DRAFT REPORT

Stock-Take of Electric Vehicle Interface with Electricity and Smart Grids Across APEC Economies and the Potential for Harmonisation

June 2012

Presented at:

APEC Electric Vehicle Connectivity Workshop 2012

APEC Project [insert project number]

Produced by:

Verdant Vision Pty Ltd.
Dr. Andrew Simpson at Andrew@verdantvisiongroup.com or
Ms. Alina Dini at Alina@verdantvisiongroup.com

For:
APEC Secretariat
35 Heng Mui Keng Terrace
Singapore 119616
Tel: 65 6891 9600
Fax: +65 6891 9690
Email: info@apec.org

APEC Publication Number [*to be assigned*]

Contents

1. Introduction 11
  1.1. What is Electric Vehicle Connectivity? 12
  1.2. Background on PEV Connectivity within APEC 13
    1.2.1. Who is APEC? 13
    1.2.2. The APEC Energy Working Group and Energy Ministers 14
    1.2.3. Progress on PEV Connectivity Issues by APEC 15
  1.3. About This Project 18
  1.4. Draft Report on EV Connectivity Conditions 19
2. Scope of Work and Methodology 20
  2.1. Scope of Work 20
    2.1.1. PEV Connectivity Architectures 20
    2.1.2. The EV Marketplace 22
  2.2. Methodology 23
    2.2.1. Identify and Survey Key Stakeholders 23
    2.2.2. Desktop Research 26
    2.2.3. Analysis 26
    2.2.4. Preliminary Reporting 27
3. Plug-in Electric Vehicles 28
  3.1. Market Development 28
    3.1.1. Experience with PEVs 28
    3.1.2. Local Production vs. Import 30
    3.1.3. Market Maturation Framework 31
  3.2. Policy Activity 35
  3.3. Deployments and Trials 39
  3.4. Market Size and Forecasts 40
    3.4.1. Current Market Size 40
    3.4.2. Forecast Growth 42
4. Recharging Infrastructure 45
  4.1. Conductive Charging 45

4.1.1. Alternating Current (AC) ... 46
4.1.2. Direct Current (DC) ... 49
4.2. Other Applications ... 51
4.2.1. Inductive Charging ... 51
4.2.2. Battery Swap ... 52
4.3. Vehicle-to-Grid (V2G) or Vehicle-to-X ... 53
4.5. Standards and Regulations ... 55
4.6. Market Development and Themes ... 59
5. Electrical Grid Characteristics ... 62
5.1. Overview of Grid Function ... 62
5.2 Peak Demand / Load ... 63
5.3 Smart Grid ... 63
6. Potential barriers for the trade of PEVs across APEC Economies ... 66
6.1. Overview of Trade Barriers ... 66
6.1.1. Definition of Technical Barriers to Trade ... 66
6.1.2. Significance of EV Connectivity Technical Barriers to Trade ... 66
6.2. Overview of Standards and Regulations in the PEV Market ... 67
6.2.1. Evolution and Use of Standards and Regulations in the PEV Market ... 67
6.2.2. Definition of EV Connectivity Technical Barriers to Trade ... 68
6.3. PEV Connectivity Technical Barriers to Trade ... 68
6.3.1. Charging interfaces ... 69
6.3.2. Network interfaces ... 74
6.3.3. Electrical safety ... 79
6.3.4. Energy market arrangements ... 80
6.4. Other PEV Barriers to Trade ... 81
6.4.1. Vehicle homologation requirements ... 81
6.4.2. Other local market factors ... 81
7. Opportunities to remove barriers to trade of PEVs ... 83
7.1. Prioritization of Barriers ... 83
7.2. Recommended Actions ... 86

7.2.1. Significant barriers that are easy to overcome 86
7.2.2. Significant barriers that are hard to overcome 87
7.2.3. Summary of recommended actions 89
8. Conclusions 91
9. References 93

Figures

Figure 1: Barriers to trade of PEVs arising from connectivity conditions 11
Figure 2: The PEV connectivity landscape 12
Figure 3: Map of APEC Member Economies (New Zealand MFAT). 14
Figure 4: Key Dimensions of EV Connectivity Architectures (Verdant Vision) 21
Figure 5: A framework for the EV marketplace (Verdant Vision) 23
Figure 6: EV Connectivity Survey Responses by APEC Member Economy 25
Figure 7: EV Connectivity Survey Responses by Type of Organization 26
Figure 8: Number of Years PEVs Have Operated in APEC Economies 28
Figure 9: Predominant PEV Powertrain in APEC Economies 29
Figure 10: Perceived Familiarity of Each Type of PEV in APEC Economies 30
Figure 11: Projected Battery Electric Vehicle Share of Sales in Select Asian Economies (Arthapan) 31
Figure 12: Explanation of PEV Market Maturity Categorization 32
Figure 13: APEC Member Economies Classified by PEV Market Maturity 33
Figure 14: PEV Market Maturity with Urbanization and Per Capita GDP 34
Figure 15: Perceived Drivers for PEV Market Activity 35
Figure 16: Perceived Government Support for PEVs 36
Figure 17: Volume of Current PEV Deployment per APEC Economy 41
Figure 18: PEV sales by country 2011-2012 (Trigg et al) 42
Figure 19: Forecast PEV Sales in Asia Pacific to 2015 (Pike Research) 43
Figure 20: Forecast PEV sales by Manufacture to 2020 (Trigg et al) 44
Figure 21: International Summary of Charging Connector Types (Francfort) 46
Figure 22: Two Mostly Likely Scenarios for Home Recharging 47
Figure 23: Two Mostly Likely Scenarios for Home Recharging 49
Figure 24: Example of DC Fast Charger in Public Car Park (Ecotality) 50
Figure 25: Diagrammatic example of HaloIPT Wireless Charging System (Qualcomm). 51
Figure 26: Example of Better Place Batter Swap Station (Better Place) 53
Figure 27: Potential for Monetizing PEV Electricity 54
Figure 28: List of Key Standards for PEV Recharging Globally 56
Figure 29: Conductive PEV AC Recharging Coupler Standards in Used APEC 57
Figure 30: DC Charging Standard Options (Roy). 58
Figure 31: Proposed Universal or Combination Connector (EU variant) 59
Figure 32: Public EVSEs through the EV Project in the USA. 60
Figure 33: Basic Electric Grid Characteristics by APEC Economy 62
Figure 34. Diagrammatic Representation of Smart Grid (EPRI) 64
Figure 35: Prevalence PEV Recharging Infrastructure Types in APEC Economies 70
Figure 36: Common terminology for conductive charging scenarios 71
Figure 37: Ranking of barriers to trade of PEVs 84
Figure 38: Classification of barriers to trade of PEVs 86
Figure 39: Barriers for PEV market establishment in APEC 89

Consultation

As APEC is a trade organization representing the interests of 21 Economies, this report reflects broad consultation of APEC Economy stakeholders with interests in plug-in vehicle connectivity. While we have taken great care to ensure data is accurate and wholly represented, some information may require review and improvement prior to the final publication of this report in August 2012.

A consultation period for this paper will commence from the date of its draft publication in June 2012 and **will close on Friday, 20 July 2012**, for a period of approximately four weeks.

Verdant Vision, the consultancy leading this research, welcomes input or comment to this report. Contributions are invited by via the following methods:

- **Completion of the web-based APEC EV Connectivity Survey**

  Survey submissions will remain open for the duration of this project. Any person or agency with interest in completing the survey on behalf of their Economy is invited to do so. For APEC Economies that have little or no representation through the survey process, your participation is encouraged. Please email the contact below for a personalized invitation to the survey, or visit https://www.surveymonkey.com/s/ZLKBXVW

- **Feedback via email**

  Any additional comments, feedback or suggested additions to the report may be submitted via email to the contact address listed below. Feedback provided by email will be kept confidential and will not be published but will be considered in analysis undertaken by the consultants prior to publishing the final draft of this report. If providing written consultation on this report, please be sure to include your name, contact details, the name of the organization and the APEC Member Economy you represent best.

- **Feedback via personal interview**

  Comments on this report may also be provided verbally through an in-person meeting (subject to geographic limitations) or via telephone or Skype through an established appointment time. To request a time for a verbal interview, please contact Verdant Vision per the details below.

Contact details for feedback on this report are as follows:

Ms. Alina Dini
Director, Verdant Vision
Phone: +61 (0) 420 796 009
Email: alina@verdantvisiongroup.com
Web: www.verdantvisiongroup.com

Abbreviations and Acronyms

APEC	Asia-Pacific Economic Cooperation
AC	Alternating Current
ACEA	European Automobile Manufacturers Association
ANSI	American National Standards Institute
DC	Direct Current
EECA	New Zealand Energy Efficiency Conservation Authority
EGNRET	Expert Working Group on New and Renewable Technologies
EMC	Electro-Magnetic Compatibility
ESV	Electric Stand-up Vehicles
EVCTBTs	EV Connectivity Technical Barriers to Trade
EVSE	Electric Vehicle Supply Equipment
EWG	Energy Working Group (through APEC)
GHG	Greenhouse Gas
GPO	General Power Outlet or General Purpose Outlet
IEA	International Energy Agency
IEC	International Electro technical Commission
LHD	Left-Hand Drive
MOU	Memorandum of Understanding
NEV	Neighborhood Electric Vehicle
OECD	Organization for Economic Co-operation and Development
OEM	Original Equipment Manufacturer

OECD	Organization for Economic Co-operation and Development
PEV	Plug-in Electric Vehicle (also referred to as "EV" for "electric vehicle")
RHD	Right-Hand Drive
SAE	Society of Automotive Engineers
TIR	Technical Information Reference
UNEP	United Nations Environment Programme
V2G	Vehicle-to grid
V2X	Vehicle-to-X

1. Introduction

Plug-in electric vehicles (PEVs) are part of a new wave of clean vehicles emerging in global markets. They are broadly known for their ability to reduce dependency on petroleum, improve urban air quality, reduce greenhouse gas (GHG) emissions from the transport and energy sectors, and strengthen local industry research and development.

PEVs are also often characterised by their potential to catalyse transformative change in the energy sector. However, scale-up of this highly-anticipated technology is dependent upon appropriate regulatory settings within markets and increasing PEV trade between markets internationally.

In particular, electric vehicle "connectivity conditions" such as current electric grid configurations and policies, standards and regulations for infrastructure and markets have a direct bearing on trade of PEVs and charging equipment between markets. These connectivity conditions govern how PEV equipment may be used, and regional differences in connectivity conditions can thereby create barriers to trade between markets and impede PEV uptake across the Asia-Pacific region. These potential barriers to trade of PEVs (Figure 1) are the primary concern for this study.

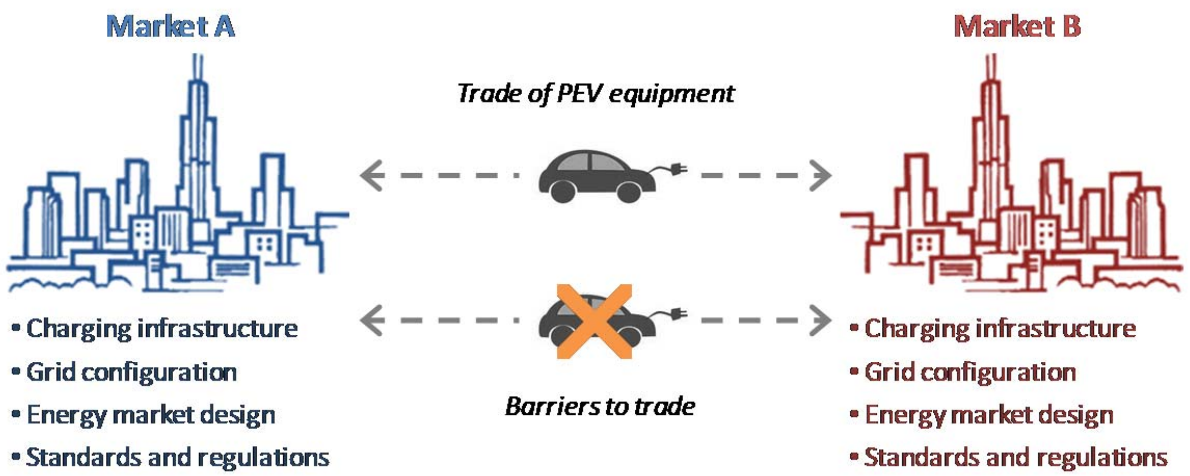

Figure 1: Barriers to trade of PEVs arising from connectivity conditions

1.1. What is Electric Vehicle Connectivity?

Electric vehicle connectivity conditions include current electric grid configurations and policies, standards, and regulations for infrastructure and markets relating to PEVs. The concept of connectivity implies a network, as can be shown by the diagram in Figure 2. The PEV connectivity landscape includes networks in the physical domain for the transfer of electrical power and exchange of information, which support transactions in the commercial domain around a variety of mobility and energy services. It is the policies, standards and regulations governing the interfaces between these elements of the system that define the connectivity conditions in a PEV market. In theory, a PEV trade barrier can occur due to any of these conditions, and in practice they often do.

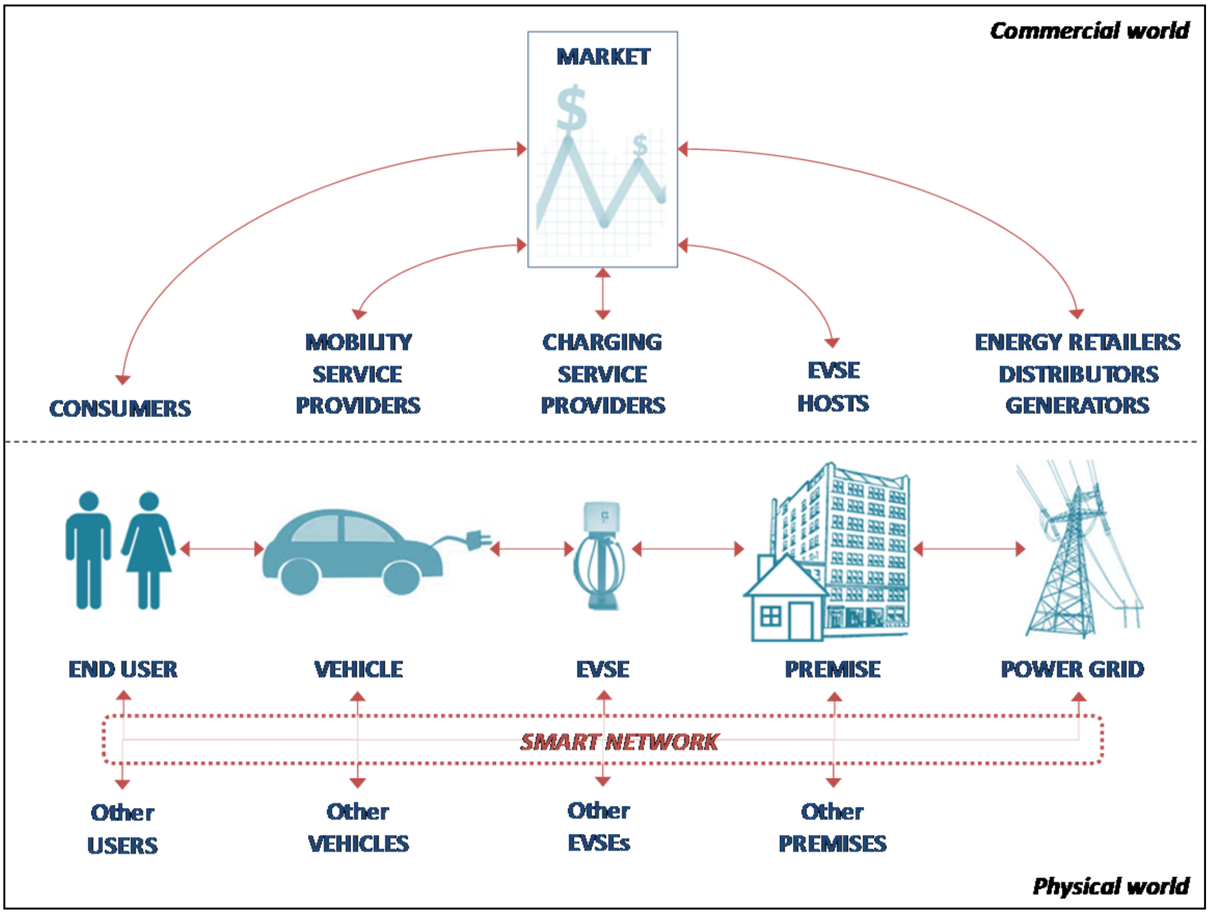

Figure 2: The PEV connectivity landscape

1.2. Background on PEV Connectivity within APEC

1.2.1. Who is APEC?

Asia-Pacific Economic Cooperation (APEC) is the premier forum for facilitating economic growth, cooperation, trade and investment in the Asia-Pacific region. APEC has 21 Members Economies that in total account for approximately 40 percent of the world's population, approximately 54percent of world GDP and about 44 percent of world trade.

The APEC Member Economies are:

- Australia
- Brunei Darussalam
- Canada
- Chile
- People's Republic of China
- Hong Kong, China
- Indonesia
- Japan
- Republic of Korea
- Malaysia
- Mexico
- New Zealand
- Papua New Guinea
- Peru
- The Republic of the Philippines
- The Russian Federation
- Singapore
- Chinese Taipei
- Thailand
- United States of America
- Viet Nam

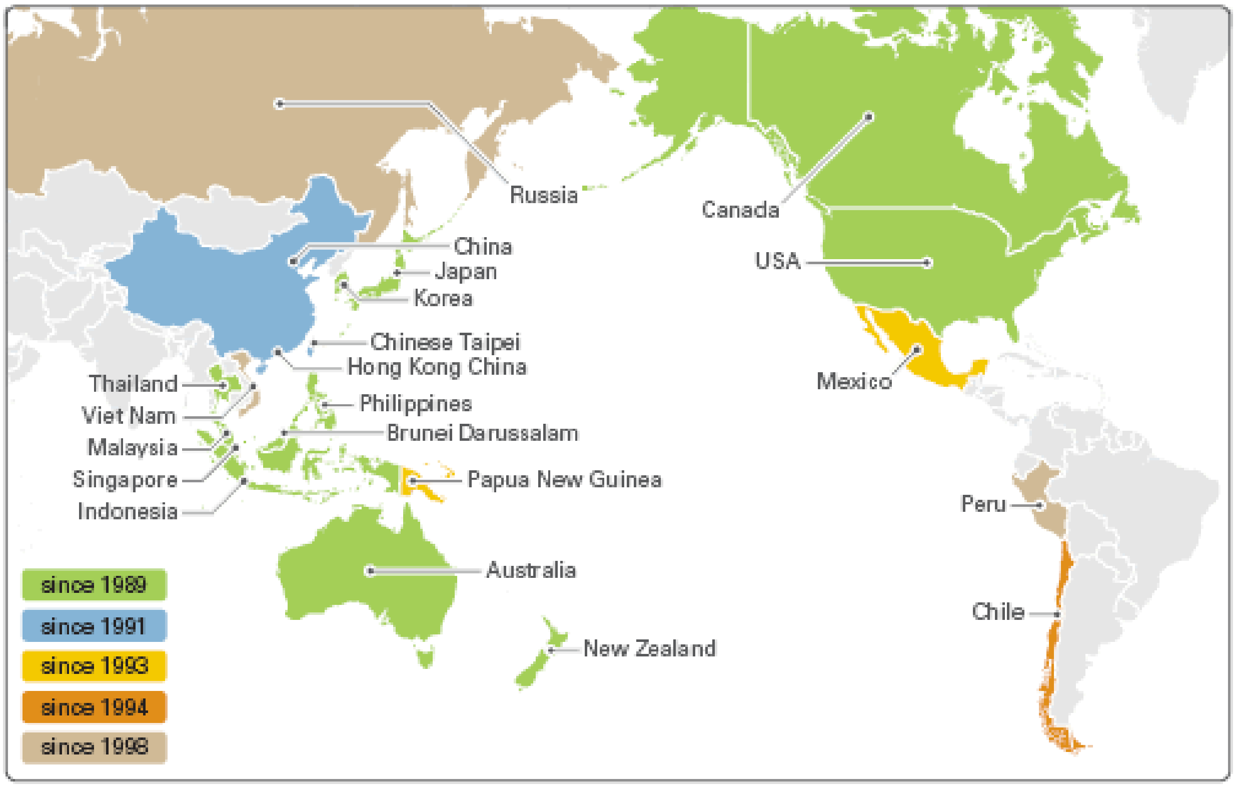

Figure 3: Map of APEC Member Economies (New Zealand MFAT).

1.2.2. The APEC Energy Working Group and Energy Ministers

The APEC Energy Working Group (EWG) is a voluntary, regional-based forum operating under the APEC umbrella. EWG helps further APEC goals to facilitate energy trade and investment, and ensure that energy contributes to the economic, social and environmental enhancement of the APEC community. The EWG was launched in 1990 and seeks to maximize the energy sector's contribution to the region's economic and social well-being, while mitigating the environmental effects of energy supply and use.

APEC Energy Ministers meet regularly to endorse work done by the EWG and also to direct future work of the Group. In their Declaration at Fukui, Japan in June 2010, the Ministers noted:

- "*the potential fuel and carbon savings from electrification of the transport sector, energy efficient freight, transit-oriented development and other energy-efficient transport strategies*;"

- that "*smart grid technologies…can help to integrate intermittent renewable power sources and building control systems that let businesses and consumers use energy more efficiently*"; and

- that "*introduction of low-carbon technologies…is vital to manage rapidly growing energy consumption in urban areas.*"

1.2.3. Progress on PEV Connectivity Issues by APEC

APEC has investigated the impacts and opportunities associated with the developing global[1] PEV market in the last few years through the EWG and its expert subgroups, most notably the Expert Working Group on New and Renewable Technologies (EGNRET). However, APEC consideration of PEVs has also occurred through the following other committees:

- *APEC Regulatory Cooperation Advancement Mechanism* on Trade-Related Standards and Technical Regulations (ARCAM)
- APEC Energy Smart Communities Initiative (ESCI)
- APEC Smart Grid Initiative (ASGI)
- The Transportation Working Group (TPTWG)
- The Industrial Science & Technology Working Group (ISTWG)
- Subcommittee on Standard and Conformance (SCSC)
- The Asia-Pacific Energy Research Centre (APERC)
- Expert Group on Energy Efficiency and Conservation (EGEE&C)

Using Smart Grids to Enhance Use of PEVs

In May 2011, the EWG published a report on "*Using Smart Grids to Enhance Use of Energy-Efficiency and Renewable-Energy Technologies*" including PEVs. In particular, the report noted that:

"*Market adoption of PEVs in APEC over the next 50 years will depend on the ability of each member Economy's electrical grid to accommodate the additional strain placed upon it by large-scale penetration of PEVs.*"

"*Smart grid capabilities support PEV deployment through real-time pricing structures, bi-directional energy flows, bi-directional metering, and vehicle-to-grid applications... These elements encourage greater market adoption by enhancing the customer's return*

[1] Noting that activity outside of APEC Member Economies also has some bearing on the Asia-Pacific.

on investment and minimize the need to invest in infrastructure to meet the demands placed on the electrical grid."

PEVs in Smart Grid Interoperability Standards

Also in May 2011, ARCAM held a dialogue on Smart Grid Interoperability Standards including consideration of PEVs. Outcomes from the dialogue noted that:

"*The two main hurdles to EV adoption are battery technology and charging infrastructure...*" [and that] "...*EV to grid interaction can have a positive or negative influence both on the consumers experience and on grid operations.*"

"*To enable the successful adoption of EVs worldwide, standards that support the diverse charging methods, business and consumer needs and Government policies are needed… Interoperability and harmonization of standards on an international scale (and therefore the standards development organizations) are needed…* [to]*… open economic markets, reduce costs and improve reliability... A comparison of national and regional policies, business goals and use cases to find commonality will be useful, particularly if done in a timely fashion to help technical experts make decisions in the development of supporting international standards."*

"…APEC Economies produce a significant share of the automobiles sold in the global market, so the policy directions of APEC members can carry weight in the global dialogue... APEC members should explore the development of an APEC vision statement on harmonized standards for EV charging and for battery swapping."

Benefits of PEVs

In October 2011 in Hong Kong, the EWG led a Workshop on Energy and Green Transport Benefits of Electric Vehicles to "*build interest among the workshop participants of the green benefits brought from the use of electric vehicle, and to encourage wider application as well as trade and investment in electric vehicles, energy storage facilities and the related charging infrastructures to facilitate the transfer of fossil fuelled to electric driven vehicles.*" During the three-day workshop, seven APEC Economies provided an overview of their individual progress on PEV policy and market development and discussed areas of further work. The workshop attracted participation of 15 APEC Economies as well as Switzerland, Portugal, Germany and Macau with over 150 individual attendees (APEC EWG Energy and Green Transport).

The 40-page Hong Kong PEV workshop report was published in January 2012, and the summary of the proceedings notes that "*Appropriate measures could be brought into* *practice to overcome the deficiencies of an EV and challenges of adopting EVs... delegates discussed and shared their experience of executing feasible means from mainly three areas in Policy, Infrastructure and Technology.*"

Delegates also identified areas for future work to assist the development of PEV markets in APEC Economies. For PEV Connectivity, the specific suggestions were:

- "*Further study of EV infrastructure business models for different cities and different kinds of consumers in order to optimize utilization and providing a consumer with more convenient driving experience.*"
- "*Acceleration of harmonizing standards of electric vehicle and charging infrastructure within a market including the charging voltage, current, power, protocol and charging plug in order to eliminate the uncertainty of EV business.*"

In addition, opportunities were identified for regional cooperation between APEC Economies to enhance the development of PEV markets. For PEV Connectivity, the suggested collaborations were:

- "*Cooperation between automobile manufacturers to standardize charging interface, protocol and other issues related to EVs.*"
- "*Establishment of information sharing network among APEC Economies for exchanging the EV policies, market information, EV adoption experience and other relevant information/data.*"
- "*Cooperation between neighbouring Economies/countries to harmonize the standards for boundary crossing EVs.*"

PEVs in Smart Grid Roadmaps

In March 2012, a Progress Report on the APEC Smart Grid Initiative (ASGI) discussed a Road Map for Development of Electric Vehicle Charging Infrastructure. The report noted the outcomes from the Hong Kong PEV workshop and, in addition to those listed above, highlighted that "*an important finding from the workshop discussion is that development of EV markets can enhance power grid operations."* In this regard, "*Standardization of the charging infrastructure, providing a harmonized communications protocol between utilities and EVs, would be helpful, as would a variety of charging modes and locations, ranging from low-voltage plugs in buildings for slow charging to dedicated high-voltage charging units for rapid charging.*" The report also noted that this current project would be the next tranche of work completed by APEC in the area of PEV Connectivity.

1.3. About This Project

In November 2011, the New Zealand Energy Efficiency Conservation Authority, as project sponsor on behalf of the APEC EGNRET, issued a Request for Proposals for:

Stock-Take of Electric Vehicle Interface with Electricity and Smart Grids across APEC Economies and the Potential for Harmonization (EWG 11/2011)

The project set out to survey PEV connectivity conditions throughout APEC Economies including current grid configurations and policies, standards and regulations for PEV infrastructure and market development. They key objectives were to identify potential barriers to international trade of PEVs and recommend areas of cooperation between APEC Economies where harmonization of standards and regulations might reduce trade barriers.

Verdant Vision successfully tendered for this project which formally commenced in January 2012. Key participants supporting the delivery of the project include:

New Zealand Energy Efficiency and Conservation Authority (EECA)
EECA is the New Zealand Government's lead agency to encourage, support, and promote energy efficiency, energy conservation, and the use of renewable energy in New Zealand. EECA secured funding from APEC for this project and provides oversight and operational control of the project on behalf of APEC.

More information about EECA is available through their website:
http://www.eeca.govt.nz/

APEC Expert Group on New and Renewable Energy Technologies (EGNRET)
Under the APEC Energy Working Group, the mission of the EGNRET is to facilitate an increase in the use of new and renewable energy technologies in the APEC region. For this project, the representatives from this Expert Group provide key input to the survey process and will review and provide feedback on the findings of the study.

More information about EGNRET is available through their website:
http://www.egnret.ewg.apec.org/index.html

Verdant Vision
Verdant Vision is an Australian company and leading international provider of trusted, independent, expert services for electric vehicle readiness, deployment and evaluation

in the Asia-Pacific region. Our Principals have a combined 20 years of deep experience in PEVs through roles in private industry, Government and academia in both North America and Australia. Verdant Vision promotes the global uptake of PEVs by serving all segments of the market including industry, consumers, infrastructure and policy.

More information about Verdant Vision is available through our website: http://verdantvisiongroup.com/

1.4. Draft Report on EV Connectivity Conditions

This report presents the draft findings from this project, based on information garnered on PEV Connectivity Conditions in APEC Economies at the time of writing. However, it is important to note that some gaps remain and the process of surveying and other data collection for the project may continue up until the time of publication of the final report.

The report contents are as follows:

- Chapter 2 describes the overall scope and methodology for the project.
- Chapter 3 summarises the current status of plug-in electric vehicle deployments in APEC Economies, including policy support and forecasts for future uptake.
- Chapter 4 summarises PEV connectivity conditions in APEC Economies.
- Chapter 5 outlines grid conditions in APEC Economies including smart grid.
- Chapter 6 identifies potential trade barriers for PEVs across APEC Economies.
- Chapter 7 presents opportunities for cooperation between APEC Economies to significantly reduce barriers to trade of PEVs.
- Chapter 8 concludes the report, followed by References and Appendices (in the final report).

These draft findings will also be presented at the APEC Electric Vehicle Connectivity Workshop in June 2012 and will be revised prior to final publication in August 2012.

2. Scope of Work and Methodology

2.1. Scope of Work

This project has surveyed all 21 APEC Member Economies to consider the current status of PEV connectivity and grid features and developments in the various markets for plug-in electric vehicles in the Asia-Pacific region.

In terms of vehicle types, the focus of the study was primarily on light-duty passenger vehicles (i.e. cars), however, as the travel demography of many APEC Economies includes two- and three-wheeled vehicles such as bicycles, tricycles, scooters and motorbikes, these have also been considered. Heavy duty road vehicles such as trucks or buses have been surveyed, but are not reported in depth. In general terms, the focus of this study is centered on mass-produced vehicles as they are most likely to be traded between APEC Economies, however for the sake of gathering current and forecast data, no vehicles (i.e. after-market conversions) have been excluded.

In terms of charging infrastructure types, all forms of electric vehicle supply equipment (EVSEs) have been considered, including standard residential or commercial outlets.

For analytical purposes, the following theoretical framework has been applied to the scope, considering the following two primary areas of investigation:

(1) **PEV Connectivity Architectures** – including existing and planned electrical grid features and policies of APEC Economies relating to EV deployment and charging.

(2) **The PEV Marketplace** – including the current and projected EV deployment, charging infrastructure, and charging practices across APEC Economies.

2.1.1. PEV Connectivity Architectures

PEV connectivity with the grid is often characterized by unknowns – there are risks that insufficient infrastructure will be provided for early PEV adopters (the commonly cited 'range anxiety' issue) vs. the risk that stakeholders will overspend on public infrastructure that ultimately may not be well-utilized once PEV user behaviors have matured. Furthermore, in the context of PEV network loading, there are possible benefits to the network (e.g. increased asset utilization) as well as possible risks (e.g.

impact on peak demand due to coincident recharging loads). Finally there are numerous potential issues around PEV connectivity interoperability.

Stakeholders can manage uncertainties around the current and future evolution of PEV connectivity architectures by defining the key dimensions that fully characterize this infrastructure. Definitions of the key attributes of a PEV connectivity point are expanded in Figure 4 below. It is these attributes that may vary between APEC Economies, and that may also vary in the PEV infrastructure provided in the marketplace over time, as a result of regulatory/standards development and evolving market preferences.

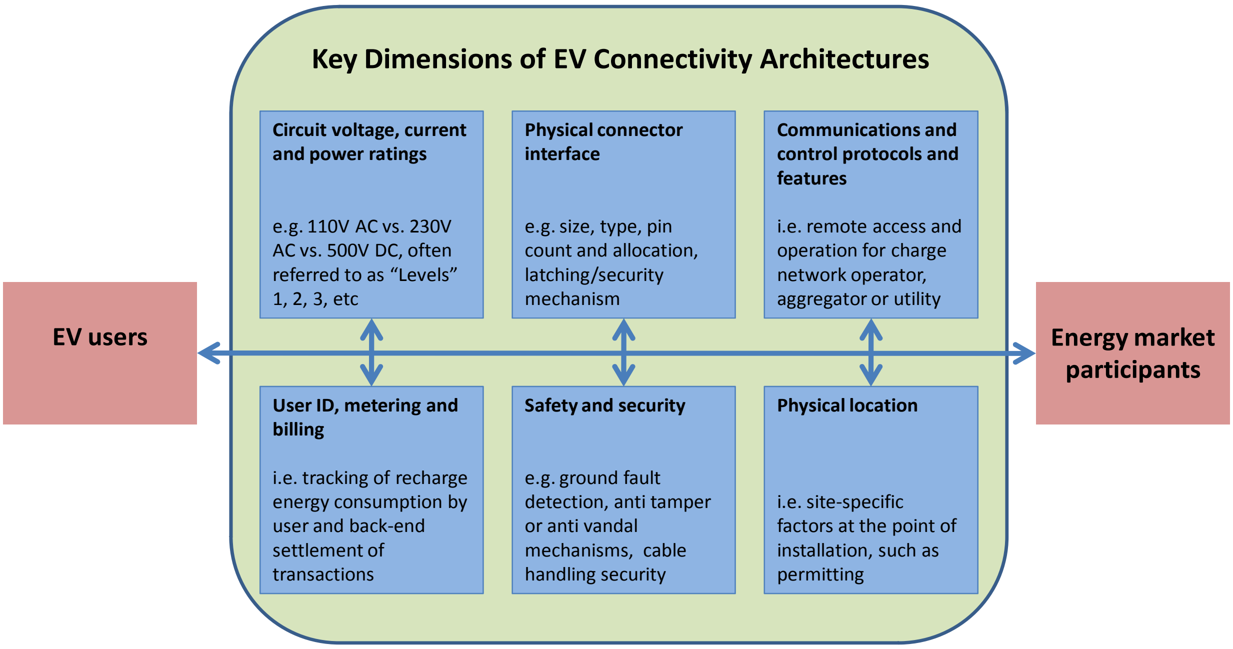

Figure 4: Key Dimensions of EV Connectivity Architectures (Verdant Vision)

In terms of PEV and grid interplay, this project has studied existing and planned electrical grid features and policies of APEC Economies in reference to:

- Plug-in electric vehicle and charging and market development;
- Grid characteristics (e.g. household voltages, peak load duration, interoperability);
- Standards and regulations that will/may apply to EV charging, connectivity, and/or interoperability; and
- Planned grid developments, with specific attention to smart grid development initiatives.

2.1.2. The EV Marketplace

Like many new technologies, PEVs offer market innovation, excitement and in this case 'green' branding, making them potentially very popular at a large scale in both popular culture and public policy. However, underlying this enthusiasm for PEVs is also a transformational change – a web of unprecedented activity between the electricity and automotive sectors, increasing the proliferation of electricity as a transport fuel. While it is logical that PEVs require plugs and sockets, a surprising interplay has developed between the automotive and electricity retail sectors through the formation of an entirely new market for PEV recharging networks (a.k.a. PEV connectivity networks). This transformation requires close coordination in development of new technical standards and regulations – across various sectors and throughout all levels of Governments internationally.

Figure 5 provides the Verdant Vision high-level view of the key actors and their roles in the emerging PEV marketplace. It must also be stressed that the dividing lines between stakeholders are becoming increasing blurred, as they play multiple roles or expand into new areas of the market, or based on the emergence of new stakeholders. For example, a local Government can simultaneously play the roles of *infrastructure provider*, *energy provide*r, *corporation* with its own fleets and buildings, *transport planner* and *transit operator*, and *land developer*, in addition to providing *public policy and regulatory settings* for the EV marketplace.

To capture the current state of the PEV market in APEC Economies, this study provides summaries of current and projected PEV deployment, charging infrastructure, and charging practices across all APEC Economies, including:

- Existing and projected numbers of PEVs; and
- Existing and projected charging infrastructure of all types.

Finally, the study analyzes the research and survey findings with specific attention to similarities and differences across APEC Economies, including identification of potential barriers for the trade of PEVs and potential areas of cooperation between APEC Economies (to reduce those barriers).

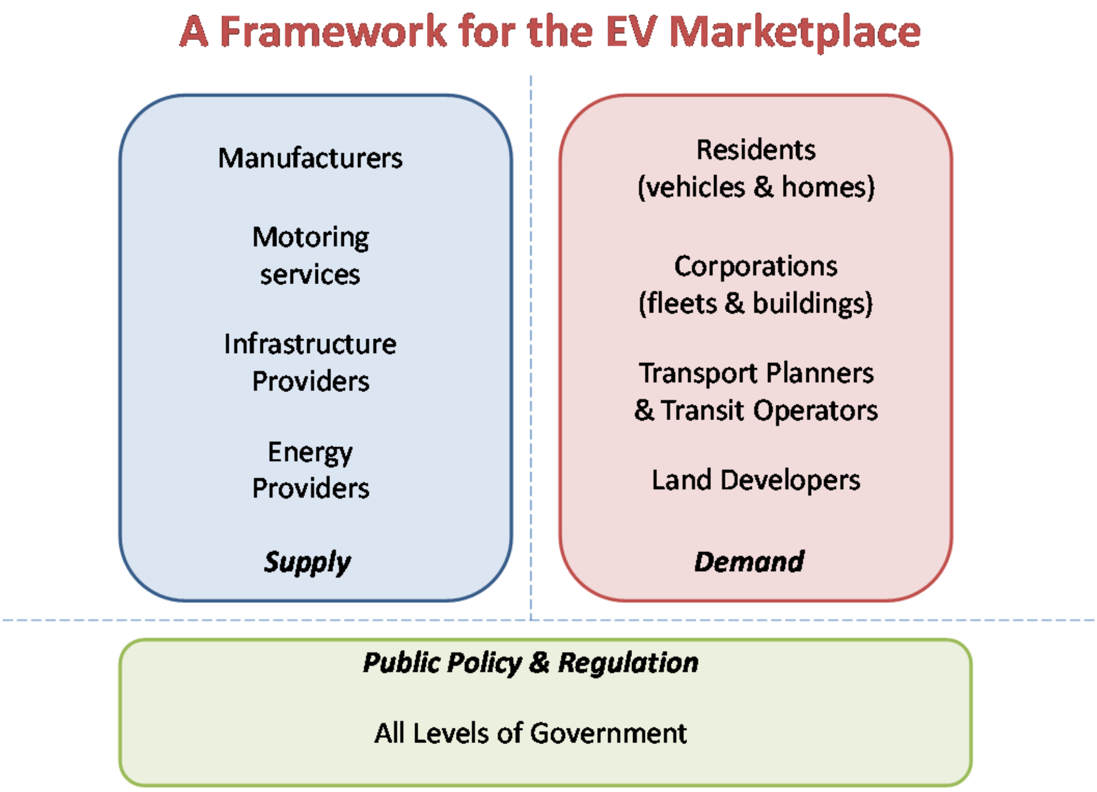

Figure 5: A framework for the EV marketplace (Verdant Vision)

2.2. Methodology

The project has been undertaken by Verdant Vision via four main areas of activity:

- Stakeholder Identification and Engagement
- Desktop Research
- Analysis
- Preliminary Reporting

2.2.1. Identify and Survey Key Stakeholders

Interaction with APEC stakeholders was central to delivery of this project and was conducted via three key steps.

Travel

The project budget did not include allocation for dedicated travel to meet with stakeholders or significant consultant time to conduct telephone interviews, therefore the primary method of data capture was via electronic survey and desktop research. However, Verdant Vision was able to leverage other business travel to engage directly with a broad array of stakeholders:

- January 2012 – Verdant Vision travelled to the USA and conducted numerous expert interviews with stakeholders in California and Colorado.

- February 2012 – Verdant Vision presented to a meeting of the APEC Expert Group on Energy Efficiency and Conservation in Sydney, which also coincided with the inaugural event of the Australian Alliance to Save Energy.

- May 2012 – Verdant Vision travelled to the USA and conducted further expert interviews in California. This trip coincided with the 26th International Electric Vehicle Symposium (EVS26) and the inaugural World Electric Vehicle Cities and Ecosystems Conference, both held in Los Angeles, and provided excellent opportunities for stakeholder engagement and additional data capture from North America, Latin America, Asia and Europe.

- June 2012 – Verdant Vision will attend the upcoming APEC PEV Connectivity Workshop in Wellington, New Zealand to provide a further opportunity for engagement with APEC EGNRET representatives.

- July 2012 – Verdant Vision will deliver an electric vehicle connectivity workshop on behalf of IBC Asia in Hong Kong that should provide further opportunities for engagement with Asian stakeholders.

Verdant Vision has achieved a very significant amount of travel and face-to-face interaction with APEC stakeholders despite the limited travel budget for the project.

Questionnaire for Stakeholder Engagement

As a first step EGNRET Member representatives were asked via email questionnaire to provide contact details for the key PEV market, utility and Government participants in their Economy. The primary objective of the questionnaire process was to broaden the range of survey respondents beyond the EGNRET representatives and ensure that the most-relevant PEV experts in each Economy had an opportunity to provide input to the survey. Recognizing that the electric vehicle market is global and significant market developments will occur outside of the APEC Membership group (e.g. in Europe), some stakeholders *external* to the APEC Member Economies were also contacted.

PEV Connectivity Survey

Survey of APEC stakeholders was conducted via two means – primarily via a web-based survey tool administered by email, but also via interviews where possible (in-person or by phone). More than 300 PEV market participants in APEC Economies were invited to take part in the email survey during April-May 2012 and, of that group, 75 full and partial responses were collected (as of June 2012). Figure 6 reflects response rates per APEC Economy. The response rates suggest that the email survey approach was not a particularly effective methodology for this project, whereas Verdant Vision benefitted from its close networks in Australia and the US to improve response rates.

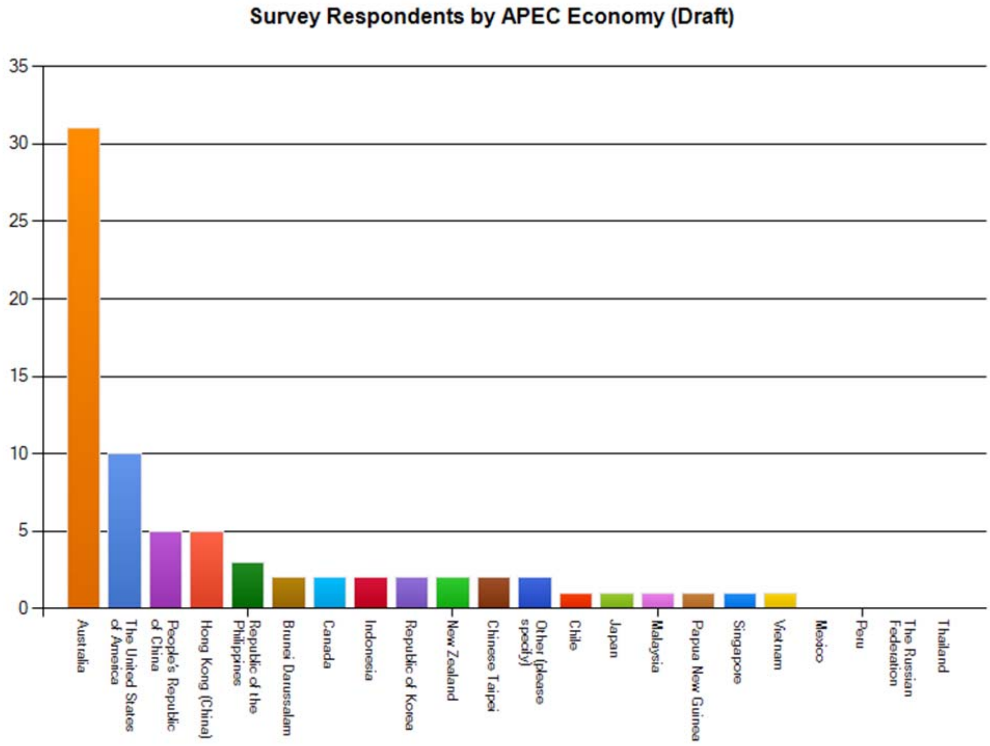

Figure 6: EV Connectivity Survey Responses by APEC Member Economy

The primary objective of the survey was to establish baseline PEV connectivity conditions across APEC Economies, as well as obtain detailed descriptions of ongoing PEV activity in those Economies that might not otherwise be obtained from the public domain (i.e. through internet and news media research). Specific survey questions were included to attempt to obtain references for official Government research publications and standards and regulatory documents, although this approach was only moderately successful. Nevertheless, the survey respondent group was relatively diverse, apart from a natural bias for Government through the use of APEC channels, as shown by the sector representation in Figure 7.

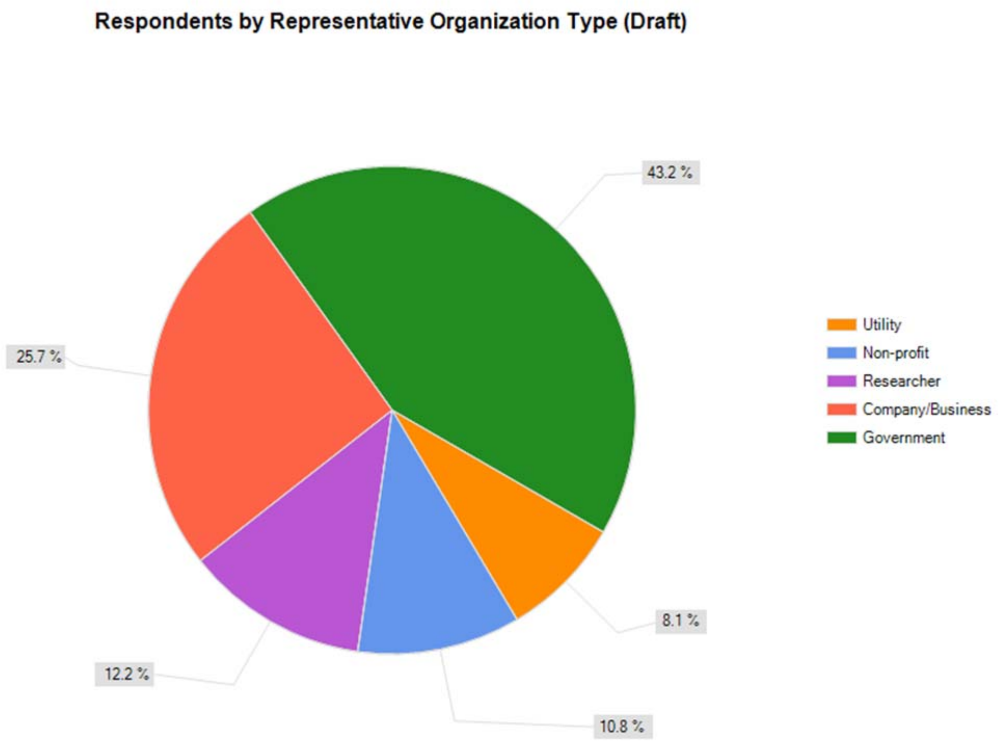

Figure 7: EV Connectivity Survey Responses by Type of Organization

2.2.2. Desktop Research

The PEV marketplace is global and extensive. While PEV technology is not new, its current breadth of application for use (i.e. HEV, PHEV, BEV), total level of support (i.e. industry investment and Government incentives), and up-take projections (e.g. 1 million EVs in the US by 2015, etc) are far greater than in previous historical deployments.

To underpin the project scope and supplement data missing from the stakeholder engagement processes, Verdant Vision used traditional forms of desktop research such as internet resources, academic and trade publications, and news media to fill gaps of understanding where possible. However, language barriers and inconsistent provision of information in the public domain on occasion has left some gaps, which may be resolved through further consultation in coming months.

2.2.3. Analysis

The primary objective of this report is to support APEC in identifying any existing barriers to trade that may exist in the PEV market stemming from connectivity conditions. Therefore, Verdant Vision has applied simple and consistent frameworks to the analysis to identify potential barriers for the trade of PEVs across national boundaries, and highlight potential areas of cooperation between APEC Economies to promote the uptake and trade of PEVs.

For barrier identification, a consistent definition was used to highlight regional market differences in standards or regulations governing EV connectivity conditions. Section 6.2.2 provides this definition in full, and Sections 6.3 and 6.4 identify the barriers.

To consistently identify opportunities for high-value barrier removal, a simple qualitative framework was used to rank barriers in terms of their significance to the international trade of PEVs and their ease of removal. This framework screened an initial list of 15 barriers and was used to identify 7 recommended actions – which are the ultimate outcomes from the study.

2.2.4. Preliminary Reporting

Through this draft report, Verdant Vision has presented preliminary findings from the "Stock-Take of Electric Vehicle Interface with Electricity and Smart Grids across APEC Economies and the Potential for Harmonisation".

These findings will be presented and reviewed at a PEV Connectivity Workshop hosted in Wellington, New Zealand by the Energy Efficiency and Conservation Authority on 20 June 2012, and all stakeholders will also have an opportunity to provide further comment on the draft report or more survey input prior to 20 July 2012 as noted earlier. Upon the conclusion of the consultation period, the report will be revised to incorporate any new data and conclusions, and a final copy will be submitted to the APEC Secretariat for publication before the end of August 2012.

3. Plug-in Electric Vehicles

3.1. Market Development

Plug-in electric vehicles have been available in the global market place in many different varieties since their inception in the early 1900s; however only in the last decade have PEVs earned broad recognition internationally as a clean and commercially viable transport alternative to conventional technologies, such as those using petroleum and diesel.

3.1.1. Experience with PEVs

Most APEC Economies have been operating PEVs for more than one year, while a few Economies such as the United States, Japan and Chinese Taipei have had some form of PEV in operation for more than five years.

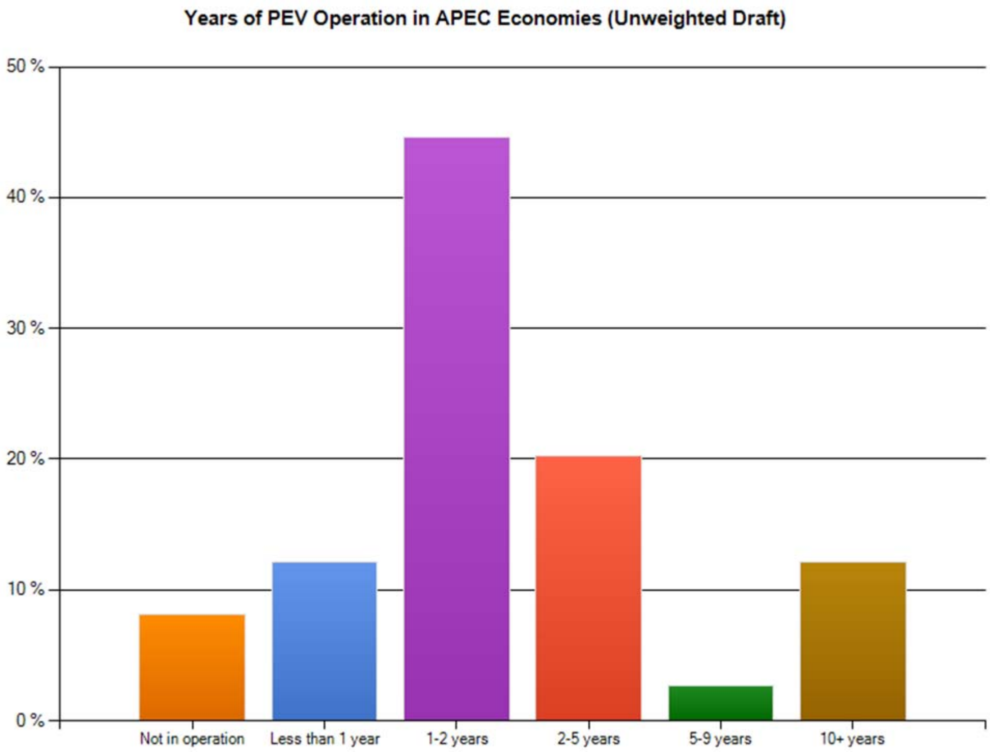

Figure 8: Number of Years PEVs Have Operated in APEC Economies

Pure battery electric vehicles are the most common power train in use according to survey respondents and it is expected that of these, most are passenger vehicles; however two- and three-wheeler products are also extremely common. It is not surprising that nearly 15 percent of survey respondents were uncertain of the type of PEV powertrains in use in their market as a recent study completed by Accenture which surveyed 7000 people internationally about their knowledge of PEVs found that only 30 percent were certain enough about their understanding of the technology to make a purchasing decision (Accenture, Changing Perceptions).

Lithium-ion is the most common PEV battery chemistry in use, consistent with recent PEV product deployment timeframes. The second most common battery chemistry was nickel-metal hydride (NiMH), indicating older variants of PEV technology (e.g. Toyota RAV4 EV) or custom-built/after-market conversion are still in operation in some cases.

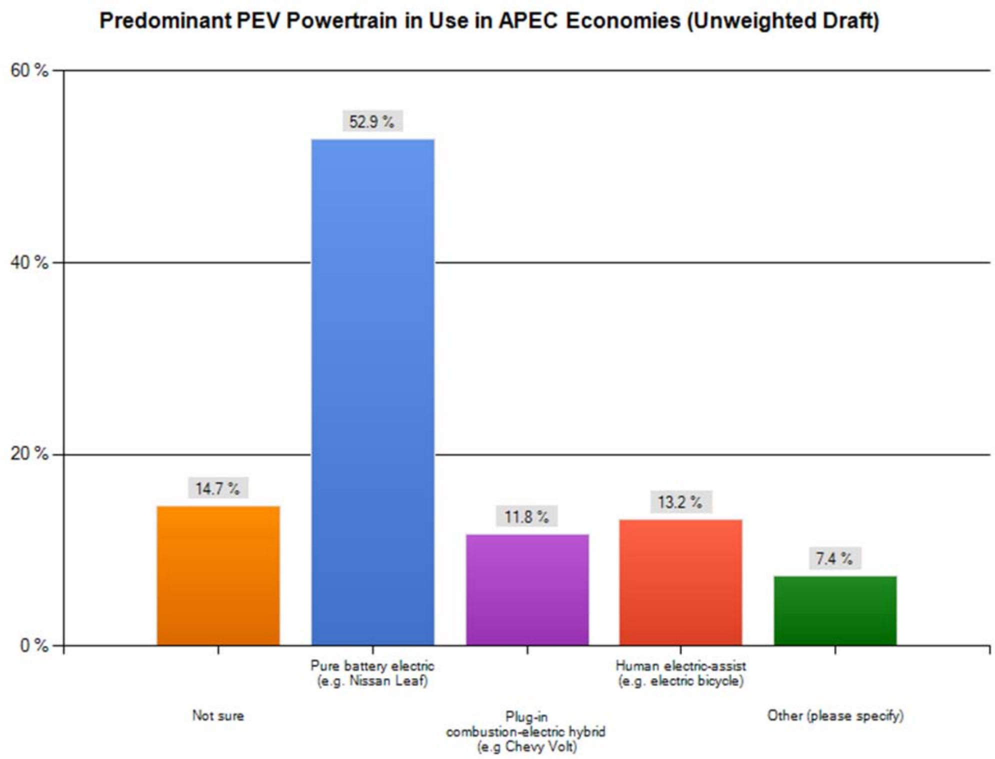

Figure 9: Predominant PEV Powertrain in APEC Economies

Nearly every APEC Economy has had some experience with PEVs, though no single Economy considered any form of PEV to be “common” or “somewhat common” when compared to other motoring alternatives. In terms of vehicle types, passenger cars are the most common type of plug-in electric vehicle in APEC Economies. Scooters/Motorbikes, closely followed by electric bicycles are second and third most common.

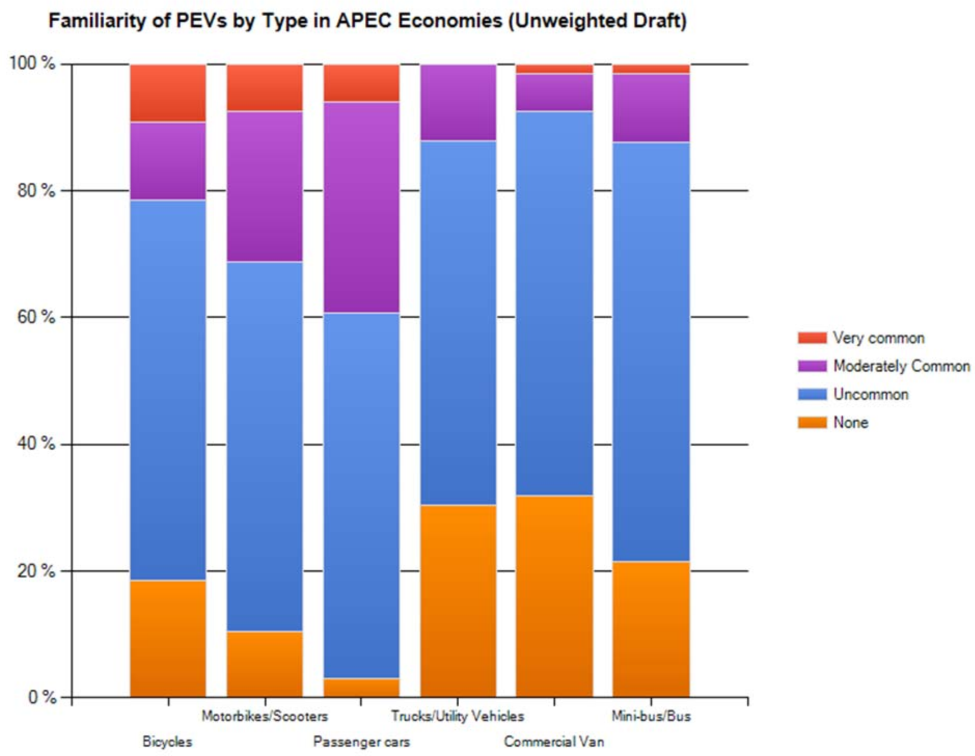

Figure 10: Perceived Familiarity of Each Type of PEV in APEC Economies

3.1.2. Local Production vs. Import

Market development of plug-in electric vehicles is defined by product development and sale, as well as by product purchase and use. According to survey respondents, most PEV products used in APEC Economies are imported, despite some of the earliest PEV products originating from the Asia-Pacific Region such as the Mitsubishi i-MiEV (released 2009) and Nissan Leaf (released 2010). Only 25 percent of survey respondents indicated their PEVs were predominantly produced locally. APEC Economies with locally produced PEVs included Chinese Taipei, People's Republic of China, The Philippines, Republic of Korea, and The United States of America.

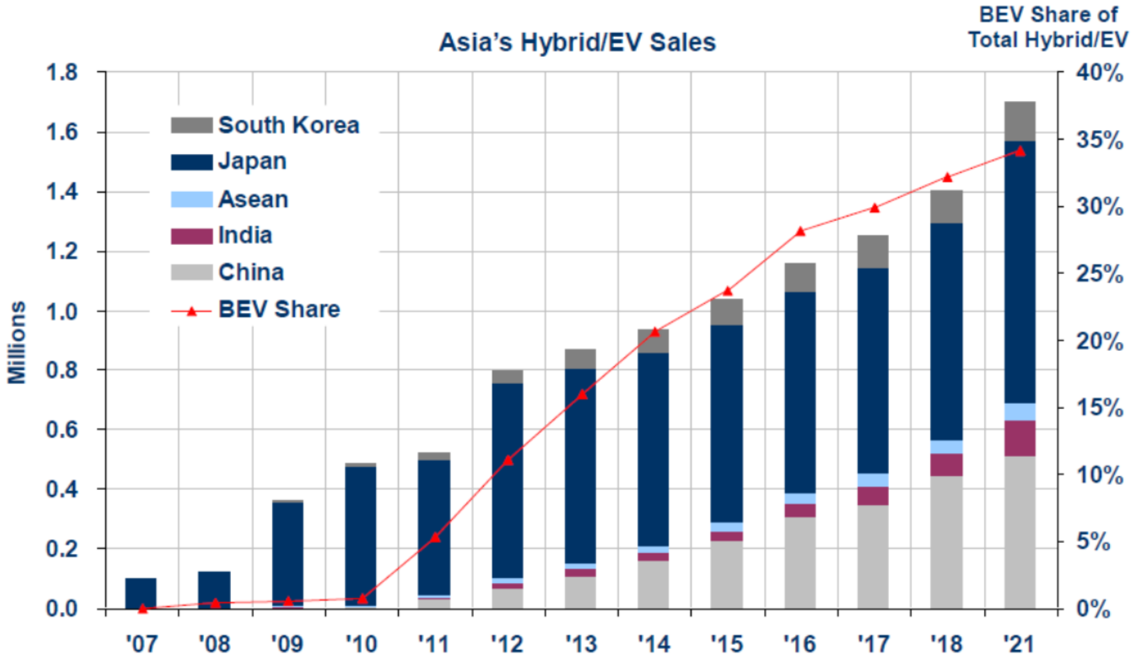

Figure 11: Projected Battery Electric Vehicle Share of Sales in Select Asian Economies (Arthapan)

Japan is also recognized as a large domestic producer of PEVs and is characterized by both McKinsey and JD Power and Associates as close competitors with The United States of America in PEV sales in 2010 and 2011. In terms of light-duty vehicles, Japan is the largest producer of PEVs with 3.1 percent of its technology production falling into this category (Arthapan). Figure 11 depicts battery electric vehicle (BEV) sales as a portion of total plug-in electric vehicle and hybrid sales.

3.1.3. Market Maturation Framework

There is substantial differentiation between market maturities of the plug-in electric vehicle market across APEC Member Economies. For summary of market development in this report, the consultant has created tiered levels of PEV market maturity and categorized each APEC Economy into one of the following categories, based on current understanding of PEV market status:

Figure 12: Explanation of PEV Market Maturity Categorization

APEC Economies were assessed relative to each other by the framework represented in Figure12 considering the following four criteria:

- Commonality of PEVs compared to conventional vehicles;
- Status of EVSE market development and functionality;
- Status of standards and regulations for PEV and EVSE products and processes (i.e. installations); and
- Level of visible Government support for the PEVs and the PEV market.

In reference to the four categories specified – "Mature," "Adolescent," "Juvenile" and "Infant" – no APEC Economy was characterized as "Mature". The United States of America is the most mature PEV market in the APEC network, and Japan a close second, however, neither was considered to have sufficient PEV volumes or product standards to fit into this category. It is quite likely that no global Economy yet fits into this category.

Mature	Adolescent	Juvenile	Infant
none	Canada	Australia	Brunei Darussalam
	Chinese Taipei	Chile	Indonesia
	Japan	Hong Kong, China	Papua New Guinea
	People's Republic of China	Malaysia	Peru
	Republic of Korea	Mexico	Russia
	The United States	New Zealand	The Philippines
		Singapore	Thailand
			Viet Nam

Figure 13: APEC Member Economies Classified by PEV Market Maturity

Six APEC Economies were characterized as Adolescent and seven as Juvenile. Adolescent Economies were those considered to have PEVs in their market as well as some in trial environments, though in many cases pre-commercial trials have ceased. These markets are well-supported by Government, either through direct policy mandate alone, or though policy mandate coupled with financial support. Government support comes from all levels in Government, including federal, state/territory and city or local council, though not every single region of that Economy is equally active as another. Recharging infrastructure for is available in public and private settings and involves conductive forms of charging as well as others (e.g. DC, battery swap, etc). Due to commercial and Government activity, Adolescent markets have standards for PEVs either finalized and published, or in draft form. All of the Adolescent markets have domestic production of PEVs in common.

Illustrating the correlation between APEC Economies with high per capita gross domestic product (GDP) and level of urbanization, Figure 14 highlights the adolescent markets with largest icons. This graphic represents the demographic similarities between the Adolescent Economies in terms of their development status. Conversely, Infant Economies have lower levels of per capita GDP and urbanization.

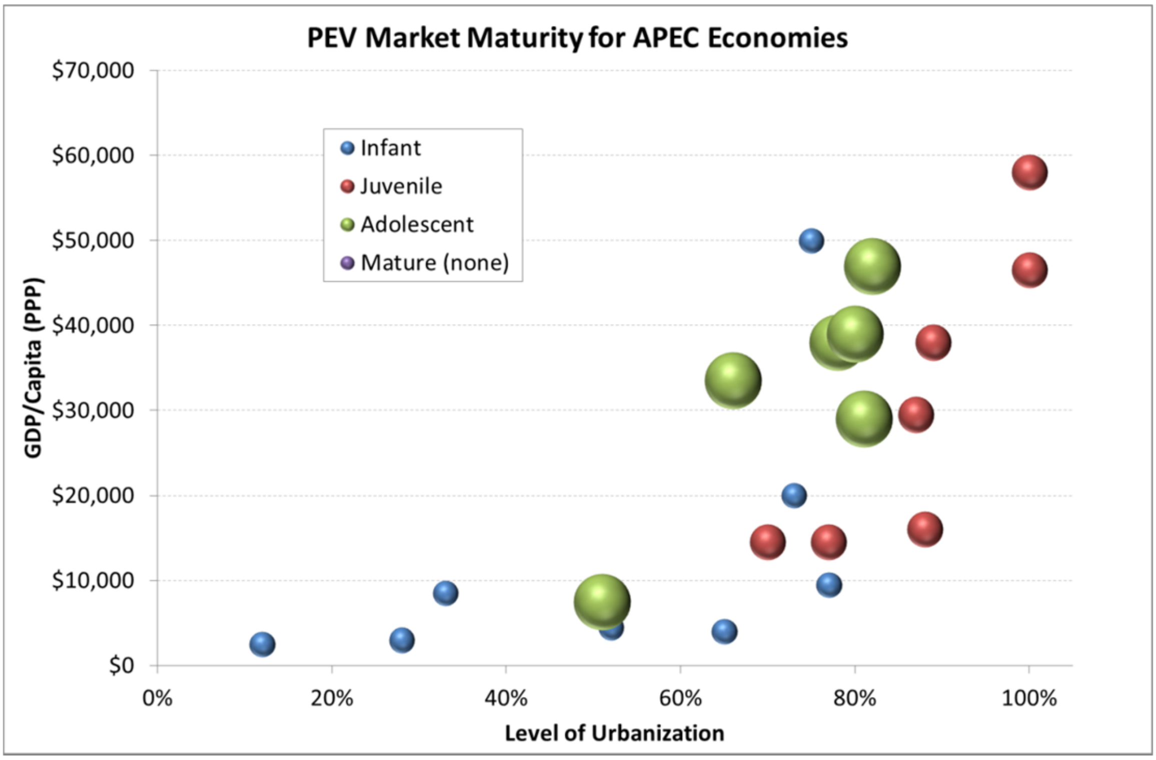

Figure 14: PEV Market Maturity with Urbanization and Per Capita GDP

Juvenile markets are progressing in the same areas as the Adolescent markets, but have not evolved at the same rate – or as comprehensively. Unlike Adolescent markets, Juvenile markets may lack one or more qualifications in each of the four criteria. For example, Australia is categorized as Juvenile because the Commonwealth Government of Australia has not demonstrated any form of support for PEV technology deployment and only one plug-in vehicle is currently available in the market. Juvenile markets may ascend the ranking to the next category up as their PEV market continues to develop over time.

The remaining eight APEC Economies only had sufficient PEV market activity to classify them as “Infant”. Infant markets are considered to be the least mature PEV markets within the APEC membership relatively speaking. While a few of these Economies have next to no PEV market activity, other have some. The apparent development of the PEV market in these Economies is generally lacking the pace and coordination of the more mature markets. For example, The Philippines has demonstrated clear interest in PEV products due to air quality concern in its major cities, but has little demonstrable activity in this space aside from an electric tricycle (or tuk-tuk) trial sponsored by the Asian Development Bank launched in April 2011.

For this draft, the following sections of this report will highlight key PEV deployments and trials, policy activity and general market development with barriers in APEC Economies according to PEV Market Maturity. A full summary of PEV activity by APEC Economy will be provided as an addendum in the final report.

3.2. Policy Activity

According to the International Energy Agency (IEA) projections from 2009, one-fifth of global energy was used to support transportation and approximately 25 percent of emissions worldwide are a result of that energy use (IEA EV City Casebook). Various environmental, energy security and economic development drivers (among others) have sparked renewed interested PEV technology in recent years and have matched conveniently with reducing battery costs and improving energy storage capacity, resulting in a confluence of opportunity for plug-in vehicle market development.

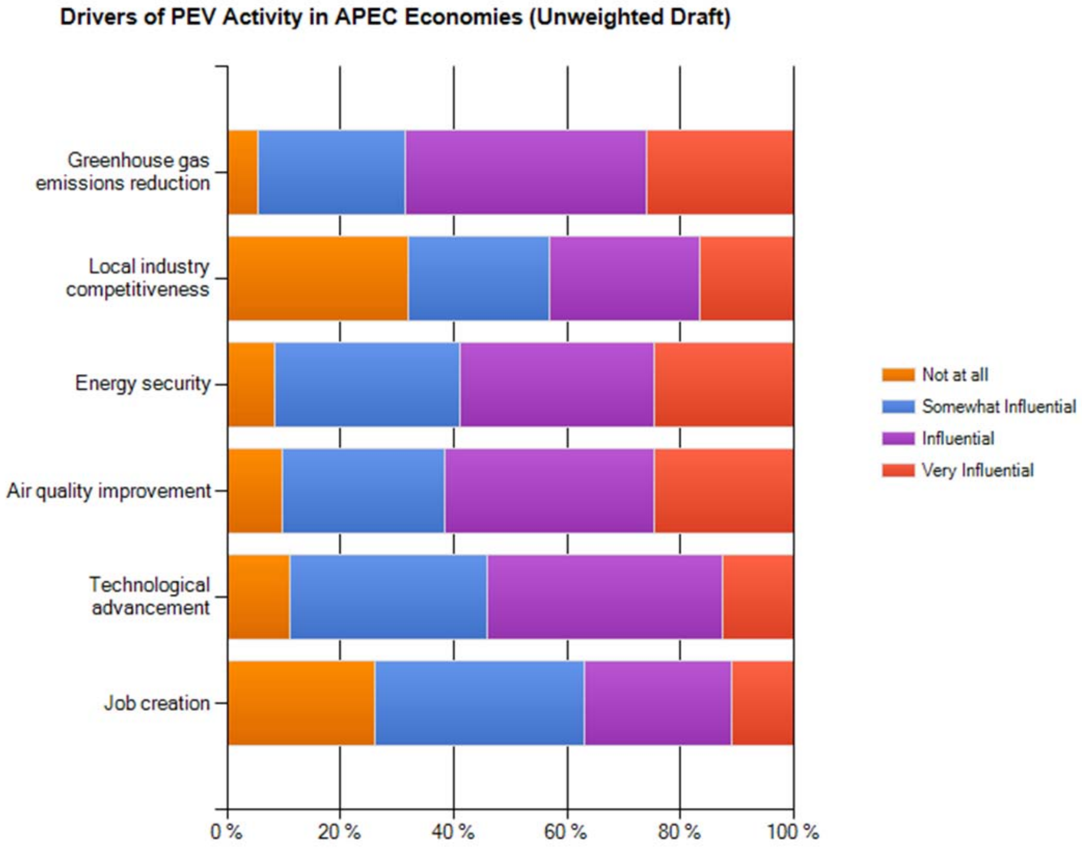

Figure 15: Perceived Drivers for PEV Market Activity

According to survey respondents, greenhouse gas emissions reduction, air quality improvement and energy security are the top three factors driving PEV interest in APEC Economies. For those Economies where PEVs are a strong policy agenda item, it is generally the case that either local automotive production or strong policy priority to combat one or more of the issues canvassed in Figure 16 underpin investment in PEVs. China and The United States of America are strong examples of APEC Economies whose Governments are in support of PEVs for both industry development purposes as well as those relating to the environment/energy security.

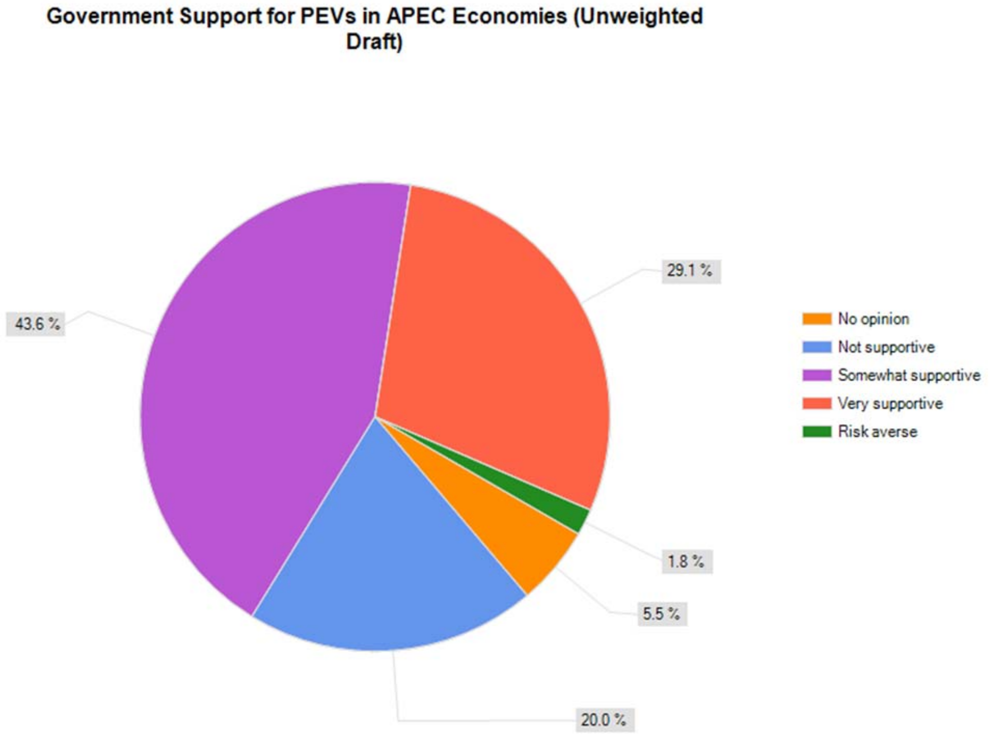

Figure 16: Perceived Government Support for PEVs

Twenty percent of survey respondents considered their Governments to be unsupportive of PEVs while only a slightly higher percentage (29 percent) perceived their Government as "very supportive". The majority of respondents – nearly half – thought their Governments to be "somewhat supportive" of PEVs.

Of the most mature or "Adolescent" Economies in APEC, the policy environment is ripe with support for PEVs as illustrated in the following examples:

- **<u>The United States of America:</u>** US support for plug-in electric vehicles has been significant since 2008 is rooted in policy objectives to reduce dependence of foreign oil and remain economically competitive in the automotive and clean technology sectors. American PEV users can receive up to US$7500 in federal subsidy for vehicle purchase and up to US$2000 for home-based recharging infrastructure and some individual states offer rebates on top of that. Commercial charging infrastructure is prevalent due to city-wide promotion of PEVs through the Department of Energy's Clean Cities Program as well as the federally-funded EV Project, the largest global PEV trial which to date has installed upwards of 6100 EVSEs. The United States' 2013 financial year budget includes $650 million for additional vehicle and battery technology development.

- **<u>China</u>**: The People's Republic of China has flagged plug-in electric vehicles as a strategic technology opportunity to support economic growth and energy efficiency goals nationally. The Ministry of Science and Technology in China has supported PEV programs starting with the publication of a national EV Roadmap and subsequent initiatives under its "863 Programme". Starting in 2009, the three Chinese Ministries combined forces to deliver a 25-city pilot supporting the release of 13,000 vehicles (Earley et al). Shenzhen, one of China's largest cities, has undertaken PEV trials with BYD products since 2010 and boasts of having the largest PEV fleet in the world. To date, 2500 PEVs have been in operation and of them, 1300 are all-electric buses (Ligget). While the BYD trial is ongoing in Shenzhen, trial managers last year reported a reduction of 1 million kilograms of carbon dioxide in the city, underscoring the success of the PEV trial in supporting the city's air quality improvement goals (NY Daily News).

Policy development in the following Juvenile Economies illustrates significant progress toward PEV market establishment, though few have national policy or financial commitment.

- **<u>New Zealand:</u>** New Zealand's PEV activities benefit from high renewable energy generation and has demonstrated support for PEVs in releasing "Deploying electric vehicles in New Zealand: A guide to the regulatory and market environment" and supporting implementation of a vehicle label for PEVs (Fuel Saver).In addition to federal activities, the from 2010, the Wellington City Council has trialed eight Mitsubishi i-MiEVs in partnership with Meridian Energy, Mitsubishi Motors, New Zealand Post Group and The Wellington Company for two years (Wellington City Council).

- **Chile**: Chile is one of the few Economies whose interest in PEVs expands from traditional energy security and emission reduction drivers as Chile is a leading producer of lithium used in many modern PEV batteries, leading to potential economic development opportunity for the Latin American country. The Chilean Ministry of Environmental Affairs has been publicly supportive of PEVs, signing an MOU with the Nissan-Renault alliance in 2010 to assess the feasibility of PEV use in Chilean urban areas (Nissan Global). Chilectra, a local utility, has also partnered with the environment ministry to offer early PEV users a "Welcome Pack" incentive package which includes free recharges at the recently installed public recharging stations, free analysis of power circuits in their homes to assess feasibility of home charging and reduced electricity rates for recharging (Chile Online).

Eight of the APEC Economies fall into the Infant category of PEV market maturity. For these Economies, PEV Government support is extremely limited, especially in the public domain. Though many of these Economies would benefit from the emissions reduction and energy security benefits offered by PEV technology, their regional differences make them unlikely "first movers" given their lower levels of urbanization, per capita GDP and small domestic automotive industry.

While there are no specific examples of policy activity in the Infant category, policy frameworks in the following cooperative global organizations may indicate support for PEVs in coming years.

- **International Energy Agency (IEA):** The IEA is in support of a budding PEV market and in June 2011 released an updated version of its *Technology Roadmap for Electric and plug-in hybrid electric vehicles*. The IEA roadmap promotes collaborative industry and policy development globally as well as aggressive action to decarbonize electricity production. Six of the IEA member nations are also Economies represented by APEC (IEA Technology Roadmap).

- **Asia Development Bank (ADB):** The ADB has funded an introductory PEV deployment in the Philippines for e-trikes with a possibility for extension into other developing Economies in future pending trial outcomes (Asia Development Bank).

- **World Bank:** According to a report published in April 2011 reviewing PEV deployments in China, the World Bank argues that a new global value chain for PEVs may reach US$250 billion by 2020 (World Bank).

3.3. Deployments and Trials

Plug-in electric vehicle trials have occurred in most of the APEC Economies though vary in terms of key characteristics such timing, size, type of study and type of vehicle studied. Many of the APEC Markets with "Adolescent" maturity have completed trials and are now experiencing early commercial product deployments.

- **Canada**: Canadian utility Hydro-Quebec is responsible for the largest trial in Canada. The trial, which runs from 2010-13, has tested 30 Mitsubishi i-MiEVs in local conditions and considering a range of impacts including charging infrastructure use and driver perceptions (Hydro Quebec). This trial is considered to be a strategic initiative stemming from the *Electric Vehicle Technology Roadmap* released by Canadian Government Natural Resources Department in 2010 (Natural Resources Canada).

- **Japan:** Thanks to the activity of its incumbent automotive suppliers, Japan has a significant number of trials on which to report. The spectrum of PEV deployments in Japan ranges from vehicle trials to battery swapping trials, many of which were the first of their kind. With support from Japan's Ministry of Economy, Trade and Industry's Natural Resources and Energy Agency, Better Place and Nihon Kotsu, Tokyo's largest taxi operator, partnered to demonstrate battery swapping at the Tokyo International airport from 2010 (Accenture, Changing the Game).

Economies classified with "Juvenile" levels of deployment are characterized by smaller-scale trials than those found in the "Adolescent" maturity category and their trials tend to have a diversity of products across a larger region rather than a single product deployment in region of smaller area.

- **Australia:** Australia has run various PEV trials, though with no strong federal Government direction, most PEV trial activity has taken place through commercial or state Government deployments. The two largest trials in Australia include a fleet and household trial run by the Victorian State Government from 2010-2014 and the Mitsubishi Motors Australia Foundation Customer Group release in 2010. The Victorian trial includes installation and use of electric vehicles in up to 180 households and installation of more than 100 smart recharge points (Victorian EV Trial), whereas the Mitsubishi Trial offered limited Government and commercial fleets an opportunity to trial pre-commercial i-MiEVs for up to three years. The Mitsubishi trial deployed more than 110 EVs throughout Australia (Mitsubishi Motors Australia).

- **Singapore**: In June of 2011, Singapore's Energy Market Authority launched its "EV Test Bed," a national trial of electric vehicle technology and recharging infrastructure. The EV Test Bed seeks the following four outcomes before its conclusion in 2012:

    - To develop suitable infrastructure and business models;
    - To test the feasibility of EVs in Singapore;
    - To facilitate the evaluation of relevant policies; and
    - To identify and develop related industry and R&D opportunities.

  Nearly 30 commercial plug-in vehicles from varying manufactures, 20 charging stations and 1 fast charger are currently in operation (Energy Market Authority).

Finally, of APEC Economies in the "Infant" maturity category, there are far fewer examples of trial PEV deployments, though some exist.

- **Brunei Darussalam:** The Brunei Times reported in February of 2012 that the Airport Police Division announced purchase of 11 Electric Stand-up Vehicles (ESV) produced by T3 Motion to assist with patrolling. There is no information available to ascertain if this trial is targeted specifically at understanding PEV technology (Brunei Times).

- **The Philippines**: In April of 2011, Philippine President Aquina officially launched a fleet of electric tricycles in the capital city of Manila. Part of an inaugural program of the Asia Development Bank (ADB), the Philippines was the first to participate in this program which deployed 20 e-trikes to support reduction emission and oil consumption (ADB, Electric Vehicles Hold Promise of Bluer Skies).

3.4. Market Size and Forecasts

3.4.1. Current Market Size

Given the relatively young age of the PEV market globally, plug-in vehicles still represent only a very small share of all vehicles which remains quite difficult to estimate in total size. While no official figures have been reported for PEV deployments within APEC, survey respondents provided some indicate of estimated volumes in the Economies.

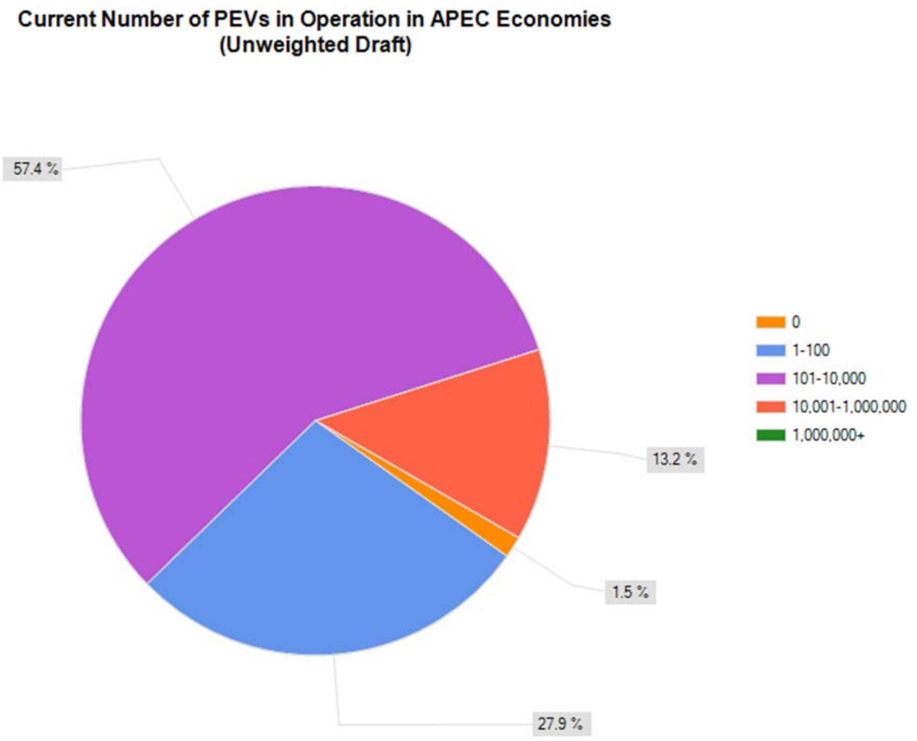

Figure 17: Volume of Current PEV Deployment per APEC Economy

The majority of APEC Economies reported have between 101-10,000 PEVs on their roads with the next greatest response rate was reported in the lower volume category of 1-100 vehicles. Respondents from The United States of America was the only Economy to report greater than 10,000 vehicles in deployment, however it is expected that China and Japan may have also eclipsed 10,000 figures. Papua New Guinea reported no vehicles in operation.

Globally, PEV sales have been on target with early estimates, with the United States and Japan leading per Figure 18, and China following as a close third.

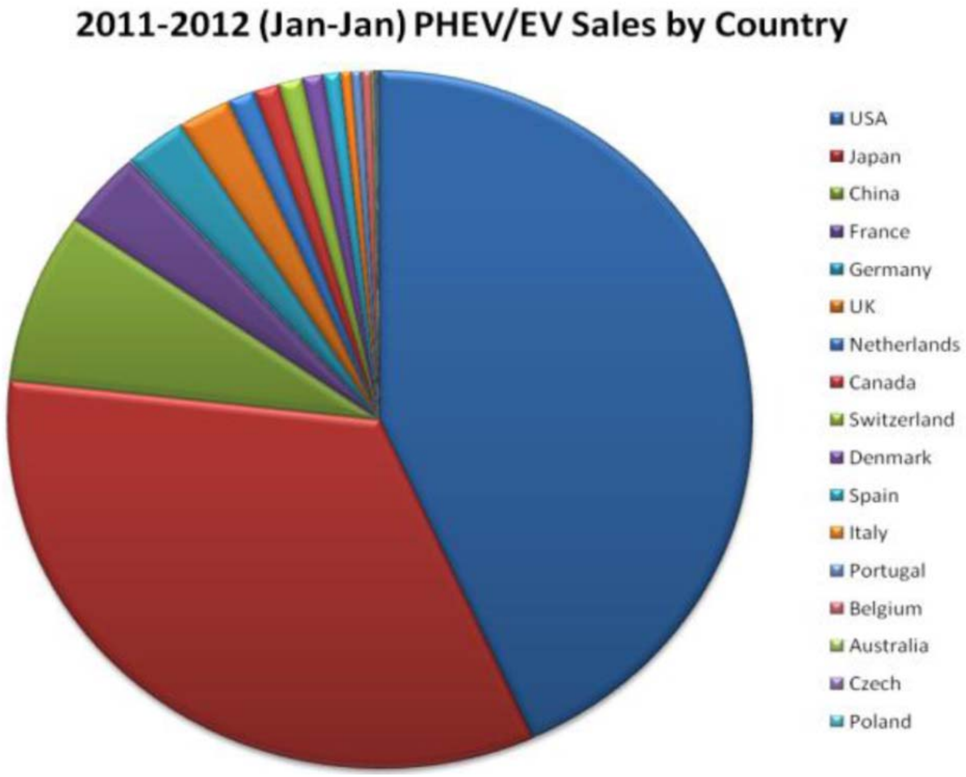

Figure 18: PEV sales by country 2011-2012 (Trigg et al)

3.4.2. Forecast Growth

Dozens of uptake forecasts of PEVs have been published in the last five years, many reflecting inconsistent expectations for market performance. Pike Research, a well-known producer of clean technology assessment pieces have recently studied the prospects of PEV uptake in the Asia-Pacific concluded that the region is on track to be the world's largest with 1.2 million units expected by 2015. The demand for PEV products is expected to increase, with China representing 53 percent of expected sales in this time period and Japan and Korea following closely behind.

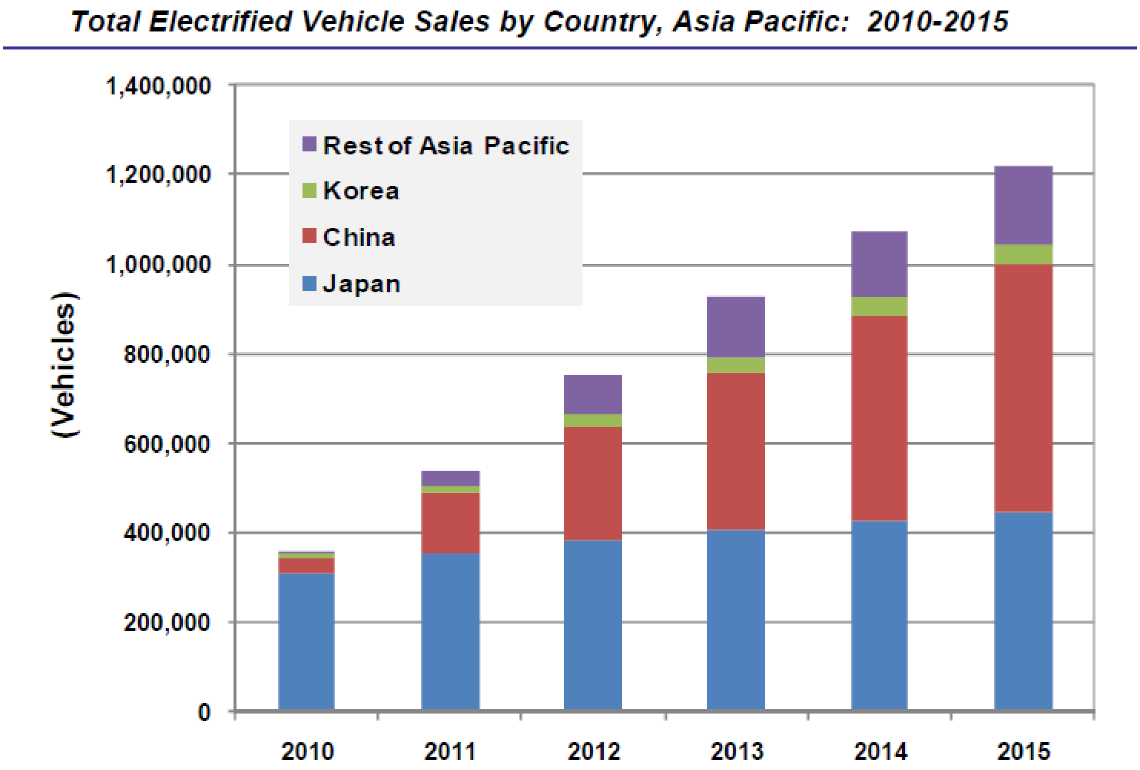

Figure 19: Forecast PEV Sales in Asia Pacific to 2015 (Pike Research)

From the perspective of automakers, PEV sales will increase through 2020 with the greatest growth period occurring from 2012-2013. Figure 20 illustrates this growth and highlights manufacturers with products currently in the marketplace (e.g. Nissan, Renault and Mitsubishi) as those who are expected to contribute most significantly to market growth in coming years (Pike Research). While two- and three- wheeler products are not represented in Figure 20, their market segments are also anticipated to experience growth in the next decade.

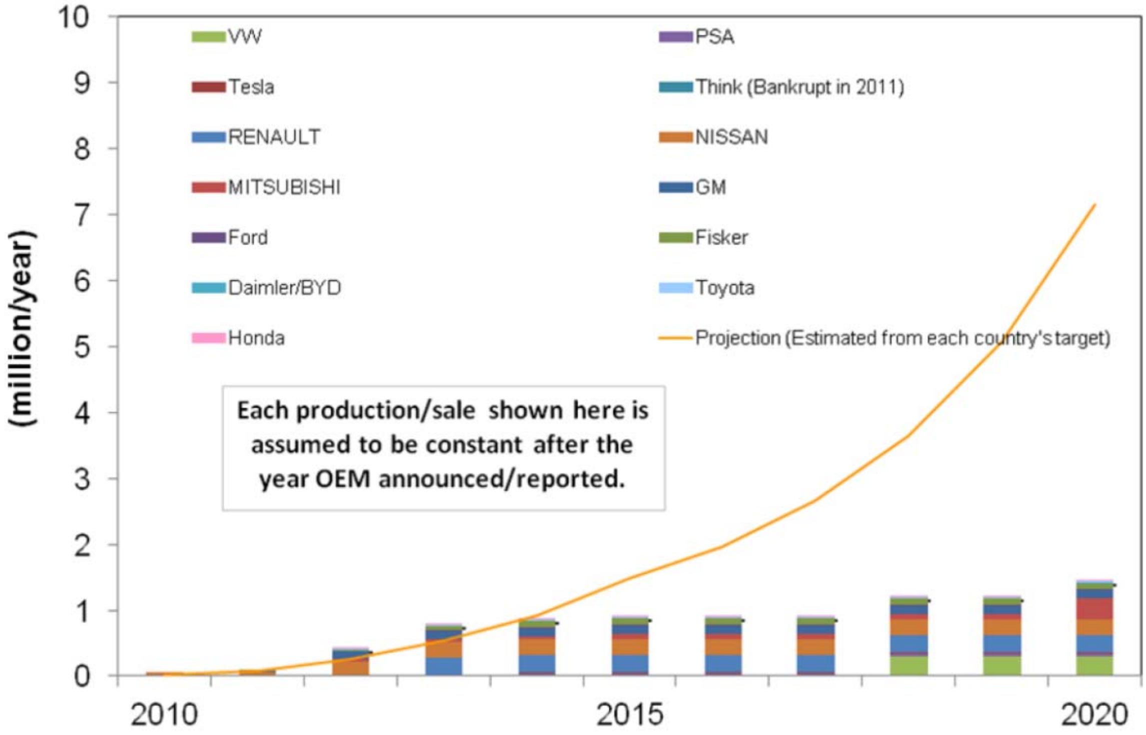

Figure 20: Forecast PEV sales by Manufacture to 2020 (Trigg et al)

4. Recharging Infrastructure

Not all types of plug-in vehicles are the same – some are purely operated by batteries, other have onboard generators – one commonality shared by vehicles considered in this report is that they plug into an electrical outlet or socket. Through this plug, they draw electrical load that is stored in an on-board battery.

For the sake of discussion, plug-in electric vehicle infrastructure will be referred to as "recharging infrastructure" in general terms and "electric vehicle supply equipment" or EVSE when speaking of an individual unit or installation.

In this section, PEV recharging is discussed thematically, based on geographic charging location. This framework captures understanding of PEV recharging in its most common form, relating to the user's behavior – most of which is subject to regional differences found in APEC Economies such as level of urbanization, daily travel distance and product offerings in the local marketplace (i.e. passenger vehicles vs. motorbikes) and their respective battery storage capacity. Later on, PEV recharging is described in terms of its technical standards, as categorized by the relevant standardization bodies, in this case, the International Electrotechnical Commission (IEC), the Society of Automotive Engineers (SAE), CHAdeMO, and the Chinese National Technical Committee of Auto Standardization. While other charging standards may be in use internationally, only standards used in APEC Economies are discussed in this section.

4.1. Conductive Charging

Conductive charging is defined as use of a physical path (i.e. plug or cable) to transfer electrical energy, typically as utility supplied alternating current (AC power) or direct current (DC power). Inductive charging is an alternative form of electrical energy transfer and is covered separately in Section 4.2.1.

Conductive charging appears to be the predominate medium for PEV charging internationally and specifically, for APEC Member Economies. According to survey respondents, conductive charging is agreed to be most common, with more than 98 percent of home recharging and 96 percent of public recharging perceived to be conductive.

Plug-in electric vehicle recharging is classified most regularly based on geography – as in where the EVSE is located (i.e. home, public, work place) – in colloquial discussion. However, mechanically, recharging infrastructure is best characterized based on the power level it uses (amperage) and its coupler interface, both of which are standardized by at least three entities internationally. Figure 21 illustrates the most common coupler interfaces used for commercially produced passenger electric vehicles within APEC Economies. It also includes the recently announced Universal Connectors (labeled as “hybrids” in this diagram), which have not yet been balloted for approval by any national, regional or international standardizing body. The diagram in Figure 21 does not include general power outlets (GPOs), which are commonly found on household appliances and can be used to recharging smaller batteries found in two- and three-wheeled PEVs.

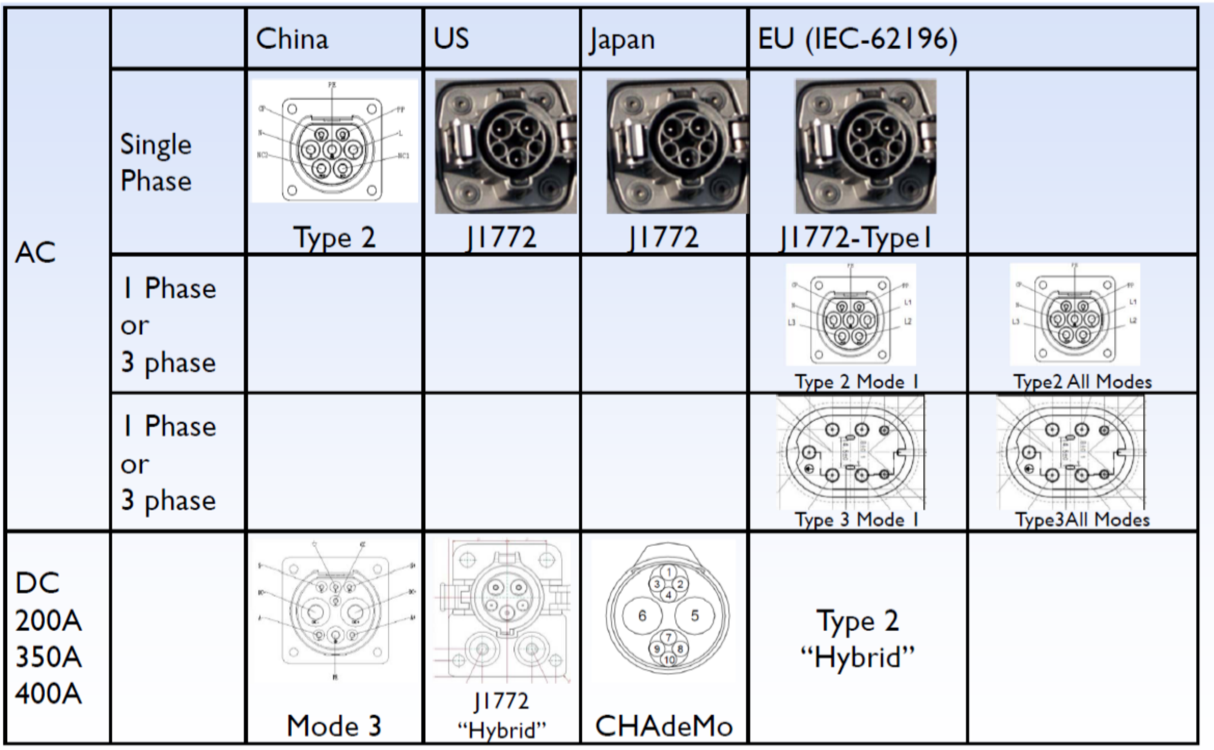

Figure 21: International Summary of Charging Connector Types (Francfort)

4.1.1. Alternating Current (AC)

Home Charging

Modern passenger PEV products are characterized by a relatively low electric range, typically at least 100 kilometers per full charge in real-world driving conditions. This key attribute of PEVs makes them well suited to shorter-distance urban driving, and requires that drivers have access to a charging point. These criteria have led to a general assumption that a majority of PEV drivers will garage their vehicles overnight on their own property, a scenario we will refer to as “home charging”.

Plainly speaking, conductive home charging is most likely to occur in two forms: either by GPO (the same standard socket used for other household appliances such as televisions, computers and lights) or via an EVSE, installed in the home. (Note: it is possible that in future scenarios home charging will also include inductive charging, DC fast charging, or other forms of charging that have not yet been characterized, but for simplicity, this discussion convers the two forms listed in Scenarios 1 and 2).

Figure 22: Two Mostly Likely Scenarios for Home Recharging

For home recharging, there are a number of factors a PEV motorist must consider when deciding which scenario suits his or her needs best. These variables include (but are not limited to):

- **Type of residence and associated home parking situation** (whether a private home, block of units, high-rise complex; how parking is provisioned and how electricity is able to be metered per considerations for multi-unit dwellings).
- **Residential household access** and whether it might be easier to recharge at work or at a public location (perhaps due to lack of off-street garaging);
- **Voltage standard** (as lower voltages pose challenges associated with slower recharge times);
- **EVSE unit cost** (and whether any rebates are available);
- **EVSE installation cost at home** (and if the house can accommodate additional load associated with higher power levels);
- **Electricity rates** and whether local electricity retails offer EV tariffs or off-peak charging discounts;
- **Daily driving distance** and whether regularly daily charging is required and at what speed (or rate); and

- **Additional Features** such as advanced metering, data collection and communications – and the price premium they add.

APEC survey respondents indicated that in their economy, PEV users were mostly likely to recharge their PEV at home without any commercial charging infrastructure (Scenario 1 as outlined in Figure 22) with 64 percent of respondents indicating this would happen "very often" or "often" within the next five years. According to survey responses, there was little agreement on the frequency of Scenario 2 as depicted in Figure 22 with respondents reporting it was likely to occur "sometimes" 29 percent of the time, "rarely" 25 percent of the time and "often" 20 percent of the time.

Early PEV deployment trends indicates that APEC Economies whose standard voltage is 100v or 110-120v are likely to favor commercial EVSEs installed in the home as they will offer PEV owners a fast rate or recharge and thus greater utility of the PEV. Canada, Chinese Taipei, Japan, Mexico and the United States of America all fit into this category while the remainder of APEC Economies use 220-240 standard voltage in the home.

Public or Commercial Charging

Despite evidence indicating that most PEV users will predominately recharge at home, the market for public recharging is active and growing. Public or commercial recharging is characterized by its installation location -- typically on the side of the road, in Government or public parking lots or garages, or in commercial location such as shopping centers, movie theaters or restaurants.

Governments, in particular cities, have used public recharging to leverage PEV market growth, installing equipment in highly visible locations to raise awareness of PEV technology and reduce motorist concern about range ("range anxiety"). Businesses have installed public EVSEs to increase their appeal to certain customer segments, anticipating that customers using their EVSEs will spend more time in their retail locations. Public EVSE installations are depicted in Figure 23, Scenario 3.

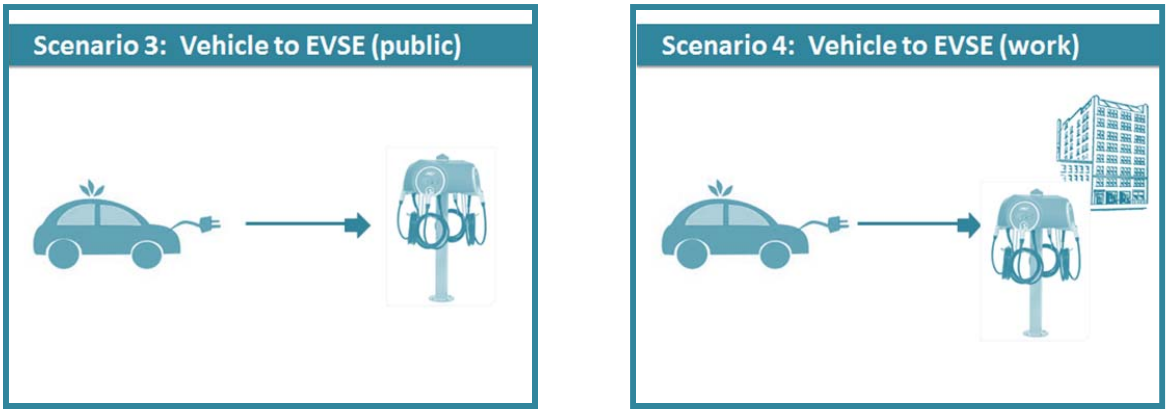

Figure 23: Two Mostly Likely Scenarios for Home Recharging

Alternative to home and public charging, PEV motorists may recharge at their place of work. Workplace recharging is constrained by the availability of parking at the workplace location, the provision of PEV recharging infrastructure at the workplace and the motorist's need to recharge at work based on his or her daily driving distance. In some cases, cost of recharging at work will also be a factor for the motorist, as some workplaces may offer complimentary workplace charging as a perk for their employees, while others may require their employees to pay. Workplace EVSE installations are depicted in Figure 23, Scenario 4.

APEC Economies have reported in their survey responses that both public and workplace recharging are most like to occur "sometimes" over the five year horizon. Of the two options, workplace charging is considered to be the most prominent type (Scenario 4). Respondents believed that motorists recharging in the work place were more likely to use commercial infrastructure rather than a standard GPO; however according to the Economies surveyed, the usage likelihood of non-commercial workplace recharging and public recharging was almost identical.

In this report, we have segmented AC charging into the aforementioned four scenarios; however it is likely that as the EVSE market matures, new scenarios may emerge. For example, it is possible that the public/commercial scenario will split such that coincidental parking during commercial activity (such as someone recharging while dining out or shopping for groceries) will differ significantly from non-commercial coincident recharging (such as recharging while visiting a park, train station or library).

4.1.2. Direct Current (DC)

Fast Charging

"Fast charging" is characterized by direct current power thus increasing the rate at which a PEV is recharged when compared to AC recharging. The method by which fast charging occurs depends on which DC fast charge standard is in use. DC Fast Charge Options are summarized in section 4.5.

AC PEV recharging is conducted at a lower rate than DC fast charging, thus requiring more time to refill a PEV battery from flat to full. DC fast charging is rarely considered to be the primary option for PEV recharging and is never discussed as a residential solution. DC fast charging will typically occur at a public or work place site, either at a dedicated public refill station (akin to a gasoline service station) or onsite of a commercial entity or corporate property, that runs a fleet of PEVs, for example.

Figure 24: Example of DC Fast Charger in Public Car Park (Ecotality)

When used by everyday PEV motorists, DC fast charging is today discussed as used "on occasion" primarily due to uncertainty about its long term impact on battery life. Despite this uncertainty, several commercially-produced passenger PEVs are equipped with DC fast charge functionality as there is a perceived market need for this function. Survey respondents believed motorists in their Economies would use DC fast charge "sometimes" but not as often as they expected public recharging to be used.

DC fast charge, regardless of its specified recharge time, is expected to be a price-premium service. PEV motorists should expect to pay significantly higher rates for DC fast charge services, and potential DC fast charge hosts should anticipate total installed costs exceeding US$50,000 per unit, in many cases. Today there is little consensus in the market place about the cost recovery potential of DC fast charge, even in the long term.

4.2. Other Applications

4.2.1. Inductive Charging

Inductive charging (also referred to as "wireless charging") involves the transfer of electrical energy to a plug-in electric vehicle without use of a cord or plug. With use of inductive charging, PEV motorists do not have to worry about plugging their vehicle into a power source, but instead can drive onto or near a power source which uses an electromagnetic field to transfer energy. Inductive chargers are considered to be safer to use than conductive chargers as they impose lesser risk of electrical shock on their users, but are less efficient in terms of the efficiency of their energy transfer, depending on the individual product. Consumer electronics such as mobile phones are increasingly available with inductive charging functionality.

Figure 25: Diagrammatic example of HaloIPT Wireless Charging System (Qualcomm).

Inductive charging for plug-in electric vehicles was common in PEV deployments in the early 2000s where products such as General Motors' EV1 and the Toyota RAV4 EV used inductive chargers produced by Magne Charge. While most of today's PEV products are not equipped to support inductive charging, there are some inductive EVSEs available for sale – and increasing support for produce development. HaloIPT, a New Zealand-based wireless charging company was acquired by Qualcomm in November of 2011, signaling promise for scaling of the technology (Qualcomm). The Energy Efficiency and Renewable Energy office of the Department of Energy in the United States has just announced a grant for $4 million to encourage development of inductive chargers for electric vehicles (DOE).

Less than two percent of survey respondents believe inductive charging to be the most commonly installed home recharging method within the APEC Economies and none believed it to be common for public recharging. Within the next five years, it is possible that inductive charging will become more common in APEC, however survey respondents believed it mostly likely that inductive charging would be used rarely (41 percent) followed by "never" (21 percent). No respondents believed inductive charging would be used "very often".

4.2.2. Battery Swap

Battery swapping involves the physical removal of a depleted battery kept on-board of a plug-in electric vehicle (most usually a battery electric vehicle as opposed to a plug-in hybrid EV or range-extender EV) in exchange for a fully-charged battery. Not all PEVs are battery-swappable – in fact, only a select few commercial-grade passenger vehicles come equipped with swappable batteries, the most notable of them being the Renault Fluence Z.E., offered in package with access to Better Place swapping stations.

Similar to DC fast charge, battery swapping is intended to increase PEV motorist functionality and convenience by cutting down multiple hour-long recharge times associated with conductive charging. Battery swapping is unlikely to occur in the home for passenger cars, though a significant number of two-wheeled PEVs such as motorbikes and electric bicycles offer battery swapping. For highly-dense urban environments where two-wheeled vehicles are common forms of transport, battery swap is a more practical choice for PEV refueling than conductive charging. Chinese Taipei is an example of an APEC Economy who considers battery swap to be a common method of PEV recharging due to its substantial two-wheeler PEV market.

.

Figure 26: Example of Better Place Batter Swap Station (Better Place)

Forty-one percent of APEC survey respondents suggested that battery swap would be used “rarely” in the next five years while less than 15 percent thought it would be used “often” or “very often”.

Battery swap is a new concept to the PEV market and is still quite uncommon when compared to other forms of PEV recharging. In the PEV recharging market, the market share for battery swap is small and limited almost exclusively to Better Place, though Tesla Motors has discussed designing its Model-S to support battery swapping in future. Despite the relatively low interest in battery swapping today, it is expected that prevalence of battery swapping will increase as the PEV market matures.

4.3. Vehicle-to-Grid (V2G) or Vehicle-to-X

One of the many communicated benefits of plug-in electric vehicles is its ability to communicate with the grid in a bidirectional manner, using its on-board battery as a supplementary storage device to feed electrical energy back into the grid (or X as in exporting to another source, such as the home) during times of need or opportunity. Vehicle-to grid (V2G) or Vehicle-to-X (V2X) has been demonstrated in many of the more mature PEV markets globally, including in APEC Economies such as Australia, Canada, Japan and the United States, however its technology is still considered to be a long term prospect as most modern PEVs available in today's market are not fully equipped for V2G or V2X. Market trends suggest that as smart grid developments progress and a market evolves for feed-in electricity, V2X will become more economical and thus, desirable.

Standards for V2X are still incomplete in most regions, further complicating product development as V2X products must synchronize with both vehicles and the incumbent grid infrastructure, which is not optimized for bidirectional electricity travel in most Economies. A list of standards for V2G/V2X can be found in Section 4.5 and additional detail about APEC Economy progress on smart grids is discussed in Section 5.3.

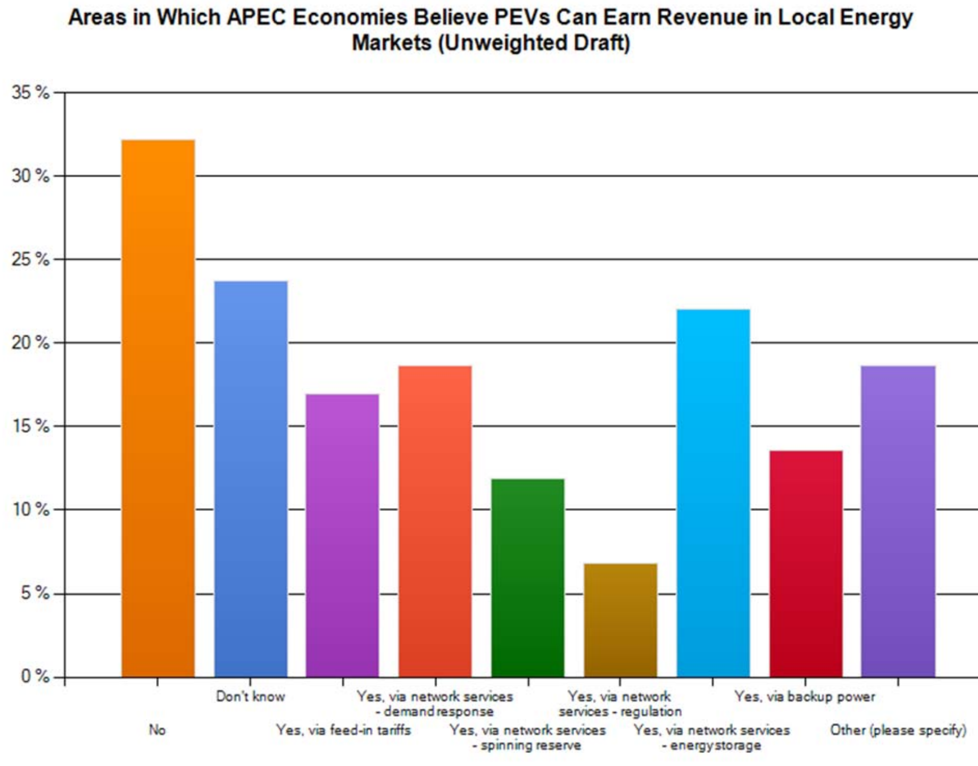

Figure 27: Potential for Monetizing PEV Electricity

Figure 27 illustrates the areas in which APEC Economies believe PEVs can be used to earn revenue in their energy market, with "No, they cannot earn revenue" as the most common response. Energy market constraints within Economies pose problems for V2X. Without a means for monetizing the benefits afforded to PEV owners when they sell their stored energy back to the 'grid' (effectively the local energy market), there is no benefit to the vehicle owner and no incentive to participate. Further investigation is necessary to understand the market potential in relevant APEC Economies for possible V2X enabled product placement and market development.

4.5. Standards and Regulations

Modern plug-in electric vehicles and EVSEs are fairly new in the market place given their current feature sets, however PEVs have been available for sale in many global markets in the past, meaning there are some incumbent standards to leverage for the current deployments. Additionally, PEVs are categorically an electrical appliance, meaning that some standards that would be used for a more traditional household appliance can also be used for PEVs.

Standards and regulations for PEVs are different in and of themselves – standards tend to be defined by industry or peak bodies, reflecting broad market preference for product specification whereas regulations are laws instated by Governments. See Section 6 for overview of the significance of standards and regulations in the PEV market.

Relating to PEV recharging infrastructure, standards vary region to region. Europe tends to follow guidelines imposed by the International Electrotechnical Commission (IEC) as does China (with whom Chinese Taipei has homologated standards). Underwriters Limited (UL) and the Society of Automotive Engineers (SAE) commonly set standards adopted in North America and Japan; however, Economy-to-Economy, there is often inconsistent homologation between standardization bodies where one Economy may choose to deviate from its precedent for a certain standard. A list of key PEV recharging related standards for each of these bodies plus CHAdeMO (the Japanese DC fast charging standard) is found in Figure 28.

KEY PLUG-IN ELECTRIC VEHICLE CHARGING STANDARDS

SAE

- J1772 - Electric Vehicle and Plug-in Hybrid Electric Vehicle Conductive Charge Coupler
- J2836 - Use Cases for Communication Between Plug-in Vehicles and the Utility Grid
- J2847/3 - Communication between Plug-in Vehicles and the Utility Grid for Reverse Power Flow
- J2931/2 - Inband Signaling Communication for Plug-in Electric Vehicles
- J2953 - Plug-In Electric Vehicle (PEV) Interoperability with Electric Vehicle Supply Equipment (EVSE)
- J2954 - Wireless Charging of Electric and Plug-in Hybrid Vehicles

ISO/IEC

- IEC 62196 -- Plugs, socket-outlets, vehicle connectors and vehicle inlets - Conductive charging of electric vehicles
- IEC 61851 - Electric vehicle conductive charging system
- IEC TC 69 - Electric road vehicles and electric industrial trucks (superceded)
- IEC SC 23H - Industrial plugs and socket-outlets (superceded)
- ISO 15118-1 - General information & use-case definition
- ISO 15118-2 - Protocol definition & OSI-layer requirements
- ISO 15118-3 - Wired physical & data link layer requirements

CHAdeMO

- DC Fast Charger

UL

- UL62 - Standard for Safety of Electric Vehicle Cable
- UL2202 - Standard for Safety of Electric Vehicle (EV) Charging System Equipment
- UL2231 - Standard for Safety of Personnel Protection Systems for EV Supply Circuits
- UL2251- Standard for Safety of Plugs, Receptacles, and Couplers for EVs
- UL Subject 2594, the Subject Standard for Safety of Electric Vehicle (EV) Supply Equipment
- UL Subject 2735 - Subject Standard for Safety of Electric Utility (Smart) Meters
- UL Subject 458A - Subject Standard for Safety of Power Converters/Inverters for Electric Land Vehicles
- UL Subject 1004-1 -Subject Standard for Safety of On-board Electric Vehicle Equipment Traction Motors
- UL Subject 2580 - Subject Standard for Safety of Batteries for Use in Electric Vehicles
- UL Subject 2733 - Subject Standard for Safety of Surface Vehicle On-Board Cable
- UL Subject 2734 - Subject Standard for Safety of Connectors for Use with On-Board Electrical Vehicle (EV) Charging Systems

Figure 28: List of Key Standards for PEV Recharging Globally

In the context of EV Connectivity, the conductive charging connector standard for AC power is the most contentious and potentially the area of standard where lack of harmonization is considered to limit trade. A more extensive list of potential barriers to trade relating both to standards and regulations for EV Connectivity is found in Section 6.3.

Within APEC, only six Economies have formally adopted a standard for AC PEV charging connectors. Canada, Japan, the Republic of Korea and the United States of America have chosen the SAE connector standards, J1772, whereas China and Chinese Taipei have adopted the IEC 62196 Type 2 standard. The remaining APEC Economies have either not yet chosen a predominant charging connector standard or information relating to their preference has not been provided by the survey process nor found in literature review process.

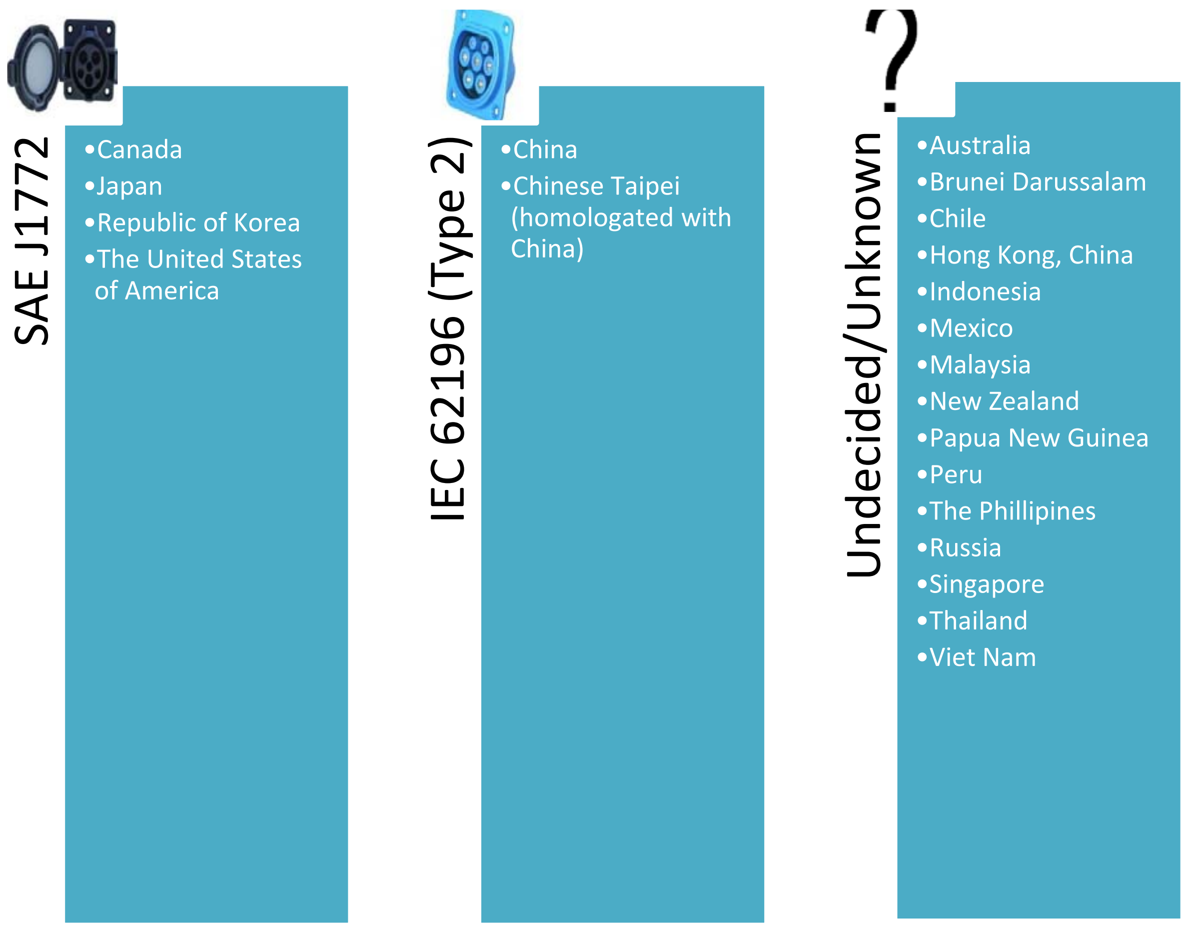

Figure 29: Conductive PEV AC Recharging Coupler Standards in Used APEC

DC charging is also a standard under debate. Figure 29 highlights the DC fast charge standard options in the global marketplace. Although four are listed, within APEC Economies only two are in use at present – the Chinese and Japanese standards.

DC charging system options

	Charging Mode	Charging Control Communication	Coupler Type
In use: Japanese proposal (based on CHAdeMO System)	Regulated	CAN	DC dedicated
Adopted: Chinese GB/T	Regulated	CAN	DC dedicated
In development: SAE	Regulated	PLC or In-Band Signaling	• Low Power: DC on AC pins • High Power: additional DC pins - Combo Coupler
Proposed: Daimler	Non-Regulated	PLC or In-Band Signaling	• Low Power: DC on AC pins • High Power: additional DC pins - Combo Coupler

Figure 30: DC Charging Standard Options (Roy).

CHAdeMO, the Japanese system, is globally the most common for DC fast charge, however its prominence is under threat since in May 2012 at the 26th Electric Vehicle Symposium, seven major international PEV automakers announced the introduction of a new standard, the Universal Connector or "Combo Connector". This connector combines features of AC and DC charging into a single coupler interface (see Figure 31 for an example), helping automakers reduce cost by adopting a single charge portal. Automakers expect the single port for recharging will also support consumer acceptance in the long term.

Despite the cooperation between seven automakers to achieve a common AC and DC standard (which is expected to homologate with both existing SAE and IEC standards), it has not been accepted by most Asian automakers, including those whose vehicles are produced within APEC. Public reception for the Universal Connector has been somewhat limited since the announcement as there is concern that introduction of a new standard at this stage of product development (and where products use another standard) may shock the nascent PEV marketplace (Plug-in America) and as it is not yet officially standardized in any market, no APEC Economy has taken a formal position on the connector.

Figure 31: Proposed Universal or Combination Connector (EU variant)

To date, few regulations exist for EVSEs in APEC Economies. The importance of regulations, in some cases, is that they often refer to standards as guidance. Without a set standard to refer to, it will be difficult for an APEC Economy to establish criteria for legally acceptable PEV recharging equipment in their Economy. Additional detail about the significance of regulations can be found in Section 6.2 of this report.

4.6. Market Development and Themes

For consideration of PEV recharging infrastructure market development, we will apply our market maturation framework outlined in Section 3.1.3 of this report. Recall that APEC Economies are reported on according to the level of progression or maturity of their PEV market with the hierarchy as (1) Mature (most developed), (2) Adolescent, (3) Juvenile, and (4) Infant (least developed) with categorization being assigned relative to each other (non-APEC Economies are not included).

Adolescent PEV markets are also the most mature in terms of PEV recharging infrastructure. Most of these markets have deployed more sophisticated EVSEs and according to survey respondents, most of these Economies believe that their motorists would pay more for “smarter” PEV recharging. Governments in these Economies tend to be extremely supportive of PEVs and therefore tend to have policies supporting broad rollout of PEV recharging infrastructure. For example, Hydro Québec announced the official launch of Canada's PEV recharging network in March 2012 when 120 EVSEs will be installed for public access (Hydro Québec). Also, in the United States, the country's largest deployment of EVSEs is currently occurring under the EV project, where more than 6200 EVSEs are currently in play (Sandalow). Home recharging is most common among this group and workplace charging is second most common. Fast charging and public charging are considered to be rarely required, with fast charging more likely than public charging. All six APEC Economies classified as "Adolescent" -- Canada, China, Chinese Taipei, Japan, Republic of Korea, and The United States of America -- have adopted standards for their AC conductive charging coupler.

Figure 32: Public EVSEs through the EV Project in the USA.

The Juvenile segment of the market is less homogenous than the Adolescent segment. These Economies have less Government support for EVSE market development, though some is in existence. Conductive AC remains the predominant form of PEV recharging, with substantial uncertainty around the likelihood of inductive and fast charging.

The Infant PEV markets have little discussion about EVSE market development, with minimal Government support for public recharging infrastructure installation. No Infant markets have standards in place, nor do they have a clear understanding of what kind of EVSE installation is predominant.

5. Electrical Grid Characteristics

5.1. Overview of Grid Function

Grid-provided electricity is available in all APEC Economies via distribution networks and is considered quite reliable. Brunei Darussalam and Papua New Guinea were the only Economies who suggested uncertainty around the consistent provision of electricity through their grid, characterizing it as “somewhat reliable”.

APEC Economy	voltage	Plug/Socket	Frequency
Australia	230v AC	I	50 Hz
Brunei Darussalam	240v AC	G	50 Hz
Canada	120v AC	A, B	60 Hz
Chile	220v AC	C, L	50 Hz
People's Republic of China	220v AC	A, C, I	50 Hz
Hong Kong, China	220v AC	G	50 Hz
Indonesia	220v AC	C, F, G	50 Hz
Japan	100v AC	A, B	50Hz & 60Hz
Republic of Korea	220v AC	C, F	60 Hz
Malaysia	230v AC	C, G	50 Hz
Mexico	127v AC	A, B	60 Hz
New Zealand	230v AC	I	50 Hz
Papua New Guinea	240v AC	I	50 Hz
Peru	220v AC	A, B, C	60 Hz
The Philippines	220v AC	A, B, C	60 Hz
Russia	220v AC	C, F	50 Hz
Singapore	230v AC	C, G, M	50 Hz
Chinese Taipei	110v AC	A, B	60 Hz
Thailand	220v AC	A, B, C	50 Hz
The United States	120v AC	A, B	60 Hz
Viet Nam	220v AC	A, C, G	50 Hz

Figure 33: Basic Electric Grid Characteristics by APEC Economy

APEC Economies either operate 110-120 voltage or 220-240 voltage, with the majority of Economies (76 percent) using 220-240 volts for basic electricity. Japan and Mexico differ slightly with voltages of 100 and 127 respectively. Frequencies by Economy experience a similar split where 13 (62 percent) utilize 50 Hertz and 6 (33 percent) utilize 60. Japan is the only exception, utilizing both 50 and 60 Hertz. There is great diversity amongst APEC Members with regard to the standard for a plug/socket, with Types A, B, C, F, G, I, L and M in use across the Economies. Figure 33 summarizes and highlights their differences.

5.2 Peak Demand / Load

Peak demand is considered by many to be a critical issue to PEV uptake as it believed (and in some cases confirmed) that large volumes of PEVs will generate additional load on the electricity network in any geographic region, and contribute to peak demand. Increase of peak demand is a threat for many APEC Economies as accommodating increase in peak demand often results in costly upgrades to network infrastructure.

Many APEC Economies reported an episode of "peak demand" for the electricity system, though peak times differ Economy to Economy, as well as region to region (i.e. states or territories or city vs. rural) within each Economy. In some cases, time of peak shifts depending on the season of the year (e.g. heating in winter and air conditioning during the hottest days of summer). Chinese Taipei reports occurrence of greatest daily peak between the hours of 12:00 and 15:00 whereas Canadians experience greatest peak load from 06:00 to 08:30 and then again 17:00 to 19:30 as a result of heating and cooking in the winter months.

Peak can be defined by peak demand (i.e. the greatest point of electricity demand at any given point during the day) versus system peak (i.e. the point at which the electricity generation is operating at its maximum). For example, Australia reports a use of 70 percent of system peak on average across its National Electricity Market. As some PEVs can command a larger load than other appliances, both peak demand and system peak can pose issues for the uptake of PEVs.

System peak was not reviewed as part of this research as low volumes of PEVs currently in the market place are generally not considered to threaten system peak. However, it may be the case that in some APEC Economies, particularly those whose electricity generation is less developed, PEV load demand may have a greater impact on system peak than in more developed Economies.

5.3 Smart Grid

Smart grid is a concept that is not easily defined. Essentially, "smart grid" refers to systematic enhancement to the existing electricity infrastructure in order to incorporate new "smart" technologies that assist in improving its long term operational efficiency.

Smart grid is the aggregate of many individual technologies working together to increase the overall functionality of electricity infrastructure; however the level of enhancement differs region to region.

Figure 34. Diagrammatic Representation of Smart Grid (EPRI)

APEC is actively engaged in smart grid work among its member countries and while PEV connectivity is an important part of that work, the smart grid agenda is much broader in terms of its scope. As discussed in Section 1.3, smart grid activities through APEC are predominately progressed through the following three forums:

- APEC Regulatory Cooperation Advancement Mechanism *on Trade-Related Standards and Technical Regulations (ARCAM)*
- APEC Energy Smart Communities Initiative (ESCI)
- APEC Smart Grid Initiative (ASGI)

For greatest relevance to this report, the consultant considered smart grid in the context of policy priority for each APEC Economy, expecting that efforts made toward smart grid development would (1) coincide with progress on EV Connectivity relating to standards and market development and (2) illustrate a trend toward greater public investment in grid connectivity and enhanced functionality.

Considering the scope refinement, only a handful of APEC Economies registered significant smart grid activities, though many Economies had some activity. Examples of Economies with greatest activity on smart grid include:

- **Australia:** The Commonwealth of Australia earmarked AU$100 million for a trial of smart grid features, including PEV connectivity, which commenced in 2010. The trial, called *Smart Grid, Smart City*, is demonstrating a commercial-scale smart grid and collecting data to analyze benefits and costs (Smart Grid, Smart City).

- **Republic of Korea:** Korea established the Korean Smart Grid Institute in 2010 and has since led substantial investment in smart grid both locally and internationally. Korea has authored a roadmap for smart grid technological integration and its governing institute supports more than 100 member organizations (APEC Energy Working Group, Using Smart Grids).

- **Singapore:** The Energy Market Authority in Singapore has led a smart meter trial and is planning a larger-scale smart grid deployment to test fully the commercial feasibility of various smart grid technologies. Smart grid development in Singapore is supported by Government and consistent with its plans for energy resilience (Energy Market Authority).

- **The United States of America:** The US has been active in smart grid since 2007, when its development was formalized through passage of energy legislation. To date, the US Government has investment more than US$4 billion to demonstrate smart grid technologies and support modernization of the existing system (APEC Energy Working Group, Using Smart Grids).

In addition to the aforementioned smart grid progress in the countries listed, above, nearly every other APEC Economy is active in smart grid, with some form of deployment or trial underway (the exceptions being Brunei Darussalam, Chile, Papua New Guinea and Peru).

6. Potential barriers for the trade of PEVs across APEC Economies

6.1. Overview of Trade Barriers

6.1.1. Definition of Technical Barriers to Trade

Trade barriers can take many forms and it is important to clearly define which trade barriers are of direct concern for this study of APEC EV Connectivity Conditions. In general, *Trade Barriers* are Government-induced restrictions on international trade, and can be classified as tariff vs. non-tariff barriers to trade. *Technical Barriers to Trade* describe the category of non-tariff barriers in the form of standards and regulations that Economies use to regulate markets and protect their consumers and natural resources. The World Trade Organization's (WTO) Agreement on Technical Barriers to Trade notes that:

"Technical regulations and product standards may vary from country to country. Having many different regulations and standards makes life difficult for producers and exporters. If regulations are set arbitrarily, they could be used as an excuse for protectionism. The Agreement on Technical Barriers to Trade tries to ensure that regulations, standards, testing and certification procedures do not create unnecessary obstacles, while also providing members with the right to implement measures to achieve legitimate policy objectives, such as the protection of human health and safety, or the environment." (WTO).

It is these standards and regulations or EV Connectivity Technical Barriers to Trade (EVCTBTs) that are of direct concern in this study of APEC Economies. That is not to say that other barriers to the trade of EVs do not exist (as some of these have been identified too), but they are not the central focus of this study.

6.1.2. Significance of EV Connectivity Technical Barriers to Trade

Through the ongoing promotion of globalization and free trade agendas, the influence of tariff barriers has generally declined causing non-tariff barriers to become increasingly visible as impediments to international trade. With regard to Technical Barriers to Trade, the Organization for Economic Co-operation and Development (OECD) has estimated that, depending on the product, differing standards and technical regulations in different markets and the need for multiple testing and certification may constitute between 2 per cent and 10 per cent of overall costs of production (Australian Government).

Given the early stage of the PEV market, the exact significance of EVCTBTs in the overall costs of PEV production is not widely known. Early findings from survey data suggest homologating PEV products to various standards across Economies will fall into this range as well. Therefore, EVCTBTs clearly warrant immediate focus to remove barriers and promote greater uptake of EVs throughout APEC Economies, particularly in this fledgling stage of the EV market.

6.2. Overview of Standards and Regulations in the PEV Market

6.2.1. Evolution and Use of Standards and Regulations in the PEV Market

Given the emergent state of the PEV market and its standards and regulations, it is helpful to understand the close relationship yet distinct differences between standards and regulations as well as how they evolve and are employed.

Standards and regulations are both employed by Governments to achieve legitimate policy objectives, such as the protection of human health and safety or the environment, and the concept of product “compliance” is familiar in this regard. However, standards and regulations may also be used by Governments to discriminate against imports in order to protect domestic industries. Furthermore, standards may legitimately be employed by industry to protect consumer interests or promote competitive advantage. Finally, Governments may use standards and regulations to protect the early market development for strategically desirable technologies (such as PEVs). The familiar concept of “interoperability” stems from a desire of both industry and Government to protect consumer interests, avoid stranded assets, and promote healthy market development. Understanding this diversity of uses for standards and regulations is necessary to understand the complex drivers for their evolution.

Standards normally evolve to represent industry best practices as distilled from input provided by a broadly consultative and inclusive stakeholder group. However standards may also evolve to promote an approach favored by a more select group of players. In the sense that standards represent best practices rather than mandatory practices, they are considered voluntary. Regulations however evolve as legal instruments used by Governments to regulate markets including the nature of goods and services traded. In the sense that they are legally binding, regulations are usually mandatory, although in certain cases regulations may also apply voluntarily e.g. to the eligibility for market incentives.[2] Lastly, regulations will often refer to standards in order to mandate best practices; therefore Governments will often develop and evolve standards for their own regulatory purposes.

In the current emerging state of the PEV market, standards and regulations are evolving and being used by both industries and Governments for all of the above reasons. Furthermore, it is only natural that different standards and regulations emerge due to varying priorities of industries and Governments in different regions. This makes it quite challenging to track the evolution of all standards and regulations, as well as uncover the true driver(s) for the emergence of a particular standard or regulation, in today's early PEV market.

6.2.2. Definition of EV Connectivity Technical Barriers to Trade

For the purposes of this study of APEC EV Connectivity Conditions, it is therefore necessary to define exactly which set of circumstances creates barriers for the trade of EVs across national boundaries, based on various standards and regulations in PEV Connectivity. This definition is used consistently in this study to identify those barriers:

"A potential EV Connectivity Technical Barrier to Trade (EVCTBT) exists where there are regional market differences in standards or regulations governing EV connectivity conditions."

6.3. PEV Connectivity Technical Barriers to Trade

Based on the scope definition for PEV Connectivity provided in Section 1.1, EVCTBTs potentially arise in the following areas:

- Charging interfaces (i.e. PEV connector standards)
- Network interfaces for PEVs and EVSEs, including standard grid plug/socket configurations and circuit ratings (voltages/currents), and network communications or control protocols
- Electrical safety for PEVs and EVSEs, including electrical safety regulations, codes of practice, wiring rules and other installation standards, EMC compliance, and permitting during infrastructure commissioning.

[2] An example of an EV regulation including both mandatory and voluntary (incentive) measures is the California Zero Emission Vehicle Regulation.

- Energy market arrangements for PEVs and EVSEs.

6.3.1. Charging interfaces

The charging interfaces between plug-in electric vehicles (PEVs) and their electric vehicle supply equipment (EVSEs) are an area of significant potential barriers to trade.

The principal types of charging interface are conductive charging, inductive charging and battery swap, and potential barriers arise from the prioritization of these different interfaces within standards and regulations throughout APEC Economies. The majority of APEC Economies believe that conductive charging will be the most prevalent charging interface in both private and public locations. In contrast, the majority of Economies believe that both inductive charging and battery exchange will rarely or never be used in the next 5 years.

These biases are generally reflected in the prioritization of standards and regulations development throughout the APEC Economies as well as globally. Nevertheless, inductive charging and battery exchange are both being deployed in several locations through the Asia Pacific with significant commercial investment behind both approaches. A lack of national standards and regulations for these charging interfaces, as well as a lack of recognition by APEC Economies that these charging interfaces may even occur in the marketplace, will certainly create potential barriers to international trade of these solutions in future.

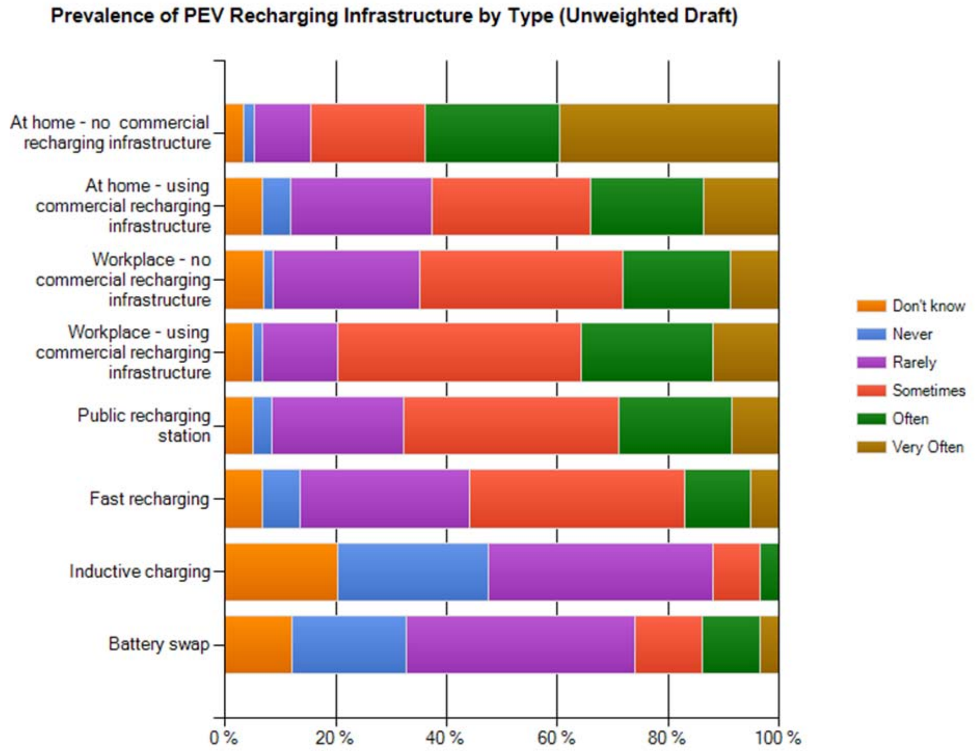

Figure 35: Prevalence PEV Recharging Infrastructure Types in APEC Economies

Conductive Charging

Conductive charging is clearly the most prevalent interface for EV charging, and should continue to be so based on APEC stakeholder expectations. Figure 35 provides a diagram and set of common terminology for conductive charging scenarios promoted by the European Automobile Manufacturers Association (ACEA). Unfortunately, potential barriers arise from the numerous, rival conductive charging solutions and standards that are currently being developed throughout the APEC Economies as well as globally. The problem if multiple charging solutions is further compounded by the fact that, in many usage scenarios, a different conductive interface is used for the "connector" vs. the "plug" (assuming a plug is required, as some charging systems are "hard-wired" at this location and therefore do not require their own plug). Figure 36 illustrates the difference between "plug" and "connector".

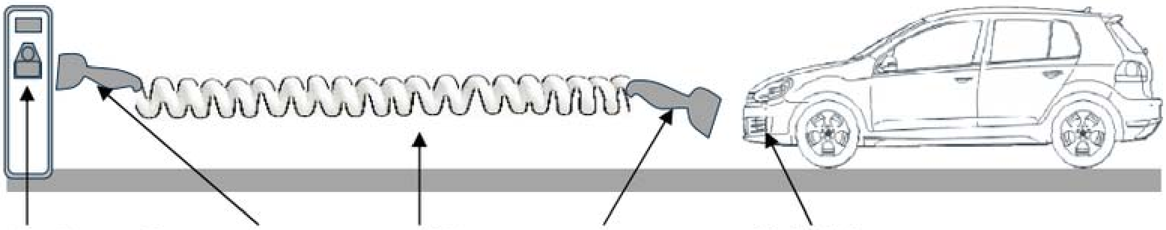

Figure 36: Common terminology for conductive charging scenarios

For example, the international standard IEC 62196 specifies a set of standardized conductive charging modes and connectors for PEV applications. Part 1 of IEC 62196 specifies four different charging modes that provide different functionalities based on various levels of charge rate, protection and control. Part 2 specifies three different connectors (Types 1-3) that can be applied to support Modes 2-3 (as well as Mode 4 in some limited cases), whereas Mode 1 only requires regular residential or industrial connectors not exceeding 16A and 250Vac single-phase or 480 Vac three-phase (at the supply side). Finally Part 3 will specify another standard connector optimized for Mode 4 operation although this standard has not yet balloted[3] with publication expected sometime during 2012-2013. While the IEC is to be applauded for its progress with IEC 62196, there are still some unresolved issues in the application of this standard to the regulation of EV Connectivity Conditions in APEC Economies.

Firstly, IEC 62196 is a standard, not a regulation; therefore it requires both industry and Governments to harmonize around the use of the standard, which is unfortunately not currently the case. Original Equipment Manufacturer (OEM) PEV products currently being sold into APEC Economies use a competing variety of charging modes and connector standards based on IEC 62196 solutions (particularly Type 1 vs. 2 connectors) as well as other solutions (such as CHAdeMO), with other standards in the pipeline for future products (such as the Combined Charging System). Many Economies have not yet regulated the use of specific mode(s) and connector(s), and they must weigh the risk of stifling PEV availability, diversity and competition in their market against the certainty for consumers and investors that regulation would provide. These issues are especially pronounced at the current early stage of the PEV market, particularly for "technology taker" markets or those markets with a very limited supply of PEVs currently available, such as Australia and New Zealand, amongst others. In contrast, the "technology maker" markets such as North America, Japan, China and Europe seem more comfortable with mandating the solutions preferred by their

[3] The IEC 62196 Mode 4 connector ballot is a contentious issue, with the long-standing CHAdeMO standard (Japanese OEMs) having been formally challenged recently by the Combined Charging System (North American and German OEMs) and the Chinese National Standard (Chinese OEMs).

domestic OEMs, but this presents an ongoing challenge for international harmonization of charging interface standards and regulations.

Secondly, IEC 62196 Modes 1-2 require the use of standard residential or industrial connectors that differ significantly between APEC Economies. The result is a unique physical cord-set required for each different outlet used in the APEC region, each of which must be tested and then manufactured in volume to bring to marketAccording to one PEV OEM (held in confidence), creation and supply of numerous cord sets " *adds significantly to the cost of importing our car*"

Finally, there are limits to the PEV conductive charging scenarios that can be supported by IEC 62196. The electrical limits of this standard are up to 690Vac @250A (50-60Hz) or 600Vdc @400A, equating to maximum charging powers of several hundred kilowatts. These power levels certainly can provide a relatively fast charge, but may not meet the needs of all users, particularly in the electric heavy vehicle sector. For example, the BYD 100kW DC Quick Charger (using the Chinese Mode 4 National Standard) can provide the BYD e6 passenger car with a 100percent/300km charge in 40 minutes whereas the same charger takes three hours to fully charge the 300km range of the BYD eBUS-12 transit bus. In contrast, JFE Engineering has demonstrated an Ultra Rapid Battery Charging System that can provide a Nissan Leaf with a DC rapid charge of 70percent (120km) in five minutes using 600A; the Proterra EcoRide BE35 FastFill transit bus in Los Angeles provides an 100percent (50km) charge in 10 minutes using over 1000A DC; the Varley Instant Charge Electric Bus in Brisbane, Australia provides an 80percent (80km) charge in less than 10 minutes using over 200A DC; and the Sinautec ultra capacitor buses in Shanghai use up to 720Vdc to provide a recharge in 30s at each bus stop. All of these charging scenarios are well beyond the capabilities of standards in IEC 62196, and alternative proprietary blade-style connectors (Proterra), pantograph-style connectors (Sinautec) and undisclosed connectors (JFE, Varley) have been developed to suit these usage cases currently in real-world deployment.

In summary, APEC PEV connectivity barriers arise in PEV conductive charging a) since current international connector standards and industry and Government trends are not conducive to harmonization, b) since APEC Economies differ in their standard residential and industrial connectors that are also used to support PEV charging, and c) since current PEV connector standards do not support all the required usage scenarios throughout the PEV industry.

Inductive Charging

Inductive charging or “wireless power” for PEVs is a far less mature technology than conductive charging, and the EV connectivity barriers in this area arise primarily from this lack of maturity.

Inductive charging has only begun to deploy in a small number of markets worldwide, but nevertheless a large group of stakeholders are taking an interest in deployment and standardization of the technology. Stakeholders include wireless power technology providers, PEV charging providers, automotive OEMs and Tier-1 suppliers, and a range of Government organizations in Economies such as the US, Republic of Korea, Japan and New Zealand.

The primary connectivity barrier in inductive charging is the lack of technical standards for the technology. Early collaborations in this area include the SAE J2954 Wireless Charging Taskforce or the Alliance for Wireless Power; however both of these efforts are still yet to release a standard.

A secondary barrier stems from uncertainty around the likely usage cases for inductive charging, which is a necessary precursor for the definition of standards. For example, the current Technical Information Reference (TIR) for SAE J2954 provides guidance on wireless EV charging in static (i.e. stationary) scenarios at powers of up to 150kW, but provides no guidance on dynamic (i.e. in-motion) wireless charging which is a scenario currently being suggested by Korea and Qualcomm.

A final barrier stems from the awareness and prioritization of inductive charging amongst APEC Economies, with most Economies suggesting little prevalence and limited awareness of the technology. This is despite the widespread participation of more than 30 corporations, including 14 automotive OEMs, in the SAE J2954 Wireless Charging Taskforce.

Battery Swap

Battery Swap or “battery exchange” or “battery switch” is similarly a less mature technology than conductive charging, and the barriers to battery swap also arise primarily from this lack of maturity.

Battery swap has been popularized for electric cars by Better Place, with their current rollout of battery switch stations in Israel, Japan and China, and with Denmark and Australia soon to follow. Other examples of battery exchange include the schemes for electric two-wheelers in Chinese Taipei and electric buses in China.

Standards for battery swap are yet to clearly emerge, although ANSI reports that "…*in June 2011 China released for public comments nine standards that deal with battery swapping including: terminology, general requirements, testing specifications and construction codes. Furthermore, the CEN/CENELEC focus group report on European Electro-Mobility from July 2011 specified the need for international battery swapping standards addressing safety, energy needs, exchangeability, ready access, data and communication framework. Recently, IEC/TC 69 has indicated that it will take up this subject using the Chinese standards as the initial input to that work."* Lastly, Better Place and Renault are also leading the EASYBAT Consortium of nine other European engineering and research contractors to develop *"…models and generic interfaces for easy and safe battery insertion and removal in electric vehicles.*" It is not clear from this APEC survey to what extent standards are being pursued for battery swap in electric buses or two-wheelers.

The main challenge for the promotion and standardization of battery swap appears to be lack of support from a widespread group automotive OEMs. To-date, Renault is the only company to have launched a battery-swap enabled car, although Better Place has also established an MOU with Chery Automobile Co and formed the EV Engineering consortium of Australian Tier-1 suppliers – in both cases to build small fleets of prototype battery-swap capable cars. Furthermore, few Governments have shown an interest in standardization of battery exchange, apart from China's leading efforts and some support from the European Commission. Very few APEC Economies have signaled an interest in battery swap, with the clear majority expecting battery swap to occur rarely or never. It seems likely that, unless significant progress is made on battery swap standardization through IEC/TC69, the burden will remain with the vested industry including Better Place and its global partners and other vehicle manufacturers in China. Fortunately, interoperability will not be a concern so long as Better Place and its partners are the only entities trading battery swap vehicles internationally, but this will of course limit battery swap's market share to that achievable by Better Place.

6.3.2. Network interfaces

Network interfaces for PEVs and EVSEs include the interfaces between elements of a charging infrastructure network as well as the interfaces from a charging network to the power grid. Therefore network interfaces is a broad category of that includes:

- Electricity grid plugs/sockets, standard voltages/frequencies and phases;

- EVSE network interfaces including the communications and control mechanisms for multiple EVSEs in a charging network; and

- Smart grid interfaces including the communications and control mechanisms for managing the charging network as part of the broader power grid.

Potential barriers arise in all three areas.

Grid plugs/sockets, voltages, currents, frequencies and phases

Figure 33 demonstrates the substantial variations in standard plugs/sockets and grid voltages and frequencies that occur throughout the APEC region.

As noted above, the variation in plugs/sockets creates an obvious barrier for IEC 62196 Modes 1 & 2 charging, since unique equipment is required to match each plug/socket combination. In contrast, this is not normally a problem for Modes 3 & 4 charging, since equipment for these modes is required to be hardwired to the grid. However, some "dual port" EVSEs support Modes 1-3 therefore it can be a problem for these too.

The differing grid voltages can also require unique equipment for each voltage.

An excellent example of these barriers and the need to provide multiple versions of the same equipment is provided by the products offered by Coulomb technologies. Their website lists seven different types of "charging stations", but closer inspection of the list reveals that even more variants are required to cater to the varying grid configurations around the world:

- Most of the Coulomb EVSE products (CT500, CT2000, CT2021 and CT2025) require a 208-240Vac/32A single-phase input, delivering charge to the PEV via a SAE J1772 connector on a hardwired cable. These configurations are suitable for any market where single-phase AC, Mode 3, "Level 2" charging is desired.

- The CT1500 EVSE is specially developed for Modes 1 &2 or "Level 1" charging in Europe and Australia/New Zealand, since it requires a single-phase, 220-240Vac/16A input and delivers charge via standard residential plug/socket combinations (this combination is not permitted in the US). Three different versions of the CT1500 are available for the plugs in the UK, continental Europe, and Australia/New Zealand, respectively.

- The CT2100 and CT2500 EVSEs are both “dual output” EVSEs providing Modes 1-3 (or “Levels 1 & 2”) charging with a separate circuit configuration for each output. However, due to regional differences in grid configurations, there are several variants of both products:
    - There are two versions of the CT2100. The “Level 2” circuit is common across both, with a single-phase 208-240Vac/32A input delivering charge via a SAE J1772 connector on a hardwired cable. However, the “Level 1” circuit varies, with a 120Vac/16A input and NEMA outlet for the US market vs. a 240Vac/16A input and AS 3112 outlet for Australia/New Zealand.
    - There are three versions of the CT2500 for the Europe and Australia/New Zealand markets. The “Level 1” circuit is single-phase, 220-240Vac/16A input delivering charge via standard outlets (for the UK, continental Europe, or Australia/New Zealand). The “Level 2” circuit however is single or three-phase input 220-240Vac/32A per phase, delivering charge via a Mennekes port built into the device. The CT2500 is not suited to the US.

This example serves to highlight the great lengths an EVSE provider must go to serve the global market with its wide variety of grid configurations. Clearly Coulomb have made a commercial decision to provide their full range of solutions, but there is clearly a cost in doing so too, with each individual model having to be designed, tested and certified for use.

EVSE network interfaces

Beyond the charging interfaces for the PEV, other EVSE network interfaces can be required to provide communication and control mechanisms for multiple EVSEs in a charging network, as well as the user ID, metering and billing functions that are a common feature of these networks.

Generally the concerns in this regard are around charging network accessibility and interoperability for all PEV users, including the possibility of roaming. However, it is a challenging area with little standardization due to the proprietary approaches used by the charging service providers in support of their varying business models.

Common questions include:

- Assuming the charging network is online, is it accessible to all users? Can a subscriber to charging network A also use network B at a reasonable cost? Are the EVSEs in network B visible to the network A subscriber (on their smart phone, etc)? Can a PEV visitor from out of town use the either network ad hoc by paying at the point of service?

- What if the charging network goes offline temporarily due to a system glitch? Can PEVs still use it during this time? Is there a default, fallback mode?

- What if the charging service provider goes out of business? Will the EVSE network become stranded?

The more-mature PEV markets are grappling with these questions as they try to scale-up their EVSE rollouts and promote competition in the PEV charging market. However, it is a challenging area due to the lack of standardization and the regional approaches are likely to differ due to varying consumer and regulator preferences. For example, the California Public Utilities Commission (CPUC), after having previously ruled that EVSEs could not be owned and operated by Californian utilities, is now implementing a US$100M settlement with NRG Energy (a US utility) that will pay for a statewide infrastructure of at least 200 public fast-charging stations and another 10,000 EVSEs at 1,000 locations around California. On top of its legal aspects, this settlement will no doubt leave a lasting impression on the Californian EVSE market as well as its ongoing regulatory treatment. But similar circumstances are unlikely to be repeated elsewhere in the APEC region, and regional differences in the regulation of EVSE networks are likely to occur.

Despite these regional differences, standards and regulations for EVSE network interfaces are only likely to become a barrier to trade if APEC Economies mandate certain requirements for EVSE network accessibility and interoperability. At the time of writing, no examples of this had been found in the APEC region. However, a good example is provided by the Mobi.E network in Portugal, which provides a unique, open and universal charging network facilitated by an electric mobility “managing entity” established by the Portugese national Government.

Smart grid network interfaces

Smart grid interfaces provide the communications and control mechanisms for integrating PEV charging networks as part of the broader power grid. However, the integration of PEVs with the smart grid is an extremely challenging area to track since the smart grid is also a “moving target” with much ongoing debate around the feature set, system architecture and interface definitions required in a smart grid. Accordingly, the regulatory treatment of smart grids throughout APEC is also in a great state of flux.

PEV-smart grid integration is further complicated by the number of ways a PEV can “connect” with the grid (see Figure 2):

- The PEV can interface with the smart grid via smart functionality in the EVSE.
- The PEV can interface directly with a smart meter (using wireless communication protocols).
- The PEV can interface with a wireless OEM network (e.g. GM’s Onstar) which then interfaces with the smart grid.
- The EVSE can interface with the smart grid or with a smart meter independent of the PEV, to provide an indirect interface for the PEV.

One of the main barriers in the standardization of PEV-smart grid integration is the lack of consensus among stakeholders around the prioritization of these differing methods.

The status of PEV-smart grid integration in APEC Economies was most-recently studied in 2011 by the Pacific Northwest National Laboratory for the APEC EWG. The report cited several examples of pilot programs occurring in the US, Australia, Japan and Korea. However, the report also noted that “*unlike other smart grid elements that are already in large-scale deployment, the benefits tied to PEV deployment are more speculative and untested.*”

This current survey suggests that the overall status of PEV-smart grid integration in APEC Economies has not progressed greatly. While the number and scale of pre-commercial trials and pilot programs in this area continues to grow, the overall benefits vs. costs and preferred system architectures for PEV-smart grid integration are still being determined, and these are quite likely to vary significantly between Economies.

Until these sub-regional preferences develop more clearly, it is quite difficult to speak definitely about the degree to which standards and regulations in PEV-smart grid integration are creating barriers to trade. As the smart grid and PEV markets throughout APEC continue to mature in parallel, care will need to be taken to identify areas of common ground between Economies that can form the basis of ongoing harmonization efforts in this area.

6.3.3. Electrical safety

Electrical safety regulations relevant to PEVs and EVSEs include a wide array of appliance and installation standards such as electrical codes and wiring rules, product compliance around electrical safety and electromagnetic compatability (EMC), and permitting procedures during the commissioning of electrical equipment.

Appliance Standards

Only limited information on electrical appliance standards throughout APEC Economies was available at the time of writing, but these clearly differ throughout the region.

For example, electrical product safety in the US is governed by regulations in the National Electrical Code and standards set by Underwriters Laboratory, whereas in Australia/New Zealand the Electrical Safety Regulations make reference to standards such as AS/NZS 3820.

Similarly, in Australia/New Zealand EMC compliance is Government by the C-Tick label, whereas is the US a FCC Declaration of Conformance is required.

In all cases, these regional variations in appliance standards create the trade barrier of extra costs of compliance for importers of electrical products. As noted in Section 6.1.2, the OECD has estimated that these costs may constitute between 2-10percent of the total costs of products.

Another potential barrier for trade of PEVs is their classification as a product type. The central question is whether a PEV is a vehicle (in which case homologation requirements will apply) or an appliance (in which case electrical appliance standards will apply). Unfortunately some jurisdictions are inclined to say both.

Installation Standards

Installation standards, such as wiring rules, are applied in the permitting process during commissioning of electrical equipment. Again, these standards vary throughout the APEC region, with the National Electrical Code governing EVSE installations in the US vs. the AS/NZS Wiring Rules governing such installations in Australia/New Zealand.

Installation standards normally do not normally create barriers to trade (as they do not govern the importation of equipment, but rather its commissioning) but they can create these barriers in rare cases. For example, the US National Electric Code specifies that appliances operating on 220-240V circuits must be hard-wired (i.e. not pluggable) unless special additional requirements are met. The implication of this regulation is that Mode 1 & 2 charging cannot be performed in the US from a standard 208-240V outlet, therefore products utilizing this approach cannot be sold into the US without greatly compromising their functionality (they can only plug into a 110-120V outlet, greatly reducing their charge rate, or they must be sold with a dedicated EVSE, greatly increasing their cost).

A “market lockout” trade barrier of this kind can arise from installation standards.

6.3.4. Energy market arrangements

Energy market arrangements are the rules governing how electrical services can be traded in a market. These rules obviously have potential implications for the use of PEVs and EVSEs. As with electrical installation standards, energy market arrangements do not normally create barriers to trade (as they do not govern the importation of equipment), but they can sometimes create a “market lockout” scenario.

For example, in California the CPUC recently made a determination that EVSEs could not be owned and operated by utilities. While this does not prevent the use of EVSEs in California, it does create a market barrier for those vendors who had developed EVSE systems optimized for utility customers.

Similarly, the CPUC has recently made a determination allowing the use of low-cost sub-metering arrangements for EVSEs, whereas the equivalent market rules in Australia currently prevent this arrangement. Therefore those EVSE providers who are reliant on low-cost sub-metering do not fare well in Australia.

Lastly, a regulation in the State of Queensland, Australia specifies that appliances using the ripple-controlled, off-peak Tariff 33 must be hard-wired on a dedicated circuit (i.e. they cannot be pluggable). This effectively prevents PEV users in Queensland from using low-cost Mode 1 or 2 charging systems with low-cost off-peak electricity, forcing them to either pay more for peak-rate electricity or a dedicated EVSE. While this is not strictly a trade barrier, it has obvious implications for the overall economic viability of PEVs in this regional market.

6.4. Other PEV Barriers to Trade

This study has also identified other potential barriers to PEV trade that fall outside the scope of EV Connectivity Conditions but yet are still quite relevant to APEC Economies.

6.4.1. Vehicle homologation requirements

Vehicle homologation requirements are those regulations governing which vehicles can be imported and sold in a market, and they vary widely throughout APEC, with obvious implications for the trade of PEVs.

For example, the USA, Canada, Australia and New Zealand all offer similar demographic potential as PEV markets due to their high oil imports, high automobile dependency, high levels of urbanization and off-street garaged parking, robust electrical grids and high feasibility for home charging. However, the irony is that since Australia and New Zealand are right-hand drive (RHD) whereas the USA and Canada are left-hand drive (LHD), Australia and New Zealand have been more easily able to establish a supply of PEVs from Japan (also RHD) rather than the North American products.

Similarly, in Australia there are restrictions on the power rating of electric-assist bicycles and there is no legal category for “neighborhood electric vehicles”, therefore the trade of these products is impeded in Australia despite their popularity in other APEC Economies.

6.4.2. Other local market factors

A broad range of other local market factors can restrict trade of PEVs.

Government incentives or lack thereof can cause OEMs to steer their (currently limited) supply of PEVs towards the most favorable markets at the expense of others. This factor has been cited as a barrier in Australia which lacks national incentives for PEVs.

As noted above, various market arrangements such as energy market rules or installation standards can create an effective market lockout to some approaches.

Lastly, intellectual property (IP) regulation has been cited by McKinsey and Company as impeding the flow of imported PEVs into China.

These are just some of the many factors that can also inhibit trade of PEVs between APEC Economies.

7. Opportunities to remove barriers to trade of PEVs

The previous Section identified potential barriers to the trade of PEVs between APEC Economies, due to a variety of PEV connectivity conditions and other non-connectivity-related factors. This Section identifies areas of potential cooperation between APEC Economies where the harmonization of standards and regulations could significantly reduce barriers of trade on EVs.

7.1. Prioritization of Barriers

A simple qualitative framework has been used to consistently rank barriers in terms of their appeal in this regard. The framework considers:

- The significance of the barrier to trade, and the potential impact of its removal (characterized as being of *major* or *minor* significance); and

- The difficulty of removing the barrier, based on the maturity of standards and regulations or their level of institutional establishment (characterized as being *easy* or *hard* to remove).

Figure 37 provides a listing of the barriers from the previous sectionsalong with the authors' judgment of their significance and difficulty. Naturally, these judgments are subjective in nature based on the consultants' insights gained during the course of the project. A detailed rationale for the assessment of each barrier is provided as an Appendix in the final report.

Potential Barrier	Significance	Difficulty
Incomplete information concerning PEV Connectivity Conditions in APEC Economies	Major	Easy
Inductive charging and battery swap: - recognition as a valid approach by all Economies	Major	Easy
Smart grid-PEV integration: - unresolved definition of architecture and interfaces	Major	Easy
Electrical safety: - regulatory classification of PEVs (vehicle vs. appliance)	Major	Easy
Conductive charging harmonization	Major	Hard
Grid configuration harmonization - plugs/sockets, voltages, frequencies, phases	Major	Hard
Smart grid-PEV integration: - unknown regulatory treatment across APEC Economies	Major	Hard
Electrical safety: - Appliance and installation regulations harmonization	Major	Hard
Vehicle homologation: - Regulatory harmonization	Major	Hard
Local PEV market factors: - Pro-EV policies, incentives, market rules, IP protection	Major	Hard
Inductive charging and battery exchange: - Lack of standardization	Minor	Easy
Smart grid-PEV integration: – incomplete standards	Minor	Easy
EVSE networks: - accessibility and interoperability regulations	Minor	Hard
Electrical safety: – “market lockouts”	Minor	Hard
Energy market arrangements: – “market lockouts”	Minor	Hard

Figure 37: Ranking of barriers to trade of PEVs

Application of this framework to classify the barriers is quite straightforward. Barriers are prioritized in the following order (Figure 38):

- Barriers of **major** significance that are **easy** to resolve:
  - These barriers are the "low hanging fruit" that should be resolved urgently for fast, high-impact outcomes.

- Barriers of **major** significance that are **hard** to resolve:
  - These barriers are great challenges that could require a long and concerted effort to resolve (in which case the effort would be justified), but might also be unable to resolve.

- Barriers of **minor** significance that are **easy** to resolve:
  - These barriers are low priority, in the sense that they do not require a concerted effort, or are likely to resolve themselves given enough time.

- Barriers of **minor** significance that are **hard** to resolve
  - These barriers are considered not being worth the effort to resolve.

	Hard	Easy
Major	• Conductive charging harmonization • Grid configuration harmonization • Electrical safety – appliance and installation regulations harmonization • Vehicle homologation – regulatory harmonization • Local PEV market factors – pro-EV policies • Smart grid-PEV integration – unknown regulatory treatment across APEC Economies	• Incomplete information concerning PEV Connectivity Conditions in APEC Economies • Inductive charging and battery exchange – recognition as a valid approach by all Economies • Electrical safety – regulatory classification of PEVs (vehicle vs. appliance) • Smart grid-PEV integration – unresolved definition of architecture/interfaces
Minor	• EVSE networks – accessibility & interoperability regulations • Electrical safety – “market lockouts” • Energy market arrangements – “market lockouts”	• Inductive charging and battery exchange – lack of standardization • Smart grid-PEV integration – incomplete standards

Figure 38: Classification of barriers to trade of PEVs

7.2. Recommended Actions

Recommended actions are suggested here based on the findings of the survey plus the ranking of barriers outlined above. Actions are recommended in the “major, easy” and “major, hard” categories only. Barriers in the other categories are not considered worthy of cooperative pursuit across APEC Economies.

7.2.1. Significant barriers that are easy to overcome

Incomplete information concerning PEV Connectivity Conditions in APEC Economies
One of the greatest challenges in this study was obtaining comprehensive information about the full spectrum of standards and regulations governing PEV connectivity in APEC Economies. It was suggested at the Hong Kong, October 2011 workshop that an **APEC PEV Knowledge Network** should be established to share the EV policies, market information, EV adoption experience and other relevant information/data. Verdant Vision strongly endorses this proposal.

Inductive charging and battery exchange – recognition as a valid approach by all APEC Economies

Recognition of inductive charging and battery exchange as valid approaches to PEV charging by all APEC Economies will promote greater EVSE marketplace awareness and competition, as well as provide greater impetus for (early) standardization and regulatory harmonization of these technologies. A greater awareness of inductive charging and battery exchange can be promoted through an **APEC PEV Knowledge Network**.

Electrical safety – regulatory classification of PEVs as vehicle vs. appliance

Awareness of how vehicle vs. appliance regulations can overlap on PEV and EVSE products can help Economies to avoid excessive compliance burdens for these products. The more-mature APEC PEV markets already have experience with these issues and could highlight them through an **APEC PEV Knowledge Network**.

Smart grid-PEV integration – unresolved definition of architecture/interfaces

Desired smart grid architectures and interfaces require further definition in order to provide the right context for standards-setting and regulatory harmonization in relation to PEVs. However, PEV-smart grid integration is only one aspect of the very broad subject that is smart grids, and it would be unreasonable to expect that PEVs alone should drive the smart grid agenda. Rather, smart grid programs will need to remain mindful of PEV considerations as both technologies and their associated markets develop in parallel. APEC's existing Smart Grid Initiative (ASGI) provides a mechanism to keep track of PEV considerations, but it is recommended that improved data collection and exchange would be enabled by the **APEC PEV Knowledge Network.**

7.2.2. Significant barriers that are hard to overcome

Conductive charging harmonization

The need for harmonization of conductive charging standards and regulations is clearly urgent given the already rapid growth of the conductive EVSE market. However, it is also one of the most challenging areas for APEC given the wide array of conductive charging approaches being pursued by APEC Economies. With the upcoming ballot to update IEC 62196, APEC Economies will quickly need to establish their position, and a united front is preferred given the emerging alliance between North America and Europe around the proposed Combo Connector. Certain APEC Economies, such as Japan and China, will be left hanging if this connector prevails.

APEC should urgently establish an **Electric Vehicle Recharging Infrastructure Taskforce (EVRIT)** to harness resident expertise in the region, develop an APEC position for the upcoming IEC 62196 ballot, and devise an interoperability strategy to manage the outcomes of the ballot process. This group could also fulfill other tasks such as promoting an awareness of other EVSE technologies and interfacing with the APEC Smart Grid Initiative.

Smart grid-PEV integration –unknown regulatory treatment across APEC Economies
As the smart grid and PEV markets continue to expand, Economies are likely to implement or update various regulatory measures that will govern PEV-smart grid integration. This survey process has not garnered sufficient data in this area, but it is also anticipated that an ongoing watching brief will be required. One of the priorities of the proposed **APEC PEV Knowledge Network** should be to track regulatory developments in these areas across APEC Economies.

Grid configuration harmonization
While varying grid configurations (plugs/sockets, voltages/frequencies, etc) throughout the APEC region clearly create barriers to trade, no further action is recommended in this area since grid configurations are so well established and entrenched. This barrier is unlikely to be resolved.

Electrical safety – appliance and installation regulations harmonization
While differing electrical safety compliance obligations clearly create barriers to trade of PEVs throughout APEC, it is unreasonable to expect that Economies would be willing to modify their appliance and installation regulations for a single appliance technology. No further action is recommended, as this barrier is unlikely to be resolved.

Vehicle homologation – regulatory harmonization
While it is clear that varying vehicle homologation requirements create barriers to trade of PEVs throughout APEC, no further action is proposed in this area since vehicle regulations are so well established and entrenched. This barrier is unlikely to be resolved.

Local PEV market factors – promote pro-EV policies
While not strictly related to PEV connectivity, other PEV market factors such as Government incentives and other policies can clearly act as barriers to trade. This is generally considered an area of high priority as was reflected in the results of the survey (Figure 39), with Government policies and incentives ranking significantly higher in priority than harmonization of PEV and EVSE standards.

APEC Energy Ministers have declared the need to prioritize the electrification of transport, and the benefits of PEVs were clearly outlined in the Hong Kong, October 2011 workshop. However, there is a need to sustain this dialogue and cultivate a pro-PEV climate and more PEV market maturity throughout the entire APEC region, rather than just in the more-advanced automotive Economies as is currently the case. Best practices can be fostered and diplomatic efforts can help focus Governments on the agreed need to prioritize PEVs, particularly in Economies where supportive policies and best practices are still somewhat lacking. The proposed **APEC PEV Knowledge Network** has a valuable role to play in bringing these issues into the spotlight.

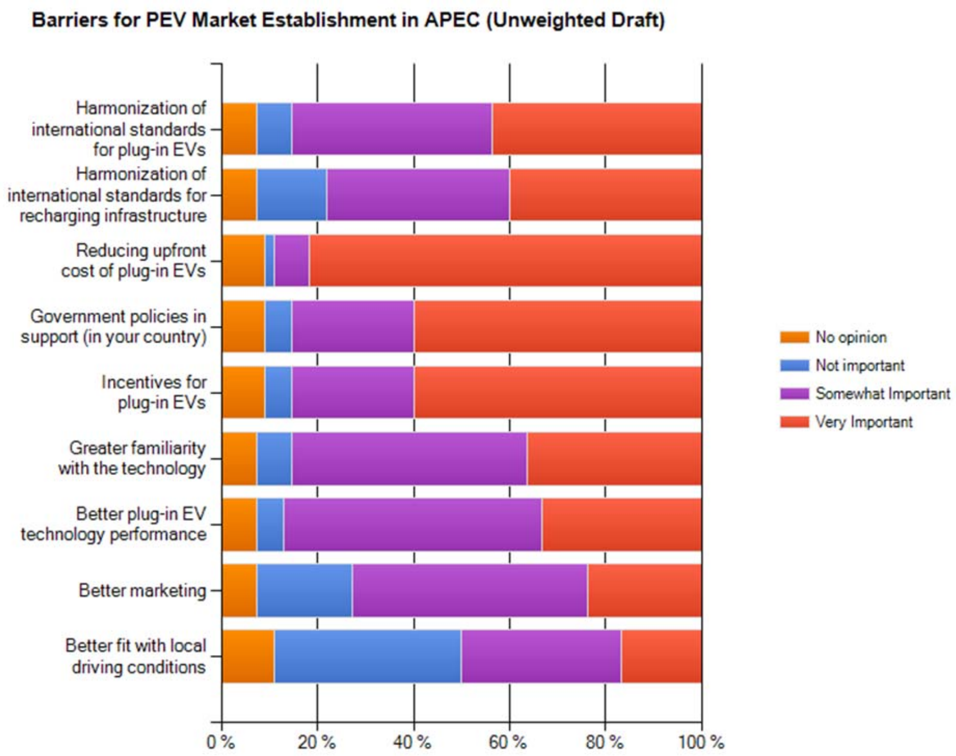

Figure 39: Barriers for PEV market establishment in APEC

7.2.3. Summary of recommended actions

The consultant recommends that an **APEC EV Knowledge Network** should be established to share EV policies, market information, EV adoption experiences and other relevant data among APEC Member Economies.

The consultant expects that this Network can help advance the overall PEV agenda in the Asia Pacific region as considered by this study. Specific actions that the Network can take to remove barriers include:

- Collecting more complete information about PEV connectivity conditions in APEC Economies on an ongoing basis.
- Promoting greater awareness among Member Economies of all types of PEV charging infrastructure, such as inductive charging and battery exchange.
- Promote greater harmonization and interoperability of PEV charging infrastructure standards in the Asia Pacific region. In particular, an Electric Vehicle Recharging Infrastructure Taskforce should be assembled to develop an appropriate position and response strategy for the upcoming ballot of IEC 62196.
- Promote greater awareness of how vehicle vs. appliance regulations can overlap on PEV and EVSE products, so as to help Economies to avoid excessive costs of compliance for these products.
- Keep track of PEV developments as part of the broader smart grid agenda, including regulatory developments in area of PEV-smart grid integration, and act as an expert interface to existing APEC smart grid initiatives.
- Promote a pro-EV environment in the APEC Region by fostering a supportive peer group for the promotion of EV policies and best practices amongst all APEC Member Economies.

8. Conclusions

This study has evaluated plug-in electric vehicle "connectivity conditions" in the APEC Member Economies. These conditions, such as current electric grid configurations and policies, standards and regulations for PEV infrastructure and markets, can have a direct bearing on barriers to trade of PEVs and charging equipment between markets.

A formal survey process, supplemented with independent desktop research, was used to gauge opinions and identify trends in PEV connectivity conditions as well as the PEV market generally throughout the Asia Pacific region. This research identified several key themes:

- All Economies within APEC are still at a relatively early stage in their PEV market development. A PEV market maturity framework was used to rank the Member Economies on this basis, with none of the Members having yet achieved a "mature" status.

- Detailed knowledge of PEV connectivity conditions within the stakeholder group was limited and gaps remained in the knowledge base after the completion of the survey despite supplemental desktop research. These gaps were attributed to the combined effects of early market development (meaning that stakeholders are still on a learning curve) plus inefficiencies in the survey process itself.

- Stakeholders generally agreed that the least-costly, least-sophisticated methods of PEV connectivity were likely to be most-prevalent in the market, due to the combined practical convenience of these methods plus end-user unwillingness to pay for more elaborate approaches. In particular, home-based recharging using existing electrical infrastructure was identified as a very popular and likely approach, irrespective of the maturity of different PEV markets. This outcome holds implications for the prioritization of various PEV connectivity topics within APEC, such as PEV-smart grid integration, and the focus of these initiatives should be reconsidered in light of this data.

Barriers to trade from PEV connectivity conditions were identified in a number of areas such as charging interfaces, grid network interfaces, electrical safety regulations and energy market arrangements. However other barriers to trade such as vehicle homologation requirements and government policies and incentives were also identified as being significant.

The recommended course of action to help resolve some of these barriers is to establish an ongoing APEC PEV Knowledge Network to share PEV policies, market information, EV adoption experiences and other relevant data among APEC Member Economies. This network can provide greater awareness of key topics and trends in standardization, harmonization and interoperability for PEV charging infrastructure. This network can also provide the foundation for APEC to represent the Asia-Pacific as a combined front in the international consideration of PEV connectivity standards such as IEC 62196. Lastly, the network can help coordinate the efforts of all APEC Economies to foster a pro-EV climate in the Asia Pacific region.

Finally, it was also recognized that some barriers to trade of PEVs throughout APEC were unlikely to be resolved through a process of harmonization, due to the established and entrenched nature of some standards and regulations. Examples in this regard include standard grid configurations, electrical safety regulations and vehicle homologation requirements.

9. References

Accenture. *Plug-in electric vehicles, Changing perceptions, hedging bets Accenture end-consumer survey on the electrification of private transport.* May 2011.

Accenture. *Changing the game: Plug-in Electric Vehicle Pilots.* February 2011.

American National Standards Institute (ANSI). *Standardization Roadmap for Electric Vehicles Version 1.0.* Last accessed 13 June 2012: http:// www.ansi.org/evsp/

APEC Energy Working Group. *APEC Workshop on Energy and Green Transport Benefits of Electric Vehicles*. 24-26 October 2011. APEC#211-RE-01.12

APEC Energy Working Group. *Using Smart Grids to Enhance Use of Energy-Efficiency and Renewable-Energy Technologies*. APEC# 211-RE-01.2

ARCAM Dialogue on Smart Grid Interoperability Standards Report to the Committee on Trade and Investment. Second Committee on Trade and Investment Meeting**.** Big Sky, United States 14-15 May 2011**.**

Arthapan, May. *Future of Green Vehicles.* Presentation Seminar on "Green: Prospects and Future Potentials for Automotive Industry" at the Malaysian Automotive Institute. March 2011.

Asia Development Bank. *Electric Vehicles Hold Promise of Bluer Skies for Manila.* Last accessed 29 May 2012: http://www.adb.org/news/electric-vehicles-hold-promise-bluer-skies-manila.

Australian Government, Department of Industry, Innovation, Science, Research and Tertiary Education. *Technical Barriers to Trade.* Last accessed 13 June 2012: http:// http://www.innovation.gov.au/Industry/TradePolicies/TechnicalBarrierstoTrade/Pages/default.aspx

Brunei Times. *Electric vehicles for airport police.* Last accessed 23 May 2012: http://www.bt.com.bn/science-technology/2012/02/18/electric-vehicles-airport-police

Chile Online. *Chile boosts infrastructure and incentives for electric cars*. Last accessed 23 May 2012: http://www.thisischile.cl/7207/2/chile-boosts-infrastructure-and-incentives-for-electric-cars/News.aspx

Coulomb Technologies. *Charging Stations.* Last accessed 13 June 2012: http:// http://www.coulombtech.com/products-chargepoint-stations.php

Department of Energy, United States of America. *Announcing $4 Million for Wireless EV Charging.* Last accessed 1 June 2012: http://apps1.eere.energy.gov/news/news_detail.cfm/news_id=18250

Electric Power Research Institute. *The EPRI Smart Grid Demonstration Initiative.* 2010.

Energy Efficiency and Conservation Authority (EECA). *Deploying electric vehicles in New Zealand: A guide to the regulatory and market environment.* February 2012*.*

Early, Robert, Liping Kang, Fend An and Lucia Green-Weiskel. *Electric Vehicles in the Content of Sustainable Development in China. Background Paper No. 9. CSD19/2011/BP9.* Prepared for the Commission on Sustainable Development, Nineteenth Session. 2-13 May 2011. United Nation Department of Economic and Social Affairs.

EASYBAT. *Easy and Safe Battery Switch in an EV.* Last accessed 23 June 2012: http:// http://www.easybat-project.eu/

Energy Market Authority, Singapore. *Electric Vehicles Test Bedding.* Last accessed 31 May 2012: http://www.ema.gov.sg/ev

EV Project (online). Last accessed 31 May 2012: http://www.blinknetwork.com/locator.html

Francfort, Jim. *Electric Vehicle Charging Levels and Requirements Overview.* Presentation, Clean Cities Webinar. 15 December 2010.

Fuel Saver. Last accessed 29 May 2012: http://labelling.fuelsaver.govt.nz/label.php

Hydro Quebec. *Transport Electrification.* Last accessed 26 May 2012: http://www.hydroquebec.com/transportation-electrification/

International Energy Agency (IEA). *EV City Casebook.* May 2012.

International Energy Agency (IEA). *Technology Roadmap: Electric and plug-in hybrid electric vehicles.* June 2011.

Ligget, Britt. *Shenzhen, China Launches the World's Largest Electric Vehicle Fleet.* Last accessed 31 May 2012: http://inhabitat.com/shenzhen-china-launches-the-worlds-largest-electric-vehicle-fleet/

McKinsey & Company. *Recharging China's electric vehicle aspirations – a perspective on revitalizing China's electric vehicle industry*. Last accessed 23 June 2012: http:// http://www.mckinseychina.com/2012/04/20/recharging-chinas-electric-vehicle-aspirations/

Mitsubishi Motors Australia. *Mitsubishi Announces an Additional 70 i-MiEV Electric Vehicles for the Australian Market in 2010.* Last accessed 30 May 2012: http://www.mitsubishi-motors.com.au/about-mitsubishi/latest-information/news-releases/corporate-news/view/mitsubishi-announces-an-additional-70-i-miev-electric-vehicles-for-the-australian-market-in-2010

Natural Resources Canada. *Electric Vehicle Technology Roadmap (2009). Last accessed 21 May 2012:* http://canmetenergy.nrcan.gc.ca/sites/canmetenergy.nrcan.gc.ca/files/pdf/fichier/81890/ElectricVehicleTechnologyRoadmap_e.pdf

New Zealand Ministry of Foreign Affairs and Trade. Last accessed 1 June 2012: http://www.mfat.govt.nz/Trade-and-Economic-Relations/APEC/index.php

Nissan Global. *The Renault-Nissan Alliance and the Government of Chile sign Memorandum of Understanding to study the introduction of zero emissions mobility***.** News Release, 20 October 2010.

NY Daily News (online). *Electric taxis drastically reduce air pollution in Chinese city of Shenzhen during one-year trial.* Last accessed 31 May 2012: http://articles.nydailynews.com/2011-05-12/news/29553946_1_nissan-leaf-electric-vehicles-taxis

OECD. *Technical Barriers to Trade. Last accessed 2 June 2012:* http://www.oecd.org/document/62/0,3746,en_2649_36251006_1842622_1_1_1_1,00.html

Pike Research. *Electric Vehicles in Asia Pacific.* November 2010.

Qualcomm. *Qualcomm Acquires HaloIPT Team and its Wireless Electric Vehicle Technology.* Last accessed 1 June 2012: http://www.qualcomm.com/media/releases/2011/11/08/qualcomm-acquires-haloipt-team-and-its-wireless-electric-vehicle-charging-

Roy, Serge. *International Standards on DC Charging Stations.* Presentation, EV 2010 VE Conference. Last accessed 29 May 2012: http://www.emc-mec.ca/EV2010P/T2S3_SergeRoy.pdf

Sandalow, David. *EV Cities and Ecosystems.* United States Department of Energy. Presentation, 5 May 2012.

Sholer, Richard. *PEV Standards Process and Status.* Presentation, Plugin 2010.

Smart Grid, Smart City. Last accessed 29 May 2012: http://www.smartgridsmartcity.com.au/

Trigg, Tali. Lewis Fulton, and Hiroyuki Kaneko. *The Road Ahead for Electric Vehicles: National Targets, Manufacturing Plans, Costs, and the Role for International Collaboration.* EVS26, Los Angeles, may 6-9, 2012.

Underwriters Lab (UL). *Electric Vehicle Standards Development Activities.* Last accessed 1 June 2012: http://www.ul.com/global/eng/pages/offerings/industries/powerandcontrols/electricvehicle/evstandards/

Van den Bossche, Peter. *Defining and Developing Standards.* Last accessed 29 May 2012: http://evtransportal.org/P_Van_den_Bossche1.pdf

Victorian EV Trial. Last accessed 31 May 2012: http://www.transport.vic.gov.au/projects/ev-trial

World Bank.*The China New Energy Vehicles Program: Challenges and Opportunities.* April 2011.

World Trade Organization (WTO). *Agreement toTechnical Barriers to Trade* Last accessed 1 June 2012: http://www.wto.org/english/docs_e/legal_e/17-tbt.pdf

Wellington City Council. *Electric Car Trial.* Last accessed 31 May 2012: http://www.wellington.govt.nz/news/display-item.php?id=4158

Yeamen, Elizabeth. *Renewable Energy in transport in New Zealand.* Presentation March 2011.