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AN OVERVIEW OF ELECTRIC VEHICLE AND POWER MANAGEMENT SCHEMES

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Abstract

Power management in electric Vehicle has been revolutionize since the old power structure introduced with first Electric Vehicles. Today, it can be power either by a single or by a combination of multiple sources and driven by a single or a combination of multiple algorithms. This development contributes in significantly superior results. This paper reviews on electric vehicle giving description for each sub-types, and then details power management schemes and charging techniques highlighting main problems and solutions. Finally, future research direction for power management and structure are also discuss.

Index Terms: *Electric Vehicle, Power Management, charging techniques, multiple sources.*

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1. INTRODUCTION

In recent era, many existing automobile manufacturers and new companies have put a remarkable effort in transforming the conventional vehicle into an Electric Vehicle that provides green and reliable solution. In terms of market share, Electrical vehicle demand is raising. It starts replacing conventional vehicle In USA, Asia and Europe. With modernized perspective and competitive price, Electrical Vehicle is a smart choice for any user, however, an extra effort is required to improve the range of dependence and vary applications.

The remainder of this paper proceeds as follows. Section II formulates the whole concept of electric vehicle, power management with hardware levels explanation, charging techniques and standards and finally introduces to multipower source architecture for EVs. Section III is devote to discuss power management low architectures and high control algorithms. Finally, Section IV includes a discussion of power management and future research. Resume of various research efforts in BEV/HEV are provide in this paper.

2. THE ELECTRIC VEHICLE

An electric vehicle (EV), is a vehicle based on one or multiple motors (electric or traction) to Ensure propulsion. The gradation of electrification varies from one vehicle to another. In fig 1,EVs are classified through a scale from zero (0=Conventional vehicle) to one (1=Full Electric Vehicle). There are some types of electric vehicles discuss as follows.

Fig-1. Degree of Electrification

2.1 BEV (Battery Electric Vehicle)/AEV (All Electric Vehicle):

The AEV or BEV uses high capacity batteries and electric motor for propulsion (Fig6.a). It derives all the power from its batteries pack and has no internal combustion engine; fuel neither cell, nor fuel tank. The only way to recharge its battery is by plugging in the vehicle to a charging point.

2.2 HEV (Hybrid Electric Vehicle):

The second type is the HEV that uses mechanically a combination of Electric Motor (EM) in low speeds dedicated for in-city traffic and a conventional Internal Combustion Engine (ICE) to be use outside urban areas (Fig6.b). When ICE mode is activate, the EM stops and batteries start charging using an alternator driven by the same equipped ICE. The

HEV get an upgrade to the Plug-in Hybrid Electric Vehicle (PHEV), it includes actually a new battery charging system that can fed externally. The combustion engine works as a backup when the batteries are deplete and the driver cannot have a break for charging. Porsche announced the new phenomenon Plug-in S E-Hybrid that replaces the old phenomenon Hybrid offering more driving responsiveness and vehicle performance.

2.3 EREV (Extended Range Electric Vehicle):

The main third type is the Extended Range Electric Vehicles (EREV or REEV); in this structure (Fig6.c), vehicle propulsion is drive only by an electric motor powered by high capacity batteries. These batteries are maintain charged by a small engine generator unit. Its small consumption, less than two liters of fuel at 100km, offers an extended range of autonomy and distance to be reach. The latest REEV introduced to the market this year are the all-new 2014 Cadillac ELR, the AUDI A1 e-Tron and Jaguar's Limo-Green series.

2.4 FCEV (Fuel Cell Electric Vehicle):

In addition to these three main types, Fuel Cell Electric Vehicle (FCEV) has been introduce to perform long distances. It uses a fuel cell system to power its on-board electric motor (Fig6.d) Proton Exchange Membrane fuel cells generally called Polymer Electrolyte Membrane (PEM) fuel cells used in FCEVs use hydrogen fuel stored onboard and oxygen from the air to produce electricity. As long as a fuel is provide FC's, continue to generate electricity, similar to conventional ICE's. However, fuel cells are much cleaner; they convert fuels directly into electricity via an electrochemical process that does not need combustion. The generated power from a fuel cell stack depends on the number and size of the individual fuel cells that comprise the stack and the surface area of the Polymer Electrolyte Membrane. A fuel cell vehicle that is fuel with hydrogen emits only water and heat. By providing clean, high-efficiency, reliable green transportation facilities, FCs have become important technology in development of electric vehicles. In addition, fuel cells are being develop for buses, boats, motorcycles, and many other kinds of vehicles

2.5 SEV (Solar Electric Vehicle):

Solar electric vehicle (SEV) is an electric vehicle powered importantly or completely by direct solar energy. Through solar arrays installed on top of the vehicle, often-photovoltaic (PV) cells, solar energy is converted directly into electric energy. Since converted solar energy is the only source, it powers all or part of SEV's propulsion, electronics, communication, navigation, security and other auxiliary features. Sensors assist the driver similar to conventional vehicles. Here, gathered information allows monitoring the car's energy consumption, solar energy capture and other parameters. SEVs can be equipped with a battery pack assistance to ensure continuous driving during shaded days or night use giving an extended range of autonomy to the users.

Practically, SEV can reliable in some uses when vehicle operates relatively little but spends most of the time parked in the sun, such as golf carts, Single-track vehicles or specific target; Solar Race Challenges: competitions taking place in all over the world are to promote research on solar-powered cars.. Commercially, Photovoltaic modules are used as auxiliary power units for different EVs specially PHEV application. Depending on the powertrain structure, solar panels usually feed batteries or energy management system (EMS) with electric power through a charge controller.

The power train structure, solar panels usually fed batteries or energy management system (EMS) with electric power through a charge controller. SEVs structure has been deed in Solar Buses. Both all-solar bus such as the TINDO project that is operating as free public transport service in Australia and Hybrid Solar Bus that uses solar energy to power electronics, video monitoring system, air conditioning and auxiliary functions, meanwhile, traction is ensure by a HEV structure

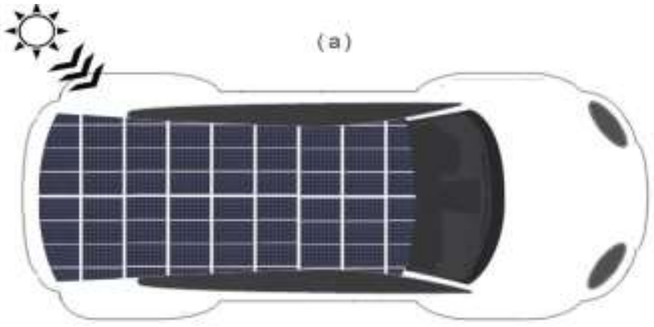

Fig-3. Improved sunroof for SEVs takes advantage CPV technology

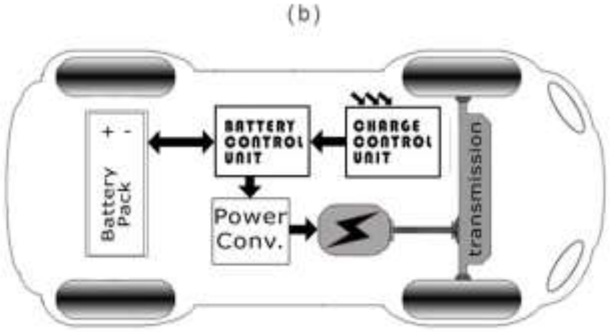

Fig-4. Simplified drive train architecture of Solar Electrical Vehicle.

Main disadvantage of pure solar electric vehicles is sun relatability. Solar arrays mounted on top cannot provide sufficient amount of electric power within a short time. Today's solar cells technology limits the opportunities we can explore in a SEV. Despite its enhancement compared to first generation PV panels, new Concentrating Photovoltaic panels (CPV) have 29% panel efficiency, nearly double that of an average PV panel

Fig-6: Simplified drive train architectures of main Electrical Vehicles: (a): Battery Electric Vehicle (b): Hybrid Electrical Vehicle(c): Range Extended Electric Vehicle (d): Fuel Cell Electric Vehicle

and have advanced temperature management which keep cells at top performance in high temperature. An interesting modified
of the electric vehicle the PHEV that has solar panels as well to assist: The 2010 Toyota Prius model has introduced mounted solar panels on the roof as auxiliary source..

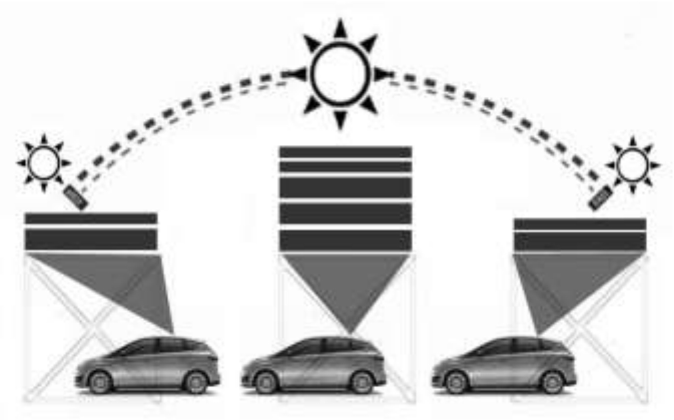

Fig-5. C-max SEV charging technique involving Concentrating Photovoltaic panels (CPV) and concentrating parking lenses.

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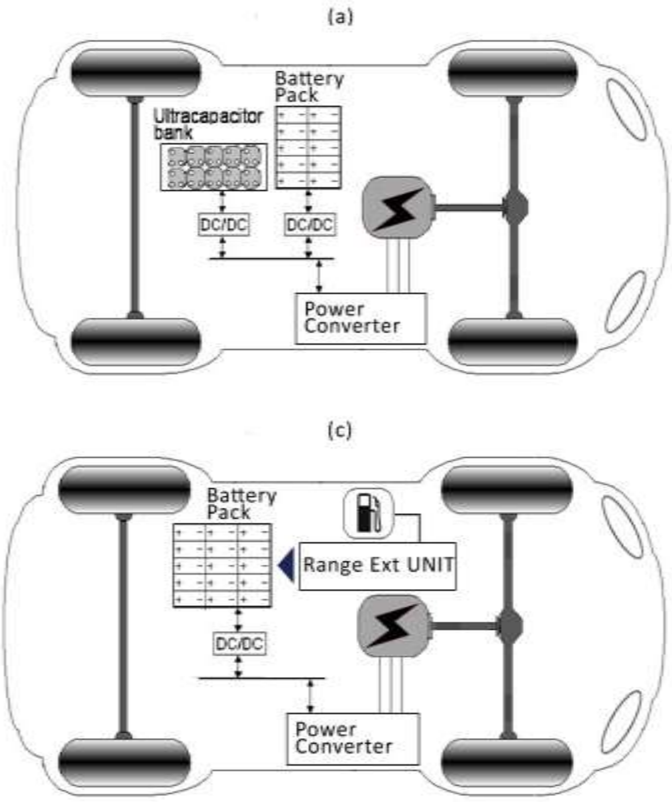

This technique has been developed and enhanced in the 2014 Ford Cmax an arbor of 23m² equipped with Fresnel lenses to concentrate solar radiation, and increase up to 8 times the electrical power produced by the photovoltaic cells of C-Max. The concept C-Max has become the first plug-in hybrid can recharge its battery without being plugged in, even if it may still be in case of requirement. Some marine applications include SEV structure too; The low power density current of solar panels limits the use of solar propelled vessels, however boats that use sails (which do not generate electricity unlike combustion engines) rely on battery power for electrical appliances (such as refrigeration, lighting and communications).

Here solar panels have become popular for recharging batteries as they do not create noise, require no fuel and often can be seamlessly add to existing deck space. Solar energy is also use in the air. Solar ships can refer to solar powered airships or hybrid airships. They are consider as unmanned aerial vehicles (UAV); solar power would enable these to stay aloft for months, becoming a much inexpensive means of doing some tasks done today by satellites.

3. POWER MANAGEMENT

Control schemes for hybrid-electric vehicles generally target several simultaneous objectives. The primary one is the minimization of the vehicle fuel consumption, while also attempts to minimize emissions and to maintain or enhance drivability. To date, the power management (PM) system in EVs is basically form by low level hardware-based control which can be divided into two control layers low level component and low level control. Hardware control layers works together to optimize PM system in EVs.

Major challenge of energy management system (PMS) in an electric vehicle is to assure optimal use and regeneration of the total energy in the vehicle. Irrespective number of sources, the powertrain configuration, at any time and for any vehicle speed, the control strategy has to determine the power distribution between different energies. When two storage systems or two fuel converters are available additional power distribution between the RESSs and between the fuel converters has to be determined. These decisions are constrained by two factors. First of all, the motive power requested by the driver must always be satisfies up to a maximum power demand already known. Then, charge status must be maintain within, permitting the vehicle to be charge continuously.

TECHNOLOGY	MERITS	DEMERITS
Hybrid Electric Vehicle (HEV)	Decrease fuel consumption and emissions; Chance to recover energy from regenerative braking	Higher initial cost; Component availability; Build complexity involving two power trains (Transmission Energy loss).
Plug-in Hybrid Electric Vehicle (PHEV)	Important grid connection potential; Reduce fuel consumption and emissions; Enhanced performance; Chance to recover energy from regenerative braking; 100% zero-emission capability.	Higher initial cost; Build complexity involving two power trains (Transmission Energy loss); Component availability; High cost of batteries and battery replacement; Added weight to be taken in attention.
Battery Electric Vehicle (BEV)	Use of cleaner electric energy; Zero emissions Vehicle; battery recharging (Overnight or equipped Parking); Possibility to recover energy from regenerative braking; Lesser operational costs; Silent operation.	Short distance range; Battery technology still to be improved; Public recharging infrastructure to be improved.
Fuel Cell Electric Vehicle (FCEV)	Zero emissions (Water & Heat only); Very high energy efficiency compared to conventional ICE; Recovered energy from regenerative braking; No dependence on petroleum	Higher initial cost; Hydrogen generation and onboard storage security problems; Availability and affordability of hydrogen refueling stations (infrastructure to be improved); Standards development in progress; Scalability for mass manufacture;
Solar Electric Vehicle (SEV)	Able to employ their full power at any speed, do not require any expense for running, quite, requires very low maintenance, no harmful emissions.	Do not have speed or power that steady cars have, can operate only in sun (unless batt. assisted), A good solar powered car is expensive.

3.1. Hardware Control:

Power management design starts with the hardware level, more specifically with vehicle power train, which is necessary in every EV. Presented in different approaches and combinations, the only purpose in power train design is to obtain optimum power management results, increase vehicle performance and robustness, and reduce energy loss in transmission. Generally, there are six transfer architectures in BEV; the first is the conventional drive train with clutch (Fig6.a). The vehicle is equipped and Energy Storage System (ESS) that delivers electrical energy to the main EM through a power converter.

The mechanical energy provided reaches the front wheels through a quite long way, a clutch, a gearbox and a differential. In second type (Fig6.b), the clutch is delete and the gearbox is replace with a fixed gear transmission unit while the entire architecture remains the same. This little enhancement simplifies the driveline configuration and reduces the size and weight of transmission system. By following the same logic, a third configuration (Fig6.c) offers a further simplification. It groups the electric motor, the single-gear box and the differential in same level with wheels. The BEV is lighter and mechanical transmission losses become marginal. The need to improve the cornering performance in BEV, each wheel gets its own fixed gearing and own electric motor. Thus, it is possible to operating different speeds. In some other configuration, the wheels were deed. In-wheel application reduces even more weight and complexity. Here, vehicle operates in direct drive without a drive shaft; wheels are equipped with the fixed gearbox and driven directly by Em. The same architecture is keep in final alignment but with more use of in-wheel application. The EM is build right in the wheel and the drive train is reduce to zero. Each EM receives power from a dedicated power converter feed by the Energy Storage System.

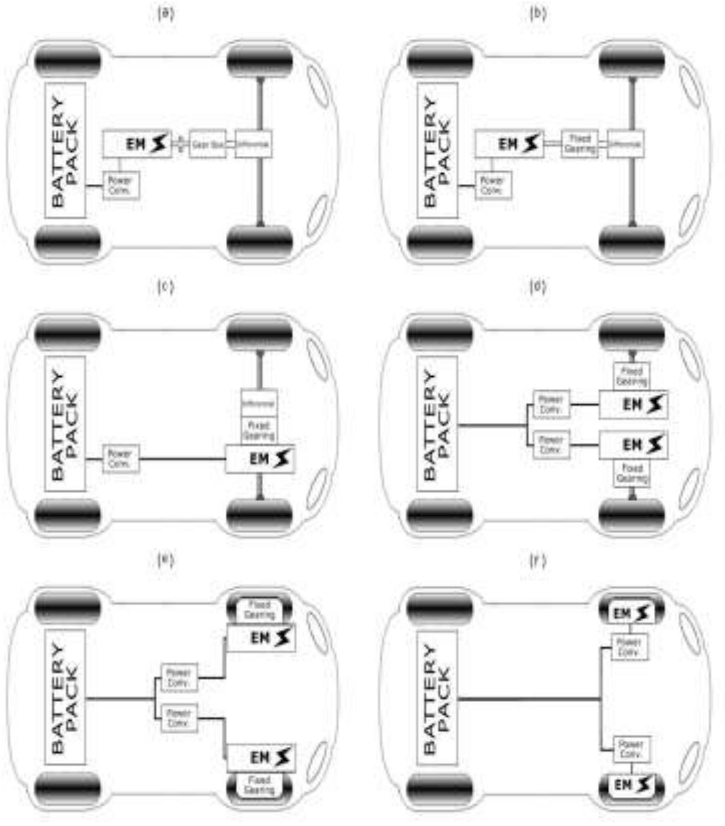

Fig-6: Main drivetrain architectures of BEV: (a): Conventional Drive train (b): Single-gear transmission architecture (c): Integrated single-gear and differential architecture (d): Separated EM and fixed gearing architecture, (e): Fixed EM and gearing architecture, (f): in-wheel drive architecture.

For HEV, mainly four architectures are available and marking different vehicle purposes; Parallel Drive Train configuration (Fig5.a) allows both ICE and EM to access transmission in parallel via couplers. Thus, electric vehicle equipped by two separate propulsion powers in two different drivelines. The way motor and engine contribute will be discussed later in further details.

The second architecture is Series Drive Train (Fig6.b). Only the EM accesses the transmission shaft. Meanwhile, the ICE is to generate electrical power but not to support the EM in transmission. The generated electric power led to power converter before reaching Battery Pack and EM.

By combining the previous configurations (Fig6.c), the Parallel Series Drive Train is figure out; the ICE supports the EM in similar way to parallel mode, however, it keeps providing electric power through linked generator.

In final design (Fig6.d), by replacing the generator in previous vehicle construction and adding a second power converter to store electrical energy in-car produced in battery, HEV become more controllable and efficient.

Both, HEV and BEV constructions use DC/AC converters to control electric motors feeding and DC/DC converters to manage two-way energy transfer for battery charging or use.

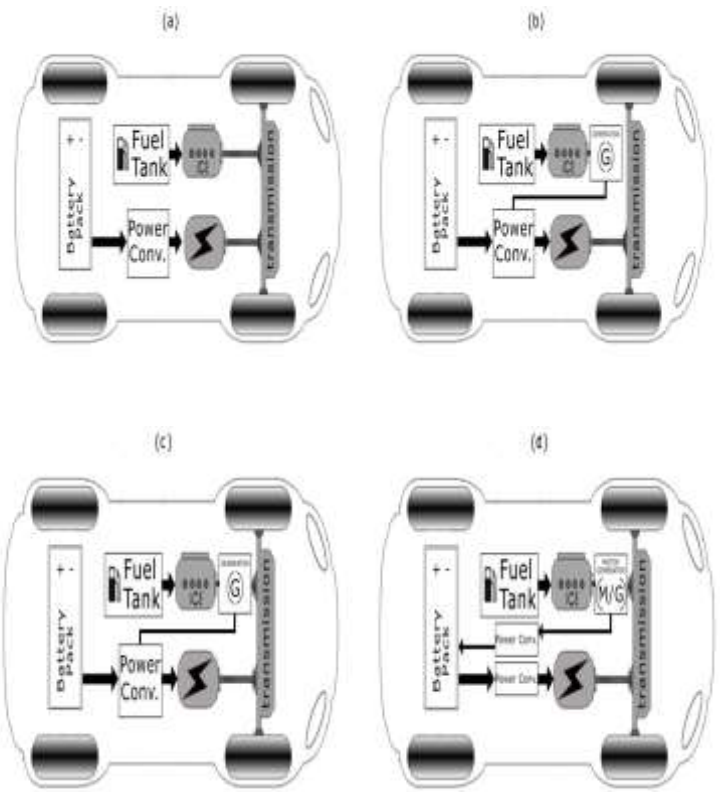

Fig-7: Main drivetrain architectures of HEV: (a): Parallel structure HEV (b): Series structure HEV (c): Series-Parallel structure HEV (d): Complex structure HEV

3.2. Multi Power Source Architecture

Many features can affect the EV performance, such as size, purpose of use, environment, driving style (sporty, soft, moderate or combined). All these factors may lead to a deep and quick discharge rate of the battery and its harm. To keep it healthy and guide it to a slow discharge even when a heavy load is on demand, the electric vehicle is power by a combination of multiple sources.

The main element is the batteries. Most of the electric vehicles use Lithium ion battery. Lithium ion batteries Eco-Friendly friendly and have higher energy density, longer life span, and higher power density than conventional battery. They have wide application in electric vehicles and other electronics. Since large number of Lithium-ion batteries used in series in electric vehicles so there arises the problems of safety, durability, thermal breakdown and cost, which limits the application of the Lithium ion battery. Around electric vehicle, use other kinds of batteries such as Plumb-Acid, Nickel-Cadmium, and lithium-polymer. The selection of a battery base on many criteria, such as energy, weight, lifetime, price, voltage, size. To attain a power boost, super capacitor is used. It has the characteristics between a capacitor and a battery. It can discharge a large charge in a short period. A super capacitor bank is hence adopt to supply sudden charge to assist the main battery in heavy consumption. The super capacitor, under management, can be charge by the main batteries.

Recently, many manufacturers conferred more attention to solar panels. They will provide the power management system with an auxiliary electric energy to be use later for battery charging or electronics power supplying.

In order to improve kinetic energy lost in vehicle breaking electric vehicles can also save energy in stop and go driving through regenerative breaking. In this technique, the Electric motor is use as a generator converting the kinetic of the vehicle's motion back to electric energy, rather than wasting it as heat in the breaks. The regenerative breaking can recover 55% to 80%of the kinetic energy for later use. This is especially valuable for vehicles that stops and start frequently like buses and in-city BEVs.

For BEVs and PHEV, Grid Power is the main energy source. It consents charging batteries and super capacitors. Many charging modes are available with enhanced charging time.

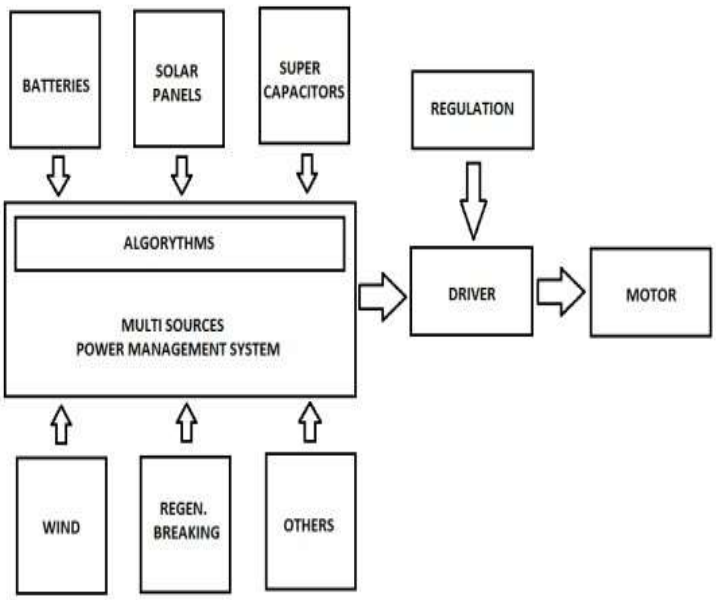

Fig-8: Multi power supply architecture for EV

Fig. 8 presents the framework of a multi-power supply system for electric vehicles. A power management unit based on smart systems manages the sources and performs combinations or timing between them to obtain optimal vehicle responsiveness and battery health. This power is transferred to a regular motor control unit witch drives the vehicle.

4. CHARGING TECHNIQUES

4.1 Conductive charging:

It is a direct electrical connection (typically through an insulated wire/cord set) between the source and the charging circuitry. The electrical system and its controls may be house within the vehicle or external to it. All new EVs are compatible with this approved standard. There are three modes of EV charging; In *Standard mode*, AC Level 1 supplies 120V single-phase power at up to 12 Amp. For example, a Nissan Leaf with its battery charge totally depleted would take about twenty hours to complete recharge. Meanwhile, *Semi-Quick mode* provides up to 3 phases 32Amp current. It takes much smaller time to charge electric vehicles compared to standard charging. Finally, *Quick mode* uses a specialized fast charger connected to a high-powered electrical source; the high power greatly reduces charging time. However, it requires infrastructure investment, spaces and extra costs. It is suitable for emergency charging purpose. The actual charge time will vary based on the charge level and condition of the batteries.

4.2 Inductive charging:

No wiring is required; instead, the energy is transfer between the charger and the "Paddle" inside the vehicle's inlet via a magnetic field generated by a high AC current. Inductive charging is still expensive and difficult to set up for end user.

4.3 Batteries swapping:

Instead of recharging EVs from electrical socket, batteries could be mechanically replace in a couple of minutes in some special stations. Here battery size and geometry should be regulate in order to relay on Battery swapping technique.

5. DISCUSSION ON POWER MANAGEMENT

The choice of the suitable topology requires preliminary empathetic of vehicle use purposes study of driving cycles, vehicle size and weight, desired performance, and type of application. Once the topology has been set, the second step is the plan of an energy management control (EMC) strategy, which is an essential key for an efficient electric vehicle.

Low level PM control offers ironic range of architectures; Series HEV is useful for stop-and1-run use, such as city driving. It can recover energy from regenerative breaking and feed batteries. Meanwhile, Parallel HEV has a weak battery capacity. The ICE and EMC complement each other while driving. Thus, it can be reliable either in city or in highway. This kind of structure gets a better efficiency because of the reduced battery pack and small electric motor. The main area, both previous architectures cannot cover is the precise control strategy. Thus tow complex configuration are used Series-parallel HEV and Complex HEV.

PHEV sustains longer in EMC mode than ICE mode. It is suitable for both city and highway, and shares the same advantages and disadvantages of a regular HEV.

For BEVs, in-wheel drive configuration is most suitable for city use due to lightweight and frequent stop-and-run situations. BEVs are design mainly for short distance autonomy despite of minimal energy loss in transmission. Handling of BEVs will be affect by the new wheel configuration and increase of its weight.

In high level, the power management controller would take advantage of different algorithms developed for this purpose, but also takes even more advantages from improving algorithms, weather conditions, weather forecast, GPS position and driving experience. Learning PMC algorithm can be improve; EVs would be able to learn from each other through communication a user experience exchange database, encrypted to respect drivers' privacy.

By providing more perfect and up to date data to power management system, fuel economy can be improved, reducing pollutant emissions, as well as extending battery lifetime and range. Practically, it will be difficult to be approve by competitive manufacturers; meanwhile, this concept can be apply within the same manufacturer's products. This unique new communication network will allow access to new infrastructure in new directions.

6. CONCLUSION & FUTURE WORK

In the future, combining diverse energy sources and power trains in optimal way, as well as performing an accurate and robust power management control, will be essential to build a reliable and reasonable EV while preserving our environment and intelligently using our limited resources.

Many different methodologies have been propose to improve our understanding of the fundamental vehicle performance challenges. However, among all the control methods, each control technique has its advantages and disadvantages.

As a first step in improving PMC, our future work will focus on enhancing power management supervisory level taking advantage of today's respectful achievements and aiming to optimize a multipower source management in BEV and HEV. This enhancement will take advantage of completely new area: Smart PMC through vehicles' intercommunication and PM experience sharing; the vehicle will be able, not only to learn from its own experience, but also from other EVs' experience with a comprehensive innovation communication system and a cloud experience database.

REFERENCES

[1] Siang Fui Tie, Chee Wei Tan, « A Review of Power and Energy Management Strategies in Electric Vehicles », 2012 4th International Conference on Intelligent and Advanced Systems (ICIAS2012), 2012, pp.
412-417.

[2] Hongjun Chen, FeiLu, Fujuan Guo, "Power Management System Design for Small Size Solar-Electric Vehicle", 2012 IEEE 7th International Power Electronics and Motion Control Conference - ECCE Asia, 2012, pp.
2658-2662.

[3] B. Ganji and A. Z. Kouzani, "A study on look-ahead control and energy management strategies in hybrid electric vehicles," 2010 8th IEEE International Conference on Control and Automation (ICCA), 2010, pp.
388-392.

[4] F. R. Salmasi, "Control Strategies for Hybrid Electric Vehicles: Evolution, Classification, Comparison, and Future Trends," IEEE Transactions on Vehicular Technology, vol. 56, 2007, pp. 2393-2404.

[5] L. Rosario, P.C.K.Luk, J.T.Economou, B.A. White, “A Modular Power and Energy Management Structure for Dual-Energy Source Electric Vehicles”, IEEE Vehicle Power and Propulsion Conference, 2006, pp:1-6.

[6] Emil B. Iversen, Juan M. Morales, Henrik Madsen, “Optimal charging of an electric vehicle using a Markov decision process”, Applied Energy 123 (2014), 2014, pp. 1-12.

[7] Chi-Sheng Tsai, Ching-Hua Ting, “Evaluation of a Multi-Power System for an Electric Vehicle” , International Conference on Control, Automation and Systems 2010, 2010, pp. 1308-1311.

[8] Philipp Elbert, Tobias N¨ uesch, Andreas Ritter, Nikolce Murgovski and Lino Guzzella, “Engine On/Off Control for the Energy Management of a Hybrid Electric Bus via Convex Optimization”, ieee transactions on vehicular technology accepted, not published yet.

[9] Manuel Salazar , Nesimi Ertugrul ,“Potential Enhancements for EV Power Management Systems in Military Vehicles”, Australasian Universities Power Engineering Conference, AUPEC 2013, 2013, pp.1-6.

[10] Ming-Fa Tsai, Chung-Shi Tseng, and Yu-Hsiang Lin, “Power Management and Control of an Electric Vehicle with Auxiliary Fuel Cell and Wind Energies”, 2013 IEEE Region 10 Conference (31194), pp :1-4.

[11] Mid-Eum Choi, Jun-Sik Lee, and Seung-Woo, “Real-time Optimization for Power Management Systems of a Battery / Supercapacitor Hybrid Energy Storage System in Electric Vehicles”, IEEE Transactions on Vehicular Technology. accept.