GSGF>>REPORT

GRID_USER_INTERACTIONS_AND_INTERFACES

JUN_2014

TABLE OF CONTENTS

1 The current situation of EV/PHEV diffusion 1

1.1 Status of vehicle and infrastructure deployment 1
1.1.1 Vehicle deployment 1
1.1.2 Infrastructure deployment 4
1.2 Incentives and regulations 6
1.2.1 Financial incentives 6
1.2.2 Non-financial incentives 7
1.2.3 Regulation 7
1.2.4 R&D 8

2 Issues of EV/PHEV diffusion 9

2.1 Needs for sustainable incentives to diffuse EV/PHEV 9
2.1.1 Case study of Norway and the Netherlands 9
2.1.2 Case study of New Zealand and Argentina – Sustainability is needed for incentives 12
2.1.3 Decreasing of cost through mass-manufacturing 13
2.2 How to solve the "Chicken and egg problem" – Vehicle or charger first? 13
2.2.1 Case study of Japan – Charger allocation 13
2.3 Fast charger allocation 14

3 The current situation of EV/PHEV and grid interactions and interfaces 16

3.1 Smart Charging 16
3.1.1 Smart Charger 16
3.2 EV/PHEV as an energy source 21
3.2.1 V2H 21
3.2.2 V2B 22
3.2.3 V2G 22

4 Issues of EV/PHEV and grid interactions and interfaces 25

4.1 EV/PHEV and grid interactions and interfaces 25
4.1.1 Benefit of EV/PHEV and grid interaction 25
4.1.2 Issues of EV/PHEV and grid interaction 25
4.1.3 Roadmap of EV/PHEV interaction with grid 26

5 Conclusion 27

References 27

APPENDIX 29

LIST OF FIGURES

Figure 1-1	Various AC charging specifications	4
Figure 1-2	Fast charger locations in the US and Europe	5
Figure 2-1	EV/PHEV sales in Norway	9
Figure 2-2	EV/PHEV sales in the Netherlands	11
Figure 2-3	Failure and success of natural gas vehicle diffusion	13
Figure 2-4	Example of EV usage expansion by fast chargers installment.	14
Figure 2-5	EV Charger allocation simulator in Japan	15
Figure 3-1	Vehicle and grid interactions and interfaces	16
Figure 3-2	OEM server concept and ADR demonstration in Japan	18
Figure 3-3	Toyota's H2V manager	18
Figure 3-4	EV power management	19
Figure 3-5	Battery combined charging station	19
Figure 3-6	Multi-Channel Fast Charger	20
Figure 3-7	Example of DR with level 2 EV chargers	20
Figure 3-8	Nissan's V2H product	21
Figure 3-9	The M-tech Labo	22
Figure 3-10	MAGICC project scheme	23

TABLE OF CONTENTS

Table 1-1	Status of total EV/PHEV owned (2013)	2
Table 1-2	Status of EV/PHEV annual sales (2013)	3
Table 1-3	Examples of financial incentives in the GSGF sphere	6
Table 1-4	Examples of non-financial incentives in the GSGF sphere	7
Table 1-5	Examples of government-lead regulation in the GSGF sphere	7
Table 1-6	Examples of R&D in the GSGF sphere	8
Table 2-1	EV promotion measures in Norway	10
Table 2-2	Comparison of cost of Nissan Leaf and VW Golf in Norway	11
Table 2-3	EV promotion measures in the Netherlands	12
Table 3-1	Situation of demand response and curtailments service	17
Table 3-2	Specification of the battery	20
Table 3-3	Status of ancillary market	23

LIST OF ABBREVIATIONS

This report uses the following standardized units and abbreviations:

www.globalsmartgridfederation.org/about-gsgf/list-of-abbreviations/

The purpose of this report is to look at EV/PHEV as a constituent of the Smart Grid, and to add value to them with grid user interactions and interfaces. Current trends in EV/PHEV deployment and developments in vehicle and grid-related technologies are also discussed. It reflects the outcome of panel discussions including members of WG 2, from Australia, Canada, Denmark, Ireland, Japan, Korea, Norway and Taiwan, and experts not part of the WG.

The report is structured as follows:

Chapter 1 discusses the current trends in EV/PHEV spread and policies aimed at increasing the spread of EV/PHEVs.

Chapter 2, the issues to spreading EVs are put into focus. These topics are examined before discussing grid user interactions and interfaces as it is important to first increase the spread of EVs in general. Successes and failures in attempts at spreading next-generation vehicles are looked at, and it is pointed out that it is important to design incentives that are sustainable and can support a long-term aim. A certain level of infrastructure development prior to large-scale spread of EV/PHEV ownership is needed, where the actual placements of chargers is of big concern.

In chapter 3, grid interactions and interfaces are discussed, and the latest trends and developments are examined. Currently, many projects are being undertaken throughout the world to demonstrate the possibilities of smart charging, and the delivering of electricity back into the grid/house from the EV battery, virtually using it as a storage device.

In chapter 4, the issues that need to be resolved, concerning grid user interactions and interfaces in order to add to the value of EV/PHEV's, are discussed.

The technologies to achieve the above are all already prepared, as shown in demonstration programs. To move forward, the final section indicates the need to promote further spread of EV/PHEV, while considering use cases which enhance the value of the vehicle in addition to just driving. To obtain this, data and knowledge about the actual uses of EV/PHEV need to be exchanged.

1 THE CURRENT SITUATION OF EV/PHEV DIFFUSION

The EV/PHEV is discussed in connection with grid interactions and interfaces. It goes without saying that EV/PHEV grid interactions and interfaces require that EV/PHEV exist in large numbers in a region. Therefore, in order to discuss those grid interactions and interfaces, first the spread of EV/PHEV ownership in the world is analysed, the challenges and opportunities connection with this spread are shown, and also some best practice cases that can help us increase the spread are discussed.

1.1 Status of vehicle and infrastructure deployment

Before discussing how to further disseminate EV/PHEV, the spread of ownership at this point of time, in early 2014 is discussed.

1.1.1 Vehicle deployment

EV sales are still slow but steady[1]. Because of high battery cost and limited range the initial market has not seen explosive sales as expected by some OEMs. However there are some good results in certain areas, as for example in Norway and the Netherlands based on substantial subsidies.

In Norway, EV sales have been incredibly high in the second half of 2013, placing an EV on top of the total automobile sales in September (Tesla Model S), October (Nissan Leaf), and December (Tesla Model S again). Total EV sales surpassed 10% of the total amount of cars sales in Norway in both November and December. The Netherlands have also experienced good times, being it on the PHEV side of the story. The Netherlands have very favorable incentives for both EVs and PHEVs, resulting in PHEV grabbing an 11% automobile sales market share in November, 2013.

Together with increasing EV/PHEV models on the market are increasing sales. In the Netherlands, the introduction of the Volvo V60 and the Mitsubishi Outlander made a huge impact in the market.

There are still questions regarding how EV/PHEV will fit into the market. What are the intentions of the buyers? Will it be mainly private owners buying the cars (as in the case of Norway), or will it be fleet owners, or even governments and local municipalities?

It is well known that the capital cost (CAPEX) is higher for an EV/PHEV than a conventional internal combustion engine vehicle, thus requiring subsidies and tax cuts to make it a feasible option, but the operating cost (OPEX) is much lower, with cheap electricity versus expensive conventional fossil fuels. Therefore, fleet owners may have a better opportunity to focus on total cost of ownership (TCO) than private consumers do.

Incentives to ease the burden of CAPEX, such as tax reduction, will drive the market. What points can be made to highlight the lower OPEX of EV/PHEV, leading to further sales? EV/PHEV sales best practices are discussed in chapter 2.

Table 1-1 and 1-2 shows the current status of EV/PHEV ownership and sales in the world.

[1] Currently, EV/PHEVs sell around 10,000 units per month in the world, which may be deemed as marginal, but it is still good for a new market. The number of the manufacturers entering the market is growing year by year.

Table 1-1 Status of total EV/PHEV owned (2013)

	EV	PHEV	Remark
Australia	728	181	As of December 2013
Canada	2,473	3,123	Total sales numbers for 2011-2013
China	31,558	7,034	Total sales numbers for 2011-2013
Denmark	1,500	5	Estimate, low share of PHEV due to full taxation
France	17,256		Total registration numbers from 2010-2013 PHEV and EV are counted in total.
Germany	13,165		Registration numbers in total, 2013 PHEV and EV are counted in total.
Ireland	403	1,100	As of December 2013
Japan	38,087	17,281	As of March 2013 EVs exclude vehicle registered as motorcycle
Korea	1,871		PHEV and EV are counted in total.
Netherlands	4,161	24,512	Registration numbers in total, 2013
Norway	19,678	691	Registration numbers in total, 2013
Sweden	979	1,615	Registration numbers in total, January 2014
Taiwan	27,500		As of December 2013 PHEV and EV are counted in total.
UK	5,299	2,170	Total registration numbers from 2010-2013
US	72,028	95,589	Total sales numbers from 2010-2013

Source:
Australia: From GSGF WG 2 member
Canada: Data originally from Good Car Bad Car.
<http://www.greencarreports.com/image/100455953_plug-in-electric-car-sales-in-canada-jan-2014>
China: Chinese Association of Automobile Manufacturers. (2012 and 2011 numbers are not available on English site, and the numbers from the following news were used:
<http://www.cars21.com/news/view/5227>
<http://www.evwind.es/2012/01/16/5579-electric-cars-sold-in-china-in-2011/15911>
Denmark: De Danske Bilimportorer (Danish car import).
<http://www.bilimp.dk/statistics/index.asp>
France Avere-France Mobilite Electrique,
<http://www.france-mobilite-electrique.org/les-ventes-de-voitures-electriques-en-france,291.html?lang=fr>
Germany: KBA.
<http://www.kba.de/cln_031/nn_269000/DE/Statistik/Fahrzeuge/Bestand/Umwelt/2013__b__umwelt__dusl__absolut.html>
<http://www.kba.de/cln_031/nn_1389900/DE/Presse/Pressemitteilungen/2014/Fahrzeugzulassungen/pm02__2014__n__12__13__pm__text.html>
Ireland: From GSGF WG 2 member
Japan: Estimated by Next generation vehicle promotion center, Japan
Korea: EVAAP. <http://www.evaap.org/electric/electric.html?sgubun=7>
Netherlands: Rijksdienst voor Ondernemend Nederland.
<http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van- zaken/cijfers>
Norway: Gronnbil. <http://www.gronnbil.no/statistikk/>
Sweden: Power Circle.
<http://powercircle.org/se/display/elbilsstatistik.aspx>
Taiwan: From GSGF WG 2 member
UK: The Society of Motor Manufacturers and Traders,
<http://www.smmt.co.uk/category/news-registration-evs-afvs/>
US: Electric Drive Transportation Association, <http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952>

Table 1-2 Status of EV/PHEV annual sales (2013)

	EV	PHEV	Remark
Australia	304	101	
Canada	1,143	1,493	
China	14,604	3,038	
Denmark	538	2	
France	8,779		EVs and PHEVs are counted in total
Germany	6,051		EVs and PHEVs are counted in total
Ireland	121	559	
Japan	16,554	13,149	EVs exclude vehicle registered as motorcycle
Korea	780		EVs and PHEVs are counted in total
Netherlands	1,273	21,876	
Norway	10,410	378	EVs and PHEVs are counted in total
Sweden	452	1,109	
Taiwan	16,000		EVs and PHEVs are counted in total
UK	2,514	1,072	
US	49,008	47,694	

Source:
Australia From GSGF WG 2 member
Canada: Data originally from Good Car Bad Car. <http://www.greencarreports.com/image/100455953_plug-in-electric-car-sales-in-canada-jan-2014>
China: Chinese Association of Automobile Manufacturers. <http://www.caam.org.cn/english/>
Denmark: De Danske Bilimportorer (Danish car import). <http://www.bilimp.dk/statistics/index.asp>
Germany: KBA.<http://www.kba.de/cln_031/nn_1389900/DE/Presse/Pressemitteilungen/2014/Fahrzeugzulassungen/pm02__2014__n__12__13__pm__text.html>
Ireland: From GSGF WG 2 member
Japan: Estimated by Next generation vehicle promotion center, Japan
Korea: EVAAP. <http://www.evaap.org/electric/electric.html?sgubun=7>
Netherlands: Rijwiel en Automobiel Industrie. <www.autoweek.nl>
Norway: Opplysningradet for Veitrafikken (Information agency for road transport). < http://ofvas.no/bilsalget/bilsalget_2013/bilsalget_i_desember/>
Sweden: Statistics Sweden. <http://www.scb.se/sv_/Hitta-statistik/Statistikdatabasen/?ExpandNode=TK/TK1001>
Taiwan: From GSGF WG 2 member
UK: The Society of Motor Manufacturers and Traders, <http://www.smmt.co.uk/category/news-registration-evs-afvs/>
US: Electric Drive Transportation Association, <http://www.electricdrive.org/index.php?ht=d/sp/i/20952/pid/20952>

1.1.2 Infrastructure deployment

For the adoption of EV/PHEV by society, there is a need for charging stations in public spaces, aside from home charging. Chargers can be divided into mainly two types: normal (including home chargers) and fast chargers. Normal chargers charge slowly, whereas fast chargers can fill an EV/PHEV battery to 80 % capacity in 20-30 minutes.

An option is not charge the battery within the vehicle, but to swap it at a so called battery swapping station where they recharge the battery and deliver it to the next customer.

1. Charging stations

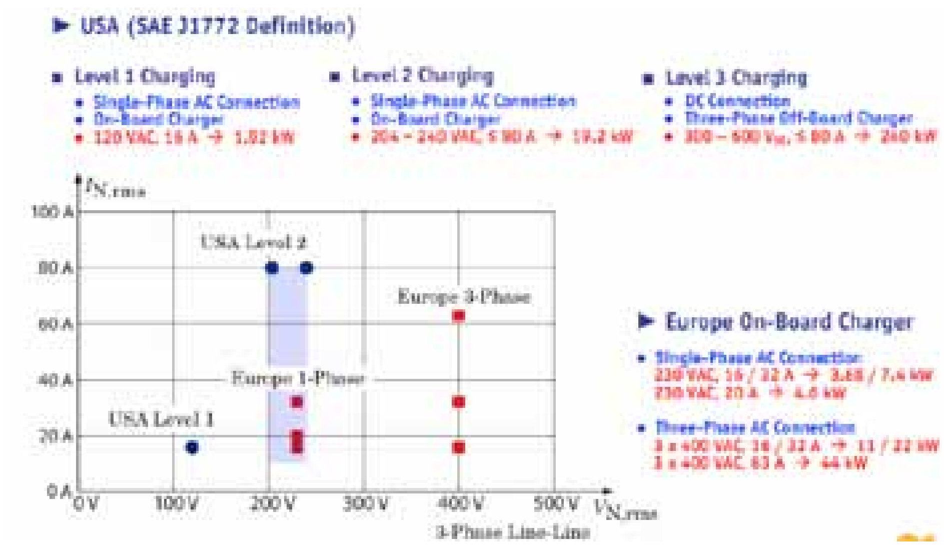
a. Normal charger

Normal chargers get the energy from the AC grid. The majority of charging at home is done in this way. Public chargers are appropriate to locate where vehicles stay long, such as at work, hotels, stations and airports.

In the US, the chargers are distinguished as level 1-3 chargers[2]. Level 1 charging is done at 1.92 kW (16 A, 120V). Level 2 19.2 kW (<80 A, 240V) and Level 3 240 kW (80 A, 300-600VDC). Charging at work is promoted by the Department of Energy (DoE).

In Europe, both single and three phase AC charging are used. Three phase charging is done at 44 kW (63 A, 400V), single phase below 7.4 kW (230V, 32A).

Figure 1-1 Various AC charging specifications



Source: http://www.pes.ee.ethz.ch/uploads/tx_ethpublications/ETH_Hartmann_ECPE_3ph_PFC_Rectifier_Topologies_for_EV_Battery_Charging_02.pdf

b. Fast charger deployment status

At present more than 3,000 fast chargers are installed all over the world, of which more than half are placed in Japan, one third in Europe and a 10% in the US. The locations of the fast chargers are shown in the below maps. In the US deployment is concentrated on the west coast and Texas and Tennessee.

[2] Level 1 charger is a simple plug with no communication. Level 2 charger has a pilot communication signal between the charging equipment and the vehicle.

Figure 1-2 Fast charger locations in the US and Europe

The world's first nationwide network of fast chargers, is established in Estonia. This network is constructed by ABB, through a contract awarded by the Estonian government. It consists of 163 DC (Direct Current) fast charging stations. The fast chargers are strategically dispersed throughout the country, along highways and in cities, so that no station is located farther than 60 km (37 miles) from the next. The actual charging spots include gas stations, cafes and shops. In all settlements with a population of over 5,000, at least one fast charger has been placed.

At first, there was mostly government owned EVs in Estonia, not using the fast chargers very much. As more and more private persons buy EVs, and a car sharing service, called ELMO rental, started, the use of the fast chargers has increased over 2013. It can be said that the infrastructure in Estonia is sufficient for a large deployment of EV/PHEV in the country.

In Europe, three-phase AC (Alternate Current) quick charging is also proposed, because of its simplicity at the infrastructure side.

One question that inevitably comes to mind when discussing infrastructure is that of interoperability; will an EV/PHEV be able to drive to the neighboring country and charge its batteries?

One attempt at answering this question is done in the Republic of Ireland and Northern Ireland: Europe's first cross-border fast charger network was launched in June 2013. The project is EU funded, with 4.2 M€, and is going to roll out 46 new chargers across Ireland. The European Commission anticipates that the results of the study will provide a framework for the further development of a standardized fast charge network in Europe.

2. Battery swapping station

Next to recharging the battery at home or at a public charger, there is also the possibility to remove a discharged battery and insert a fully charged battery at a battery swapping station. At the station, charged batteries are available to their customers, and the used batteries are recharged. It only takes a few minutes to perform this kind of action.

For example, there was a company called Better Place. Their business model was to sell the service of battery swapping for passenger EV/PHEV. It was mainly located in Israel. However, the business ended in bankruptcy in May 2013.

There have also been demonstration projects undertaken in China, in which they used battery swapping not only for passenger vehicles, but also for buses and commercial vehicles. In China it is not done for normal users, but for bus and taxi fleets.

1.2 Incentives and regulations

The current status of the vehicle and infrastructure deployment has been addressed. In order to achieve these results, economical and regulatory measures are needed, aside from the specs of the car and a sufficient infrastructure. A list of measures taken is shown below. Best practices for policies will be shown in chapter 2.

1.2.1 Financial incentives

There are many financial incentives for EV/PHEV, and these vary in different countries.

Table 1-3 Examples of financial incentives in the GSGF sphere

Type of incentive		Examples
Subsidy		• China offers up to a 60,000 RMB subsidy for EV purchase • Korea offers 14,000 USD per personal EV, 94,000 USD per EV bus, and local subsidies (2,800-8,450 USD)
Rebate		• California offers a 2,500 USD rebate for ZEVs.
Tax deduction		• The US federal government offers a tax deduction for the purchase of vehicles with a battery installed • In Taiwan, the Ministry of Economic Affairs (ROC)'s smart vehicle system projects plan to exempt from commodity tax and license taxes for three years • Maximum 3,945 USD tax deduction on individual consumption tax in Korea
Exemption/ reduction of tax	VAT	• EVs are exempted from VAT in Norway (25%)
	Import tax	• Norway (typically 45,000-75,000 NOK for small size EVs and up to 700,000 NOK for luxury high performance EVs, e.g. Tesla S) • Denmark (exemption of registration tax until the end of 2015. Taxation is 105 % up to 80.500 DKK and 180 % above)
	Road tax	• Exemption until the end of 2015 in Denmark
	Luxury tax	• The Netherlands (25 % for normal cars)
Company tax reduction		• Companies can reduce their taxable income in case of EV/ PHEV purchase in the Netherlands
Infrastructure subsidy		• 40 million DKK are available for charging infrastructure in Denmark – fleet owners can apply for funding to cover part of initial extra cost related to switching to EVs • The Japanese government offers about 100 billion JPY for the construction of charging infrastructure • Construction of fast charger for emergency and providing 1 slow charger for each EV bought (government subsidy of 6,570 USD) in Korea
Exemption from road tolls		• EVs can travel on pay/toll roads for free in Norway
Free parking		• EVs can park for free in Estonia • 50% discount for parking, in Korea
Free domestic ferries		• EV drivers only pay for the driver as a passenger and do not pay for the vehicle on domestic ferries
Cheaper electricity		• Half price on electricity in Denmark when charging is done via an operator
Congestion fee exemption		• Exemption of congestion fees in Korea (Seoul, Namsan etc.)

Remarks: 1 RMB (Chinese Yuan Renminbi) is about 0.16 USD, 1 NOK (Norwegian Krone) is about 0.17 USD, 1 DKK (Danish Krone) is about 0.18 USD, 1 JPY (Japnaese Yen) is about 0.01 USD

1.2.2 Non-financial incentives

Non-financial incentives are also available.

Table 1-4 Examples of non-financial incentives in the GSGF sphere

Type of incentive	Example
Type of incentive Use of bus lane	• EVs are able to use bus lanes in Norway
Use of HOV High-Occupancy Vehicle lane	• EVs are able to use HOV lane in California
Quick vehicle registration	• In China, conventional vehicle registration is limited in big cities, whereas there exists no such limit for EVs
Creation of best practices to increase number of local incentives	• In Japan, there is a collection of best practices called "EV/PHEV town," that allows for other towns to get inspiration. Below are the non-financial incentives listed. • Arrangement of test-ride events • Car sharing and car rental services • Creation of logo mark and homepage dedicated to EV/PHEV information spread

1.2.3 Regulation

The government can also intervene through creating rules and regulations that promote EV/PHEV.

Table 1-5 Examples of government-lead regulation in the GSGF sphere

Type of regulation	Example
Green Investment Scheme (Defined by Kyoto Protocol)	• Intensive introduction of EVs in Estonia. Under the GIS, a Party to the Protocol expecting that the development of its economy will not exhaust CO2 credits can sell the excess of its credit to another Party. The proceeds from the AAU sales should be "greened", i.e. channeled to the development and implementation of the projects either acquiring the greenhouse gases emission reductions (hard greening) or building up the necessary framework for this process (soft greening)
Sales mandate for OEMs	• OEMs must sell a certain percentage of ZEVs (Zero Emission Vehicle) in California
Procurement requirement for fleet owners	• Governmental fleets must procure a certain percentage of environmentally friendly cars in the US
Restriction of high polluting cars	• High-polluting cars were restricted in China during the Olympics

1.2.4 R&D

Research and Development is perhaps not a direct way to improve EV/PHEV sales, but it can promote industries involved, and in the long run EV/PHEV sales.

Table 1-6 Examples of R&D in the GSGF sphere

Type of R&D	Example
Demonstration projects	• Four big demonstration projects concerning EVs were undertaken in Japan • Studying the interaction between EV and the power grid is an important part of the Australian government funded "Smart Grid, Smart City" trial project • Ten demonstration projects of smart vehicle system were planned in Taiwan • The project ReLiable in Denmark aims to demonstrate the potential of Li-air batteries as an alternative to gasoline and diesel. Two companies and three universities contribute to the project with a funding of 2.5 million EUR over 4 years • Establishing Smart Transportation test bed in Jeju-Smart Grid test-bed project[3] (2009~2013, for 42 months) in Korea
Financial support for R&D	• Financial support for battery research in Germany • In Taiwan, 9.6 billion dollars will be spent for the execution and demonstration of smart vehicle system in 2012~2016. 3.3 billion was spent for R&D • Financial support for research and development of new technology of charging equipment in Norway (national body: Transnova). Norwegian Research Council supports relevant R&D projects e.g. Ecar project ended 2013) • The Japanese Government offers 9.69 billion JPY in financial support for research on batteries (of which 3.09 billion is on fundamental research, and 6.6 billion on practical application) 2009~2016, through NEDO (New Energy and Industrial Technology Development Organization) • Support for Technologies on Charging infra, V2G, ICT (2011~2015) in Korea
Test of interoperability	• NEVIC (Nordic Electric Vehicle Interoperability Center) performs interoperability tests according to the relevant standards and pre-standards • Argonne's EV-Smart Grid Interoperability Center provides the possibility for cooperation between industry and government in the US. The interoperability of SAE J2953 and interoperability between grid utility providers are tested.

[3] Haldor Topsøe A/S, a large catalyst producer; Lithium Balance, a Danish company that supplies battery management systems for Li-ion batteries; Stanford University in the US; the University of Southern Denmark; and the Technical University of Denmark

2.1 Needs for sustainable incentives to diffuse EV/PHEV

There are a myriad of ways to promote EV/PHEV sales and development. However, there is a need for these measures to be sustainable to ensure a long-lasting presence of EV/PHEV in a country.

2.1.1 Case study of Norway and the Netherlands

1. Norway's case

Norway has been gathering attention as a stellar example of how EV/PHEV sales can be promoted, where EV/PHEV have gained a significant share of the automobile market. EV sales in Norway have been surging the last couple of years, reaching unprecedented sales numbers in the latter part of 2013. For example, it was an EV that topped the car sales in September (Tesla Model S), October (Nissan Leaf), and December (Tesla Model S again) 2013. The development of the EV/PHEV market can be seen in the graph below. The total number of registered EV/PHEV now exceeds 20,000 vehicles remarkable considering the size of the country.

Figure 2-1 EV/PHEV sales in Norway

Source: http://www.gronnbil.no/statistikk/

The reason for the success of Norway is variety of incentives.

Table 2-1 EV promotion measures in Norway

Measures	Outline	Evaluation
Tax benefits	• Exemption from vehicle registration tax (VW Golf is about 45,000-75,000 NOK) • Exemption from VAT (25%) • Reduction of annual motor vehicle tax (A conventional vehicle costs 2,885-3,360 NOK per year. An EV is only 420 NOK per year)	+ / ++
Exemption of road toll	• Toll roads increased since 2000, but EVs are exempted.	++
Use of bus lane	• EVs are allowed to use bus lane on the roads with heavy traffic. The letters license plate number begins with the "EL".	++
Subsidy for charging infrastructure	• The Ministry of Transport and Communications provides subsidy for the construction of charging infrastructure.	+
Reduced ferry fares	• EV drivers are allowed to take domestic ferries with reduced fare (pay only for person, not for vehicle).	-
Free parking	• Parking of EV in public parking places is free all over Norway.	+

Discussing Norway's EV success, it is important to note that apart from the measures mentioned in the table above, the number of households with two or more cars is 39 %[4]. EVs fit the use of second cars very well, even though surveys and interviews of EV owner in Norway suggest that the EV owners consider their EV as the "primary vehicle", as it is their most frequently used car. Compared to a conventional car, the EV is still expensive, but after all the economic incentives have been added, it barely costs more than a regular car, with much cheaper operating costs. Below is a comparison of the cost of a Nissan Leaf and a VW Golf – the most popular car in Norway – for 15,000 km year over 5 years:

[4] Norwegian Ministry of Transport and Communications, "Action Plan for Electrification of Road Transport," 2009, p. 25

Table 2-2 Comparison of cost of Nissan Leaf and VW Golf in Norway

	Leaf	Golf	Difference
Depreciation	136,039	107,280	28,579
Annual tax	2,025	14,425	-12,400
Maintenance	20,000	23,000	-3,000
Fuel cost	15,000	78,750	-63,750
Parking costs	0	12,000	-12,000
Road toll	0	36,000	-36,000
Total	173,064	271,455	-98,391

Remark: Depreciation means the reduction in value over 5 years. Because of battery deterioration, the EV car value drops faster than the conventional vehicles'. 1 NOK (Norwegian Krone) is about 0.17 USD
Source: http://www.gronnbil.no/calculator

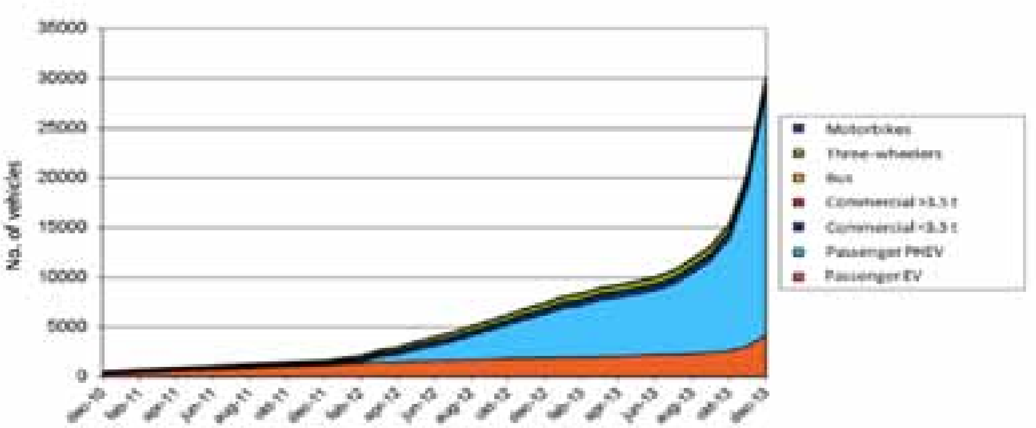
Furthermore, it should be noted that charging at public chargers at the moment is free of charge in Norway. However, since conventional fuel prices in Norway are very high, it will still be more economical to own an EV even after payment is introduced.

Therefore, an EV is more economical than a conventional car, can drive on bus lanes and charge for free, all while serving the purpose of being a second car. Norwegian authorities have signaled that many of the incentives probably will be continued but that an evaluation will be done in 2017 or when 50,000 EVs have been reached.

2. The Netherlands

The Netherlands is the other European country with high EV/PHEV sales. However, in the Netherlands PHEVs outsell EVs by miles, with PHEV getting an 11% automobile sales market share in November 2013. The graph shows the development in total ownership of EV/PHEV in the Netherlands from late 2010 to December 2013. The blue represents PHEV, and the orange EV. PHEV started selling very well after the introduction in 2012, with the number surging in late 2013.

Figure 2-2 EV/PHEV sales in the Netherlands



Source: http://www.rvo.nl/onderwerpen/duurzaam-ondernemen/energie-en-milieu-innovaties/elektrisch-rijden/stand-van-zaken/cijfers

The following incentives are available in the Netherlands:

Table 2-3 EV promotion measures in the Netherlands

Measures	Outline
Government's incentives	
Tax benefits (for vehicles with CO_2 emissions of 50g/km or below)	• When using a company car for personal use, 25 % of that value is added to the individual's income for taxation. This is exempted in the case of EV/PHEV. • The possibility to count 36 % of the price as cost (not taxable) in case of an environmental friendly investment. • Exemption of automobile tax (Progressive taxation that imposes higher taxes on high CO_2 emitting vehicles. Max. 25% for internal combustion engine cars. The system will be revised from 2014, to impose 7% on zero-emission cars.) • Exemption of road tax.
Overseas collaboration	• Invite overseas companies to participate in the demonstration project in the Netherlands.
City of Amsterdam	
Subsidies for purchasing electric vehicles	• Subsidies for private companies: • Passenger cars: €5,000 per vehicle • Taxis: €10,000/vehicle • Trucks: €40,000/vehicle
Car sharing	• Car2Go Car Sharing service started in 2011, and 300 EVs are now available for use (fee: €0.29/min.; €14.90/hour; €59/day)
Public parking	• EVs receive parking permits faster than conventional cars.
Infrastructure deployment	• The city of Amsterdam has a fund to place normal chargers in the city.

Concerning the Netherlands, there are many incentives on municipal levels, with the example of Amsterdam given in the table.

There are three important differences in the cases of Norway and the Netherlands: in the Netherlands, the possession of two cars is comparatively rare, company cars are widely used for private use, and the incentives apply to both EVs and PHEVs. Since most Dutch people go on long trips once or twice a year, long range (that cannot be provided by pure EVs at the moment) is a prerequisite when purchasing a vehicle.

The reason for the sudden increase in late 2013 was the introduction of two new PHEVs: the Mitsubishi Outlander and the Volvo V60. Also, the generous incentives noted in the table above were changed from 2014, so that EVs are more subsidized than PHEVs. The government is moving in a direction to quit the incentives in a couple of years.

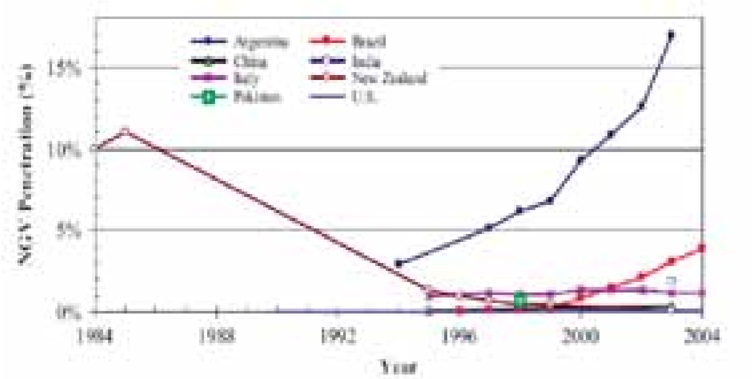
2.1.2 Case study of New Zealand and Argentina – Sustainability is needed for incentives

An entire industry cannot rely on subsidies forever, so there is a need to make the product economically competitive while decreasing the incentives. Below follows two contrasting examples in the case of NGVs (Natural Gas Vehicle).

New Zealand heavily subsidized NGVs in the 80s, leading to a massive deployment of NGVs, reaching an 11 % overall market share. After the government abruptly ended the subsidies, the number of NGVs dwindled, to almost completely disappearing around 1995.

On the contrary, Argentina introduced a sustainable incentive scheme to support the diffusion of NGVs. The government lowered the fuel tax on natural gas, while creating a model where the suppliers are guaranteed a profit margin. Now Argentina is one of the countries that have attained the highest NGV penetration rate in the world.

Figure 2-3 Failure and success of natural gas vehicle diffusion



Source: Energy Policy 35 (2007) 5865–5875

2.1.3 Decreasing of cost through mass-manufacturing

Battery costs for EV/PHEV are still high, leading to high vehicle cost. However, this can partially be solved through mass-manufacturing in big factories.

For example, Tesla Motors plans to build a $5 billion factory to produce lithium-ion batteries. Initial production is slated to start by 2017 and the plant aims to reach full capacity by 2020. Tesla believes this will drive down the cost of its battery packs by 30% by 2017 and 50% by 2020. Cost reductions achieved through mass-manufacturing could greatly accelerate the adoption of electric vehicles in the US.

Nissan has also turned to concentrating the production of batteries: in 2012, Nissan decided to focus battery production from three factories to one, located in Tennessee, US. This has led to a major price reduction on the Nissan Leaf.

2.2 How to solve the "Chicken and egg problem" – Vehicle or charger first?

The "chicken and egg problem" – no need for public charger infrastructure if no EVs, but no public infrastructure built if no EVs on the road – is crucial. Although the customers charge at home usually, for range anxiety, public infrastructure should be installed before the rollout of vehicles, to a certain extent at least. Based on the results of several countries where EV/PHEV's are successful, it tends that enough supply of public chargers evoke demand for EV/PHEV.

2.2.1 Case study of Japan – Charger allocation

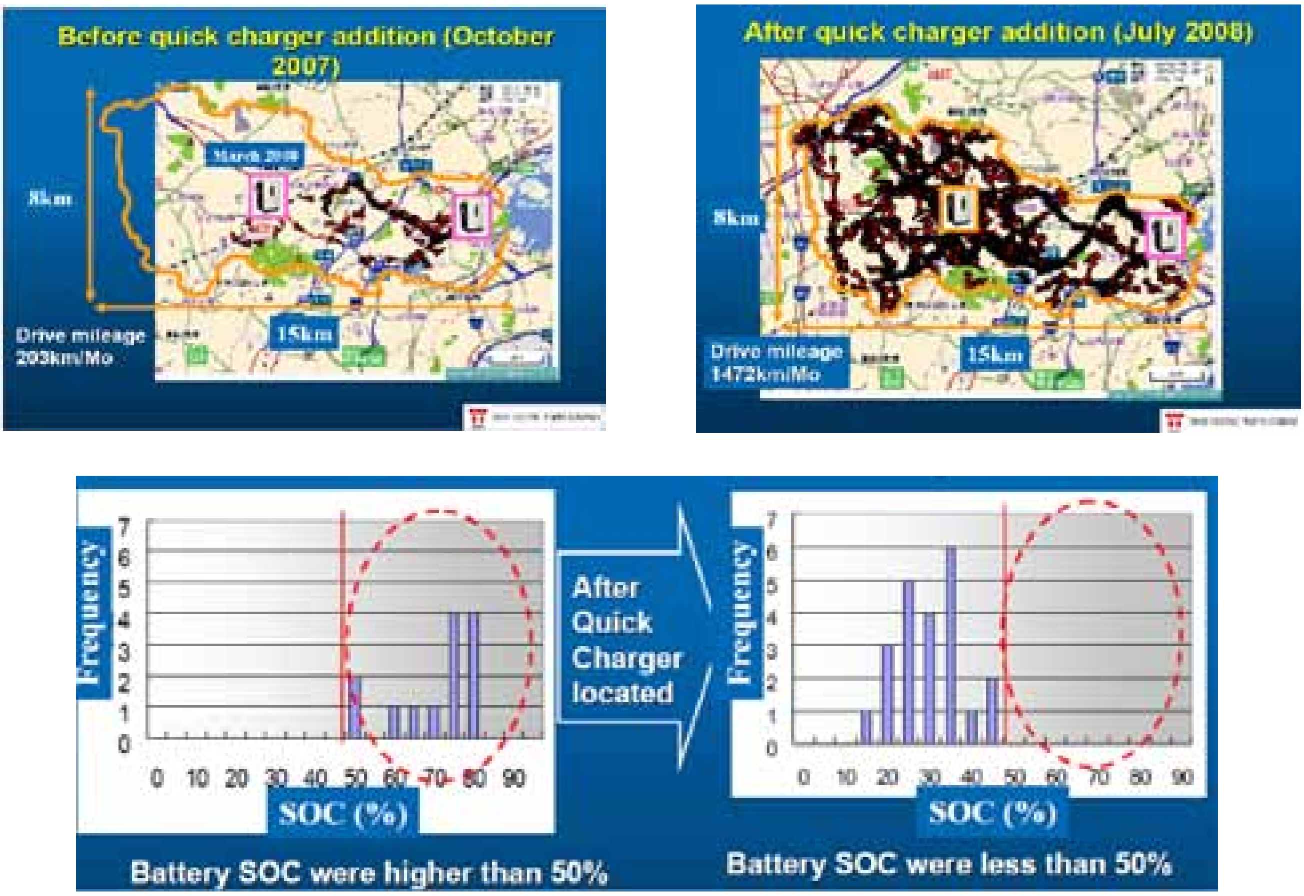
1. Needs for fast charger

Infrastructure installation changes the mindset of EV users. The example is the installation of fast chargers in an area in Japan to give confidence to drive longer trips. On the left, the EVs are not being used very much, with battery SoC (State of Charge) consistently remaining over 50%; there was a fear for being stranded with an empty battery. However, after fast chargers were installed, the amount of driving increased significantly, and the SoC after driving also dropped, meaning that drivers were more comfortable to drive longer distances. The actual use of EVs increased from 203 km/month to 1472 km/month with the installation of the fast charger.

The installation of fast chargers eliminates range anxiety and gives the opportunity to 'range expectation', via station hopping. The use of the fast chargers isn't necessarily intense, but their existence gives the driver an assurance, and is a necessity when introducing EV/PHEV.

Other countries that have taken this approach, to install chargers before cars are present in large amounts, include Norway, Estonia and the Netherlands. How to manage the fast chargers station is a matter that business operators and OEMs need to address together, because of the operating costs of the chargers, when there are not yet many EV/PHEV in the market.

Figure 2-4 Example of EV usage expansion by fast chargers installment.



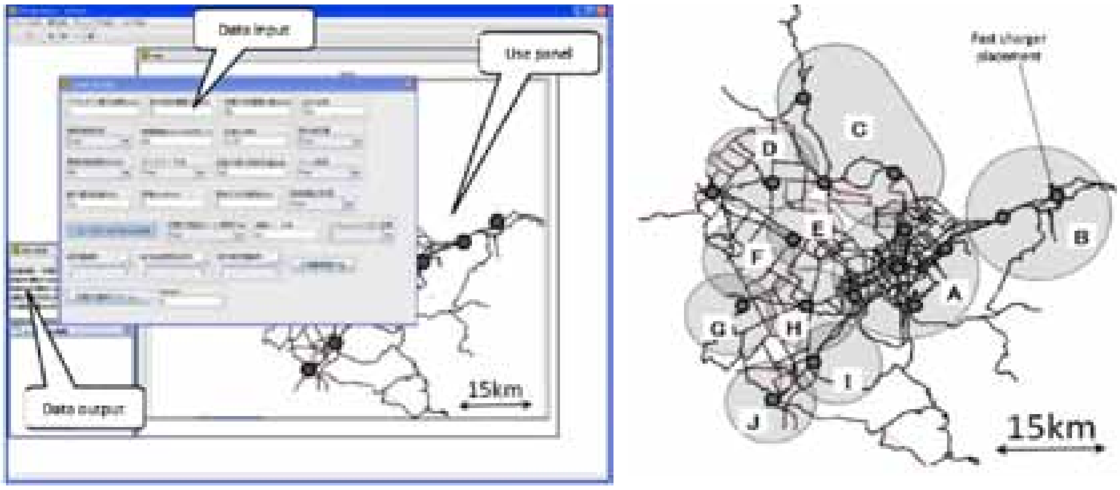
Source) TEPCO

2.3 Fast charger allocation

There is a need to install fast chargers, but the question of where they should be installed remains. The Central Research Institute of Electric Power Industry (CRIEPI) of Japan has developed a GIS (Geographic Information System) that analyzes the flow of traffic and calculates their optimal placement. The result is obtained by entering the following parameters: population data, worker data (number of workers in the area), work place data, geographical data (slopes, etc.), already built fast charger locations and numbers. (figure 2-3)

Using this simulation tool for charger placement, among others tools, Japan has paved the way and installed a considerable infrastructure already (around 2,000 fast chargers). There is a 1,000 billion JPY budget disposable for installing normal and fast charger (1/2-2/3 of cost covered) in 2014, to further build the foundation for a large scale spread of EV/PHEV. (Table 1 3)

Figure 2-5 EV Charger allocation simulator in Japan

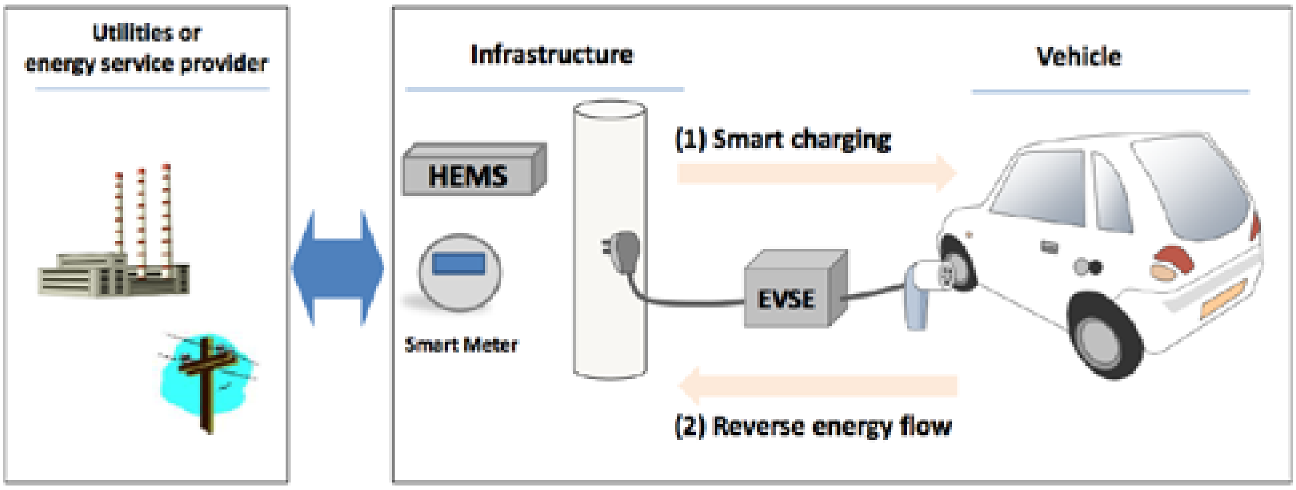


Source: CRIEPI

3 THE CURRENT SITUATION OF EV/PHEV AND GRID INTERACTIONS AND INTERFACES

Smart charging of EV/PHEV includes two parts: (1) charging the vehicle at optimal timing/load, (2) reversing the energy flow, i.e. sending electricity back.

Figure 3-1 Vehicle and grid interactions and interfaces



3.1 Smart Charging

3.1.1 Smart Charger

1. Smart charge objective

When the number of EV/PHEV increases to a level where they affect the grid, it is necessary to control the load when charging. Certain transformer banks already face critical situations when there is a sudden increase of EV/PHEV in a concentrated area. Strengthening the infrastructure is one solution, but smart charging, i.e. avoiding charging during the peak, is also applicable.

EV/PHEV batteries can be used as storage of fluctuating renewable energy. When there is too much energy fed into the grid, the EV/PHEV can be charged to avoid instability. On the other hand, when electric generation capacity is not enough to satisfy the demand, EV/PHEV can be charged during off-peak times. However, the current number of EV/PHEVs is insufficient neither to absorb the necessary amount of renewable energy nor to endanger the grid.

Even now, at the home usage level, the EV/PHEV can be charged during the night to make use of cheaper electricity and avoiding increasing the peak demand, as well as supplying energy to the house (V2H) to help peak-cutting during the day or evening. (table 3-1)

Table 3-1 Situation of demand response and curtailments service.

	DR	Curtailment
US	DR programs are present in several areas, including ERCOT, MISO and CAISO. In ERCOT, for example, the wholesale market price is determined by predicted real-time load.	Curtailment services are handled by third party providers. End-use retail customers have access to ISOs wholesale electricity market through CSPs (Curtailment Service Providers) or utilities introduce them to customer.
Japan	ToU (Time of Use) is available, with cheap night electricity. These programs are annually fixed and aim at cutting the peak demand long-term; there are no DR programs that involve sending flexible price signals "real-time". DR programs demonstration projects are ongoing.	Curtailment services are handled by vertically integrated utilities. They offer contracts for supply and demand-adjustment available for commercial customers.
Australia	Major utilities are now applying the ToU rates to manage demand. Existing ToU programs usually consist of three different price bands and are reviewed every year. In the "Smart Grid, Smart City" trial program, DR that applies real-time price signals before peak load events has been tested. A DR standard, called "Framework for demand response capabilities and supporting technologies for electrical products" (AS/NZS4755) is in place.	Not available
Ireland	Off peak tariffs are available but are currently targeted mainly at the electric heating market.	Curtailment is being trialed on a small scale along with new generation electric space and water heating as part of the provision of ancillary grid services.
Norway	Under discussion and consideration	Not available
Denmark	As an experiment SEAS-NVE has started a project involving the possibility for free electricity at night. The project involves 2.000 households for one year	Not available

Remark:

DR: Electricity suppliers send high price signal to customer to decrease demand at the event and customer can voluntary opt-in or opt-out the program.

Curtailment: Customers agree to automatic reduced load to prevent power outages, against low electricity cost or a fee

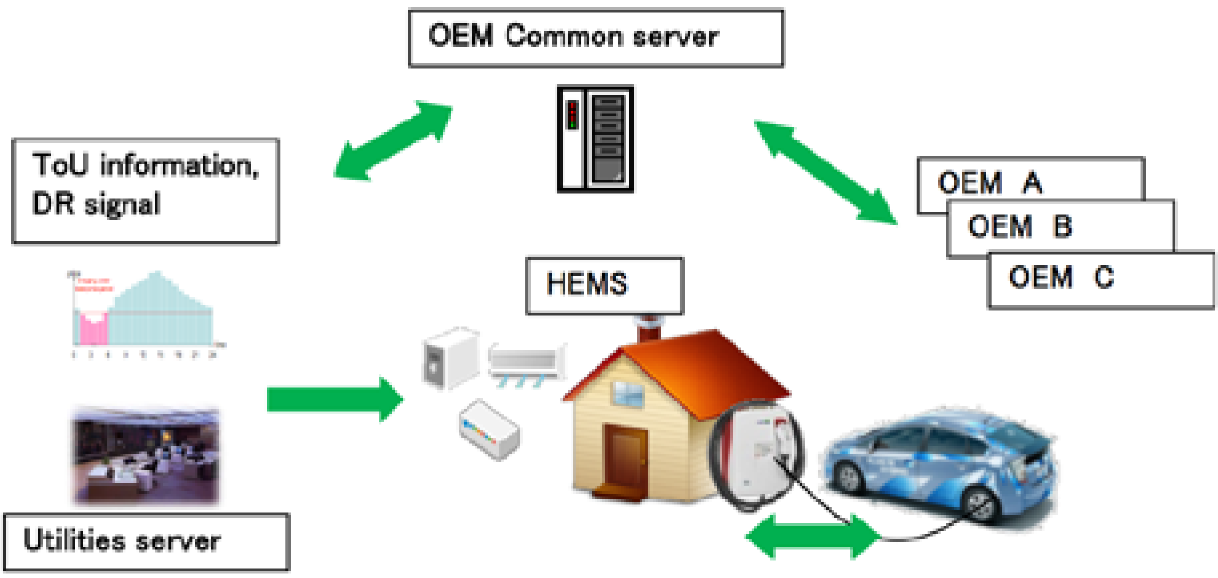
2. Case studies

1) Smart charging application as part of ADR (Automated Demand Response)

Several demand response demonstration projects are going in the world to realize smart charging in coordinating with the grid load.

In the US, OEMs, electric utilities and EPRI (Electric Power Research Institute) are working together to set up a common server that enable ADR. In the METI (Ministry of Economic and Trade Industries) projects in Japan, the following two methods are used to optimize charging times: (1) ToU information is used to give the customer information on when electricity is cheap, and (2) DR requests from utilities are delivered to EV/PHEV and the vehicle is charged considering peak price/load, without requiring the customer to manually intervene.

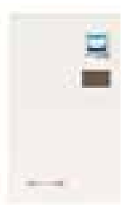
Figure 3-2 OEM server concept and ADR demonstration in Japan



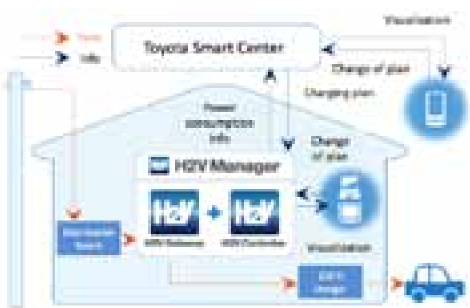
2) EV Charger as HEMS (Home Energy Management System)

After home charging was introduced, Toyota introduced their H2V (Home to Vehicle) system as an additional product to increase the use of EV/PHEV at home. The product basically works as a HEMS for the EV/PHEV, and is for sale in Japan. The H2V manager monitors the household power consumption and automatically starts or stops charging of the EV based on energy supply. It also allows users to manually start or stop charging via an application.

Figure 3-3 Toyota's H2V manager


H2V manager


H2V gateway



Source: Toyota

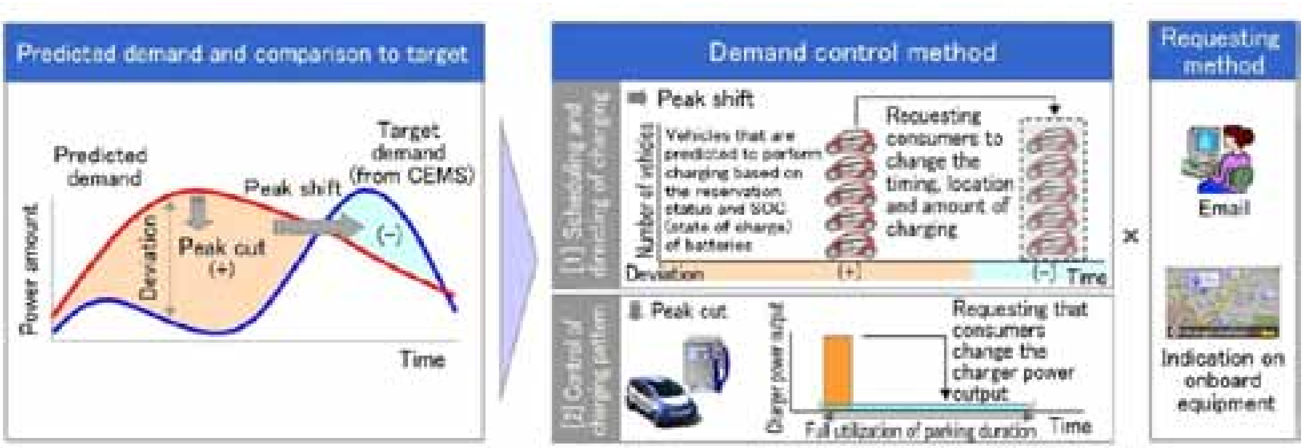
3) Smart fast charger

One of the problems of fast charger is the steep increase of energy demand. To prevent this peak demand, power management, battery combined charging station and Multi-Channel Fast Charger (M:N Charging) are demonstrated in a project in Malaga[5], Spain.

a. EV power management

For EV power management, the system monitors real-time power consumption of EVs' and chargers', with probes, and then estimates future power consumption through big data analysis. EV drivers are informed of the requests from power supplier (Endesa Group) using onboard equipment to push them to change their behavior. Such requests to drivers are delivered as recommendations via the Internet. In some cases, an incentive to change behavior, points are given to the drivers who follow the request.

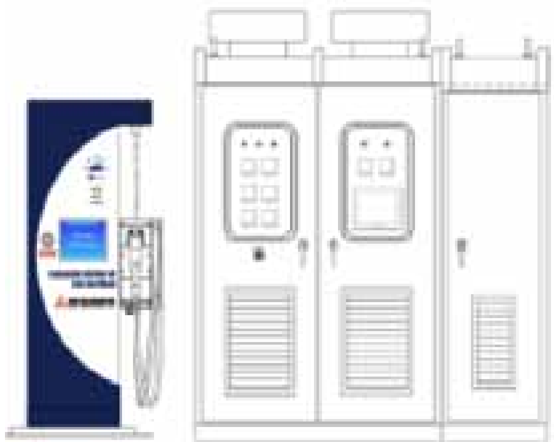
Figure 3-4 EV power management



b. Battery combined charging station

Some of the fast chargers used in the project are combined with a storage battery. This type can store some power to the battery via the QC, while the QC is not being used.

Figure 3-5 Battery combined charging station



[5] Zero Emissions Mobility to ALL (ZEM2ALL) is a field operational program of energy management for EV (Electronic Vehicle) in Malaga city in Spain. It is an international joint project of Spain and Japan initiated by CDTI and NEDO which will be continued until the end of 2015. In the project, CHAdeMO Fast Chargers are deployed to 7 locations in Malaga City, one in Fuengirola, and another one in Marbella.

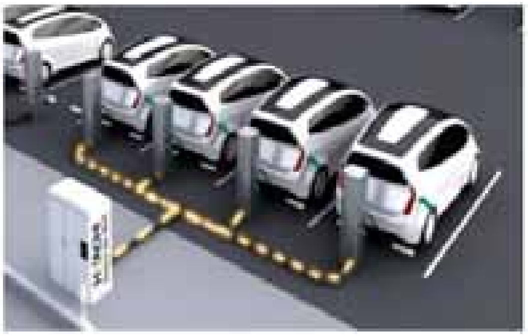
Table 3-2 Specification of the battery

1.	Power Receiving	3 Phase AC 400V
2.	Max Output for Charging EV	33 kW
3.	Capacity for Charging or Discharging Battery	33 kW
4.	Battery Capacity	32.56 kWh
5.	Charger Type	CHAdeMO
6.	Standards	CE Certification
7.	Power Supply for Emergency	1 Phase AC230V

c. Multi-Channel Fast Charger (M:N Charging)

Multi-Channel Fast Chargers are also deployed in the Malaga project. They can charge up to 4 EVs simultaneously with a single power conditioning unit. The power unit automatically divides the amount of power according to the number of EVs.

Figure 3-6 Multi-Channel Fast Charger

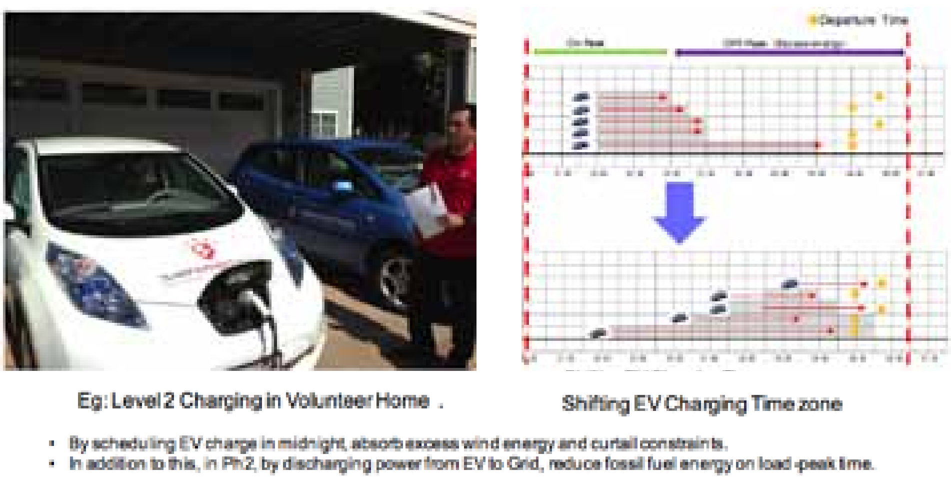


4) Direct Load Control of EV charging

With renewable energies in the grid, the electricity generated may fluctuate sharply in line with the weather, leading to imbalances in electricity demand and supply. Smart charging EV/PHEVs can help to manage this problem.

In the smart grid project in Maui, Hawaii, direct load control of EV charging has been tested. Maui aims at 40 % renewable energy (mainly wind power) by 2030. However, there have been problems with oversupply during the night and the local utility has been undertaking a demonstration project called JumpSmartMaui, directly controlling EVs to charge during the night, matching demand and supply[6] .

Figure 3-7 Example of DR with level 2 EV chargers



[6] Hitachi has developed the use of smart grid technologies to enhance islanding the electric power system operations and performance.

5) Smart Wireless Charger

It is also possible to charge EVs using wireless charging increasing significantly the convenience of EV use.

While several demonstration programs and retro-fit markets are starting, in order to promote wireless charging into the volume market, it is necessary to stipulate the regulations that should be adapted.

Standardization efforts are also made to keep the interoperability among infrastructure and vehicles. For example, at the Broadband Wireless Forum in Japan, allocation of frequency and interference electromagnetic issues are discussed. IEC, ISO and SAE are also working intensively so that wireless charging can be in the market soon.

3.2 EV/PHEV as an energy source

3.2.1 V2H

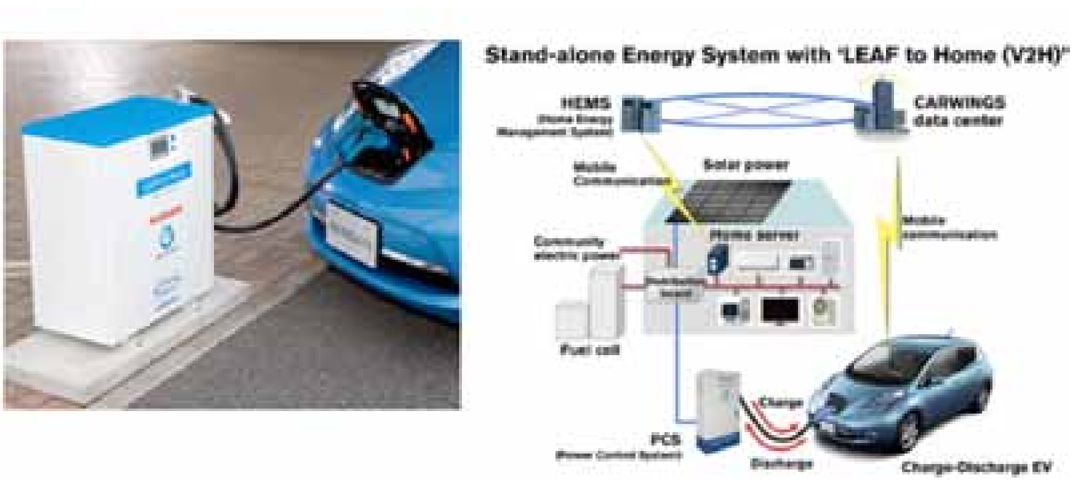
1. V2H objectives

V2H (Vehicle to Home) is a technology for feeding energy back into the home from the vehicle, in order to cut the energy demand peak and use energy in case of emergencies. At peak time, when the electricity price is usually higher, the customer can substitute electricity from the grid by energy supplied from the battery. Utilizing the energy in the vehicle to offset household consumption can also support the network at times of peak demand. The stored energy can be used in case of a power outage.

2. Case Studies

The V2H technology Leaf to home was demonstrated in Yokohama City, Japan in the summer of 2011, and is now for sale in the Japanese market. This feature allows for energy to be supplied to households in the case of power outage. It is possible to store about two days' worth of energy for a normal household in the Leaf, with its battery capacity of 24 kWh.

Figure 3-8 Nissan's V2H product



Source: Nissan

3.2.2 V2B

1. V2B objectives

V2B (Vehicle to Building) is the technology of supplying energy to a building from a vehicle, similar to V2H, with the same goal, i.e. to cut peak demand by supplying electricity stored during low-demand hours.

2. Case Studies

Mitsubishi Corporation and Mitsubishi Motors Corporation created an application called the M-Tech Labo, demonstrating the vehicle to building technology. It is part of the KEIHANNA Eco-City Next-Generation Energy and Social Systems Demonstration Project in Japan and aims at the smart use of EVs by using rechargeable EV batteries to level the electricity demand of factories.

Figure 3-9 The M-tech Labo

Source: http://www.mitsubishicorp.com/jp/en/pr/archive/2012/html/0000014509.html

3.2.3 V2G

1. V2G objectives

V2G (Vehicle to Grid) is the technology of feeding electricity stored in the car battery back into the grid. V2G technology has a possible business case because the market may pay high prices for such services in some cases. Two examples of this are: (1) charge the vehicle using energy during the night (renewables, like wind, or nuclear power), and then sell electricity back to the grid when the market purchasing price is high (i.e. during the peak), (2) join the ancillary market to be used when there is an unexpected shortage of power in the system. Though V2G has been realized technically, rules and standards between utilities and EV/PHEVs are yet to be decided, and appropriate legislation to guarantee safety and coordination with the grid is still to be decided.

Table 3-3 Status of ancillary market

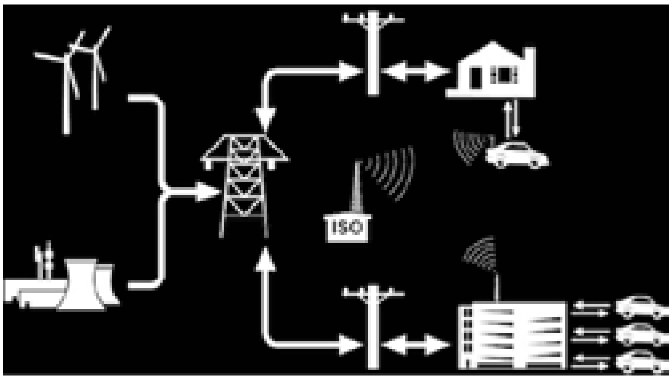
	Ancillary Market	Other notable market
US	To stabilize power system, ISOs (Independent Service Operator) purchase electricity from the ancillary market at relatively high price at the event. Two ancillary markets called "regulation" and "synchronized reserve" service exist. The regulation service corrects for short-term changes in electricity use that might affect the frequency of the grid, while the synchronized service supplies electricity if there is a sudden need for more power.	Capacity market, a market to ensure the future availability of generating capacity, is present in most areas.
Japan	Does not exist (Under consideration)	Not available
Ireland	Some ancillary services are available through aggregation of commercial electric devices. Domestic ancillary services are being tried out, largely in the electric space and water heating market, There is a research project underway for EVs.	Under development
Australia	The AEMO (Australian Energy Market Operator) is responsible for operating 8 different ancillary markets for the purpose of delivering frequency control ancillary services. AEMO also purchases network control and system restart ancillary services under agreements with service providers.	Not available
Norway	Generators can bid into the market generation resources which can be activated within 15'. Norway is participating in a common Nordic ancillary service market.	Not available
Denmark	Does not exist - demonstration of V2G has been carried out as part of the Edison project[7].	Not available

2. Case Studies

MAGICC (Mid-Atlantic Grid Interactive Cars Consortium) was created to develop, test and demonstrate V2G technology. The main players include academia and electric, automotive and communications industries (University of Delaware, PEPCO Holdings, PJM, AC Propulsion, Comverge, Atlantic County Utilities Authority). A test was conducted in the City of Newark with an electric car supplying energy to the local grid. The test was done to see if V2G can add stability to the grid with much wind power in the grid.

Figure 3-10 MAGICC project scheme

[7] http://www.edison-net.dk/WorkPackages/WorkPackage_3/8_EVs.aspx



Source: http://www.magicconsortium.org/photos/

Lately, Honda has joined the University of Delaware (supported by NRG Energy), to conduct a V2G demonstration project. The project demonstrates the technology controls, and suggests regulatory requirements along with market participation rules. A Honda Accord Plug-in Hybrid is used. The V2G system monitors the grid, and determines whether extra power sources than can respond rapidly when required. It can also determine whether there is an excess of power that needs to be absorbed. When such a supply unbalance occurs, the vehicle receives a signal from the grid operator, and charges/ discharges in accordance with the signals.

4 ISSUES OF EV/PHEV AND GRID INTERACTIONS AND INTERFACES

4.1 EV/PHEV and grid interactions and interfaces

4.1.1 Benefit of EV/PHEV and grid interaction

As mentioned in Chapter 3, it is possible to add new value to the EV/PHEV business through effective utilization of the interaction between vehicle and electrical grid specifically, smart charging, allows timely charging from power grid through interaction, to ease the impact on the grid load. Moreover, V2H, V2B and V2G technologies enable EV/PHEV to contribute as generators by discharging power from the battery. In order to realize that latent value of EV/PHEV, the interface between EV/PHEV and the charging infrastructure should be properly defined.

4.1.2 Issues of EV/PHEV and grid interaction

EV/PHEVs have not yet sufficiently spread, which prevents the full use of EV/PHEV grid interaction.

When the number of EV/PHEVs increases, they can be considered to be even more attractive than conventional vehicles, since they give utilities the opportunity to stabilize the grid, which is economical for both the utilities and the users. Furthermore, since EV/PHEV may be used both for transportation and storage of energy, they may be a benefit to the customers as a stationary storage battery or single purpose generator, in case of an emergency.

To implement the interaction of EV/PHEVs and the grid, the vehicle has to be connected to grid when needed. As data on how EV/PHEVs are used is often not collected, the use pattern of the vehicles, the total volume the vehicle can charge or discharge during a certain period of time and other relevant parameters are often unknown.

Therefore, it may be necessary to build a scheme to internationally share the EV usage data so as to obtain the expected charge/discharge volume, and to gain information on how to get EV/PHEVs to charge timely.

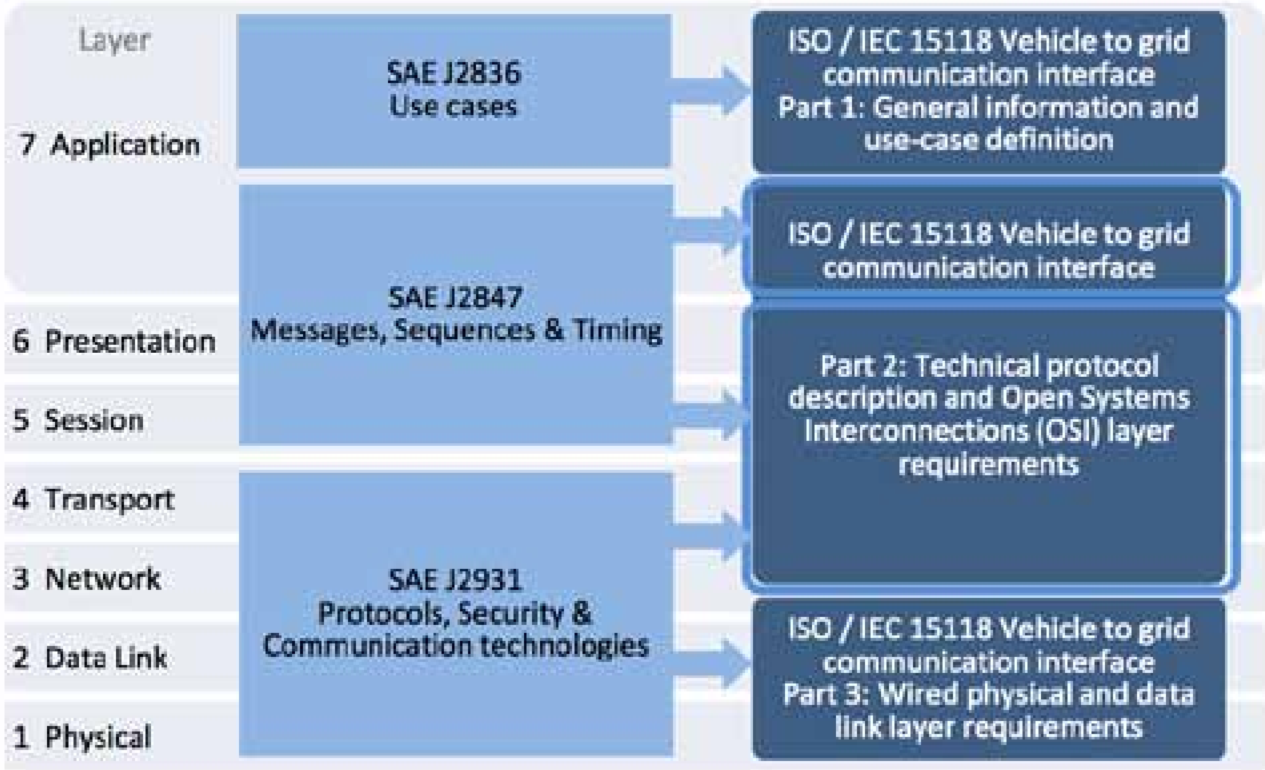
Large amounts of EV/PHEVs results in extra demand. It may have several negative effects on the grid. Firstly, EV/PHEVs connected during peak time may aggravate demand. Secondly, there may be an impact on the local distribution lines, with a need to upgrade to handle the higher peak load. Transformers may be overloaded during the night in case of smart charging. These problems can be partially solved through smart charging, peak shifting, and upgrading of the infrastructure.

As automobiles are global products, harmonization is key for OEMs, because of import/export, and vehicles crossing borders. It may be beneficial to the customers to have single standard for simplicity of use, total cost of infrastructures, and vehicle cost itself, which can be expected to drop through standardization. OEMs also hope to avoid multiple vehicle developments to comply with different standards. On the other hand, there are various perspectives of the safety of the power grids worldwide, due to historical backgrounds.

If the interface between EV/PHEV and grid varies according to countries and regions, an advanced use of EV/PHEV is hindered.

Discussions are ongoing at SAE and ISO/IEC on the interface standardization, particularly on the standardization of SAE J2836, SAE J2847, SAE J2931, linking with ISO/IEC 15118.

Figure 4-1 Status of SAE and IEC standards on EV/PHEV - grid interface



Source: SAE

Apart from these standardization activities, interfaces between EV/PHEVs and the grid have been considered by European Commission projects such as Green eMotion (DG-Move) and Mobi.Europe (DG-Connect).

Green eMotion is developing a market place system allowing the establishment of a clearing house for partners across 8 countries. The Mobi.Europe project is developing a different arrangement based on mobile phone technology for interoperability between Portugal, the Netherlands, Galicia in Spain and Ireland.

As mentioned earlier, the standards of the upper stream of the grid and in-home network remain different depending on countries and regions. Dissemination activities are done by SEP (Smart Energy Profile) 2.0 and OpenADR in the U.S. and KNX in Europe. While OEMs are expecting the harmonization of standards at IEC and ISO regarding automobiles, it is necessary to examine how to communicate via the different languages of the in-home/grid side in different regions. GSGF may actively contribute to the harmonization of grid standards and can share the outreach information, including the current issues of interaction between EV/PHEV and grid, encourage relevant parties to find a solution.

4.1.3 Roadmap of EV/PHEV interaction with grid

Roadmaps for EV/PHEV standards have already been created by EVSP (Electric Vehicle Standard Panel) in ANSI, and NPE (National Electric Mobility Platform) in Germany. Moreover, the EM-CG (Electric Mobility Coordination Group) established in accordance with the EU directive M468 is carrying out studies on EV/PHEV standards.

These American and European roadmaps for EV/PHEV standardization required about a year to prepare. Since the global perspective is needed when considering the interface between EV/PHEVs and the grid, GSGF can take up a role in making this global roadmap.

5 CONCLUSION

Necessity for promotion for the spread of EV/PHEV

E-Mobility is still in an emerging state. It is important to establish incentives in these first stages of dissemination, suitable for each region. Norway and the Netherlands serve as best practices. Such incentives need to be continued throughout the introduction stage, and afterwards they should be carefully and gradually phased out.

The use of EV/PHEVs can be expanded with the development of charging stations. They may not always be used heavily but offer a sense of ease to the drivers to drive without range anxiety, resulting in range extension, to substitute conventional vehicles.

Necessity for sustainable promotion measures

Preparing future large-scale deployment, there is a need to focus on sustainable incentives for both infrastructure and vehicle deployment to go hand in hand.

Necessity for standardization of interfaces between EV/PHEV and grid

As automobiles are global products, harmonization is key for OEMs, because of import/export, and vehicles frequently crossing borders. It may be beneficial to the customers to have single standard for simplicity of use, total cost of infrastructures, and also the cost of vehicle itself, expected to drop through standardization. Multiple vehicle developments to comply with standards are avoided. On the other hand, there exist various perspectives on the safety of power grids worldwide, due to historical backgrounds in each country and region.

If, under such circumstances, interfaces between EV/PHEVs and the grid vary according to country and region, an advanced use of EV/PHEV would be hindered. Standardization of interfaces is required.

Recommendation for policy makers.

Since battery technologies are still not sufficiently developed, EV/PHEVs are obliged to rely on the charging infrastructure. It is important to deploy adequate charging infrastructure before the spread of vehicles, and put in place the financial support to be maintained during the initial stages of deployment. As vehicle numbers increase, the infrastructure need to be expanded.

By developing public charging infrastructure, EV/PHEVs will be promoted, and the use of the infrastructure will increase.

It is recommended to share experiences and results of grid analyses where large amounts of EV/PHEV have been deployed, and to analyze the grids in areas planning to deploy more EV/PHEVs.

As technologies for EV/PHEV have proven to be ready through demonstration programs, it is necessary to consider use cases that enhance the value of EV/PHEVs, in addition to the driving itself. Analysis of shared EV/PHEV's usage data will help considering such use cases and to realize them, to increase the value of EV/PHEVs and enhance the attractiveness that cannot be given by conventional vehicles.

6 REFERENCES

(1) IEA, "GLOBAL EV OUTLOOK Understanding the Electric Vehicle Landscape to 2020" ,April 2013

http://www.iea.org/topics/transport/electricvehiclesinitiative/EVI_GEO_2013_FullReport.pdf

APPENDIX

Appendix A Members of the working group

Table A-1 Working group board member list

Name		Affiliation
Lead of the working group	Hiroshi Kuniyoshi	JSCA/ NEDO
Australia	Laurie Curro	Horizon Power
	Andy Zhao	The Univ. Newcastle
Canada	Alex Bettencourt	SmartGrid Canada
Denmark	Morten Broennum Andersen	The Danish Energy Association
Ireland	David Lee	IBM
	Darren Mawhinney	Glen Dimplex
Japan (JSCA)	Hiroshi Sano	NEDO
	Yoko Matsuzaka	NEDO
	Kunihiko Kumita	The Japan Automobile Manufacturers Association, Inc.
	Yuichiro Shimura	Mitsubishi Research Institute, Inc.
Korea	Hyeongi Lee	Korea Smart Grid Association
Norway	Helge Seljeseth	SINTEF Energy Research
Taiwan	Zong-Zhen Yang	Industrial Technology Research Institute (ITRI)

Appendix B Proposed Scope of GUII Work Group

Chairman: Hiroshi Kuniyoshi, JSCA/NEDO

This working group deals with grid user interactions and interfaces with special emphasis on electrical vehicles and small storage devices in residential and commercial buildings. The aim is to develop the necessary tools for enabling the customer to make choices regarding prices and energy sourcing, to organize the retail market and to introduce new services.

Electrification of automobiles is an effective way to implement CO_2 reduction and energy saving in the transport sector. For a larger effect, a higher rate of electrification is desired. Therefore, diffusion of vehicles equipped with large capacity batteries and connectable to the power system, like EV or PHEV (Plug-in Hybrid EV), is expected in the near future.

When we view the issue from the power system, the batteries in the vehicles could work as energy storage equipment at charging and as a distributed power source at discharging. In other words, batteries in EVs/PHEVs could work as a buffer for stabilizing the system. For EV/PHEV users, it might create further convenience if the charging and discharging is optimized.

The working group aims to sort out the present situation and potential subjects for future developments regarding activities toward EV/PHEV diffusion, interaction between EV/PHEV and the power system, and their interface. It studies and analyzes the outcomes to increase the people's interest in this type of mobility, in other words, demand, for EV/PHEVs, considering situations of each member's own country and region.

In order to ensure that we do not duplicate the work and outcome of the other workgroups we consider the following points:

- Sharing information on grid-connecting EV/PHEV (Actual cases of EV/PHEV diffusion, subsidies, systems, regulations and institutions)
- Identifying developments for the future
- (Obstacles on diffusion of EV/PHEV, problems at connection of EV/PHEV to the power system)
- Studying and analyzing the way to increase people's buying intentions considering the diffusion of EV/PHEVs

In order to set the scene, the workgroup aims to sort out the present situation and potential subjects for future developments regarding activities toward EV/PHEV diffusion, interaction between EV/PHEV and the power system, and their interface.

Based on the vision mentioned above, the charter was finalized in mid-January, and the workgroup is now going forward to set list of priority.

Using a questionnaire, information has been brought together on the following items:

1. What information the GUII-WG members can share
   Case Study, lessons learned
   Financial-supporting system
   Policy and regulatory
2. What you consider as challenges/issues to address from the viewpoint of EV mass
   introduction and interfaces between EV and the power system.

Appendix C Working group activities

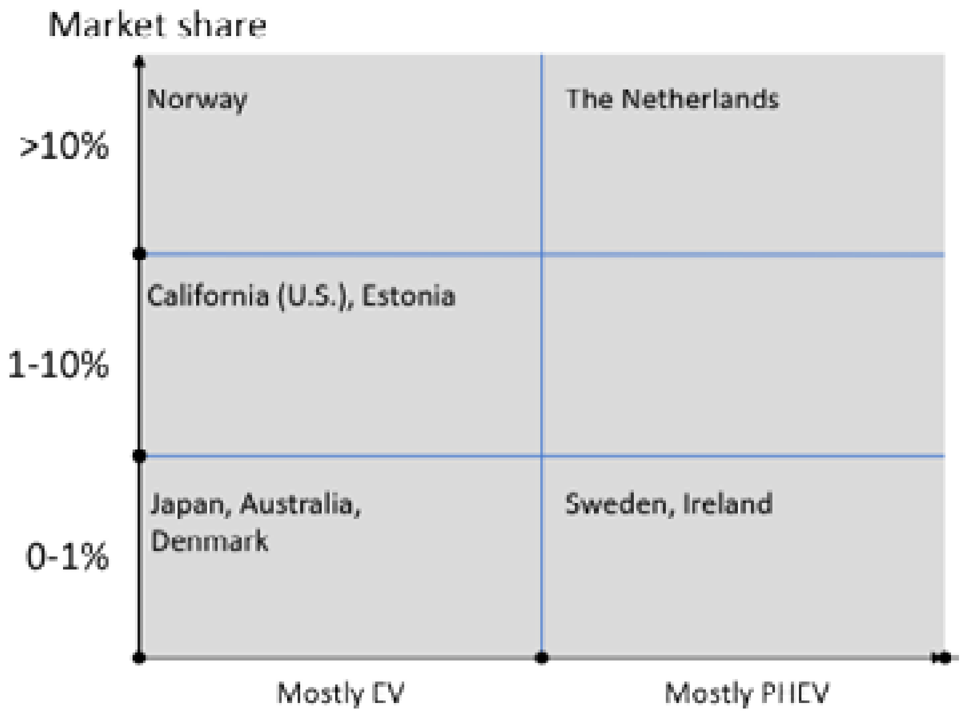
Table C-1 Working group activities

Dec. 2012	WG2 launched its activities. (Chair: JSCA)
Jan. 2013	Charter specifying the discussion contents of WG2 for the current fiscal year was prepared.
Feb. 2013	Charter completed based on the feedbacks obtained by the members.
Feb. 2013	Feedbacks were obtained from the members by e-mail on items to discuss.
Mar. 2013	Possible issues were raised during the panel discussion at the workshop in Brussels and the opinions were collected.
Apr. 2013	New members joined the working group.
Jul. 2013	Preparation started for the implementation of conference call.
Aug.2013	Teleconference by members.
Sep.2013	Input comments from members to the presentation material for workshop.
Oct.2013	Workshop in Seoul, Korea.
Nov.2013 Jan.2014	Prepared draft of white paper.
Feb. 2014	Input comments from members to the white paper.
Mar. 2014	Finalized Report

Appendix D Market shares of EVs

Below is a figure of the EV/PHEV level of shares of sold new vehicles in some of the relevant countries.

Figure D-1 Market share of EV/PHEV present sales



Appendix E JumpSmartMaui project

Below follows a more accurate description of the JumpSmartMaui (JSM) project undertaken on Hawaii.

The JSM project is currently in the demonstration phase for the smart grid testing business on the island of Maui in Hawaii. Hitachi has developed the use of smart grid technologies to enhance island electric power system operations and performance. It includes the capability to integrate distributed and central renewable energy, EV and controllable loads into the electric power system.

The objectives of the JSM project are:

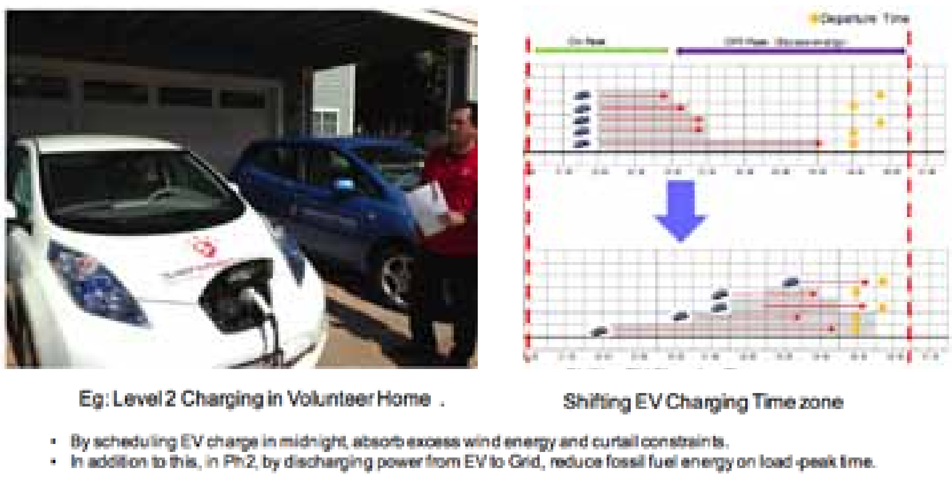
1. To provide a stable supply of electric power to customers through enhanced grid operability and reliability in an islanded environment with high penetration wind and solar power
2. To explore the capability to maximize the utilization of renewable energy on Maui
3. To provide a solution for the possible high penetration of electric vehicles the future Maui power grid
4. To leverage external resources to test new smart grid technologies and concepts in Hawaii and demonstrate their operation to other islanded grids around the world.

Salient features of the EV charging solution can be summarized as follows:

- An Electric Vehicle Energy Control Center (EVECC), installed at the Maui Electric's Data Center will monitor and control a network of charging stations throughout the island of Maui. The EVECC will also communicate with the network operation centers of the EV manufacturers to obtain charging forecasts for the utility, and to provide excess energy forecasts to the manufacturers to help the vehicles to use excess renewable energy when available.
- 20 Fast Chargers will be installed in strategic public areas to support the adoption of EV s throughout Maui.
- Level 2 EV chargers will be installed in volunteer premises. The level 2 EV chargers will monitor load and voltage.
- Micro-DMS is installed in Maui testing circuit area and at fast charging stations installed at distribution transformers that feed individual homes and the quick chargers. The micro-DMS will monitor the transformers for overloads and use voltage information to monitor voltage levels. It will also control EV charging to address any overload or voltage issues at the service voltage level.

The figure below provides one of the representative DR functionalities of the Level 2 EV charger on the project, which is addressed to absorb excess energy and shift load through scheduling the EV charging time.

Figure E-1 Example of DR with level 2 EV chargers



Appendix F Studies of grid impact of EV/PHEV introduction

In the following table is a selection of available reports and projects on the impact on the distribution grid, when EV/PHEVs are introduced.

Table F-1 Reports and projects on EV/PHEV impact on the distribution grid

Project/paper name	Author/organization	Date	Country	Summary
Impact of Plug-in Hybrid Vehicles on the Electric Grid	Oak Ridge National Laboratory (Stanton W. Hadley)	Oct-06	US	An analysis (peak demand, impact on transmission and distribution) of what if one million PHEV by 2018 entered in the VACAR subregion of Southeast Electric Reliability Council (South Carolina, North Carolina and part of Virginia) area using the Oak Ridge Competitive Electricity dispatch model (a model for simulating hourly dispatch of power generators to meet demand). It was found that local electricity demand increased by 1,400-6,000 MW (regular load of about 65 GW and supply power of around 80 GW) and that time management is needed. It also shows that for many customers, adding 1.4-6 kW to a residential feeder might lead to overload failure if they are not re-sized. Transmission lines feeding local substations may be similarly constrained if not upgraded. More investigations of the impact on transmission and distribution systems are needed. It was found that slow charging makes the peak smaller, and that higher summer peaks might become a problem.
Electric Vehicle Charging: Transformer Impacts and Smart Decentralized Solutions	IEEE: University of Vermont (Alexander Hilshey, Pooya Rezaei, Paul Hines, Jeff Frolik)	2012	US	Estimating aging impact of EV/PHEV charging on overhead distribution transformers, through Monte Carlo Simulation, especially looking at the different effects of slow charging vs. fast charging. Smart charging is deemed to be effective to minimize adverse effects, with smart charging speeding the aging process 12.8% vs. 49.4% for uncoordinated charging in the case of Level 1 charging, and 48.9% vs. 74.8% for Level 2 charging.
Evaluation of the Impact of Plug-in Electric Vehicle Loading on Distribution System Operations	EPRI (Jason Taylor, Arindam Maitra, Mark Alxander, Daniel Brooks, Mark Duvall)	Jun-09	US	A micro-level, i.e. local, analysis of the impact on the grid (distribution system; thermal loading, voltage regulation, transformer loss of life, unbalance, losses and harmonic distortion levels). Result: The system impact depends on the level of EV/PHEV penetration and charging behavior, thus the amount of EV/PHEV that can be introduced depends on the area. Utilities need to evaluate the distribution feeder levels to determine the possible levels of penetration.

Project/paper name	Author/organization	Date	Country	Summary
Technical Challenges of Plug-in Hybrid Electric Vehicles and the Impacts to the US Power System: Distribution System Analysis	PNNL (C. Gerkensmeyer, MCW Kintner-Meyer, JG DeSteese)	Jan-10	US	This paper tries to answer the three questions: (1) how many vehicles can the power delivery system support, (2) when would EV/PHEV be charged, (3) where would they be charged. An analysis of the impact on the grid in terms of the distribution system was made, involving residential feeder impact (load flow study) and distribution transformers. Conclusion is that noticeable impacts may or may not appear, depending on charging strategy and penetration level, and the philosophy of utilities to upgrade the system. System failures were rare except when the most aggressive charging strategies were applied, where new demand spikes appeared. When additional load from the EV/PHEV forces secondary distribution transformers to operate in excess of rated capacity over long periods of time, the life of these transformers is reduced.
The Impact of Domestic Plug-in Hybrid Electric Vehicles on Power Distribution System Loads	IEEE: University of Strathclyde (Sikai Huang/David Infield)	Oct-10	UK	A Monte Carlo Simulation was developed to simulate the impact on the distribution system by EV/PHEV charging. The simulation can be used for distributors to analyze the power flow in their system. The research also shows that the additional maximum load on the system increases greatly at relatively low levels (20%) of penetration. Countermeasures (upgrading of distribution transformer and lines, performing smart charging) need to be taken in order not to put too much pressure on the system.