Status Report

Electric Vehicles and the Environment Informal Working Group (EVE IWG)

Method of Stating Energy Consumption

1. Background and EVE Mandate

The EVE mandate on the method of stating energy consumption stems from the recognition that a common method which can be used to state and compare the energy used by vehicles (i.e. MPG, L/100km, or kWh/100km, etc.) is an important environmental issue. Advanced EVs represent a promising opportunity to reduce overall energy consumption and, by using electricity, EVs are potentially able to displace petroleum-based fuels. EV sales are expected to see rapid growth in the future, in part because of increasingly stringent regional CO_2 regulations. However, the development of electric vehicles will lead to displaced emissions from the vehicle to electricity grids; depending on the GHG accounting methods used, the influences of electric vehicles on a region's emissions profile may be underestimated if only emissions in transportation are considered. A standardized method for calculating and stating life-cycle energy consumption and the associated GHG emissions for electrified vehicles is recommended for consideration. Specifically, this method should consider the upstream emissions of vehicle energy.

Accounting for upstream emissions related to electrified vehicles being operated in all electric modes was identified in the Guide (OR-1855-ECE-TRANS-WP29-2014-81e-Proposal for an Electric Vehicle Regulatory Reference Guide) as an important environmental performance metric for electrified vehicles. This topic of upstream emissions, an important environmental consideration, requires knowledge from both vehicle industry and energy industry. The GRPE mandate focuses on vehicle level performance. The upstream emissions are closely related to fields of energy, and experts from corresponding areas are preferred.

2. Research Findings

The EVE IWG developed a Microsoft Excel based model to evaluate the energy consumption of electrified vehicles during Part A of the EVE mandate. Although the EVE IWG feels this model would be suitable for the information-sharing purposes outlined in Part A of the EVE mandate, the current model is best used to make one-off evaluations of the energy consumption of a specific vehicle with a user-defined mix of source electricity.

The life-cycle analysis[1] of the energy consumption and associated greenhouse gas (GHG) emissions based on the Excel model was conducted with the functional unit of 1 kilometer driven by an EV under real-world driving conditions. Impacts from transportation and upstream emission are both considered. Specifically, impacts of upstream emission include the impact of electricity generation and distribution as well as the impact of conventional fuel production and distribution. The specific metrics included are listed below, and each can be individually modified to match regional conditions:

- Source of vehicle energy
- Upstream energy consumption and emissions

[1] Life-cycle analysis refers to emissions from the life-cycle of the upstream fuel source (i.e. extraction, refining, transportation of fuels and/or in some cases, facility construction)

- Power transmission loss
- Charging efficiency and electricity loss

The energy consumption and GHG emissions intensity for a given power generation mix was assumed to be the production weighted average consumption and emissions per unit of electrical energy (MJ or kWh) from all electrical generation sources in a given region. The characteristics of energy consumption and GHG emissions differ a lot across various regions. Traditional fossil fuel power and alternative energy power were used as feedstock in power generation. The former one included coal-fired power, natural gas(NG)-based power and heavy oil-fired power. Alternative energy power was also an important part of electricity mix, including hydro power, nuclear power, solar power, wind power, biomass, geothermal, tidal and others. Energy consumption and the associated GHG emissions of each type of energy were analyzed over the life cycle of the fuel, including mining, refining, transportation, facility construction, decommissioning, and fuel utilization. The energy consumption and emissions from the preliminary stages were allocated and amortized over the total lifetime power supplied by the power generating station. Emissions and energy consumption from vehicle manufacturing were excluded for all powertrain architectures.

The tool states the fuel economy of EVs in two forms:1) power consumption (kWh /100 km); 2) equivalent gasoline consumption (Liter /100 km). The life-cycle energy consumption of EVs was assessed by primary energy consumption (MJ /km) and the associated GHG emissions were estimated by equivalent CO_2 intensity (g $CO_{2,}$ e/km).

In order to help make the model more broadly applicable, a database was established containing electricity mix data and upstream emissions factors for different power sources in some countries and regions (China, USA, EU, Japan and Canada). The energy and GHG emissions intensity of a power generation mix was calculated based on the database and the model. However, data in databases are incomplete or out of date due to various reasons, thus making the calculation result inaccurate.

3. Problem Encountered and Recommendation

The development of such a method is very challenging. It requires expertise in the composition of regional electrical grids, knowledge of the energy consumed both in electricity generation and in distribution as well as understanding of conventional fuel production and distribution. In addition, vehicle energy sources and their associated GHG emissions are geographically highly variable. In order to develop a generic model to analyze energy consumption for all cases, specific expert knowledge related to the generation and transmission of electricity are necessary.

(1) Boundaries are the key to the life-cycle analysis of EVs energy consumption and upstream emissions. Life-cycle energy consumption and GHG emission data in different electricity generation stages are incomplete in current database. Energy consumption and GHG emission of various power plants in different stages, including fuel production and distribution, facility manufacturing and factory construction operation and de-commission, should be clearly collected.

(2) Variations in grid energy and emission factors are important ingredients to estimate regional energy consumption and GHG emissions. Therefore regional marginal emission factors or average emission factors for electricity production should be clearly defined. These defining tasks require specific expert knowledge.

(3) Charging time has a significant impact on energy and emission factor of regional grid. EVs charging will lead to a new load at a given time and location. However, the influence of the load on the whole grid always changes with regional character over time. Therefore, it would be good to know more about the characteristics of seasonal or hourly electrical grids, including generation mix and emissions factors.

(4) Another consideration for electrified vehicle energy consumption and emissions is the relative efficiency associated with the upstream production of fuels and other energy carriers, because these efficiencies can vary depending on the method of power generation and source of raw input energy (heavy fuel, gas, biofuel, wind, solar, hydro etc.).

In order to better formulate this method, the EVE IWG approaches the Group of Experts on Energy Efficiency (GEEE) to request that they continue the work on the method of stating energy consumption. The EVE IWG feels that the GEEE may be a suitable home for this work due their explicit focus on these types of issues, as noted in their mandate – "Group of Experts focuses on sharing experience and best practices in the field of energy efficiency in the United Economic Commission for Europe (ECE) region". The EVE IWG would commit to fully supporting GEEE with any technical expertise required related to electric vehicles. Detailed arrangements on future research can be discussed further.