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SELECTING LOCATION FOR INFRASTRUCTURAL INVESTMENT PROJECT IN RENEWABLE SOURCES OF ENERGY USING MATLAB AND FUZZY LOGIC

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Abstract: Energy consumption in the world is constantly increasing. For environmental reasons, there is a growing social pressure to intensively use renewable sources of energy. Infrastructural investment in renewable sources of energy project is best solution for resolving energy problem. Selecting the location for renewable energy is a complex process that involves not only technical request, but also economic, social, environmental and political demands which can resulting conflicting goals, and that's why, it is necessary to create the best model that would help in the selection of infrastructure project for investment. Paper will use MATLAB and fuzzy logic methodology to determine the priorities for investment in renewable energy sources and decide which sites should be given the highest priority with respect to their benefits and costs.
Keywords: infrastructural investments, benefits & costs, energy renewable sources, Matlab, fuzzy logic

1. INTRODUCTION

Key factors of development of each country are energy and energy resources. Although the energy of fossil fuels for centuries has been the main source of energy, because of global warming and the preconditions that the temperature growth of the planet, due to global warming, remains below 2°C requires an increase in the share of renewable energy in the total energy balance. Obligations arising from international agreements and increased energy consumption require rapid development of renewable energy industries. Thus, the trends that are current in the EU and in the world in terms of investment in renewable energy are actually complementary with sustainable development and investment in energy efficiency in both the EU and the world as well as in Bosnia and Herzegovina would provide multiple benefits with regard to the current situation and ensure large investment return in the short term. Bosnia and Herzegovina has a great potential for exploitation of renewable energies, through energy obtained from wind, solar energy, energy of biomass and geothermal energy.

Many papers deal with the use of wind energy as a renewable energy source [1,2,3]. In paper [1] utilizes fuzzy logic to evaluate various sites and the bases of their benefits and costs to adopt the higher priority sites in terms of different criteria.

In accordance with the Kyoto Protocol and the directives of the European Union, based on commitments to increase the share of renewable energy in total energy consumption, many countries encourage the use of biomass as fuel. Analysis of the potential of biomass as renewable energy source in BiH is given in [4,5].

In the near future, solar energy could become the main carrier of environmentally sustainable energy development. Therefore the new how to procedures and process of converting solar energy into electricity, heat or cooling energy are explored intensively. The most common way of using solar energy is presented in photovoltaic systems, through which the solar energy is converted into electricity through the photoelectric effect. More information on the current use of solar energy is in [6].

The aim of this paper is using MATLAB and fuzzy logic methodology for determining the investment priorities for renewable energy and making the decision to which station should be given the highest priority with respect to their benefits and costs.

This work is organized so that the section 2 provides current data on the use of renewable energy sources as well as indicators of the growth trend of the share of renewable energy sources in total energy production. In Section 3 fuzzy logic methodology and fuzzy logic rules are presented. Defuzzification is explained in the Section 4. The conclusion was verified by data using on existing data and plan future research.

2. TRENDS OF RENEWABLE ENERGY USAGE

Total energy potential of renewable energy exceeds the potential of all the other available sources of energy. But renewable energy sources today occupy only a small part of global energy production. The reasons for this

are: high investment costs, relatively low efficiency, volatility in time, low to energy concentration, small possibility of effective utilization, failure to store fuel and dependence on seasonal and meteorological conditions, which is currently not possible to control.

Studies EIA showed a tendency to increase the share of renewable energy in the overall increase in production of electricity, which is shown in Fig1. (left). On Fig1 (right) future expectations of significant increase of wind energy and solar energy are seen.

At Global Wind Energy Council (GWEC, in April 2016), it is noted that wind power had another record-breaking year. After passing the 50 GW mark for the first time in a single year and in 2014, it reached another milestone in 2015 as annual installations topped 63 GW, a 22% increase. By the end of last year, there were about 433 GW of wind power spinning around the globe, a cumulative 17% increase; and wind power supplied more new power generation than any other technology in 2015 , according to the IEA [7] (Source: GWEC - Global Wind Energy Council).

Europe remains the world's leading region in the installed capacity of PV power plants with 81.5 GW in 2013, representing 59% of the world's capacity. According to the latest research, in 2015, Europe has reached nearly 100 GW of installed capacity, which remained "most solar" continent in the world.

Reviewing the IEA shows that for two years in a row global CO_2 emissions remained stable despite the growth in the world economy. This is attributed to the growing use of renewable energy, particularly in the use of wind energy, which has a significant growth.

In the data and the diagrams it is obvious that there is the imperative for greater use of renewable energy sources. Therefore, this issue is in the focus of scientific interest. Selection of the particular location for investment in the renewable energy source is also of great importance.

This paper uses fuzzy logic to determine selections of the renewable energy sources and locations based on the benefits, costs based and on various other criteria. When designing fuzzy sets we were careful to take into account those factors which are relevant for simplification of renewable energies selections. For renewable energy choices, we have taken wind energy, solar energy and energy derived from sawmill wood waste, because Bosnia and Herzegovina has great natural potential for this renewable energy. So far, these sources of energy have been under-exploited.

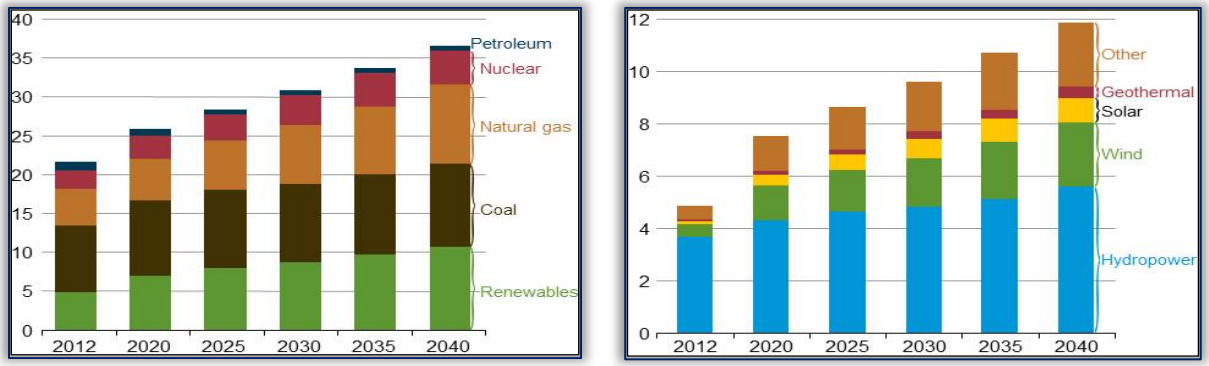

Figure 1. Shares of world electricity generation (EIA, 2016).

3. FUZZY LOGIC METHODOLOGY AND FUZZY LOGIC RULES

Fuzzy logic has a wide range of utilizations in decision making since it condenses a large amount of parameters into smaller fuzzy sets. In this paper, we have selected Mamdami method because of its closeness to human understanding, since we had a large number of rules in decision-making. The Fuzzy input/ output combination is shown in the Figure 2.

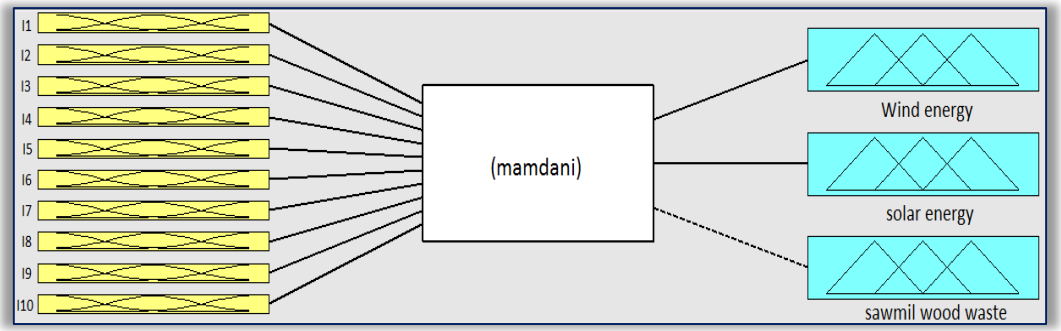

Figure 2. Fuzzy input/ output combination

The fuzzy logic decision selection of the sites options was applied according to ten inputs:

» wind resource,
» number of sunny hours during the year,
» site capacity,
» soil conditions,
» land cost,
» temperature (°C),
» cultural and environmental concerns,
» distance to transmission line (m),
» aviation/telecommunications conflicts and
» wood industry distance.

The fuzzy logic methodology is applied taking into account each site parameters for four locations in Bosnia and Herzegovina. The inputs in tables 1 are considered to be the fuzzy variables, each variable can vary over a fixed range.

Table 1. Overall fuzzy weights

	I1	I2	I3	I4	I5	I6	I7	I8	I9	I10
Location 1	1	0.9	0.8	0.3	0.2	15	0.65	10	0.1	0.2
Location 2	0.9	0.85	0.85	0.4	0.1	14	0.45	12	0.05	0.4
Location 3	0.8	0.65	0.7	0.3	0.05	10	0.35	14	0.04	0.7
Location 4	0.7	0.7	0.75	0.35	0.1	13	0.4	10	0.1	0.6

Constructing fuzzy set

Each fuzzy set for input variable is addressed as listed in Table 2, and fuzzy set for output variable is addressed as listed in Table 3.

Table 2. Fuzzy sets for input variable

Parametres	Symbol	Variable type	Linguistic variables					Range
			1	2	3	4	5	
wind resource	I1	input	VL	L	N	H	VH	0-1
number of sunny hours during the year	I2	Input	VL	L	N	H	VH	0-1
Site capacity	I3	Input	P	M	S	G	E	0-1
Soil conditions	I4	Input	R	MR	RS	MS	S	0-1
Land cost	I5	Input	VL	L	N	H	VH	0-1
Temperature (°C)	I6	Input	N	M	E			± 40
Cultural and environmental concerns	I7	Input	N	M	E			0-1
Distance to transmission line (km)	I8	input	VC	C	NF	F	VF	0-30
Aviation/Telecommunications conflicts	I9	Input	N	M	E			0-1
wood industry distance	I10	input	VL	L	N	H	VH	0-1

Table 3. Fuzzy sets for output variable

Parametres	Symbol	Variable type	Linguistic variables					Range
			1	2	3	4	5	
wind energy	WE	output	VL	L	N	H	VH	0-1
solar energy	SE	output	VL	L	N	H	VH	0-1
sawmil wood waste	SWW	output	VL	L	N	H	VH	0-1

The linguistic variables used in the fuzzy methodology are: Very low (VL), Low (L), Normal (N), High (H), Very high (VH), Poor (P), Marginal (M), Satisfactory (S), Good (G), Excellent (E), Rock (R), Mostly rock (MR), Rock/soil (RS), Mostly soil (MS), Soil (S), Moderate (M), None (N), Extensive (E), Very close (VC), Close (C), Not far (NF), Far (F), Very far (VF).

Constructing fuzzy rules

One hundred rules were used in the current fuzzy method implementation to predict the most preferable options or option out of renewable energy.

Fuzzy logic enabled us to dense large amount of data, collected to compare between different sites, into a smaller set of variable rules, to make a decision in the basis of their merits and barriers to produce energy from renewable resources.

4. RESULTS AND DISCUSSION

Finally, the mapping process takes place to provide the final decision. Defuzzification process assesses the outcome in the decision making process. Results are given in Table 4.

Table 4. Results for making decision

Parametres	Location				Range
	1	2	3	4	
wind energy	0.94	0.84	0.7	0.65	0-1
solar energy	0.85	0.88	0.55	0.6	0-1
sawmil wood waste	0.55	0.7	0.88	0.85	0-1

Based on model for verification of this solutions, it used data on existing parameters for four locations in Bosnia and Herzegovina (one location on south of country near Podveležje, one location on southwest of country near Livno, two locations on east of country near Romanija). This location is suitable for renewable sources of energy.

5. CONCLUSION

The aim of this paper is to use fuzzy logic for predict the best locations for renowable sources of energy. In deciding the used 10 input parametars and 100 rules for decision making. Based on our model, we concluded that Bosnia and Herzegovina have a many good locations for renowable sources of energy. South and southwest of Bosnia and Herzegovina is suitable for wind and solar energy, east od country is suitable for energy of sawmil wood waste.

In further research can be analysed the more input parametars, and can be improved the set of fuzzy rules. It can be verified for more location too.

Note

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