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Today's Green Revolution - Transforming Mobility

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Synopsis: From the ancient time our ancestors Started walking on two legs to our ventures into outer space today, mobility has been an intrinsic part of our evolution. The people would not have invented the wheel, let alone produce engine that would sail, drive & fly. Further, as human unlock new technologies & new sources of energy; these were incorporated into the current forms of transportation to change the face of this sector. These innovations in transportation have reduced the time, risks, costs & inconveniences associated with travel, allowing human to cross cities, countries & the planet itself. Improvement in mobility has played a dominant role in almost all economies of the world for the last century & a half. National economies are dependent on the country's ability to transport not just humans, but also goods, from one place to another. It has encouraged migration, shaped the architecture of cities & towns, changed societies, influence culture, created & grown economies, fostered job creation. The people have taken strides in marine & air transportation too. They have come a long way when it comes to mass public transportation on land, & within ground transport, automobiles cars & commercial vehicles have played the most important & dominant role in shaping modern human life. They have chosen the automobile industry as our focus in the area of mobility. At present, by all indications, the world of cars & public transport is in a state of phenomenal transformation. The next few decades will be nothing like the last century. As much as efficient & affordable transportation is essential for a vibrant economy, it brings its own share of problems. The energy needed to power transportation has posed problems that concern us all.

I. INTRODUCTION

The present shift in the mobility industry calls for an accessible, environmentally sustainable & affordable energy system to power transport. The people explore one such vision: a world where transportation is built around clean vehicle technology, driven by energy source that are clean, & creates employment & equitable access to economic opportunities for all.

This is certainly possible; they can cut petroleum consumption drastically. They can create a new transportation industry that is more inclusive, one that enables more people to participate both in creating & sharing values. Again, this is not idealistic fantasy, but a very possible reality. The people are witnessing changes in physical infrastructure & public transport systems; they are seeing 'servitizing' of transport through information technology, & smarter cargo networks & changes in human behavior underlying the new age of transportation. These are all a part of our futuristic reality. Not since then has the industry changed as much as it is changing right now. This is why they are so enthused about the transportation in this industry – which they are very much part of.

Before that though, let us try to understand the current situation in the industry as it relates to the 3 Es (Energy, environment, Employment).

II. ROAD TRANSPORTATION: AN OMNIPRESENT CONTRIBUTOR TO THE 3 ES

A. The Energy Demand – supply

The auto industry cannot begin without a discussion on the fossil-fuel industry. These two industries have taken stride in lockstep. Oil has been the fuel of choice for this industry so far. Expect for electric cars, which constitute less than 01 % of new auto sales worldwide currently, all other automobiles run on oil. Each problem enumerated in 'Energy' – from controlled supply & pricing, to increasing demand & the impact of energy extraction on the environment – will also present itself in the energy problems related to the automobile industry. Other fallouts of the automobile industry's reliance in oil, such as overdependence of some countries on imports, skewing the international power dynamics, & the widening urban-rural divide in terms of both energy production & consumption, become integral part.

Indeed, as far as the use of energy resources is concerned, the automobile industry is at a breaking point. Due to the increasing difficulty of access to depleting energy sources, increased costs &, most importantly, alarming environmental consequences of our current energy consumption patterns, the need of new energy source is now more pressing than ever before . India's energy import bill in 2016-17 was about 26% of its total import bill of $384 billion. This proportion is only likely to increase, given the desired economic development & ever-growing urbanization in the country.

As far as the refineries in India go, they are operated by handful for organizations. As it stands today, the energy setup for transport currently enable very limited participation - & therefore employment – along its value chain. And this is true of almost all non-OPEC countries.

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B. Production: A Health Hazard for the Planet & its Inhabitants

It is important to underscore the disastrous impact of drilling itself. One might have heard about the hazards entailed in natural gas extraction. Oil & gas drilling also carries many hidden costs. For instance, the water brought to the earth's surface during such extraction carries dissolved solids, heavy metals, radioactive materials & other substances of a toxic nature. This water is not usable & is not easy to dispose of either. A single shale gas formation requires not only millions of gallons of water, but also thousands of gallons of chemicals. To make matter worse, the producers do not disclose the names of all chemicals they use. Independent works have been found 630 to 750 chemicals in such gas products. Only about 350 were traceable. These chemicals can cause neurological damage & cancer, & can adversely impact the hormonal & immune systems of human & animals.

C. Consumption – Exacerbates the Looming Environmental concerns

In addition to the environmental impact of digging, energy consumption systems are wasteful & harmful too. For instance, the ICE used in most vehicles today is extremely inefficient, especially when load, road & speed conditions vary.

This wastefulness, combined with the inherent chemistry of fossil fuels, contributes to the environmental & health problems. Energy resources are increasingly inaccessible, climate change increasingly grim, & the costs of local air pollution shocking, to say the very least. The Global Commission on Economy & Climate recently reported that premature deaths from air pollution alone cost India up to 06% of its GDP.

The road transport sector can be held responsible to a great extent for these tragedies. This sector accounts for almost 63% of total consumption of petroleum products. Most Indian cities have high levels of various types of air pollutions, from carbon monoxide to particulate matter. It is estimated that the transportation sector accounts for 70% of this pollution. Road transport alone is responsible for almost 95% of carbon dioxide (CO2) emitted by the transport sector. While accounting for only 17% of the total energy consumed, this sector accounts for 60% of green house gas emissions in the country. At present 14 out of 20 most polluted cities in the world are in India. As India continues to develop, more & more small towns are going to be impacted by transportation.

In addition to the environment hazards of using vehicles the way people do, automobiles have an indirect impact on other aspects of our lifestyle too. To begin with the obvious, traffic congestion is responsible for loss of man-hours & peace of mind. The way people manage transportation causes loss of life & limb too.

D. The Subtle Impact – Loss of Money, Time & life itself

The direct impact of vehicular air pollution on our health can be seen in the form of respiratory diseases & the like. People also know of its impact on our planet through global warming. Though people all suffer the indirect impact of transportation, this impact is not reflected in the GDP & other such metrics.

Ironically, air pollution in the road transport industry is worse when traffic is not moving. The environment damage caused by inadequate infrastructure & planning is only one part of the traffic congestion problem. In 1998, New Delhi alone wasted fuel worth $3, 00, 000 every day as a result of vehicles idling at traffic signals! In 2010, this per day number stood at about $1.6 million, & 2015 at $23.5 million, expenditure due to traffic congestion in United Kingdom is expected to increase by 50% annually from 2014 numbers, to $33.4 billion ($91) million per day) by 2030. The United States is expecting to see a similar rise, & will see losses of $186 billion ($510 million per day) by 2030. But the numbers for Delhi alone are about 26% of the numbers for the entire UK, & 05% of numbers for all of the US in 2030! These numbers do not include loss of productivity in hours spent by citizens, which can be monumental by it. Another Indian city is Bangaluru losses 600 million man-hours annually on this score.

When the congestion is not too bad, road accidents leads to disability, if not a toll on life. Globally 1.3 million people die every year in car accidents. In 2017, there were 1, 46, 000 fatal road accidents in India. While this is a 03% drop from 2016, it still amounts to 17 deaths every hour. Counter-intuitively about 38% of these deaths are on roads other than national & state highways.

E. The Silver Lining – Employment

The all these factors, the current state of road transportation in terms of energy consumption & environmental destruction is so bleak that it calls for a complete overhaul of how resources are extracted & used in this industry. In terms of employment, though, the industry stands at a relatively favorable position – so far.

From mining to the roadside automobile repair centre – spanning manufacturing, road construction & logistics – transportation, across its value chain, is amongst the largest employers. In fact, in its heyday it was the symbol of middle –class prosperity. Road transportation also results in investment in roads & is responsible for viable & sustainable suburbs, all of which create employment opportunities of their own. The Indian automotive sector alone employs over 29 million, making it one of the world's largest

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employers. India ranks at the top in production of tractors, second in two –wheeler & bus production & fifth in heavy truck manufacturing – to name a few of its rankings in this sector. More importantly, for every two-wheeler produced, direct & indirect opportunities are created for one person; every three-wheeler produced creates four jobs, every car, six & every truck, thirteen! With India being one of the largest manufacturers of vehicles, the impact of this industry on employment is very encouraging. Moreover, India's logistics industry is expected to grow at a compounded annual rate of 10.5%, & employment is expected to grow at almost 08 %, which is currently at 22million.

Even as the number of jobs has been increasing so far, the quality of life has gradually taken a beating in some aspect. The very character of employment has become mostly tedious & dull, while some jobs like mining & night-time truck are dangerous too. As is the truth of our times, some of these jobs are now being taken over by mechanization & robots. Expect for tyre repair, even roadside mechanic's job is at stake. With puncture-proof tyres, people might soon not need a human for changing tyres either. Self-driving cars by themselves are expected to lead to job losses of between 12% &15%, & this loss will be quick & extremely disruptive.

The employment can be considered as a strong but weakening interest fighting the other two Es. The fact is, as individual incomes increase in developing countries which progress along financial & other metrics, vehicles on the road are on the rise, & they are choking our cities & urban areas. Healthcare costs have increased, so has time wasted in idleness. In addition, public spaces, which can be used for other purposes, are wasted on parking. The situation is grim.

New technologies & innovative asset-sharing trends have compelled us to take a downside-up look at the industry. These new innovations have their positives & make an unyielding case for examining the industry with completely fresh eyes. At the same time, could these solutions bring about greater income & more egalitarian distribution, while also reducing accidents & freeing up urban spaces? With this new paradigm as the goal, people shall pit the industry's present & future against the STEP levers.

III. STEP – DRIVING US TOWARDS TRANSFORMATION

A. Technology – undreamt-of Developments, Inconceivable Potential

In the last decade, every aspect of industry has seen enormous technological advances. Today, as people stand, at the cusp of change in this industry, three major aspects are witnessing hitherto unimagined innovation: the manner in which our vehicles are powered, or fuel they use; the manner in which people commute, a shift from ownership to shared riding; the manner in which people drive – that is not drive at all, because automated vehicles would not need us to. Each of these shift has far-reaching impacts that are going to take us by surprise.

B. Powering Engine

As an alternative to petrol & diesel, which are an environment menace, people are already using CNG & bio-CNG, which produce relatively less pollutants. But slowly & surely, electricity is becoming the new but pollution free oil. The massive more towards EVs is extremely relevant to urban transportation, even more so because an increasingly large part of humanity will live in urban areas in the decades to come.

New & cleaner technologies are coming up now. Very clearly, if a vehicle runs on electricity, it does not produce any emission where it is used, namely in the car. But how can people say that EVs do not harm the environment if the electricity they use is generated by burning coal or oil? Therefore, in the first place, the source of energy used to generate the said electricity has to be considered. If the energy generation is clean & if it burns cleanly, people have environmentally clean solution.

In the recent past, there has been a move away from generating electricity using coal & gas to using renewable sources, such as the sun, wind, waves, geothermal sources, to name a few. These sources of energy do not require fossil fuel & are therefore certainly clean. Now price parity between electricity generation from fossil fuel & electricity generated from renewable sources is on the horizon.

This brings us to the issue of electricity storage for EVs, which use electricity for power instead of petrol or diesel. EVs are either battery electric vehicle (BEVs). BEVs store energy in the battery which is converted to electricity as needed. FCEVs, on the other hand, store hydrogen in the vehicle & convert it to electricity through a fuel cell.

Currently the world is largely focused on BEVs & the infrastructure around charging BEVs. Battery costs are the largest component of the price of electricity power train, the mechanism that transmits the drive from the engine of a vehicle to the axle. The burning question of the hour then is: how do people make batteries for BEVs affordable to the common person?

The most innovation has been directed towards increasing the energy density of the battery – making a lighter battery store the energy required by an average vehicle to cover a distance between fuel stops. Every time you drive a car, you consume the

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electricity stored in the battery. Like you phone, when the battery drains, it will have to be recharged before you can use the vehicle again. The longer it takes to recharge the battery, less convenient it is to use a BEV, After all, it is rather pointless to own a car that half a day to charge for every 150 Km of driving. Across the globe, efforts are also being driven towards increasing battery capacity.

The second characteristic of a battery is its power density. The higher the power density, the less time it takes for a recharge. An ideal battery should have high energy density as well as high power density so that once charged, a vehicle can be driven a long distance, & once discharged it can be recharged quickly. Unfortunately, the world has not yet reached a stage where a battery an affordable one, has the right energy density & power density.

The energy & power requirements of a car make lithium-ion batteries the current choice to store energy. Lithium provides the required energy density. However, current lithium batteries are expensive & take a long time to charge, unless one compromise on the life of the battery. But in new technologies are progressively allowing for longer & longer drives between two recharges.

Battery technology is moving at a pace at which both these goals will be achievable in the next five to ten years. How efficiently a battery is used depends on the electronic system which guides their charging & how the battery discharges in the running of the car – the battery-management system. KPIT is playing a role in addressing battery-management issues & in deeply engaged in this working globally.

Even within various aspects of BEVs, the world's focus is on the electric personal car where the key concern is 'range anxiety', the driver worry that their car will suddenly run out of battery. So, all effort have been directed at ensuring long ranges that enable long distance drives. However, personal cars are not the only vehicles that run on the road. Already in cities, the trend of people moving away from personal cars is apparent.

Driving patterns in the case of heavily used vehicles such as cabs & buses are very different from those for personal cars. Typically, bus drivers are a known distance along its route. In India, almost 100% of urban bus routes are less than 35 km, one way the bus stops at the end of this route for about 20 minutes before travelling the same route back. So, the distances are short, making the 20 minutes break available for a quick recharge. Rental cars or three wheeled rickshaws have similar driving patterns – short drive followed by short rests. These vehicles would need quick battery recharge but do not need high-energy storage capacity at any point. A low energy battery that has a quick recharge time, which is not very expensive, & has a long life, can be the perfect solution for an electric urban public transport vehicle. People contend that such a vehicle does not need a lithium battery.

The world requires chemistries other than lithium, & which will be far more relevant for countries such as India. Such alternatives will counter the other problems related to the materials that lithium-ion batteries use- lithium & cobalt. The people suspect that dependence on lithium-ion batteries will lead to a similar situation. Lithium & cobalt will be the new oil.

Both these materials are required not just for BEVs but also phone & laptop batteries, making them an essential part of today's energy mix. Of course, this adds to the increase in demand for the two materials too. This demands is likely to increase seven to eight years.

Next the supply of lithium & cobalt is limited. While a few countries mine cobalt, Democratic Republic of Congo (DRC) supplies two-thirds of the world's cobalt, with no other country contributing more than 10% of the world supply. Cobalt production in DRC is infamous for its illegal mining, & child labor is a major humanitarian concern too. Similarly, over 76% of the world's lithium is supplied by Australia & Chile, while Argentina & china supply almost 20%.

This brings us to our contention, that FC-EVs – EVs not dependent on batteries at all – are a more appropriate solution. BEVs are most appropriate for urban drives. When you drive a BEV, you are actually carrying the battery around – the battery's weight in a Tesla is over a tonne. If you want to drive a long distance, you will obviously have to carry a larger battery, & your vehicle will be heavier. This makes BEVs an inadequate solution, especially for long – distance drives. The world has been looking at hydrogen fuel-cells in this context.

In an FC-EV, you carry hydrogen along with a fuel cell. The fuel cells use the hydrogen & convert it to electricity, which runs the vehicle. When hydrogen is so used, you get only water as effluent. So, this is possible the cleanest solution for driving vehicle. You do not carry a lot of weight around & you emit nothing other than water. While one can use FC-WVs in cities too, the solution is particularly relevant for travel between cities.

Recognizing these advantages, many countries are now joining a hydrogen mission – promoting the use of hydrogen as the right fuel. International automotive companies such as Toyota, Honda & Hyundai are currently running of FC-EVs. People too believe that this is the right way to go. This technology can be affordable & will certainly be very clean. Public are working on FC-EVs & are attempting to bring them to an acceptable price & mileage range.

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Of course, FC-EVs cannot run without hydrogen. Hydrogen can be generated from natural gas, water or biomass. Hydrogen generation from natural gas is well known process. However, you need natural gas for this purpose, which, unfortunately, is generally available through the fossil-fuel route. Making hydrogen from water is the next option.

The third possibility is hydrogen generation from biomass. In India, agriculture waste is a serious problem. The country sees a surplus of about 22 million tones of rice straw & 10 million tones of rice husk every year. Similar quantities of agricultural waste are generated by other crops, such as wheat. Rice & wheat straw, & sugar-cane bags, the pulpy residue after sugarcane is processed, is often burnt after the crop is harvested. The burnt crop is not only wasted, it is also causing other environment issues. Part of Delhi's air pollution is on account of crop burning in the neighboring states.

People believe the answer lies in generating hydrogen from biomass. This is an immensely exciting avenue - & not just technologically. Imagine, just like grain & milk flow from our rural hinterlands to our cities, creating a bridge of economic interdependence, energy through hydrogen could create another such bridge. If people can create hydrogen from biomass, rural India can provide energy from transportation for entire country.

This can generate incomes from our rural brethren, cut down our fuel-import burden, & provide clean, pollution free fuel. As cabinet minister Nitin Gadkari stresses, all fuels generated from biomass, including CNG, ethanol, methanol or hydrogen, has the potential to create 05 million jobs in the country.

The bio hydrogen solution can also provide renewable, carbon-neutral fuels from inexhaustible green resources. If this appears incredible, then one should keep in mind that replacement of a single conventional bus by a bio-hydrogen bus can reduce diesel requirement by 25 tonnes, & carbon dioxide emissions by 48 tonnes every year. The added advantages of using biomass to create hydrogen is that it would otherwise have been burnt, causing more pollution.

This is economically attractive not only at individual & city levels, but at the national fiscal-level too, because it will reduce the country's dependence on fossil-fuel imports, which today cost India $102 billion every year. Not only can 'biomass for hydrogen' solve issues of rural employment & urban pollution, it can also solve the problem of rural pollution. People believe that Indian industry can take up this challenge. KPIT is certainly contributing in this field.

C. Sharing our Rides

It can lead to clean & eco-friendly transportation, but neither BEV nor FC-EV can reduce the number of vehicles on the road, leaving the technology is solving road major issues of the city congestion & the related social costs unresolved. Beyond the application of physics & chemistry as soon above, information technology is solving road transportation issues too.

Traffic congestion is being partly solved through the use of shared transportation, either by means of public transport or by sharing rides through mobile apps. An information cloud over a geographical area can solve problems of congestion, pollution & time loss. The Olas & Ubers of our times are a part of this solution.

In addition, a move to sharing our assets can lead to even more savings. In MIT study shows that New York City could potentially observe a 75% decline in taxis if everyone moved to ride-sharing. Riding-sharing slows for movement of two to four people at a time instead of one person per taxi.

The reduce traffic on road & reduced fuel consumption will significantly bring down congestion on the road & toxins in the air, having a positive impact on both the economy & public health. This is estimated to save the city $160 billion, including savings from 03 billion gallons of fuel would not be burned by vehicles waiting in traffic & 07 billion, hours of time that would not be lost by people waiting in traffic. All this with an average waiting time is less than three minutes for cabs.

Even more efficiencies are possible.

Current technology allows route creation only after all requests are submitted. It is only a matter of time before software becomes self-learning & can reroute a vehicle on the fly, optimizing car size with the number of passengers on a given route. Other than e-hailing & car-pooling there are other transport-mobility innovation too, such as pay-per-use models & peer-to-peer car rentals. That these ideas attract funds is an encouraging sign.

Already, it is found that ride-sharing apps reduce the number of vehicles on the road in cities where such apps are well established. Moreover, they encourage multi-modal, sustainable transport, which complements public & active forms of transport, such as cycling & walking.

In addition, sharing rides has reduced car ownership. Each shared car added on the road replaces five to fifteen owned cars. Although long-distance car sharing service competes with rail & coach service, they significantly increase car occupancy & reduce emissions per kilometer.

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D. No Driving at All

What if none of the vehicle needed a human driver? What people would have dismissed a service fiction is likely to happen sooner rather than later? If they satisfy regulatory requirements, autonomous vehicles (AVs) will be here to stay. The immediate advantage of AVs is far fewer accidents & congestion-free roads.

To begin with, AVs are already a reality in industrial fleets for transportation within industrial premises. As their application & capabilities move from industrial to personal use, the entire road transportation ecosystem will change. Insurance companies will move their focus from individuals 'health to cover manufacturers' technical failure; the entire after sales service industry will see a shift which is difficult to even imagine right now;& car design will change to suit the passenger rather than the driver. As driverless cars increase in popularity, the time people would have spent in driving & in traffic lams will be free up. Parking space too will be freed up for other civic uses. Accidents are estimated to reduce by 90%.

In addition, all the technological experiments for AVs can be put to use in completely different field too. Of course, at present these developments are clearly out of reach of the common man. But that is only a matter of time, because the other STEP levers that make & break innovations are already in motion.

This brings us back to this paper core hypotheses; for any sustainable long-term change, all four levers – Technology, social engagement, public & economic model – have to work together. Let us now consider how the other three levers currently operate to impact road transportation.

E. Economic Sense is as Plain as Day. And Where it is not, it is a Matter of Time

With reducing battery prices, experts now believe that by 2025 there will be parity between the costs of ICE cars & EVs. As demand increases, costs will only reduce further. On other hand, ridesharing itself makes for a much cheaper alternative compared with owning a car, especially in cities, where parking & traffic congestion add on the economic & non-economic costs of owning a car.

People are highly optimistic about new technologies that will make road transportation more accessible economically equitable. Of course, as with all things that are for public good, EVs too will need some degree of push from public policy. This is already coming about around the world.

IV. POLICY – ADAPTING TO THE SHIFT, & YET MORE ROOM FOR DYNAMISM

Indeed, public policy has helped shift gears when it comes to creation of sustainable economic models for EVs. In time, almost every country will give right of way to electric cars, create infrastructure for free charging stations, subsidize EV infrastructure, penalize dirty vehicles trough taxes & make it inconvenient to own ICE vehicles. Countries are also working together to set worldwide standards for emissions, among other parameters. Countries like India, China, USA & Germany use subsidies for EVs. This serves the national good at various levels. First, of course, it directly reduces air pollution. Indirectly, it is not reduces the country's need for import, but also brings benefits good enough to justify the subsidies. Eventually, when environment-friendly cars become the norm, targets for emission can either be revised, or subsidies can be progressively eased out. Benefits to individual consumers as well as society would be evident enough to encourage the use of such vehicles without any policy support. Getting to this point of critical mass, however, is where policy is very helpful.

Policy can be even more proactive through procurement, which will go a long way in helping technologies reach the desired critical mass. What can be better than government encouraging EVs for its own use & electric buses for public transport? This sends demand signals to the market too. These signals are further reinforced when EVs are provided to government staff for their use. Mandates & tenders from national & local authorities can foster EV uptake for large public fleets of vehicles, including service vehicles such as garbage trucks & public transport vehicles. In India, the government has set up an energy service company, EESL (Energy Efficiency Services Limited), which has made investments worth 2400 crore (~$370million) in EVs for use by the government. Initiatives in India are taking shape through its National Mission for Electric Mobility (NMEM). One such initiative, FAME (Faster Adoption & Manufacturing of (Hybrid) & Electric Vehicles), is working towards creating the infrastructure, such as charging stations, needed to make EVs operational. Parking & zoning rules too are being used to encourage EVs. The city of Paris has mandated that all electric cars be permitted to use the chargers of its Auto-lib electric car-sharing programmed & has allowed them free parking or dedicated parking spots. The policy-led deployment of public charging infrastructure optimizes new charger installations only when there is new EVs circulation in the area.

This government push & availability of technology has led to increasing demand & use of EVs. In turn, taking their cue are being pushed by their citizens to do so.

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V. SOCIAL ENGAGEMENT – CHARGING BEHAVIOR PATTERN, A CAUSE & EFFECT OF OTHER LEVERS

People participation has had a subtle impact on technology, economic model & policy, & these three levers have in turn captured the people's involvement. Along with the impact of technology & policy on reducing the costs of EVs or AVs, & the economic sense that ride-sharing makes, there has also arisen a lot of social awareness. Every urban citizen is conscious of the problems created by unclean vehicles. Citizens are rebelling against the pollution they are suffering in their cities. People do not want the status quo. That the next generation is moving away from traditional, personally owned transportation to shared transportation is already leading to reduction of environmental & energy problems.

This trend is clearer among the young generation, especially in the western world. Over the years, in America & European cities, people do not want to own cars or drive a car themselves. Globally, the number of new driving licenses issued every year is dropping. Many people now prefer to use public transport such as buses or rental cars.

A rise in ride-sharing is a clear indicator of the move away from owning a vehicle. From a status symbol that car ownership was, the day might not be far when it might be looked down upon because you are not being eco-friendly. This is because there is a social movement towards changing our 'object of desire'.

By 2030, 25% of road miles driven in USA are expected to be through ride-sharing. Seatle has already seen a decline in car ownership – for the first time since 1970. This is true of many developing countries too. In fact, like many other intermediary technologies, such as landline telephones & banking, transportation has also skipped a technological step in any developing countries. The bottom-of-the pyramid population will not go through the step of owning a car before having to let go of it. They will directly move to using a mobile app that allows them to share a ride. This has been driven as much as the high cost of ownership of cars & increased traffic congestion as by an increase in data connectivity & the reach of the now ubiquitous mobile phone.

Indian automotive manufacturing was a little too late to the party, beginning only in the 1950s & 1960s. However, people do not need to miss the wagon again. The industry is now at an inflection point in every aspect of EV & AV technology. This is our time to be ahead of the tide.

The people are sure we will be able to play our role in making road transportation accessible to as many citizens as possible while keeping them safe & the planet clean. This is because our solutions fulfill the requirements of ASSURED Total Innovation. All the solutions enumerated above are affordable, by definition. With the right policy push, which will bring agencies together, the solutions can be scaled & sustainable in the long term – economically, socially & environmentally. The processes will include the marginalized farmers, & the bus & truck driver, so that the solution satisfies the requirement of a very universality. Again, with government backing there is nothing that can keep this solution from achieving scale with rapidity. This makes each of these solutions 'excellent', as define it, because they are developed keeping in mind the bottom-of-pyramid producer & user. In totality, all these qualities make them distinctive solutions too.

A new green revolution of our times is certainly in the offing. Cohesive work on the STEP levers can take us into a very different world. It is not difficult to imagine converting India from a large importer to a net exporter of energy sources, similar to the change that the last century's green revolution brought about. Also, let us not forget that these technologies that bring meaningful employment, while solving critical issues related to transportation, are not problems that alone faces. These are global problems.

India can truly be global technological leader. After all, every nation wants better transportation that leads to cleaner air, self-reliance & fewer accidents,& every individual in the world wants less time spent in commuting & better quality of life.

VI. TOWARDS A NEW WORLD

Indeed, when the world comes together, it is not out of line to envision a new world. People acknowledge that, given the pace at which things are changing, predicting the future will be underestimating the potential of the next generation & new technologies. Some of the predictions that make the ideal world nit too far into the distant future are too thrilling not to mention.

From solar-powered WVs to on-demand, app-driven delivery of mobility – the predictions cover the entire chain of transportation in the next ten to twelve years. A few of those are an extrapolation of what people observe today. The world is expected to have a very competitive ride-sharing industry if AVs reach the market.

This is because autonomous EVs will be cheaper than human-driven ICE vehicles. This competition will serve the customer better & be cheaper. Ads a result, TaaS (Transport-as-a-Service),will become the norm, owing just to its economic attractiveness. Each car bought will be used at least ten times more than an individual owned car today. These factors will come together to reduce the number of cars on the road. A more imaginative prediction – likely to be outsmarted – is that of recharging stations serving as community hubs, where recharging time will be used for meetings & meet-ups.

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VII. SUGGESTIONS & RECOMMENDATIONS

The predictions have total savings on transportation costs in the USA adding up $01 trillion by 2030. These saving are expected to result in a permanent rise in annual disposable income. Productivity gain as a result of reclaimed, driving hours are expected to boost the nation's GDP by another $ 01 trillion. On-road cars are expected to drop from 247 million to44 million in the same period, opening up vast tracts of land for other, more productive uses.

The TaaS disruption is also expect to reduce, if not eliminate, air pollution & the green-house gases attributable to the transportation sector. Energy demand from transportation is expected to reduce by 80% & tail-pipe emission by 90%. If combined with the use of solar & wind sources of energy, a carbon-free road transportation system in USA can be expected by 2030.

What is predicted for USA is likely to be similar, if not be bettered by, what will happen in the rest of the developed world. The developing world will not be too far behind either, because they are likely to adopt some of these innovations quicker, if skip couple of them on the way.

The people are for sure forwards to living in cleaner & rich healthier lungs. They also hope to see more people gainfully & dignifiedly employed in creating & maintaining new energy solutions for transportation. People certainly want to see an earth that does not need to be dug any more from place to place. This is not too far away. Only a decade or so will to go to achieve the said goals.

A. Abbreviations

1) 3Es – Energy, Environment, Employment.
2) OPEN – Designation used for some UK Access Land.
3) ICE – Internal Combustion Engine.
4) GDP – Gross Domestic Product.
5) STEP – Systematic Training for Effective Parenting.
6) CNG – Compressed Natural Gas.
7) EVs – Electric Vehicle.
8) BEVs – Battery Electric Vehicle.
9) FC-EVs – Fuel Cell Electric Vehicle.
10) KPIT - Kirtaney Pandit Information Technology.
11) DRC – Democratic Republic of Congo.
12) MIT – Massachusetts Institute of Technology.
13) AVs – Autonomous Vehicle.
14) FAME – Faster Adoption & Manufacturing of (Hybrid) Electric vehicle.
15) TaaS – Transport-as-a Service.

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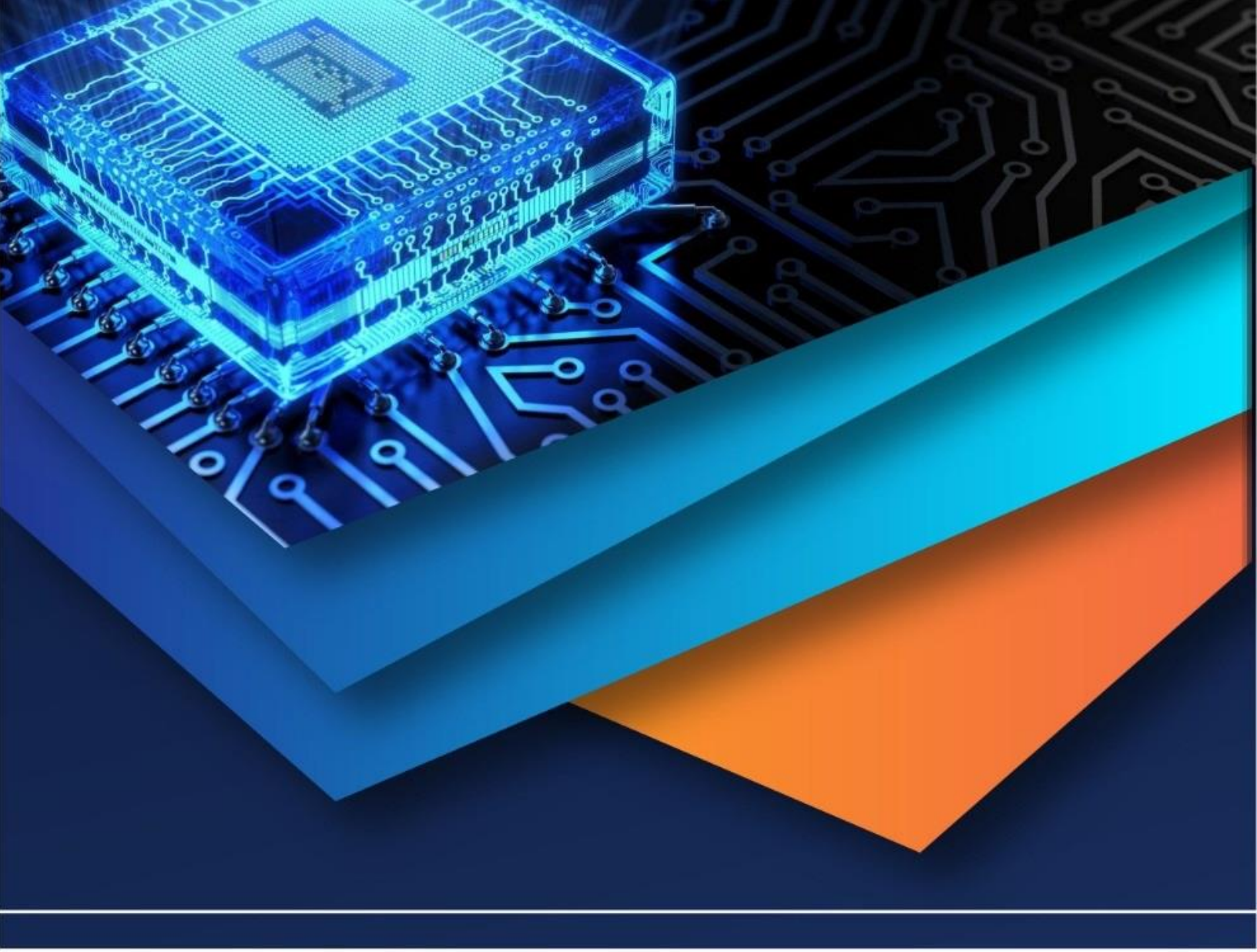

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