Asia-Pacific
Economic Cooperation

APEC Workshop on Energy and Green Transport
Benefits of Electric Vehicles

24-26 October 2011

APEC Energy Working Group

January 2012

EWG 05/2011A

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APEC#211-RE-01.12

Executive Summary

The Workshop was hosted and co-hosted by the People's Republic of China and Hong Kong, China respectively. Canada, Japan, New Zealand and the USA, were the four co-sponsors for the Workshop. The key objectives of the project were: -

i. To share the experience for power and transport planners in developed and developing economies in APEC region with a view to considering wider deployment of electric vehicles (EV) in green transport strategies and policies; and

ii. To build interest among the workshop participants of how 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.

The three-day workshop (24-26 Oct 2011) focused on the policy, infrastructure, standardization and technology of electric vehicle. The workshop had divided into 4 sessions in which 29 presentations were included. The last day was a technical visit to explore the electric vehicle manufacturers and a charging station in Shenzhen, China.

The Workshop had attracted participation of 15 APEC economies as well as Switzerland, Portugal, Germany and Macau with over 150 participants. There were totally 29 invited speakers (EV experts and delegates of participated economies) presenting and sharing their valuable knowledge and experience in EV in the Workshop.

Good discussion had been generated in the workshop especially in the areas of standards and policy. Substantial discussion was found in the charging system and standards. The discussion on battery technology, its effect to the performance of the electric vehicle, and usage of EV was also seen. Various APEC economies had shown their development in policy, electric vehicles and also the infrastructure.

In recent years, in order to reduce emission of automobiles, the adoption of electric vehicles (EV) or plug-in hybrid electric vehicles (PHEV) had been taken place rapidly in various economies. The rapid development was mainly due to two reasons. One was the development of technologies related to EV as the research in power electronics, machines, batteries and control engineering were mature for EV. The other was well-established policies of economics directing the initialization of adopting EV. This included governments' schemes of building charging facilities, subsidies/tax reduction encouraging consumers using EV and research programs for making an electric vehicle more competitive with a gasoline vehicle.

Delegates exchanged their views of the adoption and development of EVs and agreed that there would be continuous top speed establishment in EV in economies because the use of EV not only reduced emissions but also provided a number of benefits. Reduction of dependency of petroleum was necessary. In real situation, different kinds of renewable energy such as solar energy and wind energy were converted to electricity and therefore electricity to supply EV was not only coming from fossil fuels. An electric vehicle should be able to absorb wide forms of energy hence reduction of dependency of petroleum could be achieved. Fuel cell vehicle was an example. Use of bio-fuel might be another solution but it might cause huge impact to environment and ecosystem as planting of corn required large scale of land use.

Power quality improved through the development of EV. Statistics from the U.S. Department of Energy showed that in 2009, the average daily miles of a driver from center city, suburban and rural was 42km, 46.2km and 58.9km respectively. Nowadays, taking an average Japanese pure EV as an example, a normal charge of 8 hours could provide a driving range of over 160 km. Therefore, in the workshop, delegates had a discussion on that an EV could be employed as a mobile energy storage for load shifting the power grid. It could be charged in residential/suburban district at night time. During the day time, in the urban district where the driver working in, it could be discharged a portion of its storage leaving sufficient energy for driving it back. The battery in an EV was a mobile energy source. It facilitated the recent development of smart grid. It also made the grid more stable with such additional energy storage.

EV supported economy's growth through a new development of different kinds of industries related to EVs. Large scale adoption of EVs might cause industries of some automobile parts and accessories withered as the engine and fuel tank of a vehicle were replaced by a motor and a battery. In fact, the chassis of an EV should be similar to its counterpart. The manufacturing of battery and its charging infrastructure required technologies of different categories such as material engineering for the structure of battery, power electronics engineering for the battery management system, charging system and motor control, and information technology for the application of smart grid and advanced control. Therefore, the adoption of EV should be able to bring the development of EV related industries.

All these benefits were found related to three totally different natures of an EV compared to a vehicle driven by petroleum:

- Electricity was used to drive an EV.
- Batteries were used as the energy storage.
- An EV could be charged everywhere where electricity has been supplied with well established infrastructure.

Delegates agreed that a consumer was the one who made the ultimate decision to buy. In other words, an EV would be compared with a petroleum vehicle by a consumer. A consumer or a user would certainly consider the performance or difference in usage between an EV and a petroleum vehicle. In summary, the following points could be seen:

- Duration of replenishing energy. A quick charge could fill up 80% of the battery energy content. A standard charger might take several hours.
- Shorter driving range. Most EVs could run for 150km to 200km with a single charge. A quick charge could fill up 80% of the battery energy content. However, most gasoline vehicles could run for 300km to 400km with a fully refueled tank.
- Higher initial cost and maintenance cost. The cost of batteries for an EV was relatively high and practical life cycle of a battery was not fully testified. Around 1000 cycles for pure electric vehicle was possible.
- Less cost of ownership. The cost of electricity for driving an EV was a small fraction of the cost of gasoline for driving a gasoline vehicle under the same driving range.
- Flexible locations of charging infrastructures. Because the electrical safety was easily to be controlled, charging facilities could be located everywhere with electricity supplied but a gas station had to be located at a selected safe place because of the flammable properties of gasoline.

Appropriate measures could be brought into practice to overcome the deficiencies of an EV and challenges of adopting EVs. In the workshop, delegates discussed and shared their experience of executing feasible means from mainly three areas in Policy, Infrastructure and Technology. Their salient points could be summarized as follows:

- EV policy and strategy. A number of policies had been carried out or had been planned in economies including:
  - Financial subsidy / tax incentives to reduce the price of a new EV
  - Regulated administration guiding the EV market
  - International cooperation to harmonize EV standards
  - EV research and development encouragement.
  - EV business encouragement.
  - Education and promotion of electric vehicles
  - Codes and standards development
  - Collaboration with EV manufacturers
  - Market initialization by demonstration projects
  - Development of charging infrastructure by power companies, property developers, building management companies and government.
- EV infrastructure and standardization. The inconvenience of using an EV could be counteracted by suitable charging infrastructure:
  - Common or unified charging protocol between charging facilities and EVs
  - Suitable charging / discharging techniques to suit smart grid
  - Various charging mode options
  - Harmonization and unified of charging standards including the connectors
  - Optimization of performance and output power
  - Business model of EV charging facilities
  - Wide selection of charging facilities locations
- EV technology and development. The deficiencies of an EV could be eliminated by the improvement of EV technologies included:
  - Improvement of battery technologies for longer life time, higher performance, higher energy density, less charging time and lower cost.
  - Improvement of EV components for higher performance, better cooling and less weight.
  - Other measures of replenishing energy such as battery replacement technique, using super-capacitors and fuel cell.
  - Intelligent control with smart grid providing more powerful functions than a traditional vehicle. Energy utilization can be enhanced and energy mobility could be realized.
  - Component integration reducing the component count, component cost, manufacturing and maintenance procedures.

Areas for future work. Future works assisting the development of EV markets in economies identified by delegates included:

- Adoption of suitable policies on different stages of the growth of an EV market especially the policies guiding the market to change from government driven to market driven.

- 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.

- Encouragement of research and development activities to improve the performance and reduce the cost of EVs.

- Search for measures to change the mindset of consumers such as extensive EV demonstration showing the advantages of driving EVs and the ability of EVs to replace gasoline vehicle. Extensive education to general public as well as inclusion of EV information in teaching materials for schools was needed.

In addition, opportunities for regional cooperation between APEC economies to enhance the development of EV included:

- 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 research centers to accelerate the development of EVs.
- Cooperation between economies to strengthen the supply chain of different resources and EV parts/accessories.
- Cooperation between neighboring economies/countries to harmonize the standards for boundary crossing EVs.
- Negotiating the roadmap of adoption rate of EV.

In conclusion, participating economies and invited international EV experts made a great effort to the development and adoption of EVs by contributing ideas, showing facts and sharing experience in the workshop. The energy and green transport benefits of EVs, the challenges of adopting EVs, practical measures and future works were discussed. As driving an EV was still a new concept to most of consumers in the world, a number of works needed to be done in economies to move ahead and to achieve the objective of reducing emission of transportation.

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Acronyms and Abbreviations

APEC	Asia-Pacific Economic Cooperation
APERC	Asia Pacific Energy Research Centre
APAS	Automotive Parts and Accessory Systems R&D Centre
BEV	Battery Electric Vehicle
BMS	Battery Management System
BSS	Battery Swapping Station
CEPAS	Contactless e-Purse Application
CO2	Carbon Dioxide
DC	Direct Current
e-bus	Electric Bus
EMSD	Electrical and Mechanical Services Department
EV	Electric Vehicle
FTV	Fleet Test Vehicle
GWP	Global Warming Potential
HEV	Hybrid Electric Vehicle
HKC	Hong Kong, China
HKSAR	Hong Kong Special Administrative Region
HVAC	Heating Ventilation and Air Conditioning
ICE	Internal Combustion Engine
ICT	Information and communications technology
IT	Information Technology
kWh	Kilo Watt Hours
MOST	Ministry of Science and Technology
MWh	Mega Watt Hour
NO2	Nitrogen Dioxide
OEM	Original Equipment Manufacturer
PHEV	Plug-in Hybrid Electric Vehicle
PRC	People’s Republic of China
Q&A	Questions and Answers
RMB	Renminbi
RSP	Respirable suspended particulates
SAE	Society of Automotive Engineers
SO2	Sulfur Dioxide
SoC	State of Charge
SoH	State of Health
V2G	Vehicle to Grid

The Workshop

The Opening Address

The workshop was opened with the welcome remarks by Ms. GU Jun, Deputy Director General, Department of International Cooperation, National Energy Administration, People's Republic of China. It was then followed by the opening remarks of Dr. Kitty POON Kit, Under Secretary for the Environment, Hong Kong, China.

Welcoming Remarks

Ms GU discussed the policy of electric vehicles in China. There had been various initiatives in new energy vehicles development. Electric bus had been used in 2008 Beijing Olympic Games and 2010 Shanghai Expo. The trial of electric vehicles already exceeded several million km. Now the policy would work towards the establishment of standards.

Back in Sep 13 2011, APEC had organized meeting in San Francisco to discuss transportation and energy. Ministers and business representatives discussed ways to achieve clean way and low carbon development in transportation sectors. Action on low energy consumption, low carbon and sustainable development should be adopted. Ms GU said Hong Kong, China had initiated the legislation of road-side emission. In 2010, for the existing over 1 billion cars in the world of which close to 80 millions was in China, 18 million were sold in 2010. 96% of them were petroleum. In 2009, new energy vehicle initiative was called for large scale of production and sale of electric vehicles. In 2010, electric vehicle industry was recognized by the state council as the one of the seven strategic emerging industries and greatly supported by the central government. "Because of all those support of policy, we can see the steady development of new energy vehicle development in China", said Ms GU.

For demonstration in Beijing 2008 Olympic Games, almost 600 fuel cell hybrid electric vehicles had served for several million km. Since 2009, incentive had been provided to electric cars and electric buses in 25 cities. In 2010 Shanghai World Expo, 1017 automotives of super-capacitor, fuel cell, hybrid or electric powered vehicles had served for 4 million km. "Electric vehicle associated with energy efficiency and green transportation system sectors, and should be an important part of APEC energy cooperation agenda", said Ms GU. She also had suggested firstly to use the APEC Energy Working Group as a platform to facilitate technical and policy exchange. China had started to develop electric vehicle industry. It was wished that other economies should establish policy and measure, in related to technical standards, product tax, certification etc. Secondly, we should create opportunity for cooperation among industries and governments, explored possibility to create a technical mechanism for R&D, and worked together to tackle common and key technical bottom necks. Investment from other economies should be welcome. Other important issues were the work on human resource training program, to provide assistance in helping the development to train engineers and personnel in electric vehicles and alternative fuel vehicles.

Opening Remarks

Dr. POON said electric vehicle was of no emission, and should be widely used to help reducing road side emission. Positive contribution, incentives and legislation had been used to provide Euro 2 or earlier models to switch to cleaner models. One of the major sources of pollution was the power plant. We had imposed and tightened their emission cap that required retrofitting their coal-fire unit with emission control equipment and to maximize use of natural gas for electricity generation. As a result, a significant improvement of air quality had been witnessed. The road side emissions had been improved. The concentration of sulfur dioxide (SO_2) was dropped by 45% and respirable suspended particulates (RSP) was dropped by 18% from 2005 to 2010. We have been working closely with the Guangdong provincial Government to cut down emission of SO_2, NO_2 and RSP in the Pearl River Delta region.

A high level steering committee led by the Financial Secretary had been set up to promote the use of EV in Hong Kong, China. Since then, adoption of green technology and expansion of green technology on the road had begun. There were three actions organised:

1) In public transportation sector, bus companies were encouraged to switch to zero emission buses and test the use of electric buses. 36 e-buses would be tried on road by bus companies and their performance would be accessed. If positive result was found, a larger scale of e-bus would be organized.
2) A Pilot Green Transport fund of HK$300 millions was set up by the Government in March this year. Recently, approval of around $50 millions had been provided to test the low carbon transportation technology in electric buses and goods vehicles.
3) The Government had been actively liaising with EV manufacturers worldwide for production and encouragement of introduction of different models of EV to HKC. An Extensive network of charging facilities to support the development of EV was ensured. In less than 1 year, the number of EVs had been doubled to hit over 200 in Hong Kong, China.

For some EV manufacturers, Hong Kong, China was their first Asian market outside Japan. “It is our firm believe that EV will bring substantial environment improvement”, said Dr. POON. Promoting green economy also helped unleashing the economic potential that was enfolded in the design, manufacturing, marketing and servicing of this greener form of transport.

“No economy can do it alone, promoting and development of EV require collective efforts and joint collaboration by members of international community”, said Dr. POON.

EV Policy and Strategy of Participating Economies

In the workshop, representatives of seven APEC economies shared their views and their experience of EV policy and strategy. These economies were China; Canada; Hong Kong, China; Japan; Korea; Malaysia; and the USA. Each economy had its own strategy as they had different roadmaps of adopting EVs. However, the policies of establishing EV market of each economy were found to be similar: government steered. The common policies to attract consumers among the economies were to reduce the price of a new EV by financial subsidy or tax incentives and to conduct trial projects/demonstrations. The following section of this report reviewed the policy and strategy of each participating economy.

China

Presentation by Mr. WU Wei, Advisor, of Department of Industry, National Development and Reform Commission, People's Republic of China, showed the facts that the annual oil consumption exceeded 450 million tons with 55% imported in 2010 and the usage was expected to rise. Reduction of dependency on petroleum became the first objective of EV development in China. On the other hand, the Chinese Government raised maintaining sustainable and healthy development of auto industry and improving its competitiveness as a national strategy. With other objectives, such as improvement of urban environment and traffic, and keeping pace with international trend, the Chinese Government had established a number of policies included:

- Financial subsidy provided by both central government and local government for promoting the application of energy-saving and new energy vehicles in public services and their related supporting facilities.
- Encouragement of technological innovation and development of key parts of new energy vehicles in order to support the development of auto industry.
- Regulated administration guiding the market access requirements for EVs (for both manufacturers and products) and demonstration cities and projects.
- International cooperation and exchange on policies and information, harmonization of standards, research and development, and demonstration operation.

Furthermore, a number of demonstration projects had been set up in over 25 cities with more than 13,000 vehicles (including pure EV and hybrid EV). Hybrid buses were operated in 2010 World Expo in Shanghai and pure electric buses were operated in 2011 Universiade in Shenzhen. Demonstration projects provided China with excellent opportunities to verify the performance EVs and infrastructures, develop business modes, study the consumers' behavior of using EVs, and verify of policies.

In the future, various works and measures would be performed to fulfill China's objectives of EV development. These included:

- Strengthening roles of policies in guiding and cultivating the development of EVs
- Acceleration of innovation, development and construction of EV infrastructures
- Improvement of technologies and performance of EVs
- Harmonization of EV standards
- Performing more demonstration projects

Mr. WU said during the Q&A, "The development of grid, autoparts and charger is to ensure the safety charging for electric vehicles. Charging standards in China will harmonize with international market".

U.S.A.

As Mr. Steve GOGUEN, Senior Engineer for Vehicle Technologies, the U.S. Department of Energy presented, the U.S. government had set up a wide range of research programs which were cooperated with industry, covering most of the key components of an EV in order to develop more energy efficient transportation to reduce dependency of petroleum and emission of green house gas. These research programs included:

- Technologies related to battery such as materials research, high energy and power cell structure research and battery packing research.
- Technologies of electric drive such as high current and high temperature driving inverters, advancing cooling technique and packaging.
- R&D of electric motors with optimized use of rare earth material in permanent magnets or even without rare earth material.
- R&D of power electronics such as new topologies for inverters and converters, temperature-tolerant devices and packing.
- R&D of thermal management such as thermal system integration heat transfer technologies.
- Optimization of vehicle and systems such as adaptive intelligent vehicle controls, and high efficiency HVAC.
- Standardization of plug-in vehicles, charging equipment and grid connectivity.

Reducing the cost of high efficiency clean vehicle to an affordable level to public was another objective of the U.S. research projects. For example, a goal had been set up to lower the cost of battery for a PHEV to 70% of current price by 2014. With 75 testing partners in the U.S. and Canada, 112 million test miles of HEV, PHEV and BEVs was set to be the base line by 2015.

Japan

In the presentation of Mr. Kenji MIURA, Deputy Director, Automobile Division, Ministry of Economy, Trade and Industry, Japan, the experience of initializing EV markets in over 8 towns with more than 30,000 EV/PHEV by 2013 was shown. As a part of the plan of raising the percentage of EV/PHEV to 15-20% total new vehicles sales by 2020, the Japanese government had set up a target to build 2 million normal chargers and 5,000 quick chargers to establish the EV market. Similar to other economies, the Japanese government played an important role in launching the adoption of EVs with a number of measures included:

- Intensive and systematical construction of charging infrastructure in EV/PHV towns.
- Establishment of infrastructure development guidelines.
- Compiling EV/PHEV town best practice handbook.
- Business mode research for EV/PHEV towns.
- Providing subsidies for purchase of EV/PHEV.
- Introducing EV/PHV to car rental businesses.
- Organizing series of promotions.

In Japan, diffusion of EV infrastructure was found to be the backbone of adopting EVs. A basic rule of business model of infrastructure had been set up.

- EVs should basically be charged by normal chargers at night

- A certain number of quick chargers should be installed as a "safety net"

The details of business mode varied in different EV towns. In large scale urban area, such as Kanagawa, a fast charger could be found in every 10km. In tourist area, tourism model of infrastructure location was adopted. For example, in Kyoto, normal chargers were installed in some sightseeing point such as temples.

"We should use standard charger at night and quicker charger during the day which is for a safety net. We should install both types of chargers", Mr. MIURA said in the Q&A. Regarding the adoption rate in Japan, Mr. MIURA said local government should purchase EV and raised the awareness of public. The private sector was then to sell EV after that.

Hong Kong, *China*

Hong Kong, China is a city of high density high-rise buildings. Miss Vivian LAU, JP, Deputy Secretary for the Environment, Hong Kong, China, said in her presentation that improving roadside air quality was one of the objectives of promoting EVs in Hong Kong, China. The establishment of EV market in Hong Kong, China was done by adopting a multi-pronged approach. The policies included:

- Setting up a high level policy steering committee guiding cross-sectoral collaboration of various relevant sectors including property development, carpark operation, power supply sectors and technology institutions.
- Financial Incentives including tax deduction for capital expenditure on EVs and HK$300 million Pilot Green Transport Fund.
- Collaboration with EV manufacturers to draw in more EV models for consumers.
- Infrastructural support to ensure the convenient use of EV by setting up more than 1000 chargers in town by 2012.

In order to accelerate the promotion of EVs, the Hong Kong Government had launched a number of schemes:

- Concessions on gross floor area for car parks of new building developments with provision of EV charging-enabling for all parking spaces.
- Amended planning guidelines for new buildings, to recommend 30% of car parking spaces to be installed with standard chargers.
- A plan of setting up fast chargers to cover each 20km range of almost all parts of the territory.
- Earmarking $180 million for franchised bus companies to purchase 36 electric buses for trial runs.
- Adoption of EVs to government's fleet as an example of demonstration to public.

During the Q&A, Prof. CHAN said the Japanese EV now dominated the Hong Kong, China market. The use of CHAdeMO seemed a possible standard when a new building was to be installed with quick chargers. However, we should be open-minded for all standards.

Korea

The presentation by Mr. Kyung-Wan RHO, Manager, Transport Energy Team, Green Energy Cooperation Department, Korea Energy Management Corporation, Korea indicated that the targets of Korea were to produce 1.2 million green cars in domestic and to export 0.9 million that led

Korea to be the global big 4 in green car industries, and to reduce fuel consumption and CO_2 emission to 0.5 million tons and 3.3 million tons respectively by 2015. In order to achieve the targets, a number of measures had been done or planned by the government:

- Supporting to promising technologies to develop core parts for EVs, such as high power density and high efficiency electric motor, heating and cooling system for EV, system optimization, extended range per charge, cost-effective battery and chargers of reduced charging time.
- Dissemination of EVs including subsidies for public agencies purchasing EVs and chargers, tax incentives to distribute EV and guidance to motor companies and public agencies to sell and buy certain amount of green cars.
- Increasing investment to USD1.4 billion including construction of 20,000 electric chargers by 2015 to support initial EV market creation.
- Preparing regulations in terms of safety certification and standardization of EVs and chargers.

Canada

The presentation by Ms Lynda PALOMBO, Senior Manager, Business Strategy, Transport Energy Technology, CanmetENERGY, Natural Resources Canada, indicated facts that 30% of total energy was used to support transportation resulting in 25% of greenhouse gas emissions. As 99% of transportation in Canada was driven by petroleum and the use of vehicle energy is expected to increase by 31% by 2020, adoption of EV is one of the selections of alternative transportation energy sources. On the other hand, the adoption of EV raised concerns about the effect on society including:

- Increase in national and regional electrical energy and power demand
- Occupancy of pathway caused by construction of infrastructure
- Education and public relations programs increasing awareness of EVs or change the driving behaviour of consumers
- Purchase incentive programs, battery warranty/lease programs
- Building codes, electric codes and other regulations for new construction

As presented, there were 5 battery electric and 11 plug-in hybrid vehicle projects of total 70 vehicles demonstrating in Ontario, British Columbia, Manitoba, and Quebec for the purpose of studying infrastructure and vehicle, fuel consumption, emissions, usage, driver behavior, grid impact, charging, building codes, policies and regulations. Also, there were programs for R&D of EV and international cooperation especially focusing on harmonizing North American standards and technologies.

A National Information Centre would be set up to assist the public and industry. Assistance in development of codes and standards would be offered. Ms PALOMBO said in the Q&A the time frame of setting up the National Information Centre would be done in a couple of months when the official procedures were completed.

Malaysia

The presentation by Mr. SANG Yew Ngin of Ministry of Energy, Green Technology and Water, Malaysia, showed the EV policies in Malaysia and the cooperation between the Malaysia government and a local automobile manufacturer, PROTON. There were 7 key areas addressed in the deployment and development of EV master plan:

- Institutional framework covering identification and review of existing institution/agencies, financial support, and assessment of existing policies, laws, regulations and standards.
- Resources including human capital, financial, incentives, foreign partnership potential and emergency first responders.
- Technologies including vehicle components and infrastructure, research and development programs.
- Industry performance matrices formation of relationship and comparison of technical attributes such as vehicle performance and commercial value in terms of target electric driving range of an EV.
- Value chain of both supply side and consumer side, CO_2 reduction and well-to-wheel energy efficiency.
- Market and industry development ensuring supply chain of critical components and products meeting consumer needs.
- Pilot/demonstration project carrying out prerequisite study and pilot site feasibility.

In practice, the government of Malaysia had set up a strategic action plan with a number of measures including:

- Formation of an EV steering committee
- Establishing standards for EV supply equipment (Socket-to-Socket)
- Regulation for governing EV charging Infrastructure
- Regulation governing the roadworthiness of EV
- Incentives for EV charging infrastructure provider
- Incentives for EV owners and users
- Ensuring grid, supply and utility readiness
- Pilot demonstration projects
- Public awareness and education
- Research and development into EV technology

On the other hand, the Malaysia closely cooperates with local automobile industry PROTON and launched pilot project program called "Fleet Test Vehicle" (FTV). A total of 250 EVs, including 200 plug-in hybrid vehicles and 50 pure electric vehicles were expected to be in demonstrations by the end of 2012. This project was expected to result in number of benefits for both government and automobile industry:

- Providing essential information of consumer needs
- Verification of domestic EV business model for EVs with average daily traveling range of 50 km expected to be charged at home
- Verification of EV related technologies and infrastructures
- Data collection of vehicle stage of health, vehicle performance and consumer behaviours for future development
- Strengthening the competitiveness of EV manufacturing of both PROTON and Malaysia

EV Infrastructure and Standardisation

While the standardization of EV infrastructure was processing, the emerging potential to be a part of an interacting smart grid which could support bi-directional power flow between vehicle and grid made the situation complicated. Participants in the workshop discussed the issues from aspects of business models, techniques and strategies. Seven speakers presented various aspects of standards.

Business Opportunities of EV Infrastructure

Mr. Rainer SCHEMMEL, Business Development Manager, Siemens AG, Germany discussed on the business opportunities and consideration that EV infrastructure could provide in smart grid in the future. With the backbone of secure information technologies, a traditional power grid was expected to be separated into many microgrids with plenty of small scale generations such as solar panels, wind turbines and EVs. In order to control the power flow, all the charging infrastructures would be expected to be governed by the control centers to monitor EVs. In the presentation, Mr. SCHEMMEL indicated various expectations of charging infrastructure including:

- Providing services associated to charging vehicle, such as user's authentication, payment and billing, roaming, remote maintenance and load management.
- Providing information associated to driving, such as real-time navigation, traffic information, mobile monitoring and electronic log book.
- Managing parking reservation, parking signal and parking guidance.

Schedule had been set up as a part of Green Cars Initiative of European Economic Recovery Plan announced in 2008. Number of actions would be done by national/regional cooperation including:

- Proof of technologies
- Defining business models
- Proof of protocols and interfaces
- Standardizing infrastructure, network and IT applications
- Forming of policies and regulations
- Legislation

EV Connectivity Standards across APEC Economies

Another participant, Mr. Martin BROWN-SANTIRSO of Energy Efficiency and Conservation Authority, New Zealand presented on the EV market situation in New Zealand. As presented, New Zealand was expected to be an ideal EV market because of a number of facts:

- High percentage (more than 80% by 2011) of renewable electricity resulting in stable prices independent to oil prices.
- Enough renewable electricity for new demand of EVs.
- Very little demand for building fast charging infrastructure as 86% of population was in urban area.
- High percentage of daily travel demands that most charging activities were expected to be at home.
- High quality distribution system for charging at home.

These facts supported that EV charging equipment in New Zealand was mainly installed in households. The standards would be relatively simple and less demanding.
On the other hand, New Zealand was leading an APEC funded research with the main objectives of:

- Generating an APEC wide perspective of existing grid connectivity infrastructure, and regulation and standards applied to EVs.
- Identifying areas where harmonization could be achieved to improve trade and enable faster EV development.

"The public charging infrastructure is being proceeded. We also should educate the public about the range of EV", said Mr. BROWN-SANTIRSO in the Q&A. "Perhaps a second household car should be electric."

Technical Aspect of EV Infrastructure and Standardization

In the workshop, DC quick charger and EV related standards were reviewed with examples of Japanese CHAdeMO protocol and SAE standards respectively. In the presentation of Mr. Satoru KOIZUMI of Takaoka Electric Manufacturing Co., Ltd., Japan, present applications and future possibilities of quick charger were reviewed. As the battery capacity density was expected to increase in the future, a quick charger would be necessary to cope with range anxiety. The establishment of CHAdeMO protocol was the solution of various quick charging problems. They have the following functions.

- Compatibility of charging every EV with different battery which was compliant to the CHAdeMO protocol.
- Safety provided by pre-checking of insulation, locking of connector during charging, prohibition of driving EV during charging.
- Reliability enhanced by duplicated communication link between EV and quick charger, adoption of CAN currently used for vehicles.
- Standardization of cable plug.
- Standardization of charging process for both the machines and users.
- Standardization of system configuration of quick charger.

Mr. KOIZUMI also addressed other technical issues related to quick chargers including:

- Functions for reliability and usability such as the ability to reduce operation in case of fault, with low in-rush current and suppressed harmonics.
- Diversification of products to provide different output power for lower required power.
- Issues related to safety such as electrical protection, mechanical safety and electromagnetic compatibility.

During the Q&A, the issue of the quick charger was discussed. Prof. CHAN suggested that quick charger should be decoupled from the grid in order not to influence the power distribution. Renewable energy such as solar and wind could be used to store in energy storage system and it was then released to charger to assist the increasing power demand in electric vehicles.

Charging Infrastructure for Sustainable Diffusion

In another presentation, Mr. Hiroomi FUNAKOSHI of TEPCO, Japan, indicated the interaction between DC fast chargers and the grid with the CHAdeMO as an example. The power rating of quick charger was found to be the key factor of the impact to power distribution system. As an example, the load increase would be around 10% in a distributing system of 20,000kVA, supplying 5,000 houses of 4kVA with 20% of them using on-board charger of 1.5kW-3kW. However, the load increase would otherwise be 55% in a distributing system of the same power rating, supplying 1,250 houses of 16kVA with 20% of them using 44kVA quick charging. The optimal power range would be 30kW to 70kW as the charging cost was found to be high with less time benefit for higher power range.

On the other hand, the specification of CHAdeMO quick charger was planned to be extended to fulfill the application requirements of smart grid including:

- Bi-directional power flow with CHAdeMO protocol.
- Use of international smart grid technologies such as SEP2.0.
- Load optimization managed by BEMS.
- Quick charging infrastructure independent from grid power.

Mr. FUNAKOSHI also explained the safety measures of quick charger with the CHAdeMO as an example. Measures included:

- Isolated DC output circuit and ground fault detector
- Locking mechanism of charging connector
- Circuit checking before charging
- Program control

During the Q&A, discussion was made regarding the manufacturing of CHAdeMO charger outside Japan and the flexible input voltage to the charger. "The supporting service is free. Soon a new business model may be set up", said Mr. FUNAKOSHI.

EV Related Standards with an Eye towards Safety

Besides charging protocol, standardization of each component for both EV and infrastructure was found to be another important issue related to safety and performance. Mr. Gary SCHKADE, Director, Asia-Pacific Business Development, SAE International, USA, reviewed some SAE standards related to EV in his presentation. As a standard development organization of automobile, SAE International had been conducting a number of research projects to develop appropriate standards for electrical vehicles covered all parts of the systems including physical connectors, interfaces, power level, battery standards, energy exchange protocols, and vehicle to grid communication protocols. Some examples of EV standards are:

- SAE J1766 EV/PHEV Crash Integrity Testing
- SAE J2380 Vibration Testing of Electric Vehicle Batteries
- SAE J2344 Guidelines for Electric Vehicle Safety
- SAE J2464 Electric Vehicle Battery Abuse Testing
- SAE J2578 Fuel Cell Vehicle Safety

Battery had been a great issue of EV. SAE Battery Steering Committee was established to standardize the manufacturing of batteries in order to reduce the cost and to provide convenience for automakers to evaluate the batteries from different suppliers.

Wireless charging was also an interest of SAE International. The standard governing wireless charging SAE J2954 is in development. Cooperating with auto and commercial vehicle OEM's, automotive suppliers and organizations including laboratories, government agencies, universities, SDO's and power companies, SAE wireless standard would define the performance, safety, testing methodologies, charge levels, location and communications. Potential charging locations included residential, public, on-road, static charging in parking lots and curb side, and dynamic charging embedded in roadway.

The Impact of Infrastructure Standards and EV Technology Development

Mr. Eric SIMMON, United States Department of Commerce, National Institute of Standards and Technology, USA, indicated that with the use of smart grid technologies, EVs could be used to improve the performance of power grid by load shifting, transient compensation, and power quality control such as voltage control. Standardization of different blocks of the system was the key challenge as disharmony of standards resulting in unnecessary complexity, decreased reliability, increased risk, limited choices and increased cost could cause great impact to equipment manufacturers, utilities and consumers. The ultimate consequence would be harmful to EV adoption and threatening the economic growth of APEC economies. The outcome of May 2011 APEC Regulatory Cooperation Advancement Mechanism was addressed by Mr. SIMMON that actions for APEC economies were needed to "advance the development of EV and to prevent the emergence of barriers to trade and investment in EV technologies."

Speed up Charging Infrastructure Demonstration Projects

Another participant, Dr QI Zhi-xin, Program Officer, Scientific Equipment and Energy Conservation, National Energy Administration, People's Republic of China, presented on speed up charging infrastructure projects for demonstration and standardization and reviewed the strategies in China. By 2011, there were more than 185 charging stations and more than 9,700 charging piles in operation. There was also the largest battery charging station in the world for Shanghai World Expo supporting 120 pure electric buses with 112 sets of standby batteries. The number of charging facilities in China was the highest. Standardization was still in progress in China as the standards for EVs were still not matured and some important standards such as charging and battery replacing interface and battery interface were not drafted. A number of actions were taken by departments such as the State Energy Administration to overcome the situation. These actions included:

- Organizing technical research and application demonstration
- Established standardization technical committee
- Designing a charging infrastructure standard system including 26 standards
- Carrying out international standardization cooperation
- Accelerating the drafting of standards

The Chinese Government positioned the EV industry as a part of the "Twelfth Five-Year Planning" and as a strategic emerging industry, the way for energy conservation, emission reduction, and reduction of reliance on petroleum. As an essential component of EV industry, the principles for developing charging infrastructure had been defined as:

- Moderate in advance
- Market mechanism
- Giving priority to standard
- Guided by demonstration
- Coordinated planning

The development of standardization would be accelerated by organizing R&D for key technologies and equipments, actively promoting the demonstrating infrastructures, further promoting the drafting of standards, and strengthening international cooperation.
During the Q&A, there were exciting discussions on the battery swapping and direct charging.

Prof. CHAN commented that the safety, cost, convenience and emission were the most important elements for batteries. Battery swapping had to deal with the thermal management and control strategy as a replaced battery set might not be the same performance as the originally designed.

EV Technology and Development

In this section, eight experts from institutes and industries discussed on the trend and recent development of EV technology that would lead the EV industry to the success. The topic in this section covered new and future technologies and the possible development in the future. The prominent discussions were the battery swapping, auto parts integration and battery management system.

Global Outlook of Electric Vehicles Development and Their Infrastructure

In the presentation, Prof. C.C. CHAN, President of the World Electric Vehicle Association emphasized, as an EV was a kind of mobile energy storage rather than a vehicle, "Be open mind" was important to find out possibilities and potential of EV industry. "The train of EV commercialization has taken off," said Prof Chan in his presentation, "but the market will not do by itself. Therefore, innovative regulator leadership and business model are essential". Cooperation between different EV related industries, especially automobile industry and electric power industry, was found to be important as the automobile would be changed a lot by EVs as an EV could be a mobile energy storage device interacted with power grid and smart grid technologies.

Prof. CHAN also expressed his strategic views of different components related to EV industry. They could be itemized as:

- Strategy of running EV business fulfilling three key issues:
  - Good products included powertrain technology, chassis and body technology, and energy storage technology, by the integration of automotive technology and electrical technology and alliance among auto makers and key component suppliers.
  - Good Infrastructure should be efficient and convenient. It had suitable charging facilities fulfilling the charging requirement of different consumers.
  - Innovative EV/PHEV Business Model involved the government, OEM and key component suppliers, energy suppliers and users.
- Comparison and selection of EV energy replenishing techniques with the consideration of vehicle types and applications such as normal charge, fast charge, and battery swapping.
- Integration with smart grid and telemetric/ICT allowing the stability use for renewable energy by EV to achieve reduction of emission and use of fossil fuel, and providing more convenient use of EV, such as cloud application.

Prof. CHAN also reminded a number of points:

- There would be huge change to automobile industry in the next 30 years due to the massive change of energy source, control and communication of EVs. The manufacturing of automobile would change from unified production by a company to assembling large number of components from different ventures.
- The driving range of an EV should not be comparable with Internal Combustion Engine (ICE) as the daily driving range of most vehicles was 50 - 80km. Charging sufficiency for the next trip should be considered.
- The use of aged EV batteries should be considered. For example, aged batteries could be used for the energy storage for renewable energy as a non-mobility application.

At the end of his presentation, Prof. CHAN kindly reminded with the six "I", Inspiration, Imagination, Innovation, Integration, Implementation and Investment, the EV industry would be finally in success.

Adoption of Alternative Vehicles in APEC Member Economies

Mr. Luke LEAVER of Asia Pacific Energy Research Centre (APERC), Japan, discussed the underlying variables that affected the energy used in transportation. The urban design policies affected the vehicle kilometer travelled per person. The vehicle fuel efficiency was related to the efficient propulsion fuel and technology. Another factor was the number of vehicles per person which is linked to population and per capita GDP growth.

Statistics and analysis supported that the future development of EV would be promising. Some analysis showed that the increase of urban population in developing economies resulted in high growth in the middle class population. Data from United Nations showed that by 2035, there would be 38% increment of urban population in 2010 in APEC economies. The increase of passenger vehicle ownership was found in developing economies. The number of passenger cars in China, Vietnam, Thailand, and the Philippines would increase by a few times of the number in 2010. Especially in China, it was expected to be more than 400 vehicles per 1000 people by 2035 while the number of vehicles per 1000 people was around 100 in 2010. Fuel savings were more substantial as the energy prices increased. The long term retail price of hybrid vehicle and plug-in hybrid electric vehicle should be reduced.

In the workshop, another factor related to the success of EV industry discussed was consumer driven. Mr. LEAVER indicated that the upfront cost in the purchase price was a key influence rather than the potential savings in fuel cost. The upfront cost in purchasing an electric vehicle or hybrid vehicle was more than the potential saving in fuel. The demand for new vehicles was robust especially in emerging and developing economies. The business case for EV and PHEV would be improved when the energy prices increased, battery cost reduced, battery performance improved, and strong government incentives and investment to infrastructure were made.

Development of EV Industrialization in China

Cooperation of different parties, including government, automobile manufacturers and related industries, universities and laboratories, was an alternative way to push the development of EV. Presentation of Prof CHEN Quan-shi of Tsinghua University, China, discussed on the EV development in China. The development of new kinds of vehicle, included EV and PHEV, was the key project of Ministry of Science and Technology (MOST) in China's "Eleven-Five Year Plan". EV industry was respected by the China Government as the breakthrough for new round of economic growth and for the transformation of transportation energy resources. EV industry would grow gradually in China with consensus on three issues:

- EV would eventually replace vehicle driven by fossil fuel in 50 years
- The sequence of developing EV had been defined: 1. Internal Combustion Engine Vehicle, 2. Hybrid Electric Vehicle, 3. Plug-in Hybrid Electric Vehicle, 4. Pure Electric Vehicle or Fuel Cell Electric Vehicle
- Key technologies of EV had been developed. They were power batteries, fuel cells, motors, motor drives, and control techniques.

China government had led a number of pilot programs to demonstrate new energy vehicle such as the "10 Cities Each With 1,000" program. Policies included subsidy to purchase new energy city buses of 10 meters or up, introducing 60,000 fuel efficient and new energy vehicles for public transportation, assigning 13 cities as pilot cities with subsidies. Subsidy to procurement of electric vehicle or hybrid vehicle had restriction to the energy content of battery, power level and the range per charger. Up to RMB 50,000 and RMB 60,000 were provided to plug-in and pure electric private vehicle buyers respectively. Safety in electric vehicles was an exercise in China. Three recent fire accidents in hybrid and pure electric vehicles were discussed. Proper monitoring to the battery and fuel cell were enforced in vehicles. China government also led a number of standardization programs with the cooperation of different government departments, EV industries, EV associations and universities.

The battery and battery charger standards on dimensions, connection and management, namely QC/T 840-2010, QCT/841-2010 and QCT/842-2010, were approved. Another standard on batteries and chargers, namely GB/T xxxxx, had also been approved. The charging condition and management standards, namely NB/T3300x-2101, had been enforced since 1st Oct 2010. "We are at the threshold of industrialization of EVs, but challenges are still ahead", Prof CHEN concluded.

Trends and the Future of EVs Deployment

Another participant, Mr. Albert LAM, Chairman & CEO of Detroit Electric, USA, further discussed on consumer behaviour. He also agreed that consumers would look at the initial cost rather than future cost. An EV was expected to be comparable with a gasoline vehicle. The main factors of the purchase of an EV would be the initial cost, charging time, charging infrastructure, and cost of ownership rather that the driving range and life time of the battery. As Mr. LAM explained, the driving range would not be a problem if there were enough fast charging infrastructures to charge battery in a short duration. The residual value of aged battery, such as its use in distributed generation technologies in light commercial load and residential load area, should also be considered, as most of the aging batteries would suffer from depreciation in performance. One of the strategies to fulfill consumers' expectation was suggested to make the driving experience of an EV as close as to people used to be. Mr. LAM thought that from a consumer's point of view, the initial cost, charging time, charging infrastructure and cost of ownership were the concerns. As he said, "Consumer behaviour drives trends."

Another way to solve the problem was suggested to consider the design of each part of whole EV industry properly, especially the relationship between EV battery and charging infrastructure. With the proper selection of locations and output power of EV charger, the size of the battery could be reduced in reduction in initial cost. Infrastructure was now closely related to charging and V2G (vehicle to grid). The location of charging station, quick charging and making use of V2G for possible earning through battery energy to grid were its important development. Business model was part of the Infrastructure. Leasing of battery, operation charger and buy back guarantee of vehicle would be points of consideration.

"Policy is the one to drive the evolution of electric vehicle. The competition of electric vehicle does not exist yet", Mr. LAM summarized his talk in the Q&A.

Zero Emissions Strategy and Charging Infrastructure Development

Mr. Osamu NIKURA of the Nissan Motor Co., Ltd., Japan, presented on Nissan Zero Emission strategy and Infrastructure development, gave another example of cooperation of EV industries. As reported, Nissan was in alliance with another automobile industry, Renault, to achieve the target of 10% global EV market share by 2020, by combining the battery and EV manufacturing capacity of 7 EV production sites and 5 battery production sites resulting in 250,000 units/year of EV production capacity for both Nissan brand and Renault brand, and 500,000 units/year battery production capacity for the alliance. As to be a sustainable mobility provider, the alliance would take a number of actions including: conducting zero emission vehicle engineering and manufacturing, conducting battery engineering and manufacturing, searching for battery secondary-use for recycle business, recycling EV, producing Nissan-made quick charger, proposing new mobility, researching smart-grid and charging network and collaborating with governments.

Besides the strategy, the technology was another key factor leading EV industry to success. Nissan LEAF was a commercialized EV consisting of a number of advanced technologies including: newly developed battery cell with higher energy density, maximization of the number of battery cells, cooperative regeneration brake for high performance in reclaiming the energy during braking, and aerodynamic design to reduce air resistance.

Journey to Provide Unlimited EV Range

Another technology related to battery was battery changing (swapping) instead of charging. Mr. ZHOU Jianglong of Better Place, USA, explained the concept in his presentation with the example of battery changing facilities operated by Better Place. In this business model, the battery would not be included as part of a new EV. The EV owner had to join the membership of a battery changing services provider. A movie of the battery swapping was shown in the presentation. Once a vehicle was driven to the station, cleaning of the vehicle bottom was then followed by battery swapping using robotic machines. The battery charging process would be done by machines automatically within around one minute. This business model could provide a number of advantages including:

- Reduction of initial cost of EV
- Instant range extension for long trips
- Adoption of latest battery technology by switching instead of buying a new EV
- Elimination of battery cost and risk of battery failure

They would install 40 battery swapping station (BSS) and several charging spots by the end of 2011 in Israel. “Customers can have choice of selection of battery quality at different prices”, said Mr. ZHOU. Over 300 multinational companies have committed to begin converting their employee fleets to Better Place. Another market was in Denmark. 15 BSS and several thousand charging spots were expected. They had also partnered with Tokyo’s largest taxi operator for the use of Switchable taxis. 3500 battery switches and 60,000km had been experienced.

During the Q&A, delegates showed interests in the packages available for the battery swapping. Mr. ZHOU said high performance battery packs were availabe with higher cost. Users could pay for their requirment of battery quality.

Power Electronic Integration for Electric Vehicles

Technology was one of the key factors affecting the development of EV industry. Prof. Eric CHENG of The Hong Kong Polytechnic University, Hong Kong, China, expressed one of the strategies by using the power electronic integration. The university had involved and conducted the electrical design in the first commercial electric vehicle in Hong Kong, China. They also recently developed the solar air-conditioning for vehicles to address ventilation needs when a vehicle was in idling. In the future EV development, he believed that it would be biased to safety, cost reduction and simplification in manufacturing and maintenance. The integration could be a solution of the above requirements. It provided reduction of cost, device size and the complexity of installation and maintenance. Reduction in components and interfacing was known to have significant improvement of vehicle safety and reliability. Acceleration of EV production by reducing the matching, fixing and packaging of vehicle parts was now available because integration of automobile parts could provide optimization in advance.

Many similar components especially power electronic components could be found in different parts of an EV. This included motor, motor driver, battery, battery charger, power converter, vehicle electronic. However, some parts would never operate at the same time, for example, the motor and on board charger. Integration could be done by sharing of components, packaging, sharing of the thermal management and facilitate the cooling. Another example showed by Prof. CHENG was the integration of battery and super-capacitor to improve the battery life time by reducing the work load of the battery using super-capacitor. The startup and braking performances could therefore be improved because the high transient current is handled by the super-capacitor. The integration of the motor and the wheel was called in-wheel motor that reduced the mechanical subsystem such as shaft, gear, clutch and transmission. Higher dynamic performance of the propulsion, braking and steering could be realized. Intelligent motor was an integration of motor and inverter. Only control and power line were needed. “The future trend of electric vehicle is towards more integration among various vehicle components and ultimately all in one will be possible.” said Prof. CHENG.

During the Q&A, Prof. CHENG added that the braking of the in-wheel motor was designed with mechanical brake and motor electrical brake which also provided power regeneration. The active performance of the wheel was with the expenses of increased weight of wheel.

Battery Management Systems

Battery Health Management was an alternative to ensure the life of battery. Prof. Michael PECHT of University of Maryland, USA, discussed on the topic. Battery Management System could be able to perform a number of essential functions including:

- Maintaining safe conditions of operation
- Charging monitoring and control
- Managing demand from vehicle and system
- Assessing health and remaining useful performance such as SoH and SoC
- Authentication and identification
- Log book functions
- Communications between the battery, charger and system

However, a number of challenges found in the development of battery management system especially the inconsistence of the characteristics of each battery. These challenges included the detection of state of charge, state of health and prediction of remaining useful performance.

Prof. PECHT concluded during the Q&A that most electric vehicles were installed with a BMS. There were complicated versions as well as simple versions. BMS was highly dependent on the battery types, specification and characteristics.

Trial Projects and Case Studies

The session was presented by 7 speakers on their experience in the installation of electric vehicles in different scenarios. The performances of the case study were described in this section which the facility installation, charging, EV and energy usage were core discussion topics.

Green Transport and Electric Vehicle Application in Shenzhen

The presentation were made to the demonstration exercise of energy saving and new energy vehicle in Shenzhen, with stress put on the recent 26th Summer Universiade 12-23 August 2011. Shenzhen was one of the 25 cities to demonstrate new energy source vehicles. In 2009, the Energy Efficiency and New Energy Vehicles Pilot City Leading Group was formed and responsible for the implementation new energy vehicle programs in Shenzhen. Public transport was the first breakthrough. The charging system technological schemes were announced. Up to the end of August 2011, there had been 62 charging stations serving users. 2349 charging points located in private, public and government car parks and were expected to start to serve by the end of this year. In the Universiade this year, there were 1995 new energy vehicles serving. They included 1350 hybrid electric buses, 253 pure electric buses, 10 pure electric mini-buses, 300 electric taxis, and 62 fuel cell vehicles. The vehicles covered 128 public routes and had total travelling record of 400 million km, until 24 August 2011. No accidents had been reported.

The record for charging was also remarkable. Until 26 August 2011, there had been 800 vehicle-charging cycles per day with a total number of 9600. The accumulated energy was 600 MWh. The pure electric buses had daily charging energy of 250 kWh. Electric taxis had a daily charging energy of 50 kWh, hybrid electric buses had the daily charging energy of 10 kWh. The total reduction of CO_2 emission was 3146 Tons. Air quality was the best in Shenzhen during the period of Universiade since last 10 years. “It is the time to change. Government will assist the change”, said Mr. CAI Yu, Deputy Director, Energy Efficiency and New Energy Vehicles Pilot City Leading Group of Shenzhen, PRC.

Electric Vehicles Build the Future of Kyoto

“Kyoto City was the ancient city of Japan and was seriously considered for use of electric vehicles and plug-in hybrid vehicles”, said Mr. Ryosuke ITO, Assistant Chief, Environment Policy Division, Department of Culture and Environment, Kyoto Prefecture Government, Japan. They had a series of actions to promote the EV including tax incentive, charger facilities and promotion plan. The city council had put effort with residents to promote the next generation of vehicles. They also used solar energy for the standard and fast charger and were known as carbon-free charger. Totally 23 rapid chargers had been installed in which 14 of which were with solar power. There were 2 rental car businesses renting 12 EVs and 7 taxi companies with 9 EVs and 5 PHEV to provide people with opportunities to experience riding on EV and PHEV.

The targeted area Kamiseya district in Miyazu City had started a program for the replacement of gas vehicles by EV and provision of EV for trial. Kyoto Technical Institute and Kyoto Automobile Services Promotion Association had created a course to nurture EV engineers for training. The important topics for spreading EV and PHEV were mainly price, range per charge, public awareness, charging infrastructure and human resources.

The Need to Integrate Different EV Charging Infrastructures

MOBI.E is a system to integrate different EV charging infrastructures. "Every Car uses MOBI.E system", said Mr. Miguel PINTO, Head of Energy, INTELI, Portugal. The system provided real time management. The basic information like the status and the vacancy was made available. The services and billing integration would be used in parking, car sharing and domestic electricity. A mobility intelligence center was established to provide management and monitoring of charging. Data reporting can be made. It was anticipated that MOBI.E would deploy innovative solutions and market development including grid management and carbon based business model. The MOBI.Europe brought together four of the major electromobility initiatives in Europe in early stages of implementation. It was flexible to adapt different models. MOBI.E was said to have smart charging, but the smart discharging for the smart grid operation was to be considered.

Green City Solution

Electric vehicle was not their only product. They had technology for Fe battery which was the core energy storage technology. "BYD provides green city solution. City has sun to power EV", said Mr. Tom ZHAO, General Manager of Overseas Division, BYD Ltd, PRC. Two hundred e6 Taxis had been launched in August 2011. "We have over 200 eBus-12 operated for Universiade Shenzhen 2011 Events which is the largest E-bus fleet in the world" said Mr. ZHAO. It took 40 min for charging. 300 e-taxis serving for the Universiade Event. They also worked with Hertz to launch the all-electric Rent-A-Car in China.

Mr. ZHAO also analyzed on the transportation in Hong Kong, China and the expected saving when electric Bus and e-taxi were used, saving of hundreds and tens of HK$ million were expected respectively. BYD also developed energy storage station (ESS) to optimize the utilization of energy. Several to tens MWh of ESS had been adopted. They also worked on solar power. Their quick charger was 100kW and provided 3-hours fully charged for e-bus and 40 minutes fully-charged for e6. Mr. Zhao discussed the charging standard. BYD's charging technology was superior to CHAdeMo. The most prominent ones were bi-directional, higher power to 100kW, and higher IP standard.

Trend in eMobility

Singapore is a mixed cultural city. Its population is 5 millions in a territory of around 20×40 km^2. The trend of E-mobility was to provide electric power train, setup the infrastructure, link to the grid and business model. It was expected that the EV or PHEV would grow rapidly in the next ten years. Bosch had partnered with Singtel, TETS and GREENLOTs to provide infrastructure for EV charging. "It is intended to support 50+ electric vehicles and provide up to 63 charging stations", said Dr. Stefan FERBER, Global Product Manager – eMobility, Bosch Software Innovations, Singapore. The charging data would be collected using smart meter. The use of CEPAS (Contactless e-Purse Application) was used for identification. Further development was in place including value-added services in roaming, interoperability and demand side management.

Lessons from a Global Roll-out

Chevy Volt was a plug-in hybrid electric vehicle. It was designed for the extended range concept. The charger for the vehicle could select either 120V or 240V. "You can schedule the charging of the vehicle", said Mr. Keith COLE, Vice President, Government Relations and Public Policy, General Motors International Operations, China. Charging could be monitored by smart phone applications. The charging taking place in US was at residential, workplace and public areas with majority of charging facilities installed to satisfy the residential needs. For fast charger, the issue on charging connector standards was a concern. The AC or DC, communication protocol and the physical size were all different among USA, Europe, China and Japan. GM and GE have started the discussion on the common charging standards. SAIC and GM had collaborating the new battery EV architecture and wish to make it to be used globally. GM and LG have signed an agreement on EV development. LG provides the advanced battery cells for Chevy Volt and Opel Ampera. LG underwent market-testing of Chevy Cruze EV in Korea. Mr. COLE believed that "The future EV is of less weight and less battery".

Comparative Life Cycle Assessment

Mr. Marcel GAUCH, Project Manager, Empa-Swiss Federal Laboratories for Materials Science and Technology, Switzerland, presented the comparative study on electric mobility versus conventional mobility. Future driving should look into optimization of combustion engines and alternative fuels for engines. Extensive research should be made on energy storage especially on hydrogen and batteries. The perception on new energy technology should be examined. Would there be any adverse effect on the use of permanent magnet for electric machines for windmill and motors? What were the hazardous materials in battery? How did we deal with the fire or collision of an electric vehicle? Mr. GAUCH discussed the Global Warming Potential (GWP) which was the equivalence of CO_2 in kg per unit km for the possible indicator of different technologies in mobility. Different drive-trains showed different strengths and weaknesses. Because the electric mobiles were still in initial stage, they had higher potential to improve than that of the internal combustion engine (ICE). EV was environmentally friendlier than ICE vehicles if the electricity came from renewable sources.

During the Q&A, Prof. CHAN commented that China was not producing negative impact for EV. "We should not address the EV increases the emission because the power generation is from coal. ICE has higher emission generally in China. The use of EV will certainly reduce carbon footprint by at least 10%".

Closing Remark

Mr. Stephen CHAN Hung-cheung, Director of Electrical and Mechanical Services, HKSAR Government, made a conclusion remark on the Workshop. "EMSD is a government department committed to promoting the use of EVs and setting up charging facilities for the reduction of roadside emissions", he said. We shared a common vision to promote the wider use of EV for a better environment. The use of EV was still in an early stage. The Government was assuming a proactive role in promoting the setting up of charging infrastructure. Various technical guidelines had been issued on the setting up of charging facilities at car parks in new and existing buildings to facilitate the developers and property management companies. The guidelines would be kept updated with the technological movement around the world. At present, there were 300 EV charging points throughout Hong Kong, China installed by developers, power companies and property management companies. It was expected that by mid 2012 around 500 EV charging points would have been set up by the Government for public use. The number of charging points would continue to go up.

"Before EV can be widely adopted by the public, there are a number of issues needed to be overcome, for examples price of EV, charging convenience, choice of selection of EV models, maintenance and recurrent cost of EV and EV performance," said Mr. CHAN. The Government would take a leading role and create an environment conducive to the change to EV motoring.

EV Exhibition

During the 1st two days of the workshop 24-25 October, a concurrent EV Exhibition was organized by the Hong Kong, China government in the same place of the Workshop. All delegates had a chance to tour the exhibition. The vehicles shown in the exhibition included the following:

Type	Exhibitor	Model	Curb mass	Max speed	Range	Battery capacity
Bus	BYD	eBus-12	13,800kg	80km/h	250km	324kWh
Private Car	BYD	E6	2,360kg	140km/h	300km	67.6kWh
Light Bus	Hongkong Electric Co., Ltd.	Smith Electric Light Bus	3,026kg	80km/h	160km	40kWh
Private Car	Hongkong Electric Co., Ltd.	Smart for Two Coupe Electric Drive	965kg	100km/h	135km	16.5kWh
Sport car	Tesla	Roadster	1235kg	201^{+}km/h	394km	56kWh
Private Car	Universal Cars	Mitsubishi iMiEV	1080kg	130km/h	160km	16kWh
Private Car	BMW Group	MINI MiniE	1465kg	152km/h	100-190km	35kWh
Private Car	Honest	Nissan LEAF	1540kg	140^{+}km/h	160km	24kWh
Private Car	CLP Power	Converted Volks Wagen	1590kg	130km/h	200km	39.2kWh
Private Car	CLP Power	Smart for Two	965kg	100km/h	135km	16.5kWh
Truck	CLP Power	Smith Newton	4140kg	80km/h	130-160km	80kWh
Private Car	EuAuto	MyCar CV2	591kg	64km/h	100km	10.75kWh
Bike	Hong Kong Police Force	Maxi-Scooter	232kg	110km/h	100km	3.78kWh
Transporter	JCAM	Segway Personal Transporter	47.7kg	29km/h	38km	0.383kWh
Bike	JCAM	Elmoto	47kg	45km/h	65km	1.5kWh
Bike	JCAM	Brammo Enertia Plus	149kg	110km/h	138km	6kWh
Bike	JCAM	Oxygen Cargo Scooter	171kg	65km/h	100km	5.7kWh
Bike	Techforce Pro Shop	Vectric VX-1	234kg	110km/h	130km	3.8kWh
Bike	APAS	Vision 01	97kg	75km/h	90km	4.32kWh

There were also exhibits of Nissan Charger with in-cable control box and a local developed charger from the Automotive Parts and Accessory Systems R&D Centre (APAS). The Nissan charger was a dedicated unit to support its LEAF electric vehicle while the APAS charger was a 20kW unit that could provide connection to CHAdeMo DC, SAE J1772 and BS 1363 13A charging.

Technical Visit

The Third day (26th October) was a technical visit to EV factories and charging stations in Shenzhen, China. In the morning, APEC delegates visited the BYD, and in the afternoon, APEC delegates visited the Wuzhoulong Motors, the Potevio charger control station and New Energy Vehicle Showroom.

BYD manufactured both petrol vehicles and electric vehicles. Their success in the industry had been derived from an Iron-battery that was said to be saver than the conventional batteries. Their representative firstly gave a presentation of their company profiles. Their business covered battery, charger, electric car, electric bus, hybrid electric vehicles, as well as other environmental products. BYD was not only an electric vehicle company, their business also covered the environmental friendly industry such as LED, solar and battery system. The talk was followed by the briefing of the electric taxi in Shenzhen. BYD had supplied 300 *e6* taxis for trial-run in Shenzhen. They now had offices around the world.

After the presentation, the APEC delegates had a chance to test drive the vehicles *e6*. The general comments of the *e6* from the delegates were good. Most of the delegate had tried the vehicle as passengers and a driver. A few comments said the acceleration of *e6* was fine but was preferred to have higher power. The delegates also tried the electric bus during the lunch time as well. “The bus was quiet and the driving performance was no different from other petrol bus”, said one of the delegates. The delegates also visited their showroom where various products in vehicles and vehicle components were shown.

In the afternoon, the delegates visited Wuzhoulong Motors. Their chairman briefed the recent developments in the company. “Our electric bus can run 300 km for each charge and 200 km when the air-conditioning is on.” said the President of Wuzhoulong Motors Mr. ZHANG Jingxin. The development of high efficiency air-conditioning and high energy content of battery was therefore one of issues for electric vehicles. They manufactured both electric bus and hybrid electric bus. A high portion of their products were single deck. They had a number of hybrid electric vehicles under trial-run in Shenzhen.

The next stop was the visit to the charging station operated by Potevio in Futian Charging Station. Each charging point could provide high power DC charging to private car (Taxi) or Bus. The delegates had been shown with the demonstration of the charging for taxi and the structure of connectors of the charger. Delegates were particularly interested in the charger connector. The delegates then visited Shenzhen New Energy Vehicle Showroom and Control Centre. All the charging stations were centrally controlled by the control center. The center was able to monitor the power level, the number of charging operations of each station and also provided the video monitoring. “The control center is impressive. We should have such charging station center in Hong Kong”, said Ms Jessica Li, a delegate from CLP Power Hong Kong Limited, Hong Kong, China.

Conclusion

In the 3-day workshop, delegates from over the world discussed and exchanged their knowledge and ideas in electric vehicles. The discussion covered the policy, infrastructure, technology and case study. The emphasis had been biased slightly to the energy storage and its extension to charger, infrastructure and establishment of new standards. There were good discussion through the questions and answers between the speakers and the audiences. Many inspirations were generated.

Improvement of air-quality in the metropolitan area was one of the aims of the workshop. Through the exercise of promoting the electric vehicles, the demand of fossil fuel would be reduced. It would ease pressure on world fuel markets, boost energy security and improve trade balances. The workshop provided opportunities for developed and developing economies in APEC region to share their experience in electric vehicle development. Through the workshop, delegates would understand the latest technology in battery, charger, infrastructure and future development. Delegates would also learn the various projects developed in the APEC economies. In these 3 days, various case studies had been described and how different organizations and cities had challenged themselves in electric vehicles.

The workshop was supported by academia, industrialists and governments. A number of representatives from various economies/countries had made presentations in the workshop. The exciting parts of the workshop were not only the information provided for the policy, case studies and new technologies but we could also see the effort provided from different economies to challenge the electric vehicle development. From the experience shared in the workshop, delegates would extend their development to a higher level of work. It was believed that there would be more active role to be played by different economies in development of new standards, harmonization of standards, vehicle to infrastructure and advanced energy storage. More importantly investment in education, training and public awareness, and subsidy and incentive to electric vehicles manufacturers and users were agreed among the delegates.

The exhibitions of electric vehicles in the workshop showed a number of electric vehicles, ranged from bike, transporter, and private car. The visits to Shenzhen manufactures provided the delegates the history of how the business of electric vehicle was made. In review the content of the workshop, it provided the latest developmental progress and commercialization of electric vehicles. It aligned the long-term growth strategies on promoting sustainable growth and accelerating regional economic integration.

In conclusion, the workshop has achieved its objectives in providing opportunities for APEC economies in sharing the experience for power and transport planners and to actively accelerate the wider deployment of electric vehicles. It also built interest among the participants of how the benefits brought from the use of electric vehicles. It was certainly that wider application of electric vehicles, development of extensive infrastructure in energy storage facilities, charging infrastructure and smart vehicle to grid would be resulted shortly after this workshop.

Appendix: The Program

First Day - Monday, 24 October 2011		
Venue: Conference Hall 04-07, 2/F, Lakeside 2, Hong Kong Science Park, Sha Tin		
08:45 – 09:00	*Registration*	
Session I	**Opening and Photo Session**	
09:00 – 09:10	Welcoming Remarks	Ms GU Jun, Deputy Director General, Department of International Cooperation, National Energy Administration, People's Republic of China
09:10 – 09:20	Opening Remarks	Dr. POON Kit, Kitty, JP, Under Secretary for the Environment, Hong Kong, China
09:20 – 09:50	Group Photo of All Participants (**Pre-function Hall 1/F, Lakeside 2)**	
Session II	**EV Policy and Strategy**	
Session Chairperson	**Mr Edmund LEUNG, Chairman, Energy Advisory Committee, Hong Kong, China**	
09:50 – 10:10	Electric Vehicle: China's Strategic Industry Q&A on presentation	Mr WU Wei, Senior Analyst, Department of Industry, National Development and Reform Commission, People's Republic of China
10:10 – 10:30	United States Department of Energy Electric Drive Vehicle Program Q&A on presentation	Mr Steve GOGUEN, Senior Engineer for Vehicle Technologies, Department of Energy, USA
10:30 – 10:50	Japan's Next-Generation Vehicle Strategy 2010 Q&A on presentation	Mr Kenji MIURA, Deputy Director, Automobile Division, Ministry of Economy, Trade and Industry, Japan
10:50 – 11:20	*Networking Tea Break*	
11:20 – 11:40	EV Policy and Strategy in Hong Kong Q&A on presentation	Miss Vivian LAU, JP, Deputy Secretary for the Environment, Hong Kong, China
11:40 – 12:00	Korea's Green Car Policy; Status and Prospect Q&A on presentation	Mr Kyung-Wan RHO, Manager, Transport Energy Team, Green Energy Cooperation Department, Korea Energy Management Corporation, Republic of Korea
12:00 – 12:20	Plugging into the Future – A Canadian Overview of Electric Mobility Q&A on presentation	Ms Lynda PALOMBO, Senior Manager, Business Strategy, Transportation Energy Technology, CanmetENERGY, Natural Resources Canada, Canada

12:20 – 12:40	EV: Malaysia Strategies and Initiatives Q&A on presentation	Mr SANG Yew Ngin, Principal Assistant Secretary, Green Technology Policy Division, Ministry of Energy, Green Technology and Water, Malaysia
12:40 – 14:10	*Lunch* *(Happiness Cuisine, 1/F, Core Building 2, Hong Kong Science Park)*	
Session III	**EV Infrastructure and Standardisation**	
Session Chairperson	**Dr YANG Ying, CEO of Automotive Parts and Accessory Systems R&D Centre, Hong Kong, China**	
14:10 – 14:30	EV Connectivity Standards across APEC Economies and Potential Areas for Harmonisation Q&A on presentation	Mr Martin BROWN-SANTIRSO, Transport Advisor, Energy Efficiency and Conservation Authority, New Zealand
14:30 – 14:50	Present Application and Future Possibilities of Quick Charger for Electric Vehicle Q&A on presentation	Mr Satoru KOIZUMI, Deputy General Manager - Sales Division of Energy, Takaoka Electric Manufacturing Co., Ltd., Japan
14:50 – 15:10	EV Related Standards with an Eye Toward Safety Q&A on presentation	Mr Gary SCHKADE, Director, Asia-Pacific Business Development, SAE International, USA
15:10 – 15:30	Charging Infrastructure for the Business of Tomorrow Q&A on presentation	Mr Rainer SCHEMMEL, Business Development Manager, Siemens AG, Germany
15:30 – 16:00	*Networking Tea Break*	
16:00 – 16:20	The Impact of Infrastructure Standards on Electric Vehicle Technology Development Q&A on presentation	Mr Eric SIMMON, United States Department of Commerce, National Institute of Standards and Technology, USA
16:20 – 16:40	Charging Infrastructure for Sustainable Diffusion of Battery Electric Vehicle Q&A on presentation	Mr Hiroomi FUNAKOSHI, Senior Researcher, Mobility Technology Group, TEPCO, Japan
16:40 – 17:00	Speed Up Charging Infrastructure Demonstration Projects and Standardization, Promote the Development and Booming of EV Industry Q&A on presentation	Dr QI Zhi-xin, Program Officer, Department of Scientific Equipment, and Energy Conservation, National Energy Administration, People's Republic of China
17:00 – 17:45	*Tour of EV Exhibition* *(Atrium Link, Lakeside, Hong Kong Science Park)*	
End of the First Day		

Second Day - Tuesday, 25 October 2011		
Venue: Conference Hall 04-07, 2/F, Lakeside 2, Hong Kong Science Park, Sha Tin		
08:45 – 09:00	*Registration*	
Session IV	**EV Technology and Development**	
Session Chairperson	**Prof CC CHAN, President of the World Electric Vehicle Association, Hong Kong, China**	
09:00 – 09:20	Global Outlook of Electric Vehicles Development and Their Infrastructure Q&A on presentation	Prof C C CHAN, President of the World Electric Vehicle Association, Hong Kong, China
09:20 – 09:40	Projecting the Adoption of Alternative Vehicles in APEC Member Economies Q&A on presentation	Mr Luke LEAVER, Researcher, Asia Pacific Energy Research Centre(APERC), Japan
09:40 – 10:00	EV Industry Development and Standardisation in China Q&A on presentation	Prof CHEN Quan-shi, Vice Director of Automotive Research Institute, Tsinghua University, People's Republic of China
10:00 – 10:20	Plug-in Now: Trends and the Future of Electric Vehicles Deployment Q&A on presentation	Mr Albert LAM, Chairman & CEO of Detroit Electric, USA
10:20 – 10:50	*Networking Tea Break*	
10:50 – 11:10	Nissan's Zero Emission Strategy and Charging Infrastructure Development Q&A on presentation	Mr Osamu NIIKURA, Senior Manager, ZEV Strategy Group, Global Zero Emission Business Unit, Nissan Motor Co., Ltd., Japan
11:10 – 11:30	A Four-Year Journey to Provide Unlimited EV Range with a Nationwide Network Q&A on presentation	Mr ZHOU Jianglong, Head of China Business Development, Better Place, USA
11:30 – 11:50	Power Electronic Integration for Electric Vehicles Q&A on presentation	Prof Eric CHENG, Department of Electrical Engineering, The Hong Kong Polytechnic University, Hong Kong, China
11:50 – 12:10	The Key Challenge to the Electric Vehicle – Battery Management Systems Q&A on presentation	Prof Michael PECHT, University of Maryland, USA
12:10 – 13:20	*Lunch* *(Meraviglia Bar e Ristorante, G/F, Lakeside 2, Hong Kong Science Park)*	
13:20 – 14:00	*Tour of EV Exhibition* *(Atrium Link, Lakeside, Hong Kong Science Park)*	

Session V	Trial Projects and Case Studies	
Session Chairperson	**Dr Phyllis YOSHIDA, Deputy Assistant Secretary for Asia, Europe and the Americas, Department of Energy, USA**	
14:00 – 14:20	Green Transport and Electric Vehicle Application in Shenzhen Q&A on presentation	Mr CAI Yu, Deputy Director, Energy Efficiency and New Energy Vehicles Pilot City Leading Group of Shenzhen, People's Republic of China
14:20 – 14:40	The Need to Integrate Different EV Charging Infrastructures: MOBI.E as a System of Systems Q&A on presentation	Mr Miguel PINTO, Head of Energy, INTELI, Portugal
14:40 – 15:00	Green City Solutions Q&A on presentation	Mr Tom ZHAO, General Manager of Overseas Division, BYD Ltd., People's Republic of China
15:00 – 15:20	Trends in eMobility Q&A on presentation	Dr Stefan FERBER, Global Product Manager – eMobility, Bosch Software Innovations, Singapore
15:20 – 15:50	*Networking Tea Break*	
15:50 – 16:10	Chevy Volt: Lessons from a Global Roll-Out Q&A on presentation	Mr Keith COLE, Vice President, Government Relations and Public Policy, General Motors International Operations, China
16:10 – 16:30	A Comparative LCA-study: Electric Mobility vs. Conventional Mobility with Biofuels and Fossil Fuels Q&A on presentation	Mr Marcel GAUCH, Project Manager, Empa - Swiss Federal Laboratories for Materials Science and Research, Switzerland
16:30 – 16:50	Electric Vehicles Build the Future of Kyoto Q&A on presentation	Mr Ryosuke ITO, Assistant Chief, Environment Policy Division, Department of Culture and the Environment, Kyoto Prefecture Government, Japan
Session VI	**Closing Session**	
16:50 – 16:55	Closing Remarks	Mr Stephen CHAN Hung-cheung, JP, Director of Electrical and Mechanical Services, Hong Kong, China
End of the Second Day		

Third Day - Wednesday, 26 October 2011		
Technical Visit to EV Factories and Charging Stations in Shenzhen, China		
08:15	Delegates gather at Hyatt Regency Sha Tin, HKC. *(Please bring PASSPORT with China Entry Visa)*	Hong Kong, China
08:30 (Sharp)	Depart from Hyatt Regency Sha Tin, HKC.	Hong Kong, China
09:00 – 10:00	Go to Shenzhen through Huanggang Border Crossing	Hong Kong / Shenzhen, China
10:00 – 11:00	Go to BYD Automobile	Shenzhen, China
11:00 – 12:30	Visit BYD Automobile and Test Drive - Introduction - BYD Showroom - Test driving of electric passenger car (e6) - Ride on electric bus (eBUS-12) - Group photo	BYD
12:30 – 14:00	Lunch at BYD Automobile	BYD
14:00 – 14:30	Go to Wuzhoulong Motors	Shenzhen, China
14:30 – 15:30	Visit Wuzhoulong Motors	Wuzhoulong
15:30 – 16:30	Go to Futian Transport Hub Visit Futian Charging Station	Futian charging station
16:30 – 17:00	Visit Shenzhen New Energy Vehicle Showroom and Control Centre	Shenzhen, China
17:00 (Sharp)	Return to Hong Kong through Huanggang Border Crossing	Shenzhen / Hong Kong, China
18:30	Arrive Hyatt Regency Sha Tin, HKC	Hong Kong, China
	Technical Visit Ends	