PLUG-IN HYBRID ELECTRIC VEHICLES AS A DEMAND DISPATCH OPTION IN A SMART GRID

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I would like to dedicate this thesis to my parents

for their endless love and guidance which always helps me

to choose the right path

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ABSTRACT

The increasing integration of Plug-in Hybrid Electric Vehicles (PHEVs) poses unique challenges for voltage and frequency regulation in electric distribution grids. PHEVs (Plug-in Hybrid Electric Vehicle) are at present the most reliable substitutes for normal fuel autos. The mobility and variability due to PHEV loads exacerbates the problem of voltage regulation in distribution grids that are characterized by high R/X ratios. Numerous studies have explored the impact of PHEV integration on distribution grids. This thesis examines the effect of different operations and impact of PHEV on the system having voltage sensitivity analysis and choosing an appropriate time of charging and discharging cycles. IEEE-34 node test feeder is used to charge the PHEV as required and discharge it when needed. Coding was done on the latest distributed system simulator for obtaining salient results to fulfil the goals. To inspect the proposed approach and evaluate its effectiveness and the performance of PHEVs, IEEE-34 Nodes Test Feeder network is used. The adopted platform to perform the desired methodology is Open Distribution System Simulator (DSS). The simulated results are emphasizing of voltage profile on most sensitive bus.

ABSTRAK

Peningkatan gabungan Plug-in Kenderaan Hybrid Elektrik (PHEVs) mempunyai cabaran-cabaran untuk regulasi voltan dan frekuensi di grid pengagihan elektrik. Mudah bergerak dan kepelbagaian oleh beban-beban PHEV memburukkan lagi masalah regulasi voltan di grid pengagihan yang dikategorikan oleh nisbah R/X yang tinggi. Banyak kajian telah meneroka kesan gabungan PHEV pada grid pengagihan. Tesis ini menilai kesan operasi yang berlainan dan kesan PHEV pada system yang mempunyai analisis kepekaan voltan dan memilih masa mengecaj dan pusingan-pusingan mengenyahcaj yang betul. Apabila bertambah PHEV di dalam system, ia menjadi beban tambahan kepada grid. 'Time Sequence Analysis' berfungsi sebagai bahagian yang aktif untuk menggunakan PHEV sebagai penghantaran yang bijak beban. Untuk memeriksa pendekatan yang di cadangkan dan menilai keberkesanan dan prestasi PHEV, rangkaian IEEE-34 nod feeder ujian digunakan. Open Distribution System Simulator (DSS) digunakan untuk melaksanakan metodologi yang dimahukan. Keputusan simulasi menekankan profil voltan pada bus yang paling sensitif.

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LIST OF SYMBOLS AND ABBREVIATIONS

PHEV	-	Plug-in-Hybrid Electric Vehicle
EV	-	Electric Vehicle
ICE	-	Internal Combustion Engine
BEV	-	Battery Electric Vehicle
HEV	-	Hybrid Electric Vehicle
V2G	-	Vehicle to Grid
EPRI	-	Electric Power Research Institute
IEEE	-	Institute of Electrical and Electronics Engineers
AER	-	All-Electric Range
SOC	-	State of Charge
CD	-	Charge Depleting
CS	-	Charge Sustaining
EST	-	Energy Storage Technology
DFIG	-	Double Fed Induction Generator
Li-ion	-	Lithium Ion
NiCd	-	Nickel Cadmium
LDC	-	Load Duration Curve
DR	-	Distributed Resource
UPS	-	Uninterruptable Power Supply
PHES	-	Pumped Hydro Energy Storage
NHTS	-	National household Travel Survey
GW	-	Giga Watt

PCLP	-	PHEV Charging Load Profile
PNNL	-	Pacific Northwest National Laboratory
DOD	-	Depth of Discharge
ORNL	-	Oak Ridge National Laboratory
NRDC	-	Natural Resources Defense Council

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CHAPTER 1

INTRODUCTION

1.1. Background

The perpetually climbing interest of gas and expanding rate of vehicles being added to the business sector are positively a well-known risk to nature's domain. Once in a while, inventive plans have been embraced to decelerate the over use of fuel and to lessen the contamination risk to the earth. However the execution and comfort of fuel worked vehicles is yet to be matched. A noteworthy and evolutionary engineering created and acknowledged in this bearing is the presentation of Electric Vehicles. Electric vehicles as the name proposes are determined by electric force advancing from battery packs charged from an outer force source Electric vehicles don't have an ICE (Internal Combustion Engine) or a fuel tank. Module Hybrid Electric Vehicles are a venture forward from the electric vehicles. PHEVs (Plug-in Hybrid Electric Vehicle) are at present the most reliable substitutes for normal fuel autos. They are a hybrid of customary ICE vehicle and Electric vehicle [1],[2].

What makes PHEV an exceptional substitute, is that it imparts attributes of both sorts of vehicles. Like an electric vehicle it is free from the reliance on the fluctuating cost of gas and has essentially low emanation of nursery gasses.

As per IEEE; A plug-in hybrid electric vehicle is defined as any hybrid electric vehicle which contains at least: (i) a battery stockpiling arrangement of 4 kwh or more, used to power the movement of the vehicle; (ii) a method for energizing that battery framework from an outer wellspring of power; and (iii) and capability to drive no less than 10 miles (16.1km) on the whole electric mode devouring no gas [3].

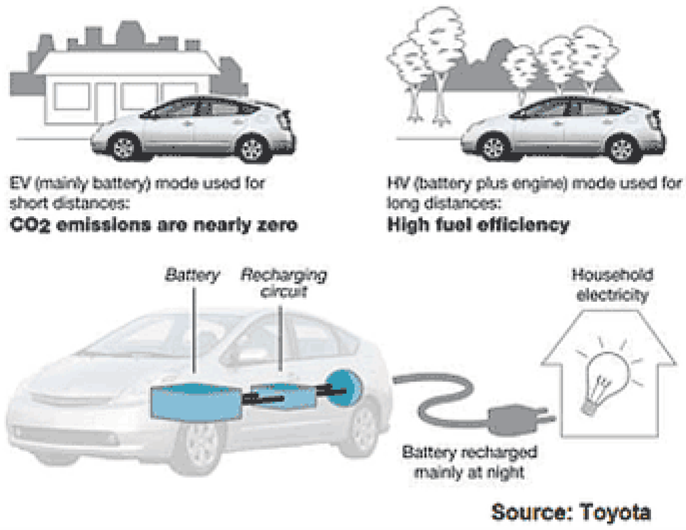

Figure 1.1 General overview of PHEV charging and benefits

1.2 Problem Statement

Rapid research in electric power grid is responsible for transforming the trend into Smart Grid, which promise for the featuring of flexible, reliable and economic power to consumers. Distributed generation (DG) provides alternative option for depleting fossil fuels that may provide significant preference for the problems of grid like reduction in power or load leveling etc.

Plug-in hybrid electric vehicles are to be charged at home from a standard outlet or on a corporate car park. These extra electrical loads have an impact on the grid which is analyzed in terms of power losses and voltage deviations. Ignoring this problem will lead to undesirable peaks in the electrical consumption. In order to combat this, Demand Dispatch allows “load to follow the generation” enabling control of both supply and demand. Time sequence analysis is playing an active part, and permitting to take care of undesirable peaks. This project work aims to provide the flexibility for PHEV as a dual source.

1.3 Objective

The objectives of this research are given as follows:

i. Model PHEV as a dual source of energy that can act as a load and generator.

ii. Simulate charging and discharging of PHEV; the hourly operation of the system on a particular daily load profile and monitoring the voltage profile.

iii. Integrate PHEV to the grid and analyzing the different combination having lumped and distributed cases.

1.4 Scope of Work

Scope of the work is bound by the following:

i. For the fulfilment of the proposed objective, PHEV can be connected to the power grid. The power flow of this connection can be bidirectional, so vehicle can charge and discharge.

ii. The adopted channel to analyze the performance of the system is open Distribution System Simulator (DSS) by Electric Power Research Institute (EPRI). Open DSS is capable of supporting distributed resource integration and grid modernization efforts.

iii. The case is applied to the IEEE 34 nodes test feeder with voltage sensitivity analysis.

1.5 Methodology

Smart grid technology is the key for an efficient use of distributed energy resources. The operation of PHEV in a distribution system will be a challenging Demand Dispatch problem from the utilities perspectives. PHEV popularization could bring benefits to power systems and an excellent resource of demand dispatch, like load leveling; increasing generation capacity to the grid during peak load periods. Different journal papers cited for absorbing the updated knowledge to justify the title of this research.

A model for the PHEV is developed; which takes into accord its built-in characteristics of charging and discharging cycles. Time sequence analysis employed to reflect the changing modes of PHEV operation during various hours of the day. Time is allocated for charging when there will be fewer burdens on the power grid. Likewise, discharge for load leveling while peak load periods, for this; load shape has been considered. The developed PHEV model was integrated into a power grid model. IEEE-34 node test feeder is used for this purpose to charge the PHEV as required and discharge it when needed. Coding was done on the latest distributed system simulator for obtaining salient results to fulfil the goals. Lastly, collecting different results to satisfy the objectives, discussion and observation are presented to conclude the project.

1.6 Thesis Outline

The provided thesis is actually consisting of five chapter, these chapters contain full explanation to justify the comprehensive meaning of the thesis title. From the beginning chapter 1 explains about the project background, problem statement, objectives to achieve, scope of the work and methodologies of the project. Chapter 2 provides an extensive study on the PHEV characteristics and properties. This chapter contains comparison between charging and discharging and their consequences. Chapter 3 emphasizes on the research methodology that is used in Open DSS, adopted to fulfil the objectives. Chapter 4 contains the results extracted from the simulation work and discusses the furnished results. Chapter 5 presents the conclusions and the future work recommended based on the adopted methodology.

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