Mega Science 3.0

Furniture Automotive Creative Tourism Plastics / Composites

FINAL REPORT

AUTOMOTIVE INDUSTRY SECTOR

CONTENTS

LIST OF FIGURES

LIST OF TABLES

Executive Summary

1 Mega Science 3.0 for Automotive Sector is a foresight study on the future possibilities of the automotive industry, both locally and globally, as the world moves towards the year 2050. This study examines the past developmental scenario of the local automotive industry, identify the current critical gaps and propose future direction and action plans for the local stakeholders to steer the nation towards continuous participations in the global mobility development.

2 Past development of the local automotive industry was assessed and missing sectorial linkages that are weakening the local industrial ecosystem was mapped out. This is an important exercise and if those areas identified remain underdeveloped not much progress can be seen on the local automotive endeavours. Large mould and die making, machine making and both products design and engineering design capabilities were highlighted as the critical weaknesses to support of the nation manufacturing activities. It is affecting vehicle development and efficient production of automotive related parts and components. The main weakness is the incapability of the local foundries and forging industry to support large components fabrications. As a result, the nation's industry is not able to support the production of large mould and die and to venture into machine making activities. The nation resource sector focus mainly on natural resources explorations with weak upstream raw materials production capability to support the raw material requirement of the downstream manufacturing activities. Steel production are now diverted mainly to support the low grade requirement of the construction sector, and plastic production focus mostly on the low end polymers and exported while engineering plastic are being imported.

Revisiting the weak linkages that exist within the local industrial ecosystem it is essential and proposed that major improvement be made to provide effective support in ensuring successful national venture into the manufacturing of "Energy Efficient Vehicles (EEV)" as envisioned by the NAP 2014.

3 At the initial stage, under the vision 2020 to industrialise Malaysia, automotive industry was intended to spur the demands for parts and component and thereby encouraging the development of small and medium industries within the industrial ecosystem. The industry now remain important and currently employing directly and indirectly some 350,000

workforce involving all stages of vehicles manufacturing in the country. Meanwhile some 250,000 employment are created to support the vehicles operations in the aftermarket sector of the industry. Apart from being major employment contributor, the industry currently contributes some 8.5% to the manufacturing sector of the nation economy accounting some 2.5% of the GDP.

4 The world is combating environmental, global warming issues and escalating energy prices and the global mobility transformation is taking place. Realising the importance of this, the NAP 2014 is making every effort to revitalise the industry towards utilisation and manufacturing of EEV locally.

5 A glance into the future reveals that the total global vehicle ownerships is expected to exceed 2.5 billion by 2050 which is more than double the current total running on the roads. New vehicles innovations are now creeping into the market places promising valuable environmentally friendly and mileage efficient characteristics. New vehicles, such as; Hybrid Electric Vehicle (HEV), Plug-in-Hybrid Vehicle (PHEV), Battery Electric Vehicle (BEV) and Fuel Cell Vehicles (FCV) are now occupying motor-vehicle expos and shows round the globe promising their market entrances sooner.

6 Despite aggressive engineering developments in the prescribed new vehicles above major vehicles OEMs are still maintaining their market focus on the Internal Combustion Powertrain (ICE) due to the uncertainty of market entrances of the HEV, PHEV, BEV and FCV (all are termed “e-Mobility”). In addition, OPEC, a very strong oil lobbyists, predicts that the global ICE powertrain will remain their major oil revenue stream till 2050, which currently dominating 81% of the global automotive market share and will begin to diminish by 2040 to some 56% market share in 2050. In this respect, Malaysia’s locally home grown automotive producers are still positive with future market availability for their current ICE powertrain vehicles produced. However, the Malaysian automotive industry are now beginning to competitively enter the energy efficient ICE powertrain in the market place which is currently being dominated by the global OEMs.

7 Development of e-Mobility vehicles are rapidly taking place, mainly by major OEMs and some innovations are now ready for market introductions. The study shows that the HEV and PHEV may well enter the market place sooner but due to current lower oil prices their

market entrance may further be delayed worldwide. More advanced BEV and FCV seems ready for market introductions but in the absence of their support infrastructures, both charging and hydrogen filling stations around the globe, their market entrance may remain uncertain for a long while yet.

8 Economic and social impacts on the general populace by the entrance of the e-Mobility and the business opportunities that can be derived from their market entrances are assessed. It is estimated on a global scale that by the 2025 the potential economic impact of e-Mobility, inclusive of Autonomous vehicles, could be $200 billion to $1.9 trillion per year. The largest impact would come from freeing up time for drivers, increased road safety, and the reduced cost of operation of vehicles.

9 More importantly and have significant impact on human capital is the new skills requirement and numerous retraining and relearning amongst the working populace that need to be conducted. This new technological investment will be extensive to provide training for the e-Mobility service providers in the aftermarket and the way vehicles are maintained and operated. The new training may need to be changed significantly since it requires new knowledge and procedures by the general populace.

New "National Occupational Skills Standards (NOSS)" for the Malaysia Skill Certification relevant to e-Mobility Skill requirements for the incoming or retraining workforce are essential to ensure the national venture remain competitive. In manufacturing plants, graduate apprenticeship programme need to be intensified to cater for the industry demand for graduate engineers.

10 The study has identified various R&D priority areas relevant to the nation's development of e-Mobility and supported by appropriate national S&T acquisition. R&D managements shall focus on the "top-down" approach in order to ensure all R&D programmes and projects are in line with the e-Mobility development in the longer term.

11 The uncertainty of the market entrance amongst e-Mobility vehicles poses some problems for national planners, both the government and the industry players, to embark on any planning initiative towards adoption of e-Mobility in the local scene. The study therefore undertook a foresight exercise to determine reasonable timeline for the e-Mobility vehicles entering the local market in significant number respectively. The timeline also considers

locally produced or imported models and all relevant factors including all support infrastructure that need to be in place to support their operations.

12 To establish the market entrances timeline for various EEV with respective powertrain types, data on vehicle stock projection towards 2050 by OPEC is the most useful reference avenue as the organisation is very influential in determining the world oil prices. It is an accepted fact that as long as the global oil prices remain low, EEV market penetration would remain difficult.

Postulation exercise based on the OPEC vehicle stock projection and the estimated global "Total Industry Volume (TIV)" growth towards 2050, it is estimated that the HEV will make the market entrance globally in the big way by 2020. Whilst PHEV powertrain vehicles will aggressively enter the global market by 2026 and BEVs will making their market in road as early as 2030. FCVs on the other hand are fundamentally BEV but are incorporation on board with fuel cell charging technology. The hydrogen powered fuel cell frees the vehicles from having to seek charging station when their battery energy level are low, instead the battery are continuously being charged as the vehicles are being driven. The expected mass market entrance of the FCV is by the year 2035. The foresighted timeline was in general accepted by participants in one of the stakeholders engagement conducted the study team.

It is noteworthy that efficient EEV will remain in demand with continuous market growth but will begin to slide beyond 2040 as the e-Mobility vehicles are capturing much bigger market share. In addition price of oil will be expansive beyond 2040 due to depletion of reserves.

13 The study proposes an automotive roadmap towards 2050 that is developed based on the above foresighted market entrance and mass production timeline. The roadmap comprised of short, medium and long terms to guide the stakeholders in all their planning endeavours venturing in powertrain evolution from existing ICE technology to low carbon technology to zero-emission technology. At the same time, critical vehicle technology such as integrated digital engineering, advanced integrated active safety, big data movement, advanced green nano materials and autonomous driving are also outlaid in the roadmap for various development planning.

14 Industrial experts seems to agree that fully-autonomous vehicles have a long way (beyond 2040) to be perfected for mass production and utilisation as the technology will impact the mobility culture, massive adoption and adaptation processes to go through before full acceptance by the society. However R&D focus on developing and perfecting autonomous vehicle will continue extensively from now on. It is estimated in 2050, the automotive industry will contribute to 15% of GDP and will generate 1.5million employment.

15 Key strategies were proposed setting the direction for all initiatives guided by the roadmap with common objectives as follows;

i. To change public perceptions on the practicality and the potential advantages of e-Mobility vehicles.

ii. To ensure that e-Mobility vehicles purchase and ownership costs and other operation conveniences are sufficient and sustainable.

iii. To encourage collaboration and integration amongst stakeholders to develop a sustainable and viable e-Mobility ecosystem.

Key initiatives to be included under the roadmap are:

i. Introduction of effective e-Mobility governance
ii. Development of e-Mobility infrastructure
iii. Public exposure to the e-Mobility concept and operation
iv. Creating a strong e-Mobility R&D community
v. Development of business collaboration within e-Mobility value chain

15 The study put forward recommendations of action plans where the government solely has major role to play particularly on the governance aspects of the e-Mobility venture, where various policy instruments are broadly identified. Development parameters needed to be in place for e-Mobility entrance locally are also recommended, where government leadership is needed in the planning, implementation and coordination.

Roles of industry and technologies respectively are also outlined in the recommendation for actions, where collaborative efforts are the essence for successful e-Mobility adaptation by the nation.

Chapter 1: Overview of Malaysia Industry

1.1 Overview

Economic transformations amongst developing nations customarily follow a predetermined sequence; from a state managed economy to privatisation of major state owned services to market liberalisation and finally to a globalised economy. Malaysia began to transform its economy with the implementation of The New Economic Policy (NEP) in the early ’70s while the nation was still a resource based country depending largely on its rich natural resources; rubber, tin, timber, oil , et cetera. The NEP envisioned a just social and economic transformation to alleviate poverty as well as fair sharing of the national wealth amongst its populace. Tertiary education for the young was instrumental as a means to expedite the economic transformation, while agriculture activities were intensified and unused land were acquired for large palm oil production. Progress made during the era of the ‘70s set the foundation for further economic transformation for the nation beginning in 1980.

The growing number of highly educated youth towards the end of the ’70s necessitated the creation of more employment opportunities in sectors other than agriculture. Industrialisation was the obvious choice in order to provide more jobs for the highly qualified younger populace of whom many were science, engineering and business related graduates.

To date, Malaysia has had more than 30 years of experience in automotive manufacturing, which was selected as the impetus for the nation’s industrialisation process, and began with the inception of national automotive industry, PROTON, in 1982. The automotive workforce of the nation now has extensive experience having gone through various stages of automotive development from vehicle cosmetic uplifting exercises to variant creations and later to the introduction of new platforms of vehicles.

The key question now is – will the current workforce and the assets invested thus far, within the automotive ecosystem, be able to face even greater challenges with the rapid evolution of automotive technologies that are now coming on to the world stage?

This chapter provides a brief preliminary review of the Malaysian automotive industry. It identifies the automotive industry strategic development over the past decades and the gaps within the existing industrial ecosystem.

1.2 Background of the Malaysian Automotive Industry

The inception of the first national automotive project, PROTON, in 1983 was the Malaysian government's initial attempt to increase local automotive manufacturing. The goal of which was to bolster the industry to achieve economies of scale and to upgrade from merely an assembly industry to a manufacturing industry with international competitiveness (Abdul Somad 1999). The first batch of PROTON cars were rolled out in 1985 and subsequently the second national automotive project, PERODUA, was established in 1993 to produce small cars. To further enhance the vehicle manufacturing sector; Malaysian Bus and Truck (MTB) was incorporated in 1994 followed by the incorporation of light vehicle commercial manufacturer INOKOM in 1997 and motorcycle manufacturer MODENAS in 1995 (MIDA 2009).

These manufacturers in turn began to consume some of the upstream outputs and other resource based manufacturing within the country. Small and medium industries mushroomed and became well spread throughout the country, transforming raw materials into parts and components required by the assembly industries.

Success appeared imminent for the Malaysian industrialisation programme which was reflected by its high annual growth rates of more than 8%, achieved in the mid '80s. More prominence was shown by the automotive sector when the total local passenger car production, which was merely 80,000 units in 1985, attained a total of more than 330,000 units in 1997. Total industry volume of both passenger and commercial vehicles was more than 440,000 units in the same year, outpacing neighbouring countries. Capturing more than 70% of the local passenger car market, both PROTON and PERODUA were on the road to success as major automotive players in the local scene. The automotive sector at the time was one of the major jobs providers for the young populace, nurturing them towards becoming skilled workers able to further enhance the nation's industrialisation endeavour.

The "Heavy Industry Corporation of Malaysia (HICOM)", inaugurated in 1980, was the custodian of these locally established assembly industries and some of the component manufacturing industries and was responsible for strategic developments of related industries in other sectors towards industrialising the nation. Guided by the Malaysian Industrial Master Plan (IMP), HICOM commenced the implementation of projects within the realm of an industrialisation ecosystem familiar to all industrialised countries. Upstream projects such as PERWAJA Steel, and many petrochemical establishments in the east coast were to translate the natural resources to cater for the raw material needs by the middle-stream and downstream industrial activities respectively.

The apparent success of the automotive industry then has given the nation hopes that the supporting upstream and the middle-stream industries such as; large foundries, forgers, large moulds, die makers and sheet metal producing mills to develop. The development of these supporting upstream and middle-stream sectors of the industrialisation ecosystem are important for Malaysia to venture into other downstream industrial endeavours such as shipbuilding, aerospace and military hardware, and thus move the nation towards an industrialised country.

1.3 Industrialisation Initiatives

1.3.1 Industrial Development Ecosystem

Figure 1.1 demonstrates the linkages of various industries that must coexist within an industrial ecosystem to ensure the eventual success of a developed nation from an industrial aspect. The industries respectively fall in five sectors that link together in order to ensure industrial movement takes place.

The ***Manufacturing Sector*** which operates on the downstream of the industrialisation ecosystem consists of assemblers (or OEMs) supported by the sub-assemblers (or Tier 1) and parts and components manufacturers, which comprise of Tier 2 and Tier 3 and the other automotive related Small and Medium Industries (SMIs). Correspondingly, players at the lower level of the value chain manufacture parts and components which are then sub-assembled and fully assembled as finished products for consumers, both domestic and for export.

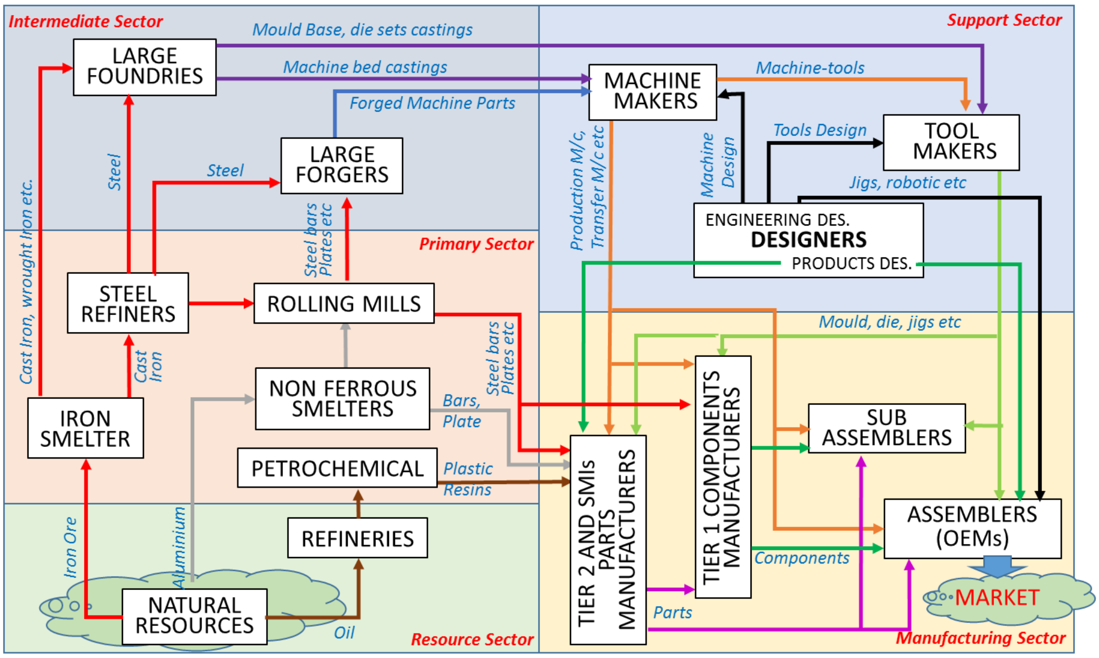


Figure 1.1: Industrial Linkages within the industrialisation ecosystem

The industries within the manufacturing sector depend on the ***Supportive Sector*** for the supply of tooling; moulds, dies, jigs, and fixtures, needed for the manufacture of products. Replenishment of machinery and new investment and expansion in the manufacturing activities call for the machine makers to fabricate new machines and equipment such as; injection moulding machines, press machines, die-casting machines, et cetera, needed by the industries within the manufacturing sector.

Engineering Designers play their role in designing the required machinery and equipment with advanced engineering so as to enhance the production capabilities of the industries in the manufacturing sector. On the other hand tooling requirements are designed and developed by Engineering Designers specialised in tooling technology.

The success of the manufacturing sector is largely dependent on the ability to generate new product ideas, which is then followed by designing and development of the products for the marketplace. In this respect, the role of Industrial Designers will become most crucial due to their effort and abilities to develop new products and prototypes in order to capture the market needs.

The Supportive Sector comprises of industries such as designers, toolmakers and machine makers which consists of highly skilled technocrats performing the core activities needed in the industrialization movement.

The roles of the Supportive sector will not be effective without the coexistence of the large-scale foundries and forgers in the ***Intermediate sector***. The machine manufacturers in the Supportive Sector require sophisticated and high quality cast and forged items to produce the various machinery and equipment. Parts such as machine-beds can only be produced by foundries capable of melting large volumes of molten iron and steel. Those from the foundries also possess the advanced know-how in the pattern making, moulding, melting and finishing techniques. Heavy capital investment is needed in order to equip these foundries with modern furnaces, laboratory and testing facilities.

On a similar accord, without the existence of large-scale foundries, large mould bases and die-sets required in the toolmaking for large plastic and metallic components would not be possible. Foundries with large melting capacities and have extensive knowledge in metallurgy and heat-treatment of metals are crucial to support the tool-making endeavours in the supportive sector.

The ***Primary Sector***, the upstream players, comprises of the main producers of the input materials required by the downstream sectors within the industrialisation movement. The smelting industries transform the raw iron into useable materials such as; cast iron, wrought iron, et cetera which are needed by the foundries and steel refiners. While the foundries use the input iron to formulate suitable ferrous materials for various machines and tooling parts application, the steel refiners refine the iron into various types of steels for use in forging and other industries in the downstream activities. The steel is then rolled or formed into various cross-sectional shapes and sizes, by rolling mills, for the consumption of steels parts producers in other sectors described earlier.

Non-ferrous materials supplied by the ***Resource Sector*** such as aluminium and copper are converted by the Non-Ferrous Smelters to usable quality and grades for the consumption by the downstream industries. Similarly, oil by-products such as plastics and various types of resin are processed by the Petrochemical industries for consumption during the downstream activities.

The Resource Sector is equally important in the industrialisation movement to explore the natural resources of the industrious nations. Those nations that lack readily available natural resources must outsource from other countries. The resources are then locally processed and can be a major contribution to the industrial ecosystem.

1.3.2 Initiatives from Early Years of Malaysia

HICOM, the key player and the investment arm of the government, was assigned to develop various industries within the industrialisation ecosystem as prescribed above. Automotive production was selected to be the leading industry in the Manufacturing Sector to spearhead the nation's industrialisation endeavour.

Automotive assemblers; PROTON (1985), PERODUA (1993), MTB (1994), INOKOM (1997), HICOM-HONDA (1985) and MODENAS (1995) were established to serve as "puller Industries" which would demand parts and components from the manufacturing sector. In turn, sub-assemblers began their operations to support sub-assembled components which were being demanded by the assembly industries. HICOM – YAMAHA (1983) is an example of these ventures (Peter 2011).

Figure 1.2 illustrates the majority of the companies developed by HICOM to help spearhead the industrialisation programme, while Figure 1.3 charts the milestones of all the related initiatives outlined earlier.

It was during these ten year industrial developmental period that Malaysia saw rapid establishing of automotive vendors and SMIs involved in the manufacture of automotive parts and components required by the assemblers and sub-assemblers. The export of automotive parts was also initiated during this time.

Coupled with the governmental strategic policies in automotive industry and the availability of young and enthusiastic manpower, the manufacturing sector of the nation thrived. In parallel, initiatives to develop other sectors of the prescribed industrialisation ecosystem were also initiated.

PERWAJA Kerteh, founded in 1982, was one of those initiatives to develop the upstream activities, and later followed by the expansion of the company's rolling mill in Gurun, Kedah.

However, further development of other sectors of the industrialisation ecosystem was stopped short except for the manufacturing of petrochemical products by companies mostly developed by foreign investors.

The onset of the Asian Financial Crisis further retarded government initiatives to continue to develop the activities in the primary sector, while activities in the supportive sector and intermediate sector were left unattended.

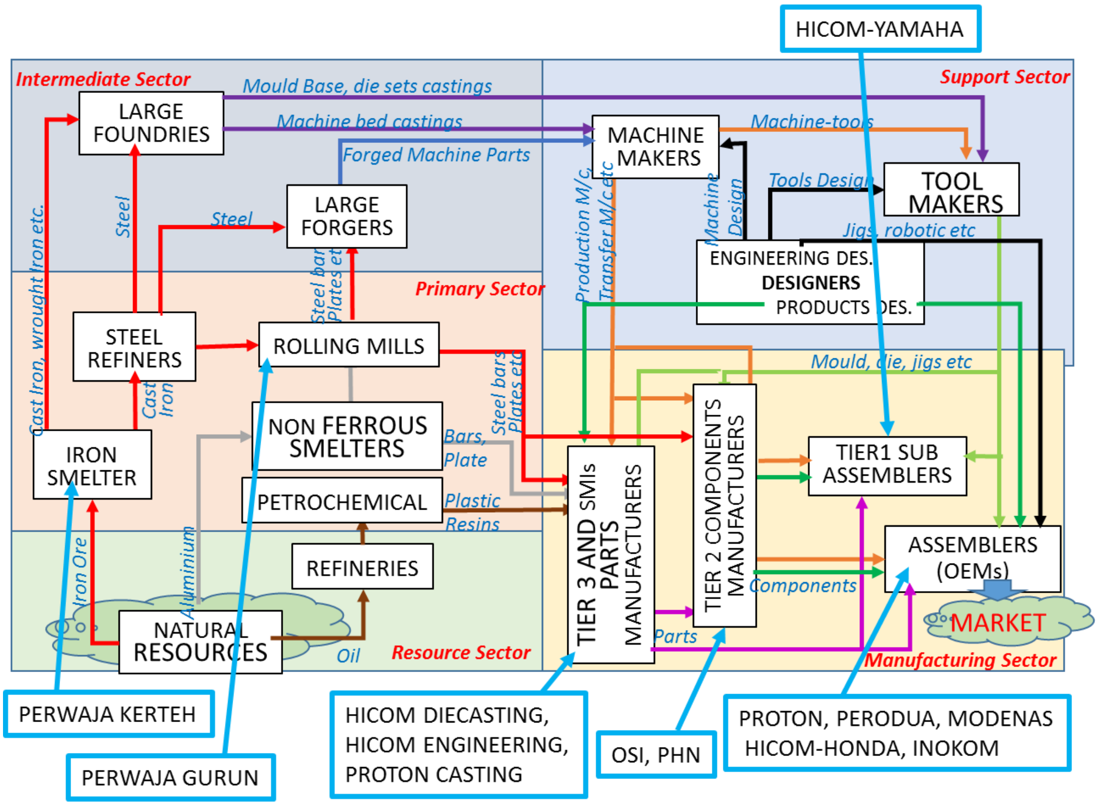


Figure 1.2: HICOM pool of companies to industrialise Malaysia

1.3.3 Fundamental weaknesses in the Malaysian Industrialisation Ecosystem

It is now clear there are weak links between sectors, and industries within each sector, that are the fundamental weaknesses within the Malaysia industrialisation ecosystem and the automotive development ecosystem. Much focus was given to develop the manufacturing sector to create the parts and components manufactures and assembly of the final industrial outputs.

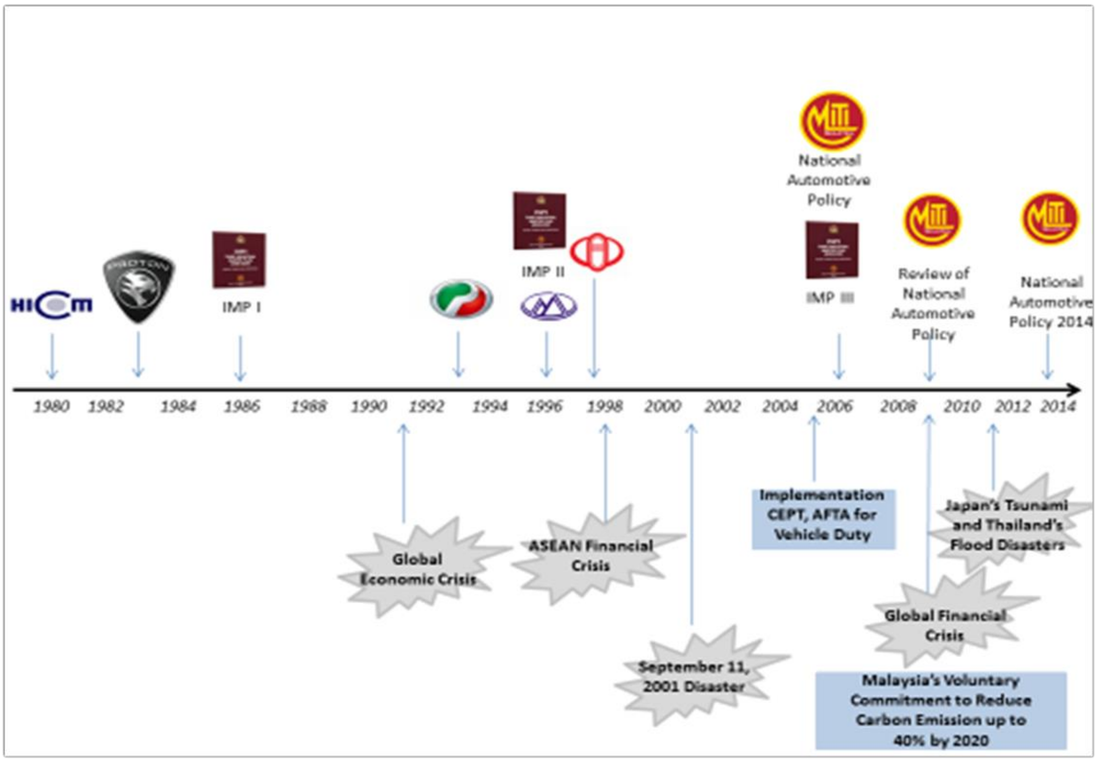


Figure 1.3: Malaysia Automotive Industry Milestone

The underdeveloped Intermediate and Supportive Sectors were rendered significantly weak in the national industrialisation programme. Although IMP2 had given a special focus on these sectors, development of machine making activities were virtually non-existent. Toolmaking activities remained limited to production of moulds and dies of small and medium sizes. The absence of large foundries capable of producing high quality large mould bases for moulds and die-sets for dies further hampered the competitiveness of the local automakers, parts and components manufacturers. These parties had to resort to sourcing their mould and die requirements from overseas, particularly the larger ones.

An attempt to develop the primary sector, focusing on iron and steel production, was made. Howsoever, the lack of appropriate rolling mills to produce the right material profiles and stocks for the consumption of downstream activities had hampered further progress in the steel production initiative. Demand for iron fell short due to the non-existence of large foundries and forgers, whose output demands in turn would depend on machines and toolmaking activities which were weak.

The most crucial amongst the weak links within the national industrial ecosystem was the lack of design capability being underdeveloped during the 30 years of industrialisation initiatives. Engineering designers who were able to design and develop machines, equipment and tooling were largely lacking. Industrial design activities, the ability to create innovative product ideas, automotive or otherwise, became an unrecognised and unattended profession.

1.3.4 Role of governmental institutions

The Malaysian government did not entirely neglect the necessity to develop those weak linkages in the respective sectors within the local industrial ecosystem. Under the various industrial master plans, a few governmental and semi-governmental organisations with the assistance of foreign governments, especially Japan, were allocated finances and were entrusted to set up centres to help spearhead the development of those critical areas.

Standards and Industrial Research Institute of Malaysia (SIRIM) was one organization that was entrusted to develop and to acquire various technologies, namely; welding, electroplating and presswork, mould and dies making, foundry, plastic technology and ceramic technology that were commissioned with the collaboration of Japan International Cooperation Agency (JICA) and SIRIM between 1980 to 1990.

Although most of the technology centres were deemed as pilot plants but the technology installed was advanced enough to develop small and medium range prototypes as well as providing manpower training in those crucial technologies for the private sector manpower requirement.

SIRIM was allocated financial assistance to set up what was earlier known as “Rasa Machine and Equipment Technology” (RAMET) centre located in Rasa, Selangor. The centre was initially planned for SIRIM to embark on acquiring technology required for machinery and equipment development and making. Today the centre is identified as well-equipped foundry facility able to produce various type of small and medium sizes casting products.

Malaysia Technology Park was another organisation entrusted to develop relevant technologies for manufacturing activities such as automated welding, robotics, Numerical Control Machining et cetera, in order to support vendor development towards parts and component manufacturing. Again the centre was more for product development, prototyping and trial production purposes.

1.3.5 Critical Gaps in the Malaysian Industrial Ecosystem Moving Forward

The above discussion highlights the crucial gaps inherent within the Malaysian industrial ecosystem. If these gaps persist, the national manufacturing sector will always be crippled and not be able to compete in the global industrial arena. If this so happens, the Malaysian industrialisation dream by 2020 may not become a reality.

1 Toolmaking

Toolmaking, regarded as the "mother of all industry" is the key for a successful and competitive industrial ecosystem. The industry plays a strategic role in ensuring competitiveness and sustainability in many key industrial sectors, such as; aeronautics, electronics, packaging, house appliances, rubber and, most importantly, the automotive sector. Absence of the sector, with skilled manpower and infrastructure able to design and produce various tooling, namely; moulds, dies, jigs, and fixtures for mass production activities in the manufacturing sector, revival of the domestic automotive, appliances and other manufacturing industries would be difficult to envision. The automotive industry alone accounts for half of all tooling consumption in the manufacturing activities of a nation.

It is noteworthy that for every new model development some 1,500 dies and mould sets are required to produce all the parts required in the manufacture of the model (Federation of Hong Kong Industries 2010). These moulds and dies are required to be completed within the timeframe set for preproduction preparation and mass production of the vehicles, which was 3 years in recent time by a local automaker, Figure 1.4. It is a challenging task for the toolmakers, vendors and the vehicle assembler alike to meet the launching dateline of a new model. The initial development cost is therefore astronomical and most of this goes to tooling, especially the large and sophisticated machines that are to be imported. The manufacturing costs of new models are nonstarter from the day one of its entering the market. Further if the volume sales of the new model is low, especially for the mass production type vehicles. The manufacturer's main concern is whether or not it would be able to compete in the marketplace.

The inability of toolmaking locally has had a significant effect on the home grown automotive companies, effectively rendering them non-competitive in the local scene let alone for the export market.

Statistically, as shown by the USA motor vehicle industry, some 50% of stamping dies produced locally are used in the automotive sector, while some 5% are consumed for agriculture equipment production, 4% by the construction industry, and 4% by the cookware industry (Bill 2012).

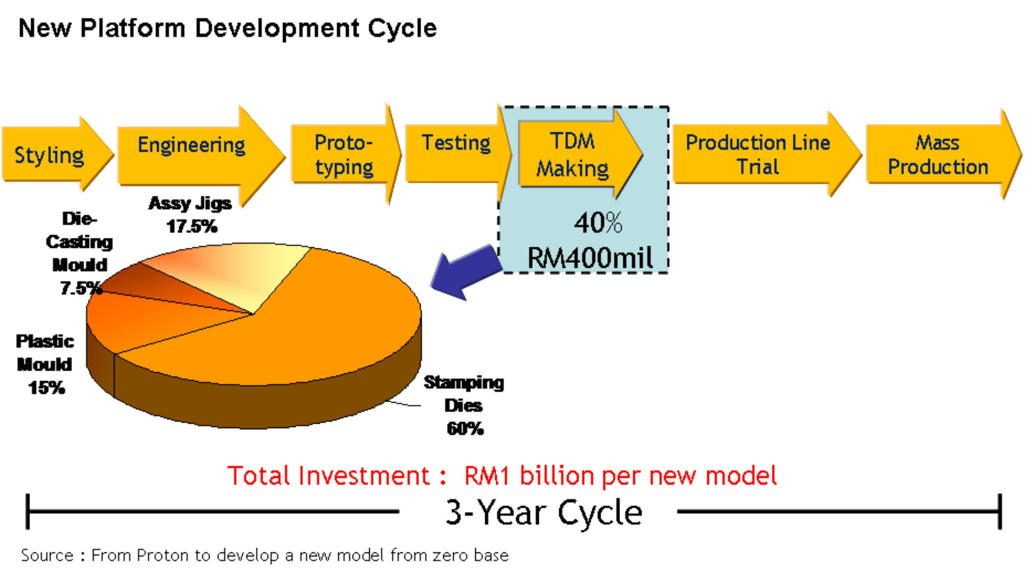


Figure 1.4: New Platform development cycle of Proton Vehicle

There are an approximate total of 240 tool-makers now operating locally, whom are members of the Malaysia Moulds and Dies Association (MMADA), involved in the fabrication of various types of tools for the manufacturing industries. Some 20 of these toolmakers are specialised in mould and die making for the local automotive sector, mostly small and medium sizes.

2 Machine making

Machine making can be categorised into three types, namely; customised machinery, production machinery and machine tool.

Customised machinery comprises of machines that are designed and developed to perform a specific function only, and a simple example would be a paper-clip production machine. The mechanism of the machine would be for the mass production of paper-clips and nothing else.

Automation and robotics can be considered as customised machinery and equipment, while they remain versatile in their application but their function is for mechanisation of industrial operation.

Production machineries are the like of injection moulding machine and die-casting machine. The machine is designed to specifically inject plastic materials into moulds to mass produce plastic parts as determined by the mould profile being attached to the machine. Changing the mould would therefore change the plastic product. Die-casting machines are production machinery for the mass production of aluminium parts by injecting liquid aluminium into dies. Various press machines are another group of production machinery designed to form metal parts from metal plates using dies.

The next category of machine, which is classified as machine tools are; lathe, milling, shaping, grinding et cetera for metal fabrication purposes. Machine tools are vital and needed in mould and die making exercises apart from major application in engineering metalwork.

It is an acceptable argument that machine making is not crucial in most industrialisation movements. However, for a nation that is not able to produce its own machinery and equipment, all initial capital investments for any industrial venture would be at a disadvantage as machines are outsourced from overseas and therefore expensive. Cost competitiveness is low at the initial commencement of any industrial investment.

3 Design capabilities

Designers are generally categorised into three work disciplines, namely; product designers, engineering designers and process designers. In the automotive industry, product designers from the industrial design background with applied art and applied science qualification conceptualise the new vehicle design. They focus on the aesthetic, ergonomic and functionality of the vehicle whilst working closely with the industrial engineers and the marketing team.

In any vehicle design endeavour, they proceed to develop full scale clay models of the vehicle which are useful for physical viewing on the new proposed vehicle design. Clay modelling techniques are still widely used while computer aided software and machineries are nowadays more popularly applied. It is during this modelling stage that design and styling flaws will be detected and corrected.

The engineering designers are tasked to develop the functioning new vehicle prototype. Modification on the powertrain, transmission, suspension and other engineering components of the new vehicle will be the major tasks necessary to fit in into the new design for optimum performance. Process designers are tasked with the design and development of all the tooling requirements during the preproduction stage of the new model. Full scale mass production proceeds upon satisfactory preproduction trial runs.

It is apparent that in all the design stages numerous engineering specialisations are required within the complicated network of developing new vehicles. Hence, the current weakness in designing ability may hamper any further growth of the automotive industry.

Weakness in local product design capability is apparent by the lack of locally available and the exportation of home developed industrial products.

4 Foundry and die-casting

Malaysian iron and steel foundry industries have been in existence dating back to the era of booming tin mining activities. The foundries comprised mostly of small to medium size operators serving largely the lucrative component needs of the open cast mines.

The industry then lacks product diversification and has hardly evolved in terms of technology upgrading.

The collapse of the tin mining sector in the early 1980's has resulted in many of the smaller foundries to cease operations while the medium sized operators have managed to switch their operations to produce other products required by the palm oil industry, quarry industry, water industry, railway, cement industry and some ship repairing or maintenance components.

Products such as mining dredge buckets and crushers are amongst those produced by the larger foundries and still remain in operation to these days.

Most of the medium sized foundries at the time were, by nature, only able to produce components on small batch order quantities, limiting them from supporting the casting components required by the automotive manufacturing localisation venture mooted in the early 80s.

In addition, the complexity in the casting of automotive components has raised doubt on the ability of the surviving local foundries to participate in the automotive supply chain especially the volume of components demand with high quality castings and safety standards requirements.

There were a few modern foundries established towards the late 90s and early 2000s, especially by HICOM. These foundries were better organised and were equipped with modern facilities capable of producing quality iron and steel castings of small and medium sizes.

The lack of large foundries in the local scene specialising in the production of high quality automotive grade iron and steel large castings for mould and die fabrication has resulted in the local automotive players outsourcing these tool components from overseas. The practice, to a certain extent, has rendered local parts manufacturing less competitive cost-wise and models facelift exercises rather expensive.

Non-ferrous parts, in particular that of the aluminium die-casting hardware items, have been produced locally for some time and the experiences have become useful to some die-casting ventures established to produce aluminium parts and components for the local automotive industries.

The lack of local ability to design and fabricate die-casting dies, for gravity, low pressure and high pressure die-casting processes, still pose problems for the local die-casting industry to remain competitive as they have to depend on foreign toolmakers for the supply of their dies requirement.

Most of the local foundries and die-casters employ composition analysis equipment, such as the spectrometer, to determine the alloying composition in their casted parts meeting the customers' specification. However, metallurgical analysis of the alloys is less practiced by most of these foundries and die-casters. Although composition analysis results may indicate to comply with customers' specifications, little microstructural analysis and X-ray examinations are done on castings.

The desired properties of materials are not solely dependent on their alloying composition but the final morphology of the cast structure to constitute the quality of the final products. This is more important when the cast parts are subjected to heat treatment processes after sand casting or die-casting.

5 Forging

Forging activities on the other hand are very minimal in the local scene. Forging is important in the production of critical parts such as crankshaft, camshaft, and flywheel for the production of a vehicle powertrain. The development of these activities was stunted primarily because most local automakers do not source their powertrain parts and components locally as the powertrain was imported whole for their vehicle assembly.

6 Ferrous raw material production

Thirty years have since passed and a few unfavourable episodes occurred, the currency crisis that occurred in 1998 for one, which have led to the fizzling of the Malaysian industrialisation ecosystem. PERWAJA, initially supposed to be the upstream producers of the iron and steel requirement for the consumption of the automotive industry, now remained to be one of the nation's steel producer focussing on the construction sector of the Malaysian economy with little engineering steel being produced.

Continued importation of iron and steel raw materials as input into the production of automotive parts would render the local automotive industry not competitive.

7 Non-ferrous material production

Aluminium is one of the most important non-ferrous materials heavily used in the manufacture of automotive parts and components where light weight is desirable.

The aluminium production process starts with the mining of bauxites, an aluminium rich mineral in the form of aluminium hydroxide. Bauxite is crushed, dried and ground in special mills where it is mixed with a small amount of water. This process produces a thick paste that is collected and heated with steam to remove most of the silicon present in bauxites. At an aluminium smelter, alumina is poured into special reduction cells with molten cryolite at 950℃. Electric currents are then induced in the mixture at 400 kA or above breaking down the bond between the aluminium and oxygen resulting in liquid aluminium settling at the bottom of the reduction cell. Primary aluminium is cast into ingots.

Malaysia is rich in bauxites however the above prescribed aluminium smelting plants are virtually non-existent, an opportunity that was underdeveloped.

8 Engineering polymers

Polymeric materials are a useful by-product of oil and numerous types of polymer parts and components are used in vehicle assembly. However, the existing petrochemical industry locally mostly focus on the production of lower grade polymeric materials and are exported, while high quality engineering polymers are still largely imported.

The above situation has been of much help in lowering the cost of local plastic parts and components for the automotive sector.

1.3.6 National Automotive Policy (NAP) 2014

In cognisance of the above weak linkages within the Malaysian industrial ecosystem, the NAP 2014 has re-examined the alternatives available to remain productive and competitive within the automotive ecosystem per se. Special recommendations were mooted by the NAP 2014 to enhance the capability of those fundamental and crucial activities in the supportive and intermediate sectors, in particular the development of large foundries, large moulds and die making. These are crucial engineering activities with output that is needed by the local automotive industry, and should these outputs continue to be imported will render local automotive parts and components not competitive, cost-wise and design wise, now and in the future.

NAP 2014 has foresighted to develop Malaysia into becoming an "Energy Efficient Vehicle (EEV)" hub in the region. EEVs are vehicles able to fulfil two essential criteria, namely; low or zero emission propulsion satisfying the environmental green initiatives and low energy consumption for a set distance travelled. EEVs are future vehicles to satisfy the international demand for cleaner earth and global energy security. Henceforth, EEV production shall demand a high level of product technology, skilled and knowledgeable manpower, extensive R&D initiatives, more sophisticated production engineering, materials and processes, thereby creating a new "S-curve" needed to revitalise the industry into the future.

Right policy instruments were outlaid in the NAP 2014 for Malaysia to serve as a hub as EEV manufacturing will encourage Foreign Direct Investment (FDI) into the country by reputed global automakers. It is forecasted some 7 million EEVs will be in demand in ASEAN by 2020, while by 2017 some 1.5 to 2 million production capacity is needed to fulfil the regional demand. It is expected more FDI in EEV manufacturing will flow into the country in addition to some already been set up for local production. Malaysia will be the favoured nation in this region for EEV production especially to non-Japanese automakers who are now in need to establish passenger vehicle production bases in the ASEAN region. While the components manufacturing has been liberalised, the presence of strong base local vendors which have no affiliation with any automaker or particular brand will be an advantage, and will be useful parts and components supporters in EEV manufacturing endeavours. EEV will open up opportunities for Domestic Direct Investment (DDI) for the local entrepreneurs to strategically venture into EEV parts and components manufacturing. In all, if Malaysia is able to achieve the desired FDI and DDI, the sustaining production volume required by the local vendors is attainable. This will be further enhanced by the successful penetration of the export markets within the ASEAN region as inspired by the policy agenda.

On the technological development front, EEV will open up a new frontier for local technocrats, academia, R&D organisations, and the players in the entire supply chain to design and develop new products, processes and materials to fulfil the EEV manufacturing requirement. Acute demand for all EEVs is the kerb weight of the vehicles, in which the unloaded total weight inclusive of all the standard equipment and the necessary operating consumables will have to be continuously reduced to achieve their EEV superiority. This prerequisite demands high end technology, extensive R&D, and creative endeavours.

In short, EEV ventures will advance the local talents in many aspects of technological development and capabilities, strategically targeted by the NAP 2014 in areas such as; Powertrain, transmission and related control system, complex mould and die inclusive of large die set and mould base production, aluminium and other non-ferrous casting, design engineering and prototyping, vehicle as well as vehicle sub-system and component testing, and the development of automotive grade steel and engineering plastic.

EEV production will demand higher level of R&D capabilities amongst local technocrats. Researching into light materials, metallic and non-metallic, will be extensive to achieve the lighter vehicle perquisite for EEV. Exploring the potential usage of local materials such as kenaf suitable for EEV light composite body will be an R&D activity in the right direction. R&D in light aluminium and magnesium materials are opportunities open for locally talented metallurgies and engineers to develop components and their manufacturing methodologies for the consumption for the EEV production. Process development such the use of laser welding and hot stamping to shape ultra-high strength steel will be useful endeavours amongst the R&D community.

Lessons learned in the past of the automotive industry lacked in the ability to design and manufacture critical components especially the power train, transmission and related control system has rendered the industry not competitive in model introduction to the marketplace. Henceforth NAP 2014 encourages the enhancement of the local capabilities in areas of digital design and engineering, coupled with rapid prototyping abilities, to assist in the design and development of EEVs. Safety aspects of EEV design and production meeting the international safety standard is a criterion for competitiveness which will be developed and simulated during early design stages of a vehicle.

EEVs will demand a different maintenance requirement away from the current maintenance practice in the aftermarket sector of the local automotive ecosystem. Henceforth the new direction will require retraining of maintenance specialists which opens up job opportunities for a new generation of skilled manpower.

Malaysia's decision to embark on being the hub for ASEAN EEV production is a long term vision to join the global inspiration to clean the planet Earth, and as a developing nation venturing into EEV production it is foreseen as a new launching pad for the nation to uplift its technological capability while providing new opportunity to strengthen its local automotive industry for the benefit of its younger populace.

Successful implementation of NAP 2014 will enhance the competitiveness and business volume of the entire automotive ecosystem, and will indirectly encourage the advancement of the middle-stream industries, and perhaps the upstream activities too, which are needed to further push the industrialisation of Malaysia (NAP 2014).

1.4 Economic and Social Contributions by the Local Automotive Industry

The automotive industry is broadly defined as incorporating vehicle manufacturers, component suppliers, service providers such as toolmakers and the aftermarket sector. The automotive aftermarket sector, inclusive of retail, repair and service are an important extension of the industry ecosystem.

In terms of Gross Domestic Product (GDP) and employment contribution, the automotive industry remains vital to the overall Malaysian economy.

Figure 1.5 tabulates the nation's GDP from 1995 to 2008 reflecting the contribution of the automotive industry to the national economy.

Year	GDP RM (mil)	MANUFACTURING RM (mil)	(MFG/ GDP) (%)	T&E RM (mil)	(T&E/MFG) (%)	MOTOR VEHICLES RM (mil)	(MOTOR VEHICLES /T&E) (%)	AUTO PARTS & COMPONENT RM (mil)	(AUTO /APC) (%)
1995	166,625	45,174	27	4,156	9	1,446	35	1,184	28
1996	183,292	53,387	29	5,552	10	2,721	49	1,133	20
1997	196,714	58,788	30	6,819	12	3,798	56	1,371	20
1998	182,237	50,898	28	3,359	7	1,424	42	1,085	32
1999	193,422	56,841	29	6,309	11	2,341	37	1,786	28
2000	356,401	109,998	31	13,270	12	2,952	22	2,456	19
2001	352,579	103,434	29	15,330	15	6,132	40	3,066	20
2002	383,213	112,076	29	16,513	15	6,605	40	3,303	20
2003	418,769	125,332	30	17,474	14	6,990	40	3,495	20
2004	474,048	144,007	30	20,094	14	8,038	40	4,019	20
2005	522,445	154,657	30	21,208	14	8,483	40	4,242	20
2006	573,736	169,761	30	21,598	13	8,639	40	4,320	20
2007	641,864	179,522	28	20,578	11	8,231	40	4,116	20
2008	740,721	195,027	26	23,781	12	9,512	40	4,756	20
Average	**384,719**	**111,350**	**29**	**14,003**	**13**	**5,522**	**40**	**2881**	**25**

Figure 1.5: GDP Contribution by the Automotive Industry

The automotive industry is classified under the Transport and equipment subsector of the Malaysian economy. The manufacturing sector averagely accounted some total of 29% of the total GDP, out of which 13% was contributed by the transport and equipment sub-sector. The automotive industry, inclusive of motor vehicles and automotive parts and components, accounted for 65% of the Transport and Equipment subsector whilst the balance were contributions from other industries, namely; aerospace and marine. Hence, the automotive industry, inclusive of Parts and components, contributes some 8.5% towards the manufacturing sector, whilst the industry contribution to GDP would account to an average of 2.5% . In comparison, the manufacturing sector of the USA contributes on average 11.5% towards the national GDP whilst the national automotive industry contributes some 3.5% towards its GDP (Kim et al 2010).

The automotive industry is a major provider of employment opportunities to the Malaysian engineering skilled workforce. Figure 1.6 (DOSH 2015) shows the employment statistics in the automotive industry from 2004 to 2008 demonstrating a steady and gradual annual growth and, to date; the total employment in the automotive sector has attained some 60,000 workers and contributes 5.84% of the total employment in Malaysia.

Employment in the Automotive Industry

	2004	2005	2006	2007	2008
Motor vehicles	19,469	20,618	21,834	23,122	24,997
Parts and Components	25,959	27,491	29,113	30,831	33,330
Total	**45,428**	**48,109**	**50,947**	**53,953**	**58,327**

Source : EPU dan Kementerian Pembangunan Manusia Malaysia

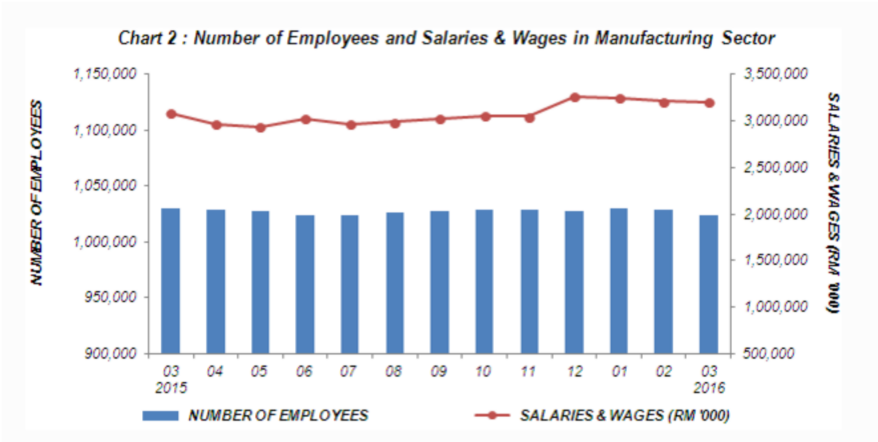


Figure 1.6: Employment in the Automotive Industry

While the above presents the direct contribution of the automotive sector to the nation's overall economy and employment, the indirect spill-over benefits within the entire automotive ecosystem are significant. The direct employment is in the form of the manufacture of vehicles, parts and components production per se, while indirect employment can be viewed as a backward linkage from toolmaking to raw material suppliers as portrayed by the industrial linkages earlier. More importantly, the aftermarket sector that developed out of the automotive manufacturing, namely; repair and maintenance, fuel supply, indirect services of all sorts (e.g. financial, insurance), auto recycling and remanufacturing activities and capital goods which supply them.

It is the linkages between automotive production, parts and components manufacturing and the aftermarket activities that clearly illustrate why the automotive industry is crucial to the long term growth of Malaysia. The current total indirect employment within the automotive sector is estimated to be some 350,000 (MIDA 2009). The automotive supply chain provides numerous businesses, employment opportunities and skill development to the national workforce. In short, despite the current unfavourable perception as to the future of the nation's automotive industry, all challenges must be confronted to ensure the survival of the industry so it can continue to play its role as an economic contributor to the nation.

The social make-up within the automotive industry is diagrammatically represented in Figure 1.7.

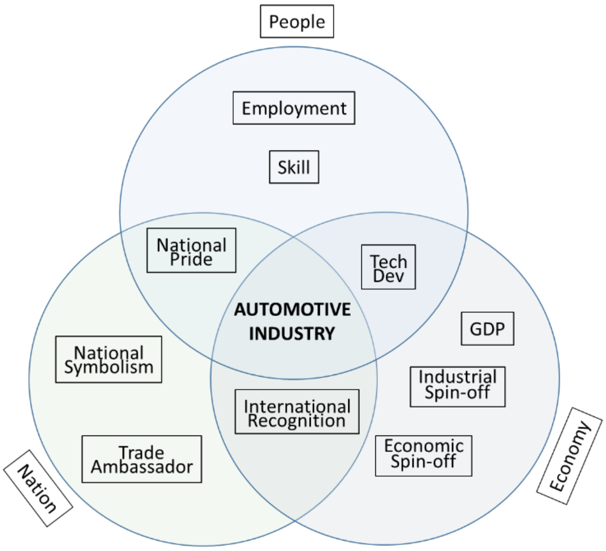


Figure 1.7: Economic and social linkages promoted by automotive industry

The earlier foundation of Malaysian automotive industry, strongly driven by the government, is to focus on enhancing three main factors of the nation's social fabric, namely; the nation's human capital development, its economic advancement in industrialization and promotion of national pride through automotive driven industrialisation.

People and economy is paramount in the industrialisation initiatives. The establishments of various automotive assemblers that consume parts and components in their respective vehicles assembly have led to the establishment of numerous automotive vendors. As at 2008 there were approximately 690 vendors (MIDA 2009) manufacturing and supplying over 4000 parts and components, where 70% was consumed by the local OEMs and the balance were for the parts replacement market. During the same year, RM6.37 billion in sales were attained by the local parts and components manufacturers with RM4.6 billion for local consumption while RM2.0 billion was for export. In 2015, the automotive parts and components account for 87% of Malaysia's total exports of automotive products, amounting to RM9.77 billion, that is 3.3% higher than 2014.

It is apparent that the local automotive industry has had the capacity to generate the economic requirement towards the nation GDP by providing business spin-offs benefiting the entrepreneurs of becoming vendors to the assemblers, generating some 58,000 jobs in 2008, in Figure 1.6. Proton and Perodua have the largest share of workforce with nearly 70% of the total employment of motor vehicle manufacturers. The industry recorded 4.9% annual average growth rate of employment over the past eight years. Thence, further social benefits towards the working population is the provision of steady employment opportunities, and in turn the workforce are able to develop their engineering skills for the automotive industry as well as other sectors of the nation's industrial establishments.

More importantly, in order to enhance the economic achievements and skills capability of the workforce, technology development is the resultant spin-off such as adoption and adaption of advanced machinery and equipment and intensification of research and development in all aspects of sciences and technologies relevant to the automotive industry.

Vision 2020 was the driving force towards industrialising Malaysia. It acted as a common goal for the national populace to realize the set target of Malaysia achieving an industrial nation status in 2020. The Malaysia automotive production is the key player to drive the vision and it was perceived as a national pride.

Malaysia marques produced by Proton and Perodua were beginning to enter the international market and, to a certain extent, became a national symbol and trade ambassador on the global stage, promoting national pride for the nation's populace. Historically the national car projects were able to attain the international recognition to some extent in which the nation can economically benefit from the international market.

The Malaysian automotive industry has expanded production five times over the years from 1980 to 2009 and has evolved from an assembly industry towards a manufacturing industry focusing on passenger car manufacturing while generating rising employment and national GDP bringing both economic and social benefits to the nation's populace.

1.5 A Glance into the Future – Demand for Automobiles

The number of passenger cars has been on the increase since 1970 with a total global production of 218 million for the year. Figure 1.8 shows the total global production for the next 10 consecutive years with figures for the year 2013 and 2014[8]. The share that developing countries represented in the global vehicle production has increased significantly over the period. In 1970, the nations produced some 6% of the global total, but in 2013 this figure had increased to 31%.

Significant increment in passenger vehicle ownership occurred in the developing countries between the years 2000 to 2014. During this period, the number of passenger cars increased by 205 million in the region, while the increase in the OECD was 101 million. While the number of vehicles in the OECD region tripled between 1970 and 2013, in developing countries it multiplied by almost 24 times.

million

	1970	1980	1990	2000	2013	2014
World	218	360	491	665	993	1022

Figure 1.8: Global passenger vehicle ownership since 1970

Figure 1.9 demonstrates the forecasted global figure for passenger vehicle ownership from now till 2040. The worldwide vehicle ownership is expected to more than double in 2040 compared to 2014, increasing from just over 1 billion to more than 2.1 billion[8]. Developing countries are anticipated to account for about 86% of the rise in the number of cars over the period 2014 to 2040. Countries in Asia, other than China and India, are expected to increase to around 101 million vehicles during the period.

India is expected to see the highest growth rate, followed by China and then other countries in Asia. China is forecasted to be the biggest market and producer of passenger vehicles in 2040 surpassing North America around 2030. The number of passenger cars in developing countries is expected to overtake OECD countries in 2026.

Figure 1.10 shows the forecasted global demand for commercial vehicles towards 2040. It is foreseen that the developing countries will be the major producers of commercial vehicles owing to the rapid development taking place in these countries. The number of commercial vehicles globally is projected to grow at an average rate of 3.1% p.a. to reach 493 million in 2040 as compared to 212 million in 2014. This growth in commercial vehicles is in tune with the economic growth of the respective nation, with developing countries being the major producers, particularly from the Asian countries.

millions

	2015	2020	2025	2030	2035	2040
OECD America	277	297	315	332	347	360
OECD Europe	253	260	266	273	278	284
OECD Asia Oceania	93	95	97	98	98	98
OECD	**623**	**652**	**679**	**703**	**724**	**742**
Latin America	76	83	95	106	117	127
Middle East & Africa	29	36	44	54	65	78
India	22	36	58	93	144	218
China	129	197	279	366	451	524
Other Asia	53	75	103	136	176	220
OPEC	43	56	73	93	117	145
Developing countries	352	484	651	848	1,070	1,311
Russia	45	51	55	57	57	57
Other Eurasia	34	38	43	47	52	57
Eurasia	79	89	97	104	110	115
World	**1,054**	**1,224**	**1,427**	**1,654**	**1,903**	**2,167**

Figure 1.9: Projection of number of passenger cars towards 2040

millions

	2015	2020	2025	2030	2035	2040
OECD America	37	41	45	50	54	58
OECD Europe	38	43	47	52	57	62
OECD Asia Oceania	26	26	26	27	27	27
OECD	**102**	**110**	**119**	**128**	**138**	**147**
Latin America	19	22	26	31	35	40
Middle East & Africa	13	16	21	25	31	38
India	13	17	24	33	44	56
China	23	30	38	48	58	69
Other Asia	25	36	48	62	79	99
OPEC	14	16	18	21	25	29
Developing countries	107	138	175	220	272	331
Russia	6	6	6	6	7	7
Other Eurasia	4	5	6	7	7	8
Eurasia	10	11	12	13	14	15
World	**219** **493**	**259**	**306**	**361**	**424**	

Figure 1.10: Projection of number of commercial vehicles towards 2040

The above forecast foresees that the automotive demand will continue to be the main economic contributor to global, regional and national GDP towards 2040 and beyond. Nations, as well as international automotive corporations, will continue to position themselves to be the takers of the possible economic pie promised in the future. However, much of their respective achievement will be largely dependent on their adaptability to the technology waves that are currently changing in the global mobility.

Alternative technologies, to the current internal combustion engine (ICE), are now being developed and successful prototypes are available awaiting for global acceptance and adoption for mass manufacturing to replace the ICE powertrain.

In the meantime, fuel efficiency improvements in the ICE have been the major initiatives by most automakers to satisfy both the environmental regulations and fuel saving per distance travelled which is attractive to the consumers. Continued developments and improvements in both engine and non-engine technologies of vehicles, such as; improved powertrains, better aerodynamics and weight reduction have increased fuel efficiency of today's vehicles.

Popular powertrains that have gained world attention as having the potential to replace the ICE vehicles are; the "Hybrid Electric Vehicle" (HEV), "Plug-in Hybrid Electric Vehicle" (PHEV), "Battery Electric Vehicle" (BEV), and fuel cell electric vehicle (FCEV). Alternative fuels technologies too are now becoming common knowledge amongst automotive users, such as the LNG and biomass vehicle powertrain.

Forecasting the market penetration of these alternative technologies is the challenges of consumers' attitudes, education, habits, national legislation, infrastructure and mobility conveniences as the determining factors of their respective usage. Issues are often mixed with economic and social considerations in their wider application for general mobility. As a result, replacement of the alternative technology vehicles may not be expected to gain significant market share in the near foreseeable future.

However, the expected evolution of passenger vehicles are foreseen to continue with a steady growth for both oil-based and alternative fuel powertrains. It is foreseen that petrol base vehicle powertrains will continue to dominate the global market up to 2040, beyond which the expected decline in global market share from current about 81% to 56% in

2040 (OPEC 2015), while the diesel driven powertrain will increase from 14% to 21% between now to 2040.

While it is predicted that petrol and diesel driven powertrain will remain significant until 2040, some countries have pledged and are already taking aggressive measures to reduce ICE cars and other forms of transport that caused pollution. In this regard, Germany is actively taking all efforts to ban the sale of new petrol- and diesel-powered cars by 2030 and hopes to reduce its carbon dioxide output caused by cars and other forms of transport between 80 and 95% by 2050 (http://www.ibtimes.co.uk).

In order to achieve this target, the German government introduced subsidies in early 2016 and provide financial aid to buyers of electric cars, similar to the £4,500 discount buyers receive in the UK. However full electric vehicles utilisation would not enter the market place in the very near future and according to the vehicle registration authority, only about 130,000 hybrid and 25,000 all-electric cars were registered in the country as of January this year, compared to 30 million petrol cars and 14.5 million diesels. This indicates that as much as the environmental factor is pressuring the automotive industry to shift from fossil to alternative powertrain technology the consumers and the market are imperative ultimately.

The end of 2015 marks the completion of the fifth full year of HEV and PHEV sales to key markets from major automakers. The PHEV is now well-established in North America, Europe, and developed Asia Pacific markets due largely to strong government support through vehicle fuel efficiency regulations, as well as purchase incentives. The weaknesses to widespread adoption of electric vehicles technologies, inclusive of; HEV, PHEV and BEV, do exist such as the plunge in oil prices that began in mid-2014. However, the global light duty EV market is expected to grow from 2.6 million vehicle sales in 2015 to over 6.0 million in 2024 (Navigant Consulting).

HEV is projected to grow from now by 1% to 14% in 2040. The number of BEV and FCEV are also projected to increase. But considering their negligible market share, the growth is not significant and the shares will remain below 1% in 2040, or in excess of 20 million units. LNG vehicle powertrains are expected to grow considerably, relative to other non-oil based powertrains, with their forecasted increase in global share market from the current 2% to 6% in 2040.

In all, improved fuel efficient petrol drive ICE will continue to dominate from now to 2040, and is forecasted to begin declining beyond 2040 as the non-fossil fuels vehicles begin to capture the world market (OPEC 2015). Continued improvements in fuel efficiency for passenger vehicles are on-going in light of established standards and efficiency targets for most countries. In addition to the established standards and targets in favour of improving fuel efficiency, automakers in a global competitive environment offer more efficient vehicles to the marketplace.

However, the life timeline for the efficient ICE may be made shorter by the disruptive EV technologies rapidly being developed and soon to be introduced to the marketplace as exemplified by Tesla USA and Faraday Future from China. Figure 1.11 illustrates the key revolution of automotive technology anticipated towards 2050.

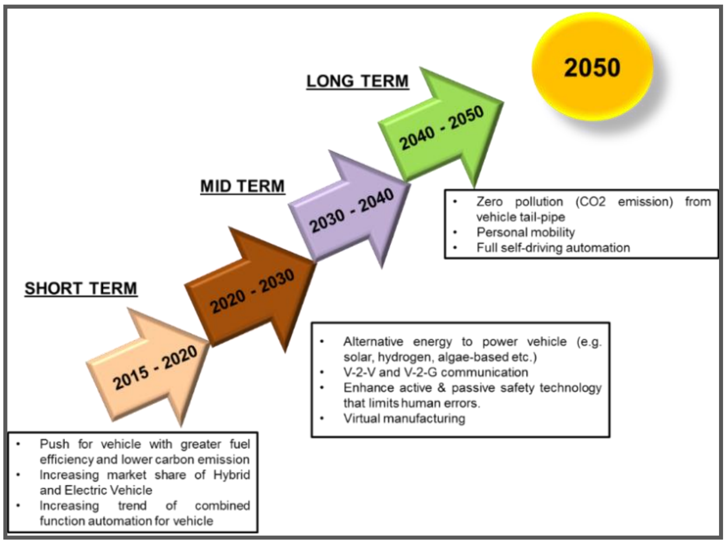


Figure 1.11: Automotive Key Revolution Moving Towards 2050

It is noteworthy to highlight at this stage that all the EEV prescribed above will eventually be developed towards the ability to operate autonomously. Autonomous technology, driver free driven vehicle, has proven to be successfully developed and this development will alter the mode of human mobility on road.

1.6 Future anticipation

1.6.1 Fundamental technologies

The current mass manufacturing technology and processes will mostly remain relevant but with continuous innovation for operational efficiency. Meanwhile, vehicle technologies will continue to rapidly evolve towards a more efficient powertrain and enhanced environmental friendliness.

It is foresighted that the efficient ICE shall remain the primary powertrain of vehicles in the global market, with innovation toward less emission, a combination of ICE and electric powertrain, like the HEV and PHEV. However, beyond 2040, the domination of ICE will slowly diminish with zero emission powertrain, with EV and Fuel-cell dominating the global market.

Taking cognisance of this foresight, the Malaysia automotive industry, with its present capability to manufacture the current ICE powered vehicles can continue to innovate and to remain in business without the fear of the ICE technology being disrupted in the shorter to medium term, Figure 1.11. However, aggressive innovation is crucial within the industry ecosystem so as to be competitively winning the sizeable and sustainable market size from now to 2040 and beyond. Being able to enter the zero emission vehicle market as soon as possible is a strategic advantage.

It has to be reiterated here that the current fundamental weaknesses within the industrial ecosystem prescribed earlier must be overcome to ensure the automotive sector is fully supported to be able to compete and to continuously grow and capture the global market. Critical actions to overcome these fundamental weaknesses within the industrial linkages are;

1. Enhancement of the domestic toolmaking capability (design and making), especially the manufacture of large moulds and dies required in the vehicle manufacturing at all level, albeit OEM and vendors.
2. Alongside the development of toolmaking, large foundries must be present to support casting needs of the toolmakers.

3 Enhancement, or retraining, of the current experienced engineers to elevate their toolmaking capabilities is essential with particular attention given on the tool design and engineering aspects.

4 The establishment of the large foundries shall be the foundation for the local industry to embark on machine and equipment making furthering the business scope of the foundry investment. Advanced automation and robotics should be developed to support mass production activities with efficiencies and enhanced products quality.

5 To ensure capability in machine making, the forging industry has to be developed.

6 To complete the fundamental support of Malaysian industrialisation, as well as the automotive industry, the availability of both product designers and engineering designers is a must. Engineering designers will ensure toolmaking is localised and their design sophistication are ascertained. Product designers are needed to ensure locally produced vehicles will reflect the Malaysian cultural identity and at the same are accepted by global customers. Spin-off of manufactured goods may add business dimensions to vendors as industrial designers are creative personnel able to visualise new product ideas and design that capture the interest of customers.

7 Malaysia is in need of steel production activity, an industrial foundation that will ensure downstream manufacturing activities are competitive. Continuous importation of steel, of all shape and sizes, will render cost of manufacture of Malaysian product, including automotive vehicles, parts and components and other manufactured products to remain high and therefore not competitive.

8 Locally available bauxite is an advantage for Malaysia to develop aluminium raw material production for the consumption of downstream manufacturing activities. More so with the government vision of creating Malaysia as the hub for EEV production in which aluminium is the key material for weight reduction of these vehicles.

9 Malaysia being an oil producing country is a major exporter of polymeric materials. However the current focus on producing lower grade plastics is of no significant advantage for the local automotive industry which consumes high end engineering plastic, the like of Acetyl Copolymer as an example. Venturing into the production of high end engineering plastics will help reduce cost of automotive parts locally as well as add value to the nation’s plastic exportation.

10 In addition to factor 9 and 10 above, EEV requires the use of advanced composite materials, both the polymeric composites and metallic composite (mostly aluminium base). Enhancement of both aluminium production and engineering of plastics will certainly help develop the advanced composites technology locally.

Strengthening and developing the above fundamental technologies should run in parallel while the local automotive industry is proceeding to develop their EEV initiatives. These non-disruptive technologies are needed in the longest term as they are key industrial manufacturing elements to a successful industrialisation.

1.6.2 Automotive industry disruptive trends

Commonly agreed by industry players and experts is that there is a rise to four disruptive technology driven trends in automotive sector, namely diverse mobility, autonomous driving, electrification and connectivity. The trends will reinforce and accelerate one another towards disruption of the conventional automotive industry foreseen in 2030. The trends may affect the growth and alter the business model of the future automotive industry by affecting traditional vehicle manufacturers and suppliers, potential new players, regulators, consumers, markets, and the automotive value chain.

Shared vehicles mobility is foreseen to be the trend of human diverse mobility as soon as 2030 (Paul, G. et al 2016), requiring a new business model amongst automakers that could expand their respective revenue by 30 percent. The concept will allow the vehicle to become a platform for drivers and passengers to use their time freely while commuting for personal activities. The expected advancement may affect the current preinstalled software in vehicles, which now are more for vehicle control and monitoring. The requirement for regular software upgrading to facilitate the autonomous travelling will require automakers to restructure their vehicle manufacture, sales and maintenance endeavours.

Overall global car sales will continue to grow, but the annual growth rate is expected to drop from the 3.6 per cent over the last five years to around 2 per cent by 2030. This drop will be largely driven by macroeconomic factors and the rise of new mobility services such as car sharing. This new mobility concept may result in a decline of private-vehicle sales, but this decline is likely to be offset by increased sales in shared vehicles that need to be replaced more often due to higher utilization and related wear and tear.

The traditional use of vehicles for all purposes may be altered by this new mobility concept. There is flexibility to choose the best travelling choice for a purpose, albeit for work or for recreational travelling and the choice can be made on demand and via smartphones. As a result of this shift to diverse mobility choices, it would be likely that one out of ten new cars sold in 2030 may be a shared vehicle, which could reduce sales of private-use vehicles. Based on this trajectory, one out of three new cars sold could potentially be a shared vehicle approaching by 2050.

Car ownership is already becoming a burden for many users due to congestion, lack of parking space, traffic congestions et cetera, which are common place in big cities and townships. The sharing mobility concept will soon be attractive to consumers whom many would no longer be able tolerate the inconveniences. On the other hand, rural areas will continue to enjoy driving without bearing these inconveniences. This mobility behaviour will drive the urban consumers to migrate to the shared mobility concept while the rural populace will remain the preferred privately own vehicles.

Another possible disruptive trend is anticipated to occur by 2030 owing to the possibility that technological and regulation issues for autonomous driving are resolved, 15 percent of new passenger vehicles sold could be fully autonomous.

Stricter emission regulations, lower battery costs, more widely available charging infrastructure, and increasing consumer acceptance will create a strong momentum for penetration of electrical driven vehicles (HEV, PHEV, BEV and Fuel Cell). Fast charging batteries that are able to store enough energy to travel acceptable distances by consumers shall be the predetermined factor for the EV market penetration. Rapid development in the EV adaptation trend may disrupt the successful development of the ICE market irrespective of the efficiency achieved. However, the internal-combustion engine will remain very relevant beyond 2030 due to the fact that electric vehicles include a large portion of hybrid electrics within its powertrain.

Chapter 2: Automotive Foresight - 2050

Shell estimated that by the year 2050 the world population will reach 9 billion people and there will be 2 billion cars on the roads. Megacities will be congested and transportation, mobility and energy are some of the everyday issues that will need to be dealt with. Questions arise as to how auto-mobility can take place in the future. In this regard, many enthusiasts and observers predict electric and digitally connected autonomous vehicles (AVs) will reign the automotive world by the year 2050.

By the year 2020, automobiles will be fully revolutionised. Vehicles will be digitally connected, auto navigate and use alternative power to move around. The development will be intensified and by 2030 vehicles are more fit-for-purpose and a vastly autonomous kind of transportation. The next two decades from thereon, AVs are expected to destructively dominate the world to the point that transportation infrastructure will be changed, culture and behaviour of society will adapt, training and education programs will be reviewed, geopolitics and the economy of the country will be significantly affected. Change is already taking place now and before long the new automotive era will be here. Malaysia needs to prepare and change for the new wave.

2.1 Overview of the Automotive Trend (2020 to 2050)

2.1.1 In the near future: Year 2020

Within the next decade, according to Booz and Company and PWC (2014), the cars of the future will be very different from the ones drivers are currently familiar with today in that cars will be far more digitally connected than they are now. Driving will be assisted with navigation systems that determine not just the fastest route but also the most fuel-efficient. Vehicle management systems will provide detailed information about the car's performance, and automatically send data to insurance companies and fleet owners. Technologies such as anti-fatigue devices will reduce accidents, and soon, systems that monitor drivers' vital functions will alert them to potential problems. Driver assistance and safety systems will let the car take over driving in traffic jams and on the highway, and drive much more safely than humans.

Automobile companies are now intensifying research and development on the cars of the future. Nissan says that they are ready to market autonomous-drive vehicles by 2020. Their vehicle will be equipped with a host of advanced equipment for autonomous operation, including cameras that can see the area surrounding the vehicle; radar sensors that measure distance; laser scanners that detect the shape of objects; a global-positioning sensor that locates the vehicle; advanced computer systems that apply artificial intelligence to that data and make driving decisions; and a variety of actuators that can execute driving manoeuvres while compensating for less than ideal conditions.

Figure 2.1: Nissan market-ready autonomous-drive vehicles by 2020

MacKinsey & Company (2016) also predicted that by the year 2020, automotive consumers want more connectivity and are more focused on active safety and ease of use. They are increasingly using digital sources in making their purchase decisions and the entire industry landscape changes where suppliers will add more value in alternative powertrain technologies and innovative applications for infotainment.

Karl Brauer (2016), a regular contributor to Forbes website, reaffirmed that by 2020 we will see more cars capable of being fully autonomous introduced to the market. These future automobiles will be equipped with features such as comprehensive vehicle tracking, driver override systems that actively disregard your commands and makes its own decisions, biometric vehicle access that will unlock and start your car without anything more than your fingerprint, Head-Up Display (HUD) with active displays capable of displaying vibrant images such as a navigation system that actually highlights the next turn, active health monitoring systems that can call paramedics when the driver has a heart attack and reconfigurable body panels that can easily adapt to the need of the situation e.g. A truck and a car in one vehicle.

Nevertheless, with regards to hybrid cars, by the year 2020 there should be a distinct shift in the automotive trend and direction towards hybrids. A report by the Society of Motor Manufacturers and Traders (SMMT) (2015) in the United Kingdom says that although hybrids will be significant, full electric vehicles will still be striving making market inroads until the late 2020s. Unless there is a substantial stimulant such as through financial incentives or regulatory encouragement, the adoption of pure-electric vehicles is expected to be modest at this time.

2.1.2 The Next Decade: Year 2030

Within the next ten years after 2020 i.e. the year 2030, observers of the development of the automobile industry predict that automobiles will be fully revolutionised. Consumer mobility behaviour will be different and one out of ten cars sold will potentially be a shared vehicle. Subsequently, this raises the market for fit-for-purpose mobility solutions. Secondly, it is also envisaged that issues such as technological and regulatory are resolved and up to 15 percent of new cars in 2030 could be fully autonomous. By this time, electrified vehicles will be becoming more and more viable and competitive.

However, while a lot of development is being carried out on autonomous and electric cars, hybrids will continue to exceed electric vehicle adoption through to 2030. In the long run, full electric vehicle technology could well be adopted at higher rates than projected but there is an urgent need to reduce battery size and price, and an increase in energy storage capacity, otherwise full battery electric vehicles will likely remain a relatively niche application. A report by AutoAnalysis (2016) said that by 2030 the production ratios of hybrid and battery electric in the European countries will reach 25% and 4% while in the North American Free Trade Agreement (NAFTA) region will only reach 17% and 4% (Refer to Table 2.1). This supports the expectation that in the next decade or two, hybrid and electric vehicles will be exerting their presence in the automotive industry.

Table 2.2: European and NAFTA hybrid and battery electric vehicle production ratios (%), 2015-2030

Region	2015	2016	2017	2018	2019	2020	2025	2030
Europe								
Hybrid %	3.25	4.6	6.25	8.1	8.9	11.25	17.5	25.1
Battery electric %	1.0	1.2	1.5	1.6	1.7	1.8	2.95	4.25
NAFTA								
Hybrid %	3.6	5.0	7.25	8.2	8.5	8.7	14.25	17.5
Battery Electric %	0.85	0.85	1.0	1.05	1.1	1.2	2.0	4

Source: just-auto.com and AutoAnalysis; note hybrids include plug-in versions.

2.1.3 Two decades onward: Year 2040

By 2040, the electric vehicle revolution could turn out to be more dramatic than governments and oil companies have yet realized. It is predicted that by this time there will be big reductions in battery prices and EVs will become a more economic option than gasoline or diesel cars in most countries. Research by Bloomberg New Energy Finance (MacDonald, J. 2016) forecasts that sales of electric vehicles will hit 41 million by 2040, representing 35% of new light duty vehicle sales in Figure 2.2. (HEVs - hybrid electric vehicles, BEVs - battery electric vehicles, PHEVs - plug-in hybrid electric vehicles)

This projected change between now and 2040 will have implications beyond the car market. The research estimates that the growth of EVs will mean they represent a quarter of the cars on the road by that date, displacing 13 million barrels per day of crude oil but using 1,900TWh of electricity. This would be equivalent to nearly 8% of global electricity demand in 2015.

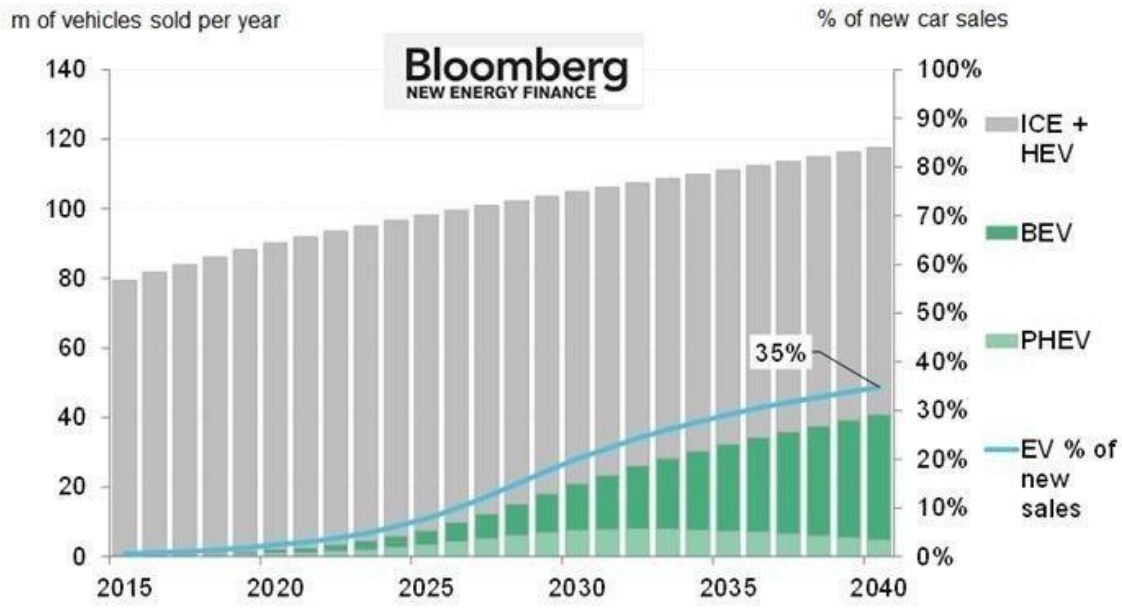
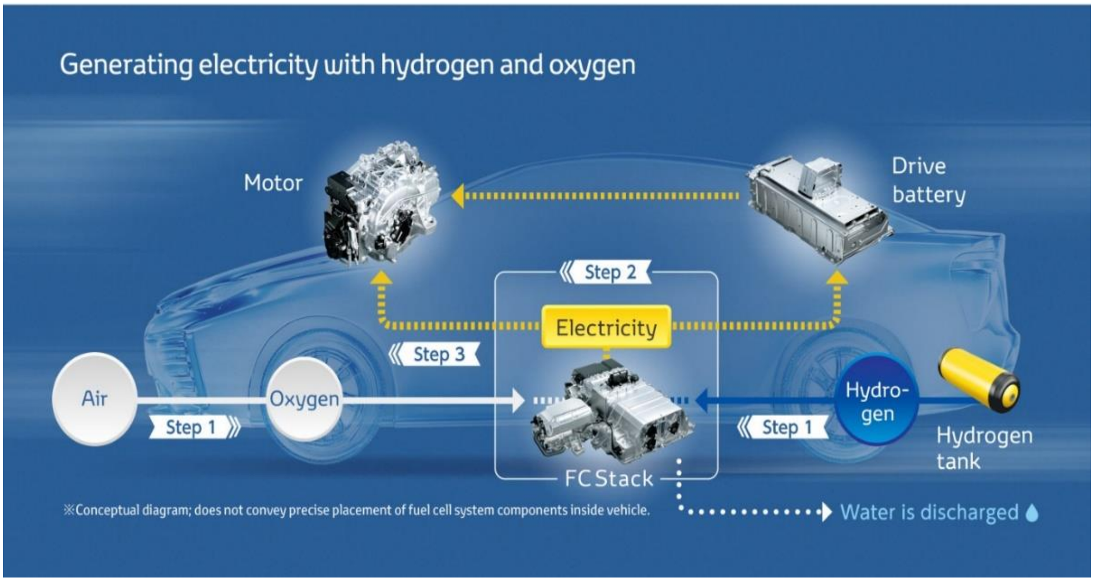


Figure 2.2: Percentage of New Car Sales

2.1.4 Mobility in the Year 2050

The trend and development of the automobile shows that by 2050, cars will be self-driving. Many leading automotive companies are working on concepts now and soon many will likely be seen on the roads. General Motors has the Super Cruise that controls the vehicle on long highway stretches when not much is happening. BMW already has the Traffic Jam Assistant and cars move along in a congested traffic area just like a school of fish. On top of these, Thomas Frey, Executive Director and Senior Futurist at the DaVinci Institute (2016) predicted that it is possible by that time the automotive industry will have gone through a very major change that the familiar mechanical masterpieces that we know as cars today will not be around anymore and are destined for the scrap yard. Passenger vehicles will be using friction-free technologies and advanced material science and will weigh less than 200 lbs or 90 kg. The average manufacturing time for a vehicle will be less than one hour because cars will be designed and manufactured with far fewer pieces and greatly reduced complexity and ultimately, the cost of an average vehicle will be so much cheaper, probably under US$5,000 or RM20,000 only.

With regards to alternative fuel for future vehicles, Toyota is aggressively pursuing research and development on Fuel Cell Vehicles (FCV) and this technology can change mobility of the future. Toyota argues that hydrogen can be produced from a wide range of primary energy sources, unlike fossil fuels, there is no need to worry about resources becoming depleted, meaning that a stable supply can be relied on. Energy production can be conducted locally through hydrolysis and electricity generated from renewable energy sources (wind power, solar power, etc.) can be stored as hydrogen for power supply. Subsequently, the hydrogen is pumped into FCV and through the chemical reaction between hydrogen and oxygen; fuel cell vehicles generate electricity to power a motor. Instead of gasoline they are fuelled by hydrogen, an environment-friendly energy source that can be produced from a variety of raw materials. Figure 2.3 below illustrates the concept of FCV.



Source: Toyota Global Site

Figure 1.3: Hydrogen Fuel Cell Vehicle

Many contributors to the future of automotive foresee that flying cars will be vehicles of the future. Scientists are working together to try and find out how to make aviation as simple and as widely accepted as driving a car and they agree that such a big change will not be achieved solely through technological advances but also other factors such as infrastructure, financial and political assistance. More research and technical breakthroughs will be needed for the first generation of flying cars to become viable. The navigation systems need to be fully automated, the airspace has to be layered with systematic directions, the take-off must have low-impact vertical, the fly-drive capability needs to be convenient for users, the engines need to be silent, and the safety systems must be specialized and not compromised. Professor Bülthoff's department at the Max Planck Institute for Biological Cybernetics in Tübingen (2015) are carrying out crucial research on vehicle's control, navigation of flying cars and propose that cars might be able to fly in ten years' time but only if people are keen to take to the skies.

Figure 2.4: AeroMobil, Slovakian company unveils flying car at Pioneers Festival 2014 (Able to drive 430 miles (692 Km) on a tank of petrol with foldable wings)

2.1.5 The Journey to the Future

The year 2050 is not too distant in the future. The time is only about 35 years or 3 or 4 decades away. However, while work is being intensified and rigorous research and development are being undertaken, passenger vehicle technology is expected to remain dependent on what is available today which are the petroleum fuels and internal combustion engines (ICE). ICE technology will continue to be enhanced through clean diesels, hybrids and new combustion techniques to ensure increased efficiency. Hybridisation will increase in popularity, in particular in congested areas with stop-start driving. Alternative fuels will also increase steadily in penetration, with second generation biofuels such as synthetic biomass-to-liquid (BTL) growing significantly by 2035 and synthetic gas-to-liquid (GTL) already expected to grow strongly in the coming decade. Hydrogen fuel and fuel cell vehicles are expected to gain popularity by 2035 and grow towards 2050. By 2050, petrol and diesel fuels will still play a major role, but their biofuel portion will be significant and electric power utilisation in transport will be the front-runner.

2.1.6 The Disruptive Technologies

Harvard Business School professor Clayton M. Christensen introduced the term *disruptive technology* in his 1997 best-selling book, "The Innovator's Dilemma" (1997). Christensen said a disruptive technology is one that displaces an established technology and shakes up the industry or a ground-breaking product that creates a completely new industry. For example, the personal computer (PC) that displaced the typewriter and forever changed the way we work and communicate, the Email that transformed the way we communicate, largely displacing letter-writing and disrupting the postal and greeting card industries, the mobile phones that made it possible for people to call us anywhere and disrupted the telecom industry and Cloud computing which hugely disrupted the business world, displacing many resources that would conventionally have been located in-house or provided as a traditionally hosted service.

Similarly, McKinsey Global Institute (2013) believes that technologies that have significant potential to drive economic impact and disruption in the future are such that the technologies are rapidly advancing or experiencing breakthroughs, broad reach i.e. touching companies and industries and affecting a wide range of machines, products, or services, have the potential to create massive economic impact and have the potential to dramatically change the status quo which can transform how people live and work, create new opportunities or shift surplus for businesses, and drive growth or change comparative advantage for nations.

The autonomous car is predicted to be the innovation that will profoundly change the world. Claudio Simão, Chief Innovation Officer, Hexagon & President Hexagon Ventures (2015) said that this innovation can dismantle an entire global industry. It can generate more than $3 trillion in revenue and generate another $1 trillion in related sectors. The business models and value chains of dozens of segments and revenue streams including the financial services, insurance, infrastructure, public safety and transportation, oil and gas, mining, agriculture and automotive industries can be completely changed. The government operations can be directly affected with significant changes to the circular flow of income, tax revenues, political policies and economic cartels. However, it is estimated that 8 million workers will be forced into unemployment but at the same time the new industry will create an abundance of new jobs never before conceptualised. At the same time, daily routines of city life will be disturbed and unsettled until the majority of the world's population is transformed.

2.2 Potential Impacts on Automotive

2.2.1 Transportation Infrastructure

AVs will significantly affect how roads and highways are organised and used. These future vehicles will be equipped with sophisticated and advanced control systems and they are expected to run closer together. They will also collectively calculate the most efficient route selection and synchronise key manoeuvres between each other, such as turning and merging. A study by Tientrakool (2011) suggested that AVs could increase road capacity by 43% (using sensors alone) to 273% (when using sensors and interacting with other AVs). This would affect the way infrastructure is planned, with current transport infrastructure better utilised, and a much-reduced need to build new or widen existing roads.

Road design and traffic management such as traffic signals and signage will change significantly. Traffic will be managed in real time through shared data. As AVs will travel at speeds suited to road environments and will automatically detect and avoid other road users' physical traffic management infrastructure such as speed humps and safety measures like guard rails and pedestrian protection can also be reduced. There might be no traffic signals in the future as AVs undertake all required manoeuvres without them.

As AVs would drop and collect passengers when required, the demand for nearby parking will be decreased significantly. Many AVs will be in continuous operation and will not park at all, or will return to depots in less expensive locations where more land is available. Cars with no drivers can park more closely together. New parking lots will be much smaller and existing parking capacity could be doubled. In the city centre, less off-street parking will be needed as on-street parking demand would diminish, creating more road capacity for AVs or reallocated for other transport modes such as cycling, walking and mass transit.

With regards to technology, Solar Roadways has researched and developed solar cells beneath a layer of glass that could replace the concrete or asphalt. They estimated that assuming the photovoltaic system is operating at 15% efficiency the entire U.S. road system would provide more than four times the current electricity needs, or about as much electricity as the whole world uses.

Figure 2.5: Solar Road

The second infrastructure invention is the Wireless Advanced Vehicle Electrification, the Wave, which enables electric buses to become more cost effective than diesel or natural gas buses, and without the need for being connected to overhead wires. Using a wave induction receiving unit on the bottom of the bus and a magnetic induction power transfer system in the road, buses will be charged when stopping to pick up passengers or at traffic lights. This frequent re-charging will enable to bus to run all day, until it returns to base for a full re-charge overnight.

Other than energy generation, the transportation infrastructure of the future will also incorporate internet connectivity along roads and highways. Sensors will be fitted along the highways and monitor traffic by sending signals to mobile devices in moving cars. This will turn the highway into a smart road, one with great capabilities for the AVs.

2.2.2 Potential Geopolitics and Economic Impact

By the year 2025, it is estimated that the potential economic impact of AVs could be \$200 billion to \$1.9 trillion per year (McKinsey Global Institute 2013). The largest impact would come from freeing up time for drivers, increased road safety, and the reduced cost of operation of vehicles. If this autonomous technology is adopted, about 30,000 to 150,000 lives could be saved per year and CO2 emissions could be reduced by as much as 300 million tons per year. That amount is equivalent to 50 percent of CO_2 emissions from current commercial aviation.

This new era of automobile and the automotive industry will open up massive opportunities to major automotive players like China, India, Western Europe, Japan, Korea, and the United States. While China and India are expected to capture manufacturing for original equipment manufacturers (OEMs) and assembly of automobiles other countries are expected to excel on design, development and advancement of the AVs.

China is currently one of the fastest growing regions in the global automobile market and is the world's largest automobile market. China will continue to establish meaningful presence and compete aggressively in the market. Slowly China will address and improve its branding image perceptions as poor quality and be the own brand leading champion of AVs. Studies conducted by McKinsey (2016) shows that there is a strong possibility that Chinese OEMs will be significantly more aggressive in their entry to developed markets and make a considerable impact on market share and profit. By this way, China will be well on their way to be the leader in the automotive industry in the future.

Similarly, the Indian auto industry is also establishing its position to be one of the largest in the world. The Indian passenger vehicles industry grows very rapidly and in FY 2014-15, around 31 per cent of small cars sold globally were manufactured in India. In recent years, India has been establishing its position in the market. The market potential rise in demand and production has increased for both home and foreign. This is reflected in the production figures of the industry especially remarkable in the passenger vehicle and three wheeler divisions, where production raised from 1,209,876 vehicles in the year 2004/2005 to 3,072,651 vehicles in the year 2013/2014. Booz & Company (2011) predicts that India will soon exceed every major European market including Germany, France and UK in automotive sales. This will make India the 4th largest automotive market by volume in the world. Over the next 20 years, India will be part of global BIG 3 i.e. China, United States and India. Booz also expects the India automotive sales to exceed the US market by mid 2030s and the twin forces (China and India) will pretty much decide the global automotive game.

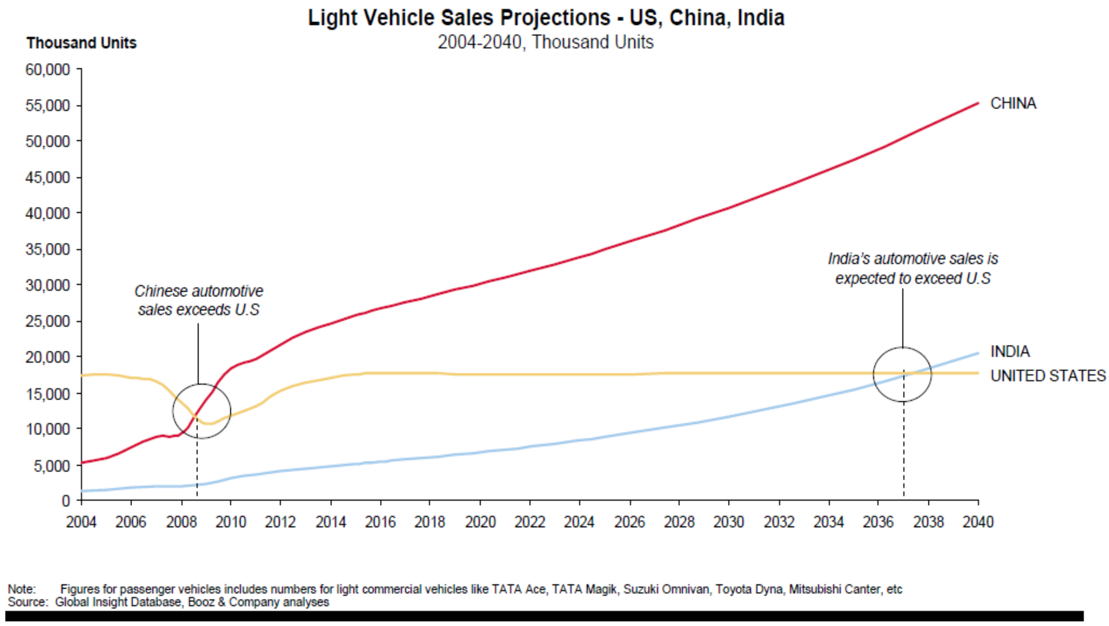


Figure 2.6: Light Vehicle Sales Projection - US, China, India Booz and Company

2.2.3 Culture and Social Implications

By the year 2050, automotive would have a revolutionising impact on our life. At that time AVs would have become so widespread that it is no longer necessary to get a drivers' license. It will probably be more economical and also it is the lifestyle at that time that people no longer find it necessary to own a personal vehicle when AVs are easily shared among multiple people. A person can place order for a vehicle pick up from any location and then be sent to any destination. There is no longer a need for parents to rush sending and picking up their children to and coming back from school as these can be prearranged through internet of things (IOT). Due to the advanced internet connectivity parents can video call their children in the AVs and see that they reach home safely. However, in the early stages of implementation AVs will not have much influence on how people go about their everyday life. It will most likely have some resistance because people will not want to give up the control of driving and move as they please. As the benefits become more apparent, people will realize how effective and helpful it can be. Figure 2.7 below shows an example of an autonomous vehicle visualised by automotive designers.

Figure 2.7: Typical Autonomous Vehicle of the Future

The AVs create more jobs in the market. According to a report by Transport and Environment (2013), the automotive sector will need about 1.1 million additional jobs in Europe by the year 2030. These jobs are created by new vehicle technology, additional vehicle production in the automotive industry, telecommunications, information technology and creative industries such as digital and media to serve new markets created by connected and autonomous vehicles. In the meantime, Internal Combustion Engine vehicles will still be popular choice as these vehicles will be either optimized or hybridized. It is predicted that in situations where Europe moves rapidly to a fleet of advanced hybrid, battery-electric and fuel-cell vehicles, EU-wide employment will increase to 2.3 million by 2050.

Similarly, Ian Henry of SMMT (2015) estimated that the production of automobiles in the United Kingdom will be well above two million units a year in the 2020s and more than 5,000 new jobs will be created at vehicle and engine facilities, and as many as 28,000 within the supply chain by this time. This would raise total employment in automotive manufacturing from the current 160,000 to nearly 200,000 by the early 2020s.

The new modes of automotive mobility will consequently change Malaysian culture and effect urbanisation behaviour. The concentration of the population is already converging around public transportation such as bus, trains and subways and the commuters’ density is increasing. The new generation is finding it better, faster and cheaper to travel using public transport in the cities instead of daily driving through urban traffic with routine problems of congestions and difficulties of find parking spaces.

An article in quarz.com - the Western world's century-old love affair with the automobile is coming to an end. The article highlighted that people are driving less and less, and in the US the number of vehicles per driver has fallen from a peak of 1.2 in 2007 to the current 1.15 (data compiled by Schroders). Young Americans are getting their drivers' licenses later than the earlier generation did in 1983 and even in 2008. Fewer Britons under the age of 30 have licenses today than those generation in the 1990s. Further many young people on both sides of the Atlantic chose not to have driving licenses at all.

Although the commuting pattern will change significantly in the future due to rapid enhancement of public transportations, it is predicted that the general populace will still in need of vehicles for private use to travel out of the city for businesses, holidays or visiting families and friends. It is therefore expected that the automotive demands will remain and the industries will grow exponentially along with the population and urbanisation growth. In addition those living in suburban and country areas, where housing costs are lower, will demand for more vehicles as public transportation in their vicinities will remain limited.

2.2.4 Automotive Training and Educational Requirement

The automotive industry is fast growing with no end in sight but the industry is also facing unprecedented challenges such as the great shifts in global economic power are causing massive upheavals in demand, consumer expectations are changing radically and new technologies are dramatically changing vehicles, from the beginning of the 'connected car' and enhanced driver support to better fuel efficiency and new or improved powertrains.

The change in automotive trend towards EEV, hybridisation and electric automobile is apparent. Within the next decade, the automotive services provider critically needs trained technical workforces to handle servicing, repairs and diagnostic requirements for new innovations in vehicle alternative fuel powertrains and E–mobility devices. The basic skills enhancements include knowledge and understanding of:

1. the new technologies of alternative fuel drive such as HEV and EV and carry out vehicle maintenance and repairs.

2. the diagnosis procedures needed to identify and test complex vehicle system faults.

3. essential knowledge and understanding of current and new safety requirements that are exclusive to alternative fuel drive sources and hybridisation.

The education system of today needs to prepare for the demand of the automotive industry of the future. In this regard, the US Government foresees that the academia has to prepare for the rapid change of automotive technology now. The government therefore has begun such programs as far back as of 2011. The Graduate Automotive Technology Education or the GATE initiative was awarded $6.4 million over the course of five years to support seven Centres of Excellence at American colleges, universities, and university-affiliated research institutions on three critical automotive technology areas: hybrid propulsion, energy storage, and lightweight materials. The GATE Centres and their respective focus areas are as follows:

a. The Ohio State University is to prepare a new generation of engineers to lead system integration projects in areas related to energy-efficient vehicles: efficient energy conversion, advanced energy storage, lightweight body and chassis systems, and vehicle systems control, including vehicle-grid and vehicle-infrastructure connectivity.

b. Regents University of Michigan conducted research on achievements in the area of electric drive vehicles, including battery electric vehicles, extended-range electric vehicles, hybrid electric vehicles, and plug-in hybrid electric vehicles.

c. Regents University of Colorado, Colorado Springs focussed on graduate education in electric drivetrain vehicles to achieve a 50% reduction in commercial vehicle fuel use.

d. Purdue University comprehensively trains, educates, and equips the next generation of research scientists and engineers to address technical challenges and respond to opportunities unique to medium and heavy-duty hybrid vehicles.

e. Clemson University trained the highly skilled engineering workforce of the future to understand and address challenges in advanced vehicle design and development, including life-cycle impact of vehicles, energy use and emissions, reliability, manufacturing, cost-of-ownership, customer preference and public policy.

More intensive training and innovative education system is urgently needed to prepare for the demand by the new innovative automotive industry of the next three decades. The entire automotive education system needs to be reviewed and realigned according to the need. Technical and higher education course syllabus needs to include subjects such as car connectivity, quantum computing, brain-computer interface, smart robots, Internet of Things, 3D printing, Cloud Computing and digital security. Automotive technology will no longer be limited to the conventional mechanical powertrain or internal combustion engine but it crosses into communications, information technology, artificial intelligence, electronics, chemical engineering as well as cognitive psychology.

In the future, the ideal factory is expected to be highly automated, employing significantly fewer people than traditional factories. Training syllabus for these advanced manufacturing factories will include subjects like:

a. sustainable manufacturing systems.

b. advanced information and computer systems, including simulation and modelling tools for design and manufacturing.

c. advanced automation including self-learning or artificial intelligence systems.

d. the use of new materials such as nano-materials and as graphene.

e. reconfiguration of systems – quick change for new products.

f. fast ramp-up production systems.

The Society of Motor Manufacturers and Traders UK anticipated that traditional processes and craft skills such as machining and welding will slowly diminish and new advanced technologies craft skills will need to be learned and re-skilled if need be. Although much of the industry will feature increasing levels of automation, overseen by a smaller number of workers equipped by different core skills to today's factory workforce craft skills will certainly be required by companies specialising in premium vehicles.

2.2.5 Disruptive Technologies and the Focus Areas

There is no doubt that the automobile industry of the future will be transformed from what it is today. The automotive technologies will be well advanced to build the future automobiles but at the same time could have very disruptive effects. Some of the identified disruptive technologies are such as the:

a. Mobile Internet – accessing the internet through mobile devices.

b. Automation of Knowledge Work - using computers to perform tasks that rely on complex analyses, subtle judgments, and creative problem solving.

c. The Internet of Things - everyday objects that have network connectivity, allowing them to send and receive data.

d. Cloud Technology - retrieved from the internet through web-based tools and applications, rather than a direct connection to a server.

e. Advanced Robotics - sensor-based robots that attempt to mimic human intelligence.

f. Autonomous Vehicle - a vehicle that is capable of sensing its environment and navigating without human input (driverless car, self-driving car, robotic car).

g. Energy Storage – capturing of energy produced at one time for use at a later time.

h. 3D and 4D Printing - making a physical object from a three-dimensional digital model (3D) and printing objects that then reshape themselves or self-assemble over time (4D).

i. Advanced Materials - obtaining superior performance in one or more characteristics of new materials and modifications to existing materials.

j. Renewable Energy - energy from a source that is not depleted when used.

Table 2.2 below establishes the relationship between disruptive technologies and all four focus areas under consideration i.e. transportation infrastructure, society, education and economy. From discussions conducted above it can be surmised that the future transportation infrastructure will be extensively equipped to provide services such as mobile internet, IOT, energy storage and energy generation from renewable resources. These technologies will be so disruptive and without them mobility will practically be at a standstill.

Inevitably, the culture and the behaviour of the society will change to suit the new order of automotive technology. People living in a metropolitan megacities will find it hard to live without advanced technologies of the mobile internet, IOT, 3D/4D printing and autonomous vehicles. In the future, the autonomous vehicles will be so widespread that taxi and school bus drivers will be out of a job and goods delivery truck drivers will have to be reskilled for other work in the organisation.

In this regard, technical training and education program will need to be carefully planned and executed to include all new innovations and advanced technologies. The education syllabus needs to cover the entire spectrum of learning and skilling of internet technology, mobility, connectivity, autonomous and energy technologies. The process will need to be continuous all throughout the education system.

The effect of the advancement of these disruptive technologies will ultimately affect the economy and geopolitics of the country. While some futurists are in the opinion that the new technologies will lay off many automotive workers, many observers are optimistic that the new technologies will enhance the economy of the country geopolitically. Although disruptive, these technologies are actually in the advanced stage today and are well on their way to build a new era of automotive industry and economic growth.

	Focus Areas	Mobile Internet	Automated of Knowledge Work	The Internet of Things	Cloud Technology	Advanced Robotics	Autonomous Vehicles	Energy Storage	3D and 4D Printing	Advanced Materials	Renewable Energy
1	Transportation infrastructure	/	/	/	/	**x**	/	/	/	**x**	/
2	Culture and Behaviour	/	/	/	/	**x**	/	/	**x**	/	/
3	Training and Education	/	/	/	/	/	/	/	/	/	/
4	Geopolitics and Economy	/	/	/	/	**x**	/	/	**x**	/	/

Table 2.2: Disruptive Technologies versus Focus Areas of Automotive Industry

2.3 Market Entrance Timeline – Foresight

Automotive, an industry recognised as one element in modern day mobility, will continuously influence and progressively transform mankind in many aspects of life, albeit; social, economy, environment, technological, politic and infrastructural. The industry, since the first invention of the Ford-T model, has been a force for change. However its very success over the past half century has generated environmental pollution and urban traffic congestion while straining the supply of global resources, in particular oil.

Concerns over climatic change and continuous increase in demand for automobiles in the coming years has attracted governments and the global community to examine the way on-the-road mobility is managed. While the economic aspect is paramount as to what the industry has to offer, safety in mobility is of equal concern.

Alternative technologies to that of the conventional ICE powertrain vehicles are now available, a result of aggressive competitions amongst global automakers and inventors. Highly efficient Internal Combustion engines (ICE), Hybrid Electric Vehicles (HEV), Plug-in-Hybrid Vehicles (PHEV), Battery Electric Vehicles (BEV) and Fuel Cell Vehicles (FCV), are now major attractions in all international motor shows enticing visitors' admirations. However, foreseeing their market penetration as to when their practicality for mass production and common usage by the global populace is indeed challenging and is subjected to many speculations and constraints. Consumer attitudes, habits, legislation, infrastructure and convenience issues are often mixed with economic and social considerations. After all, the concept of electric vehicle is not new where it was invented and attempted for mass production as early as 1880s (Future of Transportation). However, the EVs have never really entered the showrooms then as its application was not supported by the road infrastructure, especially the charging requirement. In 1996, General Motors attempted to mass produce the GM-EV1 models for the USA market but was later recalled and crashed ending the life of the EVs vehicles and its industrial production, blamed by some on the oil lobby wanting to prevent EV from progressing further for fear of reduction in oil demand for automobile consumption.

Foresights and roadmaps generated by many industry experts, journals and governmental organisations as to when these new mobility technological concepts will enter the marketplace in the big way commercially are many and accordingly various in opinions and time frames. Powertrains such as; efficient ICE, HEV and PHEV are considered transitional technologies that will be globally adopted in phases. Battery driven powertrain, BEV and FCV, are foreseen to be the eventual vehicles to achieve the "zero" emission requirement towards 2050 and beyond. Futuristic mobility such as flying vehicle are too far-fetched for adoption by the current mobility infrastructure, but will be a reality in the future nevertheless with the rate of innovativeness amongst the current scientific and engineering community. Autonomous vehicles, on the other hand, will surely be of reality as their usages are adoptable even with the current mobility infrastructure. However point to note is that all the prescribed vehicles with powertrains above can be autonomous if the vehicles are installed with the systems to enable them as self-driving vehicles.

Henceforth the foregoing roadmap will foresight the vehicles evolution, and as such the automotive industry development, based on the five prescribed powertrains. To ascertain a degree of acceptability and accuracy of foresighting the market entrance of the prescribed powertrain vehicles, reference to the oil usage prediction by the oil producing community is the closest alternative to develop the adoption and market penetration phases of these vehicles. In fact the global energy sector is the most influential community in determining the usage and market penetration of those energy efficient vehicles.

2.3.1 Global Demand foresight for Energy Efficient Vehicles (EEVs)

Global demand profile for EEV passenger vehicles is foresighted herein for the purpose of establishing the vehicle volume demand timeframe viable for mass production of respective vehicle locally. Henceforth the Malaysia automotive roadmap can be developed based on the viable volume timeframe postulated, whereupon developmental strategies can be derived.

Foreseeing and predicting the demand profile and market penetration of the alternative technology vehicles is a complex exercise and more so when attempts are made without the availability of a country-specific market and geographically studies and consumer surveys. The exercise becomes more complicated due to the fact that for many nations' EEVs usage and its regulations are still in the infant stage. Customers' attitude such as; owning a car is not always for the purpose of efficient transportation fulfilling the environmental and fuel saving criteria but more associated with enhancing the owner's social status will make EEV market penetration prediction more uncertain.

Nevertheless, initial purchase price and usage convenience due to battery range limitations are generally constraints applied globally for most EEV vehicle buyers and as such it is generally predicted that the BEVs would not be expected to gain significant market share in the near foreseeable future. However this issue may be disruptively overtaken by the recent introduction of a cost competitive, with a promise of longer driving range, EV Tesla Model 3. The Tesla announcement may alter many previous perceptions and instead BEVs may enter the market place sooner than expected. Despite the excitement, but due to global unprepared infrastructure to support BEVs, utilisation on a mass production of the vehicles in the short and medium term is less likely.

On the other hand, while awaiting for the real BEV market penetration in the medium and longer term, stopgap measures on the choice of powertrain will focus on the efficient ICE and vehicle electrification confining to various degree of hybridisation (HEV) and plug-in hybrid electric vehicles (PHEV). Efficient ICE will be broadly used both in urban centres and long range travelling while HEV and PHEV will be more suitable for urban mobility. Meanwhile Fuel Cell Vehicles (FCV) are beginning to get global attention for their unique powertrain in which the energy provided by hydrogen in the fuel cell is readily used to charge the battery in the vehicle. This in turn will elevate the vehicle from having to charge from any electric power source, instead the vehicles are filled with hydrogen as the energy source to power the fuel cell technology generating electricity and in turn storing it in batteries. Hydrogen liquid is used where the system will function like the ICE powertrain whose tanks are filled with hydrogen while ICE with petrol or diesel. However the high purchase costs of the vehicles and liquefied hydrogen and the absence of hydrogen refuelling infrastructure will render the technology less likely to achieve market breakthrough in the short and half of the medium term for foreseeable mass production ventures.

Alternative fuels such as Biofuel and Compress Natural Gas (CNG) will continue to exist without much impact on the global vehicle production volume. Biofuel may capture some growth in agriculture based nations, however due to global food sustainability issues the Biofuel driven vehicles seems to offer less attractive business ventures amongst automakers. On the other hand, efficient CNG driven vehicle demands will largely be dependent on price comparison to petrol or diesel. Most importantly the spread of gas filling stations is crucial to support the vehicles usages which for now many station owners are reluctant to allow station pumping space for CNG filling facilities.

2.4 Establishing Timeline

Two most important predictions are required in order to establish a reasonable automotive development timeline to foretell the future of the industry and for the development of its future roadmap.

One being the vehicles utilisation scenario through an examination of current and future vehicle stock on a global scale. The prediction is important to paint a picture of the quantum of vehicle types expected to be running on the road; which and when the vehicle type will grow or retard in the future global marketplace.

Second is the prediction of the “Total Industry Volume” future timeline to portrait the forecasted quantum of market entrance of those vehicles useful for future industrial production planning endeavour.

2.4.1 Global Projection of vehicle stock towards 2050

The total number of passenger vehicles worldwide is expected to more than double in 2050 from the current just over 1 billion as shown in Figure 2.8 and 2.9. The graphical profiles are useful in foreseeing the global demand distribution for each vehicle powertrain type towards 2050. On a computed assumption of 3% annual growth in 2050 the total global on the road running vehicles is estimated to be some 2.7 billion and Figure 2.8 shows the estimated breakdown apportioned to each powertrain technology vehicle from now to 2050.

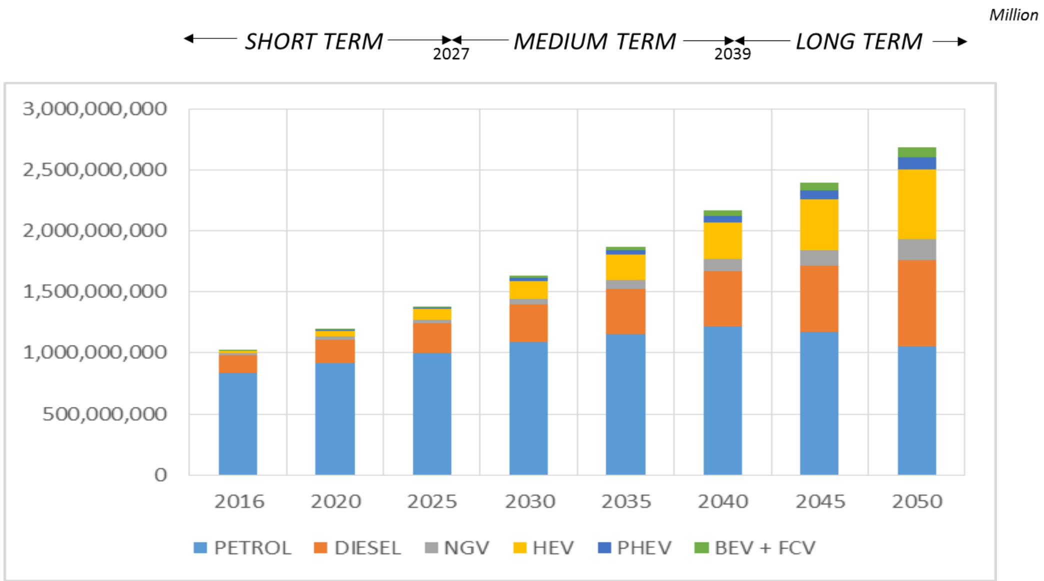


Figure 2.8: Forecasted global vehicles usage of powertrain types from 2016 to 2050

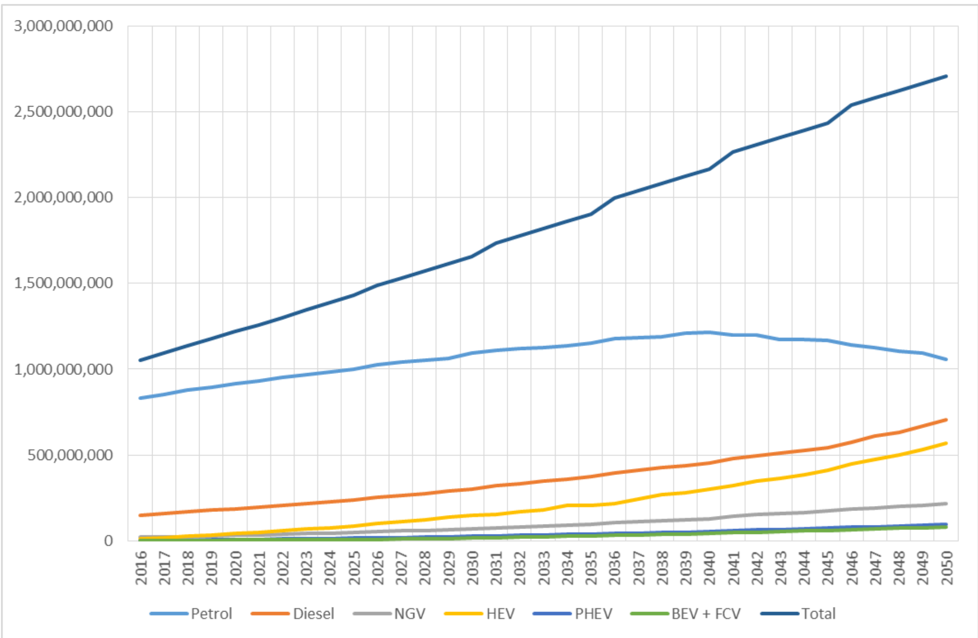


Figure 2.9: Forecasted global vehicles usage from 2016 to 2050

The oil-based fuels namely petrol, diesel and Compress Natural Gas (CNG) powered ICE powertrain vehicles, both the efficient and non-efficient combined respectively, will continue to dominate the global vehicles market. It can be expected that, moving forward, efficient engines will supersede the current non-efficient petrol powertrain. Petrol powertrains continue to enjoy the biggest on-the-road market share, with the current more than 80%, it will continue to grow but will begin to decline to 56% [2] market control by 2040. The ICE powertrain will continue the decline losing its market dominance beyond 2050.

A similar growth profile is demonstrated by the diesel driven, both efficient and non-efficient powertrain, moving forward from now with marginal growth but beginning to decline by 2040. This powertrain current on-the-road market share stood at some 14% with the expectation to increase to 21% by 2040 [2] but will begin to slowly decline towards 2050 and beyond.

The cost of CNG powertrains have now reduced to almost comparable to that of the diesel counterpart. Global community initiatives to install a growing numbers of CNG stations have contributed to the expected growth of this powertrain steadily gaining in on-the-road usage in the foreseeable future capturing sizeable market share. This is further enhanced by the availability of more efficient CNG driven vehicles today. However, it is expected the popularity of the CNG vehicles will begin to diminish come 2040 with negligible growth towards and beyond 2050. This is mainly due to pressure from the global community to achieve zero emission mobility. CNG vehicles currently contribute some 5% of global new car registrations, and the trend is growing, however its current market penetration is still below 0.2% (Booz & Company 2014). However, the vehicles are expected to see a considerable growth relative to other non-oil based vehicles increasing shares to 6% in 2040.

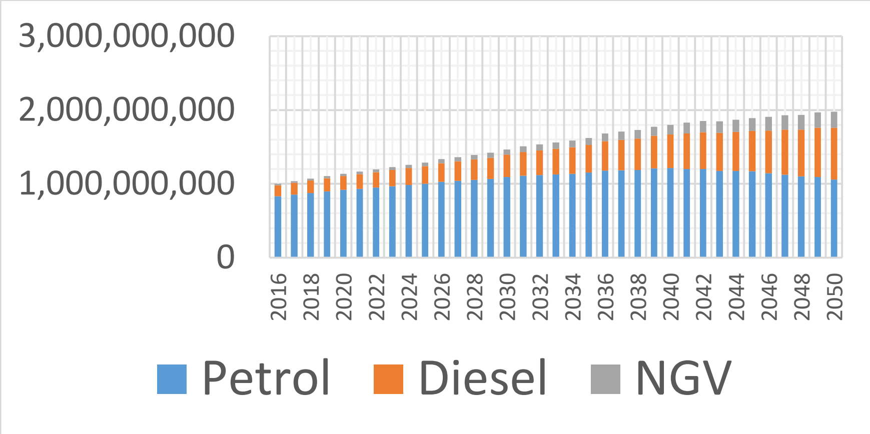


Figure 2.10: Graphical representation showing annual distribution of ICE petrol, ICE diesel and NGV powertrains

The quantum of on-the–road usage of new powertrain technologies, namely; HEV, PHEV, BEV and FCV, relative to the global on-the-road vehicles, petrol, diesel and CNG powertrain vehicles, are shown in Figure 2.11.

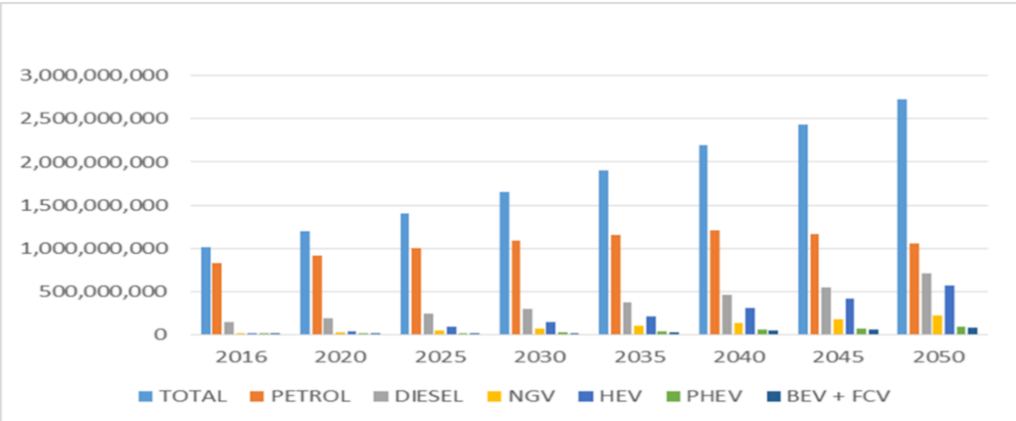


Figure 2.11: Number of vehicle with respective powertrain types from 2016 – 2050

HEV, a combination of ICE and on board battery driven motor, will be the most dominant amongst the new powertrain technologies. Primarily the vehicles are convenient for use as they are readily adaptable to the current mobility infrastructures, namely; existing petrol stations and no external charging set-up and as such no charging infrastructure required.

HEV, which mainly uses petrol as fuel, are expected to increase their on-the-road global vehicle usage share from more than 1% to 14% in the period 2016–2040[2].

Vehicles of electric hybridisation are now becoming attractive for taxis and city driving where the ‘stop-and-go’ ability of the vehicle powertrain can contribute to some 30% in fuel saving as compared to an ICE powertrain.

Sales of HEV have increased significantly over the last few years especially in automotive manufacturing developed countries, as demonstrated by Japan where hybrid vehicles sales has already reached the 30% mark (Booz & Company 2014).

Figure 2.12 and 2.13 illustrate the on-the-road usage growth profiles of the new powertrain technologies demonstrating the dominant characteristics of the HEV.

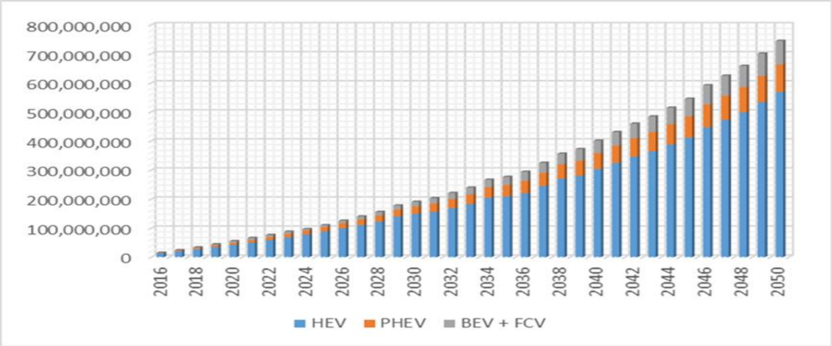


Figure 2.12: Global distribution of global New Powertrain Technologies vehicles

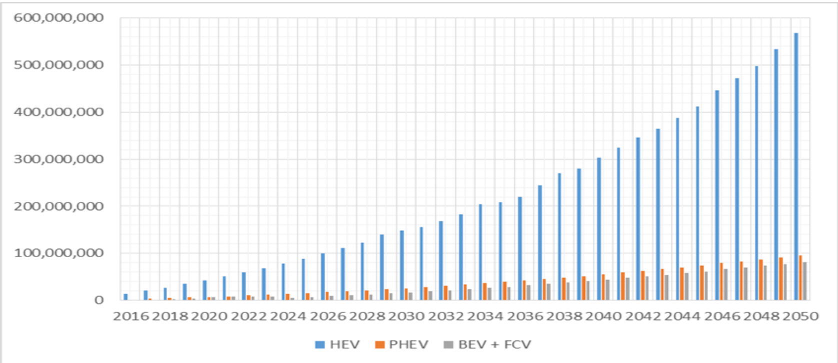


Figure 2.13: Global distribution of global New Powertrain Technologies vehicles

PHEV, although still very low in its acceptance as a mode of road mobility by the global populace as of now but their popularity is gaining momentum despite the need for charging facilities at home and outside. The interest shown by China to follow other advanced nations in the PHEV usage will increase the vehicle global mobility market penetration (Booz & Company 2014).

It is apparent that relative to the global on-the-road vehicles, the BEV usage is low and almost of no significance in the short term. However, expert opinions seem to claim that a significant number of these new powertrain technology, will spike to some 6 million by 2020 (Booz & Company 2014, McKinsey & Company 2016), marking the beginning of BEV larger usage for on-the-road mobility. The quantum of the vehicle usage will undergo a gradual increment both in the medium and long term.

Predicting a possible timeline for the BEV powertrains to reach on-the-road usage globally is a daunting task, as the success of EV is quite dependent on the evolution determinants and interplay of numerous factors in the next few decades, such; cost of batteries, EV battery range, government supports or subsidies, global and national CO_2 emission targets, global oil prices, electrical charging network, electricity prices, economy and consumer purchasing power.

More importantly, the success of the new powertrain technologies are largely dependent on governments around the globe in their efforts to implement the zero CO_2 international emission mandates as well as their respective national target.

Nevertheless, this report will adopt the general opinion that some 6 million of these vehicles will be marketed in 2020 thereby marking the beginning of the new powertrain technologies evolution impacting the global on-the-road mobility.

FCV by virtue of their technology is principally an EV with an advanced feature of refuelling, likening to the ICE powertrain. The fuel cell system is capable of charging the on-board batteries which in turn propel the electric motor of the EV. Henceforth the FCV do not required any charging infrastructure and instead needs well spread hydrogen liquid refilling stations. As such, the current study assumes the growth of BEV and FCV vehicles will run simultaneously depending on nations' infrastructure development plan and timeframe of adoption. Nationwide charging infrastructure is needed once a nation decides to embark on BEV, which will hinder the growth of FCV which requires hydrogen filling stations instead, where both are expansive. This also explains the lower global breakthrough for BEV and FCV technology for passenger vehicles for the foreseeable future. Nations and industries need to decide which mode of the two powertrains to pursue for its infrastructural support development. A point to note; once BEV usage is enlarged in any nation, it will trigger a gradual diminishing of fuel pumping stations which in turn are needed, with modification and adaptation, to serve as hydrogen filling stations for FCV vehicle.

It is for these reasons; vehicle electrification will be mostly confined to various degrees of hybridisation (HEV), with marginal inclusion of PHEV vehicles, which will dominate the new powertrain technology in the shorter term and aggressive increases in the medium term moving forward towards 2050. The HEV, taking advantage on its combination with ICE powertrain will offer added technology and costs that will pay back and lead to substantial fuel efficiency improvements, without the inconveniences related to BEV and FCV.

Below are projection profiles of short, medium and long term usage quantum of the new powertrain technology vehicles:

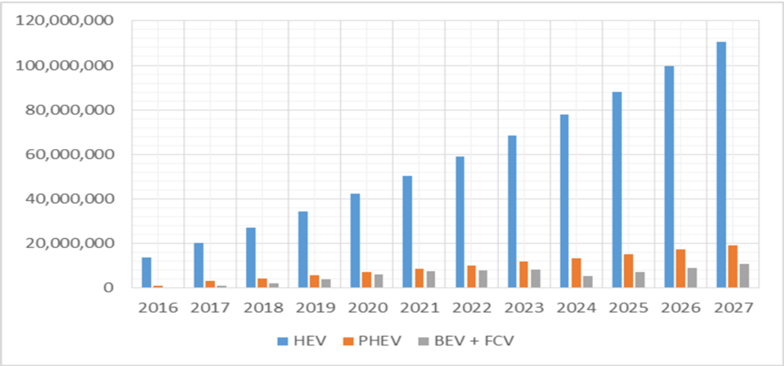


Figure 2.14: Short term projection of New Powertrain Technology

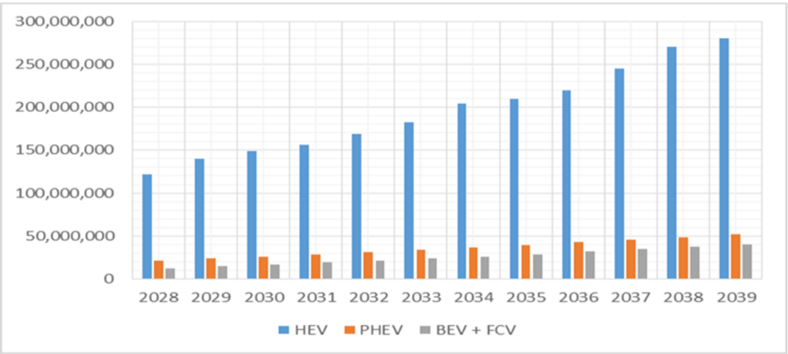


Figure 2.15: Medium term projection of New Powertrain Technology

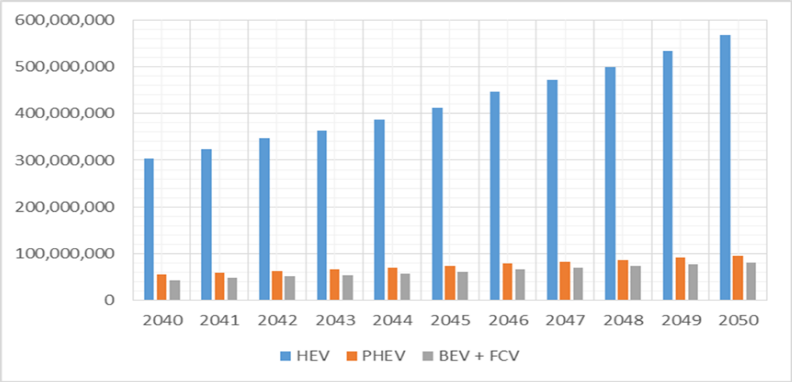


Figure 2.16: Long term projection of New Powertrain Technology

2.4.2 Global Projection of vehicle "Total Industry Volume (TIV)" towards 2050

The next parameter believed to have significant bearing on the development of the automotive roadmap would be the projected annual TIV of the industry. Based on the vehicle usage pattern demonstrated by the global vehicle stock projection earlier, couple with the projected TIV, market entrances of each of the new powertrain vehicle can be forecasted.

Table 2.3 shows the historical profile of the global TIV reflecting the annual growth or contraction relative to previous years of each of the computed years consecutively from 2005 to 2015. Nevertheless, for a reasonable estimate the average of the 10 years profile is taken to be the global TIV prospects of future years towards 2050. It is reasonable to assume in the next 35 years there are bound to be cyclical recessions befallen on the global community and the automotive TIV contractions that may occur from time to time is therefore factored in the computed average. To further add contingencies of over forecasted TIV, a further reduction on the average is applied and henceforth the considered annual average TIV from now to 2050 is taken at 3%.

Table 2.3: Historical Global TIV Average

Year	TIV	GROWTH	TPV	GROWTH
2005	57,629,349	-	66,141,739	-
2006	59,981,384	4.1%	68,950,625	4.2%
2007	65,501,184	9.2%	72,796,104	5.6%
2008	63,157,613	-3.6%	69,774,226	-4.2%
2009	61,617,161	-2.4%	60,531,281	-13.2%
2010	71,806,133	16.5%	76,261,352	26.0%
2011	75,126,116	4.6%	78,087,935	2.4%
2012	79,351,974	5.6%	82,768,050	6.0%
2013	82,535,401	4.0%	85,550,609	3.4%
2014	85,342,995	3.4%	87,587,179	2.4%
2015	87,398,073	2.4%	87,849,085	0.3%
		4.4%		3.3%

Figure 2.17 demonstrates the global TIV for all the six vehicle powertrain technologies under current study, computed based on the global on-the-road usage profile discussed earlier and additional information from various factors concerned with the vehicle evolution in the future. The two most useful guiding information for the TIV forecasting were that of the global oil community with a foreseen scenario on the overall mobility development that would take place from now to 2040. Another useful element in the TIV forecasting are the statements and assumptions made by the automotive community that projected the beginning of new powertrain vehicles entering the market place in a significant way, some 6 million (McKinsey & Company 2016, StaticShell 2016), in 2020.

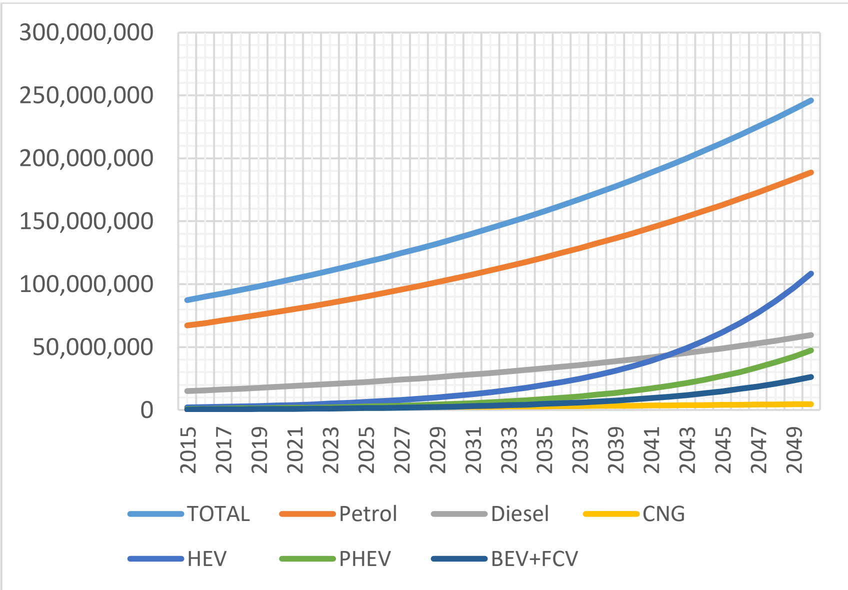


Figure 2.17: TIV forecast for all Powertrain technologies

TIV for petrol and diesel vehicles will continue to grow forward with steady increments towards 2050. Although their on-the-road usage may decline beyond 2040, as prescribed earlier, the incremental growth will persist as during these periods the vehicle which has reached the end of life (ELV) are being replaced with new vehicles.

The same can be said with diesel powertrain vehicles, although their market captive remains lower than that of petrol driven vehicles. CNG vehicles show low and very gradual TIV growth for reasons of its inconveniences in usage and confronting the challenges from new powertrain vehicles which are more environmentally friendly.

Figure 2.18 portraits the TIV for the new powertrain technology vehicles computed from now to 2050. Of late there have been many claims by automotive OEMs and inventors alike of their successful developments of new powertrain technologies the like of BEV, FCV and others. Interestingly, all these later developments demonstrate that future mobility will change global mobility and the changes may soon come.

HEV has been successful on the road and many new buyers, especially those that are environmentally conscientious, are opting for these powertrains for their mobility. The numbers are picking up and although the predicted mass utilisation will only commence sometime in 2020, the probability of aggressive marketing may bring the mass production of these vehicle earlier than predicted. However, industry experts and observers (McKinsey & Company 2016, Static Shell 2016) in general agree that 2020 would be the beginning in volume demand for these vehicles. The fact remains that new investments in the current assets for alteration or modification of production engineering and processes would be very little for the current OEMs to switch to from ICE to HEV manufacturing as most of the components are still largely in use. Price of oil remains low and the public mind-set and education are perhaps the only reasons that would render slow growth in the HEV demand. However, it is expected that most of the mass TIV of HEV will be in Japan and Europe where environmental conscientious, industry awareness and government concern are at play. Not leaving out China who now shows a high level of environmental concern and may step up their mass production of HEV.

Malaysia, on the other hand, may lag in its own participation to produce HEV in view of its current low TIV, at 665,295 units in 2015, which may pose significant competition to the ICE powertrain. However, TIV demand for efficient ICE engines are expected to increase in view of government persistence in combating environmental issues.

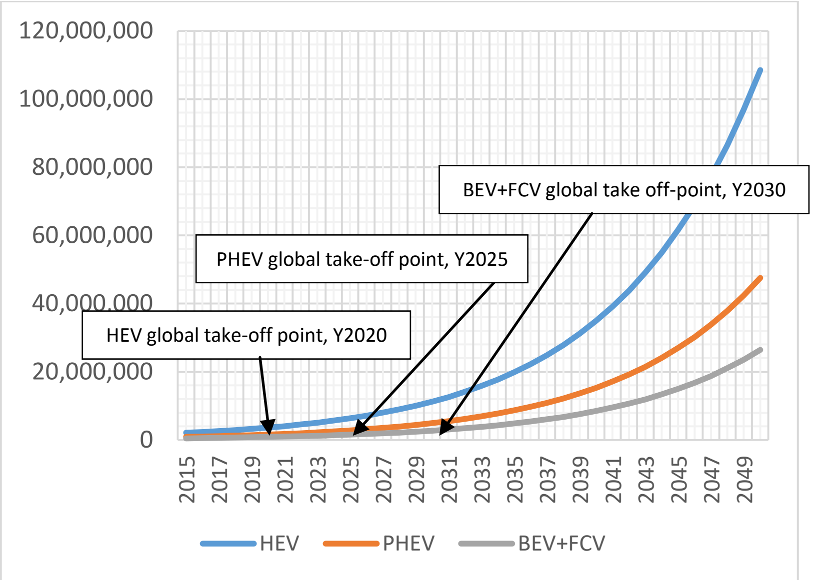


Figure 2.18: TIV forecast for New Powertrain Technologies

PHEV may be perceived as a transitional mode of efficient vehicles prior to adoption of BEV and FCV. Inconvenience of intermittent charging of PHEV system, either at home or charging stations away from home may be less likely to entice mass buyers from acquiring them. However, environmental pressure may lead to government policies with better incentives to encourage PHEV usage. This is particularly true in China which will enhance the vehicle TIV. Nevertheless the possible take-off point for mass usage of the vehicle globally is forecasted by 2025, the beginning of medium term of this report.

The number of battery electric cars and fuel cell cars are also projected to increase, but considering their low market share, their take-off point for mass usage with reasonable TIV is 2030.

2.4.3 Timeline

Figure 2.19 is the foresighted timeline for market entrances and mass production of all the powertrain vehicles.

The foresight shall serve as the foundation for developing the roadmap for the local automotive industry to be discussed later in the text.

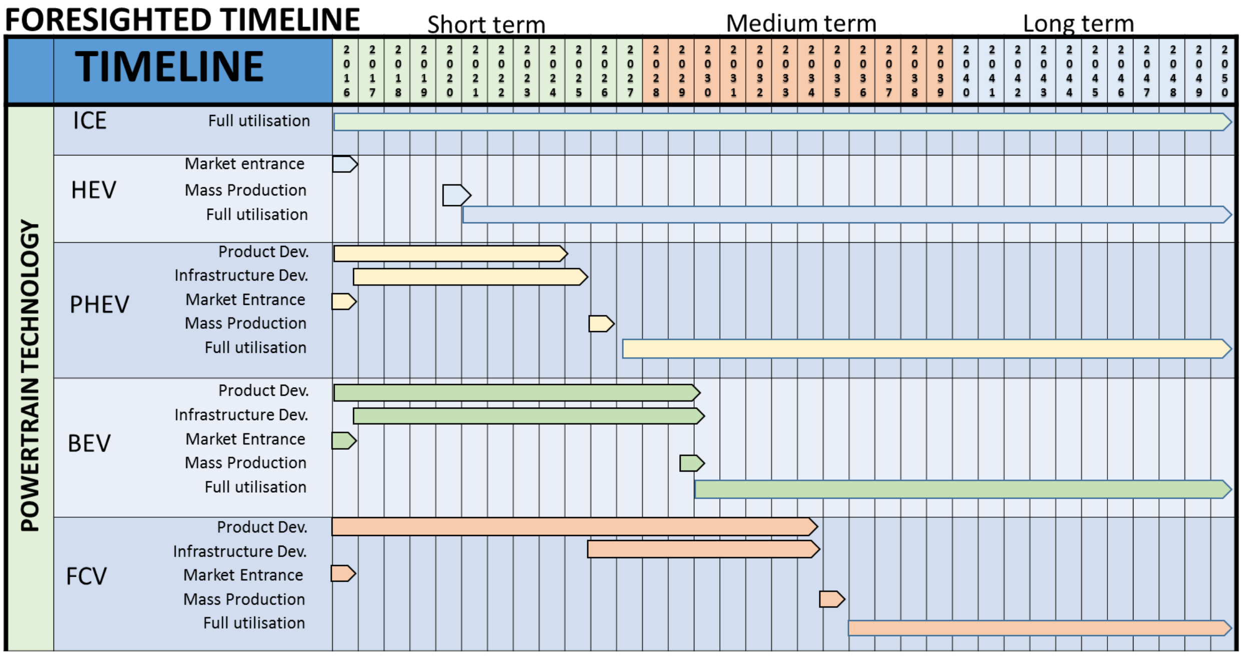


Figure 2.19: Market entrance and mass production timeline

Chapter 3: Stakeholders Engagement

3.1 Government, Academia and Industry Engagement Workshops

In order to obtain feedback on the vision of automotive industry in 2050 four (4) stakeholders' engagements were conducted in Cyberjaya, Selangor (19 October 2015), Pulau Pinang (7 Dec 2016), Kota Kinabalu, Sabah (16 Feb 2016) and Kuching, Sarawak (17 Feb 2016). The workshops were attended by top executives, scholars and senior officials from government agencies, academia and automotive companies. Government officers were represented by agencies such as the Ministry of International Trade and Industry (MITI), Chief Minister Department, Chemistry Department Sabah, Chemistry Department Sarawak, Sabah Economic Development and Investment Authority SEDIA, MATRADE Sabah and Meteorology Department Sabah. The workshops were also represented by professors and academicians from faculties related to automotive technology and engineering such as the University Malaysia Sabah, University Sains Malaysia, University Malaysia Sarawak and University of Swinburne. Some members of the industries were also invited and came to contribute actively in the workshops including Kota Kinabalu Industrial Park, PERODUA, Motor Scooter Assembler and Distributor Association, Nabula Research, VADS Berhad, CMS Consortium Ecotour, Boon Koon Group and Inokom.

Stakeholders actively contributed in the workshops and resulted in a comprehensive outlook of Malaysia's future short, medium and long term automotive direction and future trends and challenges. For the discussion in the workshops, the next 10 years is categorised as short term, then the next 20 years is regarded as medium and the next 30 years is long. In this regard, the short term is from 2016 to 2026, the medium is from 2027 to 2028 and long term is from 2029 to 2050.The following is a summary of the discussions.

3.2 Short Term 2016 – 2026

The participants are in the opinion that at least within the next 10 years (short term) Malaysia will need to remain strong on ICE technology and manufacturing. Malaysia has invested heavily on car manufacturing and will continue to stay competitive in the automobile market. The participants predicted that by the year 2020 as ICE technology progresses to become more efficient and more environmentally friendly, the demand for biofuel for automobiles will increase substantially and Malaysia will need to be ready with the resources. There are many studies conducted on the availability of oil palm for biofuel against food security. This needs to be revisited and the policy on this issue needs to be established.

However, at the same time we need to prepare for the disruptive change in the automotive industry and the participants expect that Green and sustainable powered vehicle EV will also become more prevalent in the market and begin to replace ICE. It is expected that about 10% of Government and corporate vehicles in Malaysia to be electrically powered (2 or 4 wheeler) and by 2025 about 10% of ASEAN vehicle market to be EV. In this respect, the infrastructure such as electrical or hydrogen chargers for EV need to be in place throughout the country or at least in major towns. By this time, the Government should have a clear policy on fossil fuel dependency and the promotion of alternative energy from nuclear, renewable energy resources and smart grid.

Since the technology is going to be widespread, there will be a massive need for research, development, awareness, training and education in the new automotive which does not depend on fossil fuel. The participants are in the opinion that this is an opportunity for Malaysia to lead and not be dependent on others' technology and utilise our own natural resources such as EV components and manufacturing.

The workshop in Kuching discussed specifically on the intensification of natural resources utilisation of Sarawak such as bauxite and aluminium minerals, timber and timber waste as well as others like bamboo for future light weight automotive components, composites or high end vehicle products as well as utilising bio-waste for renewable energy generation. The existing oil and gas industries in Sarawak can support new automotive plastic based components manufacturing. Subsequently, there will be a need to coordinate vehicle component vendors, car manufacturers, universities and state governments to identify potential product development that will be derived from oil and gas, natural resources or any other potential in Sarawak. These are expected to provide a rewarding economic return to the country. However, more research and development is much needed on utilising Sarawak resources.

The workshop participants in Kota Kinabalu strongly feel that Sabah can be the hub for automotive industry of the future. Sabah is strategically located geographically which is central to Taiwan, Hong Kong, China and ASEAN countries around west and east side. This can be an added advantage and policies towards the development, investment and growth of the new automotive industry need to be in place. In addition to that, more research and development is needed to explore automotive material using Sabah's natural resources.

The group also envisaged that within the next decade driverless cars or autonomous vehicles will begin to gain popularity. The way people do things will eventually be affected as the society reacts to these disruptive technologies. The IOT, inter-connection and automated mobility technology such as EV monitoring through web including vehicle maintenance, routes and performance, real-time traffic information and Intelligent Traffic System (ITS) will increasingly become standard features of AV and the lifestyle. This intelligent mobility system will offer safe, smart, clean mobility and zero accidents and that will be very much needed in the very dense traffic of the future. Personal transport ownership will be replaced by personal transport services.

3.3 Medium Term 2027 - 2038

As oil prices keep on increasing and the reserve is depleting, the EV and autonomous vehicles will become more popular well into the next two decades. Intense technological development on alternative energy for automobiles will be highly prioritised. By 2030, one of the automotive energy technologies that is expected to gain significant market niche (other than lithium) is the Fuel Cell. Extensive study on hydrogen requirements for vehicles is required. The potential of hydrogen plants in ensuring the continuity of supply needs to be explored. The possibility of accessing and converting gaseous waste in our oil industry or any other local resources needs to be considered. Study on safety issues of hydrogen for fuel cells will also need to be considered.

By the next two decades, the workshop participants expect that driverless vehicles will be in its advanced stage in that they co-exist with personal transportation. However, regulations for both will need to be reviewed and facilities will need to be improved such as infrastructures, communications as well as securities. It is expected that by this time autonomous vehicles driving regulations will be endorsed.

Cars of the future are expected to be modular, plug and play type and repairs will be easy or even can be a Do-It-Yourself weekend hobby. Purchasing or leasing a car in the future can be easily done online. The traffic will be managed by intelligent predictive and reactive systems utilising real-time traffic data.

In the medium term, Sarawak is expected to continue its effort on developing and enhancing further the utilisation of its natural resources. Sarawak foresees that future expansion and investment on the new automotive component manufacturing, sub-assembly and assembly will be most promising.

3.4 Long Term 2039-2050

The initiatives undertaken in short and medium term are hoped to ultimately turn Malaysia to become one of the key players in the automotive industry. The workshop participants foresee that in the year 2050 Malaysia will capitalise the resources particularly from Sabah and Sarawak for the development and manufacturing of automobile parts and components. The existing automobile industry in Malaysia is expected to be enhanced with new automotive design capability including new materials, new powertrains and new infrastructure of green and sustainable automotive evolution.

The new order of the automotive industry opens up new opportunities for countries like Malaysia and ultimately Malaysia needs to aim for a bigger share of the world's automobile market. Although competition will be tremendously stiff and industries in China and India are world leaders, Malaysia will need to capitalise on our strengths and excel in niche areas.

In the long term, flying car technology might be a lucrative solution for large states such as Sabah and Sarawak. Although there are a growing numbers of budget airlines and flights operating in these states, flying cars for private transportation will be useful for business executives not only to reach smaller towns around the business person quickly and conveniently but also useful to Kalimantan, Philippines or to Semenanjung Malaysia.

3.5 The Scenario

All the workshop participants unanimously agree that the Malaysian Government needs to strongly support the Malaysian automotive industry in embracing the influence of new automotive technology, the inevitable change of our cultural and societal behaviour and the necessary training and the education needed by the industry. Table 3.1 outlines summary of the result of the workshop in short, medium and long term versus four (4) key perspectives i.e. politics and economy, technology and infrastructure, culture and society behaviour and training and education.

The government needs to support the ICE and encourage the generation of alternative energy such as Biofuel, renewable energy and smart grid. In this regard, regulations towards the growth of the automotive industries need to be constantly reviewed and complemented. On the other hand, the Malaysia automotive industry needs to aggressively strive to excel in more efficient vehicles and more efficient manufacturing. More research and development is needed to utilise natural resources especially from Sabah and Sarawak. The participants also anticipate that due to the geographical condition in Sabah and Sarawak, in the long term the evolution of flying cars technology will effect automotive and the industry in that region. In this regard, related laws and regulations need to be in place.

The EV and AV technology is definitely coming into the automotive world. However, the key success factor of this new technology is the necessary infrastructure to supply the energy such as electricity and hydrogen. The supply needs to be extensive and possibly to the last mile in the long term if not sooner. The development of automotive is expected to be very rapid that one should not rule out that flying cars is a possibility in the future especially for business communities.

The EV and AV will change the future lifestyle. These new automobiles will change the way people move about and do their things in urban areas as well as rural. By the year 2050 the participants expect that transportation will be very much depending on AV and life will be difficult without it. At the same time these new revolutionary technology brings more jobs to the society. The automotive industry will need engineers and technical staff not only in typical automotive mechanical, production or manufacturing but equally important also in ICT, software, electrical, electronic as well as chemical engineering.

Consequently, more research and development and the development of new syllabus and curriculum are required immediately within the short term. Academia and the automotive industry need to collaborate and design and develop new programs including Automotive Systems, Electric Vehicle Propulsion Systems, Electronics Technology, Motors and Controls for Electric Vehicles, Electric Vehicle Data Acquisition, Sensors and Control Systems, Energy Storage, Alternative/Renewable Energies, Engine Fundamentals, Engine Performance, and Electric and Hybrid Vehicle Technologies.

Table 3.1: Malaysia Short, Medium and Long Term Plan

	SHORT TERM 2016-2026	**MEDIUM TERM 2027-2038**	**LONG TERM 2039-2050**
POLITICAL/ ECONOMY	• Remain strong in ICE technology and manufacturing • ICE more efficient, more economical • Use more Biofuel • More alternative energy (RE, Smart grid) • Sabah as auto-hub due to strategic location • Intensify use of resources for automotive in Sarawak – aluminium, timber	• Regulations on EV & AV need to be in place • AV driving will be endorsed	• Maintain as no.1 aluminium, timber component producer for automotive • Regulation of flying cars
TECHNOLOGY/ INFRASTRUCTURE	• EV and AV becoming proven technology • Need infrastructure on electrical and hydrogen chargers	• EV & AV more popular • Fuel cell technology dominating & commercialise • Need constant & widely available electric and hydrogen • More from Sarawak resource	• Provide infrastructure to the last mile • Possible flying cars become more popular in Sabah and Sarawak
CULTURE/ SOCIAL	• EV and AV change lifestyle – IOT on booking, monitoring, maintenance, routing, performance	• Mobility to the last mile – people in rural areas need to benefit	• More jobs created in the new automotive industry including software and telecommunication
TRAINING/ EDUCATION	• More R&D on new EV, AV • New training syllabus – automotive education	• More unified effort between academia and industry	• Enhance new automobile design • New material, new power train

Chapter 4: Governance

Practical and comprehensive governance is essential for the Malaysian Automotive Industry to successfully compete with other automotive players on the global stage. The followings are areas of governance essentially in need of governmental attentions for the local automotive industry to further develop and to confront possible destructive technologies forthcoming towards 2050.

4.1 Environment

It has been a few decades now that global climatic concern and environmental degradation have been the major issues debated aloud by international community. Climate change, global warming, greenhouse effect and inefficient energy utilisation have since affected and will continue to affect the global weather patterns and promoting widespread international climatic disasters, include; rise in the sea level, heavy rainfall across the globe, extreme drought, decline in crop productivity, changes in ecosystem, hurricanes, rise in temperatures and seawater has become more acidic.. Transportation sector is one of the major contributors to this environmental degradation being one of the main energy consumers, Figure 4.1 (International Energy Outlook, 2013). The sector transportation contributes 14% to the global greenhouse gasses, namely; carbon dioxide, methane, nitrous oxide and fluorinated gases, trapping heat in the Earth's atmosphere as a part of the greenhouse effect. However, human activities, primarily the burning of fossil fuels and deforestation, have intensified the global greenhouse phenomena.

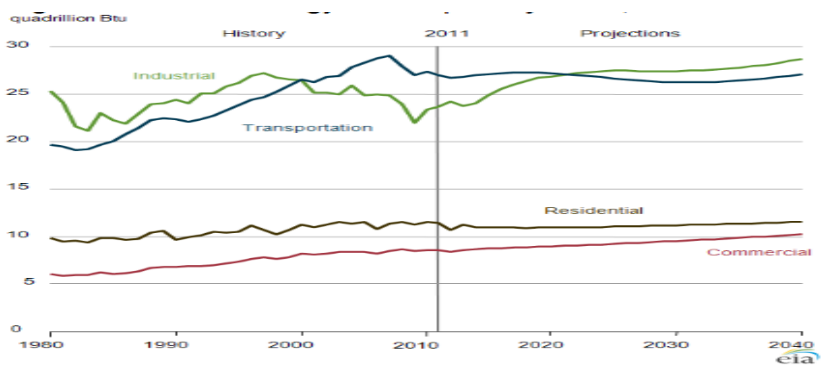


Figure 4.1: Delivered energy consumption by sector 1980 – 2040

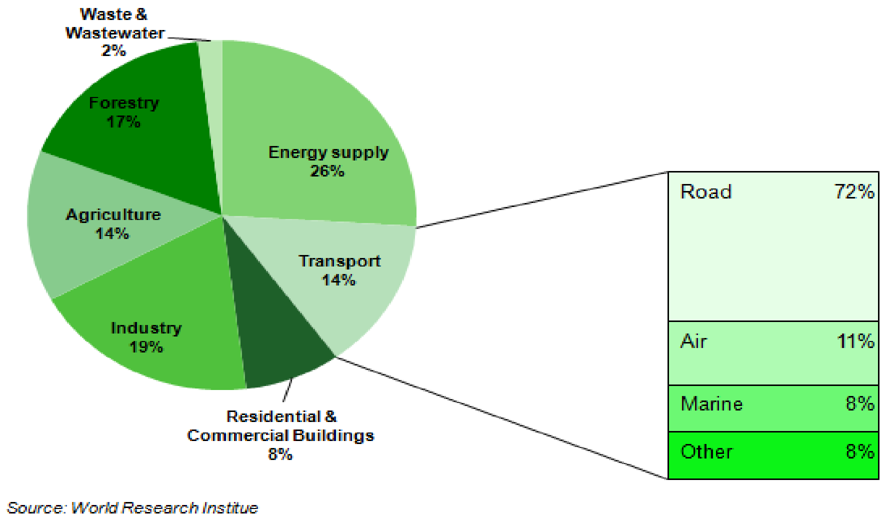


Figure 4.2: Global Greenhouse Gas Sources (World Resources Institute 2005)

Kyoto Protocol, Copenhagen Accord and Paris Agreement 2015 are the agreements within the framework of the United Nations Framework Convention on Climate Change (UNFCCC) dealing with greenhouse gases emissions mitigation, adaptation and finance. Malaysia is one of the signatory countries in these agreements. One of the objectives of these agreements is enhancing the implementation of the UNFCCC through holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels, recognizing that this would significantly reduce the risks and impacts of climate change.

The automotive industry could play a vital role to address the above issues and the NAP 2014 is promoting the use and manufacture of energy efficient vehicles (EEV) which is one of the Malaysian government initiatives to address the energy and environment concerns. The EEV initiative is a sensible future plan as the nation moves towards 2050 where the local automotive industry may embark on the production of intelligent energy efficient vehicle that would be safe and economical coupled with other advanced vehicle design feature such as; connectivity, efficient energy, autonomous and environmentally friendly.

Policies that need to be reviewed, improved, enforced and monitored include:

a. Motor vehicle regulations
b. Fuel policy on ICE, HEV, PHEV, BEV and FCV vehicles
c. End of Life of Vehicles and Remanufacturing of HEV, PHEV, BEV & FCV
d. Vehicle Type Approval on HEV, PHEV, BEV & FCV
e. Electric Vehicle Battery Disposal policy
f. Handling accident cases of electric vehicle policy
g. Vehicle Safety policy

The new e-Mobility vehicles are expected to reduce or eliminate harmful gaseous emission in the vicinities where they operate. Pollution elimination can only truly happen if the source of energy generation that power these vehicles are also green, without which the exercise is merely relocating the pollution to the energy source. If the power generation remains heavily on burning of coal, the whole initiative to reduce CO_2 footprint in the atmosphere is meaningless.

In this respect energy generation policy, namely fossil fuel policy and renewable energy policy and its timeline implementation by the government is important, however the energy production governance is outside the scope of the automotive sector.

Categorically two main environmental policy instruments are needed to ensure widespread usage of the e-Mobility vehicles:

i) Fuel Emission policy

The fossil fuel driven vehicles will continue to dominate the automotive sector towards 2050 and beyond. Henceforth to expedite the usage of the e-Mobility vehicles, fuel policy in relation to CO_2 and other harmful gaseous percentage reduction over target timelines is necessary.

ii) ELV and Recycling policy

Equally important End-of-Life and recycling policy must be put in place to ensure proper management of future e-Mobility vehicles and their related industrial wastes are well managed. More incentives are given to those who trade off their ELV for purchase of a new e-Mobility vehicle.

4.2 Businesses and Trades

Another important aspect of the automotive governance that need serious attention is the business and trade rules and regulations. Typical characteristics of the world economic leading nations are those whom have instituted well planned, implementation, monitoring and improvement that respond to the market needs with respect to their respective internal governance. NAP 2014 has postulated that the Malaysian automotive industry shall be a major contributor to the nation GDP, predicted to be some 10% by the year of 2020 and 15% in 2050. As indicated in Figure 4.3, by 2020 the transportation sector will generate US$0.114 trillion into the world economy especially when IOT is implemented within the sector. Whilst Table 4.1 (JPJ 2016), the number of vehicles registered in Malaysia will double in every 10 years. In 2004, the number of vehicles registered in Malaysia was around 13.7 million units and doubled in 2014. Henceforth Continuous and strong collaboration between the government, private sectors and Malaysian populace is essential in order to support the automotive industry to move further and to compete globally.

Table 4.1: Vehicle registration in Malaysia

Vehicle Type	PRIVATE VEHICLE		PUBLIC SERVICE VEHICLE			GOODS VEHICLE	OTHERS	TOTAL
Year	Motorcycle	Car	Bus	Taxi	Rent Car (Self-driven)			
2014	11,629,263	11,028,296	65,044	105,688	58,937	1,159,517	882,441	**25,101,192**
2013	11,087,878	10,535,575	62,784	99,921	53,954	1,116,167	862,977	**23,819,256**
2012	10,589,818	10,354,678	73,536	93,040	19,296	1,032,004	539,849	**22,702,221**
2011	9,985,308	9,721,447	71,784	90,020	19,194	997,649	515,867	**21,401,269**
2010	9,441,907	9,114,920	69,149	84,661	18,300	966,177	493,451	**20,188,565**
2009	8,940,230	8,506,080	66,581	79,149	16,579	936,222	471,941	**19,016,782**
2008	8,487,451	7,966,525	64,050	75,028	15,446	909,243	454,158	**17,971,901**
2007	7,943,364	7,419,643	62,308	72,374	12368	871,234	432,652	**16,813,943**
2006	7,458,128	6,941,996	59,991	70,409	11638	836,579	411,991	**15,790,732**
2005	7,008,051	6,473,261	57,370	67,451	11,679	805,157	393,438	**14,816,407**
2004	6,572,366	5,911,752	54,997	65,008	10,661	772,218	377,835	**13,764,837**

Source: Road Transport Department of Malaysia (JPJ) **5**

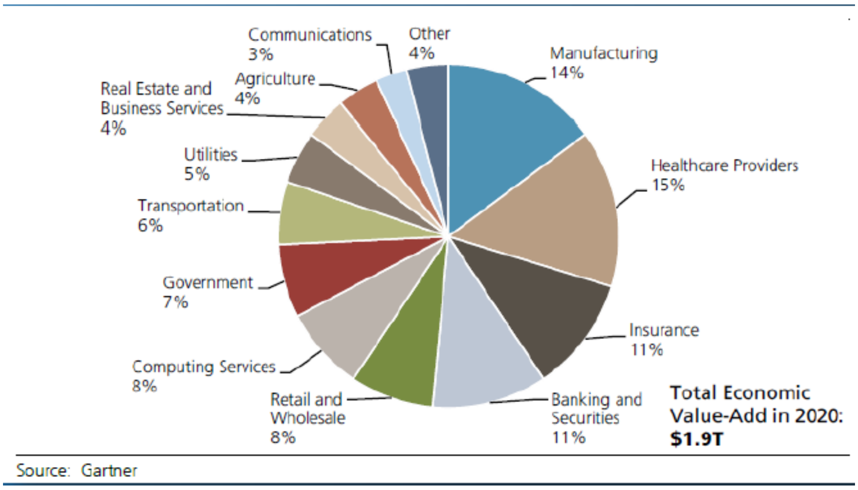


Figure 4.3: Economic value-add of IOT by sectors in 2020

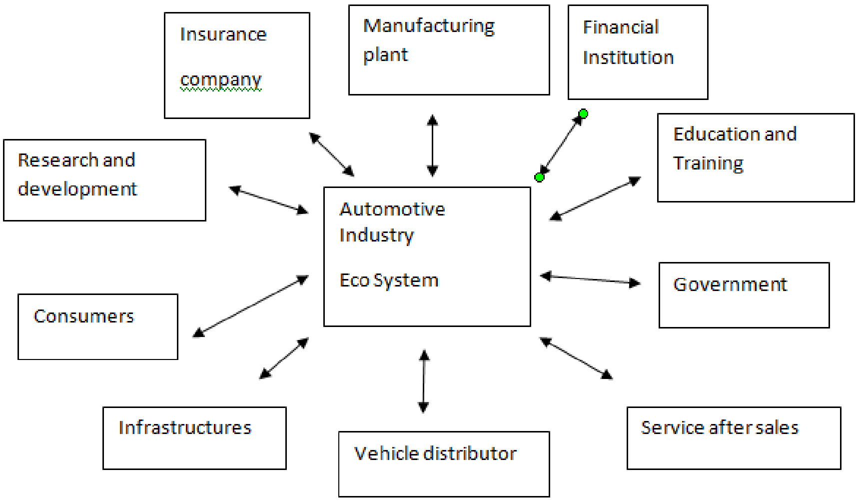


Figure 4.4: Automotive industry ecosystem

Trading and business opportunities can appear in many forms and at various levels, starting from small and medium scale enterprises to large companies as indicated in Figure 4.4. It can be from car-wash businesses up to big OEM or vehicle assemblers. Many products and businesses can be developed within this ecosystem.

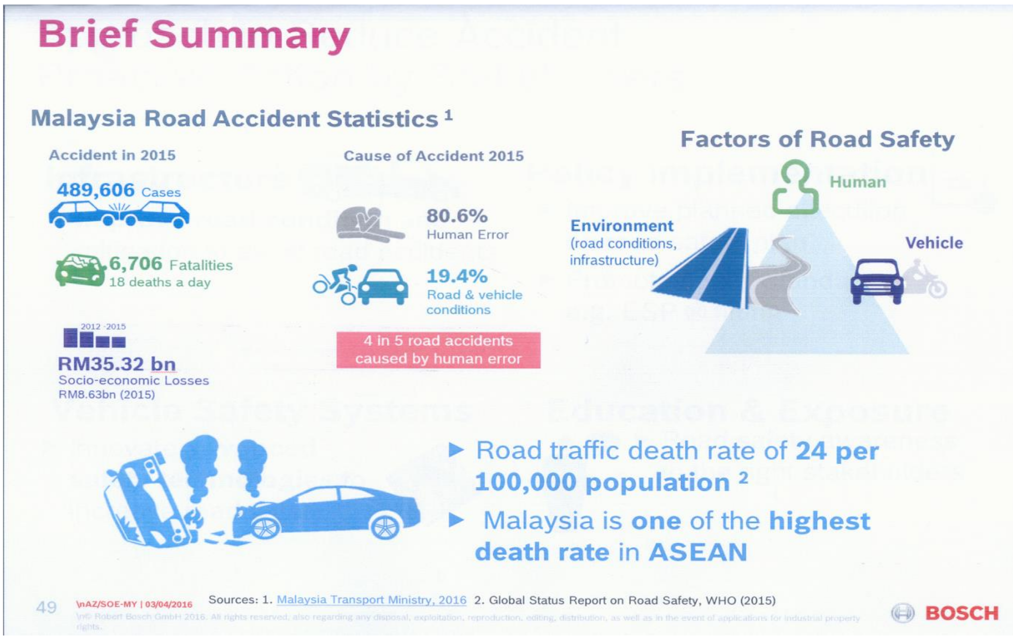


Figure 4.5: Malaysian Road Accident Statistic 2015

While the number of cars increases on highways and roads the number vehicle accidents unfortunately follows proportionately. According to Figure 4.5 (Robert Bosch 2016), in 2005, 489,606 accident cases happened in Malaysia that caused 6,706 fatalities. The total socio-economic losses between 2012-2015 is about RM35.32 billion. The requirement to have safer vehicles and road system is crucial. Advance technologies need to be developed to address this issue. Nevertheless work has already started and currently more vehicle safety technologies are incorporated in vehicles. Some of passive and active vehicle safety technologies available today but need further improvement are depicted in Figures 4.6 and 4.7 (Robert Bosch 2016).

These new technologies development is actually opening up new business opportunities. Many automotive industry players are developing more advanced and safer autonomous vehicles. Some of the safety and self-drive technologies being developed are indicated in Figure 4.8 (Robert Bosch 2016). The introduction of these new technologies supports the Malaysian government efforts to make sure that vehicles operate in Malaysia safe and comply with international standards.

With regards to compliance to vehicle standards and regulations the Malaysian Government is introducing vehicle type approval (VTA) as outlined in Figure 4.9 (JPJ 2016). This type of service could also be used by other neighbouring countries which can generate income to the government. However due to rapid automotive technology development these regulations and standards need to be reviewed regularly.

As indicated in Figure 4.10, Malaysia is one of the members TPPA. It means that the market becomes bigger and more competitive. The local companies should be prepared to take up the challenge.

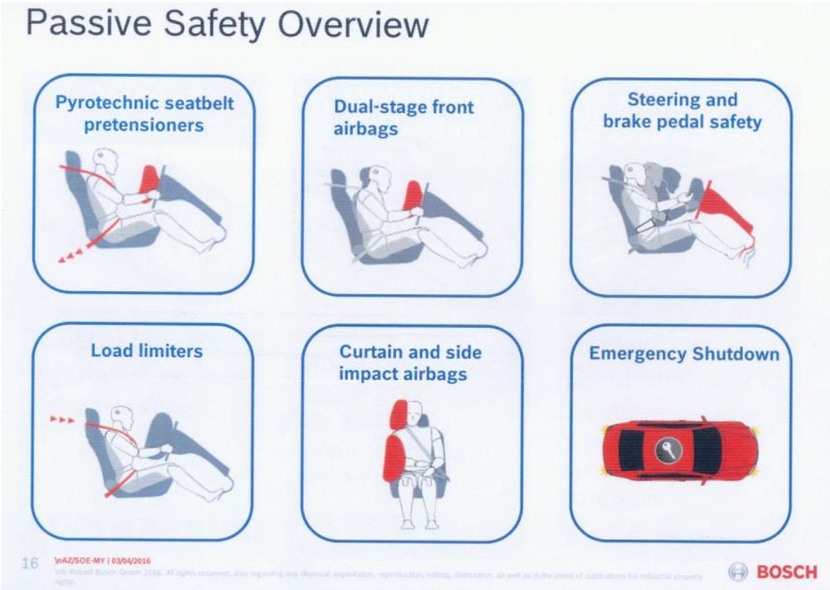


Figure 4.6: Passive safety technology

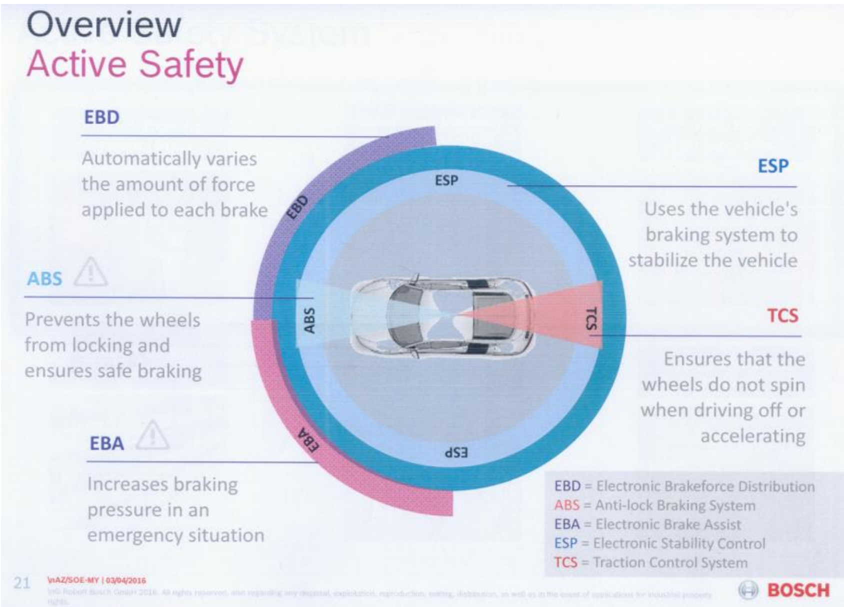


Figure 4.7: Active safety technology

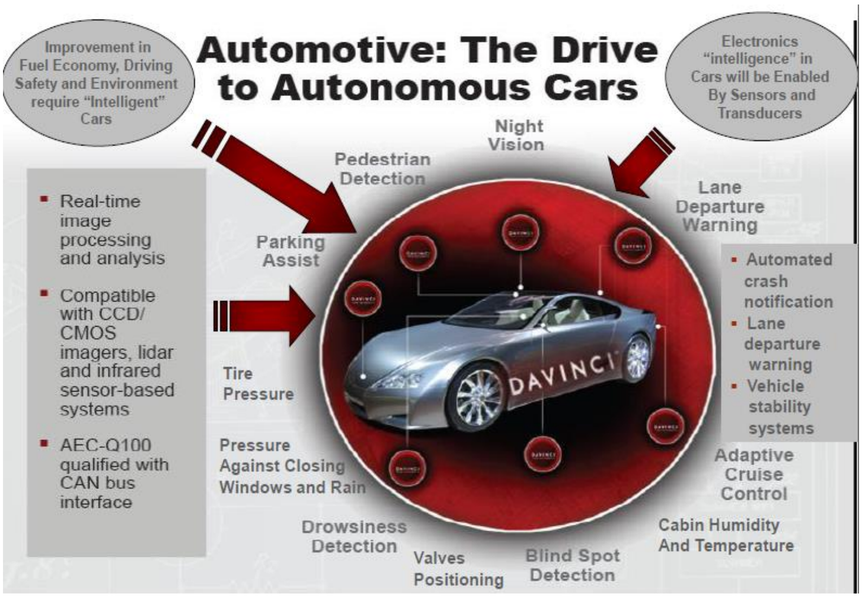


Figure 4.8: Autonomous vehicle technology

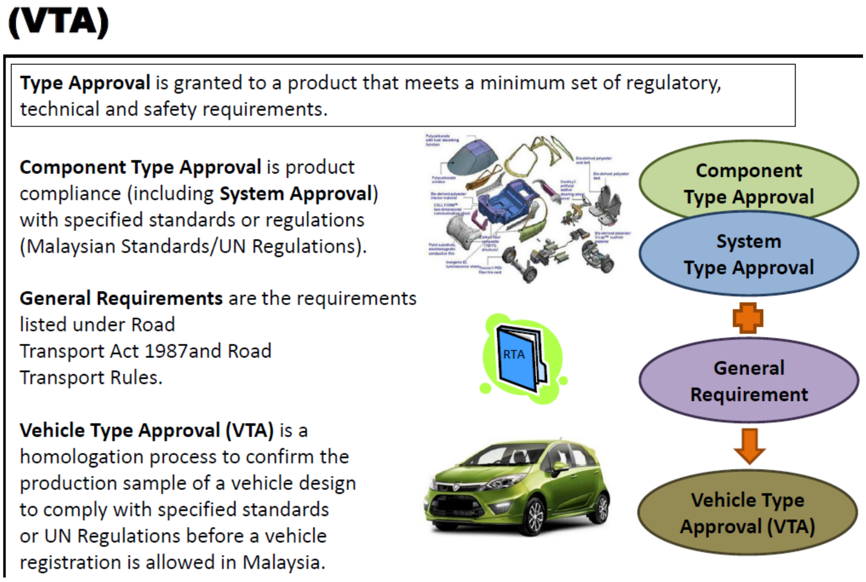


Figure 4.9: Vehicle Type Approval

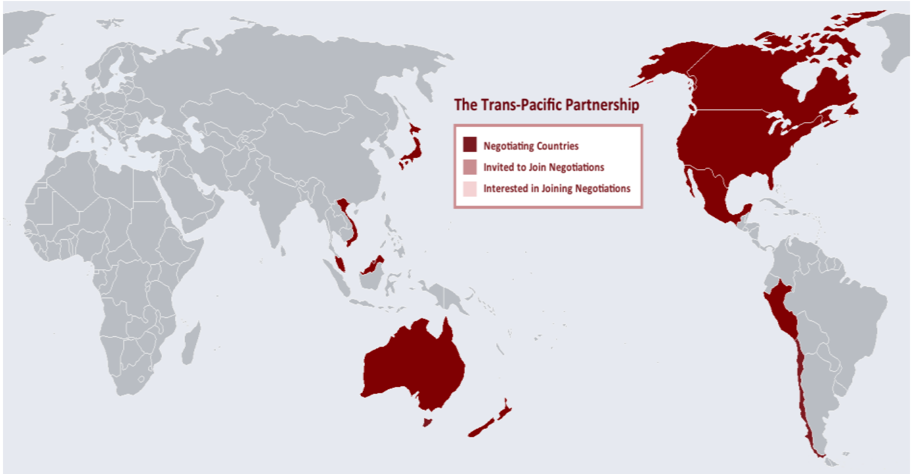


Figure 4.10: TPPA countries

While trade incentives and benefits have been formulated by various free trade agreements, the government support for local initiatives towards EEV and iEEV utilisations are needed to boost local demands. Some of which are:

a) Import export taxation - Re-examination of the current disruptive taxation scheme on conventional vehicles equally applied to EEV and iEEV need be revised.

b) Funding Promotion for public fleet - This is to encourage public awareness on the advantage of EEV and iEEV, some promotion incentive must be made available for fleet operators, albeit public or government sector.

c) Incentive for charging infrastructure_investment - Charging infrastructures are crucial for BEV to operate and as such special incentive is required for private initiatives to embark on charging infrastructure investments.

d) Tax exemption for EEV and iEEV companies - Companies may be the biggest buyers for any kind of vehicle for their operation and tax exemption of EEV purchase by company is an attractive incentive.

e) Purchase incentive for EEV and iEEV individual buyer - Incentive such as; 100% first year road tax exemption, first year income tax deductible are some possible incentives to encourage individual buyers.

f) Tax exemption electronic and electrical outputs for EEV and iEEV - Companies producing converter system, electrical motor, active and passive vehicle safety system should be incentivised by tax incentive, in particular those producing;

- main components such as power semiconductor devices that are used to develop the converter system.
- main components such as permanent magnet and winding that are used to develop the electric motor.
- main components such as sensors and actuators that are used to develop the active and passive vehicle safety system.

g) Improve and update the VTA process, regulations and standards.

h) Offer tax exemption for R & D and vehicle test companies who design and produce new products for the automotive industry.

i) Review the policy on vehicle insurance.

4.3 Labour

As indicated in Table 4.2 (NAP 2014), the manpower for automotive industry will be increased from 550,000 in 2013 to 700,000 in 2020 in manufacturing and aftermarket sectors of automotive industry. The need to have a proper comprehensive plan to prepare qualified skilled workers and professional workers for this industry is crucial.

Table 4.2: Manpower of automotive industry

Sector	**Year 2013**	**Year 2020**
Manufacturing	250,000	320,000
Aftermarket	300,000	380,000
Total	**550,000**	**700,000**

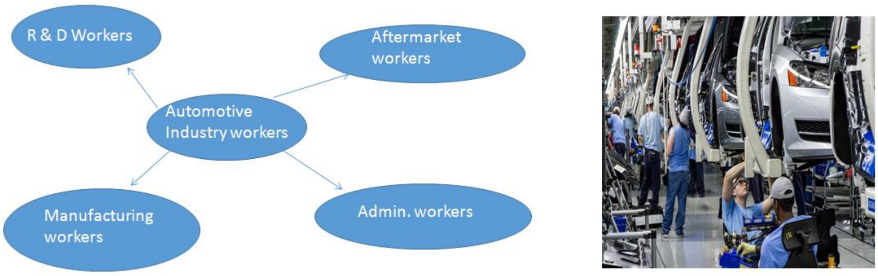


Figure 4.11: Comprehensive plan for automotive industry workforce

In order for the Malaysian automotive industry to be competitive at a global level, the workforce needs to be competent and creative. New technology needs to be produced locally. As shown in Figure 4.11, the workforce includes sectors such as R & D workers, aftermarket workers, manufacturing workers and administration workers.

There are few universities in Malaysia offering automotive courses at bachelors, Master and PhD level. However, many universities produce engineers, software engineers, programmers, researchers, managers and other professional workers who can be related to automotive industry. Due to the rising need for specialised and focused on automotive courses the government has setup a new university called DRB-HICOM University in 2016 as per Figure 4.12.

Figure 4.12: DRB-HICOM University of Automotive Malaysia

Polytechnics, Vocational Colleges and Training centres provide training for skilled workers but the syllabi of the programs need to be reviewed accordingly and effectively. Both the industry and universities could collaborate to ensure the syllabus and the training provided are relevant to the industry needs. In terms of research, both the universities and industry could work together to produce new technology in this sector.

Other initiatives which could be further improved include:

a) Retraining policy to encourage current skilled workers to advance into EEV and iEEV skills.
b) Minimum salary for various certified EEV and iEEV training would attract new labour force in EEV and iEEV related jobs.
c) Learning curriculum in EEV at various levels must be introduced in the education system of the country.

4.5 Standardisation and Certifications

Introduction of standards and certification procedures for parts and components related to EEV must be in place to ensure quality manufacturing and supply of parts within the supply chain.

EEV type approval is another aspect of regulation to be put in place. Currently two type of approvals have been in practice in Europe and are adaptable to the local scene; one is based around EC Directives and provides for the approval of whole vehicles, vehicle systems, and separate components. The other is based around UN ECE regulations and provides for approval of vehicle systems and separate components, but not whole vehicles.

4.6 Promotion of FCVs

Investment policy is required for FCVs to achieve market readiness. While the anticipated market utilisation of the vehicles is in the longer term, R&D policies should be introduced to focus on the exploration and development of concepts and prototypes of highly efficient fuel cell technology.

Government support will need to deal with the “chicken-and-egg” predicament by supporting both the development of FCV technology to bring it to market readiness, e.g., by helping manufacturers produce prototype FCV vehicles, and hydrogen supply infrastructure.

The Government need to seriously consider the appropriate taxation and/or subsidy that reduce the high initial cost of FCVs compared to conventional vehicles. The policy can be directed at either producers or manufacturers of FCVs and suppliers of hydrogen thereby reducing their production and distribution costs, benefiting the consumers who purchase FCVs. Some form of tax credits are to be introduced for hydrogen sold for use in e-Mobility vehicles.

In addition to the above, the Green House Gas emission (GHG) policy has to be consistently reviewed to reduce sectoral and/or economy-wide greenhouse gas (GHG) emissions through “carbon” pricing, regulated standards, subsidies, infrastructure spending, R&D, and voluntary initiatives. A reduction in economy-wide GHG emissions would ensure that hydrogen production generates less CO_2 emissions, reducing upstream emissions from the use of FCVs.

4.7 Institute relevant support infrastructure

Convenient charging (PHEV and BEV) and fuelling (FCV) infrastructures will be a key factor for a successful e-Mobility market. Most e-Mobility charging concepts are currently centred at home, at work or at public areas. There is absence of any regulation pertaining to issues such as taxation, insurance and safety installation of these support infrastructures that may retard the installation endeavours.

OEMs may offer home-charging solutions to customers in future e-Mobility purchases. However this may only be an attempt to kick start the charging market but wider or bigger platform integration with all other e-Mobility partners need policy, rules and regulations. If the widespread public charging stations continue to be slow in the implementation the market may be forced to focus on hybrid vehicles. FCV on the other hand will not enter the market place without consortiums afford to install well dispersed hydrogen filling stations.

Public charging and hydrogen filling infrastructure is a large-scale investment and currently there is uncertainty that any initiative would be a standalone business. There are practically non-existent pilot projects locally to initiate the infrastructure installation, neither at cooperative urban initiatives level supported by federal government funding and installed by energy utilities, state-funded projects or business-support initiative in efforts designed to show e-Mobility feasibility.

Some immediate measures must be strategically undertaken to initiate installation of these infrastructures which include:

i) Promoting e-Mobility test-beds regionally in selected cities or vicinities within cities currently suffering from massive congestions and atmospheric pollution due to ICE vehicles. Federal and State government collaborations are necessary to ensure success.

ii) Incentives for private sector initiatives, particularly automotive OEM, to develop test beds in selected urban areas through multiple tax deduction schemes, tax credits on specified number of vehicle sales for each test-bed developed and investment incentives to manufacture e-Mobility vehicles locally based on total test-bed development cost prior to commencement of manufacturing.

iii) Introduce a joint government-private “e-Mobility Committee” to monitor development and successful implementation of the nation e-Mobility initiatives and to institute e-Mobility blueprint as guideline for the e-Mobility development course.

Chapter 5: Cross-referencing Between Sectors

5.1 Transportation Sector

In 2050, ICE technologies will be more efficient and Hybrid Electric Vehicle will reduce the consumption further. Therefore the total demand for petrol, diesel or gas will be significantly affected. However, although vehicles will be energy efficient, the contribution of alternative fuel such as biofuel will be very much valued so that fossil fuel that has been reserved can be stretched as long as possible. This development will definitely benefit the transportation sector especially public transportation such as taxis, limousines, buses and vehicle rental services.

By this time it is also expected that PHEV, fuel cell and autonomous driving will become the popular choice of powertrain for vehicles and the new way of traveling. The transportation sector will need to meet the demand for charging either electricity or hydrogen. The incorporation of renewable energy resources for vehicles will be most appropriate as these will keep the carbon foot-print low. In this respect, the design of infrastructure needs to accommodate the development of the automotive technology such as the road design and the traffic management.

5.2 Energy Sector

As the number of vehicles increases on the roads, demand for energy will increase proportionately. In order to be sustainable, other than natural oil and gas, energy needs to be generated from renewable resources such as solar photovoltaic, biomass or hydro for electricity and hydrogen from a number of different processes such as thermochemical processes from biomass, water (H2O) using electrolysis or solar energy, microorganisms such as bacteria and algae can produce hydrogen through biological processes.

The energy sector need to consider the future automotive alternative energy such as second generation biofuels, specifically biofuels derived from cellulosic or lignocellulosic conversion for synthetic biomass-to-liquid (BTL) or synthetic gas-to-liquid (GTL). Advocates for the development of cellulosic conversion believe that second generation biofuel technology avoids many of the adverse consequences of first generation biofuels: it does not directly compete for food since it is based on crops such as tall grass or waste from palm oil, it causes less environmental impact than row crop agriculture, and the energy yield per hectare (ha) is generally higher.

A report on Energy by Mega Science Framework for Sustained National Development (2011-2050) recognises that energy efficient vehicles are making their way onto Malaysian roads and many plans such as the National Energy Policy, National S&T Policy II, MOSTI Strategic Action Plan, National Biofuel Policy and the New Green Technology Policy (NGTP) are formulated to support the automobiles and the automotive industries. These policies need to promote relevant research and development in alternative energy.

5.3 Electronic and Electrical Sector

The automotive sector needs very strong support from the electrical and electronic (E&E) sector. The future automobiles will essentially be electrical and electronic rather than mechanical as the conventional vehicle is today. Some of the key electrical and electronic components of the value chain that will be in great demand for the electrical and autonomous vehicles are such as the telecommunications, instrumentations, sensors, software and energy storage. Although ICE-based vehicles and EVs have much in common in terms of parts and manufacturing processes, the differences are significant and require new skills of employees involved in vehicle assembly, repair, and servicing. In this respect the E&E needs to be prepared with the right training and certification schemes for well qualified engineers and technicians to support new automotive activities such as product design and development, prototyping, manufacturing and maintenance services.

Some of the steps that can be considered to be undertaken include:

- Automobile electrification programs at the vocational level.
- Address different types of hybrids and EV at college training modules.
- Career development by Universities that direct students towards high-paying jobs that will be found in the EV industry.

- Offer training in new business models, battery engineering, relevant chemistry and physics, power system engineering, manufacturing processes, and other disciplines needed to advance EVs.
- Inter-department or inter-ministry sharing of new curriculum materials to address emerging EV issues.
- Training for Emergency responders on EVs to ensure they execute their duties in a safe and timely manner including how to deal with high-voltage batteries and flows of electricity within vehicles in order to safely extricate victims at times of collisions.

The E&E sector also needs to provide all necessary information about EVs to policy-makers in charge of developing and making difficult policy decisions in many areas concerning the progress of EVs. Policies and regulations formulated by the E&E sector will significantly affect the automotive industries and its communities.

5.4 Housing Sector

The housing sector promotes future houses to be smart and sustainable. The Smart home is capable of remote electronic control to manage smart appliances such as heaters, air conditioners, washing machines etc. The homes will conserve energy by only using energy efficient appliances and real-time access and capitalise energy data facilitated by a network of sensors and computers. With the advancement of automotive technology and with the increasing need to charge electric vehicles at home especially in the evenings and nights, the concept of a smart home needs to be extended to include this facility. It is also envisaged that future homes including apartments, condominiums and public parking facilities need to be designed to include charging facilities. In a much bigger scale the electrical requirement will actually affect the housing schemes, high rise building substations and charging stations. The housing sector will need to liaise with E&E and Infrastructure sector for the right sizing of electrical supply and provision of charging facilities for consumers.

The Housing Sector will also need to design future Smart homes that cater for effective communication with vehicles of the future such as autonomous cars.

Electronic controls will have to be designed and installed in futures homes with intelligent home-vehicle communication features such as calling for an autonomous taxi, approaching school bus, delivery vehicle is on the way and unknown vehicle is on the driveway. This inter-sector coordination will be a great value for smart homes and will be an added advantage for smart vehicles of the future.

5.5 Infrastructure Sector

The new automotive technology needs new infrastructural support. With the advancement of plug-in EV, charging facilities will be needed everywhere in the country and should be easily available. The United Kingdom Government has already announced that a wave of charge-points will be installed across the UK and the government has set out £32 million of infrastructure support up to 2020. Homes, hospitals, train stations and major roads will be some of the locations for charge-points. If Malaysia were to implement a similar scale of facilities, the infrastructural investment will roughly be around RM200 Million.

There is also a great possibility that fuel cell technology will become predominantly more popular than EV technology. Depending on the development and the success of the technology, investment on hydrogen infrastructure will need to be in place. However, to create a hydrogen future would require immense investment in extraordinarily expensive infrastructure. For example, California, one of the world's leading proponents of automotive fuel-cell technology, has pledged to invest $100 million to build just 100 hydrogen fuelling stations by 2020. This proves to be an expensive investment for a country like Malaysia and it is hoped that over time more research and development are successfully carried out to bring the cost down.

At the same time, other infrastructures such as the conventional compressed natural gas (CNG) supply system and IOT of information system will need to be extended to reach more ICE users. By the year 2050, the CNG will need to reach the last mile including remote places in Sabah and Sarawak. Along with this development, hardware of the internet communications will need to be deployed extensively as vehicles communicate with other vehicles and IOT through applications of the EV and AV.

5.6 Environment Sector

The main concern of the environment sector is to reduce carbon and greenhouse gas emissions. The automotive industry has introduced green technologies and initiatives that extend beyond automobile design (fuel, engine, materials, etc.), to include car industry infrastructure (facilities), manufacturing processes (pressing, welding, painting, etc.), logistics and supply chain (efficient routes, packaging, environmental guidelines and selection criteria), end-of-life vehicles and parts (air bags, batteries, etc.) innovation using intelligent traffic systems, and other initiatives related to environmental protection, education programmes and green philanthropy.

Taxis are an important stakeholder of environmental innovation. Research has found that while they may comprise only 1% of the urban fleet, they can be responsible for 4-6% of greenhouse gas emissions in urban centres. The environment sector needs to promote the use of electric vehicles as taxis and set up the much-needed urban infrastructure and mature technologies at lower commercial risk.

5.7 Plastic and Composite Sector

The plastic and composite sector needs to support the automotive sector through advanced materials technologies such as kevlar, kenaf, engineering plastics and special rubber. These materials will be widely used for components, body and structure of the future vehicles. The materials used in automotive engineering need to ultimately be lighter which means lighter vehicles and lower emissions. Composites are being used increasingly in the automotive industry due to their strength, quality and light weight.

The development of lightweight parts and components for automotive needs to be undertaken, with prioritization on the use of local materials. As an example, Toyota Boshoku Corporation has started a full-scale development in Indonesia of seeds of the kenaf, which is used for automobile interior parts. A door trim base material using kenaf was first adopted for TOYOTA Celsior which was launched for the domestic market in 2000. With that as a starter, currently, kenaf is being used for five components in a total of 27 car models focusing on high-end cars. However, with the target set at making all interior parts from plant materials, in using the agricultural product kenaf for industrial automobile interior parts, it has become more vital than ever to stabilize its quality, production volume and cost. This is a good lesson for the Malaysian companies and with the help of the Plastic and Components section similar and better parts and components can be produced.

5.8 Tourism Sector

Malaysia offers beautiful and scenic tourist destinations. Apart from this attractive offer, environmental pollution is one of the main concerns for most visitors. As such, maintaining non-polluting transportation vehicles in the vicinity of tourism spots is important in meeting the visitors' environmental expectation. Non-polluting EVs is the currently available transport option to operate in the vicinity avoiding pollution. In this regard, the automotive sector has the potential to contribute towards a clean environment in tourist destinations by supplying non-emission vehicles.

5.9 Agriculture Sector

The increasing demand and suitability of synthetic rubber in engineering and other applications has often resulted in drop in market value for natural rubber. On a similar accord, government intervention to discourage cigarette smoking among the general populace through heavy taxation on tobacco products has resulted in a decline in sales. As a result, rubber and tobacco production are less preferred by local plantation holders and instead they are exploring new alternatives. The rise in demand for kenaf fibre in engineering composite applications, particularly automotive components, offer alternative crops to the plantations holders with a much better market value. This potential should be exploited by the agricultural sector.

Figure 5.1: Inter-linkaging Malaysia 2050 for Automotive

Chapter 6: Talent Development

6.1 Introduction

The automotive industry is one of the main contributors to Malaysian economy. This can be noticed from published economy data in 2012. This industry is contributing some 3.2 % to GDP in 2012, accounting for RM5.3 billion in exports, investments of RM5 billion (January-October 2013: RM3 billion) (NAP 2014). In the year 2015, the contribution of the automotive sector towards GDP had increased to 4.0%. (MAI Annual Report 2015)

Since 2013, the automotive industry hired approximately 550,000 workforces and number of workforce is expected to increase to 700,000 by year 2020, where 150,000 new workers are required within the industry. Amongst the 150,000 workers required, 80% are automotive skilled engineering workforce with hands on skills, while the remaining will be those in the services sector.

The government is targeting to increase the competitiveness of the Malaysian automotive industry through resolving the structural issues such as small economies of scale, high production costs, low level of knowledge and technology, sub-optimal supply chains and human capital development which is not fully aligned with the needs of the industry.

Those structural issues need be resolved as the Government aspires to develop Malaysia as the hub for EEV manufacturing in the region through strategic investments and adoption of high technology by automotive companies for the local, regional and international market by 2020 (MATR 2014).

As illustrated in Table 6.1, in 2013, the automotive industry manufacturing sector needed 250,000 manpower while the aftermarket sector required 300,000 manpower to support its operation. In 2013, the amount of R & D professionals working in the automotive industry is less than 3000. To achieve the Vision 2020 goals, the government was asked to produce more competent and skilled workers as stated in

Table 6.1 (NAP 2014). The manpower is estimated to increase to 1,500,000 in the year 2050 that will support the growth of the industry.

Table 6.1: Manpower of automotive industry

Sector	Year 2013	Year 2020
Manufacturing	250,000	320,000
Aftermarket	300,000	380,000
R & D	3000	10,000
Total	**555,000**	**710,000**

6.2 NAP 2014 Human Capital Initiative

Human Capital Development (HCD) is one of the main strategy as laid out in the NAP 2014 in order to achieve its objectives. The HCD thrust aims to provide competent and sufficient workforce at all levels to drive the development of the domestic automotive industry. This is necessary to ensure the competitiveness of the domestic automotive industry (NAP 2014).

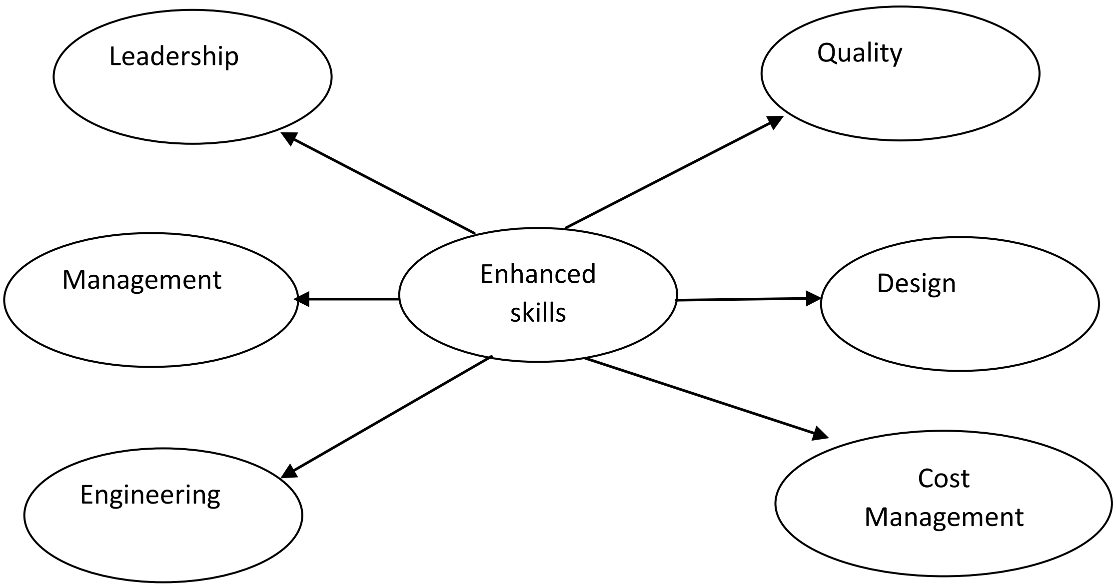


Figure 6.1: Enhanced skills recommended in NAP 2014

The HCD plan will enhance the quality of existing programmes at the technician and operator levels. The development of specific skilled labour such as in automated production system will enable the domestic automotive industry to increase the levels of automation and mechanization. This will reduce dependency on the less skilled foreign workers and consequently produce local skilled workers, capable of earning higher income. By 2020, it is expected that local skilled and semi-skilled workers will replace 80% of the foreign workers in the manufacturing sector (NAP 2014).

6.3 The Initiatives of Enhancing Human Capital Development

(i) Malaysian Automotive Institute (MAI) will continue, and develop further, the collaboration with the Ministry of Education on the apprenticeship programme in place since 2012, to accelerate the assimilation of graduates into the domestic automotive industry; and

(ii) Provision of funding amounting to RM100 million for the period of 2014 till 2020 for human capital development programmes.

MAI will also focus more into the PPT / NDTS promotion program that will be carried out personally.

- Malaysia Automotive Institute (MAI), as Industry Lead Body (ILB) appointed by Department of Skills Development (JPK) for the automotive industry, is responsible to coordinate between the industry and training institutions to ensure that both parties will effectively collaborate to develop relevant curriculum and skills standard for the Malaysian automotive industry.
- The MAI vision is to produce more skilled workers by following MAI added value for every PPT/NDTS programs. By doing this, MAI can make sure that all the skilled workers that undertake the program will become more competitive and more competent in the local market as well as the outside market. Furthermore, MAI will always do reviews and upgrade the current program with the research by following the international benchmark.

6.4 Malaysian Skill Certificate

Malaysian Skills Certificate (SKM) is a certificate issued by the Department of Skills Development (JPK), Ministry of Human Resources for vocational programs offered by training providers whether public/private. Each Stage/Level in SKM shows the credential of recognition and the level of knowledge.

SKM currently offers five (5) levels of certification, namely:

SKM Level 1	- Operations & Production Level (SKM)
SKM Level 2	- Operations & Production Level (SKM)
SKM Level 3	- Supervision Level(SKM)
DKM Level 4	- Supervision Level (Malaysian Skills Diploma)
DLKM Level 5	- Management Level (Malaysian Skills Advanced Diploma)

Its objectives are:

- To produce more skilled and competent workers for the local and international industry.
- To make all the skilled workers aware of current technology and be more competitive.

The Malaysian Skills Certificate can be earned through three (3) ways:

a) Through a Recognized Training Institutions Method through training programs at JPK accredited centres in a recognized field of specific skill level.

b) Through Industry Oriented Training Method of apprenticeship training in the **National Dual Training System (NDTS)** conducted in the industrial and skills training institutes. The benefits of NDTS are:
   - It minimizes mismatch (quality and quantity) between the companies' requirement and skills workforce development through demand-driven orientation.
   - Increases the use of new technologies more efficiently, because NDTS apprentices are exposed to various latest technologies during the learning process.
   - Improve productivity because employees who are trained under NDTS are trained to meet the needs of full employment in terms of knowledge, skills and attitudes.

c) Through the Accreditation of Prior Achievement **(PPT)** method to get the Malaysian Skills Certification through past experience (employment or training) without having to sit for the exam. Candidates are required to submit proof of the skills that have been held to be assessed by the Evaluation Officer and approved by the JPK-appointed External Verification Officer.

6.5 National Occupational Skills Standards (NOSS)

National Occupational Skills Standards or NOSS is a document that outlines the skills needed by a person working as a skilled worker in Malaysia in their respective field. The level of employment shows the path as to how achieve these skills. Key Features of NOSS are:

- Based on job.
- According to the structure of a career in the field of employment.
- Prepared by industry experts and skilled workers who carry out the work.

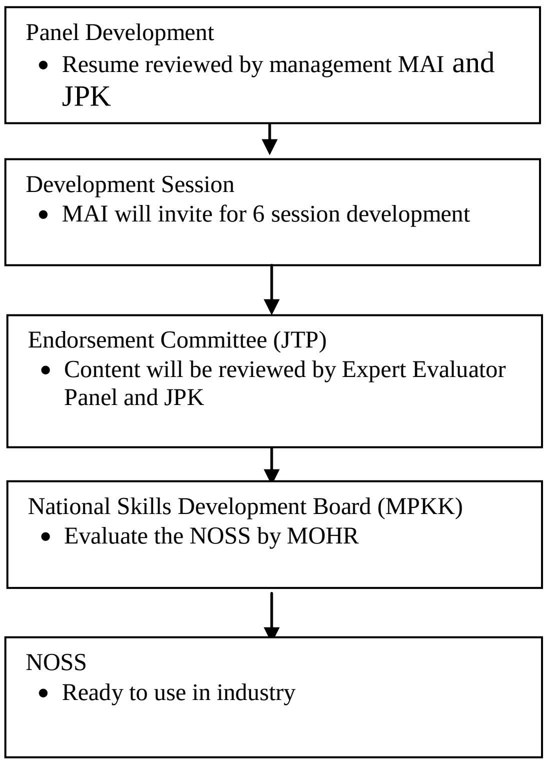


Figure 6.2: Steps of NOSS development

6.6 R & D & C Workers

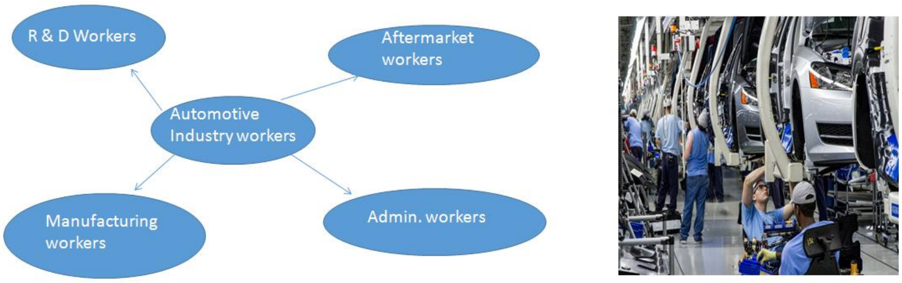


Figure 6.3: Comprehensive plan for automotive industry workforce

In order for the Malaysian automotive industry to be competitive at a global level, the workforce needs to be competent and creative. New technology needs to be produced locally. As shown in Figure 6.3, the workforce includes sectors such as R & D workers, aftermarket workers, manufacturing workers and administration workers.

There are few universities in Malaysia offering automotive courses at bachelors, Master and PhD level. Universities produce engineers, software engineers, programmers, researchers, managers and other professional workers related to the automotive industry. In 2016, the government has setup a new university that is focused on automotive courses. As depicted in Figure 6.4.

Figure 6.4: DRB-HICOM University of Automotive Malaysia

Polytechnics, Vocational Colleges and Training centres provide training for skilled workers. The syllabi of the programs need to be reviewed accordingly and effectively.

Both the industry and universities could collaborate to make sure the syllabus and the training are relevant to the industry needs. In terms of research, both the universities and industry could work together to produce new technology in this sector. Other matters which could be further improved include

i. Retraining policy to encourage current skilled workers to advance into EEV and iEEV skills. Minimum salary for various certified EEV and iEEV training would attract new labour force in EEV and iEEV related jobs.

ii. Learning curriculum in EEV at various levels must be introduced in the education system of the country.

6.7 Graduate Apprenticeship Programme

The current graduation to employment scenario amongst school leavers proved to be problematic both to the employers and the graduates themselves. Due to lack of practical experiences, most graduates find themselves difficult to adapt to the new work environment whilst the employers are in dilemma having to pay a predetermined or minimum salary the new graduates will remain unproductive for a number of years before they can truly perform on their jobs. This is particularly true in the automotive employments.

The most recognise methodology to ensure the new graduates to fully adapt to their new work place upon entering the job market is through graduated apprenticeship training popularly adopted by those earlier industrialised country such as the UK and Germany.

Apprenticeship is a methodology of learning and training the younger generation, which was adopted as early as the middle ages in Europe. A young man of that era who wished to acquire knowledge and skills of a particular trade will spend his growing up age with an elderly master craftsman who specialised in the trade. During this period, most of the training was done on the job and any theoretical knowledge that were related to the trade was taught by the master craftsman himself.

This mode of training was intensified when most of the European countries were embarking on industrial economy. Students, at the age of 15 to 17, (known as "graduate Apprentices") will start their career by being company employees and were sponsored for their tertiary education, in parallel while undergoing their training, until graduation as engineers in the field of their interest. The students were exposed to all aspects of the company operation and business, and upon graduation they were offered full employment by the company and effectively perform they job and able to develop their professional career almost immediately after graduation. Students who have undergone this graduate apprenticeship scheme have proven to be not only excellent in their academic knowledge but have the required skills and experience as they enter the employment market. Their understanding of engineering practices and applications were much broader and they were able to easily acquire new knowledge as they progress in their respective career.

Graduate Apprenticeship scheme of learning is still practiced by a number of large engineering companies in Europe and USA (also known as internship) to produce their dedicated and competent workforce.

An interesting feature of this programme is that the scholarship awarded to the respective students are channelled to the companies they are being employed as apprentice. The companies, being accountable for the funding of the students education, will disburse the fund to the students in the form of salary as if they are employees of the companies, while all education fees are paid direct to the Institute of Higher Learning.

The companies and the Institute of Higher Learning concern would have a special arrangement in order to ensure working hours and lectures are properly planned for the success of the programme benefitting both the companies and the students.

Contracts are usually signed between students and the companies to ensure an appropriate serving period with the companies by the students are fulfil upon graduation.

The programme have proven its ability to produce automotive talents in most of the well-known car makers now and the yesteryears.

Chapter 7: Research, Development & Commercialization

7.1 Introduction

Automotive technology has since advanced to a higher level to meet the ever increasing demands of the marketplace. As such, research and development (R&D) in automotive technology is becoming more complex, especially with the increasing demand for energy efficient vehicle (EEV) development.

In the local context, automotive R&D can be separated into two spectrums; firstly design and development of the vehicle per se and secondly is the development of the parts and components for the vehicles being developed.

Vehicle body R&D centred on achieving the best body profile, or styling, that will capture the customers' tastes and comfort without compromising on vehicle homologation aspects such as; structural integrity, impacts safety, vehicle aerodynamic, suspension system etc.

Powertrain R&D on the other hand strives at achieving the best customers driving experiences with respect to the vehicle propulsion ability, without compromising on fuel economy and emission quality. Interior design and development focus on providing comfort with excellent sound insulation and equip with infotainment and telematics gadgetry.

The automotive manufacturers (OEM) assume the role of designing and developing their vehicles as the outputs should comply with their respective marketing strategy, branding and design philosophy. Thus, almost all vehicles design and related R&D works are conducted in-house by the OEMs or contractually subcontracted out to associates, where secrecies are common.

The second spectrum of R&D activities is centred on producing the parts and components required by the OEMs for the vehicle assembly and nowadays are vendors entrusted. Although specifications are provided by the OEMs to the vendors, the parts and components being supplied are within the realm of vendors' innovativeness to ensure the qualities are ascertained meeting the specifications.

In this respect vendors are expected to establish R&D in-house capabilities in order to competitively support the production of quality parts and components required by the OEMs. The days where vendors merely shape without intellectual input into the parts and components are diminishing.

Strategies adopted elsewhere, for most parts and components, vendors chose collaboration with universities and research institutes as an effective route to undertake their R&D needs, while maintaining some in-house R&D capability.

A similar approach seems to be adopted by the local automotive vendors seeking R&D support from universities and research institutes to complement their own in-house initiatives. However, most R&D collaboration are focused on problems solving encountered by the vendors on their production line, at the expanse of innovative R&D for better products.

7.2 R&D and S&T Priority Areas for Local Automotive industry

High technological capability is predominant to realise the nation aspiration to develop the country towards "Energy Efficient Vehicle (EEV)" manufacturing. Malaysia now possesses the fundamental technologies to support the development of EEV industry, acquired from the nation's involvement in conventional automotive manufacturing thus far, however the nation still lacks some critical EEV specific technological requirements.

Figure 7.1 identifies the broad spectrum of manufacturing activities and the essential S&T required within the entire automotive ecosystem.

Vehicle weight is fundamental for EEV especially to achieve the lower fuel consumption per specified kilometres distance travelled. Continuous importation of light materials for EEV parts and components production, such as primary ingot of aluminium and magnesium, will not help in the longer term competitive advantage of the local EEV manufacture.

As such local aluminium production and/or recycling activities are in need technology and metallurgical knowledge of these materials and are able to produce the right primary alloys meeting the specifications for the parts and components production processes. R&D into the development of more advanced aluminium and magnesium materials, particular the metal composite aspects, would offer future competitive advantage for the local automotive produce.

Magnesium alloys is another light weight material that has gained its useful application for automotive parts, and little is known of the existence of this material parts being manufactured in the local automotive industrial scene. On similar account magnesium parts manufacturing is in need for further development locally to support the EEV initiative.

Metal composites, a combination within the metallic matrix with strong fibrous material, are important materials that have entered components manufacture for engineering applications. Aluminium composite has shown its potential for these engineering applications and more so in automotive. Adoption and adaption of this composite technology amongst the local automotive R&D and engineering community is the way forward to support the nation EEV venture and its components demands.

Malaysia petrochemical industry has been in existence since the nation oil production commenced. Plastic raw materials were in production but the types of plastics produced are limited only to those that are commonly used in the current conventional vehicles such as dashboard and other lower end interior fittings. Advanced engineering raw plastic materials are generally imported, such those of the polymeric group, and are shaped into components by the local plastic vendors. Henceforth materials R&D of more advanced plastics and polymeric materials would be very useful for EEV development and manufacturing.

Composite materials, reinforced plastics or polymeric materials with strong fibre, has been the alternative routes to replace the heavy metallic components in automotive application to achieve weight reduction. Processing technology and product development using composite for automotive components will be a new game plan amongst the local vendors to remain competitive.

Enhancement of other critical technologies and engineering abilities amongst the R&D community and industrial players within the automotive ecosystem are equally essential. Digital Engineering and prototyping, foundry practices, “green” powertrain design and development, new processes and advanced manufacturing are amongst technologies identified for further development or enhancement respectively. On the other hand recycling and remanufacturing technologies are among those priorities identified for adoption and adaption within the aftermarket sector of the automotive ecosystem.

Testing technologies applicable at various stages of a vehicle life span, from prototyping, pre-production and post-production, Vehicle Type Approval (VTA) and vehicle End-of-life (ELV) are still scanty locally and are in need of immediate attention.

Automotive vehicles are evolving from the current conventional internal combustion engine to hybrid to electric and finally to fuel-cell powertrain. Earlier foresight exercise suggests the possible entrance time frame of those vehicles types in to the global and local market place. Accordingly, it is essential that the local automotive industrial community to acquire the essential technologies in anticipation of the vehicles future presence in the local scene. Coordinated manpower development planning to support the technology acquisition processes is essential for Malaysia to embark on the manufacture of those types of vehicles in the future.

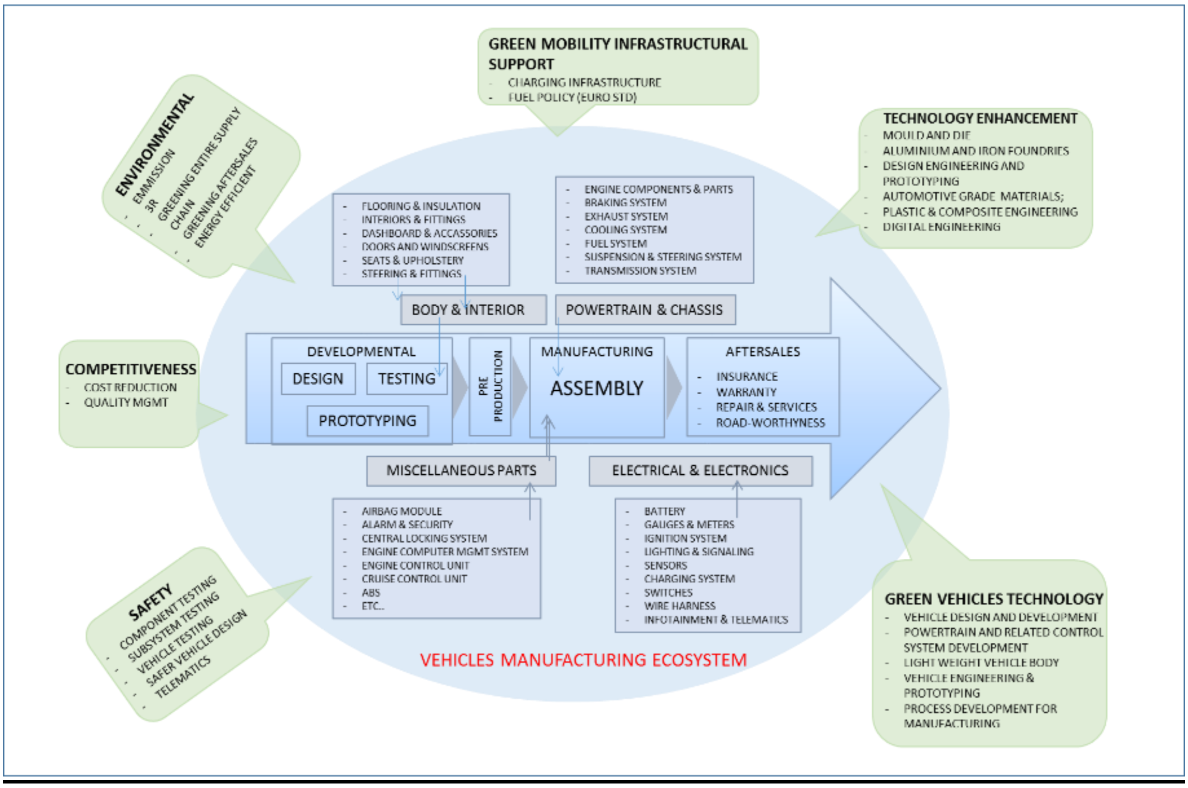


Figure 7.1: Automotive ecosystem

7.3 Relationships between Science & Technology, Research, Development & Commercialization

Malaysian research community are accustomed to the “bottom-up” approach in R&D programmes and projects formulation. Researchers identify and propose projects, usually in subject areas of their interest and expertise, whereupon the proposal will be subjected to scrutiny and approval by the higher research authority or leadership before funding are allocated. On the contrary, “top-down” approach demands the research authority to develop the research programmes and projects, while researchers in turn have to bid for the projects under the programmes and are accordingly awarded with allocated funding.

The universities and research institutes more often undertake research projects with little participation of the industry. Although such a traditional approach is acceptable for universities in their pursuing of knowledge, however findings or innovations from the exercises may remain futile and far away from being commercialised.

In order to achieve an effective consolidation and coordination the "top-down" approach would be most suitable for local automotive R&D endeavours. However, the approach demands automotive stakeholders, particularly the local OEMs and funding agencies, to come together to formulate a comprehensive research programmes. This is especially essential for the nation to achieve its future EEV endeavours.

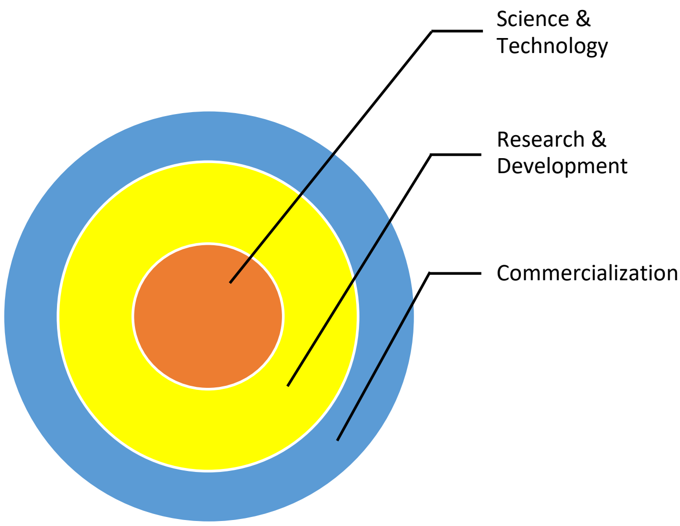


Figure 7.2: Illustration of a simple relationship between S&T policies, R&D undertakings and industrial commercialisation.

With respect to automotive development, S&T community should play a supporting and influencing roles in the academic development, research institutions agendas and national education in providing the relevant and appropriate R&D competencies and infrastructure useful for EEV automotive development. More importantly the S&T policy must favour automotive R&D priority areas with appropriate fund allocation, as well as providing R&D leadership in projects identifications.

R&D community on the other hand are the implementers of the R&D programmes and projects. While national education priority is to develop automotive R&D talents, R&D community, inclusive of S&T policy makers, research leaders and researchers and industry players must come together on the R&D level or platform to formulate appropriate R&D strategy, Plans and programmes.

Right coordination at the S&T and R&D level will only ensure all research endeavours would enter the commercialisation phase successfully. A successful and sustainable commercialization activity in automotive industry could be achieved by providing enough qualified human resource, innovative ideas, smart capital partnership, continuous supports and well planned efforts on S&T and R&D activities. Collaboration efforts need to be carried out and adopted by the shareholders such as vendors, OEM, private companies, government, research communities, universities, technical colleges and schools.

7.4 Automotive R&D Priority Areas

The automotive Intellectual Property Rights (IPRs) produced by locals are still at a very low level. In order for the country to move and perform better in the automotive industry, more research needs to be conducted. The government, universities and industry need to collaborate to produce new technology for commercialisations. Collaboration between countries should be encouraged. A special funding mechanism needs to be set up to support the R & D & C activities. The followings are technology priority areas towards the development of future automotive vehicles, particularly EEV and iEEV;

i) Integrated Digital Engineering

- Vehicle energy management system
- Smart manufacturing
- Smart material
- Navigation
- Sensors
- Actuators
- Advance power trains
- Advanced transmission system
- Advanced vision system
- Advanced Fuel and Lubrication technologies
- Advanced converter technology
- Advanced robotic and automation technology
- Advanced electrical machines technology
- Efficient ICE
- Fuel cell
- Hydrogen generator system
- Battery technology
- Super capacitor
- Light weight vehicle structure
- Vehicle ergonomic

ii) Advanced Green Materials
- Smart Material
- Advanced Plastic Composite
- Advanced Metal Composite

iii) Big Data Movement
- IOT vehicle technology
- Vehicle communication system
- Vehicle data security system

iv) Advanced Integrated Active Safety
- Intelligent system
- Embedded system
- Vehicle advanced passive and active safety system

The timeline for R&D areas mentioned above could be applied to the road map shown in Figure 8.1. It can be applied to various vehicle powertrain technology such as ICE, HEV, PHEV, BEV and FCV. The other research areas such as the infrastructure structure needed for vehicle such as charging system and hydrogen generator system are also important. R&D could also be carried out in support sectors such as banking system, insurance and education related to automotive industry.

7.5 R & D & C Funding Mechanism

There has been a steady increase in funds allocations by the government towards R&D and Commercialisation over the last few decades. Allocations and distributions are distributed through various mechanisms, with Ministry of Science, Technology and the Environment (MOSTI) being the key custodian of R&D funds. A diversification of the R&D funds and grants are made available across sixteen programmes, benefiting more sectors, including but not limited to; Communication and Technology (ICT), Biotechnology, Commercialisation, E-Content and Information and GLCs/Centres of Excellence (COEs). Some allocations are also disbursed to other ministries and agencies such as; the Ministry of Health, Ministry of Finance (MOF), Ministry of Plantations Industries & Commodities, Ministry of Agriculture & Agro-based Industry, Ministry of Natural Resources & Environment, Ministry of Education (MOE), Ministry of Communications & Multimedia, Ministry of International Trade & Industry (MITI), Ministry of Human Resources (MOHR) and the Ministry of Natural Resources & Environment have also received some allocations. Some of the major funding schemes are as follows;

- Techno Fund – MOSTI
- Science Fund – MOSTI

- Innofund – MOSTI
- Commercialisation of Research & Development Fund (CRDF) – MTDC-MOSTI
- Biotechnology Commercialization Grant (BCG) – MOSTI
- Technology Acquisition Fund (TAF) – MTDC-MOSTI
- Agro-Biotechnology Institute Malaysia (ABI) – MOSTI
- National Oceanography Directorate (NOD) – MOSTI
- Malaysian Institute of Pharmaceuticals and Nutraceuticals (IPHARM) – MOSTI
- MSC Malaysia Research and Development Grant Scheme (MGS) – KKMM
- eContent fund - KKMM
- MSC Pre Seed Funding – MDeC, KKMM
- Business Accelerator Program (BAP) – SME Corp, MITI
- Demonstrator Application Grant Scheme (DAGS) - NITC (National IT Council)

One of the conventional determinants or measures of R&D finding by government is the GERD (Gross domestic expenditure on R&D), which is represented as a percentage of the GDP. In comparison, private sector determinants is the percentage against annual revenue of companies. Malaysian current policy has set the target of increasing Malaysia’s GERD to at least 2.0% of the GDP by 2020. It is important to examine the impact of the increase in GERD. Although Malaysia had seen a rise in GERD from 0.5% to 1.13% from 2000 to 2012, at this rate of increment the country is still far from achieving its desired GERD of 2.0% by 2020.

The above discussion reflects that R&D priorities are channelled “generically” to various organisations to fund projects that are mooted by researchers, entrepreneurs and companies, conforming to “bottom-up” approach of R&D planning. Some funds are channelled directly to research establishment and were self-managed by each organisation to fulfil the R&D needs of designated or specific area of the nation’s economy. ICT is one area of such endeavour, while projects that do not fall under this designated R&D priorities are approved based on the merits of the projects and such projects fall under the TAF and the like. Funds are also allocated for commercialisation purposes such those under Techno Fund and Innofund.

Currently most automotive R&D endeavours by Institutional and Academic Researchers have not so far being designated to a specific funding scheme. Approach or applications are generally made to those generic funding schemes which are open to many sectors of the economic activities rendering less priority consideration given to automotive. A designated or specific sectorial funding by the government towards development of automotive sector is crucial to achieve the EEV and iEEV ventures. However, the fund must be managed by "Top-Down" approach in order to ensure that the R&D priorities are relevant to various technological areas within automotive sector. Towards this end, should the fund is made available, an "e-Mobility and IMS R&D Committee", figure 7.3 must be formed and given the trust to manage the fund for the national benefits, while achieving research funding partnership amongst vendors, OEMs, universities and government.

This committee, can be a subset of the proposed "e-mobility and IMS Task Force" (in Chapter 9) and the "National Automotive Council" recently instituted by MITI, as such Malaysia Automotive institute (MAI) can appointed as the committee's secretariat. The Committee will be designated to perform additional tasks as follows:

- To assist the government in formulating tax policy on R&D expenditure to be rendered to OEMs and vendors in their R&D initiatives as encouragement for them to carry out more research work.
- To formulate research collaboration and the quantum of funding sharing between government grant and private sector contribution for all approved project proposals specifically related to automotive R&D.
- To bring together government, OEMs, vendors and universities in formulating R&D masterplan and to dictate the R&D direction for the development of the automotive sector in particular the EEV and iEEV.
- To review syllabi, courses curriculums of the courses in institute higher learning suitable for automotive development and to monitor, reviewed and upgraded periodically all available laboratory facilities in support of automotive R&D and evaluate new facility procurements from governmental grant provided.
- Advice in the setting up of common vehicle test centres for OEMs, vendors and universities tailored to EEV and iEEV applications.
- Promote creative vehicle design contests for young generation in high schools and universities giving the students the opportunities to demonstrate their talents and creative ideas.

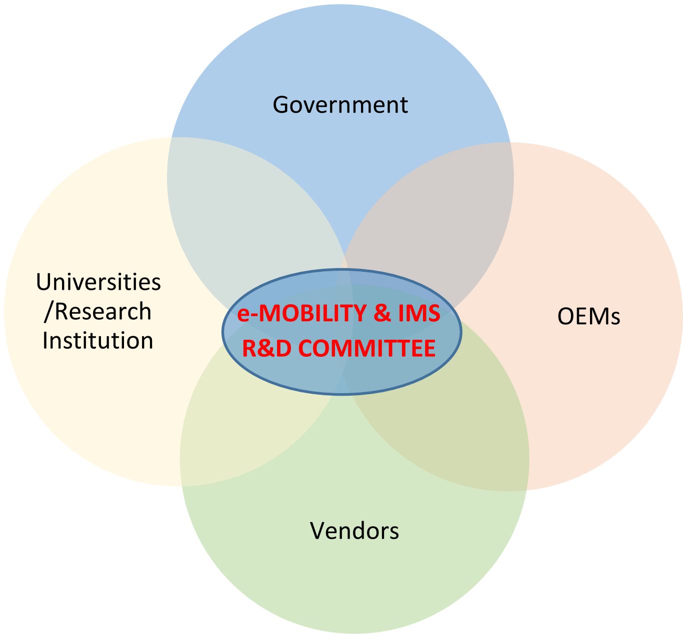


Figure 7.3: Research funding partnership

The quantum of the R&D grant can be computed base of GERD concept described earlier which is measured by the automotive sector contribution to the GDP. Private sector contribution will be based on their respective participation in the R&D proposal with matching amount of 1:1.

Chapter 8: Roadmap

Excitement about the upcoming new form of global mobility is on the rise. Information is readily available on the types of vehicles that have been developed, by inventors and OEMs alike and some of them are captured in Chapter 2. Electrically driven vehicles has, of late, become the developmental focus by major OEMs competing to demonstrate the uniqueness of their vehicles; HEV, PHEV, BEV and FCV. In some countries the vehicles have in a small way entered the marketplace where environmental policies are focusing towards non-emission mobility.

Despite the excitement, the uncertainty remains as to when these vehicles will truly enter the global and the local market. Country planners are in dilemma in their national planning and policy introduction on the timeliness to implement initiatives towards supporting the new mobility concepts.

Powertrains of all the earlier prescribed vehicles required infrastructure supports, particularly the PHEV, the BEV and the FCV. Although both PHEV and BEV are home rechargeable the powertrain necessitate public charging facilities for consumers to increase battery energy contents of their respective vehicle upon exceeding the travel range outside their homes. PHEV may continue to travel as the ICE portion of their powertrain can still power the vehicle home or to destination, but without public charging facilities the vehicle loses its intended purpose as fuel efficient and environmentally friendly vehicles.

On the other hand, without public charging facilities BEV are non-operable upon battery power exhaustion. Installing public charging infrastructures are expansive endeavours.

FCV is an alternative fuel concept using hydrogen as a means of generating electrical energy to power the vehicle. In this respect, FCV is fundamentally a BEV but with on board fuel cell technology to continuously provide the power and charge the battery. In addition, FCV may be a disruptive technology to the BEV in which it requires a spread of hydrogen filling stations to supply hydrogen for the vehicles to operate.

Should FCV come into full utilisation, this will lead to probable redundancies of the charging stations earlier installed to support the BEV operation.

Hence, there is a necessity to forecast the reasonable timeframe as to when the vehicles will make the global and local market so as to ensure that all the necessary supports are in place prior to their respective entrances. The foregoing roadmap is a foresight exercise with respect the vehicle powertrain evolution and timeframe market entrance and utilisation. The degree of acceptability and accuracy of the market entrance foresighted is ascertained by referencing to the oil producing community prediction on global oil usage in the future, as discussed in Chapter 2. By virtue of the fact that the global energy sector is the most influential community in determining the market penetration of those energy efficient vehicles, the reference is the closest alternative to develop the adoption and market penetration phases of these vehicles.

8.1 ICE technology vehicles

ICE powertrain, driven by petrol and diesel, will continue to dominate the global market with continuous engine efficiency improvement towards 2050 and beyond. Major automotive OEMs have taken various initiatives to improve current vehicle ICE technology in the area of engine systems, transmission systems, body and chassis which result in better fuel consumption and thus lower carbon emission.

The engines may resort to other alternative fuels to achieve the most environmentally friendly vehicles possible. Adoption of alternative fuel vehicles is becoming increasingly popular, especially among advanced countries in the European Union, the USA, China and Japan. Alternative fuel technologies provide the opportunities to reduce carbon and other gaseous pollutant emissions, and at the same time reduce operating cost due to fuel subsidies. The Society of Automotive Engineers (SAE) has outlined several alternative fuels in preference to substitute the conventional fossil fuels, as follows:

a. Alcohol fuels, such as those derived from either methanol or ethanol, are considered as alternative substitutions to petrol due to their low octane numbers but require large amount of ketones-enhancing additive for their applications on diesel engines. By adding co-solvents and emulsifiers, alcohol can be used as a mixture or an emulsion particulate emission, but the additives greatly increase the fuel cost and the effect of the fuel on engine durability is still uncertain.

b. Biodiesel or mixture of bio-based fuel and diesel is a clean, renewable alternative fuel derived from natural vegetable oils and fats. The process of producing biodiesel is through a chemical reaction that converts the natural oils and fats into Fatty-Acid Methyl Esters (FAME). The main advantage of biodiesel is its nontoxicity and lower emissions. Carbon monoxide and unburned hydrocarbons particulates are generally lower with biodiesel with higher NOx output. However, there also some concerns over diesel compatibility with conventional engines with respect to the thermal and oxidation stability of biodiesel. The cost of biodiesel fluctuates with commodity prices of feedstock which will influence the economic aspect of the fuel usage.

   However, biodiesel utilisation is expected to have a shorter life span as priority over global food shortage may supersede the fuel production in the future, unless the fuel is produced from non-edible biomaterials.

c. Natural Gas is a clean burning fuel that can reduce emissions considerably and is an alternative fuel for industry and motor vehicles. The fuel is used either in spark-ignition combustion process or in a dual-fuel engine configuration, and is currently useful in heavy-duty engine applications. However due to its high octane number the fuel it unsuitable for direct use in compression-ignition engines. Natural gas is used as a vehicle fuel in one of two forms; compressed natural gas (CNG) or LNG. The current passenger cars can utilise CNG with some engine modifications, where some countries such as Iran, Pakistan and Argentina are now encouragingly been using CNG, representing more than 15% of their fuel source supply network.

8.2 Low Carbon Technology Vehicles

HEV and PHEV are currently two powertrain technologies promising the low carbon emitting vehicles capability.

HEV is forecasted to enter the global and local market utilisation in 2020 and the powertrain is now steadily gaining market momentum. The technology is expected to grow and continue to dominate the market towards 2050 and beyond and has the potential to gradually replace the current ICE powertrain beginning 2040. The evolution of HEV is gauged by the ratio of ICE to electric motor combinations of its powertrain, influencing the R&D, design and engineering of the vehicles for their development and future production. Independent from the need to any of the current infrastructural alteration or additional supports, in particular fuel supply, HEV is expected to make an easy inroad into the marketplace.

PHEV on the other hand, is a hybrid rechargeable vehicle, using home charger or public charging infrastructure, and is driveable either by liquid fuel or electrical power from its battery pack or both. However, for efficient utilisation the vehicle is in need of charging stations both at home and in public areas. PHEV can be considered as a transitional vehicle for public culturing and familiarisation prior to full introduction of BEV to the marketplace. The anticipated market entrance would be sometime towards 2025.

8.3 Non-Emission Technology Vehicles

BEV, apart from being a zero emission, the vehicle can serve as the means to utilise grid energy losses of the power supply system of a nation. Some power generated by power plants is usually lost during transmission, which to a certain extent; a significant amount can be recovered by BEV usage especially if home charging is incentivised during off peak hours. This energy recovery system can be introduced during the design stage of the vehicle and widespread usage can be instituted as a policy measure.

In addition, the “stop and go” technological characteristic of BEV further helps in saving energy when the vehicles are driven during congested peak hours in cities and urban vicinities. “Kinetic Energy Recovery system” technology on the other hand recovers the energy stored during braking and is in turn used to charge the on board battery improving the driving distance of the vehicle thus saving user’s money.

Although the BEV is forecasted to gain significant market share by 2020, effort must be made from now for the local industry players to participate in the development and improvement of the BEV technology so as to prepare the industry towards mass manufacturing activities anticipated to take off sometimes in 2030.

The following are some of the technological areas in need of development for the nation to adopt BEV usage in the future:

1. Battery or any means of on board electric charge storage

   Efficient batteries largely depend on the electrochemistry and cell design. Equally important is the battery thermal management during the powering stages of the vehicle, particularly the temperature uniformity, cold and hot characteristics in the start and stop driving condition. Battery lifespan and effective operation (distance per full charge) can be affected by overcharging and electric current fluctuation during charging and/or discharging of the battery.

2. Power Electronic control

   On board electronic power management and control is the most important parts of a BEV. Overheating of the electronic components is common place during driving and as such good design is necessary to ensure safe and useful usage of BEV. Failure of the power electronic control can have a detrimental effect on the BEV performance and efficiency. Heat dissipation mechanism is useful to help create paths to eliminate electronic losses. In this respect preparation must be made to ensure that aftermarket service and maintenance technicians are familiarised and acquire knowledge and skills required to provide right diagnostic and maintenance work of the power control system, which is critical in the BEV operation.

3. Traction motors and invertors

   Direct current and alternating current traction motors shall be the main BEV powering device in the world of electric vehicles. Convertors and invertors, on the other hand, are devices for the motors adaptability in their usage. An efficient traction motor runs with minimum energy loss due to friction and heat, with minimum vibration which is important for smooth vehicle operation. Compatibility of the motor system integration, battery and other related electronic components and control features need to be developed to ensure the BEV is able to operate safely and for the customer's comfort and satisfaction.

4. Electromagnetic Compatibility (EMC) / Electromagnetic Interference (EMI)

   Interference of all the on board electric and electronic equipment must be eliminated or at the very least minimised so as to ensure each component performs efficiently attributing to the overall efficiency of the EV.

FCV, expected to enter the market in the 2035 to 2045 timeframe, have a significant potential to reduce emissions from the transportation sector, because they do not emit any greenhouse gases. The vehicle fuel cell will be powered by hydrogen generated from natural gas. A fuel cell vehicle would produce less carbon dioxide-equivalent compared to HEV and FCV would have near-zero if the hydrogen were made, for example, from electrolysis powered by renewable energy.

However there remains several major hurdles to commercial deployment of FCV and must be overcome before any environmental benefits from FCVs are realised. These challenges include the production, distribution, and storage of hydrogen; fuel cell technology; and overall vehicle cost. FCVs are considered one of several possible long-term pathways for low-carbon passenger vehicles with the offered benefits such as; high energy efficiency of the fuel cell powertrains, diverse methods by which hydrogen can be produced, unlike BEV comparable vehicle range and refuelling time similar to ICE vehicles and very low or no upstream emissions associated with hydrogen fuel production.

Technology associated with FCV is centred on the fuel cell which includes; the fuel cell stack, hydrogen production and the on board hydrogen storage tank of the vehicle. Further development and commercialisation of FCV is subjected to the ability to overcome the current "chicken-and-egg" predicament between vehicle manufacturers and the hydrogen suppliers. Vehicle manufacturers are unwilling to produce vehicles unless there is a guaranteed supply of hydrogen, while hydrogen producers will not supply fuel unless there is a demand for it.

8.4 Intelligent Mobility

Systems such as anti-lock brakes, traction control, stability control, lane departure warning, active lane control, and blind spot detection are intelligent features that are common on today's modern and high end vehicles. Such features are not only to assist in the safety aspect of driving but driver comfort and alertness are also assured. Numerous sensors are now developed and installed in vehicles both for powertrain and vehicle efficiency and active safety driving. The days of passive driving and defensive vehicle structure integrity is ending but being replaced with light weight super strength material such as composite materials.

Advancements in technology have since been able to remove human function during driving and perform complicated driving tasks for humans. Inputs from sensors, radar, on-board computers, and GPS have since demonstrated the ability of vehicles to navigate without human intervention, and combination of robotics, automation, sensing, and computer software has led to the development of recent autonomous vehicles by major OEMs and inventors. The vehicle is fully automated and can perform all driving functions and monitor roadway conditions for an entire trip. The driver may 'communicate' with the system on his or her driving desire and the system will be fully in-charge during the entire driving journey.

Industrial experts seems to agree that fully-autonomous vehicles have a long way to be perfected for mass production and utilisation as the technology will impact the mobility culture, massive adoption and adaptation processes to go through before full acceptance by the society. However R&D focus on developing and perfecting autonomous vehicle will continue extensively particularly in the field of connectivity, integrated digital engineering, advanced integrated active safety, big data movement and advanced and green nano-materials.

Figure 8.1 shows the local automotive roadmap developed based on the foresighted market entrance and mass production timeline previously discussed in chapter 2. Opinions mooted during the stakeholders' engagement discussed in chapter 3 are considered in formulating the roadmap.

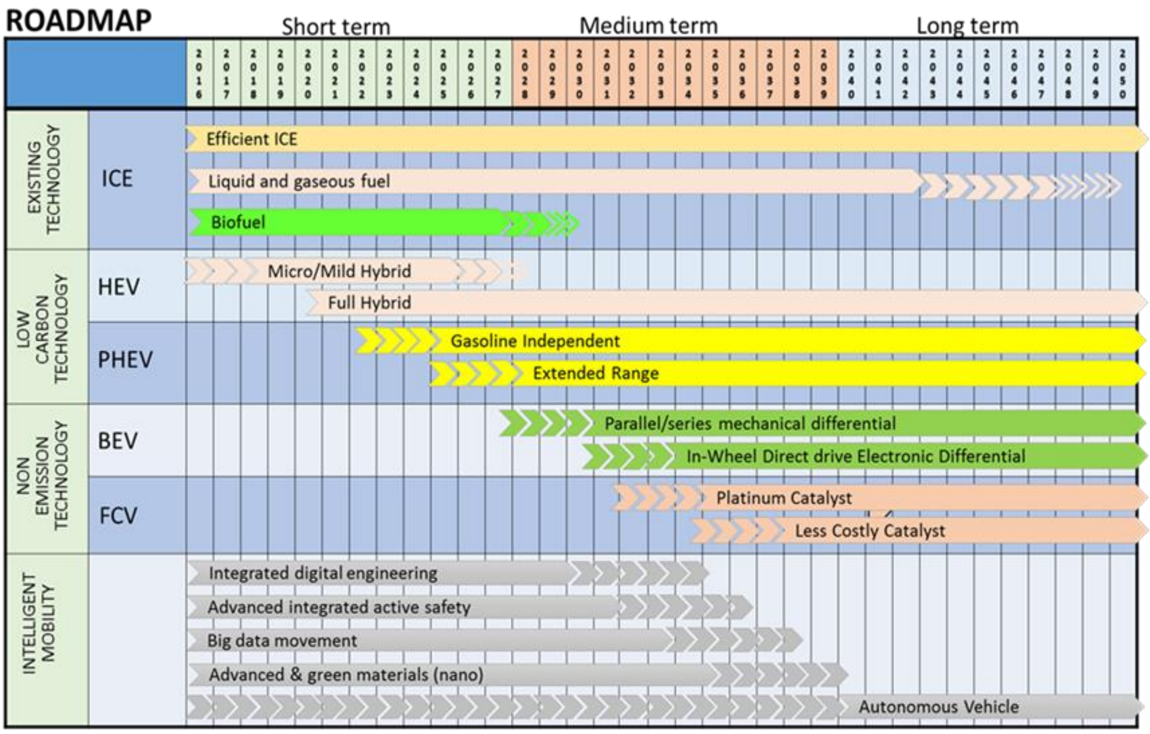


Figure 8.1: Roadmap

Chapter 9: Key Strategies

The advent of today's energy efficient vehicles is driven by the global community desire to achieve cleaner atmosphere and reducing the global carbon footprint in addressing the climate changes around the globe.

While the ICE and the HEV powertrains promise the biggest market share in the forthcoming vehicles utilisations, the lower and zero emission vehicles with the potential market growth in the longer term requires strategies to shorten their market entrance timeline. Unlike traditional ICE vehicles, HEV inclusive, the "e-Mobility" (PHEV, BEV an FCV) require different value chains and processes to support their on-the-road operations.

Intelligent Mobility Systems (IMS) including autonomous vehicle technology, connected vehicles, smart highways and big data are also beginning to have a major impact on our road transport sector. The autonomous vehicle or "self-driving," vehicle technologies offers the possibility of significant benefits to social welfare — saving lives; reducing crashes, congestion, fuel consumption, and pollution; increasing mobility for the disabled; and ultimately improving land use.

At the same time, the use and storage of data is predicted to become one of the most important issues facing IMS. The automotive industries and the infrastructure are likely to be re-shaped by the magnitude of customers, drivers and vehicles data that will be generated in coming years. This data will be varied, come at incredible velocity, and will need to be stored, processed and analysed within both existing and future regulations and infrastructure. While these new data offer benefits for both industry and consumers, it also presents significant challenges in the control and storage of personal and/or commercially sensitive information.

Henceforth, a timeline for these vehicles and the associated IMS to enter an era of common usage will only be expedited with right strategies initiated both by the government and the private sector (OEMs) community working together to achieve the common objectives such as the following:

i. Changing public perceptions on the practicality, functionality, and the potential advantages of e-Mobility vehicles.
ii. Strive to ensure that the e-Mobility vehicles purchase and ownership costs, operation conveniences, travel range, aftermarket and operating infrastructures are sufficient and sustainable.
iii. Encourage collaboration and integration amongst stakeholders to develop a sustainable, viable e-Mobility and Intelligent Mobility ecosystem.

The followings sections and subsections outlines major strategies that will ensure long-term viability and key success factors of e-Mobility vehicles in the market.

9.1 Introduce e-Mobility and IMS Governance

As previously described in Chapter 4, there are essentially five (5) focus areas of policy review or policy studies required to be debated and instituted in order to enhance the development space for e-Mobility and IMS progression. The focus areas are:

i. The Environment governance with special attention given to:
   a) Energy Policy
   b) Fuel Emission Policy
   c) ELV and Recycling Policy
ii. Business and Trade promotion with special consideration on:
   a) Import and export taxation
   b) Funding promotion for fleet operation of EEV, iEEV and IMS
   c) Incentive for charging infrastructure investment
   d) Tax exemption for companies using e-Mobility and IMS vehicles
   e) Purchase incentive for e-Mobility and IMS vehicles individual buyer

iii. Workforce and Human Capital Enhancement

   a) Retraining Policy

   b) Learning curriculum and school and higher tertiary education

iv. Vehicles and parts standardisation

   a) Standard development and certification

   b) Vehicle type testing and approval

v. Incentive Options to help promote e-Mobility and IMS

   a) R&D policy for e-Mobility and IMS

   b) R&D Grant for FCV development

   c) Tax credit for hydrogen usage in e-Mobility

   d) Adoption of Green House Gas emission (GHG) policy

9.2 Develop support infrastructure

As previously described, convenient charging (PHEV and BEV) and fuelling (FCV) infrastructures will be the key factors for a successful e-Mobility market. These charging and fuelling infrastructures for BEV and FCV respectively are large scale investment for private sector undertakings to ensure extensive EEV and iEEV utilisation nationwide. At the same time, the integration of IMS with the e-Mobility will need infrastructure that meet user needs through efficient, effective, green transportation, integrated, accessible, smart living using reliable networks, vehicles and transport services.

In order for the nation's automotive industry to keep pace with the global automotive progression, it is inevitable that the support infrastructure must be in placed prior to national acceptance of the e-Mobility and IMS.

The followings are strategic measures necessary to initiate local participation in the e-Mobility concept:

i. Promote e-Mobility and IMS test-beds in selected cities or vicinities within cities currently suffering from massive congestions,
ii. Provide incentives for private sector initiatives, particularly automotive OEMs, to develop test beds in selected urban areas through multiple tax deduction schemes, tax credits on specified number of vehicle sales for each test-bed
iii. Introduce a joint government-private "e-Mobility and IMS Task Force" to monitor the development and successful implementation of the entire spectrum of the nation's e-Mobility and IMS initiatives including infrastructure support development, e-Mobility R&D and human capital development.

9.3 Expose consumers to new vehicle usage and benefits

For many generations, the global populace is accustomed to the current ICE mobility. Changing that paradigm is the introduction of HEV; however the change would not alter the current consumer's behaviour that much, except for the concern on environmental issues.

For the most part, consumers link an environmentally friendly mind-set to e-Mobility. To transform this anticipated e-Mobility market into reality will lie in the ability of OEMs to address current consumer concerns about e-Mobility and to offer the expected e-Mobility experience.

a) Battery Range

The key concern about batteries in electric cars losing power before reaching a destination or charging point is most prevalent of current concerns. It is among the most common perceived disadvantages of electric vehicles. Therefore, the consumers' perception of e-Mobility will continue to play a major role in the evolution of the market. OEMs and the government must respond to this perception effectively.

b) New vehicle purchase

New vehicles are continuously being introduced in the market place and customers' choices are confined to numerous brands of ICE powertrain. Introduction of e-Mobility and IMS will broaden the selection options to a wider scope.

To enhance market opportunity for e-Mobility and IMS upon their respective market introduction calls for various initiatives on the part of OEMs and the government alike:

i. Public education and exposition will have to be introduced and intensify on e-Mobility as timeline approaches highlighting issues such as; fuel cost savings, lower emissions, low maintenance costs, fewer maintenance cycles, sales and tax incentives, avoidance of volatile fuel prices at the pump,
ii. The IMS will need to be explained and promoted to understand the preferences and behaviours of people and businesses, exploit data, and capitalise on advances in technology in areas such as the Internet of Things, sensors and autonomous systems, transport networks operation
iii. Change of perception related to usage anxiety, conveniences, safety and aftermarket support system
iv. Creation of test-beds in areas of attractions to facilitate public e-Mobility and IMS familiarisation
v. Introduction of lease-or-buy concept to encourage initial purchases of e-Mobility vehicles
vi. Operating infrastructure development must commence at a right timing.

9.4 Create a strong R&D community

Science and Technological inputs into the development and manufacturing of e-Mobility and IMS vehicles is crucial for local OEMs to venture competitively in the e-Mobility and IMS market. Total dependence on foreign intellectual property (IP) outputs may be costly to support local e-Mobility and IMS products rendering the local industry non-competitive.

Software development, e-Mobility hardware, digital Engineering utilisation, advanced integrated active safety technology and hardware, Big data movement utilisation and gadgetry, advanced green light-weight nano-materials technology are areas of priority for R&D focus to support local e-Mobility and IMS development. The following initiatives may help enhance the local R&D efforts:

a) Introduce "e-Mobility and IMS R&D community association" to inculcate academic and industrial collaboration in all initiatives relevant to e-Mobility and IMS development. Malaysia Automotive Institute may be the initiator and secretariat for these associations supported with government and OEM funding for its sustainability.

b) Establish an "e-Mobility and IMS R&D Committee" comprising of government leadership, local scientists, renowned automotive industrial players, high level local OEM representatives, academicians and head of relevant research institutions. The committee will be responsible for identifying and prioritising R&D programmes with a "Top-down" approach and to propose funding requirements from the government. Major focus of R&D Programmes would be in the areas of; e-Mobility and IMS software and hardware, digital engineering utilisation, advanced integrated active safety technology, big data movement, advanced green light-weight and equally important development and adjustment of Core Operations and Processes as a result of technological shift from the conventional production technology.

c) Introduce a "Young e-Scientists and e-Engineers" programme to develop new generation of automotive industrial players. Scholarships are to be allocated to finance the identified talents from the programme to pursue further education and research work in e-Mobility and IMS technologies in appropriate institute of higher learning. Industrial apprenticeship in e-Mobility and IMS establishments is necessary for those pursuing degree levels of science and engineering courses. This initiative is aimed at creating a new breed of automotive leaders specialising in e-Mobility and IMS related endeavours.

9.5 Develop business collaboration within the e-Mobility and IMS vehicles value chain

The rise to disruptive technology-driven trends in the automotive sector will shift the automotive business of the future. The diverse e-Mobility, autonomous driving, electrification, and connectivity will reinforce and accelerate one another and cause the automotive industry to be ripe for disruption. These game-changing disruptions are already on the horizon and they will affect traditional vehicle manufacturers and suppliers, potential new players, regulators, consumers, markets, and the automotive value chain. Initial collaboration to create the e-Mobility and IMS business community is therefore essential to strategically position the nation as one of the global e-Mobility consumers. Some of the key business issues and opportunities of the new automotive industry include:

a) Rising need for lightweight competencies suppliers of new materials, such as carbon fibre and aluminium composite.
b) Increase in profit for the machinery industries due to market demand for new production technologies and new tools for lightweight material parts and components production.
c) More profit for the materials industry due to increasing volumes and prices (e.g., high-strength steel and aluminium composites), and new material suppliers may emerge, mainly carbon fibre composite. Whilst traditional steel suppliers may experience shrinking revenues being unable to deliver high-strength steel with lower gauge thickness.
d) Opportunities for OEMs with possibility of creating new designs and concepts based on the new materials, as well as having competency in lightweight materials, for future cost competitiveness.
e) New business through the development of new software that has the capability of interpreting all vehicle's sensors and able to learns and mimic driving skills and experiences of the very best drivers. (Google is the current technology leader in this arena, according to IHS Automotive estimates, which suggest the

technology company has invested nearly $60 million so far in autonomous vehicle research and development, at a run rate of nearly $30 million per year).

f) New revenue streams for energy storage through the manufacturing and new services providing both electricity generators and consumers and address the issues of technology, energy security, energy savings and revenue generation.

g) New market and business growth for electronic instrumentation and next-generation (5G) wireless gears and other technologies including significant growth opportunities for test manufacturers as new automobiles will move towards being more connected, zero-latency, and autonomous.

h) Significant growth in the electric motors and drives services market including installation and commissioning, training, engineering, consulting, maintenance, spare parts and consumables supplies, repairs, extensions and upgrades (retrofits), replacements, end-of-life and advanced services.

i) Increasing demand of sensors is expected as diverse automobiles are highly dependent on advanced sensor technologies such as MEMS (Micro-Electro-Mechanical Systems) sensors, wireless sensors, and radar sensors as they are used in applications namely chassis, powertrain, body electronics, security and control to measure inertia, pressure, flow and other parameters in automotive applications. Also, application of automotive sensors includes powertrain, vehicle security system, body electronics, safety and control, telematics and others. Geographically, this market covers major countries such as: America, Europe, and Asia Pacific countries.

j) Demand for alternative energy growth is expected in areas such as solar, hydrogen, bio-fuel, fuel cells and energy conservation technologies. Development, installation and creative application of these technologies are all opportunities for entrepreneurs. Entrepreneurs will have to find their niches and build flexible companies that can react as the energy market changes.

k) Increasing need for specialised automotive workshops for maintenance and repair as future vehicles will be more complex, more sophisticated diagnostic equipment will be needed.

9.6 Action plans and time frame

The above discussion on key strategies identifies various action-plans needed to support and to develop e-Mobility and IMS in Malaysia, as tabulated in Table 9.1 below.

Table 9.1: Action Plan

	IDENTIFIED ACTIONS	Short Term	Med. Term	Long Term
	Policies			
1	Energy Policy	/		
2	Fuel Emission policy	/		
3	e-Mobility ELV and Recycling policy		/	
4	Import export taxation	/		
5	Funding Promotion for fleet operation		/	
6	Incentive for charging infrastructure investment	/		
7	Tax exemption for company using e-Mobility and IMS vehicles		/	
8	Purchase incentive for e-Mobility and IMS - individual buyer		/	
9	e-Mobility and IMS Retraining policy	/		
10	e-Mobility and IMS Learning curriculum	/		
11	e-Mobility and IMS Standards and Certification	/		
12	e-Mobility and IMS Vehicle type testing and approval		/	
13	R&D grant Tax credit for hydrogen usage in e-Mobility		/	
14	Adoption of Green House Gas emission (GHG) policy		/	
15	A joint government-private "e-Mobility and IMS Task Force"	/		
	Business & economic			
16	Lightweight competencies	/		
17	New production technologies and new tools	/	/	
18	New materials industries and suppliers		/	
19	Designs and concepts competency		/	
20	Development of new software	/	/	
21	Energy storage	/	/	
22	Electronic instrumentation and 5g wireless gear	/	/	
23	Electric motors and drives services	/	/	/
24	Advanced sensor technologies		/	
25	Alternative energy conservation technologies	/	/	/
26	Specialised e-Mobility and IMS automotive workshop		/	/

	Social			
27	Battery dev. and production with higher battery Range		/	
28	Public education and exposition	/		
29	Public usage anxiety, conveniences, and safety	/		
30	e-Mobility aftermarket support system	/	/	
31	Creation of test-beds for public familiarisation	/		
32	Ease-to-buy concept to initiate purchase	/	/	
33	Timely installation of Operating infrastructure		/	
34	Infrastructure development coordination	/		
35	Promoting e-Mobility and IMS test-beds regionally	/		
36	Incentive to develop test beds in selected urban areas	/		
	Technology & R&D			
37	Establish a joint government-private “e-Mobility and IMS	/		
	R&D Committee”	/		
38	Introduce “e-Mobility and IMS community R&D			
39	association”	/	/	
40	“Young e-Scientists and e-Engineers” programme	/		
	Establish OEM “graduate apprenticeship programme”			

Chapter 10: Recommendations

Malaysia's automotive industry is poised for continued growth in both vehicle power train design and development and production of e-Mobility and IMS en-route for year 2050 and beyond. This report forecasts that by 2050, the world's total number of passenger vehicles will be doubled and at the rate of 3% per annum growth there will be 2.7 billion vehicles. EEV petrol, diesel and gas powertrain is expected to dominate the market until 2040 and make way for the HEV, PHEV, BHEV and FCV significant market entrance by 2050. The automotive industry is expected to continue to invest in Malaysia. The government of Malaysia need to continue to attract investment attractiveness in terms of taxation, regulation, labour flexibility and the overall business environment and support new technologies, including hybrid and electric vehicles, as well as autonomous and connected technology and this will be a major boost to the industry. The automotive industry need to strongly collaborate with technology developer to continue to remain competitive and significant in the fast changing automotive world. Unquestionably, the most important role that contribute to the growth and advancement of the automotive industry is the role played by the automotive technologists be it from the industry, government or the academia.

10.1 The Government's Roles and Responsibilities

In anticipation of the rapid change of the automotive technology, the government of Malaysia need to begin to act on the national automotive policies now. Some of the short term policy measures to be considered are such as:

i. Energy Policy that relate to power supply for transportation mobility, in particular automotive sector to generate and supply charging infrastructure.
ii. Fuel Emission Policy that focus on emission allowances within the timeframes from the current emission quantity to zero emission.
iii. Import-export Taxation Policy and regulations on all powertrain type vehicles and their respective power capacities.
iv. Tax Exemption Schemes for companies using e-Mobility vehicles
v. Reviewing the adoption of the Green House Gas emission (GHG) Policy to encourage vehicle purchase.

vi. Implementation of e-Mobility and IMS Retraining Policy for private organisations and government sectors to undertake retraining of current personnel for skill enhancement in new vehicle powertrain technology and to enlarge manpower capability including the development of e-Mobility Learning curriculum.

vii. Establish joint government and private sector e-Mobility and IMS Task Force mainly to monitor the development and successful implementation of e-Mobility and IMS national initiatives including infrastructure support development, e-Mobility R&D and human capital development

Beginning early period of the middle term the government will need to:

i. establish coordination committee responsible for the e-Mobility and IMS infrastructural development.
ii. promote public education and awareness to increase knowledge on e-Mobility and IMS particularly the usage and safety of the vehicles.
iii. provide incentives to encourage private sector creation of test beds.
iv. provide incentive for charging infrastructure investment by local and foreign identity.
v. intensify the e-Mobility and IMS development and promote test sites in selected urban centres to familiarise the Malaysian public with e-Mobility and IMS.
vi. offer tax credit and R&D grant for hydrogen usage in e-Mobility and IMS.

At the same time the government is also expected to intensify government, industry and automotive technologists' collaboration effort on:

i. the preparation and adherence of standard operating procedures for battery disposal or recycling to avoid environmental pollution and degradation by the battery and electrolytes.
ii. the preparation and adherence of ELV regulation when disposing and recovering e-Mobility and IMS vehicles at the end of their useful life.
iii. social restructuring towards e-Mobility and IMS such as aftermarket service and support systems are major and crucial to gain the confidence of the users.
iv. developing e-Mobility and IMS Standards and Certification schemes for local e-Mobility and IMS participation.

v. developing, promoting and financing e-Mobility and IMS fleet operators for rental services for recreational and tourism transportation.
vi. formulating tax exemptions for individual, private companies and corporate organisations buying e-Mobility and IMS vehicles for their daily operation.
vii. introducing vehicle type testing and approval procedures.
viii. providing incentives for developing and promoting test beds in selected urban areas and regions for public education and awareness.
ix. coordinate and timely widespread the installation of charging or refuelling infrastructure to encourage the growth of e-Mobility and IMS usage.
x. inculcate future e-Mobility and IMS talents through a "Young e-Scientists and e-Engineers" programme instituted with provision of scholarship awards to further studies and research in e-Mobility and IMS arena.
xi. provide scholarships for "graduate apprenticeship programme" with universities and industry to produce well rounded automotive engineers and technologies of the future.

The government, the automotive industries and the technologists are expected to aggressively establish various committees or coordinating bodies such as the following:

i. a "Joint Government and Private e-Mobility and IMS Task Force" to oversee the infrastructure development and implementation of the e-Mobility and IMS.
ii. an "e-Mobility and IMS community R&D association" aimed at bringing together all R&D expertise and industry players to integrate and to help develop ideas and R&D programmes relevant to the growth of local e-Mobility and IMS.
iii. an "e-Mobility and IMS R&D Committee" with assignment to assess all R&D programmes and projects in support of "Joint Government and Private e-Mobility and IMS Task Force" to endorse all proposals and to develop R&D mega programme in the national effort to achieve e-Mobility and IMS in the longer term.

10.2 The Automotive Industry's Roles and Responsibilities

The future e-Mobility and IMS industry need new research and development, new production and manufacturing techniques, new marketing strategies and enhanced collaborations with the government and the technologists. In order to be competitive, the industry need to consistently develop new e-Mobility and IMS research and development on revolutionary concepts and designs that are suitable for Malaysian market. In this regard, the Malaysian automotive industries are expected to invest in related design and technological capabilities as well as enhancing the industries collaboration with more advanced companies or universities. Subsequently, the industry is also expected to enhance its capabilities on the development of new production techniques and new tools necessary for the new automotive designs.

The future e-Mobility and IMS demands for enhanced industry-government-technologists collaborations. Key areas that need to be focussed are such as:

i. energy storage and the production of higher battery range
ii. new research and development on lightweight materials
iii. the development of light-weight material supply competencies to support the current weight reduction initiatives in ICE and HEV powertrain vehicles
iv. setting-up of new e-Mobility and IMS infrastructure

The industry is also expected to initiate new e-Mobility and IMS purchasing schemes to encourage market acceptance. Schemes such as easy-to-buy concept or lease-or-buy concept of acquiring e-Mobility and IMS vehicles should be introduced in the early usage of the vehicles which will help in the public familiarisation and adaption to e-Mobility and IMS usage.

10.3 The Technologist's Roles and Responsibilities

The designers, engineers, researchers, manufacturers are in this case called the Technologists have immense roles and responsibilities towards the success of the e-Mobility and IMS. The key technological areas that need to be developed and enhanced are such as:

i. software design and development competencies within the automotive community to embark on e-Mobility and IMS endeavours.

ii. electronic instrumentation and 5G wireless gear,
iii. electric motors and transmission system including electric motor servicing and specialised workshops
iv. advanced sensor technologies.
v. development of energy storage (battery and other means)
vi. 3D printing for durable concept models, prototypes, tooling and low-volume parts
vii. hydrogen usage on fuel cell vehicles.

In addition to the technological areas that need to be developed, relevant technical training on e-Mobility and IMS that need to be provided are such as the following:

i. Advanced vehicle technologies and the development of Electric Vehicles
ii. High voltage electrical safety and high voltage vehicle safety systems
iii. Hybrid engines
iv. AC induction electrical machines and permanent magnet electrical machines
v. Power Inverter Systems
vi. Electric Circuit systems
vii. Electric Propulsion Sensing Systems
viii. DC-DC Converter Systems
ix. Transaxles, Gears and Cooling Systems
x. Energy Management Hardware Systems
xi. Battery Construction and Technologies
xii. Latest Development in Battery Technologies
xiii. Nickel-Metal Hydride Technologies
xiv. Lithium Ion Battery
xv. Battery Management Systems
xvi. Hybrid Vehicle Regenerative Braking Systems
xvii. Electric Car and Hybrid Climate Control Systems
xviii. Computer Aided Design (SolidWorks software)
xix. Design and Making an Adapter for an Electric Motor (workshop)
xx. Design and Making a Fiber-Glass Battery Box (workshop)
xxi. Conversion of an Internal Combustion Car into a 100% Electric Car (workshop)
xxii. First Responder Safety for Emergency Situation
xxiii. Basic Electric Car Maintenance

REFERENCES

2050 and the Future of Transportation. Available from http://www.futuristspeaker.com/2008/05/2050-and-the-future-of-transportation [15 January 2016].

A. BORETTI AND I. ARIS, 2015. Regenerative Braking of a 2015 LMP1-H Racing Car, *SAE Brake Colloquium & Exhibition - 33rd Annual*, South Carolina 4-7 October 2015, 15BC-0023/2015-01-2659. http://papers.sae.org/2015-01-2659.

A. BORETTI, A. OSMAN AND I. ARIS, 2011. Direct Injection of Hydrogen, Oxygen, and Water in a Novel Two Stroke Engine, *International Journal on Hydrogen Energy*, Elsevier (36), 10100-10106. (Impact factor: 4.053).

A. BORETTI, A. OSMAN AND I. ARIS, 2012. Design of Rankine Cycle Systems to Deliver Fuel Economy Benefits over Cold Start Driving Cycles, *SAE 2012 International Powertrains, Fuels & Lubricants Meeting*, Sweden 18-20 September 2012. SAE 2012-01-1713.

ABDULSOMAD, K., 1999. 'Promoting industrial and technological development under contrasting industrial policies: the automotive industry in Malaysia and Thailand'

ADOLF, J. ET AL (2014). Passenger Car Scenarios for Germany to 2040. Shell Deutschland Oil GmbH, Hamburg

ALEX, F., MUSTAFA, K, May 2007. Autonomous Cars and Society. Worchester Polytechnic Institute.

ARTHUR, W. & MCKINSEY AND COMPANY, 2012. Bigger, Better, Broader: A perspective of China's auto market in 2020.

Automotive World (8 November 2013). The world in 2050.

BILL, C. (16 March 2012). The Tool and Die Industry: Contribution to U.S. Manufacturing and Federal Policy Considerations. Industrial Organization and Business, Congressional Research Services

Booz & Company (2011) India Automotive Market 2020.

Booz & Company, 2014. The bright future of connected cars by in 2014. Available from www.strategyand.pwc.com [15 January 2016].

CHUANJUN, L., XUNMIN, O. & XILIANG, Z., (November 2014). China automotive energy consumption and greenhouse gas emissions outlook to 2050, Mitig Adapt Strateg Glob Change (2015) 20:627–650.

CIAST, http://www.ciast.gov.my

CLAUDIO, S., 2015. Autonomous Cars: The most disruptive innovation ever.

CLAYTON, M. C. (1 May 1997). The Innovator's Dilemma: When New Technologies Cause Great Firms to Fail. Harvard Business School Press.

Co. Exist's Futurist Forum, 2013. Solar Roads, Charging Roads, And The Future of Transportation.

DELOITTE, T.T., 2009. A new era: Accelerating toward 2020 — an automotive industry transformed.

Department of Skills Development (2016). DSD [online]. Available from: http://www.dsd.gov.my

Department of Statistics Malaysia (DOSH) (December 2015). Employment in Manufacturing Sector.

EIA, International Energy Outlook 2013.

Electric Vehicle Market Forecasts - Global Forecasts for Light Duty Hybrid, Plug-In Hybrid, and Battery Electric Vehicle Sales and Vehicles in Use: 2015-2024, Navigant Consulting, Inc.

ELIZABETH, S., October 2015. What will we be driving in the future? Electric vs. hydrogen fuel cell vehicles. Science Friday

ENERGY.GOV, OFFICE OF ENERGY EFFICIENCY AND RENEWABLE ENERGY, Vehicle Technologies Office: Graduate Automotive Technology Education (GATE).

FELKER, G. & RASIAH, R. (Eds): Industrial Technology Development in Malaysia: Industry and Firm Studies, Routledge, New York

FORTUNE, 25 February 2016). A Third of New Cars Sold by 2040 Could Be Electric.

Germany Targets 2030 Ban on New Petrol and Diesel Car Sales. Available from http://www.ibtimes.co.uk/germany-targets-2030-ban-new-petrol-diesel-car-sales-1565570 [18 September 2016].

HONG KONG MANUFACTURING SMES: Preparing for the Future -Industry Situation Report Mould & Die Manufacturing. Federation of Hong Kong Industries, Trade and Industry Department.

IAN, H (October 2015). The future of UK automotive manufacturing in 2025 and beyond. The Society of Motor Manufacturers and Traders (SMMT).

IAN, H., 2015. The Future of UK Automotive Manufacturing in 2025 and Beyond, *The Society of Motor Manufacturers and Traders (SMMT)*

International Specialised Skill Institute, 2015. Automotive Vehicle Powertrains and e-Mobility – The Future, Australia.

ISHAK BIN ARIS, 2009. Guest Speaker: Development of Electronic Control Unit and its diagnostic for CNGDI vehicle using MPC555. Freescale, Petaling Jaya.

ISHAK BIN ARIS, 2009. Keynote Speaker: The experience of Designing and Fabricating Green Technology Vehicle, *IEEE Student Conference on Research and Development*. Thesis (PhD). Universiti Putra Malaysia.

ISHAK BIN ARIS, 2010. Keynote Speaker: Compressed Natural Gas Direct Injection Vehicle: Collaboration between Malaysian Universities, Malaysian Government and Industries, *SAE International Conference on Sustainable Mobility*, UPM 1 – 3 December 2010. UPM, 51-60.

ISHAK BIN ARIS, 2010. Keynote speaker: Electronic Control Unit for automotive engine. Automotive Research Centre, Universiti Kebangsaan Malaysia.

ISHAK BIN ARIS, 2011. Guest speaker: Advances in Green Technology. *Automechanika 2011 – Green: prospect and Future potential for automotive Industry*, KLCC 31 March – 2 April 2011, 5-20.

ISHAK BIN ARIS, 2011. Keynote Speaker: Moving towards high income, sustainable and developed nation by 2020, Challenges, Strategies' and Opportunities, *26th International Conference on CAD/CAM, Robotics and Factories of the Future 2011*, Kuala Lumpur 26 – 28 July 2011. UPM, 5-8.

ISHAK BIN ARIS, 2012. Keynote Speaker: Role of Electrical, Electronic and Computer Technologies in Energy Efficient Vehicle for Sustainable Mobility, *IEEE International Conference on Electrical, Electronic and Computer Technologies*, Noorul Islam University, Kumaracoil, Kanyakumari District, Tamilnadu, India 21 & 22 March 2012. UPM 2-4.

ISHAK BIN ARIS, 2013. Invited Speaker, "Intelligent and Safer Sustainable Mobility", SAE 2013: Southeast Asia Safer Mobility Symposium", 21st. October 2013, Melaka.

ISHAK BIN ARIS, 2013. Invited Speaker: Advancement in Vehicle data Communication System, *Quarterly Engineering Technical Session*, Proton, Shah Alam,, 9 April 2013. UPM, 4-9.

ISHAK BIN ARIS, 2013. Keynote Speaker: Sustainable Computing and Communication Technologies for Energy Efficient Vehicle, *2nd International Conference on Computing and Communication Technology, ICCCT2013*, Immanuel Arasar JJ College of Engineering, Nattalam, Marthandam, Kanyakumari, Tamil Nadu, India 1-2 March 2013. UPM, 3-6.

ISHAK BIN ARIS, 2013. Keynotes Speaker: Green Computing and Intelligent Networks for Smart Grid Applications, *IEEE International Conference on Green Computing, Communication and Conservation of Energy 2013*, R. M. D. Engineering College, Chennai, Tamil Nadu, India, 12-14 December 2013. UPM, 5-6.

ISHAK BIN ARIS, 2013. Keynotes Speaker: Sustainable Energy Efficient and Intelligent Vehicles, *IEEE International Conference on Renewable Energy and Sustainable Energy 2013*, Karunya University, Coimbatore, Tamil Nadu, India, 5 - 6 December 2013. UPM, 3-4.

ISHAK BIN ARIS, 2014. Invited speaker: Impacts of IoT and Big Data to Advanced Power Electronic Research, Faculty of Engineering, Universiti Technikal Malaysia Melaka, 26 November, 2014, UPM, 5-10.

ISHAK BIN ARIS, 2015. Invited Speaker: Impacts of IoT and Big Data to Smart Cities, *4th International SmartCity Workshop*, Serdang 2-3 September 2015. UPM, 2-3.

ISHAK BIN ARIS, RATNA KALOS ZAKIAH SAHBUDIN AND AHMAD FAIRUZ MOHAMMAD AMIN, 2015. Impacts of IoT and Big data to Automotive Industry, *Proceeding of 10th Asian Control Conference 2015*, Kota Kinabalu 31 May – 3 June 2015, 1577 – 1581.

KIM, H., DEBRA. M., & ADAM, C. (April 2010). Contribution of the Automotive Industry to the Economies of all Fifty State and the United States. Center for Automotive Research, Economic Development and Strategies Group. CAR Research Paper.

KPMG, 2010. The Transformation of the Automotive Industry: The Environmental Regulation Effect.

KPMG, 2015. The UK Economic Connected and Autonomous Vehicles – Opportunity.

KRISHNAVENI, M. & VIDYA, R., 2015. International Journal of Current Research and Academic Review Growth of Indian Automobile Industry.

MACDONALD, J. (25 February 2016). Electric Vehicles to Be 35% Of Global New Car Sales by 2040. Bloomberg New Energy Finance.

MCKINSEY & COMPANY (January 2016). Automotive revolution – perspective towards 2030.

MCKINSEY & COMPANY. The road to 2020 and beyond: What's Driving the Global Automotive Industry.

MCKINSEY GLOBAL INSTITUTE, 2013. Disruptive technologies: Advances that will transform life, business, and the global economy.

MIDA (July 2009) Malaysia's Automotive Industry. Malaysian Industrial Development Authority, Kuala Lumpur.

MINISTRY OF EDUCATION MALAYSIA, 2014. *Malaysia Education Blueprint 2013-2025*, Malaysia: MOE.

MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY, 2014. *Human capital roadmap for future automotive manpower needs (MATR)*. Malaysia: MITI.

MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY. "*MITI Media Statement: National Automotive Policy 2014.*" 21st Jan. 2014. Web. 10 Mar. 2016.

MINISTRY OF INTERNATIONAL TRADE AND INDUSTRY. "National Automotive Policy 2014 (NAP 2014)". Jan 2014. Web. 10 Mar. 2016.

Office for Low Emission Vehicles, September 2013. Driving the Future Today a strategy for ultra-low emission vehicles in the UK.

OPEC Secretariat (October 2015). 2015 World Oil Outlook. Organization of the Petroleum Exporting Countries (OPEC)

PATRICK, G., ELENA, G. & DAVID, W. 2014. Recent Trends in Manufacturing Innovation Policy for the Automotive Sector: A Survey of the US, Mexico, EU, Germany, and Spain, APRC Automotive Policy Research Centre.

PAUL, G., HANS, W.K., DETLEV, M. & DOMONIK, W., 2016. Disruptive trends that will transform the auto industry. McKinsey and Company.

PETER, W. & CHANDRAN, V.G.R. (2011). Automotive industry in Malaysia: an assessment of its development. Int. J. Automotive Technology and Management, Vol. 11, No. 2.

Pewartaan & pelaksanaan peraturan teknikal kenderaan motor, Bahagian Kejuruteraan Automotif, Jabatan Pengangkutan Jalan, Malaysia, SAE Seminar, 29 Mac 2016.

PR NEWSWIRE, February 2016. Electric Vehicles to Be 35% Of Global New Car Sales by 2040. Available from http://www.prnewswire.com/news-releases/electric-vehicles-to-be-35-of-global-new-car-sales-by-2040-300225689.html [8 February 2016]

RICHARD, R., 2012. IEEE Says That 75% Of Vehicles Will Be Autonomous by 2040. The Car Connection.

Self-Driving Cars Moving into the Industry's Driver's Seat (2 January 2014).

Shell Passenger Car Scenarios up to 2030 Facts, Trends and Options for Sustainable Auto-Mobility. Available from: http://s06.staticshell.com/content/dam/shellnew/local/country/deu/downloads/pdf/publications 2009shellmobilityscenariossummaryen.pdf [18 January 2016].

SITI MAISARAH MOHD PISAL, ISHAK BIN ARIS, M MADANI SAHARI, CHO CHEE SENG, SHAHRUL NIZAM BIN BUKHARI, NOR FAIZA BT. MANSOR AND MOHD FIRDAUS BIN MOHD MUNIR, 2015. Moving Towards Sustainable Human Capital Development for Malaysian Automotive Industry, *Proceeding of 10th Asian Control Conference 2015*, Kota Kinabalu, 31 May – 3 June 2015, 1999 -2002.

STELIOS, R., 2014. The Impact of Autonomous Vehicles on Cities. JOURNEYS.

Texas Instruments, 2015.

The Fiscal Times, 2013. Why You Won't Be Driving an Electric Car in 2040.

The future of UK automotive manufacturing in 2025 and beyond October 2015. Available from http://www.smmt.co.uk/wp-content/uploads/sites/2/ [13 March 2016].

The Western world has turned its back on car culture. Available from http://qz.com/337398/the-western-world-has-turned-its-back-on-car-culture/ [20 September 2016].

Transport and Environment (June 2013). Auto-sector innovation could create millions of jobs by 2030 and help revitalize Europe's growth.

VEHICLE SAFETY: It's more than you think, Robert Bosch Sdn. Bhd. April 2016.

World Greenhouse Gas Emissions in 2005, World Resources Institute.

APPENDIX

TEAM MEMBERS

I. **Mr. M. Madani Sahari – Sectorial Leader**

M. Madani Sahari currently hold the position of CEO of the Malaysia Automotive Institute (MAI), a focal point and coordination center, under the custodian of the Ministry of International Trade and Industry (MITI). He is a highly qualified executive manager with more than 18 years' experience in manufacturing and service industries of the automotive sector, M. Madani Sahari carries with him vast experience with national and international automotive manufacturers such as Proton, Perodua, Honda, Toyota, Renault, Hyundai, Nissan and General Motors in the areas of strategic collaboration, project development and manufacturing.

II. **Mr. Helme Hashim – Group Expert**

Mr. Helme Hashim is currently a Senior Associate to MAI since June 2010, assuming role as an advisor with regard to the strategic planning of MAI. Prior to that, he was working with SIRIM for the past 17 years where his last position was as General Manager. He was also involved in the first project on national EV called Perusahaan Otomobil Elektrik Malaysia (POEM) where he assume the role of Managing Director. He was involved in numerous projects / programme particularly in the area of material and foundry; among note-worthies were establishment of the Foundry Complex in Rasa, Selangor in 1987 and involvement as a Member of the Secretariat for automotive sector under the "Bumiputera Commercial and Industrial Community (BCIC)" in 2006 that recommended for the establishment of Malaysia Automotive Institute.

III. **Mr. Zainal Abidin Ahmad – Group Expert**

Mr. Zainal Abidin Ahmad is currently the Executive Director of Perodua Auto Corporation Sdn Bhd. He has been with Perodua since May 1995 when he joined as an Assistant Manager, Cost Control Department. Zainal, who graduated from Seattle, USA, in Management Information Systems and Accounting, in his present capacity, is responsible for Finance and Accounting, Corporate Planning, Human Resources & Administration, Property and Corporate Finance (including Group Secretarial).

IV. Prof. Dr. Ishak Aris – Group Expert

Prof. Dr. Ishak Aris is currently a Professor at the Department of Electrical and Electronic Engineering, Universiti Putra Malaysia (UPM). He obtained his bachelor degree in Electrical Engineering from George Washington University, USA in 1988 and later his Master and Doctorate Degrees in Power Electronics Engineering from University of Bradford, UK from 1990 – 1995. He involved in numerous research projects, either funded by UPM, MOSTI, MOHE, MIMOS and MIDA in many areas including intelligent control and communication system, wireless charging device and EV & Electric Scooter project.

V. Ir. Dr Ahmad Zainal Abidin – Group Expert (January 2016- Current)

Ir. Dr Ahmad Zainal Abidin is currently an Associate to MAI since November 2015, assuming role as an advisor with regard to the strategic planning and technology development of MAI. Prior to that, he was working with SIRIM for the past 33 years where his last position was as General Manager for Renewable Energy Research Centre. He was also act as Chairman of Working Group for the development of Malaysia Standard on Hydraulic Turbine for Renewable Energy and freelance module writer for Energy Efficiency and Energy Conservation Course Module for Malaysian Green Technology Malaysia. He also involved in Technical Evaluation Committee for Sciencefund and Technofund under MOSTI as expert member.

VI. Mr. Mohd Nazmi Mohd Nur – Group Expert (January 2015 - January 2016)

Mr. Mohd Nazmi Mohd Nur is currently heading the Research Unit under the Strategic Research Division of MAI. He had graduated with Bachelor Degree of Engineering (Aerospace) from Universiti Putra Malaysia (UPM). During his early working career, he started as an engineer in a consulting engineering company, managing several projects related to auto parts & components. He later served the Malaysia's Ministry of Science, Technology and Innovation (MOSTI) for couple of years as a Research Officer. To date, he has involved in numbers of study and report on local and global automotive related to policy & regulation matters including involvement in the task force team reviewing the National Automotive Policy that recently announced by MITI. Among other notable areas of involvement throughout his career in MAI including Fuel Economy Standards, Vehicle Fuel Labelling, Fuel Quality, Green Technology Foresight etc

VII. Ms. Nurul Fateha Aziz – Research Officer

Ms. Nurul Fateha Aziz had graduated from Universiti Malaysia Pahang in 2012 with a Bachelor Degree in Manufacturing Engineering. She is currently working as a research officer in MAI since 2012.

VIII. Ms. Amida Amaran – Research Officer

Ms. Amida Amaran had graduated from Universiti Teknologi Mara (UiTM) in 2014 with a Bachelor Degree in Mechanical Engineering. She role as a research officer in MAI from 2014.

IX. Ms. Nur Farhana Helme - Research Officer (January 2016- Current)

Ms. Nur Farhana Helme had graduated from International Islamic University Malaysia in 2009 with a Bachelor Degree in Aerospace Engineering. She is currently working as a Senior Executive in MAI since 2015.

X. Ms. Siti Fatirah Jaladin – Research Officer (January 2015 – July 2015)

Ms. Siti Fatirah Jaladin had graduated from UniKL MICET in 2012 with a Bachelor Degree Chemical Engineering Technology (majoring in Bioprocess). She started working in MAI from 2012 as a research officer.

XI. Ms. Izzaty Asmuni – Research Officer (July 2015- January 2016)

Ms. Izzaty Asmuni had graduated from International Islamic University Malaysia in 2014 with a Bachelor of Economics. She started working in MAI from May 2015 as a research officer.

ATTENDANCE MEGASCIENCE 3.0 AUTOMOTIVE SECTOR WORKSHOP

Date: 10 October 2015
Venue: MAI Auditorium

No.	Company	Name	Position
1	Petron Malaysia	Adrian Teh	Distributor Business Adviser
2	Shell Malaysia	Mahendran S.	Fuel PQ Excellent Lead
3	Sendok Group/ MAARA	Gwee Bok Wee	Managing Director
4	Sendok Group/ MAARA	Wong Say Ho	Project Director
5	Nuclear Malaysia	Nor Azwin Shukri	Research Officer
6	Nuclear Malaysia	Siti Salwa M.Shirajuddin	Research Officer
7	Global Impress	Aiman	Officer
8	Global Impress	Natasha Gineon	Officer
9	EPU	Mohamamd Radhi Abdul Razak	Deputy Director
10	EPU	Noorhidayah Salman	Assistant Director
11	Department of Standard Malaysia	Nur Afifah Ijap	Assistant Director
12	UTM	Halim	Lecturer

Date: 7 December 2015
Venue: Cititel Hotel, Pulau Pinang

No.	Company	Name	Position
1	Jabatan Kimia Malaysia, Pulau Pinang	Sukhairi Bin Samsudin	Director
2	Jabatan Kimia Malaysia, Pulau Pinang	Teoh Choon Ping	Director
3	Malaysia Automotive Institute	Nizmar Mohd Nazar	Head of IOT and Big Data Management
4	Malaysia Automotive Institute	Ahmad Zainal	Research Associate
5	University Science Malaysia (USM)	Dr. Tan Keng Hong	Lecturer School of the Arts
6	University Science Malaysia (USM)	Seyed Reza Moosavi Jafari	Lecturer School of the Arts
7	Boon Koon Group	Stephen Bion	Manager
8	Eclimo Marketing Sdn. Bhd.	David Samuel	Manager
9	Eclimo Marketing Sdn. Bhd.	Dato’ Dennis Chuah	Executive Director
10	Eclimo Marketing Sdn. Bhd.	Liew Chung Peng	Managing Director
11	Eclimo Marketing Sdn. Bhd.	Kendrick Hung	Manager
12	Mobula Research Sdn.Bhd.	Y.L.Tan	Chief Technology Officer
13	VADS Berhad	Mas Adli Mohd Abu Bakar	Manager,BPO GTM Strategy & Planning
14	VADS Berhad	Hairil Izwar Abd	Officer

		Rahman	
15	VADS Berhad	Mohd Faizal Shebli	Officer
16	CMS Consortium Ecotour Sdn. Bhd	Dr. Mohd Azman Zainul Abidin	Executive Director
17	Boon Koon Group	Zainuddin Awang long	Manager
18	INOKOM Corporation Sdn. Bhd	Shah Jihan Shahrul Hameed	Manager Research & Development
19	Motorcycle & Scooter Assembler and Distributors Association of Malaysia (MASAAM)	Dato' Syed Mohamad Aidid Syed Murtaza	President

Date: 16 February 2016
Venue: Promenade Hotel, Kota Kinabalu

No.	Company	Name	Position
1	MITI, Sabah	Peter Brian M Wang	Director
2	Kota Kinabalu Industrial Park (KKIP)	Victor Petrus	Senior Executive
3	Kota Kinabalu Industrial Park (KKIP)	Ir Melvin G. Disimond	CEO
4	Kota Kinabalu Industrial Park (KKIP)	Lawrence Kimkuan	Senior Manager
5	Kota Kinabalu Industrial Park (KKIP)	Frida Farah Bungga	Manager, Marketing
6	Kota Kinabalu Industrial Park (KKIP)	Victor Petrus	Senior Executive
7	University Malaysia Sabah	Dr Razak Mohd Ali Lee	Deputy Dean of Faculty of Engineering
8	Department of Industrial Development & Research	Tseu Kei Yue	Principal Assistant Director, Investment Promotion Division
9	Sabah Economic Development and Investment Authority (SEDIA)	Karen Christine Mijin	Senior Executive, Investment & business Development
10	Pejabat Meteorologi Sabah	Marreta Abdul Hamid Curativo	Director
11	Jabatan Kimia Sabah	Ephraim John	Science Officer
12	ASM Fellows	Dr. Rahimatsah Amat FASc	

Date: 17 February 2016
Venue: Riverside Majestic Hotel, Kuching

No.	Company	Name	Position
1	MITI, Sarawak	Griffith AkGoba	Director
2	MITI, Sarawak	Daniel Anggue	Assistant Director
3	MITI, Sarawak	Ricko Benedic	Officer
4	Jabatan Ketua Menteri Sarawak	Dr. Abdul Rahman Deen	Director
5	Centre of Excellence	Tn. Hj. Syeed Mohd Hussein Wan Abdul Rahman	CEO
6	Jabatan Kimia Malaysia, Kuching	Harun Ahmad	Officer
7	Jabatan Kimia Malaysia, Kuching	Mohd Riduan Md Bakhir	Officer
8	University Malaysia Sarawak (UNIMAS)	Assoc Prof Dr. Saiful bahari Hj. Mohd Yusoff	Deputy Dean Postgraduate and Research
9	Swinburne University of Technology Sarawak Campus	Dr. Almon Chai	Senior Lecturer and Coordinator (Robotics and Mechatronics)
10	Swinburne University of Technology Sarawak Campus	Assoc Prof. Wallace Wong	Director, Research and Consultancy
11	Swinburne University of Technology Sarawak Campus	Ir. Dominic Ong	Lecturer
12	Swinburne University of Technology Sarawak Campus	Dr. Patrick Then	Lecturer
13	Swinburne University of Technology Sarawak Campus	Dr. Ng Sing Muk	Lecturer
14	MATRADE, Sarawak	Twa Poonau Gilbert Taylu	Manager
15	Sarawak State Planning Unit	Dayang Naimah	Officer

Date: 6 May 2016
Venue: MAI Auditorium

No.	Company	Name	Position
1	BMW	Hafiz Zaim Hussin	Manager
2	BMW	Sashi Ambi	Head of Corporate Communication
3	Mazda	Zahrul Nizam Abd Samad	General Manager
4	Multicode Electronics Industries Berhad	Mohd Faridh Dol	BDM Director
5	Multicode Electronics Industries	Nurul Syazwani Suaidi	Marketing Executive

	Berhad		
6	Oriental Summit Industries Sdn Bhd	Lokman Hakim Lot	Section Manager
7	Oriental Summit Industries Sdn Bhd	Mohd Fouad Rahmat	Section Manager
8	Perodua	Alias Abu Hassan	General Manger
9	Perodua	Borhan Din	General Manger
10	Perodua	Zulkafle Ismail	Senior Manager
11	Perodua	Datuk Aminar Rashid	CEO
12	Perodua	Kazuyoshi Nagata	Executive Director
13	Perodua	Zainal Abidin	Executive Director
14	Perodua	Jehan Adnan	Deputy General Manager
15	Tan Chong Management Service Corporation Sdn Bhd	Leong Chee Meng	Senior General Manager
16	Tan Chong Management Service Corporation Sdn Bhd	Lew Jium Shang	General Manager
17	Tan Chong Management Service Corporation Sdn Bhd	Bryan Tan Teow Chang	General Manger
18	Asia Pacific Natural Gas Vehicles Association	Lee Giok Seng	Executive Director
19	PHN Industry Sdn Bhd	Azhar bin Taib@Jalal	COO
20	PHN Industry Sdn Bhd	Mohd Shazali Abdul Yusoh	Head of BD Department
21	PVA / Sanden Air Conditioning Sdn Bhd	Hj Azalan Omar	GM
22	TC Subaru Sdn Bhd	Gavin Lee	Deputy GM
23	TC Subaru Sdn Bhd	Edgar Seah	Senior Manager
24	Go Auto	Ahmad Azam Sulaiman	CEO
25	Go Auto	Farok Maasom	Director
26	Go Auto	Zuraimi Mohd Razali	Manager Corporate Planning
27	Pong Codan Rubber	Kam Cheong Loong	Executive Director
28	Sapura Industrial Berhad	Adnan Jamal	Senior GM
29	Sapura Industrial Berhad	Mohd Salleh Jani	GM
30	Sapura Industrial Berhad	Aiman	Engineer
31	Honda	Mohd Faizal Amir bin Baharin	Head of Government Liaison
32	Honda	Tee Chien Siong	Manager, Procurement Division
33	Mercedes Benz	Dr. Claus Weidner	President / CEO
34	Mercedes Benz	Veerappan Annamalai	General Manager
35	Ingress	Adzha Ghani	Deputy GM
36	UMW Toyota	Muhamad Hafiz	Manager
37	UMW Toyota	Ruszita Mansor	Executive
38	KVP / Sipro	Puan Noraini Soltan	Managing Director
39	HMSB (HSC) / Sipro	Tengku Muzafar	Member, KVP
40	KVP	Hasniza	Secretary, KVP
41	Sipro	Ami Nuddin	GM
42	Sipro	Suheri	Head R&D
43	KVP	Razali	Member, KVP

44	KVP / Sugihara Carpet	Soo Hak Min	Executive Director
45	KVP / Sanyco Grand	Ho Harn Ping	HOD-new business development
46	KVP / WSA	Datuk Dr. Wan	President, KVP
47	JPJ	Mohd Sharulnizam Sarip	Deputy Director
48.	JPJ	Ahmad Abdul Hadi Hamzah	Engineer
49	Delloyd	Paul Gan	Director of Group Marketing Automotive Parts Division
50.	Proton	Dato' Radzaif Mohamed	Deputy CEO
51.	Proton	Abdul Rashid Musa	CTO
52.	Proton	Khairul Ridzwan Suhaimi	Asst Manager, CEO's office
53.	MIDA	Puan Hafizah Amminuddin	Deputy Director, Transportation Technology
54.	MIDA	Muhamad Shahrul Farhan Abdul Wahab	Assistant Director, Transportation Technology

ABBREVIATIONS/ACRONYMS

AC	Alternating Current
AGM	Absorbed Glass Mat Battery
BEV	Battery Electric Vehicle
BMS	Battery Management System
CNG	Compressed Natural Gas
CVT	Continuously Variable Transmission
DC	Direct Current
DTC	Diagnostic Trouble Code
ECU	Electronic Control Unit
ECVT	Electronic Continuously Variable Transmission
EV	Electric Vehicle
HEV	Hybrid-electric-vehicle
HSG	Hybrid Starter Generator
HV	High Voltage
ICE	Internal Combustion Engine
IMA	Integrated Motor Assist
ISAD	Integrated Starter Alternator with Damping
LIB	Lithium-Ion Battery
LNG	Liquefied Natural Gas
LPG	Liquefied Petroleum Gas
NiMH	Nickel–metal hydride battery
OEM	Original Equipment Manufacturer
PHEVs	Plug-in hybrid electric vehicles
PPE	Personal protective equipment
RESS	Rechargeable energy storage system
SELV	Separated extra-low voltage
SOC	State of Charge
SUV	Small Urban Vehicle
WHS	Workplace health and Safety
IMS	Intelligent Mobility System
iEEV	Intelligent Energy Efficient Vehicle