Risk Analysis Factors of the Emission in Transportation A Case Study- Dubai Taxi

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ABSTRACT

Increasing number of traditional vehicles threaten the economical development, pollutes our air and creating environmental hazards. Urban areas in UAE are currently facing growing traffic congestion by rising air pollution as a result of vast growth of population and consequently number of vehicles in the last twenty years. The spotlight of this study is to identify the critical risk factors that can be used to assess the impact of transportation emission on overall environmental risk. In this study risk analysis factors in transportation system focuses on Dubai Taxi fleet as a case study. The most critical emission levels are from; Carbon monoxide (CO), Nitrogen oxide (NOx) and Hydrocarbons (HC), which will be analyzed. The objective is to develop a sustainable transportation planning will help to solve this problem. The approach is based on a comprehensive assessment to address the negative effect of the vehicles on the environment at different period of times. The research considers different solution for the pollution problem by using a proposed model to evaluate and test its effectiveness within the international standard of air emission regardless of the vehicles or population growth in the future.

Keywords: Air pollution, Risk factors, Transportation planning and Hybrid vehicle

1. INTRODUCTION

The framework spotlights on transportation emissions that have three primary risk components: (1) carbon monoxide (CO), (2) nitrogen oxide (NO_X), and (3) hydrocarbons (HC). Dubai is deeply committed to sustaining our environment by conserving natural resources – ensuring that a healthy environment and provide top quality transportation services, [1]. The environmental initiative assists communities and transportation agencies in planning and implementing sustainable transportation systems that will meet the needs of the growing economy while contributing to a better environment. The environmental practice focuses on supporting transportation climate change policy, greenhouse gas emissions analysis. Dubai government builds close working partnerships with the public and private sectors - with the goal of developing and implementing practical solutions for short and long term environmental challenges. Research indicates that long-term exposure to fine particulate air pollution common to many cities, [1]. It considers an important risk factor for the development of cardiopulmonary diseases (i.e. asthma, bronchitis) and lung cancer mortality. Children are most at risk from exposure to such air pollution, asthmatic adults and children, individuals with pre-existing heart or lung disease and the elderly. Fine particle air pollution often comes from fuel combustion power plants, vehicle emissions, diesel buses and trucks, construction and demolition activities.

A study by the Brookings Institution and the American Enterprise Institute (2002) found that public transportation in the U.S uses approximately half the fuel required by cars and light trucks, [1]. In addition, the study noted that "private vehicles emit about 95 percent more carbon monoxide, 92 percent more volatile organic compounds and about twice as much carbon dioxide and nitrogen oxide than public vehicles for every passenger mile traveled", [2]. A study conducted by Dubai Municipality (DM) in Feb 2008 revealed that Dubai's increasing traffic contributes to some of the world's highest air pollution, [1]. Dubai scored 13%, compared to 2.5% in Virginia, 2% in Michigan and 4.7% as an average across Canada. Emissions from motor vehicles are a significant source of air pollution. Vehicle emissions contribute to ambient concentrations of pollutants such as carbon monoxide, oxides of nitrogen & sulfur and fine particulates. These pollutants at sufficiently high concentrations can cause health problems as well as degrade the environment and quality of life. Arab countries spend more than $4.8 billion yearly to fight health problems that resulted from emission from vehicles, [1].

Air quality can be spoiled by a variety of contaminants such as particulates (PM_{10}) and gaseous pollutants including tropospheric ozone (O_3), carbon monoxide (CO), nitrogen oxide (NO_X), and hydrocarbons (HC). Air pollutants are released by stationary and mobile sources, [3, 4]. The emissions are generated from the exhaust, the road-tire interface and from the brakes, engine, bodywork and catalytic converters. Some pollutants such as CO are relatively stable and others are less stable such as nitrous oxide, which, depending on the meteorological conditions, oxidizes to nitrogen dioxide (NO_2) and reacts with other pollutants. The oxides of nitrogen are considered to be the major causes of pollution in the emirate of Dubai [5, 6]. Table 1 illustrates the main pollutant emissions from transport for various types of air pollution, where XX indicates higher risk than X. The transportation share in total emissions at a national scale, and urban traffic share in total road traffic emissions. Many cities and congested towns across the world are experiencing high levels of air pollution resulting from emissions from a series of sources, with road traffic being the governing source in the most urban areas . As a result, inhibiting strategies need to be developed that minimize the environmental impact and in the meantime maximize the motorized transport efficiency, [7].

Table 1 Main pollutant emissions from transport for various types of air pollution [7]

Risk Factors	Perceivable pollution	Impact on health	Forest decline	Ozone depletion	Green-house effect
NO_x		X	XX	X	X
CO_2					XX
Part.	XX	XX			
HC/ VOC	X	XX	X	X	X
CO		X			X
SO_2		X	XX		X
Pb		X			

The main objective of this study was to develop solutions for vehicle emission of the Dubai hybrid taxi trail. The solution was calibrated for Taxi vehicle categories using emission driving cycle's data. The emission driving cycle was used to validate the estimation capabilities of the proposed solution.

2. DATA COLLECTION

Data were collected from two sources; Road and Transport Authority (RTA), and Dubai Municipality (DM). The following Taxi growth data was extracted from the Road and Transport Authority (RTA, [1]. Between 2002 and 2008 Dubai's population grew at an average rate 9.4 Compound Annual Growth Rate (CAGR). In 2008 the population reached 1.65 million. An increase of 3.5% is expected in 2010. Due to Dubai's demographics, especially the large number of expatriate workers, high proportion of the population is economically active which generates high vehicular trips. Dubai's population structure consists of Emirate nationals, low-skilled expatriates / laborers and highly-skilled expatriates.

3. GROWTH BEHAVIOR

Dubai's population growth is projected to reach 1.8 million by end of the year, 2.6 million in 2015, and 3.09 million in 2021 (Figure 1).

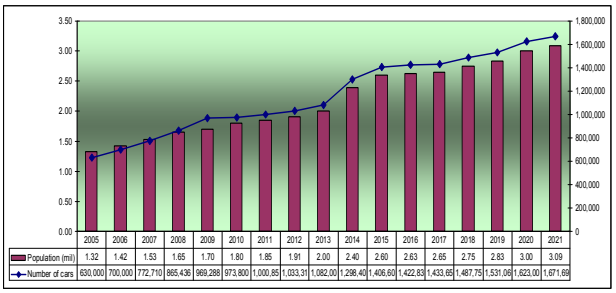


Figure 1 Dubai's population growth rate with Vehicles Growth rate

There are two main taxi operators in Dubai. One of them is consider to be the agent of RTA, the second one is build from four different taxi operator called Franchisee. (National, Cars, Arabia, Metro).The growing affluence in Dubai; also seen an immense growth in the taxi population .With expected projected economic growth and using RTA's formula taxi-population ratio of 1:250 the projected Dubai Taxi Fleet Size is shown in Figure 2.

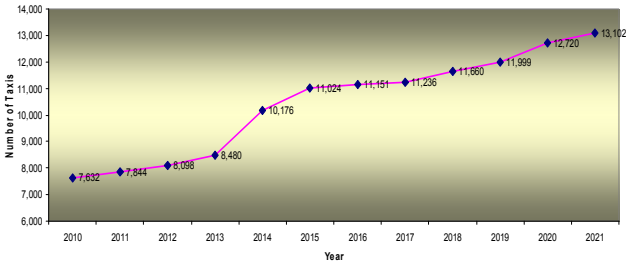


Figure 2 Dubai Taxi Fleet Projected Fleet Size

4. AIR QUALITY MANAGEMENT IN DUBAI

The Environment Protection and Safety Section (EPSS) in the Environment Department at Dubai Municipality is in charge of the monitoring of air quality and the management of air pollution in the emirate of Dubai, [1]. The number of vehicle in Dubai increasedwith the existence of huge power stations; oil/gas processing plants, cement manufacturing, continuing construction and demolition activities. These activities has the most

impact on the air quality of the city, [1]. The Environmental Protection and Safety Section in Dubai Municipality have put regulations and rules in order to protect the environment against dangerous and harmful levels of air emission and pollution. The emission standards and the ambient air quality were set up to accomplish as well as preserve good air quality. Harsh limits on highly poisonous emissions may have unfavorable health effects were also set, [1]. Table 3 shows how the vehicles emission rate in Dubai from 2000-2009. Table 4 illustrates the international standard for air emissions.

Table 3 Emissions Vehicles data in Dubai.

Year	CO	HC	NO_x
2000	1.15	0.4	2.5
2001	1.2	0.41	3.5
2002	1.25	0.43	4
2003	1.29	0.45	4.5
2004	1.33	0.47	4.75
2005	1.34	0.48	4.9
2006	1.35	0.49	5
2007	1.36	0.50	5.5
2008	1.37	0.51	5.75
2009	1.38	0.52	6

Table 4 International Standard of air emissions

g/KWh	EURO III	EURO IV	EURO V	EEV
CO	2.1	1.5	1.5	1.5
HC	0.66	0.46	0.46	0.25
NO_x	5	3.5	2	2
Particles	o.1	0.02	0.02	0.02
Smoke Opacity	0.8	0.5	0.5	0.15

5. PROJECTION OF RISK FACTOR EMISSION

Dubai currently has no formal environmental standards and EURO II & below compliant vehicles is allowed to register in UAE. Table 5 shows Emission Standards Comparison. The current taxi fleet size of 7,632 is Euro II compliant and has a carbon footprint of 7.4 tons per year per car of CO^2. (Note: Carbon Footprint Score measures a vehicle impact on climate change in tons of CO^2 emitted annually. The carbon footprint measures greenhouse gas emissions expressed in CO^2 equivalents. The estimates are "full fuel-cycle estimates" and include the three major greenhouse gases emitted by motor vehicles: carbon dioxide, nitrous oxide and methane. Full fuel-cycle estimates consider all steps in the use of a fuel, from production and refining to distribution and final use. Source: (US Department of Energy, GREET Model 1.7, Argonne National Laboratory and Environmental Protection Agency). The current fleet of taxis emitted a combined 56,477 tons of carbon emissions per year and the carbon footprint (Figure 3).

Table 5 EU Emission Standards Comparaison

Country	Tier	Date	CO (g/kWh)	NOx (g/kWh)	HC (g/kWh)	PM (g/kWh)	Smoke
EU	IV	06–08	1.50	3.50	0.46	0.02	0.5
EU (wef sept 09)	V	09–12	1.50	2.00	0.46	0.02	0.5
Current UAE Standard	**1.** Absence of formal environmental standards. **2.** Currently EURO II & above compliant vehicles are allowed to the UAE						

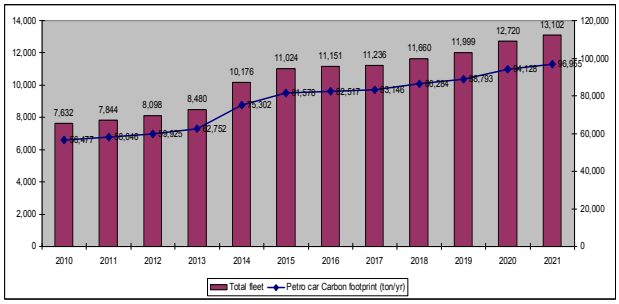


Figure 3 Petrol car carbon footprint (ton/yr)

Based on the predictions discussed before, by the year 2021, a fleet size of 13,102 taxis will contribute to the carbon footprint of 96,955 tons of CO^2 emitted in a year. It will definitely have an adverse effect on the quality of life and the environment. In UK, road transport is the third largest contributor to total emissions with 20% (REF). Of this 20% Carbon dioxide share is over 85% which majority comes from vehicles running on road and this transportation sector is growing. This is the reason for stringent emission norms set by European Union, Japan and USA. The projected carbon footprint emissions emitted by the taxi fleet in three 4 years plan consecutively; 2010-2013, 2014-2017, 2018-2021 as depicted in these graphs.

Table 6 shows that from 2010 to 2013 Dubai taxis population will increase progressively from 7,632 to 7,844 in 2011, 8,098 in 2012 and culminating in 8,480 in 2013. With this increase in fleet size, the carbon footprint will simultaneously increase in tandem. In 2010, the fleet size of 7,632 will produce 56,477 ton of carbon emissions. In 2011, it will produce 58,046 tons, in 2012 it will produce 59,925 tons, in 2013 it will produce 62,752 tons. By the end of 2013 the total combine carbon emissions emitted will be a whopping 237,200 tons. It shows also a production of carbon emissions of 75,302 tons in 2014 with an increase of taxi fleet size of 10,176 vehicles. With the increase in fleet size to 11, 024 in 2015 there is an corresponding increase of carbon emissions of 81,578 tons. In 2016, the fleet size of 11,151 will produce 82,517 tons of carbon emissions.

And in 2017 a carbon emissions of 83,146 tons will be produced by 11,236 taxis. And the total combine of carbon emissions emitted will be 322,543 tons. Also, it shows that in 2018 with a fleet size of 11,660 the carbon emissions produced will be 86,284 tons. In 2019, the fleet size of 11,999 vehicles will produce 88,793 tons of carbon emissions. In 2020, the fleet size of 12,720 vehicles will emit 94,128 tons of carbon emissions. And in 2021, the fleet of 13,102 will produce 96,955 tons of carbon emissions. The total combine will be a substantial 366,160 tons of carbon emission being emitted.

Table 6 Carbon footprint emission- three years plan.

Plan	2010-2013	2014-2017	2018-2021
Total Fleet	8480	11236	13102
Petrol car Carbon Footprint (ton/yr)	237200	322543	366160

6. EMISSION CONTROL

To control the risk of the vehicle emissions, the following recommendation of environmental policies are suggested:

- Setting of Emission Standards
- Adoption of cleaner fuels
- Legislation & Enforcement
- Awareness
- Government enablers – Promotion of Green Vehicles.

6.1 Setting of Emission Standards and Adopting of cleaner fuels

As mentioned earlier, there is no formal environmental standards and procedures to go for cleaner air quality Euro IV emission standards and adopting fuel quality standards (ultra low sulfur (ULS) content 50 ppm diesel fuel).The ULS diesel fuel will help to reduce the levels of sulfur dioxide and PM (particulate emissions). It will also pave the way to implement the more stringent EURO IV emissions standards. Recently, there have been great advancements in alternative fuels and propulsion technologies (i.e. vehicles powered by compressed natural gas (CNG), Liquid petroleum gas (LPG), hybrid gasoline, hybrid diesel and electric vehicles (EEV)). These green vehicles emit less pollutant than conventional petrol and diesel vehicles. The only drawback is the initial purchase price of the green vehicles. The price of the green vehicles will be reduced with larger scale of demand in the future. In the meantime, the authority must provide GVR (green vehicle rebates) to narrow the cost differential between the green vehicles and conventional vehicles. With vehicle population expected to increase, an alternative fuel vehicle such as hybrid, or CNG should be encouraged in tandem with an efficient public transportation system.

6.2 Legislation and Enforcement

There are two schemes recommended to keep the environment from risk emission factors. These are as following:

A. Mandatory Periodic Inspection. All in-use vehicles are recommended to undergo compulsory periodic inspections at RTA approved inspection centers. This is to ensure that vehicles are not only meeting emission requirements but also roadworthy.

B. Enforcement against smoky exhaust. Make it an offence for owners to operate vehicles emitting visible smoke on the road. The appointed agency needs to carry out daily random checks by recording images, using video cameras of vehicles emitting smoky exhaust to take enforcement against them. These vehicles will have to be sent to a vehicles inspection center for a chassis dynamometer smoke test (CDST). The owners of the vehicles that fail the ensuing CDST will be fined. They are then required to repair the vehicles and then send them for retests before allowing them on the roads again.

6.3 Awareness

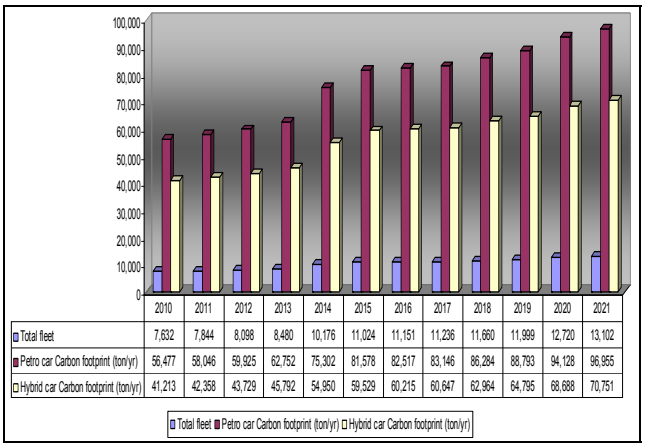
The appointed Agency is recommended to work closely with its partners to educate fleet operators and vehicle owners on the cause of excessive emissions. For example, information booklets on prevention of black smoke emission from diesel vehicles provide advice on issues such as the common causes of excessive emission, proper and regular maintenance, proper driving habits and proper payload to prevent excessive emission due to overloading of goods vehicles. The appointed Agency will also conduct regular dialogues and meetings with fleet owners, such as bus, trucks, and taxi companies to update them on measures to control vehicular emissions and to work with them to tighten the maintenance of their vehicle fleets and implementing self-regulating and self-monitoring measures to help reduce emissions from their vehicles.

6.4 Government Enablers

To encourage the widespread use of Green Vehicles, the Government must intervene to introduce green vehicle rebates or tax incentives to commercial transport companies or motorists. This will greatly help to make green vehicles affordable and thus able to reduce the carbon footprint as well. Green vehicles emit less pollutant than conventional petrol and diesel vehicles. The only drawback is the initial purchase price of the

green vehicles. Economy of scale in volume sales should keep the price affordable. Meanwhile, the authority must sent GVR (green vehicle rebates) to narrow the cost differential between the green vehicles and conventional vehicles. With vehicle population expected to increase, an alternative fuel vehicle such as hybrid, or CNG should be encouraged in tandem with an efficient public transportation system.

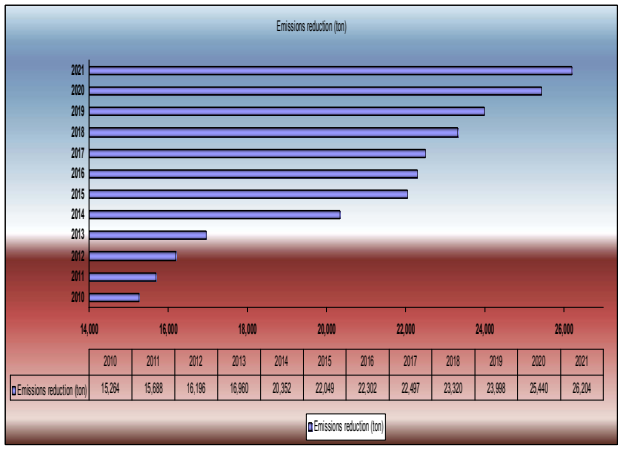
Figure 4 shows the amount of carbon emissions emitted from 2010 to 2021 comparison between petrol and hybrid powered taxis as the taxi population progressively increases over the years. If the fleet size of taxis are hybrid powered there is a substantial reduction of carbon emissions than if there are petro powered.Figure 5 shows the amount of carbon emissions that can be reduces if the fleet of vehicles is switch from petrol powered to hybrid powered. Carbon emissions can be reduced if the combined fleet is being replaced by hybrid powered.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Total fleet	7,632	7,844	8,098	8,480	10,176	11,024	11,151	11,236	11,660	11,999	12,720	13,102
Petro car Carbon footprint (ton/yr)	56,477	58,046	59,925	62,752	75,302	81,578	82,517	83,146	86,284	88,793	94,128	96,955
Hybrid car Carbon footprint (ton/yr)	41,213	42,358	43,729	45,792	54,950	59,529	60,215	60,647	62,964	64,795	68,688	70,751

Figure 4 Carbon footprint projection comparisons between petrol & hybrid powered taxis (2010-2021)

From 2013 henceforth the hybrid replacement program already full kicked in. Assumption: 182,500 km per car per year. Hybrid car produces 5.4 tons CO^2 per car per year and petrol car produces 7.4 tons CO^2 per car per year.



	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
Emissions reduction (ton)	15,264	15,688	16,196	16,960	20,352	22,049	22,302	22,497	23,320	23,998	25,440	26,204

Figure 5 Reductions of carbon emissions, tons per year if vehicles are hybrid (2010-2021)

If the fleet size of vehicles is replaced by hybrid powered taxis, there is a reduction of 15,264 tons of carbon emissions per year in 2010, in 2011 the carbon emissions reduction will be 15,688 tons, in 2012 a reduction of 16,196 tons, in 2013 a reduction of 16,960, in 2014 a reduction of 20,352 tons, in 2015 a reduction of 22,049 tons, in 2016 a reduction of 22,302 tons, in 2017 a reduction of 22,497 tons, in 2018 a reduction of 23,320 tons, in 2019 a reduction of 23,998 tons, in 2020 a reduction of 25, 44, and finally in 2021 a reduction of 26,204 tons. A total of 250,270 tons of carbon emissions can be reduced if the combined fleet is being replaced by hybrid powered. From 2010 to 2012 there is a transition of hybrid vehicles replacement. From 2013 henceforth the hybrid replacement program already full kicked in. It was assumed that 182,500 km will be travelled per car per year, hybrid car produces 5.4 tons CO^2 per car per year and petrol car produces 7.4 tons CO^2 per car per year.

Figure 6 shows from year 2000 to year 2009 all Dubai taxis are petrol powered and produced 4.05 tons per 100,000 km. This scenario continued until 2009 where the transition programmes to replace the petrol powered taxis with hybrid starts to kick in. As the life span of petrol vehicles is three years there is a transition from 2010 to 2012, where the petrol powered taxis are progressively being replaced by hybrid powered. It is depicted in the graph that from 2010 to 2012 the carbon emissions produced has drop from 4.05 to 3.51 tons per 100,000 km during this transition period. From 2013 henceforth, all petrol powered taxis would have been replaced by hybrid powered. From there the carbon emissions produced will further reduce from 3.51 tons per 100,000 km to 2.96 tons per 100,000 km.

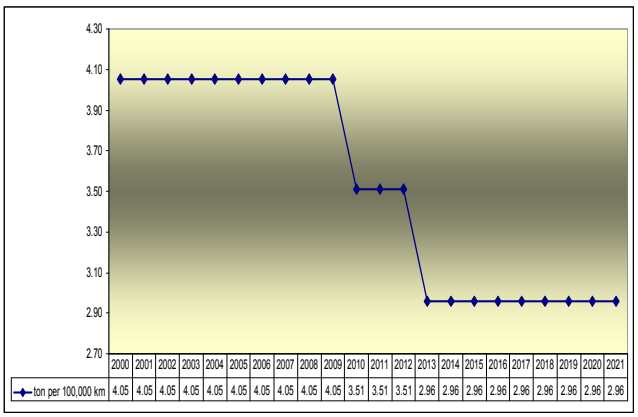


Figure 6 Carbon emissions ton per 100,000 km from 2000 to 2012 and from 2013 henceforth the hybrid replacement program kicks in to 2021 (2000-2021)

7.0 CONCLUSION

The findings and conclusions are the results from the pilot scheme, the feasibility analysis, the review of emission standards in the country and the evaluation of other fuel alternatives. It is observed that the hybrid Camry achieved 46% fuel efficiency but the purchased cost is 76% higher over the petrol version. It has a better cost ratio of 1.53 over 1.36 of the petrol version. In order to replace the current vehicles with hybrid requires the Government to offer incentives to narrow the difference in the higher purchased cost. The findings also revealed that both the police and Municipality should co-ordinate to enforce the rules against visible smoky exhaust. Other fuel alternatives like CNG, LPG are difficult to implement at this stage due to infrastructural issues. But device like road detection using remote sensing devices can be implemented as such technology is less dependent on substantial infrastructure. Further research will be conducted to obtain cost effective replacement policy over the next ten years to replace all present taxi fleet with the hybrid vehicles.

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