

**Report of the 16th Session of the
Electric Vehicles and the Environment Informal Working Group (EVE IWG)**

Location: 150 Kent St, Ottawa, Ontario, Canada
Time / Date: 09h00 – 17h00 October 19th, 2015
08h15 – 17h30 October 20th, 2015
Chair: Mr. Michael Olechiw (USA)
Co-Chairs: Mr. Kazuyuki Narusawa (Japan)
Ms. Chen Chunmei (China, by teleconference)
Secretary: Mr. Andrew Giallonardo (Canada)

1. Welcome, Introductions, and Agenda (item 1)

Mr. Michael Olechiw, Chair of the informal working group, welcomed participants to the meeting. The meeting was well attended, with approximately 20 participants from contracting parties, other WP.29 working groups, and industry organizations making the trip to Ottawa, and an additional 10 participating via teleconference. In addition to Mr. Olechiw, Mr. Narusawa (Co-Chair), Ms. Chunmei (Co-Chair, by teleconference) and Mr. Giallonardo (Secretary) were present at the meeting.

Mr. Stéphane Couroux, Director of the Transportation Division of Environment Canada (host organization for EVE-16) welcomed participants to Ottawa, and wished all a productive meeting and an enjoyable time while in the nation's capital and while visiting the Environment Canada's testing facilities. Mr. Couroux highlighted the importance of the EVE IWG's work and the role electric vehicles are expected to play in allowing manufacturers to meet their requirements under Canada's domestic GHG emission regulations for light-duty vehicles. Mr. Couroux also highlighted Canada's past contributions to the EVE IWG including their role as secretary and work on the EV reference guide.

Mr. Olechiw outlined the objective for the 16th EVE meeting, which was to continue work on Part A of the new EVE mandate. Building on issues discussed during the previous EVE IWG meetings, lead parties/organizations were to present an update on the status of their work with a view towards the EVE IWG's recommendations to GRPE in June 2016.

The agenda for the meeting (EVE-16-02e-Rev1) was reviewed and accepted by all participants.

2. Review EVE IWG #14 Meeting Report (item 2)

Speaking to agenda item 2, Mr. Giallonardo reviewed the action items from the EVE-15 meeting (EVE-15-10e). Some of the 16 action items are ongoing; however on-going Action 4 from EVE-15 related to the literature review has been closed. Subsequent ongoing action items have been renumbered accordingly. EVE-15 Actions 7 through 16 were completed before or during the EVE-16 meeting. The ongoing action items are re-named below:

ACTION 1 (EVE-15 Action 1, ongoing): Concerning future work under Topic 2, the EVE group will consider the development of a technical report that could be added into the SR1 and/or RE3 documents and discuss further at the next EVE meeting.

ACTION 2 (EVE-15 Action 2, ongoing): The EVE group will continue discussion with the WLTP IWG and European Commission about potential areas for collaboration in EV work.

ACTION 3 (EVE-15 Action 3, ongoing): All interested parties are encouraged to contribute data to build the database proposed by China by reaching out directly to Ms. Chen Chunmei (chencm@miit.gov.cn).

ACTION 4 (EVE-15 Action 5, ongoing): All interested parties wishing to participate in the work related to determining power of EVs led by Germany and Korea should reach out directly to Mr. Holdik (Hans.Holdik@bmvi.bund.de) and Mr. Dongseok Choi (dsechoi@ts2020.kr).

ACTION 5 (EVE-15 Action 6, ongoing): Any interested parties and/or stakeholders wishing to speak to the issue of battery recyclability at future EVE meetings should inform the EVE Secretary ahead of the meeting so they can be added to the agenda.

3. Update on other GRPE and WP.29 IWGs (item 3)

Mr. Olechiw led a roundtable discussion of work related to EVs occurring in four other GRPE and WP.29 IWGs, with a focus on potential linkages to current EVE work. An update was given by Mr. Per Öhlund on the activities of the Worldwide harmonized Light vehicles Test Procedure (WLTP) IWG using document EVE-16-11e. Mr. Öhlund indicated that the drafting subgroup hoped to finalize a draft GTR in mid-October for submission to GRPE in January.

Several items were discussed as being relevant to EVE work.

- a) The WLTP EV subgroup proposed to use the interpolation approach to, with some special conditions, to obtain all parameters (excluding R_{cd}) of electrified vehicles. Some issues around R_{cd} were noted.
- b) The WLTP EV subgroup proposes a shortened test procedure for PEV to obtain Range and EC and reduce testing burden.
- c) The WLTP EV subgroup agreed on a cycle modification for EVs which cannot achieve the maximum speeds within the WLTP.
- d) The WLTP EV subgroup agreed on a decision flow for EVs with a mode selectable switch.
- e) The WLTP notes that they are awaiting recommendations on a method of determining EV power from the EVE IWG.

Mr. Olechiw noted that there is some overlap between the issues WLTP IWG is considering for phase 2 of their work with the current work of the EVE IWG, specifically related to power determination and EV durability. The EVE IWG requested that the WLTP IWG clarify the work they intend to pursue over the next year and the items they are looking to have provided by the EVE IWG.

ACTION 6: Mr. Per Öhlund to discuss the issue with the WLTP subgroup and provide additional clarification at the next EVE IWG meeting in January.

A presentation updating the EVE IWG on the status of work program for the Environmental Propulsion and Performance Requirements (EPPR) IWG was provided by Mr. Petter Åsman (document EVE-16-05e). Mr. Åsman was not able to attend in person or via teleconference, so the review and discussion of the presentation was led by the chair. The group was to have a draft GTR related to evaporative and crankcase emissions completed by mid-October for approval at GRPE in January. The extension of the mandate of the EPPR IWG was recently extended by GRPE and WP.29 for the 2016-2020 timeframe.

Mr. Kazuyuki Narusawa noted that the minutes from the most recent Electric Vehicle Safety (EVS) IWG had not yet been completed, and he submitted an oral report to the EVE IWG. Mr. Narusawa outlined the work of the 9 task groups within the EVS, and the schedule for upcoming EVS meetings. The group noted that Mr. Brian Lawrence (Jaguar) had mentioned at the last EVE meeting that he would be interested in presenting industry concerns about the impact of the work of the EVS could impact the work of the EVE IWG (Action 7 from EVE-15). This presentation was not given, but the EVE IWG reaffirmed their commitment to remain updated on the work of the EVS IWG and restated their openness about hearing concerns from industry regarding how the work of the two IWGs could affect each other.

4. Update on subgroup activities for Part A of the new EVE mandate - Determining power of EVs (item 4)

Mr. Mike Duoba (Argonne National Laboratory) made a presentation (EVE-16-12e) on the recent work of the SAE J2908 (Hybrid Electric Powertrain Power Test Methods and Definitions) committee. He outlined their progress so far in developing a method to determine the power of EVs. The SAE J2908 committee has run many tests, collected data, and has reached a decision point about how to report system power of EVs. In their work, three methods of measuring/stating system power emerged.

- a) Engine Power_{estimated} + DC Power_{measured}
- b) Σ Shaft Powers_{estimated}
- c) Axle/Wheel Power_{measured}

The SAE committee noted that methods which are the easiest to verify (measuring axle/wheel power) is the least useful to consumers as a comparison to conventionally powered vehicles, while the method most useful to consumers (the total combined shaft power of all motors) is the most difficult for regulators to verify. Mr. Duoba also stated that to produce the most robust results, data signals must be filtered avoid transient spikes or signal noise. The SAE committee is still debating which method would be the most appropriate. SAE has reached an impasse and is now considering questions such as whether hybrid system ratings should be molded to fit the way conventional vehicles are currently rated and whether all vehicle power ratings should switch to a wheel/axle power basis.

The EVE IWG members considered the points raised by Mr. Duoba, and were generally in agreement that a method which best allows the power of hybrid systems to be compared with that of conventionally powered vehicles would be the most useful. Mr. Norbert Klein (Hyundai) noted that comparing the power of conventional and hybrid vehicles is also a priority for the WLTP IWG. Mr. Hans Holdik (Germany) noted that the method measuring axle/wheel power is the only method which can be independently verified, and that all others will require input from the manufacturer.

Mr. Masao Kubodera (Japan) gave a presentation (EVE-16-06e) updating the EVE IWG on the work of the ISO HEV System Power Working Group. The ISO WG has a 36 month mandate,

which began in June 2015. The ISO WG is investigating the determination of power for propulsion of hybrid electric vehicles. The goal is the development of an international standard which contains a test procedure to determine the maximum HEV system power. Mr. Kubodera highlighted that the ISO WG is considering many of the same questions as the EVE IWG, such as how easily the rated power of HEV and conventional vehicles can be compared and the accuracy and repeatability of any test method or procedure. Mr. Kubodera led a discussion on different HEV system architectures, and stated that the current ISO viewpoint is that HEV system power should be stated as a combination of the internal combustion engine (ICE) and battery outputs available to propel the vehicle. Mr. Kubodera also outlined a possible method of determining maximum HEV system power through constant speed testing on a chassis dynamometer testing.

The EVE IWG considered the points raised by Mr. Kubodera and the discussion that followed the presentation mainly focused on the technical details of how the procedure could be implemented. Mr. Olechiw asked how the procedure could account for efficiencies downstream of the ICE and battery. The EVE IWG agreed that the ISO work had the potential to be quite valuable, and expressed a desire to remain updated on the progress of the ISO WG.

Mr. Hans Holdik (Germany) gave a presentation (EVE-16-07e) updating the EVE IWG on the work of the subgroup focused on determining power of EVs, which is being led by Germany and Korea. The power determination subgroup has compiled and evaluated the responses to the survey (EVE-14-07-Ref1e) submitted by EVE IWG members. Some of the responses indicated preferences for development of a GTR while others preferred an international standard from an organization such as ISO. Mr. Holdik outlined the planned activities of the subgroup until EVE-17, which included determining a formal structure and work breakdown for the power determination subgroup, and drafting a mandate document which, depending on further progress, could be ready for presentation to GRPE in January, 2016.

Mr. Olechiw noted that while the EVE IWG does not have a mandate for GTR development at this time, a recommendation or development of a test method for determining HEV system power is a specific request from the WLTP IWG, and it has added some additional urgency and importance to the work of this subgroup. Due to the time constraints of outside experts who were scheduled to present (FEV consulting), additional discussion on this topic was tabled until Day 2 of the EVE-16.

5. Update on subgroup activities for Part A of the new EVE mandate - Battery performance and Durability (item 5)

Several members from FEV Consulting, a contractor who prepared a literature review draft report for the EVE IWG entitled *Battery Durability in Electrified Vehicle Applications* (EVE-16-04e), gave a presentation (EVE-16-10e) highlighting selected findings from literature review, and recommendations for next steps. The presentation covered topics such as degradation mechanisms, and the ways by which factors such as thermal effects and depth of discharge can affect how a battery degrades over time. This was followed by FEV answering several questions from members of the EVE IWG about the draft report. Some members of the EVE IWG felt that the draft report should more clearly distinguish conditions experienced at the cell level with conditions experienced by the battery pack as a whole; noting that battery management software is normally designed to prevent the individual cells from experiencing the types of operating conditions which can accelerate degradation. There was also some debate

about whether an appropriate end of life criterion is a reduced capacity (max state of charge), or when the battery can no longer provide the desired power levels.

ACTION 7: EVE group members should send final comments for FEV concerning the literature review outlined in EVE-16-04e and EVE-16-10e to Mr. Olechiw (email: Mr. Olechiw, olechiw.michael@epa.gov, cc: Mr. Tom Casciani, casciani@FEV.com, andrew.giallonardo@ec.gc.ca).

ACTION 8: FEV Consulting to complete a final literature review report based on written comments submitted by members before and after EVE-16, and comments made during the meeting.

ACTION 9: Mr. Brian Lawrence (Jaguar) to look for alternative definitions of battery End of Life (EOL) which can be shared with FEV for the literature review, specifically related to reduced ability of the battery to provide power, not simply a reduced max state of charge.

The group acknowledged that nearly all manufacturers are trying to maintain more consistent performance throughout the life of the vehicle with battery management systems. Some EVE IWG members also felt that battery durability management was best left as a warranty issue between manufacturers and consumers, rather than regulators. Several manufacturer representatives also noted that any steps to predefine battery aging conditions (temperatures, cycle depths, etc.) would lead to some manufacturers optimizing performance only for testing conditions, and not real world conditions.

6. Update on subgroup activities for Part A of the new EVE mandate - Method of stating energy consumption & battery recyclability (item 7)

Day 2 of the meeting began with Ms. Chen Chunmei (China) introducing EVE-16-14e, EVE-16-15e, and EVE-16-16e, which outlined China's work developing a preliminary model to calculate the life cycle energy consumption of EVs, and included a draft Excel model. Mr. Feng Yingdong and Mr. Ou Xinming (China) then began the presentation and noted that their literature review had found many papers assessing energy consumption and GHG emissions from EVs, but also noted that characteristics of the upstream power supply needed to be taken into account. The presentation included suggested guidelines for considering operation and upstream energy consumption separately. China welcomes support from other contracting parties in supplying data or suggestions for improvement of China's proposed methodology and the preliminary Excel tool based on experience in other jurisdictions (U.S., EU, etc.)

Some working group members were interested in how emissions levels for various sources of electricity (nuclear, coal, etc.) were quantified, as well as assessing the composition of the grid in different regions.

ACTION 10: Ms. Chen Chunmei to coordinate the update of the reference document (EVE-16-15e) to include an explanation of data sources used in the model to quantify upstream emissions for various fuel sources. This explanation will also address specifically which types of upstream emissions are and are not included in the model. i.e. Does the upstream emission value for coal plants include upstream emissions from coal extraction and transportation of the coal from the mine to the power plant, or just the emissions from the burning of the coal at the plant?

ACTION 11: Ms. Chen Chunmei to ensure that the reference document (EVE-16-15e) also includes a few examples of how the model calculates emissions for different types of vehicles (BEV, PHEV, etc).

ACTION 12: All working group members to share appropriate data with Ms. Chen Chunmei with comments on the model's functionality and data on the emissions intensity of the electricity grid in various jurisdictions.

ACTION 13: Mr. Mike Safoutin to share a recent Carnegie Melon University publication discussing EV performance with the Secretary, who will post the document on the EVE IWG's site.

Battery recyclability

The EVE leadership did not receive any new information on this topic or requests to discuss this further, so no discussion on battery recyclability occurred, but Action 5 will remain ongoing for future meetings.

7. Continuation of discussions concerning determining power of EVs and battery performance and durability (items 4 & 5)

Mr. Olechiw called attention to the literature review recommendations (EVE-16-04e) on battery performance and durability, and highlighted the importance of preparations for the EVE IWG's next status report. Several group members once again highlighted the importance of trying to meet the needs and timelines of the WLTP IWG for information related to determining the power of EVs.

Mr. Norbert Klein noted that a method for determining system peak power and a way to put that into a GTR should be a first priority. Several other members agreed.

ACTION 14: Mr. Hans Holdik will communicate with representatives of the WLTP IWG and prepare a short document specifically defining the needs of the WLTP IWG and the work the EVE IWG will undertake to support those needs.

ACTION 15: Hr. Holdik to invite Mr. Heinz Steven to the next meeting of the power determination subgroup.

Mr. Olechiw noted the need for a plan on how the EVE IWG intended to move forward on the topic of EV and battery durability. Members noted that all manufacturers are managing durability differently. Ms. Anika Ahlberg-Tidblad stated that she felt that different vehicle classes would likely have different battery durability needs. Members also discussed factors which affect battery durability and their relative importance. Ms. Ahlberg-Tidblad also noted that battery aging is very path dependent. The group also discussed how battery durability would have a different impact on the emissions from a BEV versus a hybrid system. Some members pointed out that when the battery on a BEV degrades, there is a loss of range, but there is not a large change in the upstream emissions from the vehicle; while a HEV will generally have higher emissions due to more frequent use of the conventional powertrain as it's battery degrades.

Several members noted that any effort to define the testing conditions for EV battery durability would likely influence the way that EV batteries are designed. Some members indicated that specifications around battery durability may limit innovation in the field. Ms. Ahlberg-Tidblad

highlighted the example of research into cheap, conveniently recycled batteries which wear out quickly, and must be replaced occasionally like tyres on current vehicles.

Mr. Olechiw proposed, and the EVE IWG agreed, that a small drafting group be formed to compile the views of the EVE IWG on battery durability. Mr. Michael Safoutin agreed to lead this effort, and support will include Ms. Anika Ahlberg-Tidblad. Mr. Narusawa emphasized that battery durability itself is not the primary issue for the EVE IWG, but rather the effect that battery durability has on the environmental performance of EVs.

ACTION 16: Mr. Safoutin to form the drafting group with Ms. Ahlberg-Tidblad and others to begin drafting a document regarding the environmental impact of battery durability.

8. Review of Roadmap for EVE mandate, Part A (item 8)

Mr. Andrew Giallonardo presented document EVE-13-06-Rev1e, reminding the group that the roadmap was developed based on the EVE mandate document approved by WP.29 (2014 formal document 88, amended by informal document WP.29-164-15). Key tasks going forward include: status report from each subgroup (Jan 2016 GRPE), informal discussion and approval by GRPE on the proposed workplan and (if appropriate) requests for GTR or Regulation development (June 2016 GRPE) and approval by WP.29 of the proposed workplan and (if appropriate) GTR or Regulation development (November 2016).

Mr. Olechiw noted that the subgroups are generally on-track with their respective projects. EVE IWG should have recommendations available going into EVE-17, so that they can be reviewed at EVE-18 and be submitted to GRPE at EVE-19 in June 2016.

EVE IWG members agreed that the schedule be discussed with the WLTP IWG to assess the compatibility of each other's timelines. Mr. Olechiw noted that the power determination subgroup is at a threshold, and could potentially be ready to contribute to GTR development as early as January 2016 (by EVE IWG or WLTP IWG). Recommendations to GRPE should include a plan for who will conduct specific work activities.

Mr. Olechiw noted that the EVE IWG's current mandate is to conduct research and make GTR recommendations, but would likely need a new mandate to develop a GTR.

ACTION 17: The EVE group should review the EVE-13-06-Rev1e document ahead of the EVE-17 meeting.

9. Discuss next EVE meeting (item 9)

Mr. Olechiw stated that EVE-17 would be held on January 11th, 2016 in Geneva from 9h30 – 12h30, and that the group would prepare their report to GRPE at that time and discuss the spring EVE meeting.

The EVE IWG also noted that they would make their preference for Monday afternoon meetings over Monday mornings, to ease the travel burden of members located within Europe.

ACTION 18: Mr. Giallonardo will prepare the draft EVE-17 agenda and invitation, and post it on the EVE IWG website.

10. Concluding remarks, Closing (item 10)

Mr. Olechiw closed the meeting by thanking participants for attending, and thanked Environment Canada for hosting.

ACTION 19: Mr. Giallonardo will prepare the report of the 16th meeting of the EVE IWG and share with the EVE IWG.

11. Tour of Environment Canada facilities (item 11)

Participants joined Mr. Giallonardo on a tour of Environment Canada's vehicle and engine testing facility and research laboratory.