# Calculation Method of the Actual $CO_2$ Emissions from Power Plant Caused by the Charging of a Battery Electric Vehicle (BEV) and Comparison of the $CO_2$ Emissions with a Hybrid Vehicle (HEV)

Koichi Hatamura[1)] Kazunari Shiraki [2)]

*1) Graduate School of Engineering, Hiroshima University*
*1-4-1, Kagamiyama, Higashihiroshi-shi. 739-8527, Japan*
*2) EEP Research, Yachio-shi, Japan*

**Y WORDS: environment･energy･resources, recyclable energy/renewable energy, heat-trapping gas/greenhouse gas,** life cycle management, energy manufacturing (D2)

In Europe, $CO_2$ emissions of BEV are calculated without including the $CO_2$ emissions during charging, which gives a significant regulatly incentive to the BEVs and may lead their rapid spread in the market. Moreover, it can be said that successive bans of engine vehicle or promotion of BEVs is rather an industrial procection policy vailed by an environmental policy. It is common practice to evaluate the $CO_2$ emissions included that of BEV's chargeing because $CO_2$ is also emitted from the power plant during it's charged. Furthermore, the LCA (Life Cycle Assessment) method is considered to include even the $CO_2$ emission during manufacturing batteries as well as that of the power plant.

Even the $CO_2$ is not emitted on the spot of using electricity, but emitted at the power plant, the using electricity shall be, therefore, evaluated as emitting $CO_2$. The emission factor of the average power supply of the grid power is generally used for the calculations due to the difficulty to identify the types of electricity generation. Evaluating the effect of power saving on $CO_2$ emissions by the power source average coefficient means that all power sources; such as thermal power generation, nuclear power generation, and hydroelectric power generation, utilize a fomula for reducing the amount of power generation on average. Decreasug on average is obviously not reflect clearly the actual situation, because, when demand decreases, the operation will be curtailed from high-cost power sources due to economic rationality.

In the GHG protocol, a proposed idea of "Marginal Power Supply" consists of the evaluation method by combining the short-term margin OM (Operational Margine) and the long-term margin BM (Bild Margine). OM is a power source of adjusting the amount of power generation according to the operation of the power plant, and BM is that of changing depending on the construction and disposal of the power plant. The marginal power source is determined by various factors and by the situations of countries or regions, but, in Japan and in many countires – though some exceptions, thermal power generation can be said as the marginal power source for both OM and BM.

In Japan, although no big difference between the average power emission factor and the marginal power emission factor in 2013 for many of nuclear power plants' shutdown, the expected values in 2030 is an about twice differences, due to the high rate of renewable energy generation. This fact shows that the result of evaluation is significantly depending on which foctor is used.

However, the provided above, when the renewable energy is the marginal power sources, it is exceptional and the $CO_2$ emissions are almost zero. Yet, it is necessary to charge the BEV during the time when the electric power becomes excessive and the renewable energy power generation is suppressed. If the suppression becomes remarkable in future, the BEV will contribute to $CO_2$ reduction by appropriately controlling the charging time. I would like to emphasize here that it is not appropriate to calculate $CO_2$ emissions using the emission factor of the average power supply in order to create a charging mechanism which charges the BEV when surplus power is generated. It is necessary to use that of the marginal power supply for correct evaluation.

It is important to highlight that simply popularizing BEVs keeps thermal power generation for charging BEV as the marginal power supply, and BEV produces more $CO_2$ emisions than HEV. The rapid spread of BEVs requires a large amount of investment in BEV purchase costs (subsidies and user burdens) and infrastructure development in a short period of time. It is recomended to control the rapid expansion of BEVs, and to evaluate the effectiveness of $CO_2$ emission reduction and social cost, appropriately. It is also important, by combining BEV with other means such as HEV, to build a power supply configuration that reduces $CO_2$ emissions and to popularize several types of suitable powertrains in order to reduce $CO_2$ emissions comprehensively and actually.

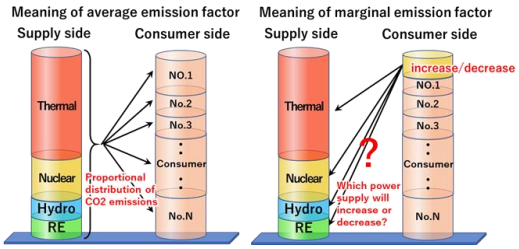


Fig.1 Meanig of average/marginal emission factor

Table2 Average/Thermal power emission factor in the Global Warming Countermeasures Plan

| | Average Emission factor | Thermal power Emission factor |
|---|---|---|
| 2013Actual value | 0.57 kg/kWh | 0.65 kg/kWh |
| 2030Assumed value | 0.37 kg/kWh | 0.66 kg/kWh |

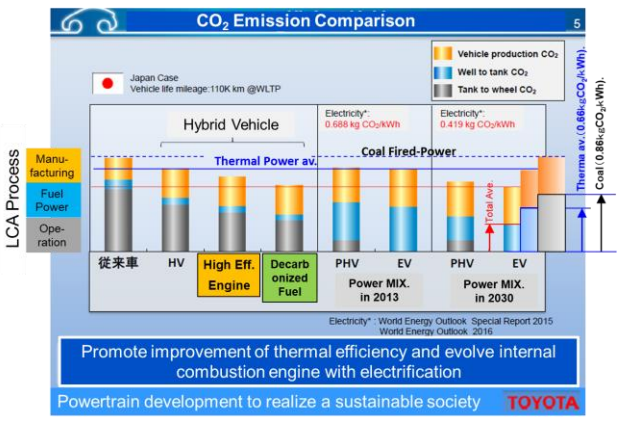


Fig.4 $CO_2$ missions in LCA Assessment of HEV and BEV