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MODELLING CARBON MONOXIDE EMISSION LEVEL OF DIESEL ENGINE GENERATORS IN NIGERIA

Abstract: Diesel engines exhausts vehemently threaten the environment and are one of the significant sources of air pollution. This research paper is aimed at predicting the risk level of carbon monoxide (CO) emission produced by diesel engine generators. Emission data on the diesel engine and the emission parameters were obtained for 105 diesel engine generators. The four input variables used to develop the model were: the installed capacity, the purchase time, the operating time and the time last serviced. Multiple linear regression modeling technique was used to develop the output (risk level of emission). The adjusted coefficient of determination, R^2 value of the optimum model, was 0.382 which explains about 38.2% of the variance in CO emission; also the Cook's distance (0.131) was less than 1 which signifies minor or no problem in the sample size used. Model validation showed a strong correlation of 89.5% between the model predictions and human predictions. At a significance level of 5%, the t-test showed that there was no significant difference between the model prediction risk level and the human prediction risk level. The model in this study is useful to industry, government environmental protection agency and private users during the determination of the risk level of CO emissions from diesel engine generators.

Key words: emission, generator, regression model, risk

INTRODUCTION

Toxic emissions from internal combustion engines are environmentally concerned because of their consequential effects on air quality, human health, and global warming [1]. Thus, there are more efforts by the governments to control them. Toxic emissions include but are not limited to unfettered hydrocarbons (HC), carbon monoxide (CO), carbon dioxide (CO₂), nitrogen oxides (NO_x), and particulate matters (PM) [2,3]. Emission is a general term that may be used to describe the unsafe gases and particles which are released into the air or emitted by different sources. Carbon monoxide (CO), lead, nitrogen dioxide (NO₂), ozone (O₃), CO₂, PM and sulphur dioxide (SO₂) are the pollutants of serious concern that pose high risk to human health and the environment. These are the criteria pollutants. The sources of these pollutants are diverse (include facilities from factories and power plants), mobile sources, (automobile vehicles, lawn mowers, airplanes, and any other mechanically propelled machineries and pollutants releases into the air), biogenic sources, (such as trees and vegetation, gas seeps, and microbial activity) and area sources (these are smaller stationary sources like dry cleaners and degreasing operations). Diesel fuels are a blend of hydrocarbons compounds with other smaller constituents especially impurities whose constituents majorly contain hydrogen, carbon atoms, nitrogen and sulphur.

In a perfect or ideal engine, oxygen in the air reacts with the hydrogen in the fuel to yield water while carbon in the fuel to carbon dioxide and nitrogen in the air often remain inert. In fact, the combustion process can neither be perfect nor ideal, but automotive engines emit various magnitudes and types of pollutants. Hydrocarbon emission is a consequential effect of partial or complete combustion of fuel in the engine. It reacts with the sunlight and nitrogen oxides to form ground-level ozone, a prominent constituent of smog. This ozone irritates the eyes, negatively affects the lungs, and worsens respiratory tract health issues. It is common and not effectively managed urban air pollution challenge. Mostly, hydrocarbons exhaust gases are toxic not only to animals but to environment, with the high potential to cause health issues such as cancer. Generators, lawn mowers, water pumping machines, earth moving equipment like excavators, vulcanizing machines, outboard and inboard engines on marine vessels are powered with fossil fuel, and they emit gaseous emissions consequently affecting the air quality. Diesel engine exhausts are considered one of the major sources of air pollution. The basic exhausted gases (pollutants) from internal combustion engines are prominently oxides of nitrogen, CO, CO₂ total organic compounds, and particulates (these particulates include non-visible and visible emissions). The dwindling electricity generation strength and its capacity in an amazingly increasing population, with little or no

suitable strategy to correspond to this alarming state, necessitate more electric power to subdue the existing supply. In the year 2000, the issue aggravated Nigeria electricity supply challenges, consequently led the Federal Executive Council in the year 2001 to approve the National Electric Power Policy that resulted in significant review of ownership, control and regulation of the power sector. The ineffectiveness of the Power Holdings Company of Nigeria (PHCN) to render electricity supply has resulted in massive use of generators [2-5] making Nigerians to be chronic users of private power generators across the globe [6-8]. Despite the privatization of PHCN, almost 75% of the Nigerian population still lives without access to regular electricity supply. However, the usage of generator keeps on increasing all over the country due to poor rate of awareness among the Nigerians and the laxity of the government to put effective measures to the menace of power supply.

According to a global research published, Nigeria is the leading market in terms of demand and consumption of diesel, petrol and gas generators in Africa. It was forecasted to experience the growth rates of 8.7% driving up the market volume for generator estimated at NGN 71.55 billion (\$450 million) in 2011, which tend to reach NGN 151.16 billion (\$950.7 million) by the year 2020. This is due to a consequential effect of the epileptic power situation in the country. Hence, noise from generating plants in many areas in Nigeria coupled with the associated exhaust emission has seriously contributed to the depletion of the ozone layer in the atmosphere [9, 10]. To worsen the situation, there are currently no accurate data on this subject matter and a higher percentage of generator users in the country faced with emission problems are ignorant of the menace on their health and environment.

In Nigeria currently there is a lack of the appropriate data on the consequence of generator usage on the environment. Even though, there are small number of essential health issues related to generator usage; the generators emit CO, CO₂, particulate matters comprising seared hydrocarbons and oxides of nitrogen that enhance air pollution. The condition of generator determines its exhaust, since incomplete combustion of hydrocarbon products (usually unburnt hydrocarbons) often do more harm than good to the ecological set-up. In a moment, it was noted that majority of business owners believe that generator usage in real sense of present usage is not safe for human health and the environment, but on the contrary about 22 percent thought otherwise [11]. To this end, the main goal of this research study is to develop a statistical risk model that will estimate the level of carbon dioxide emission derived from the use of diesel generating sets. The motivation herein will reveal the damage to climate change and the need to develop policy for sustainable environmental planning and improvement in the nation's power supply.

LITERATURE REVIEW ON EMISSION STANDARDS

Emissions have standards that are predetermined by organizations and even countries worldwide. Benchmarks for human and public health purposes have now been set and must not be exceeded. World Health Organization (WHO) is one of such international agencies of the United Nations (UN) saddled with the responsibility for international public health. American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) was established in 1894; it is an international society moving forward human well-being through sustainable technology for healthy environment. In Nigeria, there exists Federal Environmental Protection Agency (EPA), the National Emission Standards for Hazardous Air Pollutants, with the primary responsibility to protect human health and environment. Table 1 shows the recommended emission standards for Tier 1-4 EPA non-road diesel engine.

Table 1. Recommended emission standards [2,12]

Emissions	ASHRAE	WHO
CO	9 ppm	10 ppm for 8 hrs exposure. 25 ppm for 1 hr exposure
CO ₂	<700 ppm	300-500 ppm
Temperature	75-80 °C	-----
Particle matter	-----	25 µg/m ³ for 24 hours exposure
Relative humidity	<60%	-----
Humidity	<65%	-----

FACTORS AFFECTING EMISSION LEVELS OF DIESEL ENGINE GENERATORS

Two separate factors often affect the emissions produced by diesel engine generators. Firstly, it is a known fact that, as generator ages and accumulates more mileage, the engine slowly wears and produces higher emissions despite the fact that diesel engine depreciation is acknowledged slow for tenacity of certification. This imply that, for instance, a ten years old generator would definitely produce higher emissions after a decade of usage than it did when it was new. Secondly, the inevitable change in technology is another factor. The changing technology suggests that the engines produced today are technically different or upgraded especially in the area of electronic, size and control, which need to meet

more stringent emission standards. Convectional fuels other than usual diesel may serve as a means of reducing heavy-duty engine emissions. Fuels like liquefied petroleum gas, compressed natural gas and a number of alcohols have been invented and used but some mostly require engine modifications for operation. However, employing usual diesel or a diesel equivalent may yield significant drops in engine emissions while circumventing the cost of generators modifications. New fuel upgrade can affect diesel engine generators and reduce NO_x and PM considerably [14]. Fuel additives can be used to reduce the emissions, The work load on diesel engine generators determine its emission - the higher the work load, the higher the emission produced [15].

MODELLING EMISSION TECHNIQUES

By determining the model's purpose, a modeler makes the later choices of both components and structure practicable. There are various modeling techniques commonly used. These include: system dynamic models, conceptual and physical models, mathematical models, artificial neural networks model, logic data model and statistical models. Researchers have developed several models for emission control. [16] developed an integrated model on the framework of STELLA software, used to provide effective urban energy planning for a low-carbon city. [17] developed a model using the artificial neural network to forecast the emission features of any upgraded or newly formulated biodiesel and its blends functioned at varying load conditions in a cylinder diesel engine. [18] also used artificial neural network approach in predicting engine-out emissions and performance parameters of a turbo charged diesel.

The statistical model described in this paper is a simplified, mathematically-developed to near reality and to make forecasts from the approximation. [19] employed multiple linear regressions and statistical analysis system software to develop CO₂ emission models from 40h of emissions data (on a light-duty gasoline automobile vehicle on main roads or highways) obtained with a second resolution using on-board emission measurement systems (Horiba OBS-1300). The developed models involved some variables such as velocity, acceleration and collaboration stint. The primary aim of this study is to develop a statistical model for determining CO emission level from diesel engine generators.

MATERIALS AND METHODS

STUDY AREA AND SUBJECTS

The primary data for this study were collected amid generator sets users in 150 sites located in Abeokuta and Lagos, the Southwestern states of Nigeria. Abeokuta is the major city and the capital of Ogun State in Southwestern Nigeria. It is located 64 miles north of Lagos by railway and 81 miles by water.

Lagos State is one of the three most heavily populated States in Nigeria and located on the narrow coastal flood plain of the Bight of Benin. It is restricted in the North and East by Ogun State of Nigeria, in the West by the Republic of Benin, and in the South by the Atlantic Ocean [20]. Ogun State accounts for 78% of manufacturing investment nationally while metropolitan Lagos contributes over 53% of manufacturing employment in Nigeria. This agrees with [21, 22] that Lagos State contains then more than 80% of manufacturing industries in Nigeria

METHOD OF DATA COLLECTION

Four variables are considered for the model building process. These variables are: the installed capacity, the purchase time, the operating time and the time last serviced. A questionnaire was designed with the objective of measuring these variables among the 150 users. The variables were presented as follows: the installed capacity (measured from the manufacturers' manual), the purchase time (in months), the operating time (in hours) and the time last serviced (in months). The interview was conducted and interpreted in English and Yoruba languages as applicable to each subject. On the average, each interview took about 45 minutes. Before the interview commenced, all potential volunteers agreed, and their consents were taken in oral and / or written form; also, they were informed that their participation in the study remained voluntary. The drive of the study and the confidentiality of the facts provided were stressed.

MULTIPLE LINEAR REGRESSION ANALYSIS

In this study, a multiple linear regression model is denoted as shown in Equation (1)

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \varepsilon_i \quad (1)$$

where:

Y_i = Response variable

X_k = Predictor variables ($k = 0, 1, 2, \dots, p - 1$); p is number of variables

β_0 = Y intercept of the regression plane

β_k = Parameters ($k = 0, 1, 2, \dots, p - 1$); p is number of parameters

ε_i = Random error in Y for observation i [23].

The details of the subjects' responses were input into a Statistical Package for Social Sciences. The optimum model was selected through accepted regression modeling practices which included: maximizing the adjusted R^2 , minimizing model variances, and inclusion of only variables that have been proven to be statistically significant through statistical tests. The modeler coded variables on a 5-point scale, as shown in Tables 2 to 5, to satisfy the model to be developed.

Table 2. Linguistic interpretations for variable 1
(Installed Capacity (KVA))

Variable ratings	Intervals (KVA)	Linguistic interpretations
1	below 10	Not important contributor
2	10 - 15	Less important contributor
3	16 - 20	Average important contributor
4	21 - 40	Important contributor
5	above 40	Very important contributor

Table 3. Linguistic interpretations for variable 2
(Purchase Time)

Variable ratings	Intervals	Linguistic interpretations
1	below 1	Not important contributor
2	1-2	Less important contributor
3	3 - 5	Average important contributor
4	6 - 10	Important contributor
5	above 10	Very important contributor

Table 4. Linguistic interpretations for variable 3
(Operating Time)

Variable ratings	Intervals	Linguistic interpretations
1	below 2	Not important contributor
2	2 - 4	Less important contributor
3	5 - 6	Average important contributor
4	7 - 10	Important contributor
5	11 - 15	Very important contributor

Table 5. Linguistic interpretations for variable 4
(Time last serviced)

Variable ratings	Intervals (months)	Linguistic interpretations
1	Below 1	Not important contributor
2	Between 1-2	Less important contributor
3	Between 3-4	Average important contributor
4	Between 5-6	Important contributor
5	Above 6	Very important contributor

The output variable is the risk value (Y) generated from the equation,

$$Y_i = a + b_1X_1 + b_2X_2 + b_3X_3 + \dots + b_xX_x \quad (2)$$

The emission risk value (Y) was rated using Table 6.

Table 6. Linguistic interpretations for carbon monoxide risk level

Variable ratings	Intervals	Linguistic interpretations
1	0-12.4	Very low risk
2	12.5-15.4	Low risk
3	15.5 - 30.4	Medium risk
4	30.5 - 40.4	High risk
5	40.5 - 50.4	Very high risk

MODEL VALIDATION

The Cook's distance is employed in regression analysis to find the outliers in a set of the variables. Cook's distance value was computed to find the maximum value. The Cook's distance maximum value should be less than 1.0 to mean that no predictor variables are having an undue influence. In order to validate the model, the responses of 15 users of generator sets to the predictor variables in the model (using the questionnaire) were used to compute the outcome of emission risk level using the MLRM developed, and were made available for the subjective opinions of four professionals from the academic environment. The ratings for each subject (emission level) using the two media were given the linguistic interpretations using Table 6. These values and their linguistic interpretations were compared for correlation strength. Spearman's rho was used for significance tests of correlation coefficients at a p-value of 0.01. Correlation strengths was measured as strong $|r| > 0.7$, moderate, $0.3 < |r| < 0.7$ or weak, $0 < |r| < 0.3$. The independent sample t-test was also employed to analyze unrelated groups (the model, and the human professional, mean values) at $p < 0.05$.

RESULTS AND DISCUSSION. THE OPTIMUM MODEL.

Table 7 shows the optimum model with the predictor variables namely; the installed capacity, the purchase time, the operating time and the time last serviced. The coefficient table gives the constant or intercepts term and the regression coefficients (B) for each explanatory predictor variables. The constant value (0.598) represents the intercept, which is the predicted emission rate when other predictor variables are at zero. The maximum coefficient of determination (R^2) value was 0.405 and the adjusted R^2 value was 0.382. The 4 variables in the model proved to be statistically significant through F-test (F statistic = 17.045, $p = 0.000$) as shown in the Table 8.

Table 7. Regression coefficients of model

Model 4	Unstandardized Coefficients		Standardized Coefficients	T	Sig.
	B	Std. Error	Beta		
(Constant)	0.598	0.606		0.987	0.326
Installed Capacity (IC)	0.534	0.106	0.413	5.051	0.000
Purchase Time (PT)	-0.164	0.099	-.129	-1.664	0.099
Operating Time (OT)	0.302	0.096	.251	3.157	0.002
Time Last serviced (TLS)	0.179	0.058	.244	3.059	0.003

Table 8. Analysis of Variance (ANOVA) of the Model

Model	Sum of Squares	Df	Mean Square	F	Sig.
Regression	35.266	4	8.817	17.045	0.000 ^a
Residual	51.724	100	0.517		
Total	86.990	104			

MODEL IMPLEMENTATION

The Multiple Linear Regression Risk Model developed to predict the level of CO emission in diesel engine generators derived from Table 7 is given as:

$$Y_i = 0.598 + 0.534V_1 - 0.164V_2 + 0.302V_3 + 0.179V_4$$

where, Y denotes the dependent variable (i.e., risk level of carbon monoxide emission), V_1 denotes the variable one (i.e., the installed capacity), V_2 denotes the variable two i.e. the purchase time, V_3 denotes the variable three i.e. the operating time and V_4 denotes the variable four (i.e., the time last serviced).

Using the model, user inputs the relevant ratings for the 4 variables using the 5-point scale (1= not important, 5 = very important) and then calculate the emission level(Y). One predictor variable, V_2 (Purchase time), had negative β coefficient (-0.164), this indicates that the correlation is insignificant because the generator can be bought and kept without being used, so this has little or no contribution to the emission level of the generator. The model summary provides for a new value for R^2 for the expanded model (Adjusted $R^2 = 0.382$) which explains about 38.2 % of the variance in emission (see Table 9). Also, $F = 17.045$, $df = 20$, $p < 0.005$ means that the MLRM is better at predicting the outcome than using the mean outcome because it generates some significantly smaller residuals.

Table 9. Model summary of optimum model

Model 4	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.637 ^a	0.405	0.382	0.71920

^a Predictors: (constant), time last service, purchase time, operating time, installed capacity

Table 10. Residuals statistics of model

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted value	2.7907	5.5051	4.0095	.58232	105
Std. predicted value	-2.093	2.568	0.000	1.000	105
Cook's distance	0.000	0.131	0.011	0.019	105
Centered leverage value	0.007	0.178	0.038	0.028	105

Table 11 displays the results of fifteen tested scenarios randomly selected from the numerous data collected. All the 4 predictor variables in the optimum model, the values of the predictors, the model and the human professional predicted values (HPPV) and the interpretations are all indicated. From Table 11, the model predictions have higher interpretations of HR compared to the HPPV predictions. Samples (1, 3, 4, 5, 6, 8, 11, 13, 14, and 15) have same interpretations for both the model predictions and the human experts' predictions.

After comparing the results of predicted values of the model with that of human predictions for correlation strength using spearman's rho, a significant correlation was found, $r = 0.895$, $p = 0.0001$. The coefficient of determination of 0.895 suggests 89.5% variability which signifies a very strong correlation (Table 12). The t-test to determine the mean difference between the human prediction values and the model prediction values found that the model prediction showed a statistically significantly lower level of risk (3.0667 ± 0.205) compared to human prediction (3.3667 ± 0.419), $t(28) = -0.643$, $p = 0.526$ as shown in Tables 13 and 14, respectively. However, the group's means were not significantly different, since the t-test evaluated value was greater than critical value of the t-test at 5% level of significance.

Table 11. Comparison of model predictions and human predictions of implementation of the optimum risk model for CO emission level

Sample	A	B	C	D	Model Predictions	HPPV Predictions			
					Model Values	Risk	Interp	Risk	Interp
1	5	3	4	4	4.7	4	HR	4.3	HR
2	4	2	4	3	4.151	4	HR	3.5	MR
3	4	3	4	2	3.806	3	MR	3.3	MR
4	5	3	4	3	4.521	4	HR	4.5	HR
5	5	4	4	3	4.357	4	HR	4.3	HR
6	2	2	4	2	2.602	2	LR	2.4	LR
7	5	2	3	3	4.685	4	HR	3.6	MR
8	5	4	4	3	4.357	4	HR	4.5	HR
9	5	3	4	3	4.521	4	HR	3.6	MR
10	4	3	4	3	3.383	3	MR	2.8	LR
11	2	4	2	1	2.397	2	LR	2.3	LR
12	4	3	4	2	3.808	3	MR	2.9	LR
13	2	3	4	3	2.919	2	LR	2.8	LR
14	4	3	4	2	3.808	3	MR	3.1	MR
15	2	4	4	3	2.755	2	LR	2.4	LR

Table 12. Non Parametric Correlations analysis of model outputs

			Model	Human
Spearman's Rho	Model	Correlation coefficient	1.000	0.895**
		Sig. (2-tailed)	.	0.000
		N	15	15
	Human	Correlation coefficient	0.895**	1.000
		Sig. (2-tailed)	0.000	.
		N	15	15

**Correlation is Significant at the 0.01 level (2-tailed)

Table 13. Descriptive statistics for correlation test for model outputs

	Mean	Std. deviation	N
Model	3.0667	1.62422	15
Human	3.3667	.79252	15

Table 14. Independent t-test results for model predictions and human predictions at 5% level of significance

t-test for Equality of Means							
Sources of variations				Mean Difference	Standard Error Difference	95% Confidence Interval of the Difference	
	t	df	Sig. (2-tailed)			Lower	Upper
Predictions	-.643	28	.526	-.30000	.46663	-1.25585	.65585
	-.643	20.309	.527	-.30000	.46663	-1.27243	.67243

DISCUSSION OF RESULTS

A multiple linear regression risk model was developed to predict the risk of carbon monoxide emission from the use of diesel engine generators. The model, using four predictors, the installed capacity, the purchase time, the operating time and the time last serviced, was suitable for predicting the outcome by statistical analysis judgments. The installed capacity of a diesel engine generator from statistical proof ($p = 0.0001$) means that generators' capacities greatly affected the emission rate for a diesel engine generator. The primary use of a generator may have an effect on the

emissions produced. Hence, the higher the load on the generator, the higher the amount of emission produced. For example, the load and the operating time of the generator used in an industry will be higher than that used in a house thereby producing higher emissions which can be very dangerous to subjects and the environment. The operating time stated in this research is on frequent 'start and stop' mode i.e. the generator is not running continuously. The emission products can however be rated for necessary regulations using the developed model.

The time of purchase of diesel engine generators may not pose threat proportional to the emission rate, especially when the purchase time of a generator is not the time the users put it into use. A generator that was purchased and has not been used cannot produce emission; therefore, for this model; the purchase time actually indicated a negative beta value. There were two separate factors of generator age that may affect the emissions produced. In the first instance, it is anticipated that, as a generator ages and accumulates high mileage, so the engine slowly wears and produces higher emissions although diesel engine depreciation is acknowledged to be slow for purposes of certification. A ten-year-old generator may produce higher emissions after ten years of usage than it did when it was newly bought; this is in line with the conclusion of [9,2]. The later factor is the change in technology, which suggests that the engines produced today are different from the older ones especially in the areas of electronic systems, materials type and control which essentially needs to meet more austere emission standards.

The risk level predicted by the developed model from the statistical analysis was lower than the human experts' predictions risk level. The lower result of model predictions may appear due to typographical error during the input of data, or error from collection of primary data among others. In the case of higher human prediction values, errors may also occur as a result of the subjective opinion of the human expert. They might predict the risk under some influential circumstances. However, the percentage of correlation between the model predictions and the human predictions was very strong. The model developed in this study can be significant in many areas. Any organizations or private individuals using generators can be able to predict the risk of emission level from the power generating device without reference to human experts which are in most cases very scarce.

CONCLUSIONS

The CO emission of diesel engine generators which poses great threat to humans and its environment has been considered in this research paper. The following conclusions can be drawn:

- (a) Significant predictors of CO emission were identified as: the installed capacity, the purchase time, the operating time and the time last serviced.
- (b) A multiple linear regression was developed using the four predictors.
- (c) The multiple linear regression models have high R^2 regression coefficients.
- (d) The methodology and the developed model can find their applications in government environmental protection agencies for determining the levels of harmful emission from diesel engine equipment, and the subsequent contributions to greenhouse gas (GHG) effects.

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MODELIRANJE NIVOA EMISIJE UGLJEN-DIOKSIDA KOD GENERATORA SA DIZEL MOTORIMA U NIGERIJ

Olansunkanmi Akinyemi, Olasunkanmi Akinyem, Hezekiah Adeyemi

Rezimw: Izduvni gasovi dizel motora u velikoj meri ugrožavaju životnu sredinu, i predstavljaju značajan izvor zagađenja vazduha koji negativno utiče na ljudsko zdravlje. Cilj ovog istraživanja je da predvidi nivo rizika emisije ugljen monoksida (CO) koji proizvode generatori sa dizel motorima. Podaci o emisiji izduvnih gasova dizel motora, kao i parametri emisije su prikupljeni na uzorku od 105 generatora sa dizel motorom. Četiri ulazne varijable korišćene su za razvoj ovog modela: instalisani kapacitet, godina nabavke, vreme rada i vreme od poslednjeg servisa. Tehnika modeliranja višestrukom linearnom regresijom upotrebljena je za dobijanje rezultata (tj. određivanje nivoa rizika od emisije). Vrednost prilagođenog koeficijenta determinacije (R^2) optimalnog modela je 0,382 što objašnjava procenat odstupanja od 38,2%; osim toga, Kukovo rastojanje koje iznosi 0,131 je manje od 1, što označava relativno korektnu veličinu uzorka. Validacija modela je ukazala na značajnu korelaciju (89,5%) između predikcija dobijenih modelom i ekspertskih predikcija. Vrednosti t-testa na nivou statističke značajnosti od 5% su pokazale da ne postoji značajna razlika između nivoa rizika koji se određuje modelom predikcije i nivoa rizika dobijenih ekspertskom predikcijom. Model prikazan u ovoj studiji je koristan za različite industrijske sektore, resorne državne agencije za zaštitu životne sredine i ostale korisnike za određivanje nivoa rizika od emisije CO iz generatora sa dizel motorom.

Ključne reči: emisija, generator, regresioni model, rizik