An Empirical Analysis of Natural Gas as an Alternative Fuel for Internal Transportation

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Abstract—This study aimed to measure the usage natural gas can be an effective alternative fuel for internal transportation. In order to interpret the present analysis, a quantitative approach was used. The current research focused on assessing the usage of natural gas as an alternative fuel for internal transportation. The present research was analyzed using a questionnaire. Sample design is the technique or process that the researcher is able to accept in selecting objects for the survey is referred to as sample design. The research sample was chosen using a random sampling method and carried out in various locations in Kurdistan region of Iraq. A total of 125 questionnaires were issued, but only 111 participants completed them correctly. Participants were asked to rate the value of each object on a five-point scale ranging from unimportant to highly important. The findings revealed that the usage of Natural Gas Fuel strongly predicts internal transportation, implying that the usage natural gas can be an effective alternative fuel for internal transportation.

Keywords—Natural Gas Fuel, Internal Transportation, Economic, Kurdistan region of Iraq.

I. INTRODUCTION

Fossil fuels are now the main source of electricity for the world's energy needs. Nonetheless, these fuel supplies have a number of drawbacks, including a decrease in air quality, the production of hazardous waste, and the depletion of natural resources (Pfoser et al. 2018). As a result of these issues, a great deal of study has been undertaken on renewable energy options, including an emphasis on pollution and fuel economics. Several studies have been undertaken around the world to preserve the atmosphere and reduce the rapid depletion of fossil oil supplies. Alternative energy options are the most environmentally sustainable energy sources available, as well as the safest way to avoid over-reliance on fossil fuels (Dyr et al. 2019). In light of this, natural gas is being seen as a viable renewable energy option due to its many advantages. These include ease of use in conventional internal combustion engines, low carbon content in comparison to other hydrocarbon fuels, and widespread availability (Yaqoob et al. 2021). The perfect clean fuel options for today's global energy needs are hydrogen and natural gas. Natural gas is known as a fossil fuel, although it can be produced using renewable resources. In general, natural gas continues to have higher thermal efficiency to internal combustion engines (Anwar, 2017). Natural gas has a lower carbon content and a higher methane content than diesel fuel, allowing vehicles to run at higher compression ratios. Furthermore, since natural gas has a lower carbon content than gasoline, it has better “anti-knocking” properties (Khan, 2017). Natural gas is compressed and used as a transportation fuel in most countries. The benefits of CNG over diesel or gasoline-powered cars have been discovered in several trials. Because of its safe origin, natural gas emits less nitric oxide (NO), hydrocarbon (HC), and carbon monoxide (CO). However, the main disadvantage of using CNG in internal combustion engines is its sluggish rate of combustion. As a result of "misfires" and incomplete combustion, unutilized methane is released into the atmosphere. Methane gas adds by a factor of twenty to global warming impacts as compared to global warming gases like carbon dioxide (Rahman & Ahmad, 2019).
The number of natural gas-powered vehicles has increased dramatically over the last decade, especially in Latin America and Asia-Pacific countries. This has been made possible by the renewable quality of natural gas, which results in lower combustion pollution from natural gas-powered cars. Furthermore, natural gas has a greater global supply than oil and is not subject to volatility in global oil markets (Anwar, 2016). Abdullah et al. (2017), tested the durability of a passenger car that ran on compressed natural gas. It was discovered that driving a vehicle on CNG reduces formaldehyde, PAHs, HC, NOx, and CO emissions as opposed to driving a vehicle on gasoline (Anwar & Balcioğlu, 2016). The only disadvantage of using natural gas is the highest spark advance, which is caused by natural gas’s slower laminar combustion speed. Hydrogen is blended with natural gas to improve combustion efficiency, which solves this issue. As hydrogen is added to natural gas, the result is HCNG, or Hydrogen Compressed Natural Gas (Shrivastava et al. 2020).

Natural gas is a hydrocarbon, which means it is made up of hydrogen and carbon compounds. Methane (CH4) is the most basic type of hydrocarbon, containing one carbon and four hydrogen atoms. Natural gas is located deep under the earth’s atmosphere, deep within the earth. Natural gas, like any other electricity source, can be used for both residential and industrial heating. It can also be used as a transportation substitute fuel (Mohsin et al. 2019).

Natural gas is becoming more common as a transportation/vehicle fuel, despite the importance of other energy sources. This is due to the fact that natural gas is the cleanest burning fossil fuel and, as a result of lower carbon dioxide emissions, has a much better environmental efficiency than palm oil, diesel, and coal (Hameed & Anwar, 2018). Furthermore, natural gas is readily available and less expensive than other fossil fuel energy sources. Furthermore, since natural gas is silent, it can significantly decrease noise pollution from car engines. As a result of these features, natural gas has improved its status as one of the most widely consumed energy sources (Liu, 2019).

II. LITERATURE REVIEW

HCNG as an Alternative Fuel

It’s worth noting that hydrogen is well-known for having a quick flame propagation rate and a wide flammability range. Because of these characteristics, HCNG produces less emissions, has a higher thermal efficiency, and burns cleanly (Anwar & Ghafoor, 2017). Because of its higher performance and clean features, hydrogen has a greater potential for use as an alternative energy source (Osorio-Tejada et al. 2017). As a result, hydrogen is predicted to be used as an alternative energy supply in the future. However, various conditions must be met before it can be licensed for general use in internal combustion engines. Inadequate refueling stations and facilities, for example, are major roadblocks to the widespread use of hydrogen cars (Mursheed, 2020). A lot of studies has been done on the effects of combining hydrogen with natural gas to reduce the enormous need for pure hydrogen. This mix, without requiring any key hardware modifications, requires current CNG engines and natural gas systems to be used. As a result, HCNG has been accepted as a viable replacement for fossil fuels in current combustion engines (Wang & Su, 2020).

Assessment of Emissions between Natural Gas Engines and Diesel Engines

The Supreme Court of India ordered all public vehicles in Dehli to switch from gasoline and diesel to compressed natural gas (CNG) (Abdullah & Othman, 2016). As a result, Dehli is the city with the greatest number of CNG-powered public transportation vehicles. Following this decision, SO2, NOx, and TSP levels were reduced by 22 percent, 6 percent, and 14 percent, respectively. The Dutch government funded a campaign in 1993 to equate the amount of emissions emitted by natural gas to those produced by diesel and gasoline. Natural gas, it was observed, produced less emissions than diesel and gasoline (Ahmed et al. 2020). Similarly, Anwar & Qadir, (2017) performed an experiment to assess the amount of pollution emitted by four garbage collection trucks in Milan. One truck was powered by a Euro V diesel engine, while the other three were powered by a Euro V CNG engine. A portable measuring device was mounted in each of these trucks to calculate the amount of pollution. The findings showed that CNG vehicles emitted significantly less PM and NOx than diesel vehicles. However, they had a lower average output reliability than diesel cars (Prabhu et al. 2019). Wang & Zhan, (2019) tested the performance of a Proton Magma12-Valve 1468cc engine with four cylinders. Its engine was fitted with a bi-fueling unit and then converted from a gasoline form. It was discovered that when the engine was run at 1500 to 5500 rpm, CO2, CO, and HC were reduced by 20%, 80%, and 50%, respectively, when compared to fuel. NOx emissions, on the other hand, increased by 33% (Ahmed et al. 2019). In Tehran, Khan, (2018) tested the exhaust emissions and efficiency of a B2000i Mazda bi-fuel engine that runs on gasoline and natural gas. The authors discovered that the quantity of HC, CO2, and CO pollutants decreased significantly. NOx emissions were the only ones that rose in quantity (Othman & Abdullah, 2016).

Dondero et al. (2005) looked at the pollution of CNG-powered vehicles as well. NMHCs, CO, and CO2 emissions...
were reduced by 66 percent, 53 percent, and 20 percent, respectively, as compared to gasoline cars. NOx pollution, on the other hand, increased by 171 percent. In addition, the pollutants emitted by 37 CNG-powered vans were analyzed by two separate laboratories (Anwar & Shukur, 2015). The amount of emissions emitted by a gasoline and a CNG engine were compared by Abdullah & Abdul Rahman, (2015). The findings revealed that CNG vehicles produced less CO2, CO, and HC emissions, but higher NOx emissions as compared to gasoline vehicles. Special organic compounds such as ethylbenzene, mp-xylene, toluene, and benzene, as well as NOx and CO emissions, were tested in automobiles that ran on various fuels. As compared to diesel, CNG equivalents resulted in a 90% reduction in ozone contaminants and CO (Poruschi & Ambrey, 2018).

III. Method

In order to interpret the present analysis, a quantitative approach was used. The current research focused on assessing the usage of Natural Gas as an Alternative Fuel for Internal Transportation. The present research was analyzed using a questionnaire. Sample design is the technique or process that the researcher is able to accept in selecting objects for the survey is referred to as sample design. The research sample was chosen using a random sampling method and carried out in various locations in Kurdistan region of Iraq. A total of 125 questionnaires were issued, but only 111 participants completed them correctly. Participants were asked to rate the value of each object on a five-point scale ranging from unimportant to highly important.

Research hypothesis

Hypothesis: The usage natural gas can be an effective alternative fuel for internal transportation.

IV. Findings

The current research focused on assessing the usage of Natural Gas as an Alternative Fuel for Internal Transportation in Kurdistan region of Iraq. In order to measure the usage of Natural Gas, the researchers a main research hypothesis which stated that the usage natural gas can be an effective alternative fuel for internal transportation. The researchers applied a simple regression analysis to measure the usage natural gas can be an effective alternative fuel for internal transportation in Kurdistan region of Iraq.

| No | Factors                  | N of Items | Sample | KMO | Bartlett test |
|----|--------------------------|------------|--------|-----|---------------|
| 1  | Natural Gas Fuel         | 12         | 111    | .795| 4514.2        |
| 2  | Internal Transportation  | 12         | 111    |     | .000          |

As we can see in table (1), the outcome of KMO is .795 which is higher than .001 this indicates that the sample size used for the current study was more than adequate. Furthermore, the result of Chi-Square is 5127.2 with the significant level .000.

| No | Components                | N of Items | N    | Eigenvalue | Rotation Sums of Squared Loadings |
|----|---------------------------|------------|------|------------|----------------------------------|
|    |                           |            |      |            | % of Variance | Cumulative                 |
| 1  | Natural Gas Fuel          | 12         | 111  | 1.258      | 12.528             | 39.632                      |
| 2  | Internal Transportation   | 12         | 111  | 2.74       | 12.251             | 41.012                      |

Table (2) demonstrates the usage of natural gas fuel as independent variable and internal transportation as dependent variable. As for the usage of natural gas fuel as independent variable, which had twelve item explained 12.528% of the total variance. As for Natural Reward Strategies as second skill of self-leadership, which had twelve items explained 12.251% of the total variance.
As seen in table (3), the reliability analysis for 24 items used to measure the usage natural gas can be an effective alternative fuel for internal transportation in Kurdistan region of Iraq. The above 24 questions were distributed as follows: 12 items for the usage natural gas, and 12 items for internal transportation. The researchers applied reliability analysis to find out the reliability for each factor. The findings revealed as follow: as for the usage natural gas was found the Alpha to be .749 for 12 questions which indicated that all 12 questions used to measure the usage natural gas were reliable for the current study, and as for internal transportation was found the Alpha to be .801 for 12 questions which indicated that all 12 questions used to measure internal transportation were reliable for the current study.

**First Research Hypothesis**

Research Hypothesis: The usage natural gas can be an effective alternative fuel for internal transportation.

As it can be seen in table (4), the correlation analysis between the usage of natural gas fuel as independent variable and internal transportation as dependent variable in Kurdistan region of Iraq. The finding revealed that the value of Pearson correlation ($r = .776^{**}$, $p<0.01$), this indicated that there is positive and strong correlation between the usage of natural gas fuel and internal transportation.

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| Variables          | Pearson Correlation | Natural Gas Fuel | Internal Transportation |
|--------------------|---------------------|------------------|-------------------------|
| Natural Gas Fuel   | Pearson Correlation | 1                | .776**                  |
| Sig. (2-tailed)    | .000                | .776**           | 1                       |
| N                  | 228                 | 228              | 228                     |
| Internal Transportation | Pearson Correlation   | .776**           | 1                       |
| Sig. (2-tailed)    | .000                | .776**           | 1                       |
| N                  | 228                 | 228              | 228                     |

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

| Model | R   | R Square | Adjusted R Square | Std. Error of the Estimate |
|-------|-----|----------|-------------------|----------------------------|
| 1     | .711| .703     | .732              | .25221                     |

a. Predictors: (Constant), Natural Gas Fuel
Regression analysis is the study of interactions between variables. \( Y = f(x_1, x_2, \ldots, x_c) \) The aim of regression analysis is to determine how \( Y \) can affect and alter \( X \). The natural gas fuel approach is treated as an independent variable in this section, while sustainable competitive advantage is treated as a dependent variable. The volatility of a comparative advantage will be used to calculate its total difference. The variations are determined by calculating the sum of the squares of the expected competitive advantage values by the overall mean divided by the number of participants. After dividing the variance by the overall variance of comparative benefit, the researcher discovered the sum or percentage of total differences or variances that are compensated for using regression analysis. The number can range from 0 to 1 and is defined by R Square. The value of R square = .732 as seen in Table (5), indicating that 73 percent of total variation has been clarified.

**Table 6-ANOVA**

| Model          | Sum of Squares | df | Mean Square | F     | Sig. |
|----------------|----------------|----|-------------|-------|------|
| 1  Regression  | 121.214        | 1  | 124.212     | 121.221 | .000 |
| Residual       | 25.225         | 621| .035        |       |      |
| Total          | 146.439        | 622|             |       |      |

a. Dependent Variable: Internal Transportation  
b. Predictors: (Constant), Natural Gas Fuel

Table (6) shows that the F value for the usage of natural gas fuel as an independent variable =121.221, indicating that there is a significant relationship between the usage of natural gas fuel (121.221 > 1).

**Table 7-Coefficients**

| Model               | Unstandardized Coefficients | Standardized Coefficients | t     | Sig.  |
|---------------------|-----------------------------|---------------------------|-------|-------|
|                     | B                            | Std. Error                | Beta  |       |
| 1                   | (Constant)                  | .312                      | .014  | 2.524 | .000  |
| Natural Gas Fuel    | .732                        | .035                      | .736  | 25.41 | .000  |

a. Dependent Variable: Internal Transportation

Table (7) shows the implications of the first hypothesis: the usage of Natural Gas Fuel strongly predicts Internal Transportation (Beta is weight 0.732, p.001), implying that the usage natural gas can be an effective alternative fuel for internal transportation.

V. CONCLUSION

The use of fossil fuels as primary energy sources has had detrimental consequences for the atmosphere, including inadequate air quality, the production of hazardous waste, and the depletion of natural resources. As a result, several research on renewable energy sources have been conducted, with a focus on carbon and fuel costs. As a result of its wide supply, higher methane content, and low carbon composition, natural gas is favoured as a good replacement for fossil fuels. Furthermore, since natural gas has a lower carbon content than oil, it has lower anti-knocking properties. As a result of these benefits, most countries have turned to CNG as their main transportation fuel. This transition has been aided by the lower levels of NOx, HC, and CO emissions generated by CNG vehicles. Furthermore, the low levels of ozone pollutants emitted by CNG vehicles have prompted countries like India and Italy to move from diesel to CNG engines in order to minimize emissions. The only disadvantage of CNG is the sluggish rate of combustion in engines. Hydrogen can be combined with natural gas to increase combustion efficiency and thereby eliminate this issue.

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