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APPLICATION OF THE MODIFIED AHP METHOD AND ECO-LABELS FOR BIOMASS BOILER SELECTION FOR A SMALL HOTEL IN A MOUNTAIN REGION. A CASE STUDY

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ZASTOSOWANIE ZMODYFIKOWANEJ METODY AHP I EKOETYKIET DO WYBORU KOTŁA NA BIOMASĘ DLA PENSJONATU W MIEJSCOWOŚCI PODGÓRSKIEJ. STUDIUM PRZYPADKU

STRESZCZENIE: W artykule zaprezentowano wielokryterialną ocenę kotłów na biomasę dla pensjonatu położonego w miejscowości podgórskiej. Oceny dokonano zmodyfikowaną metodą Procesu Analizy Hierarchicznej (z ang. *Analytic Hierarchy Process*, AHP). Problem budowy hierarchii kryteriów rozwiązano w oparciu o zasadę trwałego rozwoju oraz o międzynarodowe kryteria, wypracowane w programie ekoetykiet. Wszystkie przyjęte do obliczeń dane dotyczą rzeczywistych kotłów i paliw.

SŁOWA KLUCZOWE: analiza wielokryterialna, zmodyfikowana metoda AHP, Proces Analizy Hierarchicznej, HIPRE, wybór kotła na biomasę, ekoetykiety.

Introduction

The practice shows that most decision-making situations is considered by decision-makers from the perspective of more than one criterion. The reason for this approach is the complexity of the world around and multidimensionality of human perception. Man by nature seeks to maximize his satisfaction in all possible aspects[1]. Helpful could be multi-criteria methods, which try to take into account the multitude of requirements defined by the decision maker.

The subject of the analysis is the selection of a biomass boiler for a small private hotel located in Bukowina Tatrzańska. This is a typical modern mountain hotel with an area of 500 m^2, consisting of 20 rooms, a common area and catering facilities. According to calculations, the demand for thermal power for heating purposes is 50 kW and for the preparation of hot water (accumulated in hot water tanks) 20 kW. The seasonal heat demand for heating and hot water purposes is respectively: 350 GJ and 99 GJ. According to the hotel manager, the process of heat production should not put much pressure on the environment because of use of biomass. The manager wants to expose this fact as an advertising element.

In order to evaluate the selected biomass boilers, the authors decided to use multi-criteria analysis in the form of modified AHP (Analytic Hierarchy Process) method described in the article by Stypka and Flaga-Maryańczyk[2]. The AHP-HIPRE method is both relatively easy and transparent to use, and additionally there is a free software to facilitate the analysis process[3]. The hierarchy of criteria was developed using the concept of sustainable development and the European program of ecolabeling – a voluntary method of environmental performance certification for products or services with proven environmental stand up. All the data and parameters about the boilers and analyzed fuels are real ones.

1 B. Roy, *Paradigms and challenges, Multiple Criteria Decision Analysis: State of the Art surveys*, New York 2005, p. 3–24; Z. Piotrowski, *Algorytm doboru metod wielokryterialnych w środowisku niedoprecyzowania informacji preferencyjnej*, doctoral dissertation, Szczecin 2009, p. 23–32.

2 T. Stypka, A. Flaga-Maryańczyk, *Możliwości stosowania zmodyfikowanej metody AHP w problemach inżynierii środowiska,* "Ekonomia i Środowisko" 2016 no. 2(57), p. 37–53.

3 HIPRE, www.hipre.aalto.fi [20–10–2016].

Biomass boilers

Combustion of biomass is considered beneficial to the environment than combustion of fossil fuels, because the content of harmful elements (mainly sulfur) in biomass is less than in the average coal[4]. Biomass also has a more favorable balance of carbon dioxide due to the fact that, in the growing phase, it absorbs carbon dioxide in the process of photosynthesis. In addition, the use of biomass instead of fossil fuels saves non-renewable resources of the latter.

For energy purposes are used mainly wood and waste from wood processing, plants from energy crops, agricultural products and organic waste from agriculture. Different types of biomass have different properties. The more dry and dense biomass is, the greater value presents as a fuel. Therefore, biomass is often converted into a stable form of uniform shape, calorific value and moisture content. Such processed (refined) form of biomass are briquettes and pellets, which are obtained by drying, grinding and pressing of biomass[5].

Producers of biomass boilers recommend to use high quality fuels (preferably with certificates). However, it should be taken into account that the more processed biomass is, the better energetic parameters it has of course, but also has higher price which results in higher annual cost of heating. On the other hand, the processed form of biomass enables the use of advanced technologies (e.g. automatic feeders), which guarantee a higher combustion efficiency and comfort for potential user.

Biomass combustion requires the use of suitable boilers, which are specially adapted to such fuel. In contrast to coal and coke, non-volatile carbon compounds, which in a traditional boiler burn on the grate, in the biomass constitute a minority. The major part of the biomass are volatile compounds, which burn above the grate, therefore efficient combustion of biomass requires appropriate conditions.

Since 2014, new boilers for coal and wood, introduced on the market must fulfill criteria of PN-EN 303–5: 2012 "Heating boilers"[6]. This standard defines three classes of boilers: 3 (lowest), 4 and 5 (highest). Belonging to a particular class defines the conditions relating to both the thermal efficiency of the unit and emission limit values for this class. Emission limits are

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4 M. Ściążko, J. Zuwała, M. Pronobis, *Współspalanie biomasy i paliw alternatywnych w energetyce*, Zabrze 2007, p. 20.

5 BIOMASA.ORG, www.biomasa.org [05–10–2016].

6 PN-EN 303–5:2012 "Kotły grzewcze – Część 5: Kotły grzewcze na paliwa stałe z ręcznym i automatycznym zasypem paliwa o mocy nominalnej do 500 kW – Terminologia, wymagania, badania i oznakowanie."

given with regard to the type of fuel, nominal power of the boiler, and the way of fuel loading. Table 1 presents emission limit values for different classes of biofuel boilers of nominal power 50–150 kW, loaded manually or automatically. According to the limits the replacement of the class 3 boiler with the class 4 boiler reduces emissions significantly. The difference in emissions between boilers class 4 or 5 is not so dramatic. The use of class 5 boiler can, however, significantly reduce operating costs due to the greater efficiency.

Table 1. Emission limit values for biomass boilers of nominal power 50–150 kW

Way of fuel loading	Emission limit values (mg/m³ at 10% O_2*)								
	CO			OGC			Dust		
	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5	Class 3	Class 4	Class 5
manual	2500	1200	700	100	50	30	150	75	60
automatic	2500	1000	500	80	30	20	150	60	40

* related to the dry flue gases, 0°C, 1013 bar
Source: own elaboration based on PN-EN 303–5:2012.

Choosing the biomass boiler is not an easy task. The decision maker should take into account the possibility of burning a given type of biomass, a variety of technical solutions guaranteeing suitable efficiency and emissions, the expected comfort for potential user and finally the costs. The authors decided to take into account many aspects of this complex issue using multicriteria analysis in the form of modified AHP (Analytic Hierarchy Process) method[7]. The problem of the influence of the biomass boiler and fuel on the environment is solved based on the eco-labels. Due to the fact that the evaluation criteria in the eco-labeling program are prepared by experts, and are for a narrow group of products, and the evaluation covers the entire period of the production, use and disposal of the product it seems that eco-labels may be an important decision-making criterion. In developing a hierarchy of criteria for the AHP analysis also single criteria of eco-labels procedures can be used. In the article the two approaches were mixed.

Among the analyzed biomass boilers are boilers which have both Polish certificates and international eco-labels:

- Das Österreichische Umweltzeichen[8] – Austrian eco-label, which main objectives are: the use of environmentally friendly energy sources and the use of systems with low emissions and high energy efficiency.

7 T. Stypka, A. Flaga-Maryańczyk, op. cit.
8 Das Österreichische Umweltzeichen, www.umweltzeichen.at [21–10–2016].

- Blue Angel (Der Blaue Engel) – one of the oldest (since 1997) eco-labels, taking into account the entire life cycle of the product[9].
- Polish certificate "ENVIRONMENTAL SAFETY MARK" ("ZNAK BEZPIECZEŃSTWA EKOLOGICZNEGO")[10] – which contains energy-emission characteristics of the boiler (together with the class of the boiler), designated in accordance with the standard PN-EN 303–5:2012 "Heating boilers"[11].
- Polish certificate "Environmentally friendly device" ("Urządzenie przyjazne środowisku") – a document similar to "ENVIRONMENTAL SAFETY MARK".
- BAFA list – BAFA (Bundesamt für Wirtschaft und Ausfuhrkontrolle) is German Federal Office of Economics and Export Control, publishing a list of the boilers that meet the highest technical parameters and thermal efficiency[12].

The analyzed variants of solutions

The analyzed variants of solutions are combinations of boilers and fuels. (Table 2). The analysis included only the most popular types of biomass: wood, straw, pellets and briquettes. All the data and parameters about the boilers and analyzed fuels are real ones.

Table 2. Combinations of possible solutions BOILER-FUEL

		Biomass boiler					
		K1	K2	K3	K4	K5	K6
BIOMASS	Wood	K1Dr	-	K3Dr	-	-	-
	Straw	K1S	-	-	-	-	-
	Pellets	-	K2Pe	K3Pe	K4Pe	-	K6Pe
	Briquettes	-	-	K3Br	-	K5Br	-

Authors assumed that biomass will be acquired from the neighborhood, with a maximum distance of 20 km. On this basis, the availability of biomass was investigated. It was considered that if there is the possibility of permanent access (store, warehouse), it is better than random biomass source,

9 Ekologia.pl, www.ekologia.pl [20–10–2016].

10 ICHPw, www.ichpw.pl [21–10–2016].

11 PN-EN 303–5:2012 "Kotły grzewcze", op. cit.

12 BAFA, www.bafa.de [20–10–2016].

because it ensures continuity of supply. Authors selected three types of pellets, two types of briquettes, and one type of wood and straw (table 3). Selected pellets and briquettes can be purchased at shops in the neighborhood, about 20 km from the hotel. Some of them have different kinds of certificates confirming their quality, hence the analysis assumed different variants of pellets and briquettes. Straw and wood are more random in nature and seasonal (especially straw) and they do not have any certificates. For the analysis only one, the currently available, type of straw and wood was selected. Biomass prices adopted for the analysis and their calorific values were determined on the basis of literature data and information available from the manufacturers of biomass[13]. Prices include delivery.

Table 3. Types of biomass selected for analysis

Type of biomass	Calorific value [MJ/kg]	Price [PLN/t]	Certificates
PELLETS A	18	965	-
PELLETS B	19,1	983	DIN 51731 FSC
PELLETS C	19,8	1025	DINplus 7A247 ENplus A1 FSC
BRIQUETTES A	16	546	-
BRIQUETTES B	16,8	689	quality testing (accredited lab.)
WOOD	16	330	-
STRAW	15,2	230	-

Variable biomass quality is the common problem during the boiler's operation. Therefore, one of the most important criteria for biofuels, should be its quality which directly translates into calorific value and ash content. This quality can be confirmed based on specific standards (eg. ENplusA1, DIN or DINplus)[14]. In addition to the above certificates, some wooden biofuels also have FSC label (Forest Stewardship Council®) – the most reliable of the existing certification systems in the world forest resources, taking into account social, environmental and economic issues[15].

13 Energet, www.pellet.com.pl [21–10–2016]; biomasa.org, www.biomasa.org [21–10–2016]; W.M. Lewandowski, op. cit.; Zielony serwis, www.drewno-kluczynski.pl [21–10–2016]; R. Tytko, *Odnawialne źródła energii*, Warszawa 2011, p. 433–518.

14 Biomasa.org, op. cit.

15 Kupuj odpowiedzialnie, www.ekonsument.pl [22–10–2016].

Table 4. Variants of solutions

Variants of solutions	Description
K1Dr	boiler 1 fuelled by wood
K1S	boiler 1 fueled by straw
K2PeA	boiler 2 fuelled by pellets A
K2PeB	boiler 2 fuelled by pellets B
K2PeC	boiler 2 fuelled by pellets C
K3Dr	boiler 3 fuelled by wood
K3PeA	boiler 3 fuelled by pellets A
K3PeB	boiler 3 fuelled by pellets B
K3PeC	boiler 3 fuelled by pellets C
K3BrA	boiler 3 fuelled by briquettes A
K3BrB	boiler 3 fuelled by briquettes B
K4PeA	boiler 4 fuelled by pellets A
K4PeB	boiler 4 fuelled by pellets B
K4PeC	boiler 4 fuelled by pellets C
K5BrA	boiler 5 fuelled by briquettes A
K5BrB	boiler 5 fuelled by briquettes B
K6PeA	boiler 6 fuelled by pellets A
K6PeB	boiler 6 fuelled by pellets B
K6PeC	boiler 6 fuelled by pellets C

Combining possible solutions BOILER-FUEL (table 2) with selected types of biomass (table 3) 19 potential alternative solutions were created (table 4) which, in the following part, will be subject to multi-criteria evaluation.

Building hierarchy of evaluation criteria

All criteria and their weights were developed using the individual preferences of the hotel manager. The criteria of the first level were selected implementing the idea of sustainable development, and having in mind the necessary balance among social (USER), economic (ECONOMICS) and environmental (ENVIRONMENT) aspects of development. The criteria from boilers' and fuels' ecolabeling programs were used to develop the user's hierarchy[16].

16 Nordic swan, www.nordic-ecolabel.org [18.10.2016].

The criterion ECONOMICS was divided into two subcriteria: INVESTMENT COST and RUNNING COST. The criterion ENVIRONMENT was divided into: ECOLABELS, BOILER'S CLASS, FUEL CERTIFICATE, POWER CONSUMPTION, and CHLORIUM CONTENT. The category USER was divided into: AUTOMATIC fuel feeder, STORAGE, WARRANTY, FLEXIBILITY, SERVICE and CONFIDENCE of fuel supply (figure 1).

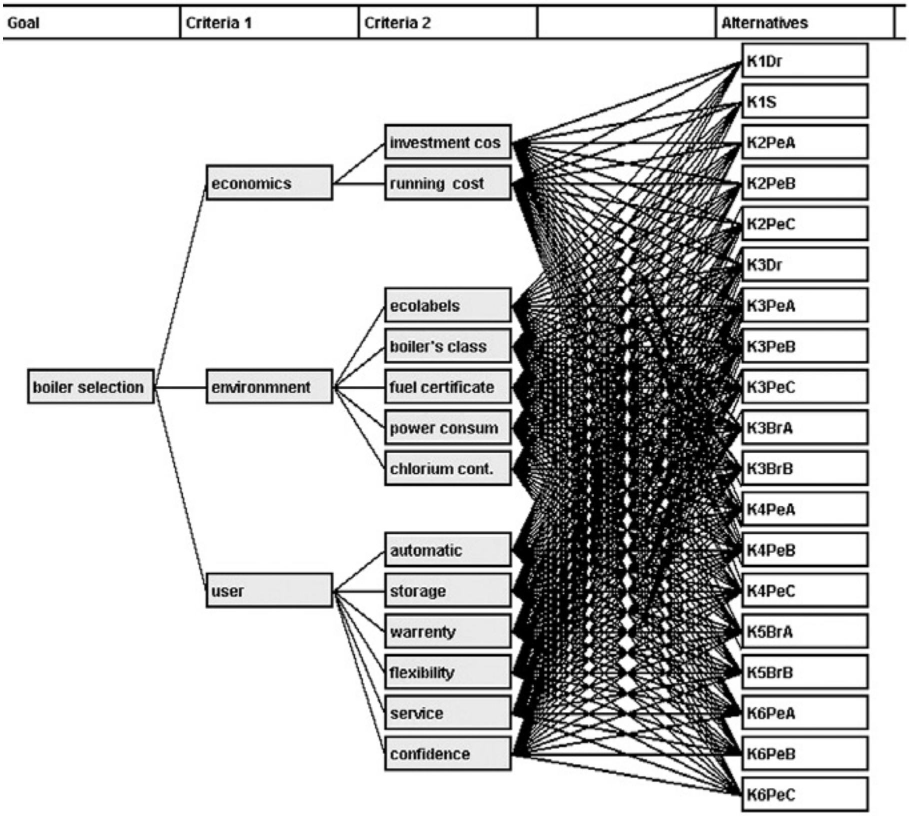

Figure 1. Hierarchy of criteria (screen from the HIPRE software)

The criteria ECOLABELS, BOILER'S CLASS, and to some extent FUEL CERTIFICATE give the user guarantee that the environmental impact of the boiler is limited. The criterion POWER CONSUMPTION reflects the impact of the selected boiler on the environment by measuring the boilers electric energy consumption.

One of the elements present in biomass is chlorium, which negatively impacts both, on the environment, and on the boiler[17]. Research shows[18] that chlorium content in fuel varies; in wood it is below 0,005% to 0,057%, but in fuels made from one year old plants (for example straw) it is up to 1%. Because of this fact, in criterion ENVIRONMENT subcriterion CHLORIUM CONTENT in fuel was distinguished. This approach allows distinction especially between the straw and wood. They both do not have the certificates like pellets do (also including chlorium content) and from environmental point of view are significantly different in chlorium content.

The level of user's satisfaction (criterion USER) of the boiler operation depends on the technical advancement of the boiler such as the presence of the automatic feeder (AUTOMATIC), the necessary fuel storage capacity for the entire heating season (STORAGE), quantity-year warranty, which should translate into a period of trouble-free operation (WARRANTY), the possibility of replacing the fuel for other (FLEXIBILITY), the availability of the service (SERVICE), and confidence of continues supply of the fuel (CONFIDENCE).

The next step in the analysis is to determine the weights of the various criteria by comparing them in pairs on a scale of 1 to 9 (from the "balance" to "total dominance")[19]. Obtained, as a result of this analysis, weights are presented in Table 5. Weights were chosen taking into account the expectations of a hotel manager for whom the most important aspect is the cost (hence the weight of 0,713 for this criterion), with a focus on investment cost (which adequately reflects the weight of 0,75). ENVIRONMENT gained weight 0,127, and the criterion USER – 0,16.

The next step in the analysis is to evaluate the options of the analyzed boilers and fuels using accepted criteria. Summary of the results, which are the input data for the analysis, presents table 6. The operating costs of each option was calculated taking into account the total annual demand for heat in the hotel, the efficiency of individual boilers and heating value of selected biofuels. Other data come from the manufacturers or sellers of boilers or biomass. Also, the minimum and maximum acceptable values for criterion was adopted. These values define for any solution, the largest or smallest satisfaction from meeting the criterion. Next, the satisfaction function for each crite-

17 D. Król, J. Łach, S. Poskrobko, *O niektórych problemach związanych z wykorzystaniem biomasy nieleśnej w energetyce*, www.rynek-energii-elektrycznej.cire.pl [24–10–2016]; T. Hardy, W. Kordylewski, K. Mościcki, *Zagrożenie korozją chlorkową w wyniku spalania i współspalania biomasy w kotłach*, www.spalanie.pwr.wroc.pl [24–10–2016].

18 N. Bątorek-Giesa, B. Jagustyn, *Zawartość chloru w biomasie stałej stosowanej do celów energetycznych*, "Ochrona Środowiska i Zasobów Naturalnych" 2009 no. 40, p. 396–404.

19 T. Stypka, A. Flaga-Maryańczyk, op. cit.

rion was adopted. Part of the functions are decreasing (user satisfaction decreases with increasing value of the parameter) eg. COST; for most parameters, user satisfaction increases with the value criteria. Satisfaction value ranges from 0 to 1 for each criterion.

Table 5. Weights of different criteria

Criteria		Weights	
ECONOMICS		0,713	
	Investement cost		0,750
	Running cost		0,250
ENVIRONMENT		0,127	
	Ecolabels		0,450
	Boiler's class		0,251
	Fuel certificate		0,137
	Power consump.		0,080
	Chlorium cont.		0,081
USER		0,160	
	Automatic		0,489
	Storage		0,177
	Warranty		0,067
	Flexibility		0,067
	Service		0,067
	Conf. of supply		0,134

Results of the AHP analysis

After inserting the ratings into the HIPRE software numerical and graphical results were obtained. Figure 2 presents in graphical form the results of the analysis. The height of each bar represents the total user's satisfaction with the selected solution. Satisfaction is set to 1 if the selected boiler and fuel meet 100% user expectations in all categories. In the adopted modified AHP method result of each solution is independent of the results of other analyzed solutions.

Table 6. Ratings of the analyzed boilers and fuels using the AHP criteria

VARI-ANTS	Running cost	Ecolabels	Boiler's class	Fuel certificate	Power consump-tion	Auto-matic	Storage	Warranty	Flexibility	Invest-ment cost	Chlorium content	Service	Confi-dence of supply
	PLN	pkt	pkt	pkt	W	0/1	0/1/2	lata	0/1	PLN	0/1	0/1	0/1/2
K1Dr	11 949	0	0	0	300	0	1	2	1	12 500	1	1	1
K1S	8 767	0	0	0	300	0	0	2	1	12 500	0	1	0
K2PeA	27 276	1	1	0	325	1	2	2	0	31 250	1	1	2
K2PeB	26 185	1	1	3	325	1	2	2	0	31 250	1	1	2
K2PeC	26 338	1	1	7	325	1	2	2	0	31 250	1	1	2
K3Dr	11 293	1	3	0	795	0	1	2	1	25 793	1	1	1
K3PeA	26 452	1	3	0	795	1	2	2	1	25 793	1	1	2
K3PeB	25 394	1	3	3	795	1	2	2	1	25 793	1	1	2
K3PeC	25 543	1	3	7	795	1	2	2	1	25 793	1	1	2
K3BrA	18 686	1	3	0	795	0	2	2	1	25 793	1	1	2
K3BrB	22 457	1	3	1	795	0	2	2	1	25 793	1	1	2
K4PeA	26 023	2	3	0	965	1	2	2	0	32 841	1	1	2
K4PeB	24 982	2	3	3	965	1	2	2	0	32 841	1	1	2
K4PeC	25 128	2	3	7	965	1	2	2	0	32 841	1	1	2
K5BrA	19153	0	1	0	1550	1	2	2	0	32 841	1	1	2
K5BrB	23018	0	1	1	1550	1	2	2	0	32 841	1	1	2
K6PeA	25553	6	3	0	102	1	2	10	0	68 866	1	1	2
K6PeB	24531	6	3	3	102	1	2	10	0	68 866	1	1	2
K6PeC	24675	6	3	7	102	1	2	10	0	68 866	1	1	2
MIN	8 767	0	0	0	0	0	0	2	0	10 000	0	0	0
MAX	27 276	6	3	7	1550	1	2	10	1	68 866	1	1	2

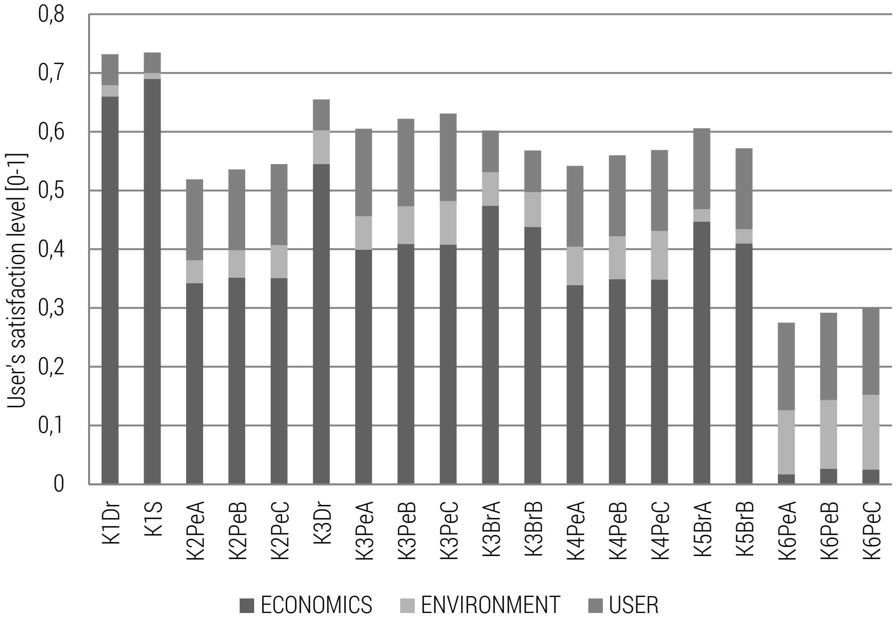

Figure 2. The results of the AHP analysis divided into core evaluation criteria

In the analyzed case user's satisfaction ranges from 74% for straw-fired K1 boiler to only 28% for pellet-fired boiler K5. A decisive impact on the overall assessment is the economic criterion, i.e. investment and operating costs. This is due to the very high weight of this criterion for the user (0,713). The options K1S, K1Dr, K3Dr, K3PeC and K3PeB turned out to be the best. All other analyzed solutions satisfy the user at a maximum of 60%. The last three options, based on K6 boiler performed the worst. The K6 is a very expensive, and technologically advanced boiler that technical superiority does not offset the prohibitively high investment costs. High efficiency of burning expensive fuel also gave no top marks for cost of operation (figure 3).

The level of user's satisfaction (USER), although different for each solution proved to be irrelevant to the final outcome. In practice, the level of user's satisfaction was determined by the ability to automatically feed fuel (AUTOMATIC). The criterion for the service turned out to be irrelevant, because after the diagnosis of the market, it was found that all analyzed boilers have service at the same level.

The crucial role of economic criteria also determines the selection of fuel. Straw and wood turned out to be the best solutions. This is due to their relatively low price. Occurring in the straw higher levels of chlorine or characteristic for this fuel unreliable supply, or the need to secure a large area for storage did not change the overall assessment.

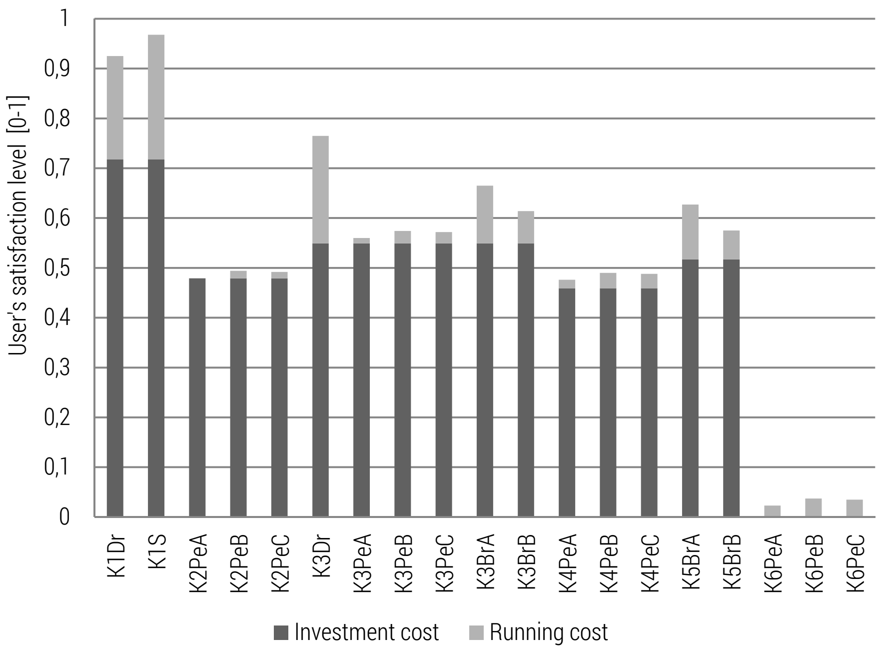

Figure 3. Results of the AHP analysis of biomass boilers due to economic criteria

The obtained results are the sum of a numerus assumptions, and are subject to errors resulting from the subjectivity of assessments. The user does not receive a clear answer, which device to choose; it seems more appropriate to propose a set of similar solutions which give the same range of total satisfaction. In the present case, this means that one should choose among solutions K1S, K1Dr possibly K3Dr, K3PeC or K3PeB. This is a choice between the boiler K1 and K3 and fuels: wood, straw and wood pellets B or C, as well as between manual (K1S, K1Dr, K3Dr) and automatic (K3PeC, K3PeB) fuel loading.

The change of criteria weights can have a very serious impact on the final results. Economic criterion proved to be decisive for the outcome of the analysis, because the user estimated its importance as 0,713. Sensitivity analysis showed that if the weight is greater than or equal to 0,61 the cheapest boiler K1 is the best solution, regardless of the type of burned fuel (straw, wood). If the economic criterion weight varies from 0,25 to 0,61 the best option proves to be solution K3PeC, which is characterized by relatively low price and high efficiency of the boiler combined with the best quality fuel (pellets C). For weight less than 0,25 K6PeC is the best solution. This is an option with an expensive efficient boiler, incinerating most expensive fuel (pellets C). All in all, solutions based on the boiler K1 and K3 (a variant with high quality pellets C), are the best solutions in quite likely weight range of economic criteria.

As to others first level criteria, if the weight of the criterion ENVIRONMENT ranges from 0,29 to 0,51, K3PeC is the best solution. If the weight is below 0,29 boiler K1 (regardless of the type of fuel burned) turns out to be the best. If the weight is above 0,51 the best is variant K6PeC – based on the boiler with the best certificates (two international ecolabels) incinerating the best quality fuel (pellets C). If the weight of criterion USER is below 0,27 the best options are K1S and K1Dr, based on the boiler without fuel feeder. Above this value, the advantage gains option K3PeC followed by K3PeB, based on boiler with the automatic fuel feeder. Just as in the case of the economic criterion, it seems, that solutions based on the boiler K1 and K3 (a variant with high quality pellets C), are the best solutions within large scope of weights for environmental and user criteria.

Conclusions

Choosing the biomass boiler is not an easy task. The multi-criteria analysis, taking into account many aspects of this complex issue, may be helpful. Particularly used in the article modified method of the Analytical Hierarchy Process is handy. This method is both relatively easy and transparent to the application, and in addition there is a free software that facilitates the analysis process. Construction of the hierarchy of criteria is a very subjective step and requires a large technical knowledge of the analyzed systems. This problem can be solved by ecolabeling programs.

In the analyzed case the best solution is simple boiler K1 burning cheap fuel (straw or wood) or advanced boiler K3 (with automatic fuel feeder) burning high quality pellets. These are the best solutions in the broad range of weights. If the weight of the economic criterion increases significantly simple and cheap boiler K1 shows its superiority. If the user weights comfort and environmental performance the boiler K3 (a variant with high quality pellets C) turns out to be better. The real case study shows that economic criteria overweight the environmental performance or user-friendliness. This has to be considered when designing the subsidies programs particularly in poor and environmentally degraded areas.

The contribution of the authors in the article:

Agnieszka Flaga-Maryańczyk, Ph.D – concept and objectives, literature review, research (50%)

Tomasz Stypka, Ph.D – concept and objectives, literature review, research (50%)

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