International Journal of Advanced Research in Engineering and Applied Sciences

ISSN: 2278-6252
Impact Factor: 7.358

PLUG IN VEHICLES- A TECHNOLOGY FOR THE FUTURE

Srinidhi Suresh, Deptt. of Chemical Engineering, Nathalal Parekh Marg, Matunga, Mumbai

Aman Shah, Deptt. of Chemical Engineering, Nathalal Parekh Marg, Matunga, Mumbai

Prerna Goswami, Deptt. of General Engineering, Nathalal Parekh Marg, Matunga, Mumbai

M.A.K. Kerawalla, Deptt. of General Engineering, Nathalal Parekh Marg, Matunga, Mumbai

Abstract: *A plug-in vehicle (PEV) is a motor vehicle that can be recharged from an external electricity source. PEV is a set of all electric vehicles like Battery Electric Vehicles (BEVs), Plug-in Hybrid Vehicles (PHEVs). Plug-in cars have several benefits compared to conventional internal combustion engine vehicles with regard to the environment and safety issues. They have lower operating and maintenance costs, and produce little air pollution. Thus, such vehicles are becoming more popular. However, they also have some drawbacks such as the impact of charging these cars on the electrical utilities. The main objective of this paper is to highlight these advantages, the research done in this field. Experiments have been conducted on several smart grids to analyze the impact on the energy distribution, network energy losses, cost etc. This paper reviews the economics, the disadvantages of PEVs, methods to counter them, recent government incentives, the current market trends and impact of PEVs in the future markets.*

Keywords: *Plug-In Vehicles, Smart Grid, Energy Distribution, Network energy losses, Economics, Current trends and Future strategies.*

1. INTRODUCTION

The fast developing technological industry coupled with the growing concerns of increasing environmental pollution, oil prices and depleting sources of energy have led to the invention of innovative automobiles. One such example is the Plug-In vehicles (PEVs) that can be classified into Hybrid Electric Vehicles (HEVs), Battery Electric Vehicles (BEVs), and Plug-in Hybrid Vehicles (PHEVs). Electricity is supplied from different sources such as a wall socket or rechargeable battery packs is used to charge the PEVs. In electric vehicles, the challenges are to achieve high efficiency, ruggedness, small sizes, and low costs.A PHEV has characteristics of both- a hybrid electric vehicle, with an electric motor and an ICE, with a plug that connects to the electrical grid. PHEVs also dissolve the problem of whether the vehicle will reach its desired destination associated with electric vehicles, because the I.C.E. acts as a backup when the batteries run out, giving PHEVs a driving-range that is along the lines to of vehicles that have gasoline or diesel tanks. [1]

2. WORKING

The working of HEVs is basically based on the powertrain of the assembly of the vehicles.

The electric motors are quite different from gasoline engines. An engine needs to spin around to work more efficiently. However, wheels do not need to move fast. For example, when you are starting from a cold start at a signal, the engine needs to produce more torque and start off at a very low speed. On the other hand, while moving on a highway, you need the reverse i.e. more speed and less torque. In an I.C.E you need to burn more fuel to produce more power or torque, which is the basis of the law of conservation of energy. So it is referred to as 'Stepping on Gas'. But in an electric motor- the same power is produced irrespective of how slow or fast the wheels spin. [2]

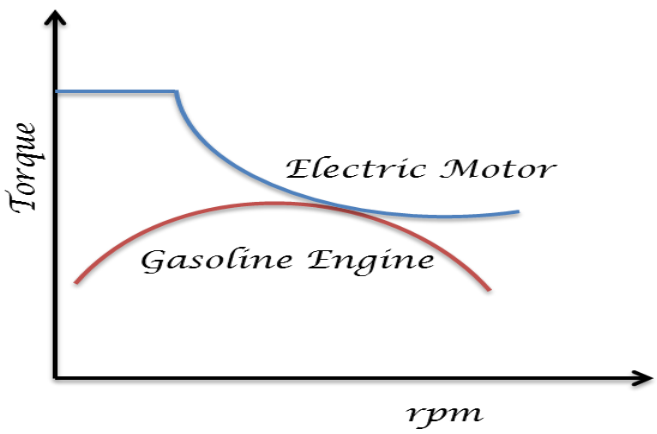

Figure 1: Torque vs. rpm for Gasoline and Electric vehicles

The working of the electric motor forms the basis of the powertrain of the hybrid electric vehicles. It is because of this principle that the electric vehicles have an edge over internal combustion engine vehicles.

2.1. Hybrid Electric Vehicles

A Hybrid Electric Vehicle (HEV) converts the stored chemical energy into mechanical energy, to drive a vehicle in a useful and an environmentally friendly manner. The powertrain of a HEV includes electric motors, generators, batteries and an internal combustion engine running on gasoline. (Refer to Fig 4).

Types by Powertrain Structure [3]

2.1.1. Series

Series Hybrids use an I.C.E in order to run a generator which then turns the electric motor through a battery and rotates the wheels. The battery Is used to store excess charge (Flywheels). Over short distances, the battery can be used without engaging the I.C.E. examples: Chevrolet Volt, Opel Flextreme, Coaster light-duty passenger bus etc.[4]

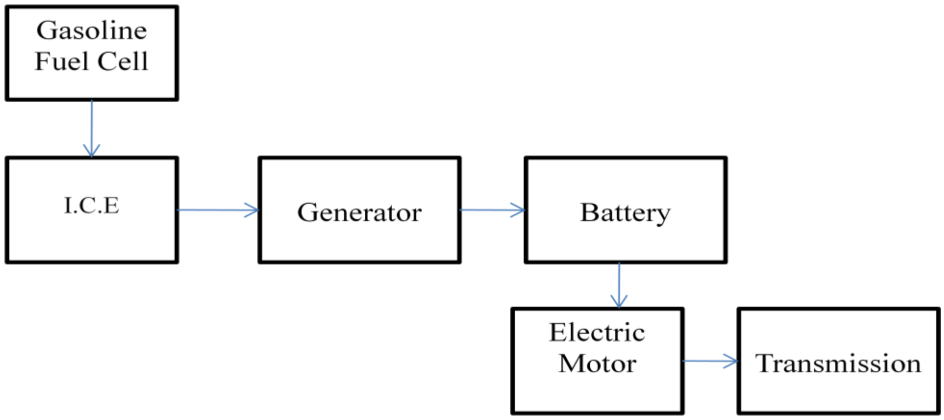

Figure 2: Working of Series Hybrid Electric Vehicle

Advantages of Series Hybrid Vehicles [5]

1. No mechanical link between the combustion engine and wheels and so no mechanical transmission.
2. The generator can be located anywhere.
3. More efficient during stop and go in-city driving.
4. Separate electric wheel motors can be implemented.

Disadvantages of Series Hybrid Vehicles [5]

1. The weight, cost and size of the powertrain is excessive because the electric motor, generator and I.C.E are all connected to handle the power.
2. Over large distances, the overall efficiency is less because of energy conversions.

2.1.2. Parallel

In contrast to series hybrids, parallel hybrids can use two different sources of power simultaneously – an I.C.E. and a battery driven electric motor. The advantage of using a parallel over a series hybrid is that electric motor can be used at low power over short distances (increases fuel economy) whereas the I.C.E can be used over long distances at high power which helps to reduce range anxiety. Examples: Honda Insight, Accord and Civic etc. [6]

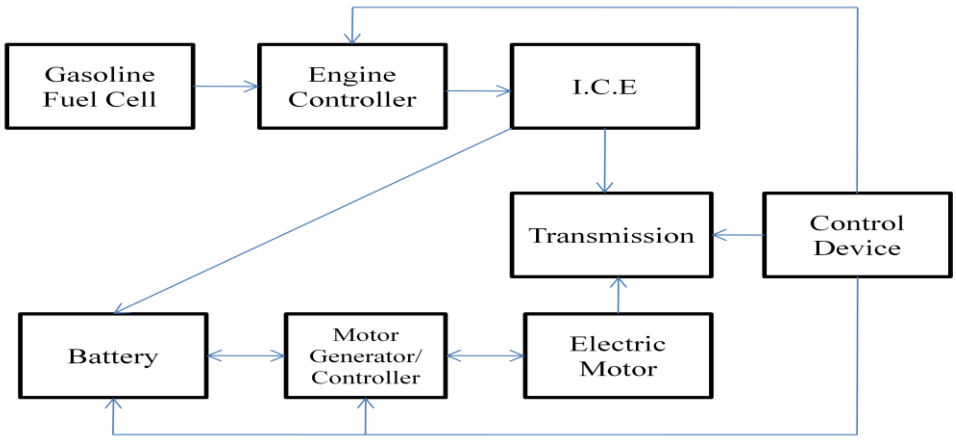

Figure 3: Working of Parallel Hybrid Electric Vehicle

Disadvantages of Parallel Hybrid Electric Vehicles

1. It has a complex design.
2. I.C.E is not decoupled with the wheels; so it cannot be charged at standstill.
3. It doesn't operate in a narrow range of RPM and so the efficiency is low at low rotation speed.

Advantages of Parallel Hybrid Electric Vehicles

1. Overall efficiency is high over long distances. It can easily switch between I.C.E and electric power.
2. Only one motor or generator is required and so it can be designed for a less powerful I.C.E vehicle as it is assisting traction.

2.1.3. Series-Parallel

When the vehicle is can be operated in the series mode and the parallel mode depending on the situation, it is a series-parallel hybrid. Examples: Toyota Prius, Ford, Nissan, Lexus etc. [7]

2.2. Battery Electric Vehicles

An Electric car is a plug-in battery powered automobile which is run by electric motors. These cars usually use DC motors wound in series. Recent advances have used a variety of AC motors as they cannot wear out easily.The power supply to the motor is controlled by the motor controller. Depending on the motor type, it supplies either AC or DC power.

Table 1: Fuel use in vehicle design[5]

Vehicle Type	Fuel Used
All-Petroleum Vehicle	Petroleum
Hybrid Electric Vehicle	Less use of petroleum (cannot be plugged in)
Plug-In Vehicle	Less use of petroleum, more of electricity
All-Electric Vehicle	Maximum use of electricity

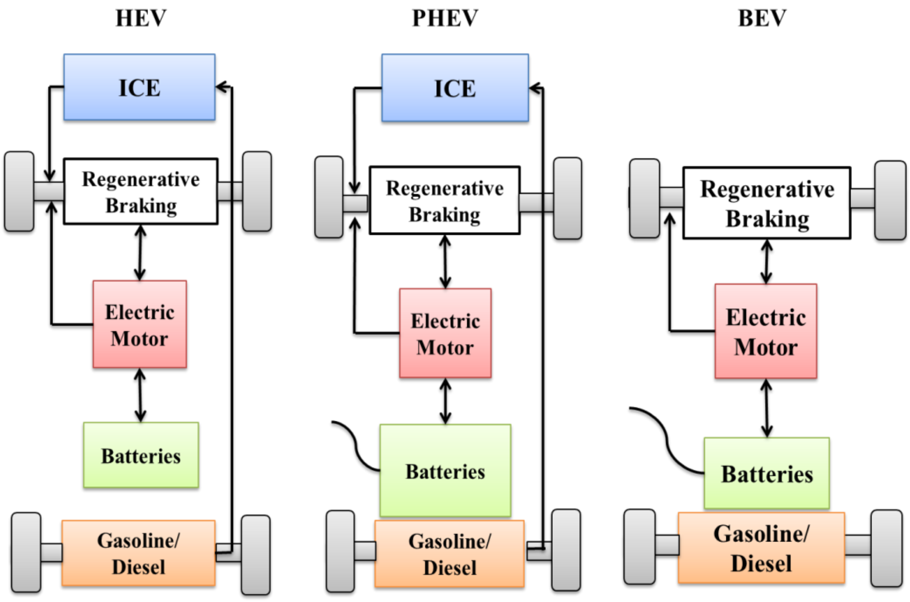

Figure 4: Comparison between HEV, PHEV, BEV

Types by Degree of Hybridization [5]

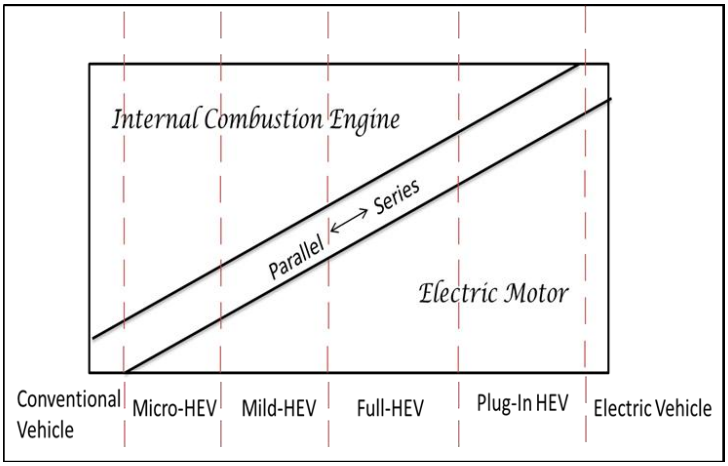

Figure 5: Properties of I.C.E and Electric Motor

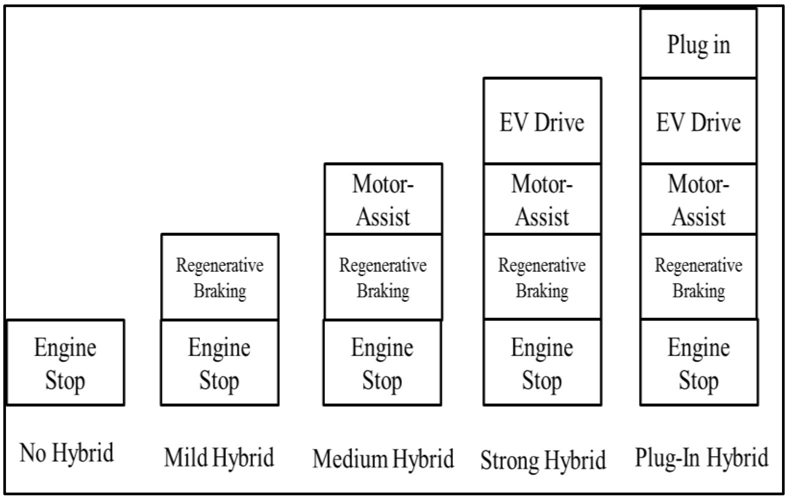

Figure 6: Overview of Hybrid-power train concepts

3. ADVANTAGES OF PEVs

3.1. Reduction in Air Pollution and Greenhouse Gas Emissions

The exhaust gas from conventional gasoline/diesel vehicles consists of carbon dioxide, carbon monoxide, nitrogen oxides, particulate matter, etc. The release of these gases into the atmosphere results in global warming, acid rain, carbon monoxide poisoning and smog among other detrimental effects to the environment.

Gasoline and diesel are both obtained from fossil fuels for which the resources are depleting at an alarming rate. While drawing power from the battery, the automobile releases no pollutant and is hence environmentally friendly. PHEVs thus, are a great step forward in improving the quality of air around us and reducing our dependency on the meager resources of fossil fuels.

3.2. Mileage and Overall efficiency

Gasoline/diesel based vehicles are most efficient on highways whereas their efficiency is very low in the city where traffic is high. Since a PHEV is a hybrid of both-fuel based vehicles and battery operated electrical vehicles, the efficiency does not drop down. In regions of high traffic, the automobile utilizes energy from the pre-charged battery and in regions of low traffic or on the highway, the car is driven by the internal combustion engine using the fuel since in cases of long drives, the charge in the battery will get extinguished.

I.C.E has a very low efficiency because the majority of the energy generated from the fuel is lost as heat while the engine is idling. On the other hand, PHEVs convert stored energy to drive a vehicle much more efficiently. Efficiency of vehicles using gasoline does not go beyond 15% and for diesel based engines; the maximum efficiency achievable is around 20%, whereas for PHEVs efficiencies around 80% are observed.

3.3. Mechanical Advantages of PHEVs

- The maintenance cost for an I.C.E is much greater than the maintenance cost for a PHEV because mechanical systems break down much more often as compared to electrical and electronic systems.
- The amount of driving between consecutive recharges determines the claimed fuel economy for plug-in hybrid electric vehicles.
- PHEVs reduce the overall operating costs due to electric power being much cheaper than the ever depleting fuel resources.

- To stabilize CO emissions using efficient vehicles, "Pacala and Socolow wedges" approach is used for which PHEVs can be used as an element.
- PHEVs have the potential to balance the load or reduce the load on the grid during peak loads.
- They can send power back to the grid by the use of the excess battery capacity and then recharge during off peak loads.
- No need to change the oil and other routine maintenances are also avoided.

4. DISADVANTAGES OF PHEVs

4.1. Cost- Batteries and Ownership

The cost of Plug-In Vehicles is more than that of the conventional Internal Combustion Engine because of the additional cost of the lithium-ion battery pack. According to a survey done in 2012, the cost of a lithium ion battery is USD 1,700/kWh and knowing that an average PEV-10 requires 2.0kWh which is considerably high. There is also a decrease in the mileage over long distances because the I.C.E does all the work whilst carrying unwanted weight. [8][9][10]

Cost reductions can be made feasible by advances in the battery technology thus increasing the production of PEVs and help it compete with the Internal Combustion Engine Vehicles.

Another study published in 2011 revealed that the gasoline cost savings in PEVs did not increase the purchase of PEVs due to short run time. [11][12]

4.2. Availability of Recharging Facilities

The ecofriendly aspect of PEVs is based on the assumption that recharging facilities will be easily available in all places such as streets, parking structures, commercial setups etc. Without the infrastructure, PEVs will not attract majority of the crowd due to range anxiety. However, a huge investment from both private and public sectors will be required for a project of this magnitude.

Battery Swapping: Is a solution deployed by 'Better Place' for recharging of batteries. In this, customers are sold the car without the battery. Since they aren't allowed to buy batteries separately, these are rented to them by better place that has set up various charging sectors that allows people to travel by PEVs over long distances. [13][14]

4.3. Risks of Battery fire

Thermal runaway and cell rupture is a common occurrence in lithium-ion batteries due to overcharging or over heating which in some cases can also lead to combustion.This is similar to phones exploding.In case of a collision there are worries of potential dangers. Manycompanies stopped production of PEVs due to many cases of battery fires and accidents.

In 2014, The U.S. National Highway Traffic Safety Administration (NHTSA) conducted a study to establish if lithium-ion batteries in PEVs posed a potential fire hazard. The research established whether high-voltage batteries caused fires when they were being charged and when the vehicles were involved in an accident. [15]

4.4. Potential overload of the electrical grid

The electrical grids present as of now do not have the capacity to cater to the additional power load that will arise due to recharging of PEVs. Also there is a significant increase in the power losses. The charging of a PEV consumes three times the electricity consumed by a home. Therefore overloading problems may arise. To counter this problem, there is a dire need to modify the existing electrical grids.[16] Currently, General Motors is carrying out the Pecan Street demonstration project in Texas. The main objective is to review the charging patterns and how a fleet of residential PEVs might strain the local grid.[17]

4.5. Risks associated with noise reduction

Electric vehicles run at lower speeds and consequently produce lesser road noise as compared to the regular I.C.E vehicles. However this noise serves as an aid to the visually impaired in crossing roads. Although many studies [18] have recently proved that such incidents are purely coincidental and bear little relation to the noise produced by the PEVs, some companies such as Chevrolet and Nissan have addressed this concern and launched PEVs with an electric warning sound.

In 2013, a rule was published by the National Highway Traffic Safety Administration (NHTSA) that requires hybrids and electric vehicles traveling at less than 30 km/h to give warning sounds that pedestrians must be able to hear. [19][20]

5. ASSESSMENT OF IMPACT OF PEVs ON DISTRIBUTION NETWORKS [21]

From the point of view of the distribution system operator, the additional power loss is of huge economic concern. Also the voltage deviations are a concern for power quality. It's better for the PHEVs to be charged at night to avoid generator startups which lead to a decrease in the efficiency. This allows for intelligent or smart charging. The research/experiment conducted focuses on an urban area with more than 6000 low-voltage

ISSN: 2278-6252
Impact Factor: 7.358

customers and an industrial area with more than 61,000 customers.This model is also called the Reference Network Model. [22 – 26]

A large-scale distribution network planning model has been used for the calculation of the required network investment with different future levels of PEV penetration.Two large scale distribution areas have been analyzed. Three scenarios of 35%, 51% and 62% PEVs penetration have been considered. [27]The two base distribution networks chosen are as shown in Fig 7& 8.

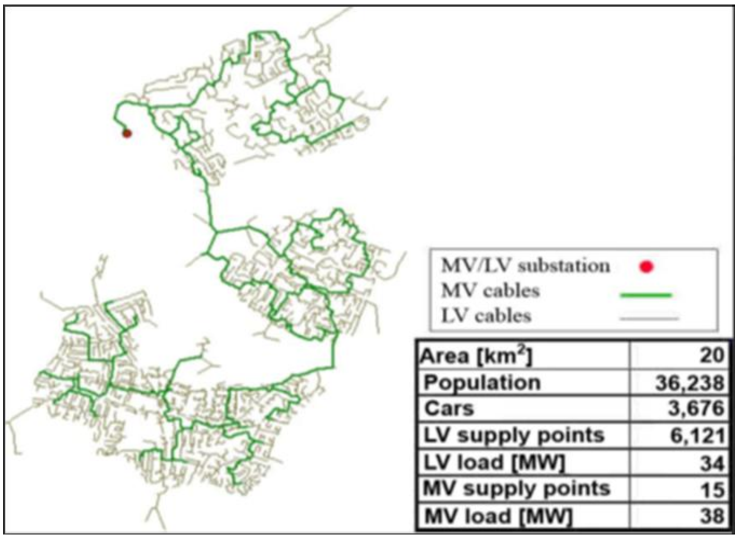

Figure 7: Distribution network in area A

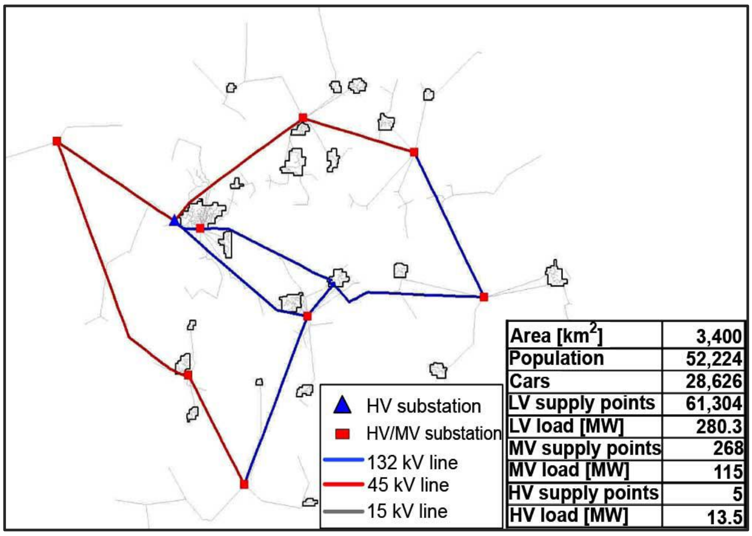

Figure 8: Distribution network in area B

This experiment calculated the peak load of charging via the 'simultaneity factor'. A simultaneity factor of 1 means all the PEVs are charging at the same time. If it is less than 1, then intelligent or smart charging strategies are implemented. The experiment considered various permutation and combination of the above conditions to get various results on the required and incremental investment, energy losses etc.

The following inferences have been made from the results of the experiment:

- If Smart charging strategies are implemented, then 60-70% of the required incremental investment can be avoided. But there is a limit up to which this is satisfied.(see Figure 9)
- The energy losses can increase up to 40% of the actual value in the off-peak hours if all the PEVs are in charging mode. Energy losses increase with an increase in the penetration level.[28](See Figure 10)
- If there are some strategies that devise that some PEVs are charged at off-peak hours instead of peak hours it will lead to saving of up to 5% - 35% of the required investment can be avoided. However there are some limitations such as the population density, power load etc. after which the investment increases.

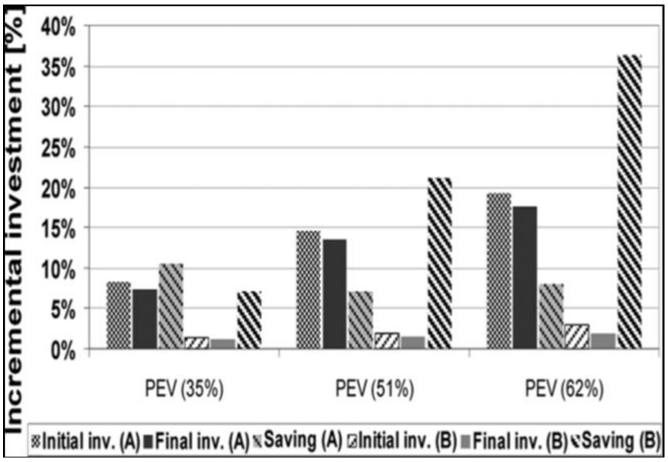

Figure 9: Savings obtained by moving battery charging from peak to off-peak

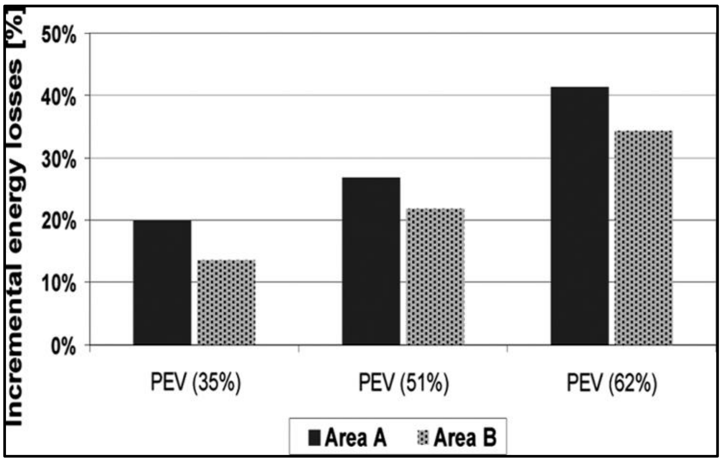

Figure 10: Incremental energy losses in off-peak hours

Future research will focus on the design and implementation of smart charging by avoiding the simultaneity of charging time.

6. ECONOMICS OF PHEV'S

The cost benefit analysis of Plug In hybrid electric vehicles includes a comparison between the lifetime of the vehicle and the ownership cost. Here the cost of ownership includes the cost of consumption of energy as well as the retail cost, but excludes the differences in cost of maintenance. A high cost of 5 USD per gallon of gasoline is assumed for the near term scenario. The cost of consumption of electricity is assumed to be 0.09 USD per Kilowatt-hour. [29]

7. GOVERNMENT INCENTIVES

Since reduction of pollution is the need of the hour, several public and private sectors have invested in this particular field of interest. Grants, tax credits, financial and non-financial incentives have been promoted in order to push consumers to buy PEVs.

Countries all over the world have come together to make this initiative successful.

7.1. Asia

7.1.1. China

In June 2010, the Republic of China started a program to give up to USD 8,785 for private purchase of BEVs and USD 7,320 for PEVs in five different cities.[30][31]

7.1.2. Japan

In 2009, the Japanese Diet started the "Green Vehicle Purchasing Promotion Measure". It allows for tax deductions and exemptions for eco-friendly and fuel efficient vehicles. It provides subsidies for purchasing a new passenger car. [32]

7.2. Europe

In April 2010, most of the European Union(EU) member states provide tax, exemptions, and bonus payments for buyers and subsidy incentives for PEVs. Both the private and business fleet buyers are eligible for the government grant. [33][34]

7.3. *North America*

7.3.1. *United States*

The American Clean Energy and Security Act of 2009 and the Energy Improvement and Extension Act of 2008 in the United States of America granted tax credits for new qualified PEVs [35]. Federal tax credits for converted PEVs were permitted by the American Recovery and Reinvestment Act of 2009. This tax credit for new PEVs is worth USD 2,500plus an extra

ISSN: 2278-6252
Impact Factor: 7.358

USD417 per kWh of battery capacity over 5 kWh. The maximum credit allowed for new PEVs is USD 7,500. Several incentives, tax exemptions and other non-monetary incentives have been established by multiple states for BEVs and PHEVs. [36]

A goal of having 1 million PEVs on the road by 2015 was set by Barack Obama but owing to the slow rate of PEV sales in mid-2012, this goal was underachieved by a very large margin. Another goal was set in September 2014 by the Governor of California in the Charge Ahead California Initiative bill of placing over 1 million vehicles emitting zero and near zero pollutants on the road in California by 2022. [37]

7.3.2. Canada

For the purchase or lease of PEVs after July 1, 2010, a rebate of USD 4,900 to USD 8,320(varying according the size of the battery) was established by Ontario to the first ten thousand applicants who qualified.[38]

Quebec offered rebates of up to USD 8,485 for new PEVs equipped with a 4kWh battery and PHEVs are permissible for a USD 1000 rebate. BEVs with high-capacity batteries are offered rebates of USD 7,985. PEVs and low range BEVs are also given some reduced incentives. [39]

8. FUTURE MARKET TRENDS

There are two types of scenarios that can be used to predict the future trends:

- Near term scenario
- Long term scenario

8.1. Near term scenario

Here the hybrid electric vehicles will cost lesser than a conventional vehicle after approximately 10 years. But plug in hybrid electric vehicles will never be cheaper than a conventional vehicle or an HEV over the 15 year lifetime of the vehicle. The cost considered here includes the retail cost of the vehicle and the cost of the energy consumed only. [40]

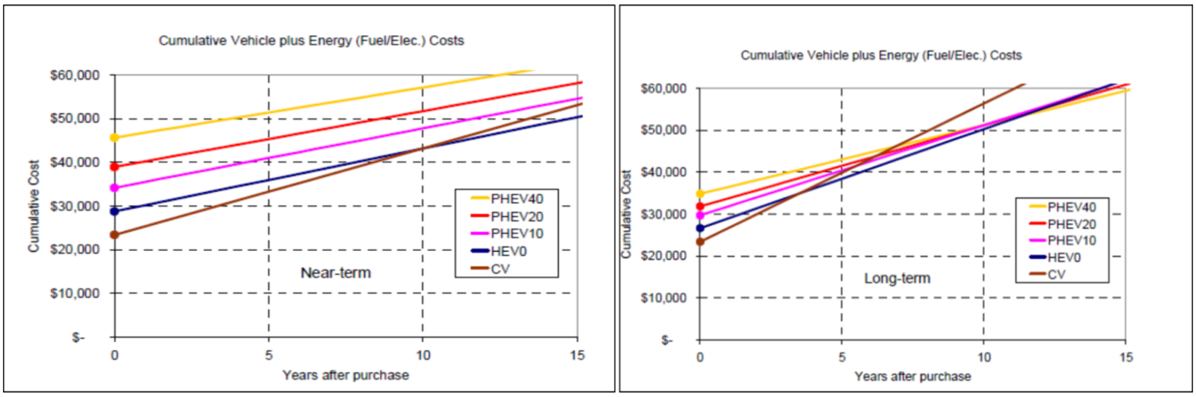

Figure 11: Economic comparison of PHEVs in the near-term and long-term scenarios

8.2. Long term scenario

This scenario shows a major change with the hybrid electric vehicle being cheaper than the conventional vehicles in approximately 4 years and the PHEVs becoming cheaper than the hybrid electric vehicles in around 12 years. [40]

From this analysis it is evident that the gasoline and vehicle retail cost is strongly affected by the assumptions taken into consideration for the cost of the battery in each scenario. Another observation made from this comparison is that if the cost of the battery is not reduced and if gas prices remain the same, then it is clear that the economics of Plug in Hybrid Electric vehicles are not promising.

Despite these uncertainties PHEVs may be cheaper due to tax incentives, air pollution, greenhouse emissions, national energy security, reduced maintenance; fewer fill-ups at the gas station; convenience of home recharging; improved acceleration from high-torque electric motors; opportunities to provide emergency backup power in the home; and vehicle-to- grid applications. Alternative business models—such as battery leasing—also deserve further consideration since they might help to mitigate the daunting incremental vehicle cost and encourage Plug in Hybrid Electric Vehicle enthusiasts to focus on the potential for long-term cost savings.

9. CHARGING OF PEVS BY RENEWABLE RESOURCES [41]

The solution to the depleting resources of energy is the integrated use of renewable energy resources along with PEVs and PHEVs. Considering the significant and fluctuating cost of conventional fuels, a potential for Plug-in Electric Vehicles was observed by the U.S. Electric Power Research Institute[42]. However, the load on the power grid increases by the use of Plug-in electric vehicles. Hence, more power generating plants need to be installed to supply the peak load which will become very expensive. This will also require complete modification of the existing gasoline stations as well as the current electricity infrastructure. The problem of emission cannot be solved solely by PEVs and Plug-in hybrid electric vehicles since they need electricity which itself is a major source of emissions. This is why the success of PHEVs depends significantly on the utilization of renewable energy resources. Renewable Energy Sources (RESs) are a time varying resource and a dynamic approach is required to optimize their effects on the on the electrical and transportation industry in terms of the cost and the emissions generated.

The effects of PEVs and PHEVs on the electricity and transportation industries are optimized using two models-

- **Load-Leveling Model**: A random system is not feasible because the charging-discharging process cannot be optimized due to the randomness and the peak load is 50% more in the worst possible case. Thus, another possible solution is load-leveling. Load-leveling optimization is used to charge the electric vehicles through conventional generation. Estimating that a vehicle covers an average distance of 32 miles a day, requiring 0.25kWh/mile. Thus, 1 EV will require 8kWh/day. Assuming an average of 50,000 electric vehicles to be operating simultaneously at the peak load; 400 MWh/day of extra electrical energy will be required. To counter this problem, this extra required energy is leveled and equally distributed over the off-peak hours to reduce the peak load.
- **Smart-Grid Model**: Here, EVs are charged from RESs and discharged back to the grid acting as a source of electricity. In this model the following are observed:

i. RESs reduce emission from the electrical power plant.

ii. EVs are used smartly as a load, small portable power plants and energy storages.

iii. Parking lots can be utilized as virtual power plants.

iv. A bio-inspired algorithm is used to minimize both, emissions and costs. This method is based on the behavior of birds and fishes. This algorithm is called Particle Swarm Optimization. Every potential solution (particle), flies with a velocity, dynamically adjusting it according to its own and other particles' flying experience in a multidimensional search space. The search space dimension, here, is reduced by binary and integer Particle Swarm Optimization.

Using these features, a smart schedule is generated for proper decision making, control and operations for maximum utilization of RESs efficiently to reduce emissions and the cost electric power.

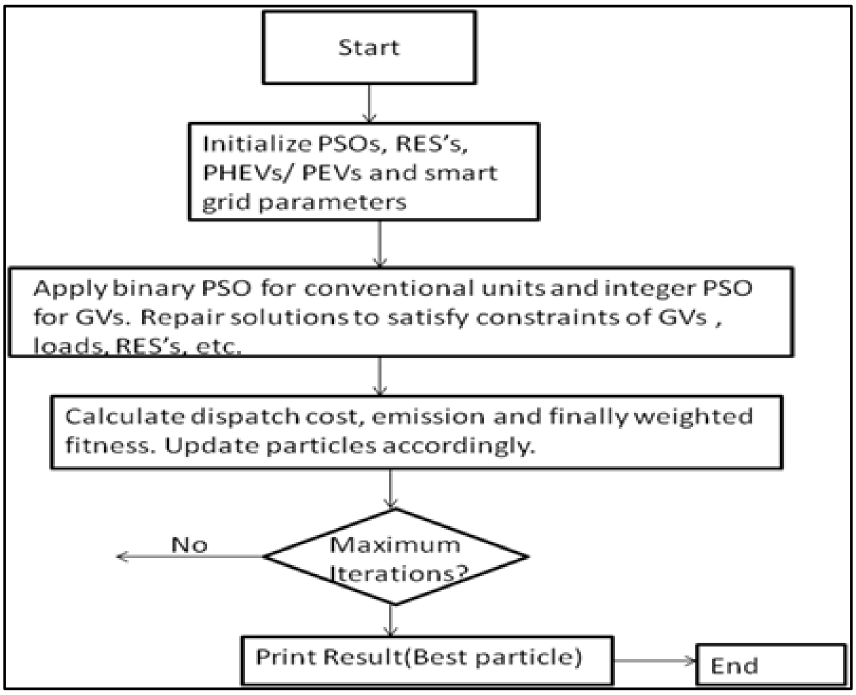

Figure 12: Flowchart for minimization of cost and emission using GVs and RESs

The disadvantage of the smart grid model for the optimized use of RESs is the high capital investment required for the establishment of RESs.This capital cost depends on the solar insulation and wind speed profile.

10. CONCLUSION

The advantages, disadvantages, economics, working, market trends, government incentives and the impact of PEVs to our future have been reviewed in this paper. A PHEV is preferred over a BEV due to its ability to function over large distances. PEVs are going to play a major role in the reduction of emissions and in improving the air quality. The cost of the battery, noise pollution and the overloading of the electrical grid are the issues that hamper the extensive use of PEVs in the present day scenario.

The impact of PEVs on the distribution networks is the most important problem that needs to be addressed for PEVs to replace conventional vehicles globally. Use of renewable resources such as solar and wind energy reduces the emissions from electrical power plants. Smart-grids and load-leveling are some solutions that can be used to optimize the effect of PEVs. Further research must be done in the future to make the use of PEVs globally sustainable.

REFERENCES

[1] Kliesch, J. and Langer, T. "Plug-In Hybrids: an Environmental and Economic Performance Outlook" American Council for an Energy-Efficient Economy, Sep. 2006

[2] Thomas H. Bradley, Andrew A. Frank, Design, demonstrations and sustainability impact assessments for plug-in hybrid electric vehicles, Renewable and Sustainable Energy ReviewsVolume 13, Issue 1, January 2009, Pages 115–128.

[3] Smets, Stefan, Overview of Battery Technology for HEV. (IA-HEV Annex VII – Hybrid vehicles.)Global Powertrain Congress, Novi, Michigan, USA. September 19–21, 2006.

[4] Schwoerer, Martin (2010). "REX Means Range". EV World. Retrieved2014-10-11.

[5] Hybrid Electric Vehicles, http://www.ae.pwr.wroc.pl/filez/20110606092353_HEV .pdf

[6] BC Climate Exchange (2005) "Hybrid Basics" Hybrid Experience Report. Retrieved June 19, 2007.

[7] "Toyota Prius Plug-in Hybrid Review", HybridCars.com. Retrieved 2012-03-18.

[8] National Research Council (2010). "Transitions to Alternative Transportation Technologies--Plug-in Hybrid Electric Vehicles", The National Academies Press. Retrieved 2010-03-03.

[9] Jad Mouawad, Kate Galbraith (2009-12-14). "Study Says Big Impact of the Plug-In Hybrid Will Be Decades Away". New York Times, Retrieved2010-03-04.

[10] National Research Council (2009-12-14). "Plug-In Hybrid Vehicle Costs Likely to Remain High, Benefits Modest for Decades". National Academy of Sciences,Retrieved 2010-03-04.

[11] Henry Lee, Grant Lovellette (July 2011). "Will Electric Cars Transform the U.S. Vehicle Market?"Belfer Center for Science and International Affairs, Kennedy School of Government, Retrieved 2011-08-07.

[12] Henry Lee Grant Lovellette (July 2011). "WillElectricCars Transform the U.S. Vehicle Market?" (PDF)Belfer Center for Science and International Affairs, Kennedy School of Government, Retrieved 2011-08-07, Discussion Paper #2011-08.

[13] "Renault-Nissan and Project Better Place Sign MoU for Mass Marketed EVs in Israel; Implementing New Ownership Model", Green Car Congress. 2008-01-28. Retrieved 2010-05-16.

[14] Shai Agassi, David Pogue, Gavin Newsom (2009-03-19). Making The World A 'Better Place' (YouTube). San Francisco, CA: CBS News Sunday Morning; CBS Interactive, Inc. Event occurs at 3:45, Shai Agassi: "We [Better Place] don't let you [the customer] buy a battery; we [Better Place] buy the battery.

[15] Neil Roland (2012-08-09). "Feds Researching Fire Risks from EV Batteries".MSNAutos.Retrieved 2013-06-23.

[16] Todd Woody and Clifford Krauss (2010-02-14). "Cities Prepare for Life With the Electric Car". New York Times,Retrieved 2010-03-07.

[17] David Biello (2013-06-18). "Will You or the Grid Control Your Electric Car?",Scientific America, Retrieved 2013-06-23.

[18] M. Muirhead and L K Walter (2013-03-01). "Analysis of STATS19 data to examine the relationship between the rate of vehicle accidents involving pedestrians and type approval noise levels" (PDF). Transport Research Laboratory, Retrieved2013-03-17. Client Project Report CPR1131

[19] David Shepardson (2013-03-18). "Automakers concerned NHTSA's 'quiet cars' rule too loud". The Detroit News,Retrieved 2013-03-22.

[20] "Proposal for Noisier Electric Cars at Low Speed", Times. Associated2013-01-07 Retrieved 2013-01-08.

[21] Luis PieltainFernández, Tomás Gómez San Román, Rafael Cossent, Carlos Mateo Domingo, Pablo Frías, Assessment of the Impact of Plug-in Electric Vehicles on Distribution Networks, IEEE TRANSACTIONS ON POWER SYSTEMS, VOL. 26, NO. 1, FEBRUARY 2011

[22] J. Román, T. Gómez, A. Muñoz, and J. Peco, “Regulation of distribution network business,” IEEE Trans. Power Del., vol. 14, no. 2, pp. 662–669, Apr. 1999.

[23] J. Peco and T. Gómez, “A model for planning large scaleMV networks considering uncertainty in reliability modeling,” in Proc. 6th Int. Conference Probabilistic Methods Applied to Power Systems, Madeira, Portugal, Sep. 25–28, 2000.

[24] V. Levi, G. Strbac, and R. Allan, “Assessment of performance-driven investment strategies of distribution systems using reference networks,” presented at the IEE Proc. Generation, Transmission and Distribution, 2005.

[25] C. J. Wallnerström, L. Bertling, “Investigation of the robustness of the Swedish network performance assessment model,” IEEE Trans.Power Syst., vol. 23, no. 2, pp. 773–780, May 2008.

[20] A. Navarro and H. Rudnick, “Large-scale distribution planning—part simultaneous network and transformer optimization,” IEEE Trans.Power Syst., vol. 24, no. 2, pp. 744–751, May 2009.

[26] R. Cossent, T. Gómez, L. Olmos, C. Mateo, P. Frías, “Assessing the impact of distributed generation on distribution network costs,” in Proc. 6th Int. Conf. European Energy Market, Leuven, Belgium, 2009, pp. 586–593.

[27] Environmental Assessment of Plug-in Hybrid Electric Vehicles, Nationwide Greenhouse Gas Emissions, 1015325, Fin. Rep., EPRI and NRDC, 2007, vol. 1, pp. 1–56.

[28] L. PieltainFernández, “Impact of plug-in hybrid electric vehicles (PHEVs) on power systems,” M.Sc. thesis, Univ. PontificiaComillas, Madrid, Spain, 2009

[29] A. Simpson, Cost-Benefit Analysis of Plug-In Hybrid Electric Vehicle Technology, Presented at the 22nd International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exhibition (EVS-22) Yokohama, Japan October 23–28, 2006.

[30] "China Announces Plan to Subsidize EVs and Plug-in Hybrids in Five Major Cities". Edmunds.com. 2010-06-01. Retrieved 2010-06-14.

[31] Jim (2010-06-02). "China to Start Pilot Program, Providing Subsidies for Electric Cars and Hybrids".New York Times, Retrieved 2010-06-02.

[32] "Fact Sheet - Japanese Government Incentives for the Purchase of Environmentally Friendly Vehicles" (PDF). Japan Automobile Manufacturers Association. Retrieved 2010-12-24.

[33] "Growing Number of EU Countries Levying CO2 Taxes on Cars and Incentivizing Plug-ins". Green Car Congress. 2010-04-21. Retrieved 2010-04-23.

[34] Paul Hudson (2010-02-28). "£5,000 grant to buy plug-in electric cars". London: The Daily Telegraph. Retrieved 2010-04-23.

[35] "Notice 2009-89: New Qualified Plug-in Electric Drive Motor Vehicle Credit". Internal Revenue Service. 2009-11-30. Retrieved 2010-04-01.

[36] "Consumer Energy Tax Incentives: Plug-In Hybrid Conversion Kits". U.S. Department of Energy,Retrieved 2010-04-01.

[37] Jerry Mitlitski (2011-02-18). "Raising the Volt-Age: Is Obama's Goal of 1 Million Electric Vehicles on U.S. Highways by 2015 Realistic?", Scientific American, Retrieved 2012-05-11.

[38] "Ontario Paves The Way For Electric Vehicles". Newsroom Ontario. 2010-06-18. Retrieved 2010-06-21.

[39] Eric Loveday (2011-04-11). "Quebec to offer plug-in vehicle rebates of up to C$8,000", AutoblogGreen, Retrieved 2011-06-08.

[40] U.S. Energy Information Administration online, www.eia.doe.gov

[41] Ahmed Yousuf Saber, Ganesh Kumar Venayagamoorthy, "Plug-in Vehicles and Renewable Energy Sources for Cost and Emission Reductions", IEEE TRANSACTIONS ON INDUSTRIAL ELECTRONICS, VOL. 58, NO. 4, APRIL 2011 1229

[42] Elect. Power Res. Inst. (EPRI), Palo Alto, CA, 1006891 Comparing the Benefits and Impacts of Hybrid Electric Vehicle Options for Compact Sedan and Sport Utility Vehicles2002.