HEVTCP TASK 26 WORKSHOP

MEETING 6: INSTALLATIONS AND ALIGNMENT

25-26 APRIL 2017

HOSTED BY

VEDECOM

2, ALLEE DES MARRONNIERS

78022 VERSAILLES, FRANCE

ABOUT US

International Energy Agency (IEA) Mission and Work

The International Energy Agency (IEA) is an autonomous intergovernmental organization that was established in 1974 through the framework of the Organisation of Economic Co-operation and Development (OECD). Over the years, the IEA has evolved and expanded and today, it works to examine the full spectrum of energy issues including oil, gas and coal supply and demand, renewable energy technologies, electricity markets, energy efficiency, access to energy, demand side management, and much more. Through its work, the IEA advocates policies that will enhance the reliability, affordability, and sustainability of energy in its 29 member countries and beyond.

IEA Organisational Structure

The Governing Board is the IEA's main decision-making body and is composed of energy ministers or their senior representatives from each member country. The Governing Board is supported by six internal groups – four Standing Groups and two Standing Committees – as well as affiliated groups from business and industry that provide input into the agency's work.

IEA's Committee on Energy Research and Technology (CERT)

One of the IEA's Standing Committees is the Committee on Energy Research and Technology (CERT). Comprised of senior experts from IEA member governments, the CERT considers effective energy technology and policies to improve energy security, encourage environmental protection, and maintain economic growth. Within the CERT are four working parties that consider national policy developments and technology trends relating to their area of specialization. These are the Working Party on Energy End-use Technologies (EUWP), the Working Party on Fossil Fuels (WPFF), the Working Party on Renewable Energy Technologies (REWP), and the Fusion Power Co-ordinating Committee (FPCC).

Comprised of programme managers and technology experts representing member governmental agencies, each of the four working parties supports and facilitates research, development, demonstration, and deployment (RDD&D) co-operation among member countries, and, as appropriate, seeks opportunities to collaborate with partner countries. In particular, each working party oversees the RDD&D activities of IEA's Technology Collaboration Programmes that fall within their respective portfolios.

Technology Collaboration Programmes (TCPs)

IEA's Technology Collaboration Programmes (TCPs) are at the core of the agency's RDD&D and knowledge transfer efforts and comprise its energy technology network. TCPs are independent, international groups of experts that enable governments and industries from around the world to lead programmes and projects on a wide range of energy technologies and related issues. At present, there are 39 TCPs involving over 6,000 experts globally and nearly 300 public and private organisations in 51 countries. With the exception of two cross-cutting TCPs, the work of each TCP is overseen by one of the four CERT working parties. TCPs are governed by a flexible and effective framework. Their activities and programmes are managed and financed by the participants. To learn more about the TCPs, please consult the short promotional film or the *Frequently Asked Questions* brochure.

TCP on Hybrid and Electric Vehicles (HEV TCP)

Created in 1993, the activities of the TCP on Hybrid and Electric Vehicles (HEV TCP) are coordinated by the CERT's EUWP. The aims of the HEV TCP are to produce and disseminate balanced, objective information about advanced electric, hybrid, and fuel cell vehicles. The HEV TCP accomplishes this through multilateral task-force projects. Each of these task-force projects is known as a Task. For further information on the HEV TCP including a complete list of ongoing and completed Tasks, please see http://www.ieahev.org/.

Version	Date	Details	Prepared by:	Reviewed by:	Approved on:
V 0.0	June 8, 2017	Initial draft	Julie Francis & Burak Ozpineci	Burak Ozpineci Lee Slezak	n/a
V0.1	September 13, 2017	Demonstration edits included	Julie Francis	Burak Ozpineci Lee Slezak	
V0.2	December 18, 2017	Reviewer edits included	Julie Francis	All Task Members	
V0.3	January 22, 2018	Task Members edits included	Julie Francis	n/a	FINAL RELEASE

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1 Task Approach

Multilateral task-force projects within the Technology Collaboration Programme (TCP) on Hybrid and Electric Vehicles (HEV TCP) are known as Tasks and are organised under the auspices of the Implementing Agreement for Co-operation on Hybrid and Electric Vehicle Technologies and Programmes (IA-HEV). Participation in a Task is an efficient way of increasing national knowledge, both with respect to the specific project objective and in terms of information exchange with peer institutions. Shared activity allows Task members to combine strengths, optimize resources, mitigate risk, and share knowledge.

1.1 Objective of Task 26

Task 26 aims to develop a greater global understanding of wireless power transfer (WPT) systems and interoperability through a focused study of WPT technologies being developed in the participating countries. This task includes a study of country-based standards (e.g., JARI, SAE, ISO/IEC), technical approaches, grid interactions, regulatory policy, and safety codes for WPT. The Task that operates from Summer/Fall 2014 through May 2019 conducts two workshops per year, with each workshop focused on a particular aspect of wireless charging.

It is hoped that participants in this Task benefit from their involvement in the following ways:

- Broadening and deepening the expertise of automotive research organizations in WPT for electric vehicles (EVs) and related technologies.
- Strengthening working relationships and international collaborations.
- Gaining access to information on research performed by other participants.
- Receiving updates on recent developments in other countries.
- Staying informed on the state of standards that may facilitate (or hinder) interoperability with WPT for EVs.

1.2 Focus of Workshop

This was the sixth workshop conducted under Task 26 as shown in Figure 1. The focuses of this workshop were installations and alignment of EV wireless charging systems. Workshop organizers sought speakers with good insight into both the technical and practical challenges associated with installing wireless charging systems and alignment solutions pertaining to these technologies. With the support from the Task Members, workshop participants were able to review these two topics from various perspectives.

Workshop #	Month	Year	Focus	Location / Host
1	October	2014	Kickoff	Vancouver, BC – Canada
2	May	2015	Leading Applications	Seoul, Korea / EVS 28
3	October	2015	Power Levels	Goteborg, Sweden / RISE Viktoria
4	June	2016	Interoperability & Standards	Rotterdam, The Netherlands / proov
5	October	2016	Safety of WPT Systems	Knoxville, TN USA / ORNL
6	**April**	**2017**	**Installations & Alignment**	**Versailles, France / VEDECOM**

Figure 1. Task 26 Workshop Topics.

2 Workshop Activities

2.1 Host Location

This workshop took place in Versailles, France on 25 and 26 April 2017. The hosts for this event were Stephane Laporte and Alberto Rossi of VEDECOM, and IEA's Technology Collaboration Programme on Hybrid Electric Vehicles (HEV TCP). Versailles is of significance because it and the Yvelines département in Île-de-France region are home to many French automotive industry research and development firms. Among the automotive companies situated in this research hub are Renault's Technocentre, PSA Groupe, and Renault Trucks. It is less than 20 km from Paris where other international automaker's French headquarters are located.

2.2 Host Activities in Support of Plug-In Electric Vehicle Deployment

VEDECOM was founded in February 2014 with the objective of becoming the leading institute in France for autonomous and connected vehicles and their uses. Over the last 3 years the institute has grown from 10 founding members to 40 members comprised of industry, academia and local governments. Industry members include firms from the automotive, aerospace, and mobility ecosystem sectors. VEDECOM has a staff of 140 with a target size of 200 researchers and staff. The institute has been able to secure €300 million of funding for over the next 10 years across 19 projects. Projects are a mix of work brought by the members to the institute and activities solicited by joining forces with others in this research space.

The research institute's sole focus is individual, carbon-free and sustainable mobility. To achieve this goal the institute does research in three areas of mobility: vehicle electrification, driving delegation and connectivity, and shared mobility and energy. VEDECOM's wireless charging projects are part of their vehicle electrification research area. The WPT research activities are exploring coupler design, associated power electronics, electric road design and detection algorithms. Both simulation tools and experimental tests are used to perform research and validate those activities.

2.3 Workshop Presentation Topics

With the support of the Task Members, 14 speakers were identified to present on installations and alignment of EV wireless charging systems. Presentation topics included experimental charging setups, bus and tram pilot projects, fully operational bus installations, electric road design, electric road cost considerations, and an alignment system using the power transfer coils. Figure 2 contains a comprehensive list of presentation topics, the individual presenters, and their affiliations.

Presentation	Presenter	Affiliation
Introductions & HEV TCP Welcoming Remarks	Burak Ozpineci	ORNL
VEDECOM involvement in FABRIC	Stephane Laporte	VEDECOM
EMF compliance assessment of a 20-kW dynamic wireless charging track for electric vehicles	Leandro Percebon	Qualcomm
VEDECOM Welcoming Remarks	Luc Marbach	VEDECOM
European Commission projects for Green Vehicles charging	Maurizio Maggiore	European Commission

Presentation	Presenter	Affiliation
Construction and on-road integration of the electrical infrastructure for a dynamic IPT system: challenges and lessons learned from a real implementation	Paolo Guglielmi	Politecnico di Torino
Electric road construction: Road infrastructure impacts and solutions	Damien Bateman	TRL
VICTORIA project	Hans Bludszuweit	CIRCE
Wireless Charging Systems at VEDECOM	Mustapha Debbou	VEDECOM
Essential Enabling Alignment and Communication Subsystems for Advanced Automatic Wireless Charging	Bruce Long	Momentum Dynamics
Optimization of the system Electric Vehicle – Grid with Wireless Power Transfer	Giampiero Brusaglino	Centro Ricerche Fiat
Low cost electric highway solution	Leslie Adrian	Lesla, Ltd
On-Line Electric Vehicle (OLEV) Project and Vehicular Wireless Power Transfer Technology	Seungyoung Ahn	KAIST
Lessons Learned in Commercial Deployments of Wireless Charging for Electric Buses in Public Transportation	Michael Masquelier	WAVE & Co-Chair SAE J2954 HDV

Figure 2. Installations & Alignment Presentations at HEV TCP Task 26 Workshop 6.

2.4 Demonstration

The demonstration conducted during the workshop is part of the **Fe**a**s**i**b**ility analysis and development of on-**r**oad chargi**n**g solutions for future electric vehi**c**les (FABRIC) project titled, *Feasibility analysis and technological development of on-road charging for long term electric vehicle range extension*. The 4-year project began in January of 2014 and includes 23 partners coordinated by Institute of Communication & Computer Systems. Total project costs are €9 million. The VEDECOM-Satory facility visited is one of the demonstration sites that are part of FABRIC. Figure 3 through Figure 5 provide the partners, general charging principles for dynamic wireless charging, and characteristics of this specific demonstration. This section of the report describes the primary aspects of the demonstration: the track, the WPT system, the vehicle design, and the system capabilities testing witnessed by workshop participants.

Figure 3. Satory project partners.

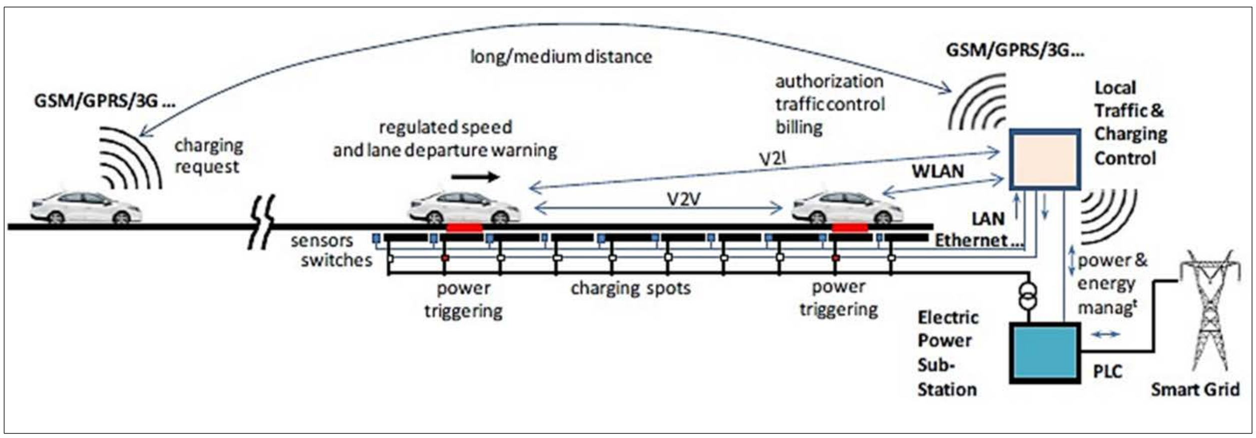

Figure 4. Dynamic Wireless Charging Principles.

Project Characteristics	
Location	Satory – Versailles
Number of Vehicles	Three light-duty passenger vehicles: • Two fully electric Renault Kangoos • One Renault Kangoo with electric load
Power transfer nominal rating	20 kW per vehicle
Operational speed during charging	Up to 100 km/h
Length of charging lane	100 m
Other characteristics	Custom user interface for driver guidance and proper aligning with the charging lane. Charging system developed by Qualcomm.

Figure 5. Project Characteristics.

2.4.1 Satory dynamic charging test track

For this demonstration VEDECOM developed a 100-meter long, 4-meter wide test track outside of their laboratories. The lane is comprised of typical road surface materials with a center channel which contains the ground portion of the wireless charging system as shown in Figure 6. The central channel is a drained area of 80 cm by 20 cm made of prefabricated concrete. The channel is covered by composite filled glass fiber panels 3 cm thick. These panels were tested and deflected less than 2 mm under maximum load.

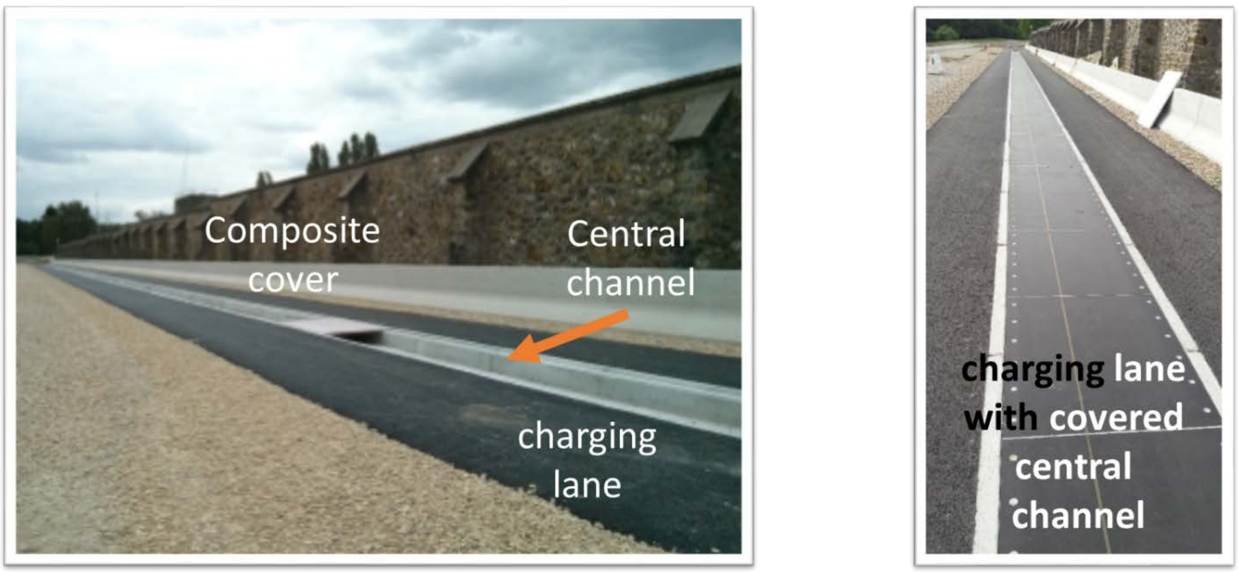

Figure 6. FABRIC dynamic charging test track.

2.4.2 Dynamic Wireless Charging System

The central channel described houses a Qualcomm Halo^{TM} dynamic wireless charging system. The electrical architecture of the 100-meter charging lane is of four 25-meter stubs each powered by its dedicated roadside cabinet. The cabinets are fed from the main electrical stations with 900 VDC. Each stub powers 14 Base Array Network (BAN) blocks. The magnetics in each block are powered by a BAN power controller which itself is coupled magnetically to the power distribution backbone cable as shown in Figure 7. The BAN block, BAN power controller, communication cables and power distribution backbone cable in Figure 8 are located in the central channel of the charging lane.

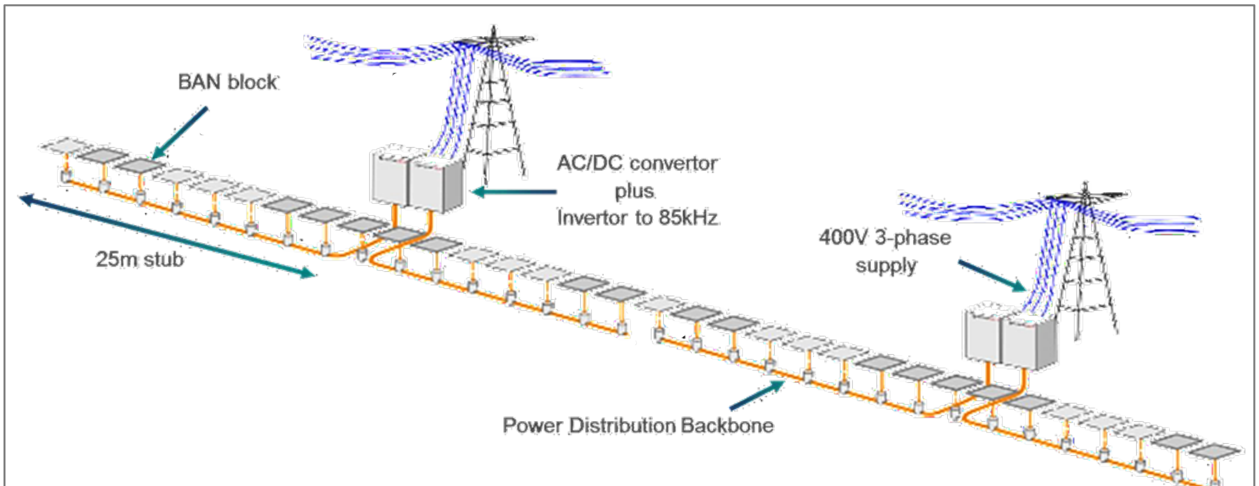

Figure 7. Qualcomm Halo™ dynamic wireless charging system at the test track.

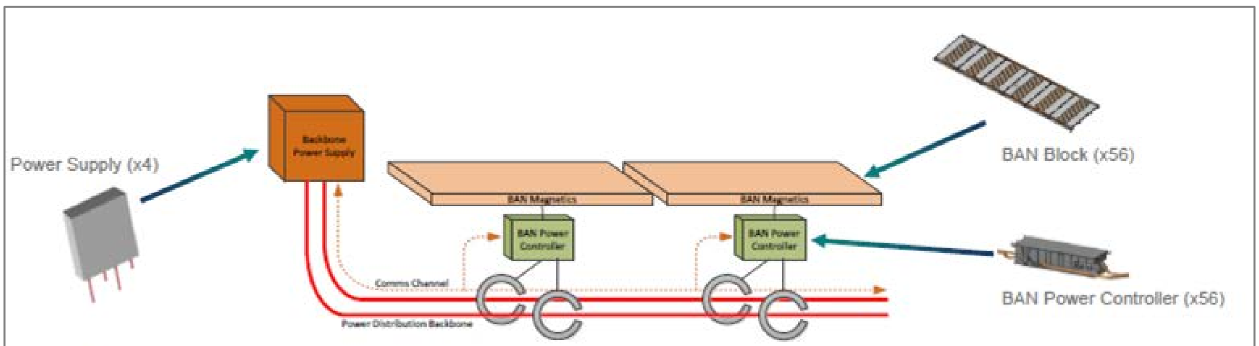

Figure 8. Layout of the test track components.

2.4.3 Vehicle Design

Renault provided two vehicles for testing at this track. Both are fully electric Kangoos, a light-duty goods vehicle. In addition, Qualcomm provided a diesel-powered Kangoo that was used for preliminary system testing with transferred power being dissipated to an electric load. Qualcomm provided two vehicle coil pads and their controller for each Kangoo to be integrated into the vehicle by VEDECOM. The pads were installed on the vehicle’s underside near the wheel axles. The coils are each capable of 10 kW power transfer for a total power of 20 kW to the vehicle. The vertical gap between the BAN blocks and the vehicle pads was 170 mm for this demonstration.

2.4.4 System Capabilities Testing

The demonstration of this system included several tests to show how the power transfer operated under different driving conditions. Multiple tests were witnessed which included:

- Single vehicle in the charging lane at multiple speeds to show impact on power transfer.
- Single vehicle in the charging lane swerving over the ground coils to show impact of alignment on power transfer.
- Multiple vehicles in the charging lane to show sensor and power triggering capability of the system.

VEDECOM's control room included feedback on power transfer levels as well as the sensor switching and power triggering operational information on the different BAN blocks in real-time. Figure 9 shows one of the feedback screens from the graphic user interface controller provided with the Qualcomm prototype system.

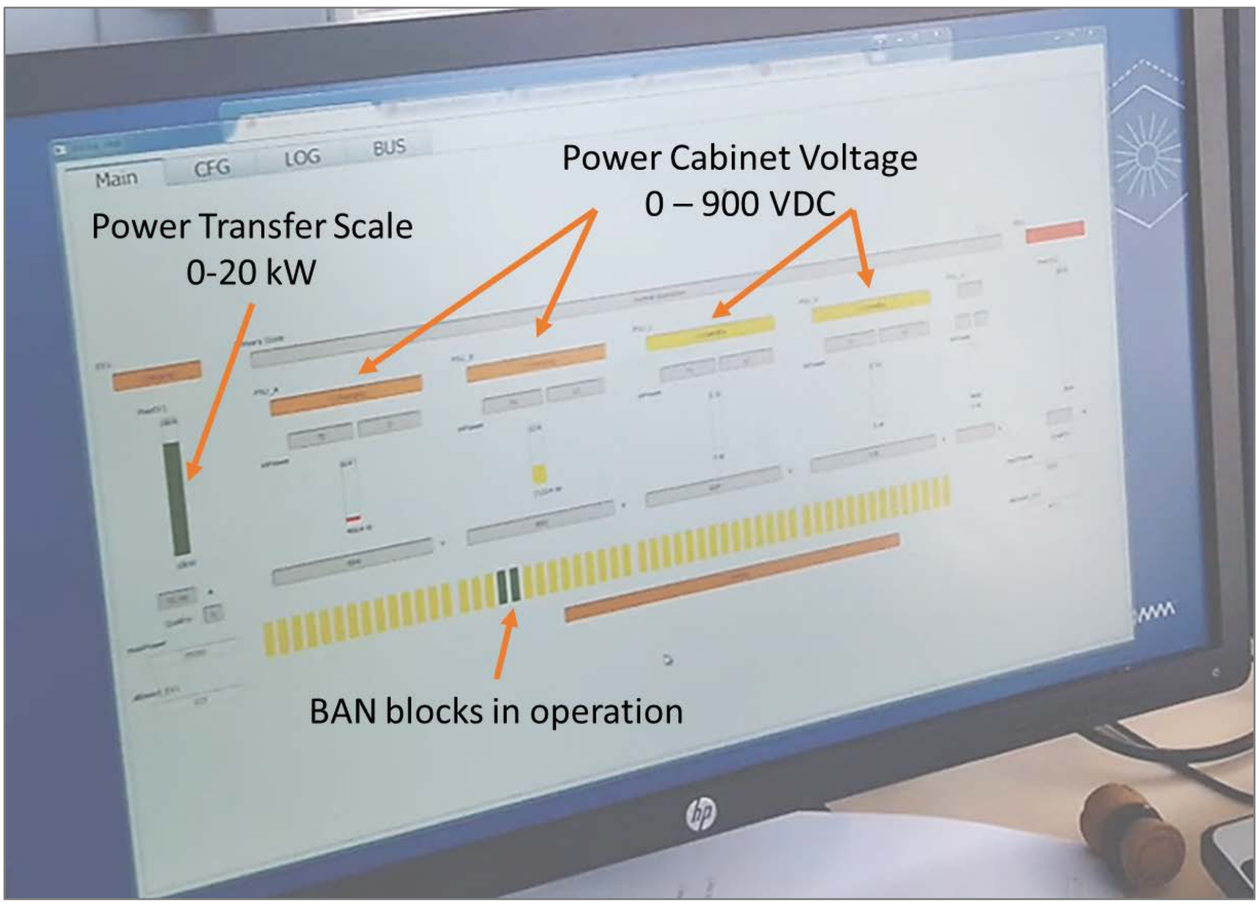

Figure 9. Dynamic wireless testing information.

3 Key Findings

Based on the presentations of this workshop and the demonstration witnessed, Task Members had an in-depth discussion of installations and alignment. A number of key points emerged during the workshop. These ideas are listed below. The order in which they are presented is not intended to reflect their relative importance.

- There was a terminology difference when presenters described wireless charging systems. FABRIC presenters called charging while parked *Static Charging* while others call it *Stationary Charging*. Wireless charging during short stops is typically called *Opportunity Charging* or *quasi-dynamic (static)* while it was called *Stationary Charging* by some of the presenters.
- It is still not clear what the best approach is for installations, especially for in-motion charging. The available options are trench-based, micro-trenched based, full lane width, and full-lane width precast construction. Each have their advantages and disadvantages. The trench-based approaches typically have lower initial costs but higher long-term costs while the opposite is true for the full-lane width approaches.
- Pavement composition and the bitumen must not interfere with the magnetic flux of the DEVC system. The material under and around the ground coil must be realized with specified magnetic properties, i.e. using electrical conductive shielding plates below the ground coils.
- The standards being developed continue to be a concern for the attendees. One of the presenters talked about an open standard the presenter is developing.
- Rules and regulations can delay the installation of wireless charging systems in urban locations. The aesthetics of the wireless charging boxes and the location of the stops require a lot of discussions with the city officials.
- Trained workforce for wireless charging installations does not exist which results in lost hours due to the breakage of the equipment. The wireless charging coils and boxes need to be assembled and protected against drops and other possible damage before they are installed on the roads and parking spots.
- Adequate drainage is needed for the installations for water not to accumulate around the wireless charging systems in the ground.
- The lessons learned from the demonstration included the fact that the drivers can align the vehicle well while they are driving on the wireless charging coils. For stationary charging, a low-cost coil sensor was presented for better alignment.
- One of the presenters talked about a way to cancel the fringe electromagnetic fields under a vehicle to reduce worries about leakage of magnetic fields.

4 Conclusions

The main conclusions of the workshop are listed below. The order of the points is not reflective of their importance.

- Pavement composition and road construction are two issues for better installation of wireless charging systems.

- Understanding the rules and regulation of the installation areas would ease the permitting process. Educating government officials in technology would also help.
- Workforce training is needed for future installations of wireless charging systems.
- Testing with drivers indicates that vehicle and plate alignment during a dynamic wireless charging event may not be of concern. Lane assist systems on newer vehicles could also aid in wireless charging alignment.

5 References

Debbou, M. (2017) *Wireless Power Transfer at VEDECOM.* PowerPoint presentation at the workshop of IEA's HEV TCP, Versailles, France.

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Laporte, S. (2017) *VEDECOM Institute for Energy Transition.* PowerPoint presentation at the workshop of IEA's HEV TCP, Versailles, France.

Percebon, L. (2017) *Integration of Qualcomm Halo™ DEVC technology onto a Renault Kangoo – EMC & EMF assessment simulation report*. PowerPoint presentation at the workshop of IEA's HEV TCP, Versailles, France.