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Research Article

Comparative Study of Natural Gas Vehicle vs Electric Vehicle in Transportation

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Abstract

The paper tries to find out comparative analysis between natural gas vehicle & electric vehicle with reference to different parameters. It has been done by applying a suitable methodology through a research model and testing the hypothesis. When it comes to clean and green environment both natural gas vehicle (NGV) and electric vehicle (EV) plays important role. As natural gas can also be used to generate electricity which in turn will charge the electric vehicle, therefore in this paper we will study the importance of natural gas in fulfilling the requirement of both NGV & EV in future perspective. The enormous application of NGV & EV not only improve the transportation sector in terms of technological innovation but also at the same time will help in lowering the global warming.

Keywords: Natural Gas Vehicle , Electric Vehicle, Energy & Environment

1. Introduction

With the easy availability & affordability of natural gas through various city gas distribution network, there has been increasing us of CNG vehicles at all metro cities. Now CNG vehicle are proliferating to all new adjacent cities in all across the country because of it's inherent advantage on different parameters as compared to other fuel based automobiles.

When different parameters are compared on the basis of Emission, Economy, Filling cost, Vehicle Cost, Filling time, Efficiency, Public Awareness, Safety, Vehicle Range, Fuel cost, Maintenance of vehicle for identifying the advantage and disadvantage of natural gas vehicle over the Electrical vehicle, it is observed that both type of vehicle have future prospective.

However natural gas being both used as primary fuel for natural gas vehicle and secondary fuel in the form of generating electricity which in turn being used to charge the electric vehicles, there is more future prospective consumption of natural gas as hybrid vehicle are also being developed by automobile sector for using both version of CNG & Electricity in a single vehicle.

With the potential to reduce fuel consumption, fuel costs, clean & green environment switching of vehicle from conventional fuel like petrol & diesel to natural gas & electricity are gaining increasing interest as evident from Table:-1 & Table :- 2. From the Table:- , it is understood that the CNG & Electricity are having lower carbon emission and from Table-2 , it is clear that fuel cost of CNG & Electricity are almost 2times less than the gasoline cost

2. Advantage & Disadvantage Of Ng Vehicle Vs Electric Vehicle

The global climatic change is mostly attributed to @ 80% of the world's greenhouse gas (GHG) emissions due to burning of fossil fuel. Hence there is a need to switch from polluted fossil fuels to unpolluted fuels. There has been most of the development have been made in the natural gas & electricity generation for using the same in transportation, industrial processes, commercial buildings, and residences.

The government's plan to popularise electric vehicles (EVs) and phase out the sale of fossil fuel driven vehicles beginning 2023 can put at risk the planned investments of more than Rs 1.2 lakh crore in city gas distribution business.

The problem in feasibility of NGV is policy made by Niti Ayog for selling only electric car after 2030.The proposed phase-out timelines for different categories of fossil fuel-driven vehicles are: April 2023 for three-wheelers, April 2025 for two wheelers below 150 cc, and April 2026 for taxis. The EV policy drive, which has unnerved automakers, is also scaring many companies that have won city gas distribution.

In just about a year, the downstream regulator has awarded licences for 136 geographical areas covering about half of India's population. To win licences, the 20-odd state-run and private companies have pledged to build 7,200 compressed natural gas (CNG) stations, connect 3.5 crore homes with gas pipelines, and lay 156,000 inch-km of pipeline by March 2029.

From the above fact it is clear understanding that both EV & NGV will penetrate into the market in the forthcoming decade depending on situation. The advantage & disadvantage of the CNG Vehicle and Electric vehicle has been tabulated in Table:-2

The strategy of the research is to find out the feasibility study of the future perspective of natural gas vehicle on the basis of various Natural gas factor like application of natural gas in automobiles , Competition among other alternative fuel , Government regulation on the usage of natural gas and finally marketing of natural gas in such a way that the commercially the NGV shall be acceptable.

3. Research Methodology

In order to analyse the future perspective of natural gas vehicle and electric vehicle, we have made the both Primary and secondary analysis. The primary analysis is to identify the dependent & independent variables in a research model and testing the hypothesis and the secondary analysis is on the basis of advantage and disadvantage of Natural gas Vehicle vs Electric Vehicle on various factors and arriving at conclusion.

3.1 Primary Analysis

Under primary analysis the structured questionnaire is set for all dependent and independent variables and on the basis survey of 608 respondents the hypothesis is tested considering the correlation among the dependent and independent variable

3.1.1 Dependent & Independent Variable :-

Dependent Variable:

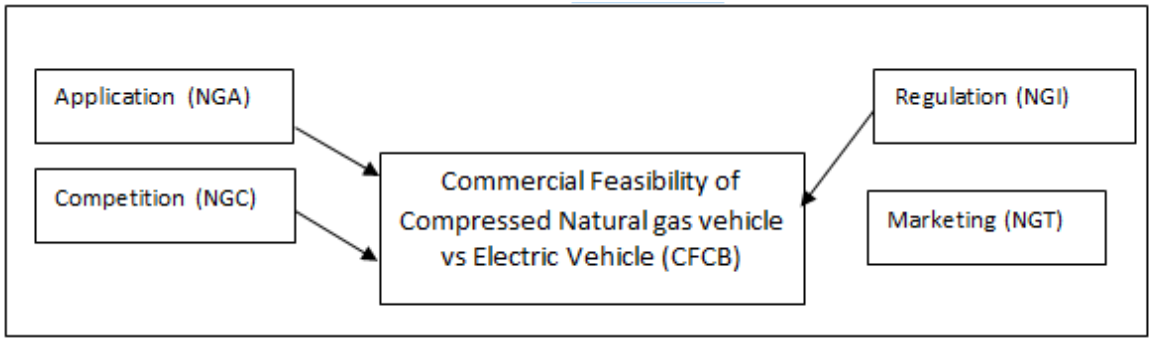
1. Future perspective of Natural gas vehicle with commercial feasibility study

Independent Variable:

1. Application of Natural gas
2. Competition of Natural gas
3. Regulation of Natural gas
4. Marketing of Natural gas

3.1.2 Research model

FIGURE-1



3.1.3 Research Hypothesis :-

H1 : The Application of Natural gas will positively affect The future perspective of NGV

H2 : The Competition of Natural gas will positively affect The future perspective of NGV

H3 : The Regulation of Natural gas will positively affect The future perspective of NGV

H4 : The Marketing of Natural gas will positively affect The future perspective of NGV

3.2 SECONDARY ANALYSIS

Under secondary analysis, the comparison of different fuel in different time period is analysed as mentioned in the Table:-1. Similarly, the advantage of natural gas vehicle is compared with the advantage of electric vehicle and other gasoline vehicle and similarly the disadvantage of natural gas vehicle is compared with the disadvantage of electric vehicle and other gasoline vehicle. The advantage and disadvantage of natural gas vehicle is mentioned in the Table-2. Also the life cycle global warming studied for different fuel and it is observed that the for natural gas the CO2 emission is less as compared to gasoline vehicle as mentioned in Figure:-1

TABLE-1

Comparison of different Fuel cost in different time period

	2010	2030				2050			
		Alternative Fuel	Gasoline	Total	Fuel Cost, billions	Alternative Fuel	Gasoline	Total	Fuel Cost, billions
Gasoline	18,464		22,806	22,806	$9.7		30,325	30,325	$15.3
Natural Gas (100%)		16,921		16,921	$4.3	22,063		22,063	$6.3
Electric (coal mix & 25% gasoline)		11,701	3,556	15,256	$3.5	4,480	4,728	9,208	$6.2
Electric (no coal & 25% gasoline)		5,511	3,556	9,066	$3.5	2,110	4,728	6,838	$6.2
Electric (no coal & 25% biofuel)						2,110	1,516	3,056	$6.2

Assumptions underlying Table: Fuel Economy standards will remain 35.5 mpg after 2016. A CNG vehicle will travel 230 miles using 1000 cf of natural gas. A PHEV 10 or 40 will travel 10 or 40 miles on electricity before converting to a liquid fuel. Electricity generated in Colorado will use 20% less fossil carbon by 2030, and 80% less by 2050, compared to 2005 levels. DOE projected retail fuel prices in 2030 (2008$): gasoline: $3.75/gallon; electricity: $0.10/kwh; natural gas: $1.40/100 cubic feet.

SOURCEwww.swenergy.org/data/sites/documents/publications/Ozone_Precursor_and_GHG_Emissions

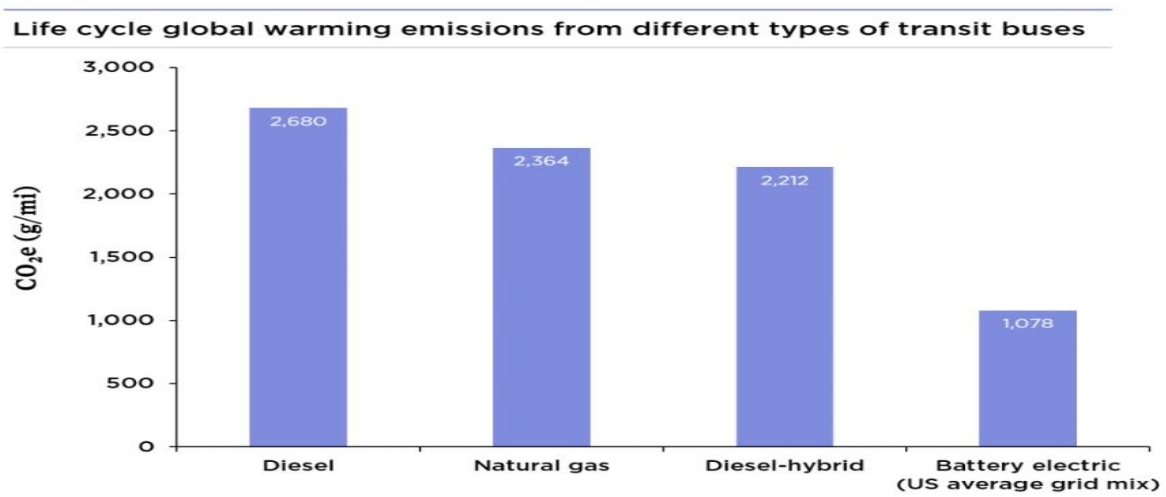
TABLE-2

Comparison of advantage and disadvantage of CNG & Electric Vehicle

ASPECT	CNG VEHICLE	ELECTRIC VEHICLE
Environmental Pollution	Less CO2 emission	No CO2 emission
Noise Pollution	Less Noise Pollution	Almost Quite operation
Safety Hazard	100% safe to use	safety provision inside car
Maintenance upkeep	Low maintenance cost	Low maintenance cost
Range and Model of Vehicle	Wide range	Few range
Filling/Charging Station	More charging station	No charging station
Economy in Fuel Cost	Almost same	More
Efficiency	Less	More
Vehicle Cost for same size	Less	More
Filling / Charging Time	Less	More
Popularity	More popularity	Gaining Popularity
Vehicle size	Small to Big Size	Small Size as per Battery
Millage Range and Speed	More	Less
Suitability with Power Shortage	Suitable	Not Suitable

Source: From various research papers

FIGURE-2



Source: Union of Concerned Scientist , https://blog.ucsusa.org/

Table-3 :- Growth in natural gas infrastructure

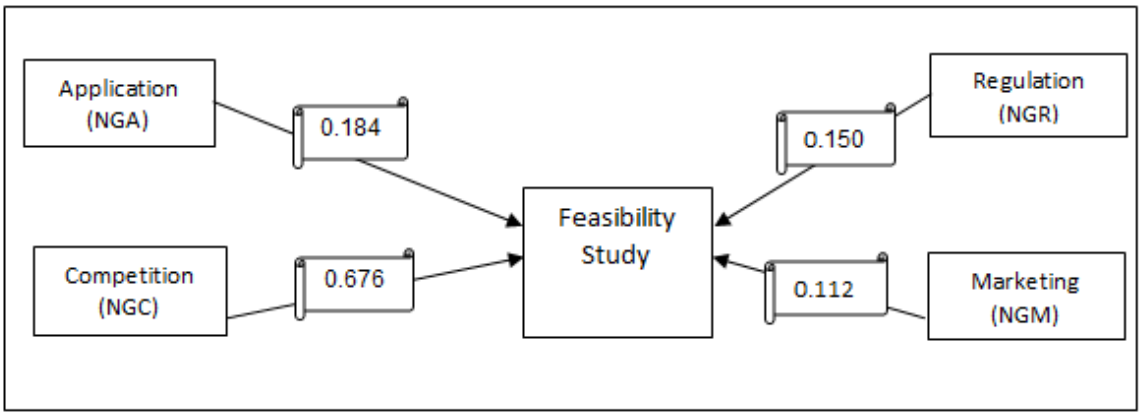
	Sector	2014	2020	Change
Area covered*	No. of GAs awarded	34	232	582.35%
	No. of districts covered	66	407	516.66%
CNG*	CNG Station	938	2300	145.20%
	CNG Vehicles in Lacs	22	33.75	53.4%
PNG*	Domestic Conn. In lacs	25.4	60.68	138.89%
	Commercial/Industrial PNG Conn.	28,000	40,880	46.0%

Source : PPAC , Figures as on Apirl2020

4. Results

4.1 The results on the basis of Primary analysis

FIGURE 3



Final Outcome of MODEL with Feasibility study as focal point

Under the primary analysis , the testing of hypothesis have been done through multiple regression analysis of SPSS IBM software 19. The R^2 value represent the model's overall analytical fit. The β value of each natural gas factor in the hypothesized model are presented in Figure:-3. The hypothesis H1, H2, H3, H4 are about finding out the influence of Application, Competition, Regulation and Marketing on Feasibility study of Natural gas Vehicle at Aburoad. As expected, Application(β=0.184,t-value=4.385) & Competition(β=0.676, t-value=14.670) had highly progressive influence on the commercial feasibility study of Natural gas Vehicle at Aburoad and Regulation (β=0.150, t-value=3.675) & Marketing (β=0.112, t-value=2.743) had a substantial encouraging effect on the technical feasibility. Hence, hypotheses H1, H2, H3, and H4 were sustained. Therefore the anticipated model has significant variance on loyalty (R^2=60.9%, F=value=234.696). The detailed data analysis are as given below

Table-4 : KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.898
Bartlett's Test of Sphericity	Approx. Chi-Square	13422.640
	df	105
	Sig.	.000

Table-5 : Rotated Component Matrix[a]

	Component			
	1	2	3	4
NGA1	.770			
NGA2	.779			
NGA3	.730			
NGC1		.847		
NGC2		.887		
NGC3		.879		
NGR1			.843	
NGR2			.879	
NGR3			.889	
NGM1	.839			
NGM2	.846			
NGM3	.845			
CFCB1				.834
CFCB2				.871
CFCB3				.856

Extraction Method: Principal Component Analysis.

Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 6 iterations.

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
.952	.955	15

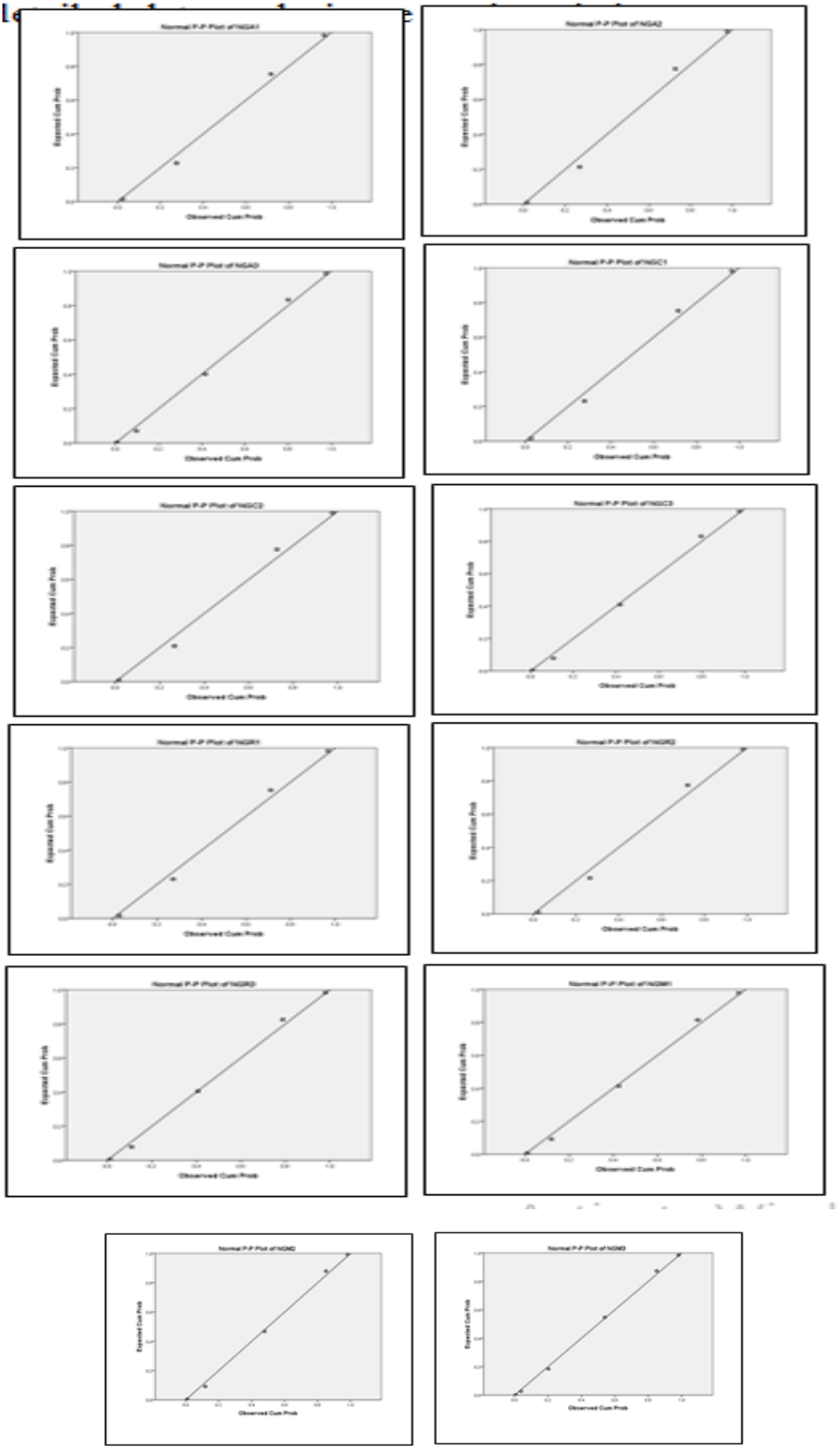


Table-7 ANOVA with Cochran's Test

		Sum of Squares	df	Mean Square	Cochran's Q	Sig
Between People		3236.947	607	5.333		
Within People	Between Items	1572.812	14	112.344	3576.304	.000
	Residual	2170.655	8498	.255		
	Total	3743.467	8512	.440		
Total		6980.414	9119	.765		

Grand Mean = 3.8719

Table-8: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.780[a]	.609	.606	.54252	.609	234.696	4	603	.000

a. Predictors: (Constant), NGM, NGR, NGA, NGC

b. Dependent Variable: CFCB

Table-9: ANOVA

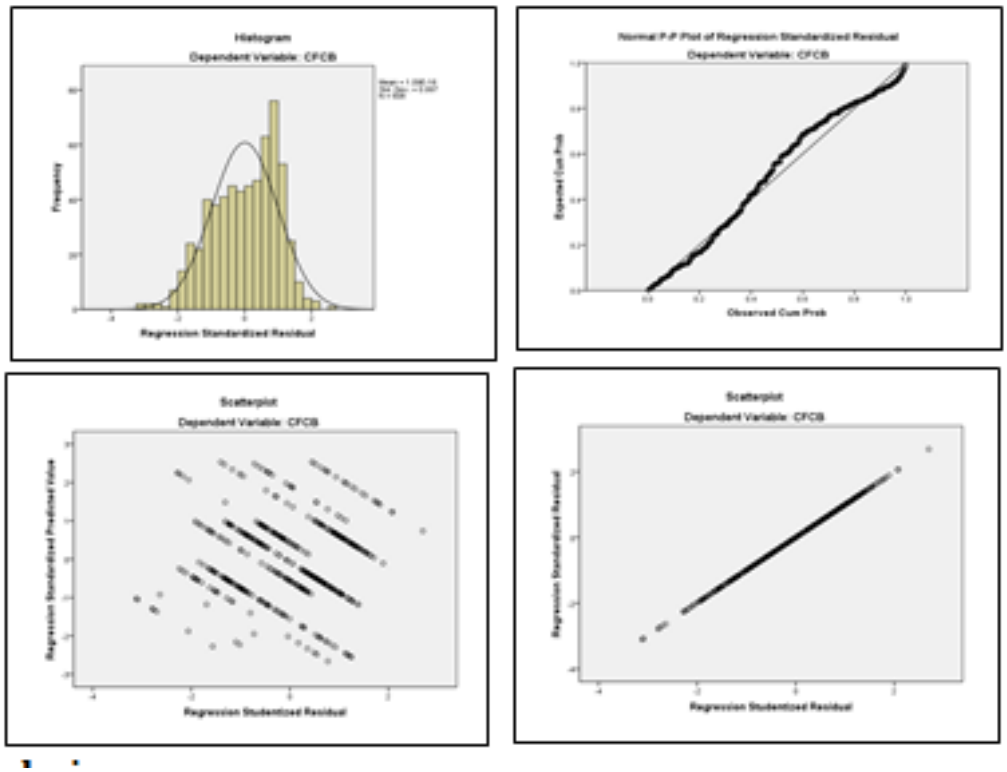
Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	276.306	4	69.076	234.696	.000[a]
	Residual	177.477	603	.294		
	Total	453.783	607			

Table-10 : Coefficients

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	(Constant)	.182	.146		1.240	.215		
	NGA	.184	.042	.151	4.385	.000	.550	1.818
	NGC	.676	.046	.537	14.670	.000	.484	2.065
	NGR	.150	.041	.121	3.675	.000	.601	1.663
	NGM	.112	.041	.091	2.743	.006	.591	1.693

Table-11:- Descriptive Statistics

	Mean	Std. Deviation	N
NGA	3.7409	.70790	608
NGC	3.7451	.68679	608
NGR	3.7408	.69667	608
NGM	3.7435	.70360	608
CFCB	4.3792	.86463	608



4.2 The results on the basis of Secondary analysis

When NGV and EVs are compared to each other considering the respective advantage and disadvantage in respective category , it is observed that in case of Aburoad , the NGV has more perspective as compared to EV . This is because there are no electric charging station presently available at Aburoad which is a primary requirement for successfulness of Electric Vehicle , but if see the future perspective of CNG vehicle , then it can be seen that alredy the survey has been done by M/s Gujrat Gas Limited to set up the CNG stations at different location of Aburoad. Also comparing to mileage and popularity there is more perspective of Natural gas vehicle and other parameters are at par with Electric Vehicle.

In addition this the natural gas can be used both as transportation fuel along with use the same to generate electricity which is primary requirement of electric vehicle. If natural gas is used for generating electricity for running the electric vehicle , then the mileage of EV shall be 60% more than the NGV. Also in the time period from now onwards to 2030 and up to 2050 there shall be enormous consumption of natural gas. Similarly looking into the climatic change towards global warming there shall be more future perspective for natural gas vehicle as compare to another alternative fuel vehicle as evident from Table-1, Table-2 , Table-3 & Figure-2 respectively.

5. Discussion

Through it is observed that there are two technologies available for vehicle in terms of NGV & EV looking at various advantages like low price, low pollution and the availability of natural resources in future forecast of demand, but at the same time there are also disadvantages of both NGV & EV. This is due to the fact that there are poorly developed network of CNG stations for NGV and similarly no Charging station for EV in case of Aburoad and also high costs of CNG kit in NGV and Battery in EV

From the result obtained from Primary survey of feasibility study of NGV, it is observed that by different application of naturals gas in the competitive environment through favourable government regulation with strategic marketing, it is feasible to have NGV at Aburoad.

Similarly through secondary survey , the result is showing favourable for NGV looking into it's future perspective. Also following study conducted by various researcher are supporting the future perspective of natural gas vehicle in transportation

As per Sh. Subrata Ray in the research paper **"**Making India A gas based economy" International Journal of Engineering and Technical Research (IJETR) ISSN: 2321-0869 (O) 2454-4698 (P), Volume-6, Issue-3, November 2016, The India is going to be a gas based economy with advent of smart cities with the planning to

connect 326 cities with city gas distribution network (CGD) by 2022 for meeting 100% demand in the CNG (Compressed Natural Gas) segments.

As per Sh. Subrat Sahu and Sh.Varun Singh in the research paper International Journal of Chemical Engineering and Applications, Vol. 4, No. 1, February 2013Natural Gas Business and Market in India, the CNG application in transportation , railway and marine with the use of Technologies, Innovative practices and development has paved the way towards improvement in demand of natural gas business and market . However demand for natural gas for using in natural gas vehicle will be the function of supply, competition , regulation as compared to alternative energy like Electric Vehicle.

As per Sh.Mahmamd Imran Khan in the research paper "Policy options for the sustainable development of natural gas as transportation fuel" Energy Policy 110 (2017) 126–136, Introduction of CNG as transportation fuel and establishment of sustainable market is considerably and effectively done in developing countries due to market based incentive like exemption of custom duty on CNG kit, reduction of sale tax on NGV and non-monetary incentive like Allotment of land for CNG stations and pipelines on priority basis , Exemption of NGVs from Odd-Even day traffic rule

6. Conclusion

The climatic change has pushed the world to switch over from conventional gasoline fuel to more clean & green natural gas as result there has been a shift away towards Natural gas based car production. This is going to be the next great industrial revolution. Natural gas vehicles being most efficient and cost effective, there has been a forecast of more future perspective of same.

However, if we consider the case of Aburoad, there is no charging station and electrical vehicle are running on the road. But we can see that there are more upcoming CNG stations and natural gas pipeline crossing Aburoad. Hence there is more future for NGV as compared to EV. Also we can see the natural gas can be both way used in transport sector directly in the form of CNG and also indirectly to produce electricity which can further charge the EV . Therefore, in the near future there is more chance and feasibility of natural gas being widely used in transportation sector directly and indirectly to power the NGV and EV respectively in case of Aburoad region

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