A review of challenges for the electric car adoption in México

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Abstract
Air pollution is a major concern in most populated cities in México. The introduction of a Zero Emission Vehicle (ZEV), or a plug-in hybrid, on these population centers could help solve the problem, but it is necessary to address some issues that make it difficult to implement a widespread deployment.
We review the most urging obstacles that arise, like the high cost of the ZEV's and hybrid vehicles. Also, there is lack of infrastructure for Electric Vehicles, as only a small number of public charging stations exist and the national electric grid lacks the capacity to support the insertion of large number of EV's into public roads. Another factor to add is that México is a major international manufacturer of Internal Combustion Engines (ICE) vehicles, so this is a negative incentive to transition to ZEV’s.
Even if all these hurdles are overcome in the short term, there is a big obstacle ahead: the lack of the mexican federal government support to EV’s and hybrids vehicles. While countries like the USA, and the majority of countries in the EU give tax incentives to owners of ZEV’s, and in some places there is a tax refund for purchasing a ZEV, in México there’s no such program.

Introduction

Air pollution is a major concern in the most populated cities in México. According to the Multicity study of air pollution and mortality in Latin America (the ESCALA study in 2012), the high concentration of particulate matter of less or equal diameter of 10 in aerodynamic diameter (or PM10) in some cities of México, is related to an increased risk of mortality with increased ambient concentrations of PM10. Also, cities with a high average concentration of ozone (O3) have a statistically significant increase in mortality. PM10 was also significantly associated with increased mortality from cardiopulmonary, respiratory, cardiovascular, cerebrovascular-stroke, and chronic obstructive lung diseases [ESCALA]. A previous study by Calderón Garcidueñas et al in 2004 established that individuals exposed to high concentrations of PM10 and O3 suffered from brain inflammation and alzheimer-like pathology [Brain].
Most of the air pollution in cities like México City, Monterrey, Guadalajara comes from passenger vehicles with internal combustion engine (ICE). By 2014, México City and nearby cities had 8 million registered passenger vehicles. 4.6 million of which were from the megalopolis and 3.4 from neighboring municipalities [Economista]. Using the Environmental Protection Agency (EPA) Average Annual Emissions and Fuel Consumption fact sheet, we can multiply the number of automobiles and emissions of carbon dioxide and nitrogen oxide (a precursor to ozone) to estimate the volume of pollution generated by traffic. A passenger vehicle

consumes annually in average 1,881 liters of gas, produces 4416 kilograms of CO_2 and exhausts 9 kilograms of nitric oxide (NOx), a precursor of ozone [EPA]. This gives us a minimum of 20.3 million metric tons of CO_2 and 41.4 tons of NOx every year in the limits of México city.

México doubled its vehicle fleet in the last 10 years, from 13.4 million passenger cars in 2004 to 25.5 million [Inegi]. Gasoline consumption went from 658,000 barrels per day in 2005 to 800,000 in the first quarter of 2016 (an increment of 21.5%) [Kemp].

From 1986 to 2016, several environmental contingencies have occurred in México city as the levels of ozone concentration have raised above healthy levels. As much as 53 contingencies in 30 years [Publímetro]. Local authorities reacted and established a plan to limit the daily number of vehicles on the road, and when a contingency is declared, the restrictions are raised, so even less automobiles could be moving on the streets. This measures help protect the health of the citizens, but has a negative effect on mass transportation: People that can not drive their car, have to move using public transport, already with high demand. In March 2016, after an environmental contingency was declared in México city, the Metro service saw an increment of 4% in ridership, while Metrobus had an increase of around 28% in daily commutes [Milenio].

The introduction of a Zero Emission Vehicle (ZEV), or a plug-in hybrid, on these population centers could help solve the problem of air pollution on the megacities of México, but economic infrastructure and policy factors must be addressed.

Brief history of ZEV's

In 1990, the California Air Resources Board established the Zero Emission Vehicle (ZEV) regulation. It dictated that at least 2% of the passenger cars sold by any company in the State of California in 1998, should be ZEV vehicles, incrementing this percentage to 5% in 2001 and 10% in 2003 [ZEVCAL]. It was a tight schedule for the car manufacturing companies.

The modern electric car was designed and developed by General Motors (GM) and was introduced in 1996 as a direct response to California ZEV regulation [DrivingFut]. The EV-1 (Electric Vehicle one) was a compact, which in its first generation had an electric motor with lead and acid batteries with a range of 100 kilometers on a charge. EV-1's second generation was introduced in 1998, this time with a nickel–metal hydride battery (NiMH) that boosted its range to 250 kilometers per charge [Ready].

Due to the high cost of development and fabrication of the vehicles, GM didn't sell them, it leased them for 3 years with a monthly charge of $400 - $550 US dollars. GM evaluated and terminated the EV-1 project in 2004, as it showed that it was not commercially viable: A total of 1,117 EV-1 were produced [America] while the development costs of the program was close to a billion dollars [GMPulls], around 900,000 USD per vehicle. GM recalled and destroyed all EV-1 except for a few vehicles that are on exhibition at diverse museums [America].

The California ZEV regulation has been revised a number of times and in its last revision it dictates a goal of 1.5 million ZEV's in the state's road by 2025 [DrivingFut].

In August of 2009, President Barack Obama of the United States of America announced the federal program "American Recovery and Reinvestment Act of 2009", with a total investment of 2.8 billion dollars for the manufacture and deployment of electric cars in the United States. Around 1.5 billion were used in the design and development of new electric batteries. A fund was also set up to build up a network of national public charging stations electric and incentives of up to $ 7,500 in federal tax cuts on ZEV car purchases, effectively reducing the electric car prices for consumers [DrivingFut].

The ZEV regulation was also credited with the success of Hybrid Vehicles [ZEVCAL], as it helped introduce around 400,000 Hybrid vehicles into that state. This type of vehicles has an internal combustion engine (ICE) that is connected with an electric motor, reducing the energy consumption from the ICE in peak times, effectively cutting the exhaust emissions and increasing the range per gas tank. The best representative of this category is the Toyota Prius, introduced in Japan in 1997. As July 2015, Toyota has sold 3.5 million Priuses and a total of 7.1 million Hybrid Electric Vehicles [Toyota].

According to the report “Evolution: Electric vehicles in Europe: gearing up for a new phase?” [Evolution], there are currently 6 powertrains technologies for motor vehicles: Internal Combustion Engines (ICE), Hybrid-Electric Vehicles (HEV), Plug-in Hybrid-Electric Vehicles (PHEV), Range-Extended Electric Vehicles (REEV), Battery Electric Vehicles (BEV) and Fuel Cell Electric Vehicles (FCEV). In Table A we can see that HEV and REEV cars rely on an ICE as a source for energy generation, even though some of its energy is generated through regenerative braking.

Powertrain	**Primary propulsion**	**Secondary propulsion**	**Energy generation source**
Internal Combustion Engine (ICE)	ICE		ICE
Hybrid Electric Vehicle (HEV)	ICE	E-motor	ICE
Plug-in Hybrid Electric Vehicle (PHEV)	E-motor ICE	ICE E-motor	ICE Plug-in
Range Extended Electric Vehicle (REEV)	E-motor	ICE	ICE Plug-in
Battery Electric Vehicle (BEV)	E-motor		Plug-in
Fuel Cell Electric Vehicle (FCEV)	E-motor	Fuel Cell	Fuel Cell Plug-in

Table A. Powertrains and source of energy [Evolution].

According to Eberhard and Tarpenning, Battery Electric Vehicles (BEV’s) are the cleanest [Tesla]. Even though BEV’s don’t produce tailpipe exhaust gases, it must be taken into account that these vehicles plug into an electrical grid, and the electricity is generated burning fuel, causing air pollution. They found that current gasoline powered vehicles have an emission rate of 141.7 g/km of CO_2, while the Hybrid Vehicles only reduce its CO_2 emissions to 130.4 g/km. The electric vehicle accounts for only 46.1 g/km of CO_2 produced by a natural gas electric plant and distributed by the electrical grid.

Electric Vehicles prices

The range of mobility of an EV or an HEV is dictated by the capacity of its battery. The batteries with more capacity are the ones made of Lithium ions (Li-ion), a type of battery that has high density of energy and low weight. These batteries are expensive to produce, and represent most of the cost of the EV. The United States Energy Information Administration (EIA) published in 2013 its Annual Energy Outlook report and stated that the price per kilowatt-hour of a Li-ion battery was of about $1,000 dollars, and projected a low descent of prices, hitting $400 per kwh in 2025 [Vehicle], but in 2015 a directive from Tesla Motors predicted that a price of $100 dollars per kwh in 2020 is achievable [Hybridcars] and as recently as April 2016, another representative of Tesla Motors stated that their cost per kwh is already below $190 dollars [BatteryPack].
Currently the following electric automobiles are on sale in México: Twizy, from Renault, a two seater EV at $16,000 dollars and a range of 100 kilometers [unocero], the Nissan Leaf, an EV with a range of 135 kilometers per charge, with a sticker price of $35,000 dollars [NissanLeaf], the Chevrolet Volt, a REEV, has a price of $38,000 and a range of 676 kilometers [ChevroletVolt], the Toyota Prius, an HEV, has a price of $19,000 dollars [ToyotaPrius], and the Tesla Model S, with a 270 kilometers range per charge and $70,000 dollars price [TeslaModelS].
In 2015, México registered record sales of passenger vehicles, with 1,351,648 units sold, 19% greater than 2014 sales [Amia], but the top ten automobiles sold in the country are compacts and subcompacts with a price between $8,000 and $13,600 dollars. The most popular auto in México is the Chevrolet Aveo, an ICE with 51,531 units sold in 2015 and its current base price is around $8,500 dollars. (See table B), while the HEV Toyota Prius sold 1,437 units in the same period, and the Nissan Leaf just sold 250 units in 2015 in México [Leaf].

Model	**Units sold**	**Base Price in US Dollars**
Chevrolet Aveo	51,531	$8,500
Nissan Versa	43,524	$11,000
Volkswagen Vento	40,106	$11,000
Nissan Tsuru	36,282	$8,000
Nissan March	35,198	$9,100
Volkswagen Jetta	32,955	$13,000
Chevrolet Spark	31,512	$9,500
Nissan Sentra	25,571	$13,600
Nissan Tiida	20,866	$9,600

Chevrolet Matiz	20,545	N.A.

Table B. The top ten automobiles sold in México in 2015 [Forbes].

Barriers

The high cost of electric vehicles is a barrier for it mass adoption in México. The HEV's on sale have double the price of the most popular vehicles in the country, and the EV prices are at least 3 times larger. Various industry leaders have indicated that the electric battery will be more affordable in the 2020-2025 timeframe, around $100 dollars per kWh, dropping EV prices to the range of $20,000-$25,000 dollars (without inflation), and in the process, HEV's would become more affordable, with prices around $15,000 dollars, as their batteries are smaller than the ones in an EV.

To help the introduction of the EV and HEV in México, it is necessary to announce public policies that promote them, write legislation favorable to Zero Emission Vehicles (ZEV) and Ultra Low Emission Vehicles (ULEV's) and penalize the use of vehicles that consume too much gasoline or have high emissions of NOx, CO2, as well as other harmful gases. In 2015, the federal government issued an ordinance to exempt the federal tax ISAN (Impuesto sobre Automóviles Nuevos / Tax over new automobiles) to EV's, HEV's, PHEV's, REEV's and FCEV's. This tax, for a $35,000 vehicle, is about 9% of its total value [Isan]. The United States of America has a tax refund that helps reduce the cost of EV's to the consumer with up to $7,500 dollars [DrivingFut], while some european countries grant up to 5,000 euros in tax exemption [Acea] to buyers of EV's. México could implement a similar program to make these vehicles more affordable, or establish a program revolving around the removal of old vehicles, giving credit to buy new ones, preferably ULEV's or ZEV's.

Another obstacle for the introduction of EV's in México is that the country is a major producer of ICE vehicles. In 2015, it manufactured 3.4 million light vehicles, and had record sales of 1.3 million vehicles in the internal market [Amia].

In order to have electric vehicles in México, it is necessary to have public charging stations. In May of 2016, there were 31,896 public charging stations in Europe [Chargemap], 13,473 in the United States and only 119 in México [Chargenow]. Both the automobile industry and the government have to increase the number of these stations in México, both in cities and in the highway network, without them, people would not buy an EV because of "range anxiety", or fear to deplete the battery charge far from home.

The national electric utility in México, Comisión Federal de Electricidad (CFE) offers to install a secondary energy counter to owners of an EV or PHEV, to save money while splitting the consumption for home and the vehicle [Chargenow], although this does not grant a preference rate.

In order to have EV's in México, it is necessary to invest in electricity generating plants that need to satisfy the current energy demands of the country, and the demand of the new EV's on the road. As of 2014, México had the capacity to produce 65,452 Megawatts (MW) of electricity, with 230 power plants operating or in construction, 16,047 MW come from renewables sources (24%) and the rest from oil, gas and nuclear plants. The projections from

Secretaría de Energía is to add 19,761 MW by 2018 and have 59% of the energy produced by hydropower and 21% by wind [Promexico].

Conclusions

There's an urgent need to have ZEV's and ULEV's in México, the health of millions of citizens in the megacities is affected by the pollution from ICE vehicles. If we introduce clean cars and renovate the vehicle fleets of our cities, in 15 to 20 years we could have a big impact in the air quality and health cost. The federal government has to signal a change in policies, favoring EV's and HEV's in general, and draw a plan to bring mass adoption of these vehicles, in order to invest publicly or privately in infrastructure (charging stations, renewable power plants, etc).

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