during the combustion of fossil fuels. Forests protect biodiversity and provide a natural environment for many animal and plant species. In urban areas, forests act as natural barriers and decrease noise level. One 60 years old beech tree produces oxygen consumed by 10 people and removes CO₂ produced by 6 people. This example shows the importance of protecting every individual tree.

On the other hand, compared to fossil fuels, wood is still the cleanest and the safest fuel that can be used for heating. If it is used in the proper manner, wood can be used as a renewable energy source in the foreseeable future. In order to find some balance between produced and consumed wood, it is necessary to decrease wood consumption. A biomass is a perfect medium to fulfill this goal through recycling wood residuals from construction, timber and other industries and using it for heating. It is also an area where the effect of energy efficiency can be seen in the best possible way. Energy efficiency is not related only to the appliance's performances but also to the user's behavior. Increasing energy efficiency at global level considers the following steps:

- Replacing fossil fuel energy sources with renewable energy sources
- Replacing old appliances with low efficiency and high emissions
- Introducing new standards related to the construction and thermal insulation of buildings
- Introduction of temperature regulation in the buildings
- Introduction of new efficient heating appliances

Energy efficiency has direct consequences to reducing heating costs and protection of the natural environment. At an individual level, every user of a heating system should try to use the system in the most efficient way. It is also important to raise customer's awareness to choose heating appliances that fulfill eco-design requirements and have energy class A+ or A++. People should be aware that efficient heating systems provide rational use of energy and better functionality and comfort while also protecting the natural environment.