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Original Research Article

Converting Combustion Engines to Electric Cars: Requirement, Perception, and Viability in Under-Developed Countries

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Abstract

Despite barely being a novel concept, EVs have been rising in popularity because of the development of the technology and infrastructure required to support EVs on a large scale, a growing concern for the climate, and a fight to lower carbon emissions. Even though the demand for EVs rising every year, there have been a few major roadblocks that are affecting the growth and development of EVs in developing countries and households with lower incomes, specifically the high initial cost of building the infrastructure of EVs, EVs being more expensive than regular Internal Combustion Engine cars, and a skeptical consumer market. However, making conversions of ICEs into EVs or Plug-in Hybrid EVs (PHEVs) might circumvent many of these issues, including combating the problem of replacing every single ICE with a brand-new EV in the span of a few decades. This paper discusses the cost, efficiency, and public perception of converting ICEs to EVs and what a viable business model can look like while paying particular attention to customer needs and public perception.

Keywords: Electric Vehicles transition, Automotive business models, Sustainable Transportation, Public Perception of EVs.

INTRODUCTION

Transportation is one of the world's leading emitters of greenhouse gas emissions, making up for about 23% of yearly emissions (IPCC, 2020). Because of this, the transportation industry has been receiving increasing attention from climate activists and governments to try to cut emissions. Electric vehicles (EVs) are the most efficient way to reduce emissions in the transportation industry. EVs have been slowly gaining popularity since the late 1990s, but after the launch of the Tesla Model S in 2012, the first production EV that found contemporary success in the United States, Canada, and Europe. Despite the promise that EVs have brought with them, there are also some significant roadblocks in the production and the widespread adoption of EVs, especially in underdeveloped and low-income countries. The initial expense for a consumer to buy an EV has been on a sharp rise over the past few years, with there being a 13% increase in the price of a new EV from 2021 to 2022 to a staggering $66,000 [2], it puts it well out of reach of most consumers interested in purchasing one. Not only is there a significant financial burden for the consumers, but there is also a possibility of a poor public perception of giving up their already-bought ICE vehicles for brand-new EVs. Companies are also challenging to remain profitable in this increasingly competitive and costly field, with every significant EV startup other than Tesla finding it difficult to earn a profit consistently (Sopjani *et al.*, 2020). In this case, car manufacturers and EV startups would prioritize having a cheaper business model to follow. At the same time, consumers would want to obtain an EV at prices much lower than what the average EV is going for today. ICE to EV conversions could be instrumental in transitioning from an automotive industry dominated by ICEs to primarily EV-centered. Not only does it help a growing environmental concern for businesses and government, but it also benefits consumers with lower operating costs than ICEs. Conversions have already happened, directed by hobbyists and small businesses, and have shown to be significantly cheaper than acquiring a new one [3]. This paper aims to include a viable business model, paying particular attention to customer needs and public perception. The business model implications highlight how a company can set up and integrate ICE to EV conversion into existing market structures.

RESEARCH METHOD

This study investigates potential customers' perception of underdeveloped countries that converting internal combustion engines to Electric cars is more viable than buying new Electric vehicles. This study explores the customer's requirements, perceptions, and expectations by collecting data based on targeted campaigns and semi-structured interviews. I have used a random sampling technique for survey research that provides a reliable way to obtain a representative population sample. I created smaller clusters of regions (both urban and rural) and targeted users of different age groups. I have also engaged officials from these departments in a semi-structured interview to get their views on the critical factors in my analysis.

1. Data Collection

For the research, I took help from government agencies that issue licenses, perform registrations, and handle insurance. The data was gathered in a survey with questions on their preferences, awareness, and current situations. It helps reduce the bias in the survey results and increases the generalizability of my findings to the larger population.

This can be extrapolated to valuable information and insights into a population's attitudes, beliefs, and behaviors. This gives us more insight into customers' expectations and intentions. In this questionnaire (constructed for individuals), potential customers express themselves more freely independently of their social environment about their monetary situation, their capability to buy a new car, and their perception of the environmental crisis.

As explained above, the survey targeted the different sections and segments of society in these countries. The idea was to gain insight into consumers' appetite, awareness, and intent to move to EV. The questions were structured in four different categories -

1. General questions.
2. Specific questions.
3. EV related.
4. Conversion related.

The semi-structured interview has been constructed using a questionnaire guide; it covers most of the requirements and perception areas and does deep individual exploration. People were interviewed using this semi- structured interview, in which 6 were potential customers and 4 were industry professionals. Other than semi-constructed interviews, online surveys are done to collect extensive data.

Questions were posted through a mobile-based survey app, and many people took that survey to express their thoughts and opinions on this topic. Semi-Structured interviews effectively collect data when the researcher wants to 1) collect qualitative data, 2) explore the attitude, thoughts, behaviors, and subconscious beliefs 3) investigate sensitive issues (ref Semi-Structured interviewing in primary care research: a balance of relationship and rigor; Melissa Dejonckheere and Lisa M Vaughn).

1.1 Survey Questions and responses

The segmentation was carefully done to cover multiple regions, states, and cultures. 23588 users of different races, communities, cultures and economic classes have participated in a targeted campaign for 30 days. The questions were segmented into four categories: Personal, Behavioral, EV-related, and conversion-related. I wanted to keep the survey focused and objective-driven, limiting the options to specific choices only.

The questions and the responses are summaries in the below sheet. The data was aggregated from the targeted countries to show the collective results. The survey tool I used supported very biased reporting. I had to rely on manual processing to create trends and patterns.

1.2 Findings from the Survey:

The initial set of questions was targeted toward personal preferences. The key findings are:

- On the expected lines, most of the participants were between the age of 25 to 40 and belonged to the lower-middle to middle class
- Most of the respondents have more than five years of driving experience and have owned a driving license for more than five years.
- Most of the responders suggested that they have bought cars for commuting, regularly service the vehicle, own a dedicated parking area for their car, and prefer selling the old vehicle when they buy a new one.
- A marginal group of respondents feels vehicles as a status symbol.
- Only a few respondents own multiple cars or have altered their vehicles.
- Most responders feel it is tough to dispose of a vehicle but easy to sell.
- Most respondents do not get any benefits or support for owning/buying a vehicle.

The next set of questions was targeted toward green vehicles and perception. The key findings are:

- A tiny group of respondents owns EVs (~2%) today
- Most respondents are keen to switch to EVs (or consider switching), but they need to figure out the infrastructure and charging grids.
- Respondents feel the Cost of EVs, infrastructure, and benefits are the key factors shaping Evs' future in their country.
- Most respondents feel that the charging system is premature today and that the government will have to do much more before a significant percentage can adopt EVs.

- On the question of conversion (Combustion Engine to EVs), responders feel conversion is cost-effective and a viable alternative.
- Most of the respondents are unaware of support, benefits, and provisions for converting their Vehicle to EVs
- Most respondents are open to conversion to EVs if they get tax benefits, support, or provision.

S.NO	Question	Type	Option 1	Option 2	Option 3	Option 4	tal Responde	Responded 1	Responded 2	Responded 3	Responded 4
1	Age	Single Choice	<25	25-40	40-60	>60	23588	15%	50%	25%	10%
2	Sex	Single Choice	Male	Female	want to comment		23588	71%	28%	1%	0%
3	Marital Status	Single Choice	Married	Unmarried	want to comment		23588	59%	39%	2%	0%
4	Languages	Single Choice	1	2	3	>3	23588	12%	45%	28%	15%
5	Current Savings	Single Choice	% of the Inco	% of the inco	% of the inco	% of the inco	23588	33%	37%	18%	12%
6	Current liabilities	Single Choice	% of the Inco	% of the inco	% of the inco	% of the inco	23588	13%	28%	48%	11%
7	Number of children	Single Choice	1	2	3	>3	23588	12%	31%	8%	49%
8	Driving experience	Single Choice	1-5	5-10	10-15	15+	23588	13%	52%	26%	9%
9	License owned since	Single Choice	1-5	5-10	10-15	15+	23588	29%	49%	16%	6%
10	Car owned since	Single Choice	1-5	5-10	10-15	15+	23588	35%	25%	28%	12%
11	Number of Cars owned	Single Choice	1	2	3	3+	23588	62%	22%	11%	5%
12	Car driving per day	Single Choice	<10km	10-20km	20-50km	>50km	23588	21%	28%	36%	15%

S.NO	Question	Type	Option 1	Option 2	Option 3	Option 4	tal Responde	Responded 1	Responded 2	Responded 3	Responded 4
1	Why do you need a car	Multiple Choic	Commute	Leisure	Show-off	Earning	23588	42%	18%	6%	34%
2	Most important thing in car for you	Multiple Choic	Safety	Luxury	Longevity	Reliability	23588	41%	17%	19%	23%
3	What is your car type	Multiple Choic	Disael	Petrol	Hybrid	EV	23588	30%	68%	0%	2%
4	How long do you keep your car	Single Choice	<5 years	5-10 years	10-15 years	>15 years	23588	42%	22%	24%	12%
5	Do you buy new cars only	Single Choice	Yes	No			23588	39%	61%	0%	0%
6	What do you do with your old car	Single Choice	Sell	Trade-in	Gift	Dispose	23588	53%	27%	17%	3%
7	Did you ever buy a car with alteration	Single Choice	No	Once	Twice	>2	23588	74%	23%	2%	1%
8	How ofter do you service your car	Single Choice	ess than a yea	1-2 years	2-5 years	>5 years	23588	58%	27%	10%	5%
9	Monetary benefit (supplimental) by owning a car	Multiple Choic	No	ernment Sub	Corporate aid	Other benefit	23588	92%	3%	4%	1%
10	Where do you park your car	Single Choice	Garage	ned parking (s	ed Parking (O	side (Road, e	23588	38%	25%	20%	17%
11	How easy is it to sell a car in your country	Single Choice	Easy	Difficult			23588	83%	17%	0%	0%
12	How easy is it to dispose a car in your country	Single Choice	Easy	Difficult	No system		23588	16%	84%	0%	0%

S.NO	Question	Type	Option 1	Option 2	Option 3	Option 4	tal Responde	Responded 1	Responded 2	Responded 3	Responded 4
1	Do you own any Green car	Multiple Choic	EV	Hybrid	Hydrogen	No	23588	2%	0%	0%	98%
2	Do you want to buy a Green Car in the future	Multiple Choic	EV	Hybrid	Hydrogen	Other	23588	42%	2%	3%	53%
3	Do you have provision for charging in your garage/F	Single Choice	Yes	No	Don't Know		23588	11%	69%	20%	0%
4	Do you have charging stations in your neighborhooc	Single Choice	Yes	No	Don't Know		23588	3%	55%	42%	0%
5	Does your Government grant aid for switching to E	Single Choice	Yes	No	Don't Know		23588	4%	38%	58%	0%
6	What benefits does your Government offer	Multiple Choic	Tax Rebate	Discounts	No benefits	Don't Know	23588	9%	8%	38%	45%
7	Do you want to completely switch to a green car	Single Choice	Yes	No			23588	43%	57%	0%	0%
8	What percentage of neighborhood has EV(s)	Single Choice	<10%	10-20%	20-50%	>50%	23588	92%	5%	2%	1%

S.NO	Question	Type	Option 1	Option 2	Option 3	Option 4	tal Responde	Responded 1	Responded 2	Responded 3	Responded 4
1	Does your country have a system of combustion en	Single Option	Yes	No	t know / Can't say		23588	6%	69%	25%	0%
2	Have you ever converted your car from Combustion	Single Option	Yes	No			23588	0%	100%	0%	0%
3	Do you know of anyone who has coverted his car	Single Option	Yes	No			23588	1%	99%	0%	0%
4	Does your government provide any financial suppor	Single Option	Yes	No	t know / Can't say		23588	15%	66%	19%	0%
5	Are you open to Convert your car to EV if you have a	Single Option	Yes	No			23588	63%	37%	0%	0%
6	Are you open to convert your car to EV if the goverr	Single Option	Yes	No			23588	77%	23%	0%	0%
7	Do you prefer buying a new EV or converting your c	Single Option	Buy EV	Trade-In	Convert		23588	29%	36%	35%	0%
8	Do you have charging station at your work place	Single Option	Yes	No	t know / Can't say		23588	7%	47%	46%	0%
9	Provided EV conversion system in place, how long v	Single Option	<1 year	1 - 5 years	5 - 10 years	Never	23588	11%	26%	28%	35%

2. Analysis

2.1 Customer Requirement

Requirements for vehicles in undeveloped countries are much different than in developed countries. In places like the United States, Japan, and Europe, where people usually stick to their car for ten years or so, they are ready to say goodbye to their decade-old vehicle to welcome a new one, which is probably more advanced in technology and power. These antique vehicles, which are relatively not used, are exported to low and middle-income countries like Africa, Nigeria, Ghana, etc. With the growing awareness of the environmental need to lower the carbon emission, many automobile companies are completely electrifying their vehicles, whereas in developing countries where used cars found their extended life span struggling to keep up with the need to reduce Greenhouse emission gas.

There are a few concerns in the transition from conventional vehicles to electric ones:

1. Mass production of EVs will lead to more air pollution by emitting carbon.
2. Buying a new EV is way too expensive, especially in low-middle-income countries or developing countries.

3. Discarding old used cars by scraping or dumping them will further cause pollution.

Considering these concerns, converting an Internal Combustion Engine to an EV is an easier transition. While answering the questions in the interview, most of the potential customers came out with their inability to buy EV cars as that will add up to the cost (buying a brand-new EV car will cost $30,000 - $50,000, whereas converting the existing vehicle to EV will cost around $6,000 - 7,000). So, Converting the Internal Combustion Engine seems more realistic to them.

2.2 Perception

In this section, we will discuss potential customers' perceptions and attitudes toward converting ICE into EVs. Based on the broad online survey and semi-structured interviews, we found out that about 35% of people in the online survey agreed that they would be more comfortable converting their existing car to EV, and 6 out of 10 people in the semi-structured interview said that restoring the conventional vehicle to EV is the best tool for the transition.

We found that about 66% of people have yet to learn about government subsidies on EV cars if the government brings awareness among people by setting up the ecosystem with electric charging stations in every area.

Affordability is also a significant concern in low and middle-income countries; the sky-high price of EVs in the market makes the transition unaffordable. Many innovative companies are developing the pioneering technology to convert regular fuel vehicles into EVs at a fraction of the price.

In the USA, conversion of the ICE to EV costs about $6,000 - $ 7,000. In the UK, a DIY kit starts at around 5,000 pounds, with specialists charging between 15,000 to 30,000 pounds, which is significantly cheaper than buying a new EV.

77% of people agreed to convert their regular fuel cars into EVs instead of getting a new one because converting the engine to EV is far more reasonable than buying a new one.

Particularly many potential customers feel that with the increasing petrol and diesel prices this is a good alternative. In the United States, diesel fuel vehicles cost 10 cents per mile; ten years of using EV vehicles will save $6,320. 63% of people also believe that they can contribute to less carbon emission and conserve energy by doing this.

The targeted questions for social and behavioral issues show a clear bias toward moving to green vehicles. There needs to be more awareness about the possibilities and benefits of converting a vehicle to EVs. The economics of buying a new car and disposing of/selling the older one is a critical factor that pushed the adoption of EVs in underdeveloped countries. The survey shows that most respondents are open to the idea of conversion. This bias gets more robust if they get aid from the authorities through grants, discounts, or tax benefits.

The infrastructure (for conversion and charging) is critical in the transition. Unlike developed countries where buying a new EV is convenient, offers tax benefits, and reflects social status, the research data shows that people are receptive to the conversion that offers more significant savings, easier adoption, and fits into their budget.

2.3 Viability

2.3.1 Prerequisites

The condition of the vehicle and its weight are essential aspects. Published materials have confirmed that heavier vehicles do not perform as well with EV conversion kits. The dimension of the vehicle is crucial from a battery standpoint. Tiny cars are complex, as we will need help finding a place to install the batteries. It is essential to consider the vehicle's age, mileage, and mechanical condition. Even though the engine and many other components are removed during the conversion process, most drivetrains remain in place. It is worth thinking about the parts' state and possible future spending due to wear and tear. Basic conversion kits may not address things like air conditioning, power steering, etc., which needs additional expenditure.

2.3.2 Cost of conversion and ROI

Converting from combustion to EV is typically more affordable than buying a new EV. In a few cases, purchasing a used combustion vehicle and restoring it is cheaper than buying a new electric car [5]. EV conversion kits can range between $7,500 to $25,000. Some include batteries, while others do not. So, assuming battery procurement and installation charges are essential if that is not included in the conversion kit. As per the Journal of green engineering [4], the Energy storage (battery) of an electric powertrain decides the cost of an electric powertrain. It is observed that with current costing at the international level, payback for a 70 bhp engine converted to PHEV with a 60 km range comes to be less than three years for standard values. However, it increases to more than five years with actual values. ROI is observed to be around 37% and is expected to increase to nearly 41% in 2020 and about 47% by 2030 for traditional values. Moreover, with the local Asian market, due to the comparatively lesser battery price, results are promising for conversion, and payback is observed to be around 1.6 years for traditional values and 2.7 years for actual values [6].

2.3.2 The broader picture

The spread of electric cars is increasing rapidly. The conversion of combustion engine vehicles to EVs is a solution to accelerate the transition to more sustainable transport efficiently. A viable business model would pay particular attention to customer needs and take public opinion into account.

From our research standpoint, people in underdeveloped economies prefer EVs over combustion engine vehicles. However, they feel the government must offer incentives for the switchover. There is less resistance to conversion due to the factors like cost, resources, and ease of transition.

The research also highlights the need for a better infrastructure for EVs (charging grids, financial aid, etc.). This paper explores how a viable business model can look, paying particular attention to customer needs and considering public opinion.

The business model implications highlight how a new start-up can set up and integrate ICE to EV conversion into existing market structures. This includes essential items like electricity supply and disposal management of electric batteries, which are still uncertain challenges associated with electric vehicles' energy storage.

Putting things in perspective, the cost of transition and public perception are critical indicators of the future in underdeveloped countries. Per a report [7], Conversion for mass production models should be less expensive, and if take- up is to be effective, then it needs to be to stay within reach of most car owners.

Researchers at the University of California, Berkeley say they may be cheaper to build than internal combustion models in as little as five years. Moreover, replacing the engines in older cars with electric motors could make EVs affordable to millions more.

A few big companies like Ford and General Motors are offering electric conversion kits. General Motors announced its converter kit in 2020 that includes a motor and battery. Independent suppliers, auto-mechanics, and startup companies also deliver and fit a wide range of conversion kits, from rusty old trucks to modified two-wheel scooters [7].

As per a research report [8], the conversion of internal combustion engine vehicles into EVs has proved to be a viable alternative. This viability derives from the low average cost, i.e., 0.16 R$/km on average, considering an energy price of 0.63 R$/kWh, which can reach zero if solar radiation is used to generate electricity through photovoltaic panels.

The results of several tests indicate that the conversion is feasible, as the car reached an average traveling cost of 0.16 R$/km, assuming a price for the energy of 0.63 R$/kWh. Moreover, this cost could be as low as zero if solar radiation is utilized to generate electricity through photovoltaic panels, which is an even more environmentally sustainable solution.

As per research [9], further studies could also be carried out to understand the total cost of ownership, influence on the peak electricity demand, total electricity consumption, and environmental impacts of EVs in a particular region or country.

CONCLUSION

Global warming has become the most concerning topic these days. Countries are finally taking measures to reduce greenhouse gas emissions. The UK will ban all petrol/diesel-run vehicles by 2035. Electrification of public and private transport has become the most talked about initiative in bringing the world to zero greenhouse gas emissions.

Almost all Car companies are speeding up their EV production and slowly reducing the production of conventional fuel vehicles. Transitioning from regular fuel cars to electric ones in developing countries has become challenging. Countries like Africa, Ghana, Nepal, etc., mainly depend on used vehicles from places like the US and Europe.

Based on my extensive research, we figured out that people in developing countries for whom cars are not a luxury but a mode of transportation are willing to spend little money on buying new EV cars. However, they are comfortable with converting ICE to EV because it is a cost-effective way of transitioning to EV.

They need more awareness about the government providing subsidies on tax and tolls for electric vehicle owners. The government needs to make people aware of the benefits of having EV cars.

Also, our study found that most car owners in low and middle-income countries are interested in converting the ICE to EV. Converting conventional fuel cars to electric vehicles is the best option in developing countries because mass production of EVs will also cause many carbon emissions, and the old used regular fuel cars will be dumped to cause further pollution. It is easy and affordable for the people of developing countries.

Other benefits of moving from conventional to electric vehicles are less carbon emission (better air quality) and reduced dependency on imported fuel. (Economic viability of electric vehicles is strong and improving in many developing countries).

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