ICT Integration for Electro Mobility Application Drivers, Policies and Challenges

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Abstract –The technology of electro mobility is a boosting and will become the future of vehicle driving power in the automotive industry. This study discusses the concept of electro mobility and the most important issues associated with this concept such as electric vehicle (EV), the integration of information communication technology (ICT) in an electric vehicle. The result shows that the future of cars is electromobility technology that contributes to better performance and clean environment. The integration of ICT in developing electric vehicles first involves a new ICT architecture in future cars, second it changes the main core competencies as well as lowers barriers to automobile market entry, third electro mobility with the integration of ICS will change the market's rules and increase competitions between car vendors especially those who still depend on fuel engines in their production. It is recommended that governments should accelerate the change toward a viable future ICT architecture in electric vehicles through new regulation, public purchasing policy, and an expansion of infrastructure. In addition to that car manufacturers must steadily enhance their competitiveness through continuous improvement towards full adoption of electric vehicles in their cars, and more innovation and change in electro mobility fields.

Keywords—Electric Vehicle, Electro Mobility, ICT, Automotive Industry

I. Introduction

ELECTRO mobility embodies the theory of using in-vehicle information, electric power train technologies, and future communication technologies as well as connected infrastructures to allow the electric force of vehicles and fleets [1]. In a motor vehicle, the term power train is used to describe the key components that contribute to generate power and then deliver this power to the road. This includes the transmission, engine, differentials, drive shafts, and the final stage of driving (the drive wheels) [2]. The technology of electro mobility today and in the future marks more and more the automotive industry, the normal lives of those contributing in traffic and the use of transport. This technology bears many issues in the fields of energy and environment, transport, technology, infrastructure, all these aspects are the central issue of the modern economy [3].

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Electro mobility efforts are driven by the necessity to address the efficiency of fuel and best emission requirements, moreover, market demands for minor operational costs. Therefore, automotive and mobility has a robust focus on the future of care, mobility where people sense secure and happier in vehicle at every day of their lives. Software is playing a significant role in electro mobility, and this contribution is increasing now. Most of the current and future electro mobility innovations are driven by software [4]. Over the previous 30 years, it is found that information communication technology (ICT) with the associated software has achieved a significant impact on innovations in vehicle power technology: from the anti-lock braking system which is invented in 1978 to the last decades' development in electronic stability control in 1995 and recently emergency brake assist in 2010. Nowadays, ICT contributes strongly to some 30-40% of total added value in automotive production. The electric vehicle is the eventual result of very promising innovative technologies in car manufacturing, which now shows the potential influence of purely electrically powered vehicles and hybrid-electric, and also obviously point to the directdem and to roll the several forces active in the electric vehicle field so that to successfully adopt electro mobility. But due to the imperfect storage capacity of the battery in electric vehicles, the consumption of energy by electric vehicles has to be more efficient as possible. Semiconductors also play a key role in this process and the relay points in not only in a national power network, but also in every electric vehicle [5].

II. Significance Of Study

The main significance of this study is identifying the main technical challenges facing the technology of electric vehicles as well as predicting the future of this technology. Moreover, the result of this study will enhance the knowledge of Electromobility and its main advantages to the environment and consumers of cars.

III. The Purpose Of This Study

This study discusses the concept of electro mobility and the most important issues associated with this concept such as electric vehicle (EV), the integration of ICT in electric vehicle, the software and hardware used in electro mobility production, the policies of ICT integrated in EV in the international level, the technical challenges facing EV, and the future of ICT applied in EV. The study sets recommendation of future ICT in electro mobility technology and summarizes the main findings of this study.

IV. The Electric Vehicle EV

First positive attempts to design an electric vehicle system back to the earliest period of the 19th century, i.e. Some decades before the combustion engine has been invented. At the beginning of 1900, the electric vehicles were ordinarily seen, mainly in big cities, people can see the advantages of gasoline engine vehicles were most noticeable: small level of smell, noise and vibration are combined with the comfort of operation as well as there was no manual effort needed to trigger the engine. Actually, due to the poor performance of batteries at that time, the development of electric vehicles was quite difficult and required long time for recharging, and with the development in gasoline stations network and their promising limitless range, and with great innovations like the electric starter engines with the ease of the internal combustion engine vehicle, it was very hard for the electric vehicle to compete with fuel engines [6]. One major innovation within the automotive domain is the introduction of electric vehicles. It is widely understood that the approach of replacing the engine of a conventional car with an electric engine is only an intermediate solution on the way to a fully customized electric vehicle. Therefore, the embedded electric systems and many software challenges and obstacles in electric vehicles are far beyond the efficiency of fuel engine. Today, the electric vehicle replaced the combustion (fuel) engine with an electric motor in order to use clean environment, transport mean, while in a Hybrid Electrical Vehicle (HEV), the situation is a little bit different because the combustion engine is kept and just supplemented with an electric motor [7]. Therefore, it is required to redesign the additional architecture and communication in all electric vehicles, but even though this step seems a good development but it bears many technical challenges. For example, the today electrical/electronic architecture involves around 100 Electronic Control Units (ECU). These complex architectures are becoming a strong obstacle to innovation and a need for redesign is important and necessary to overcome this complexity. Moreover, most vehicles suppliers are much focused on providing special functionality in devices; it is found, this is the main reasons why the number of Electronic Control Units has been grown rapidly in recent years. According to that, this method will not be reduced as more functionality is going to be implemented with software and electronics, which include electric vehicles as well. Hence, a modelin vehicle market is shifting from distributed hardware to another dimension focus on distribution of software [8]. For this goal, there is a need for flexible electrical/electronic architecture and developed software component systems for electric vehicle software are required, for example a system called Automotive Open System Architecture) is very essential and may become one of the basic requirement of electric vehicles [9]. In current cars the implementation of semiconductors is important and could ensure that car's batteries are less costly and featured as smaller and light-weight comparing to the past, while concurrently providing longer age and travel range. But still the recharge requirement is necessary as all batteries finally become empty and need for recharging to be quickly rechargeable for further usage. That is where the semiconductors are needed due to their contribution in increasing the travel range of electric vehicles and become an important factor in developing future EVs [10].

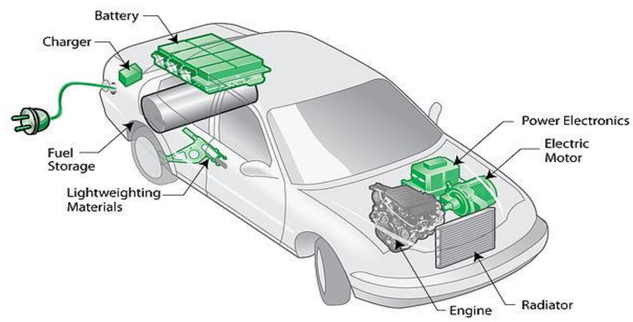

Fig1.Hybrid Electric (25)

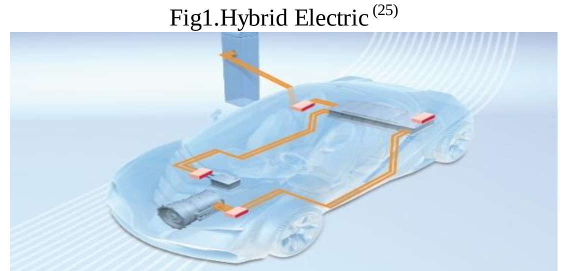

Fig.2: and Electric Cars (10)

The study suggests that the electric power train alone is not fully enough, but still is cost-effective, clean, environment-friendly, and more efficient comparing to the traditional. In addition, it offers the opportunity to improve part of the dynamic energy that may be lost during stop of cars and braking so that can be reused for better acceleration. Moreover, recent development in the enhancement of Li-ion battery efficiency and performance shall be improved. Therefore, many vehicle manufacturers nowadays announced their strong intention to enter the electric vehicle market recently.

V. ICT And EV

ICT becomes the basis of the driving for EV. For that reason, the technologies and architectures of ICT become the main innovations of EV, as they were before. Over the past three decades, ICT reform the technology of the EV by applying on-board electronics in, building them together with the related software, the ICT has produced a significant innovation in EV as well as developed the automotive domain to new dimensions: starting with the anti-lock braking system which was introduced in 1978, and in 1995 the innovation of electronic stability control, and recently the innovation of the emergency braking system in 2010. According to current estimates, currently the contribution of ICT is about 30-40% in the automotive industry. This is a promising percentage that is highly expected to increase in the future. But, ICT architecture has become more complicated in parallel with more innovations. Nevertheless, the development in ICT and mainly its software, has extended significantly in recent decade, comparing to very limited codes in 1970s (about 100 lines)and reaching to around ten million lines of code in recent years [11].Despite the great advantage of ICT, it is not yet possible to overcome the high cost of electric cars. For example, the current range electric vehicles (fully electric) will be limited to a maximum 200 km in the short term. Moreover, EVs may require fewer hours to recharge the battery every day (see Fig-3). Even though it seems that a range of distance around 200 kms is sufficient for most drivers, but this is not the final target, this distance should be increased at least to 400km without the need for recharging for regular use, this particularly in urban cities, the range limit may be a psychological barrier indeed that may deter swift market adoption. Today, there are mainly two approaches under development to face this issue, the first approach is based on using internal combustion engine to increase the range of distance (for example the Chevrolet Volt) and, it is based on ICT internally in order to enhance the efficiency of energy which leads to increase the range of travel distance of the electric vehicle, this approach also will help the driver to be aware of available energy in the battery and contributes to better energy usage (this approach is now applied in some Nissan vehicles).

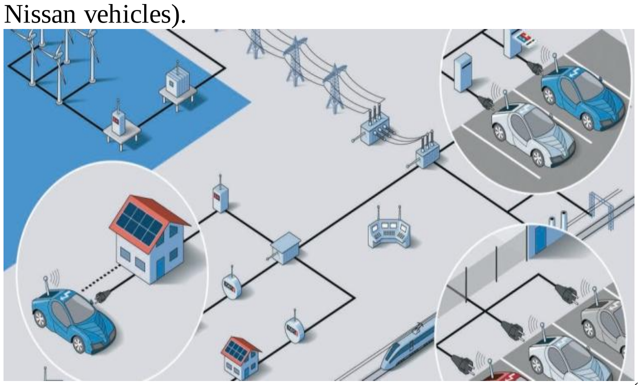

Fig.3: Charging map units for EV in different locations in cities [11].

The second approach is focused on ICT as well. It is targeting the reduction of complexity and thus less weight as well as increasing the efficiency of energy usage by participating electronic control to a higher level, this will contribute to better adaptive capabilities and enhances the intelligence of vehicle internal system.

Based on the above, the study concludes that the main contribution of ICT technology and its solutions is constructing smart systems for energy consumption by efficient integration of electronic control of EVs. In addition to that the benefit of ICT for EVs can be summarized as follows [12].:

1) By providing aware, caring and robust means of power and energy routing between accumulator cells, battery packs, motors and grids
2) By applying adaptive control and power electronics converters to electric motors and wheels
3) By actively enhancing the safety of road transport based on batteries and lightweight vehicles
4) By making the driver aware of the availability of energy and power and of the resulting restrictions in terms of range and comfort
5) By guiding the driver to the next recharging station in case the car runs out of battery power.

Thus, smart systems based on ICT will add synergy and harmonic interplay to the building blocks of the electric vehicle such that the drawbacks of today's batteries, e.g. The lack of energy density, lifetime and affordability, can be compensated. Based on the above study concludes that electro mobility has a double impact. First, it necessitates a new ICT architecture in cars. But at the same time it opens up the opportunity for such a revolutionary architecture for the first time. It shifts the necessary core competencies, lowers barriers to market entry, and thus changes the market's rules of the game. With a new ICT architecture, a newcomer can rise more easily from the low-cost to the premium segment of electromobility than a business in the premium segment can switch from conventional non-electromobility ICT architecture for the future architecture that includes electro mobility. Therefore, new competitors have a chance to penetrate into established, saturated markets

With a new ICT design and development, a newcomer can rise more easily from the low-cost to the premium segment of electromobility than a business in the premium segment can switch from conventional non-electromobility ICT architecture for the future architecture that includes electromobility. Consequently, new competitors have a chance to penetrate into established, saturated markets. The study refers to the importance of ICT as the base for developing an engine for the electro mobility of the future. Also ICT, in the form of electrics and electronics in cars, has been already essential to the competitiveness of automobile car makers. Its most notable effects are to improve driving performance and comfort, and to enhance both passive and active safety. But the effects go further in electric vehicles.

VI. THE SOFTWARE AND HARDWARE IN ELECTRO MOBILITY

Software is evolving and currently is one of the main driving force behind the innovation in the automotive industry. Nowadays, about 80% of worldwide innovations in vehicles are technology transfer and development in information systems [13]. ICT enhanced form electronics and software together in vehicles by combining them to better car technology. It is an essential factor for better competitiveness in the electric vehicles in particular and in the automotive industry in general, where its most significant effects are the growth of driving performance and more driving comfort, and the improvement of both active and passive safety. But the effects go further beyond that, such as electric vehicles: now ICT becomes the basic backbone of all relevant technologies and functions of EVs. Moreover, the technologies and architectures of ICT in vehicles cannot be neglected and viewed simply as gradual innovations. This line would lead to a rise of complexity in cars, which becomes very hard to control and manage them. Instead, the innovation in ICT architectures must be amended so that they can achieve their necessary role in cars in the near future. The most troublesome in developing this technology change are currently might be the main chance for such a change, but the need for more advanced ICT architecture [14].

The hardware of EV is composed of the following [15]:

1) Centralized Computer Architecture: It represents the future of ICT architectures and must work on scalable electronic units and computing systems, which affect all provided hardware that operates independently.
2) Highly-integrated Mechatronic Components: The Sensors will be smarter components that provide better communication over data standardized interfaces with canter computers
3) Standardized Communication Backbone: All the viewed experts in EV assumed that in the prospect a real-time network backbone will substitute today's communication buses.

The software of EV is composed of the following [15]:

1) Consideration of Extra-functional Properties: Operating extra-functional properties into account
2) Plug&Play Capabilities: New functions, sensors, actuators, and other components can be easily integrated in the vehicle if the platform supports Plug&Play
3) Resource Awareness: A Plug&Play mechanism needs information about assigning and available resources to be fully functional
4) Abstraction of Communication Infrastructure: Incurrent ICT architectures, every communicating component has to know what kind of infrastructure is used in order to fulfil timing or quality-of-service (QoS) requirements
5) Energy Management: The cruising range of modern electric vehicles is hampered by the energy requirements of rapid acceleration and the use of comfort systems.
6) Sensor Fusion: Input given by a variety of potentially faulty sensors has to be combined to generate complex data like the vehicle status
7) Security: In order to protect internal vehicle data and individual services, security mechanisms have to be implemented at the platform level

VII. Policies Of Ict For Different Countries

The key role of ICT becomes instantly apparent when relating to the definition of smart systems of the European Technology Platform on Smart Systems Integration (EPoSS) stating that smart systems:

1) Are able to sense and diagnose a situation and to describe it mutually address and identify each other
2) Are predictive and able to decide and help the user to decide operate in a discreet, ubiquitous and quasi invisible manner
3) Utilise properties of materials, components or processes in an innovative way to achieve more performance and new functionalities
4) Are able to interface, interact and communicate with the environment and with other smart systems
5) Are able to act, perform multiple tasks and assist the user in different activities

Consistently, policy makers and public authorities worldwide, often in the framework of economic recovery measures responding to the economic crisis of 2008, launched funding programmes aiming at a mass deployment of electric mobility within a decade [16].

Vehicle manufacturers worldwide has already launched the first series production of electric vehicles or are preparing for it [17]. The International Energy Agency stated, electric vehicles by the year 2050 will reach 30% of the global EV America Performance Results Toyota RAV4 EV and General Motors EV1, Idaho National Laboratory 1998 [18].

The electromobility Policy stated in the International conference “Breakthrough for Electric vehicles" June 11th, 2015 OSLO, NORWAY in the EU Electric vehicles (BEV and PHEV) can save up to 30% of CO_2 emissions compared to conventional petrol or diesel vehicles in urban areas and more if electricity is produced with renewable energy. This conference identified three main barriers for electro-mobility:

1) High price of vehicles and batteries
2) Small range and lack of infrastructure
3) Lack of consumer information

Electro-mobility brings also benefits in terms of reduction of noise as indicated in the White Paper Policy adopted in March 2011 mandates:

1) To halve conventionally fuelled cars in cities by 2030
2) Free CO_2 logistics CO_2 in major urban centres by 2030

VIII. Technical Challenges Facing Ev

Today's ICT architecture again faces similar problems, but this time because of the large number of ECUs. The required integration and testing effort to exclude undesired interactions of features or functions is growing enormously [15]. The design of electric vehicles requires a complete paradigm shift in terms of embedded systems architectures and software design techniques that are followed within the conventional automotive systems domain. It is increasingly being realized that the evolutionary approach of replacing the engine of a car with an electric engine will not be able to address issues like acceptable vehicle range, battery lifetime performance, battery management techniques, costs and weight, which are the core issues for the success of electric vehicles. While battery technology has crucial importance in the domain of electric vehicles, how these batteries are used and managed, pose new problems in the area of embedded systems architecture and software for electric vehicles. At the same time, the communication and computation design challenges in electric vehicles also have to be addressed appropriately. This paper discusses some of these research challenges [19].

An in-vehicle communication network for electric vehicles has to satisfy very high availability and reliability requirements. At the same time, protocols have to guarantee real-time properties for safety-critical and advanced driver assistance functions. Possible candidates for next-generation networks in electric vehicles are FlexRay [20] and (real-time) Ethernet as well as the combination of these two protocols. Novel concepts and scheduling approaches have to be investigated to provide the required safety and flexibility for upcoming systems in electric vehicles. In the following, bus protocols for in-vehicle networks of electric vehicles, the device integration challenges, and the development of time-triggered automotive systems are discussed [21].

IX. THE FUTURE OF ICT VEHICLE

The future of electro mobility is very promising. Electro mobility has potential for the technology and business location, as well as for the protection of climate and environment. There are many great advantages of electro mobility for human life. For example, drive and charging solutions for hybrid and electric vehicles are helping automobile manufacturers around the world to meet their CO2 targets. Electrified city buses make urban traffic, quieter, cleaner, and cheaper for operators [23].

Various trends affect the ICT in EV, and result in changes. The main potential development of the ICT in EV development is summarized below:

1) Social Trends

A suitable ICT architecture offers a basis for meeting these requirements. Replacing mechanical and hydraulic components with electronic ones (such as “X by wire”) reduces vehicle weight and increases range.

2) Technological trends

In technology, there is a trend toward greater miniaturization and toward developing intelligent modules. Hig0hly integrated mechatronic components are evolving that can be integrated into vehicles by way of a data interface. Sensors and actuators are becoming more intelligent and more and more capable of universal use, including for pre-processing and simple adjustment tasks. In software technology, an intermeshing of concepts from safety-critical embedded systems and Internet technology is becoming evident, especially in middleware

A report identifies three different scenarios for how the automotive industry could manage the upcoming changes [22]:

1) Low Function/Low Cost for 2020

This scenario is the most probable for new market participants focusing on low-cost vehicles. The vehicles' functionality and customers' expectations about comfort and reliability are relatively low. The scenario is well suited for introducing a re- vised, simplified ICT architecture that includes a drive-by-wire approach; actuator components are connected directly to the power electronics and the ICT. In that way, actuators can draw energy locally and be triggered via software protocols, reducing the amount of cabling and the number of control devices.

2) High Function/Low Cost for 2030

The considerations behind this scenario are based on a further development of the revolutionary approach to ICT architecture that was described in the “Low Function/Low Cost” scenario above. ICT has been optimized over the years and is now very reliable, so that even customers with high expectations buy this kind of vehicle. This trend is reinforced by the ability to integrate new functions easily into vehicles, and to customize them.

3) High Function/High Cost

This scenario addresses electric cars in 2020 whose architecture concept builds very largely on what is already known from conventional internal-combustion-engine vehicles. What is primarily electrified is the drive train; the existing ICT architecture is still used with no developmental advances.

The following table (I) shows the future of ICT in Electric Vehicle.

TABLE I
COMPARISON OF ICT IN TODAY AND FUTURE VEHICLES (26)

	ICT today's vehicles	ICT of future vehicles
Energy- / Cost-Efficiency	Optimization level at component	Optimization at system level Weight reduction Intelligent predictive control manager
Zero Accidents	Pro-active safety functions are slowly getting integrated Safety relies mostly on passive mechanisms	Pro-active safety functions
Seamless connectivity	Integration of CE devices possible Interaction with cloud possible No software update without proprietary firmware or a visit of the local workshop	Integration and interaction with CE devices Interaction with cloud possible Software updates over the air (OTA)
Personalization	Currently possible but vendor specific	Vendor independent

The following table (II) shows service of the future of ICT in Electric Vehicle

TABLE II
ICT SERVICES IN TODAY AND FUTURE VEHICLES (26)

Vehicle Access/ Security	Telematics	Electric Vehicles	Navigation	Mobility
Vehicle Locator	Emergency Assistance – App	EV Billing	Turn by Turn Navigation	Car Sharing Vehicle Access
Vehicle Access – converting phone in to smart key	Real Time Video Traffic Feeds	Interior PreConditio n App	Dynamic POI Finder	Car Sharing – Choosing, Reservation and locating cars
Remote Car Starter/ Security	Diagnostics – TPMS, service/oil notifications,	Charging Station Locator	Real time Traffic Information	Car/Van Pooling – car and van pooling apps,
Remote Vehicle Horn/Light Flash – Security App,	Integrated Telematics – eCall/bCall/	State of Charge Monitoring App	3D Navigation with Video Support	Multimodal Transport – apps for real time bus/transit

X. THE DEVELOPMENT IN FUTURE EV

The vision for a 3rd generation fully electric vehicle meeting the described requirements has been sketched in the description of milestone 4. Its core features are energy efficiency, safety and convenience. The transition to a new age of mobility will be a gradual one. As we move beyond the

Carbon Age and our dependence on fossil fuels, Hybrid Electric Vehicles (HEV) will play an important role alongside lower-carbon combustion engines during the transitional period. Although electric drive trains are already more energy-efficient than combustion models, further improvements are still required.

Vehicles combining an electric drive with a compact battery and complementary internal combustion engine basically will pave the way for all-Electric Vehicles (EV). Drivetrain electrification calls for high-power semiconductors designed to automotive quality standards. Expertise in both power semiconductors and automotive electronics is thus essential to successfully serve the emerging HEV and EV market (see Fig.4) [24].

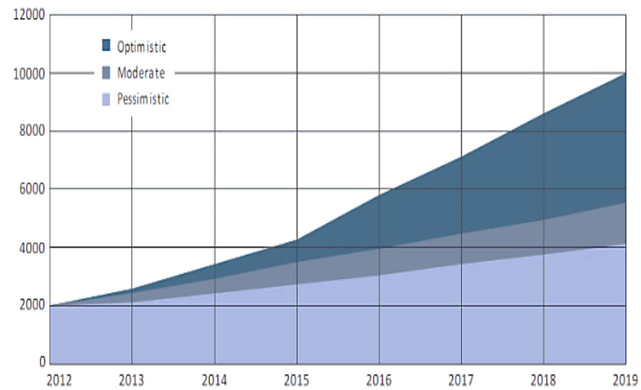

Fig.4: Future development in Hybrid and Electric Vehicles [24].

XI. Conclusion And Future

Although the combustion engine still dominates the automobile market, today's the technologies of drive train, electrification is significantly emerging as a progressively strong force in future green mobility scene. Today, many well-known manufacturers such as Siemens, BMW, Mercedes, and Toyota have passed long way in development electro mobility applications which enables automobile industry to deliver market-leading hybrid electric and electric vehicle solutions already today. In this study, the researcher discussed a number of issues associated with ICT integration in electro mobility systems and software as well as discussing related challenges in the context of electric vehicle and future development in these vehicles. The study found that electro mobility is the future technology of automobile industry and it has three main impacts on this industry. First, it involves a new ICT architecture in future cars. Second, it changes the main core competences as well as lowers barriers to automobile market entry. Third ,electro mobility with the integration of ICS will change market's rules and increase competitions between car vendors especially those who still depend on fuel engines in their production. Moreover, Electromobility will make the integration of ICT in future cars much more important and valuable. However, there is a certain amount of uncertainty about electro mobility that cannot be avoided within the automotive industry.

The study also found that not only new EV structures need to be redesigned, but they also car manufacturers have to be supported by the government through efficient communication networks and protocols which encourage them to fully adopt electro mobility in future production plans.

Finally, the study concluded that by offering highly efficient EV systems based on latest ICT technologies with outstanding quality, and increase the development in the design of EVs as well as finding new solution towards more sustainable electro mobility choices, then people will more dependent on EV and stop using fuel engine cars which contribute to better clean and green environment.

Based on the findings of the study, the research sets the following recommendations:

- Public aspect, government can accelerate the change toward a viable future ICT architecture through regulation, public purchasing policy, a pooling of all efforts, and an expansion of infrastructure. Government can stimulate demand through regulation, but also set a good example by converting public fleets. To achieve the above goals, the government should generate a maximum demand for functionality through astute regulation.
- Business aspects, Companies must steadily enhance their competitiveness through continuous improvement, innovation and change in electro mobility fields.
- Education aspects, research and science Education, research and science are encouraged to provide methods, technologies and skilled workers to develop electro mobility. Research results must be processed for transfer to industrial applications, and companies must be helped to achieve their goals with- in the terms set by the government.

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