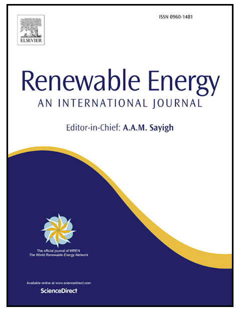
Accepted Manuscript



Decision making model development in increasing wind farm energy efficiency

Lutfu Sagbansua, PhD, Figen Balo

PII: S0960-1481(17)30238-0

DOI: 10.1016/j.renene.2017.03.045

Reference: RENE 8638

To appear in: *Renewable Energy*

Received Date: 25 May 2016

Revised Date: 3 February 2017

Accepted Date: 14 March 2017

Please cite this article as: Sagbansua L, Balo F, Decision making model development in increasing wind farm energy efficiency, *Renewable Energy* (2017), doi: 10.1016/j.renene.2017.03.045.

DECISION MAKING MODEL DEVELOPMENT in INCREASING WIND FARM ENERGY EFFICIENCY

Lutfu Sagbansua [1,1], Figen Balo [2]

[1, 1] Industrial Engineer, PhD

E-mail: lutsua@gmail.com

[2] Department of Industrial Engineering, Firat University, Turkey

E-mail: figenbalo@gmail.com

Tel: +90 0424 2370000/5646; Fax: +90 424 2370000

Abstract

Renewable energy is a significant input for environmental, economic and social development. The wind energy has become the quickest thriving renewable energy resource. It is worth noting that wind power has the least emissions and lowest water consumption, but it has comparatively high costs. Thus, making wind energy station planning decision requires an operation of balancing various technical, economic, ecological, and environmental aspects over time and space. This paper is constructed to choose a convenient turbine from various perspectives for developing a wind energy station. For 2 MW, the best wind turbine brands are listed based on expert interviews and literature review and they are used to establish a decision-making model with four main criteria consisting technical, economic, environmental, and customer attributes with various sub-criteria. Determining the related criteria and grouping them in main categories is the novel approach provided by this research. The constructed model can be solved by various multi-criteria decision making techniques. The selection of the best wind turbine is determined by using AHP technique. The results are significant both from engineering and economic perspective as the applied methodology is practically implementable and commercially viable. Accurate and up-to-date data are obtained from leading companies in the industry.

Keywords: AHP, Wind turbine select, Renewable energy, Energy efficiency, Multi-criteria decision making.

Abraviations used: *AHP, Analytic Hierarchy Process; TOPSIS, Technique for Order Preference by Similarity to Ideal Solution.*

[1] Corresponding author. E-mail: figenbalo@gmail.com
Tel: +90 0424 2370000/5646; Fax: +90 424 2370000

1. Introduction

Among renewable energy resources, wind energy is one of the most profitable, clear and powerful way to supply the applications of renewable energy [1], during the time that the generation of the wind energy has increased 32% per year in the past 10 years [2]. The potential for wind electricity generation around the World is displayed in Fig. 1 [3]. Fig. 2 shows the top 15 countries by total wind installations [4]. The wind energy station planning effort requires finding some of resources and conversion mechanisms in order to fulfill the energy demands / requirements of all the tasks in an optimum attitude [5]. The feasibility outcomes of wind energy station design works depend on the characteristic of the present meteorological report as well as on the suppositions about available space and technology [6]. These results can just ensure an approach of the all wind power potential and it can change considerably for diverse regions [7]. Using meteorological data, the wind energy output can be calculated for a wind turbine brand [8]. The distribution of the wind turbine brands worldwide is given in Fig. 3 [9]. The diverse brands of wind turbine generate diverse quantities of energy linked to the wind speed for a specific region [10].

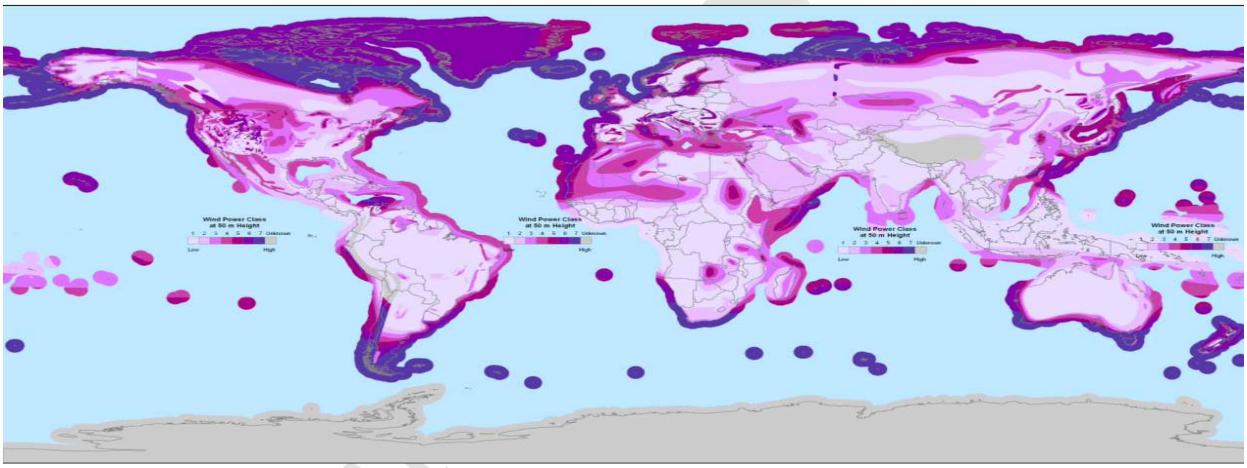
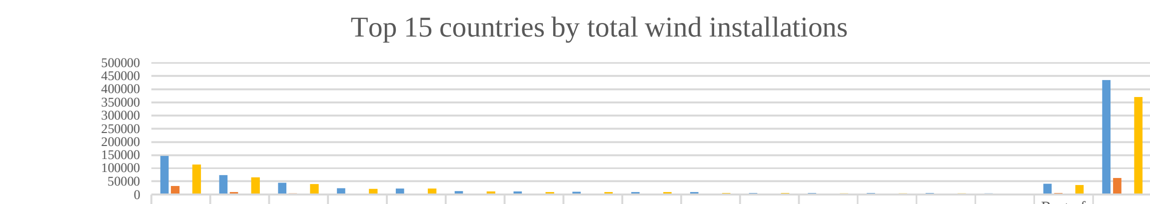


Fig. 1. The potential for wind electricity generation around the world [3]



	China	United States	Germany	India	Spain	UK	Canada	France	Italy	Brazil	Sweden	Poland	Portugal	Denmark	Turkey	Rest of the World	Total
	1	2	3	4	5	6	7	8	9	10	11	12	13	14		15	
Total capacity 2015	148000	74347	45192	24759	22987	13614	11205	10293	8958	8715	6025	5100	5079	5064	4718	40800	434856
Added capacity	32970	8598	4919	2294	0	1174	1511	997	295	2754	615	1266	126	217	955	5000	63690
Growth rate	29	13.1	11.7	10.2	0	9.4	15.6	10.7	3.4	46.2	11.1	33	2.5	3.7	25.4	14	17.2
Total capacity 2014	114763	65754	40468	22465	22987	12440	9694	9296	8663	5962	5425	3834	4953	4883	3763	35799	371374

Fig. 2. Top 15 countries by total wind installations **[4]**

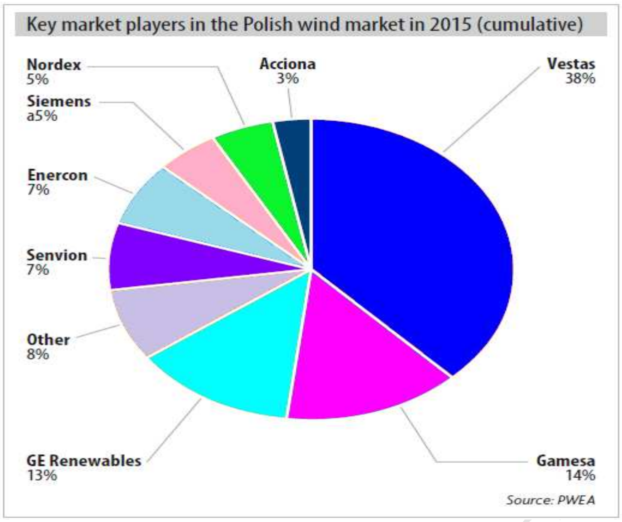


Fig. 3. Distribution of the wind turbine brands worldwide [9]

For this reason, the best wind turbine selection has a significant task evidenced by a few good investigations found in the literature. With an optimization model, Borissova and Mustakerov evaluated twenty-four different wind turbine brands [11]. Al-Hadhrami assessed the generating wind energy of sixteen different wind turbines in the group of 50–80 kW, 15–20 kW, 5–10 kW and 1–3 kW rated wind energies, and the influence of the hub height on generating wind energy; the best proportion changing in yearly energy generation efficiency acquired for a rise in the hub height of 30 m from 10 to 20 m [12]. Alimi et al. evaluated eight different wind turbines at diverse hub-heights for the wind energy production in Tunis [Nordex (2300 kW) N90-100, Vestas V80, Anbonus MK III-30, V82-0.9, V39-35, GE 1500 kW, Dewind 1250 kW, and Repower (2000 kW) MM 70-65] [13]. Filho and De Araujo Lima evaluated by using three diverse brands of wind turbine (Bonus Mk III, Bonus Mk III and Vestas V27) in Paraiba [14]. Jowder applied a classic method to comparison five wind turbine brands [Gamesa (G58, G80) and Nordex (N60, N70, N80)] at 60 m height, identifying that the best turbine was G58 [15]. For the Niger region, Adaramola et al. appraised the performance of four different wind turbine brands ranging from 500 to 35 kW [ZEUS 500, G-3120, WES-30 and P19-100], acquiring that the wind energy output from G-3120 was the best [16]. Adaramola assessed the wind energy generation in Ghana by using four diverse wind turbines [Garbi150/28, Polaris 15–50, CF-100, and WES30] [17]. With an evaluative algorithm, González et al. evaluated the four wind turbines for the optimization of wind energy station turbines [18]. Montoya et al. used a multi-objective optimization algorithm for the best wind turbine selection by using the energy outputs of twenty-six diverse brands of wind turbines [19]. Kolios et al. ensured a systematical methodology by the TOPSIS for evaluation and classification of diverse present wind turbine backing structures [20]. Martin et al. used the TOPSIS method for evaluation of conception design process of wind turbine support devices [21]. Lee et al. applied a multi criteria decision making method, with the unification of AHP and the risks, costs, opportunities, and benefits, concept to help choose an appropriate wind energy station project [22]. For selecting the best of wind turbine, Nahi and Nabavi defined the network using Monte Carlo method and wind speed data in the region Manjil. For necessary simulations, they used Random Numbers Simulation method by using the software EXCEL and MATLAB [23]. Pohekar and Ramachandran used the multi-criteria decision making method for renewable energy planning [24]. Fthenakis and Haaren applied different economic and ecological criteria such as the precaution of economic costs to the wind energy generation [25]. Demirtas applied AHP in evaluating renewable energy technologies from environmental, technical, economical, and social perspectives [26]. Shokrzadeh analyzed the performance of parametric and non-parametric methods over four selected wind turbines using simulated data sets [27]. Somma et al. studied operation optimization of distributed energy systems. The results indicate that exergy efficiency can be improved while cost of energy reduced [28, 29].

The objective of this paper is to introduce a decision-making model consisting a wide-range of criteria. Although there are studies in the above-mentioned literature providing various decision-making techniques, their approach consists a limited perspective. In this paper, multi-criteria decision making method is utilized in evaluating the anticipated performance of several popular brands of wind turbines for 2 MW, and experts in wind energy stations are invited to offer their expertise in detecting the relative significance of the factors of different wind turbine brands. The wind turbine brands are evaluated based on 13 different criteria, grouped under technical, economic, environmental and customer categories. Considering each and every factor, the best wind turbine for installation is determined after the required calculations.

The obtained results can serve as reference for the new wind energy station designs in choosing the best wind turbine brand. Determining the related criteria, grouping them in main categories and determining their relative weights based on expert opinions are the main contributions of this research. The constructed model can be solved by various multi-criteria decision making techniques. The selection of the best wind turbine here is determined by using AHP technique. The obtained results are commercially feasible and applicable. Accurate and up-to-date data are obtained from leading companies in the industry.

2. Multi-criteria decision making in wind turbine selection

2.1. Main criteria

In an AHP hierarchy for choosing a wind turbine, the goal would be to choose the best turbine. Technical, economic, environmental, and customer related factors are the four main criteria that are used in majority of the related literature [21, 22] for making a decision. These criteria are often subdivided into several sub-criteria. In this study, the technical criterion is subdivided into output, capacity, rotor diameter, hub height, cut-out wind speed, and nominal wind speed. The cost criterion is subdivided into total cost and state support. The environmental criteria include noise and electromagnetic effects. Finally, the customer satisfaction is measured using service, availability of spare parts, and reliability. Six alternative 2 MW wind turbines are compared using AHP technique. The hierarchy composed of these criteria is constructed as shown in the Fig. 4.

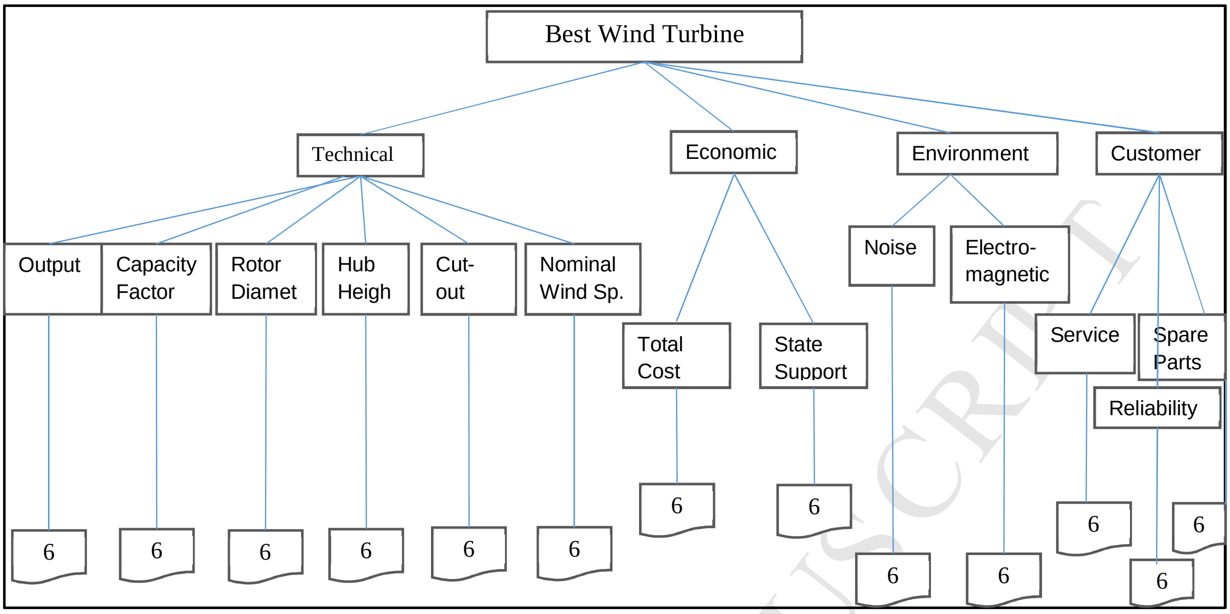


Fig. 4. The network for 2 MW wind turbine selection

While measurements for some criteria are readily available, some others like customer satisfaction can only be estimated with respect to other variables. As it is the case in all multi-criteria decision making methods, the relative weights of such criteria need to be determined. In AHP, this is accomplished by pairwise comparison of the elements, starting with the main criteria. Fig. 5 is displayed the resulting priorities of technical, economic, environmental, and customer related factors.

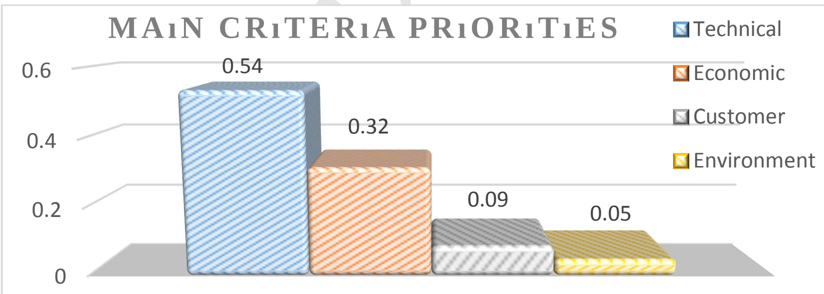
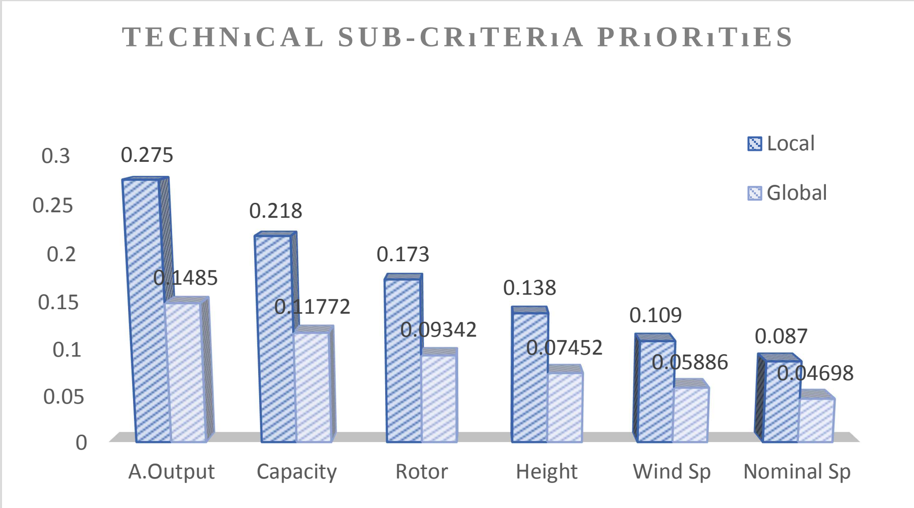


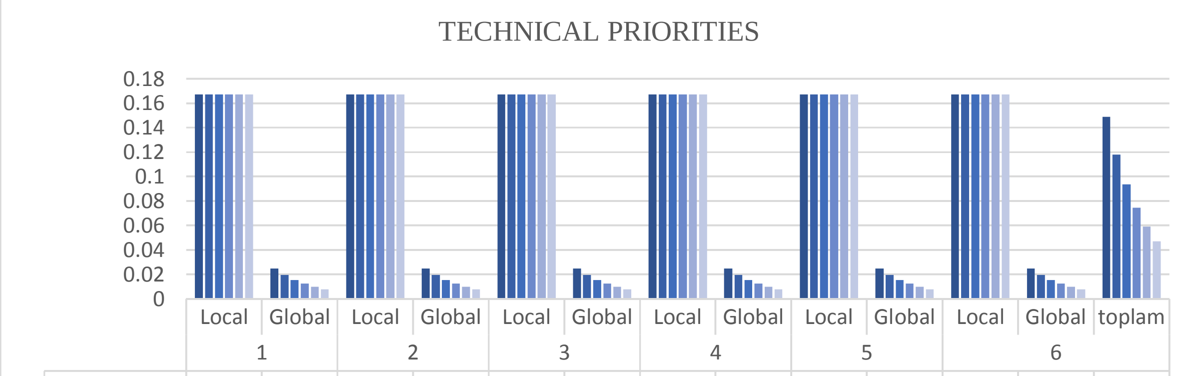
Fig. 5. Main criteria priorities

2.2. Sub-criteria

At this point, the comparison for technical criterion has been made, and the AHP method has derived the local priorities for this group (Fig. 6). These priorities reflect on how much it contributes to the priority of its parent, thus we need to calculate the global priority of each sub-criterion. That will show us the priority of each sub-criterion with respect to the overall goal. The global priorities throughout the hierarchy should add up to one. The global priorities of each technical sub-criterion are calculated by multiplying their local priorities with the priority of technical criterion.



(a)



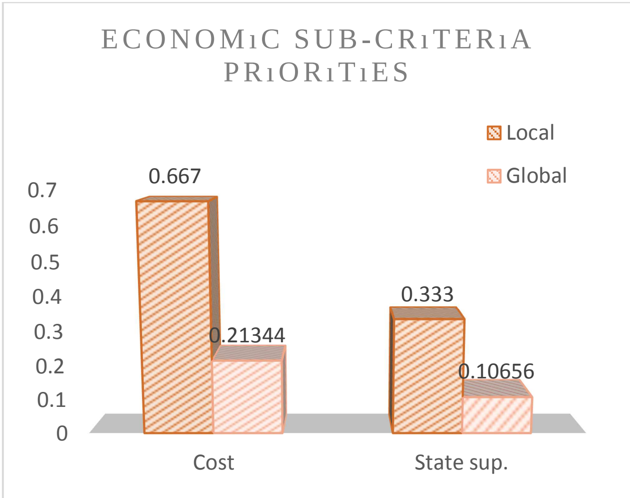
	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global	toplam
	1		2		3		4		5		6		
A.Output	0.167	0.0248	0.167	0.0248	0.167	0.0248	0.167	0.0248	0.167	0.0248	0.167	0.0248	0.1488
Capacity	0.167	0.01966	0.167	0.01966	0.167	0.01966	0.167	0.01966	0.167	0.01966	0.167	0.01966	0.11796
Rotor	0.167	0.0156	0.167	0.0156	0.167	0.0156	0.167	0.0156	0.167	0.0156	0.167	0.0156	0.09361
Height	0.167	0.01244	0.167	0.01244	0.167	0.01244	0.167	0.01244	0.167	0.01244	0.167	0.01244	0.07467
Wind Sp	0.167	0.00983	0.167	0.00983	0.167	0.00983	0.167	0.00983	0.167	0.00983	0.167	0.00983	0.05898
Nominal Sp	0.167	0.00785	0.167	0.00785	0.167	0.00785	0.167	0.00785	0.167	0.00785	0.167	0.00785	0.04707

A.Output Capacity Rotor Height Wind Sp Nominal Sp

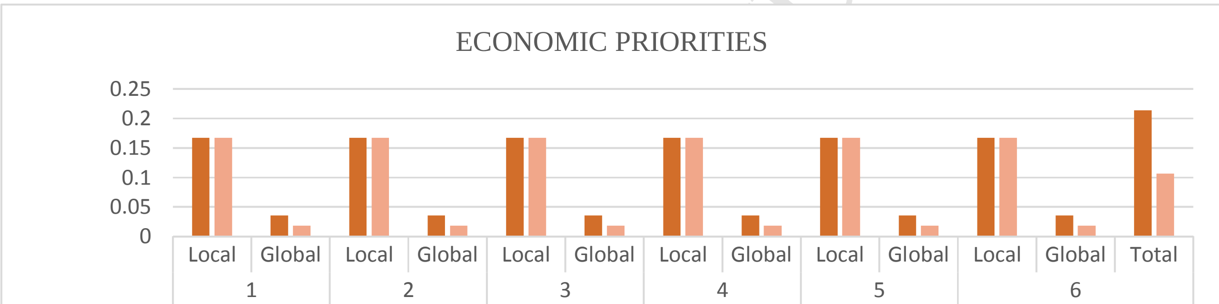
(b)

Fig. 6. a. Technical sub-criteria priorities **b.** Local and global priorities

In the economic subgroup, there is only one pair of sub-criteria, namely total cost of investment and state support available. These elements are compared as to how important they are with respect to the economic criterion. Fig. 7 is showed the economic sub-criteria priorities.



(a)



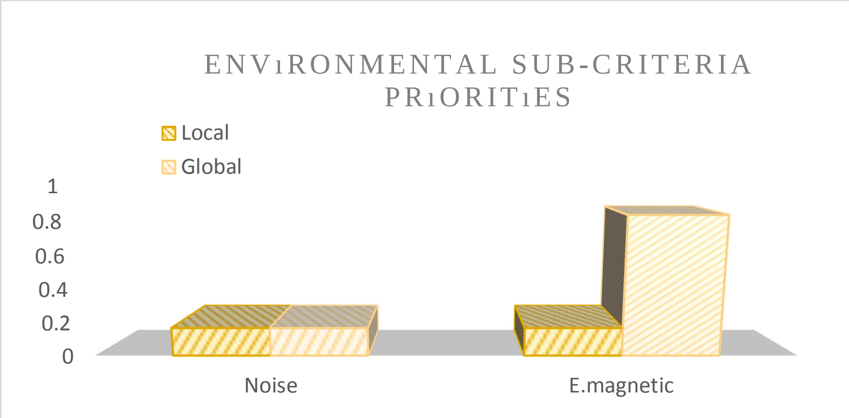
	1		2		3		4		5		6		
	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global	Total
Cost	0.167	0.03564	0.167	0.03564	0.167	0.03564	0.167	0.03564	0.167	0.03564	0.167	0.03564	0.21387
State sup.	0.167	0.0178	0.167	0.0178	0.167	0.0178	0.167	0.0178	0.167	0.0178	0.167	0.0178	0.10677

(b)

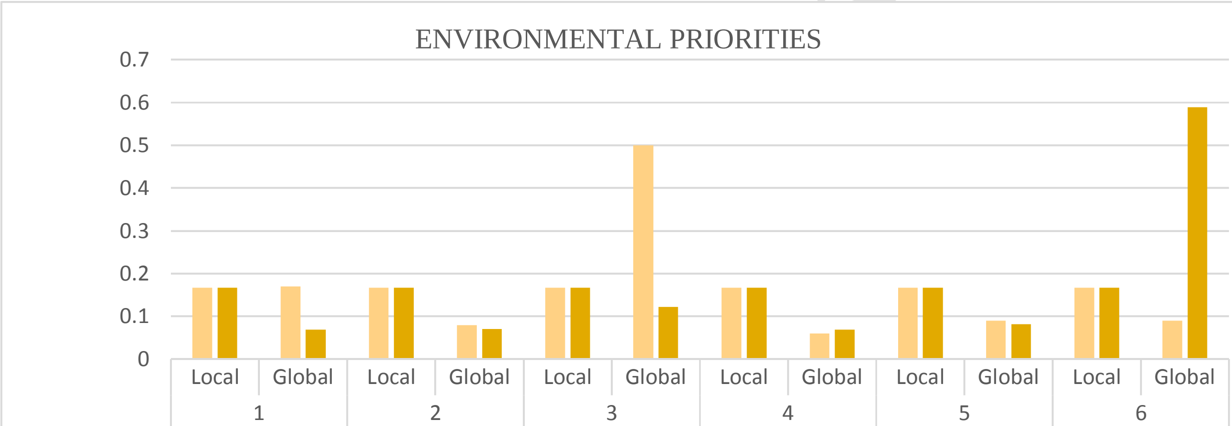
Fig. 7. **a.** Economic sub-criteria priorities **b.** Local and global priorities

Environmental factors considered are noise and electromagnetic effects. Comparison of these elements with respect to the environmental considerations leads to the resulting weights. The environment sub-criteria priorities are shown Fig. 8.

Finally, there are three sub criteria in the customer satisfaction subgroup, namely service, spare parts, and reliability. These elements are compared as to how they add value towards the customer satisfaction. These are the resulting weights based on the pairwise comparisons. Fig. 9 is displayed the customer sub-criteria priorities.



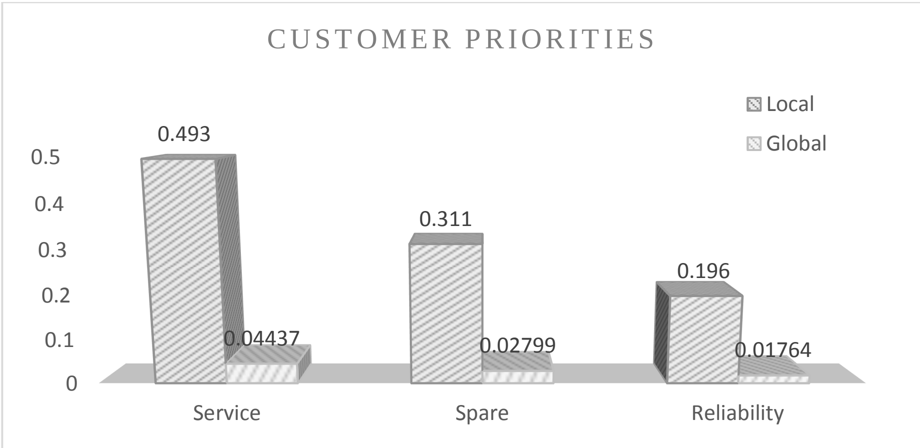
(a)



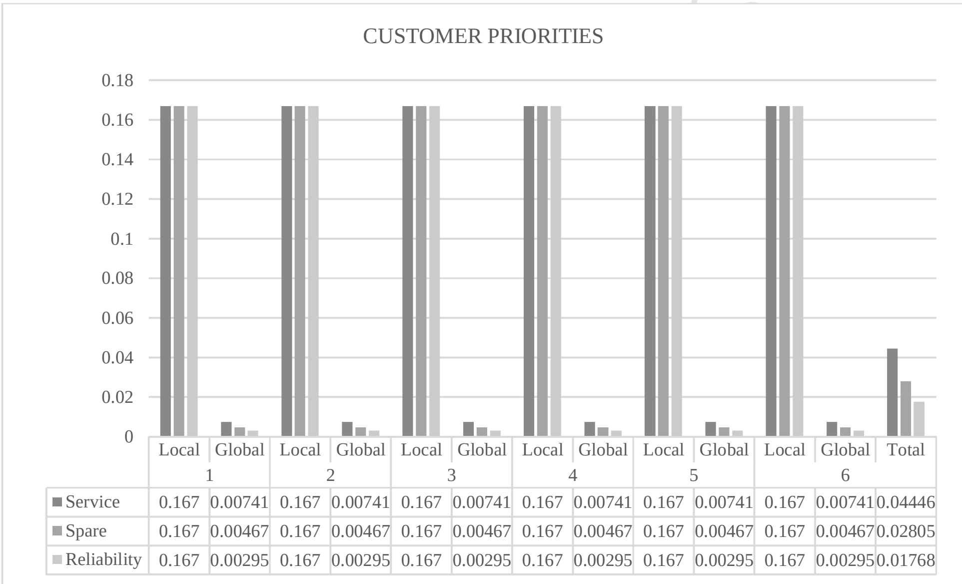
	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global	Local	Global
	1		2		3		4		5		6	
Noise	0.167	0.17	0.167	0.08	0.167	0.5	0.167	0.06	0.167	0.09	0.167	0.09
E.magnetic	0.167	0.069	0.167	0.07	0.167	0.122	0.167	0.069	0.167	0.082	0.167	0.589

(b)

Fig. 8. a. Environment sub-criteria priorities **b.** Local and global priorities



(a)

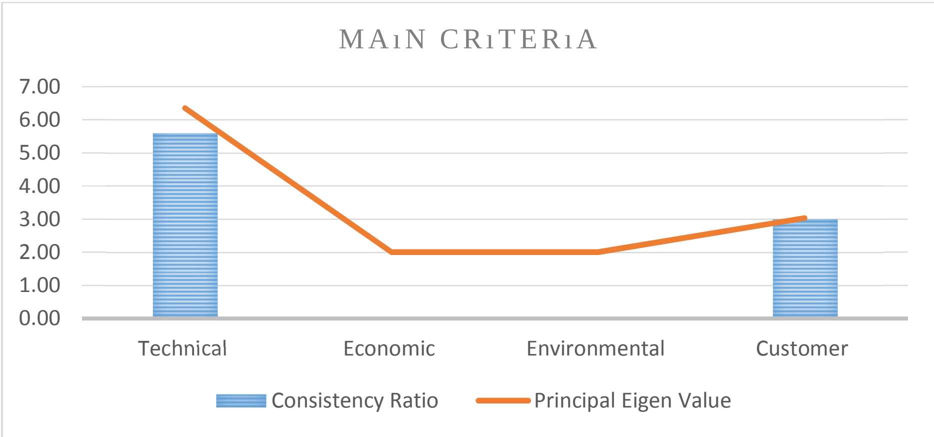


(b)

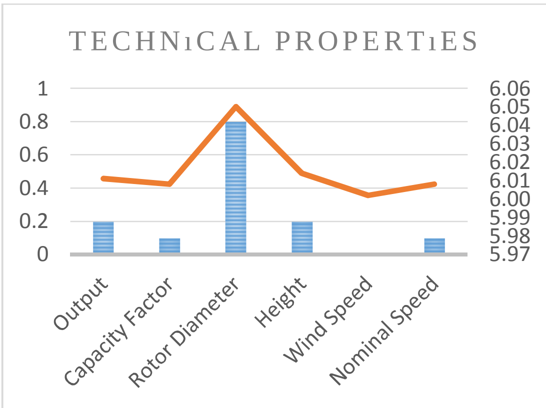
Fig. 9. a. Customer sub-criteria priorities **b.** Local and global priorities

2.3. Pairwise Comparison of the Alternatives with Respect to the Criteria

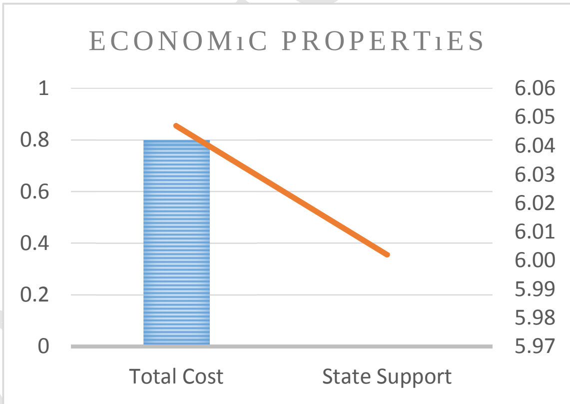
As seen in Fig.10 below, the resulting weights are based on the principal eigenvector of the decision matrix. After determining the priorities of each criterion with respect to the overall goal of selecting the best wind turbine and priorities of sub-criteria with respect to their associated main criteria, the turbine alternatives need to be compared two by two with respect to each sub-criterion.



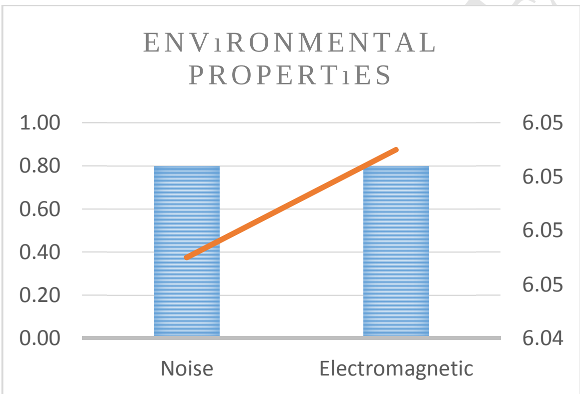
(a)



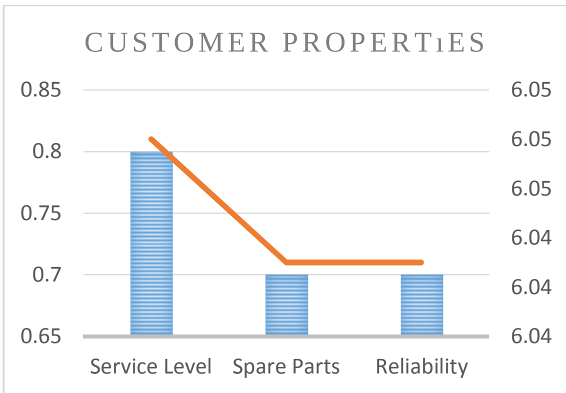
(b.1)



(b.2)



(b.3)



(b.4)

Fig. 10. The resulting weights **a-** main-criteria **b-** sub-criteria

The technical properties of the selected 2 MW wind turbines are presented in Table 1. Cut-In Wind Speed, Turbine Output, and Frequency values for all turbines are kept constant while the remaining values are used to compare the alternatives.

Table 1. Technical Properties [30]

Turbine Name	T1	T2	T3	T4	T5	T6
Cut-In Wind Speed	3.0	3.0	3.0	3.0	3.0	3.0
Turbine Output (V)	690	690	690	690	690	690
Frequency (Hz)	50, 60	50, 60	50 (60E)	50/60	50	50/60
Annual Output (8 m/s) in KWh	9 269 000	9 327 000	8 498 000	9 074 000	8 825 000	8 676 000
Capacity Factor	32.4	32.9	30.2	32.0	31.1	30.7
Nominal Rotor Diameter (m)	114	116	103.0	110	98	92.5
Hub Height (m)	80/ 93/125	80/94	80/ 90	80/ 95	60/80/98	64/80/100
Cut-Out Wind Speed (m/s)	25.0	25.0	22.0	20.0	25.0	24.0
Nominal Wind speed (8 m/s)	12.0	10.0	10.0	11.5-12	15	12.5

The economic properties of the alternatives are presented in Table 2.

Table 2. Economic Properties [30]

Turbine Name	T1	T2	T3	T4	T5	T6
Total Cost (million$)	4.00	3.89	3.45	3.82	4.25	3.67
Support of Government	0.330	0.316	0.315	0.440	0.450	0.300

Table 3 shows the environmental effects of the turbines. Noise level and the electromagnetic effects are chosen as the differentiating elements among different turbine alternatives.

Table 3. Environmental Properties [30]

Turbine Name	T1	T2	T3	T4	T5	T6
Max. sound power (dB)	101,6	105	98.6	107.6	103.5	102.9
Electromagnetic effects*	8-19	9-18	7-16	8-19	8-17	7-13

* Range of variation

In order to measure the customer satisfactions towards the wind turbines, three sub-criteria are defined: customer service, spare parts available, and the reliability of the company. Service is evaluated to be positively related to the number of branches available for each company. Spare parts are measured by the inventory levels of the companies while the reliability is measured by their market shares and sales. The companies are ranked from 1 to 6 to be able to generate a medium of comparison. Table 4 is summarized Customer Service properties.

The next step in applying the AHP technique is two by two comparisons of the turbine alternatives with respect to each sub-criterion. In order to design an objective scheme for this purpose, the maximum and minimum values of the alternatives for each sub-criterion are determined. This range is divided into nine even classes since AHP requires pairwise comparisons on a scale from 1 to 9. Finally, each alternative is placed in one of these classes based on their values to compare them with each other. Remainder of this section presents the priorities obtained under each subcategory using this scheme.

Table 4. Customer Service Properties [30]

Turbine Name	T1	T2	T3	T4	T5	T6
Service support	3	4	6	2	1	5
Spare part	2	4	5	3	1	6
Reliability	4	3	6	2	1	5

3. Results and Discussion

3.1. Making the Decision

Based on the calculations above, the relative priorities corresponding to the attractiveness of each wind turbine about all factors of technical, economic, environmental and customer satisfaction are presented Fig. 11.

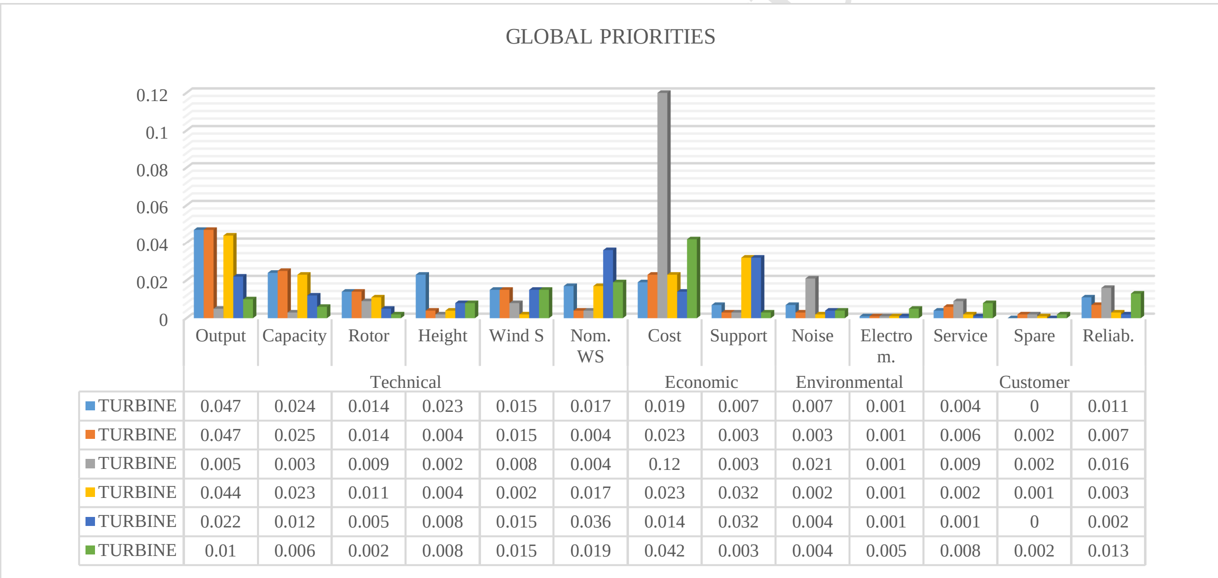


Fig. 11. Global Priorities

4. Conclusions

Wind energy systems have proven their benefits for the last ten years, one way or the other, wind technology has been commercialized for energy generation purposes in more than 30 countries including both the developing and the developed ones. In this study, we demonstrated that it is possible to utilize AHP as the multi-criteria decision making method for the selection of the best wind turbine. Consistency ratios calculated throughout the analysis are in acceptable limits, showing the legitimacy of the results. Below conclusions can be drawn from the analysis in the present paper:

1-The six wind turbine brands as the result of the exhaustive study were investigated through four main criteria; technical, economic, environmental impact and customer satisfaction.

2-With the ultimate purpose of optimizing the output and trying to determine the optimum wind turbine of commercially present ‘‘Wind turbine brands’’, all the criteria are examined by AHP.

3- Within the first stage of the wind turbine brands, alternatives and utilities were put to the essay of ‘‘priority’’ and evaluated, important results were obtained, the technically optimum wind turbine was observed to be T1.
4- T3 is the most significant turbine considering the economical properties of wind turbine brands.
5- From the perspective of environmental effects, the best wind turbine was observed to be the T3 as well.
6- The fourth stage was searching to find out customer satisfaction effects of wind turbine brands. Once again, T3 brand withstood the expert opinions and completely exhaustive of criteria arose from the application among the all wind turbine brands.

For 2MW, the best wind turbine brands are listed based on interviews with experts and literature review and they are used to establish a decision-making model with four main criteria. Although 2MW turbines are used to apply in this study, a robust model is developed so it can be applied for all cases. Determining the related criteria and grouping them in main categories is another contribution provided by this research. The selection of the best wind turbine here is determined by using AHP technique. The results are significant both from engineering and economic perspective as the applied methodology is practically implementable and commercially viable.

References

[1] A.B. Sebitosi, Energy efficiency, security of supply and the environment in South Africa: Moving beyond the strategy documents, Energy. 33.11(2008) 1591-1596.

[2] S. Pacala, R. Socolow, Stabilization wedges: Solving the climate problem for the next 50 years with current technologies, Science. 305.5686 (2004) 968–972.

[3] www.im9.eu

[4] http://www.wwindea.org/the-world-sets-new-wind-installations-record-637-gw-new-capacity-in-2015/

[5] R.B. Hiremath, S. Shikha, N.H. Ravindranath, Decentralized energy planning; modeling and applicationda review, Renewable and Sustainable Energy Reviews. 11(2007) 729-52.

[6] F. Manzano-Agugliaro, C. San-Antonio-Gómez, S. López, F. Montoya, C. Gil, Pareto-based evolutionary algorithms for the calculation of transformation parameters and accuracy assessment of historical maps, Computers & Geosciences. 57(2013) 124-132.

[7] Q. Hernandez-Escobedo, F. Manzano-Agugliaro, J.A. Gazquez-Parra, A. Zapata- Sierra, Is the wind a periodical phenomenon? the case of Mexico, Renewable and Sustainable Energy Reviews. 15.1(2011) 721– 728.

[8] Q. Hernández-Escobedo, F. Manzano-Agugliaro, A. Zapata-Sierra, The wind power of Mexico, Renewable and Sustainable Energy Reviews. 14.9(2010) 2830–2840.

[9] www.windmonitor.de

[10] J. Slootweg, S.W.H. De Haan, H. Polinder, W. Kling, General model for representing variable speed wind turbines in power system Dynamics simulations, IEEE Transactions on Power Systems. 18.1(2003) 144–151.

[11] I. Mustakerov, D. Borissova, Wind turbines type and number choice using combinatorial optimization, Renewable Energy. 35.9(2010) 1887–1894.

[12] L.M. Al-Hadhrami, Performance evaluation of small wind turbines for off grid applications in Saudi Arabia, Energy Conversion and Management. 8.10(2014) 19–29.

[13] S.E. Alimi, T. Maatallah, A.W. Dahmouni, S.B. Nasrallah, Modeling and investigation of the wind resource in the gulf of tunis, Tunisia, Renewable and Sustainable Energy Reviews. 16.8(2012) 5466–5478.

[14] L. De Araujo Lima, C.R.B. Filho, Wind resource evaluation in são joão do cariri (sjc) – paraiba, Brazil, Renewable and Sustainable Energy Reviews. 16.1(2012) 474–480.

[15] F.A. Jowder, Wind power analysis and site matching of wind türbine_generators in kingdom of Bahrain, Applied Energy. 86.4(2009) 538–545.

[16] M.S. Adaramola, O.M. Oyewola, O.S. Ohunakin, O.O. Akinnawonu, Performance evaluation of wind turbines for energy generation in niger delta, Nigeria, Sustainable Energy Technologies and Assessments. 6(2014) 75–85.

[17] M.S. Adaramola, M. Agelin-Chaab, S.S. Paul, Assessment of wind power generation along the coast of Ghana, Energy Conversion and Management. 77(2014) 61–69.

[18] J.S. González, A.G.G. Rodriguez, J.C. Mora, J.R. Santos, M.B. Payan, Optimization of wind farm turbines layout using an evolutive algorithm, Renewable Energy. 35.8(2010) 1671–1681.

[19] F.G. Montoya, F. Manzano-Agugliaro, S. López-Márquez, Q. Hernández-Escobedo, C. Gil Wind turbine selection for wind farm layout using multi-objective evolutionary algorithms, Expert Systems with Applications. 41.15(2014) 6585–6595.

[20] A. Kolios, M. Collu, A. Chahardehi, F.P. Brennan, M.H. Patel, A multi-criteria decision making method to compare support structures for offshore wind turbines, In: European Wind Energy Conference. (2010) 21- 23.

[21] H. Martin, G. Spano, J.F. Küster, M. Collu, A.J. Kolios, Application and extension of the TOPSIS method for the assessment of floating offshore wind turbine support structures, Ships and Offshore Structures. 8.5(2013) 477–487.

[22] A.H.I. Lee, H.H. Chen, H.Y. Kang, Multi-criteria decision making on strategic selection of wind farms, Renew Energy. 34.1(2009) 120–6.

[23] S. Nahi, S.M.H. Nabavi, Choose Suitable Wind Turbines for Manjil Wind Power Plant using Monte Carlo Simulation, International Journal of Computer Applications. 15(2011) 0975 – 8887.

[24] S.M.J. Baban, T. Parry, Developing and applying a GIS-assisted approach to locating wind farms in the UK, Renew Energy. 24(2001) 59–71.

[25] S.D. Pohekar, M. Ramachandran,Application of multi-criteria decision making to sustainable energy planning-A review, Renewable and Sustainable Energy Reviews. 8.4(2004) 365–381.

[26] O. Demirtas, Evaluating the Best Renewable Energy Technology for Sustainable Energy Planning, International Journal of Energy Economics and Policy. 3, Special Issue, (2013), 23-33.

[27] S. Shokrzadeh, Wind Turbine Power Curve Modeling Using Advanced Parametric and Nonparametric Methods, IEEE Transactions on Sustainable Energy, 5,4. (2014).

[28] M. Di Somma, B. Yan, N. Bianco, G. Graditi, P.B. Luh, L. Mongibello, V. Naso, Operation Optimization of a Distributed Energy System Considering Energy Costs and Exergy Efficiency, Energy Conversion and Management, vol. 103 (2015), pp. 739-751.

[29] B. Yan, M. Somma, N. Bianco, G. Graditi, P.B. Luh, L. Mongibello, V. Naso, Exergy-based operation optimization of a distributed energy system through the energy-supply chain, Applied Thermal Engineering, 101 (2016) 741-751.

[30] Wind turbine data sheets, (2016).

Research Highlights

1. Proposing a novel approach to select of the best wind turbine.
2. Developing this approach for determining the criteria as well.
3. Including analysis of the proposed multi-criteria decision making method
4. Developing this concept from the feasible and applicable points of view.
5. The selection of the best wind turbine brand except that conventional methods.