

Electric Vehicles: A Sustainable Way Out for Vehicular Air Pollution in Dhaka City

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Abstract

Vehicular Air Pollution (VAP) is a significant reason why the quality of the air of Dhaka city is being worsened day by day. Vehicles using fossil fuels emit harmful gases and particles detrimental to human health. This paper is a qualitative study based on secondary data from an array of sources endeavored to find out a sustainable solution to this problem using Multi-Level Perspective (MLP) of transition studies. Air pollution problem and its dimensions have been explored here as a socio-technical landscape which is a driving force to make a transition happen in existing vehicle fuel regime in Dhaka. Later, the response of government to address vehicular air pollution and the success and failure of those initiatives were analyzed. Primarily, those initiatives were not proved that much effective and sustainable. After that Electric Vehicle (EV) was introduced as a potential sustainable solution for VAP in Dhaka. Some policy initiatives with the introduction of electric bus service as niche initiative was provided for wider diffusion of Electric Vehicles in Dhaka. At last, main challenges and recommendations in the way of adopting electric vehicles are incorporated.

Key Words: Vehicular Air Pollution, Multi-Level Perspective, Electric Vehicles

1. Introduction

Air pollution, the greatest environmental challenge of modern world is responsible for more than sixty lakh death around the world (?About Air,?n.d.). This problem is a matter of grave concern here in Dhaka which is the administrative headquarter of Bangladesh and is now the ninth biggest megacity in the earth with 19.578 million people. At the speed it is expanding, within 2030, it will secure the fourth position worldwide (United Nations Department of Economic and Social Affairs, 2016). As urbanization is happening at a great speed in Bangladesh like many developing nations on the planet, Dhaka is being loaded with a huge number of people consistently. The quantity of enlisted vehicles has increased multiple times during last decade in coping with the need of the consistently expanding urban individuals (Motor Vehicle Registered, 2018). This is the situation of enrolled vehicles while unregistered vehicles are considerably more than this. Very few cities in Bangladesh are facing vehicle blast as much as Dhaka. Practically, all the vehicles

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use petroleum, diesel and other type of fuels which emanate destructive gases like carbon oxides, Nitrogen Oxides, sulfur oxides, Particulate Matter (PM 2.5 and PM 10) and some more. These gases are primarily responsible for deadly air pollution in the city. These contaminations are dirtying the air as well as making lethal sicknesses city inhabitants. Likewise, these gases are responsible for climate change also as air pollution and climate change are connected with each other (Begum, B.A., Hopke, P.K. and Markwitz, A., 2013).

The issue of transition in any socio-technical system arises mainly due to various environmental difficulties which destabilize the existing regime gradually. Sometimes, these environmental issues create a great social challenge. The source of such challenges can be of diversified in nature. Lately, Multi-Level Perspective (MLP) on socio-technical transitions has become important in analyzing transitions in energy sector. Besides clarifying technical aspects and consumer habits, it also scrutinizes social aspects in the way of transition. Transition as a process involving different actors is seen to be the result of interactions among three levels of socio-technical systems namely, protective niches for innovations, conventional regimes and landscapes destabilizing existing regimes. Generally, it takes ages to make a successful transition happen (Darnhofer, I., 2015).

In addition, my study is focusing Vehicular Air Pollution (VAP) in Dhaka for some obvious logics: Firstly, Dhaka is the largest city in both the number of people living there and vehicles plying on roads. These ever increasing vehicles are polluting its air disastrously and make it more unlivable than any other city of Bangladesh (Chowdhury et al., 2018). Vehicular emission which is one of the main causes of air pollution in this city is making the dwellers vulnerable to various lethal diseases (Begum, B.A. et al., 2011). A recent report on the environment of Bangladesh by the World Bank shows that by reducing the ambient level of particulate matter (PM10) under two scenarios, a reduction of 20 percent and a reduction to the proposed national standard of 50 g/m³ annually, the number of cases of mortality and morbidity that can be avoided come to between 1,200 to 3,500 and 80 million to 235 million, respectively (P.1, Chowdhury, T. and Imran, M., 2010).

The main query of the study is: can electric vehicles be the possible way out for vehicular pollution in Dhaka? Electric Vehicle (EV) initiative is described here briefly in response to the main research question. There are few more secondary queries which I tried to find out through this dissertation: the reasons why polluted air severely detrimental to dwellers of Dhaka city, the socio-technical landscape destabilizes existing regime of vehicle fuel and requires the transition to take place, the initiatives already taken by the government

of Bangladesh to deal with vehicular air pollution, the process of building up a niche for diffusing electric vehicles and potential barriers of such initiative in the context of developing country like Bangladesh.

2. Problem Statement:

The advancement of modern life is determined by the total use of power and vehicles. Megacities like Dhaka where modern life is attracting more and more people day by day is facing a huge leap in the number of vehicles for last few decades. The rate of this increasing number is minimum 10% per year and it has been polluting the air of the city drastically (Dhaka has very high air pollution level,? 2008). These vehicles emit harmful gases like Sulphur Di Oxide (SO₂), Nitrogen Di Oxide (NO₂), Carbon Monoxide (CO), Carbon Di Oxide (CO₂), Benzene, Ozone (O₃), Hydrocarbons (HCs), Particulate Matters specially PM_{2.5} & PM₁₀ and other substances. As a result, Dhaka has one of the worst air qualities in the world. Among many sources of such severe air pollution in Dhaka city, Emissions from vehicles is the most prominent one ((PDF) Analysis of Exhaust Emission of Vehicles in Dhaka City of Bangladesh, n.d.). According to Azad, A.K. & Kitada, T., The major sources for SO₂ emissions are traffic vehicle (55.8%) followed by brick field (28.8%), industry (10.5%) and navigation vessel (4%); for NO₂, they are traffic vehicle (54.5%) followed by brick field (17.5%), residential activity (9.5%), industry (8.8%) and navigation vessel (7.7%) (P. 2004, Azad, A.K. and Kitada, T., 1998). Another report on air pollution conducted in 2009 stated that the air of Dhaka had a high quantity of Particulate Matter 2.5 also. It also revealed that motorized cars emitted the greater portion of PM_{2.5}. (Wadud, Z. and Khan, T., 2013). The concentration of lead another deadly substance in the air of Dhaka is ten times higher than the normal level. It's even higher than Mexico which is the city with highest concentration of lead in the world. And again the culprit is emission vomiting' vehicles (Air Pollution Kills 195,000 Bangladeshis Each Year, 2011).

3. Research Questions:

Main Research Question of this study is:

Can Electric Vehicles (EV) be the possible way out to reduce vehicular air pollution in Dhaka?

Secondary research questions are:

- a) Why is the polluted air severely detrimental to dwellers of Dhaka?
- b) Which socio-technical landscape destabilizes existing regime of vehicle fuel?

- c) What kinds of steps have already been taken by Dhaka City Corporation (DCC) or the government to reduce VAP?
- d) How can a niche for electric vehicles be developed?
- e) What are the impediments for such initiative?

4. Literature Review:

The change in world climate has been a major concern from last few decades which has brought about significant alterations in socio-technical systems in every region. There are lots of environmental problems created from man-made reasons which need to be addressed by bringing change in existing path dependent technologies, rules and regulations, societal values and institutions (Bagherian and Lettice, n.d.). These changes lead to a successful transition towards sustainability. The multi-level perspective which is a theoretical framework for evaluating social and technical transition sees sustainability transition as an output of interactions among social and technical regimes, niches and external landscapes (Geels, F.W., 2011). It primarily focuses on the chronological development of different components of socio-technical systems. It also reveals that transition in a system takes place when that system doesn't work properly or the coordination among the sub systems is not in a harmony. And the transition itself is a slow and steady process which takes a long time to happen. In most cases, the relations among various drivers of socio-technical system control the speed of the transition. In a nutshell, the alignment of the three stages: niche, socio-technical regime and socio-technical regime is solely important for a successful transition in energy sector (Darnhofer, I., 2015).

Those actors who wish to make the transition happen create niche to protect the innovation in order to help it flourish. Niche is said to be the most unsteady phase of transition process where kind of tryouts happen. Unlike niches, social and technical regimes are steadier phase of the transition framework. This phase contains traditions and values of other actors like creators, users, government and private institutions etc. Another phase is the macro form of transition which is called socio-tech landscape. It provides the broadest perspective of transition occurred like climate change or lasting financial advancement. The scholars of social and technical transition emphasizes on niche innovations with a view to framing newer regulations and expressions of manner and etiquette but they put more light on state consultants, local elites, non-government organizations, entrepreneurs and similar actors of socio-technical regimes. These actors prioritize a specific way which creates stability in the regime. Consequently, it locks in a precise way of socio technical system. On the other hand, in case of influence of some outer factors of the system, the system loses its steadiness. This creates the opportunity for

innovation and triggers a transition (Lawhon, M. and Murphy, J.T., 2012).

The major challenge for this modern world is not the distance. It is the impact of distance overcoming transportation system of present world which is posing a major threat to combat against air pollution. Fuel is the prime cause of air pollution from motorized vehicles. The process how it is burnt inside the engine specifies the quantity of pollutants discharged from it. So, the possible solution for emission pollution should look for decreasing fuel use, alternative and less harmful fuels, developing more efficient car engines and setting up emission regulator (Goyal, S.K., et al., 2006). The transition from heat engine vehicles to electric vehicles (EVs) can have a significant impact in facing climate change targets. Electric vehicles (EVs) have the prospect to cut the emission of Green House Gases (GHG) up to half in comparison with traditional vehicles. Moreover, EVs can be a potential solution for poor air quality of the cities. As Electric vehicles are going to bring a revolution in locomotive transport sector in coming years, governments can consider adopting these vehicles as cleaner substitute of conventional vehicles (Electric vehicles: driving the transition - Business, Energy and Industrial Strategy Committee - House of Commons,(n.d.).

4.1 Data collection:

I have gathered data from secondary sources and summarized the gist of them. Then I also tried to set up a direct linkage of summarized outputs with my aim of the research. Finally, I have formed an outline from the data that I have found in different sources. For analyzing data, I was interested in using inductive method of sorting out information from secondary sources which helped me to make my output more realistic and widely accepted (Thomas, D.R., 2006). Accordingly, the exploration was founded on the research works done by different scholars from both developed and developing countries. The investigation reviewed scholarly and articles from various sources. A niche initiative considering the government efforts in this regard has been tried to develop according to the multi-level perspective theory. As niche creation is a key point of MLP theory, this research work has tried to study the niche initiatives of different countries for creating one for Dhaka city transport fuel regime. For theoretical framework, I have gone through the research articles from Nature, Science Direct, Emerald journals, Taylor & Francis, Social, Technical and Environmental Pathways to Sustainability (STEPS) Centre of University of Sussex.

Applying The Multi-Level Perspective (MLP):

For providing the dissertation with a solid theoretical base, I took multi-level perspective as a theoretical framework for explaining the problem of vehicular air pollution in Dhaka city and finding out a solution as well. Different academicians like F. W. Geels, I. Darnhofer, M. Lawhon, F. Avelino and many more have contributed a lot in the field of multi-level perspective. Rationally, I went through their enriched articles for shaping the problem according to their assumptions. The core of multilevel perspective constitutes the niche initiative for coming out from an existing regime. I have tried to make a framework for establishing a protective place for electric vehicles for Dhaka where it will be grown up and diffused gradually across the country. Moreover, I have searched in government documents of the UK, Netherlands, the USA, Japan, China and obviously Bangladesh for finding out a structure for niche for electric vehicles in Dhaka city.

4.2 Air Pollution in Dhaka

Air pollution is the presence of contaminant or pollutant substances in the air that do not disperse properly and those interfere with human health or welfare, or produce other harmful environmental effects (OECD Glossary of Statistical Terms - Air pollution Definition, 2001). According to this definition the air of Dhaka is severely polluted because the presence of contaminant in the air of Dhaka and its effect on city dwellers is proved by different researches. According to the World Health Organization (WHO), Dhaka is within their top list among three thousand cities in terms of the presence of PM_{2.5}. Because of this deadly substance almost fourteen thousand people died in this city (Bangladesh's Air Pollution Problem Grows, Brick by Brick, 2018). Vehicular emission is considered to be the greatest cause of polluted air of Dhaka city. Another particulate matter PM₁₀ is the contribution of automobiles specially two-stroke three wheelers. And more or less fifty percent of PM less than 2.5 is sourced from motor vehicles plying in the roads of Dhaka. Not only PM_{2.5} or PM₁₀ but also many other hazardous gases and substances are present in the air of Dhaka (Begum, B.A. et al., 2006).

The air of megacity Dhaka (Hackenbroch, K., 2012) is polluted in two ways: emissions from manufacturing industries like brick-laying, garments factories, leather industries etc. and from automobiles (Air Pollution In Dhaka City,n.d.). Though both the sources pollute the air of Dhaka, later one causes more havoc than the first one because city dwellers are directly exposed to such kind of pollution. Furthermore, most of the industrial establishments are around city area not within it (Hoque, M.S. et al., 2006) which makes it tough for their harmful emissions and discharges to affect city people directly. So, it is a bit clear that a different category of vehicles' emission has major contribution in

polluting city air. The main fuels used by vehicles in Dhaka are gasoline, petrol, diesel and octane etc. These fuels sometimes impure and mixed with other substances emit following disastrous gases:

- a) Diesel- Suspended Particulate Matter (SPM), Sulphur Oxides, Nitrogen Oxides etc.
- b) Petrol & Octane – CO, HC, NOx, SOx, Lead particles and carbon elements etc.

4.3 Air Pollution as Landscape:

At least 0.123 million individuals died on account of air contamination a year ago in Bangladesh as indicated by an exploration on worldwide air contamination. It additionally said that the life expectancy of a Bangladeshi child will be diminished all things considered by 30 months since they are raised in present huge phases of air contamination. Air pollution is responsible for more deaths than any other reasons here. The nature of air in Bangladesh proceeded with tenaciously poor, particularly in Dhaka where local people are exposed to excess level of PM2.5 from 90s (United News of Bangladesh, 2019).

Opportunities of creating niche for innovative technologies are shaped by traditions or governmental efforts or severe change in environmental issues which are popularly known as socio-technical landscape. These sometimes force energy areas which influence policy makers to bring alterations in regulations. To find out landscape actors, it can be necessary to go beyond national boundaries. In case of a transformation in a regime in a consequence of interactions among different levels, it is not abnormal that fresher regime can bring alteration in socio-technical landscape. On the other hand, landscape issues can remove existing regime encouraging policymakers by creating protective space for sustainable solution (Leipprand, A. and Flachslund, C., 2018). Similarly, severe air pollution of Dhaka increased concern at government level and they tried to address this socio-technical landscape issue through different policy initiatives as they realize the impact of reducing the pollution could be worth 0.5 billion dollar annually (Anon, 2014).

5. Destabilization of Fossil Fuel Regime & Government Initiatives:

5.1 Destabilization of Fossil Fuel Regime:

Existing fossil fuel regime of vehicles in Dhaka has been being weakened since the beginning of last decade. There are reasons behind destabilization of a regime like scarcity of resources or lack of backing from the government and entrepreneurs or declining performance of present regime actors and factors. In addition, few other causes haven't identified in different literatures:

Newer inventions lead the way to weaken existing regime as these have some advantages comparing to previous system. These advantages always work as cutting edge technology.

Sometimes, the market for existing technology has become narrow or altered by another similar but better option or new competitor enters into the same space. Any of these options can phase out existing technology.

Policy makers can change their policy against present system due to environmental concern. This also can weaken the existing regime.

Some theorists described destabilization of a regime as a result of internal dysfunction which declines the regime step by step (Turnheim, B. and Geels, F.W., 2012).

None of the reasons mentioned above is solely responsible for making transition in transport fuel sector in Dhaka. Multiple reasons influenced political actors to bring change in fuels for vehicles. Moreover, vehicles of Dhaka have polluted the air severely and millions of people have affected directly by this pollution. This socio-technical landscape mainly destabilized the fossil fuel regime which created pressure on government to take steps to address the issue.

5.2 Government Initiatives:

The Government of Bangladesh has taken several initiatives including prohibiting buses already used more than twenty years and trucks already used more than twenty five years, setting ideals of emission, subsidizing Compressed Natural Gas (CNG) and gasoline powered vehicles. These initiatives lessened the scale of pollution than before. Nevertheless, the presence of PM and other harmful gases in the air is higher than the standard level of the city (Chowdhury, T. and Imran, M., 2010). This chapter will go in detail about the major initiatives taken by government in changing paradigms of vehicle fuel in Dhaka city.

- Refined or unleaded Gasoline
- Banning scooters (two-stroke three wheelers)
- Promoting CNG Conversion of Vehicles

5.3 Effectiveness of Initiatives

According to World Air Quality report of 2018, Dhaka is still stood second amongst the capitals of the world in terms of air pollution (Anon, 2019). Another real time scoring by Air Visual, the air of Dhaka is termed as 'hazardous' even in this year ('Dhaka air pollution today world's worst,' 2019) These information makes it clear that the quality of air in Dhaka is not up to the mark nowadays. Even if we consider the air quality comparison from 2014 to 2017 (Table 1), it will show that the air quality is decreasing day by day. From table 2, we can see that there is no significant change even after taking some steps to improve air quality of Dhaka rather the number of days with acute pollution has increased significantly.

		Number of Days with			
Year	Total Days	AQI\leq100	AQI 101-200	AQI 201-300	AQI\geq300
2014	295	108	117	16	54
2015	356	121	119	48	68
2016	340	148	108	45	39
2017	359	133	130	23	73

Table: 2 Condition of air quality of Dhaka after previous initiatives

Source: ("Reports & Publications." n.d)

6. *Electric Vehicles & Policy Support for Introducing EVs:*

6.1 Electric Vehicles:

What we have seen from previous lesson is the destabilization of present regime irrespective of petrol, diesel or natural gas for multifarious reasons. As almost all the vehicles in Dhaka are entirely reliant on fuels from unsustainable sources, transport sector in Dhaka is a prime source of greenhouse gases and air polluting gases. With the development of high capacity battery in recent years, EVs have become a burgeoning sector in transport around the world which is helpful in removing pollution from air. Many countries like the UK, USA, Norway, Germany, China, Japan and Singapore have already initiated electric vehicles regime (Tran, M.et al., 2012). They adopted electric vehicles to address climate change and local pollution because these vehicles run by electricity

Topic of Comparison	Electric Car	Automobile
1. Consumption with the daily mileage	11KWh	3751 KWh
2. The cost of daily run	127.5 Kazakhstani Tenge/ 0.27 Pound	401.5 Kazakhstani Tenge/ 0.85 Pound
3. Time for charging/ refueling	8 hours	2 minutes
4. Cost of charging/ refueling	267.6 Kazakhstani Tenge/ 0.57 Pound	800 Kazakhstani Tenge/ 1.70 Pound
5. Average consumption per month	320 KWh	861 KWh
6. Average cost per month	3600 Kazakhstani Tenge/ 7.66 Pound	9235 Kazakhstani Tenge/ 19.65 Pound

Table 3: Calculation of average rates of the EVs with regular automobiles in present situation (Page 4, Gelmanova et al., 2018)

release far less harmful gases than traditional vehicles both for human health and world climate. These also ensure fuel safety and security for the countries specially which hardly have any energy resources (Grauers et al., 2013). From table 3, we can see that the cost for EVs at present is at least 2.5 times less than traditional automobiles. The only drawback is charging time which is going to be solved very soon.

6.2 Policy Support for Introducing EVs :

The policy makers of Bangladesh have to keep recent advancements in this field in mind while planning for future transportation, as they are facing a disastrous landscape of air pollution across the country specifically in Dhaka. Following points are to be incorporated for the purpose of diffusing EVs across the country:

a) Financial Benefits for People or entrepreneurs:

People of developing countries like Bangladesh have main problem with the money as most of them are lower class and lower middle class. So, encouraging the poor buyers, government can proclaim a supportive financial benefit for buyers of electric vehicles. With a view to flourishing EVs to address massive air pollution and climate change, some developed countries offer sponsorships for electric vehicle adoption and utilization. Motivators for EV reception exist at the government level in many countries of advanced

economy. In a similar fashion, the government of Bangladesh can introduce two kinds of subsidies: for EV manufacturers and for buyers. These endowments can be immediate, similar to tax reductions or then again direct installments (Bosworth, Ryan, C., et al., 2017).

b) Building up Permanent and semi-permanent Structure:

Different types of agents regarding their importance in managing set up for charging have to be identified initially. The agents who are already present in the scenario and fresh agents have their role to play in shaping the infrastructure for EVs (San Román, T.G., et al., 2011). Required number of charging places and their connectivity with supply line must be adjusted for easier charging facilities. Charging ports is considered to be the lifeline for electric vehicles.

c) EV Friendly Regulations:

Sometimes, apparently less important regulatory initiatives have enormous impact on common people towards using a new technology. These initiatives do not cost that much in comparison with their great influence over the local community. Free access to city centres, free parking, special lanes and free charging for electric vehicles can be few of them which can change psychology of common people in favour of EVs. When people are getting easy access to city centres with EVs, they are encouraged to buy EVs.

d) Making people Aware of advantages of using EVs:

An ongoing study showed that a great number of people are not interested in electric vehicles because of the apparent absence of charging locations or the staggering expenses or worries over the range. In fact, these reasons are quite common for commoners as there are some truths in it. From a similar study in America, it was found that more than sixty people in every hundred people are not really conscious of electric vehicles (Lambert, 2017).

e) Adopting Pilot Project For EVs:

As EV technology is entirely new to the users in Bangladesh, they will be afraid of adopting this unknown technology. Someone has to remove their fear of knowing the unknown. In developing countries, these risks are taken by governments usually. Implementation of electric vehicles must need a protective place where it will get a support from government for competing with traditional vehicles in the market. A

provision of niche market for electric vehicles at a limited space must be incorporated in policy measures otherwise these vehicles will face difficulty to get flourished. When public project for EV will be in operation, people will know it is easy, comfortable and safe travelling in such vehicles. They will also come to know the environmental impacts of EVs.

f) Specifying Allocation of Business for Better Coordination:

The adoption of electric vehicles is a multi-departmental effort. It is impossible to implement this project by a single department of a government or by a local government body. So, it requires participation of each actor related with the introduction of EVs. Most of the time central government omits the interest of localities for serving national interest but local issues need to be addressed properly by the central body. For an operational and successful policy collaboration among different stages of government is urgently needed. This can be congenial for commoners to get accurate information about availability of EVs and charging locations countrywide.

6.3 Creating Niche for EVs:

The core of transition lies in creating a protective niche for possible users of a particular technology. It includes exclusive areas where it can be applied for further dissemination. This effort helps a transition endeavour to find out its faults for final application. Niche is basically a test case for preparing it for competitive market through learning by doing. It is prepared for seasoning the new innovation effort with a different and unknown setting by offering an array of supportive measures like tax incentives, subsidies and interest free loans etc. These protective places are useful for diffusing new knowledge which can help in forming a web of social relation in favour of new practice. It also has the ability to substitute existing system pushing innovation (Raven, R.et al., 2010).

Naturally, government has to play a pivotal role in creating a test place for new inventions or efforts. If it is the case where transition effort requires heavy investment which is quite impossible for private investors, there is no alternative to government initiatives (Electric Buses Are Not Only Clean but Less Costly to Run, (n.d.)). Therefore, government of Bangladesh should come forward to create an experimental space for electric vehicle for mass people so that they can learn through experience. This paper suggests the introduction of electric buses in Dhaka as niche for transition of vehicle fuel from petrol, diesel to electricity. There are few reasons behind adopting public electric buses as an experimental case:

a) Public buses are the most popular transport in Dhaka city which is used by 41% of the total city dwellers. At present, public buses emit black smoke and these buses are noisy enough to discourage citizens to use them. On the contrary, developed and less emitting electric buses can attract more passenger than before because these are almost smokeless and noiseless (Mahmud, K., Gope, K. and Chowdhury, S.M.R., 2012).

b) Electric vehicles are unknown in the local auto market and investment in such initiative is highly risky. Common people will invest only when they will be sure of the fact that there is required infrastructure. It will be difficult for government like Bangladesh to provide necessary infrastructure for private vehicles as an experimental case. On the other hand, limited numbers of public buses cover a limited area in the city which will be more realistic to be used as protected place.

c) Most of the buses, to speak the truth 90% of the buses in Dhaka city are badly managed and have no fitness at all and they discharge a huge amount of harmful fume. Other vehicles' emission has somehow been managed partially by some measures taken by government. However, buses are still unmanaged in terms of emitting poisonous gases and particles (Air Pollution In Dhaka City, n.d.). So, adoption of electric buses can play a significant role in curbing the rate of pollution to a great extent.

Following factors need to be addressed by the government of Bangladesh to set up experimental space for electric buses in Dhaka:

i) Breaking Myths and Facilitate Availability of Electric Vehicles

It is very important to bring all the actors in confidence about EVs so that they feel interested about it. Government of Bangladesh can raise awareness through arranging seminars, focus group discussions, advertisements etc. At this juncture, government has to introduce sufficient number of electric buses in the city for public transport. For this purpose, it needs to import electric buses from the countries which already have reputation in manufacturing electric buses. As it was said before the buying price for electric buses is higher than traditional ones but it's ultimately cheaper if you consider maintenance and fuel cost during their lifetime which is on an average 13-15 years. In addition to that traditional buses require massive repairing works at its middle age while an electric one doesn't require such repair works usually (Electric Buses Are Not Only Clean but Less Costly to Run, n.d.). From this aspect, it can be an effective idea to import refurbished buses and create such market here in Bangladesh. It may help local investors in this sector. Government can also provide private importers with zero interest loans.

ii) Set Ups for Charging:

If not the most important, it must be one of the most important preconditions for facilitating EVs to get a solid start. Most of the buses are run for a long shift of 10-12 hours and more than 250 kilometer every day and it is mandatory to set a charging infrastructure in the roads. If any country doesn't have that capacity, it should not present electric buses for mass transit (Angeles and Beach, n.d.). Thus, without a proper set up of charging EVs, it is next to impossible to nurture local markets for electric vehicles. Likely, it is also crucial for establishing a protective experimental space for EVs.

iii) Ensuring Sufficient Power Supply:

Electricity supply must be affected by the provision of introducing EVs in the city. As the number of vehicles is increasing, it will require additional amount of power if these are converted into electric ones. Initially, for introducing electricity led buses in Dhaka, government must ensure sufficient power generation for this purpose. Bangladesh has got the capacity of generating 17,340MW of electricity at this moment (?Key Statistics,? n.d.) but it is building power generation plants planning 24,000MW in 2021 and 40,000MW within 2030 (Express, n.d.).

iv) Technology Transfer:

EV technology is not a stable one so it is being developed day by day. Basically, developed countries control the technology which makes it difficult for developing country like Bangladesh to deal with it. Bangladesh is dependent on technological know-how derived from other countries irrespective of sectors. It is obvious that Bangladesh will be largely reliant on the countries like UK, Germany and China who have advanced knowledge regarding EVs (M. Bell, 2007). So, the government of Bangladesh needs to measure how many buses it will need, how to buy those and from where these can be bought. It is very important how much technical support it will get from the exporter country.

Major Challenges to Implement EVs in Dhaka & Recommendations:

Electric vehicle, a solution to fight with climate change issues and local air pollution taken by many developed countries could be a potential initiative for Dhaka to control its vehicular air pollution. Nevertheless, it has not got that much importance by policy makers of Bangladesh for various and multidimensional reasons (Steinhilber, S., Wells, P. and Thankappan, S., 2013). Government of Bangladesh has to identify the barriers in the ways of introducing and diffusing EVs in local market and find out the solutions. Few

possible recommendations are given below:

- Sufficient Electricity supply is the most vital precondition for building infrastructure and encouraging investors for EVs. Besides setting up new high capacity power stations, government has to ensure that the power stations must use renewable sources or nuclear energy to produce electricity otherwise the main objective of using EVs instead of ICE vehicles will not be fulfilled.
- One of the basic challenges for diffusing EVs and creating markets is charging facilities as this facility offers sufficiency, accessibility and mobility to owners of EVs in recharging vehicles. Government has to take necessary steps to improve its supply network consisting of cables, feeders and transformers as additional electricity demand will create pressure on national grid.
- Electric transports are more costly to produce than ordinary diesel transports. The vast majority of the additional costs comprise of the costly electric segments, for example, battery, electric engine and power hardware, and the building improvement work particularly on the framework the board. Since the vast majority of the electric parts require generally relentless activity conditions, fluid cooling is frequently used to deal with the warm balance which requires extra subsystems and control the executives.
- Another important impediment for electric vehicle diffusion in Dhaka is lack of knowledge of common people about new technological advancement in the field of electric vehicles. On the contrary, the policy makers here in Dhaka do not have that much knowledge about electric vehicles let alone common people. Certainly, government has to take steps to spread the idea of electric vehicles and its advancements.
- Government has to lead the unknown sector of electric vehicles. Bangladesh government should take a policy to phase out traditional petrol or diesel run vehicle step by step within a specific timeframe. To be more specific, for the procurement of new vehicles in coming years, they can adopt the policy of buying only electric vehicles. When there will be a large number of electric vehicles on the road, investors will be inspired to invest their capital in infrastructure for EVs.

7. Conclusion:

The air quality of Dhaka has become so bad that the government had to think of finding alternative ways to get rid of it. Simultaneously, this exogenous environment of air

pollution in Dhaka as a socio-technical landscape leads to a transition in the prevailing vehicle fuel regime. As a part of vehicle fuel transition government has tried several options including using developed emission technology in vehicles, refined fuels as substitute of petrol, diesel or gasoline and Compressed Natural Gas (CNG) as vehicle fuel. Those efforts were successful in the sense that they have brought a short-term change in retaining quality air in the city. However, it does not have a long-term effect on improving air quality. That is why even after a decade of introducing those efforts of replacing traditional vehicle fuels, in 2012, Dhaka was termed as 2nd worst megacity in context of air quality by a UK based weekly 'The Economist' (Neema, M.N. and Jahan, J., 2014.). So, it was found in this research that the efforts were not successful to address the issue of severe air pollution of the city after exploring the answers for second and third sub question. Furthermore, Bangladesh is totally dependent on imported petrol and diesel and it has a limited reserve of natural gas which will be finished within next few decades. In a nutshell, government decision of using unleaded gasoline and CNG in vehicles is not sustainable at all.

Regarding fourth secondary question, introducing Electric Bus in Dhaka city was suggested as a niche initiative where it can grow up within a protective space avoiding pressure of present regime. Majority of public buses with poor fitness are most widely used in Dhaka and they are one of the major contributors to air pollution. Electric bus as an experimental project recommended because governments of developing countries should play the central role here and public buses in Dhaka are managed and operated by Bangladesh Road Transport Authority (BRTA) which is a government organization. Government can easily provide sufficient budgetary and infrastructural help. In this respect, required supports for electric buses like sufficient power supply, charging points and technological backing staffs can be easily ensured by government with proper policy formulation and coordination. As a vital part of multi-level perspective, scaling up niche initiative of electric bus in the city could help in the further diffusion of Electric Vehicles (EVs) in Dhaka.

The latest secondary question was about the potential challenges of adopting EVs in Dhaka. In identifying the possible challenges for EVs adoption in Dhaka, I have found establishing more renewable power plants, ensuring sufficient power supply and setting up adequate charge stations for EVs most influential. Dhaka has immense possibility to implement EVs in a large scale but it has to overcome the challenges successfully to diffuse the niche of EVs in Dhaka. Nevertheless, to make a transition happen is not an easy task as it takes a long time to bring manifold components in an alignment so that they head towards one direction (Rotmans, J. et al., 2001).

To be honest, some restrictions make it harder to find out and explore necessary

information regarding this dissertation. Shortage of time and no funding for travel are two the limitations which impede my research work. For doing a proper research it is very important to have some interviews as the dissertation has connection with policy initiatives of Bangladesh government. The interview of responsible officials of relevant ministry or local government body could enrich my dissertation. In addition to that some quantitative analysis with responses from the stakeholders of EVs in Dhaka (using a structured or semi-structured questionnaire) and then mixed analysis of both quantitative and qualitative information might make the dissertation a better one. Nonetheless, I have left no stone unturned to find out proper information regarding initiative of EVs in Dhaka. I would like to add that there is hardly any case where Multi-Level Perspective (MLP) on socio-technical transition has been applied in context of Dhaka. So, there are scopes to conduct further research on sustainable transition in vehicle fuel regime specially focusing on the role of transport leaders within political actors.

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