Environmental consideration in materials selection for electric vehicles

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Abstract - Electric vehicles contain unique materials and components that are less prevalent or even non-existent in traditional vehicles. In order to ensure that the promotion of electric vehicles does not lead to undesired side effects, it is necessary to conduct environmental assessments before their widespread implementation. Furthermore, it is also important for designers and engineers to be knowledgeable in environmental consequences of their technical decision in the development of electric vehicles. This paper aims to give an overview on the contribution of materials and components to the total environmental impact of electric vehicles. Progress in methods and tools to assist designers and engineers in considering environmental impact in their workflow is also described.

I. INTRODUCTION

Electric vehicles have been long promoted as a promising alternative to the current fossil fuel-based mobility system. Greenhouse gas and air pollutants emissions, rising fuel costs and supply uncertainties have contributed to the proposal of changing our mobility system towards electric mobility. The promise of low or no tailpipe emissions has been vigorously heralded as the main advantage of electric vehicles.

However, the direct tailpipe emissions are only one part of the total environmental impacts that might occur during the life cycle of electric vehicles [1]. For example, the indirect emissions of electric vehicles are heavily dependent on the power generation infrastructure in a specific region/country, e.g. fully renewable or fossil fuel-based power generation. Such issue can be addressed by assessing the environmental impact of proposed electric vehicles over the whole life cycle phases; thus, minimizing the so-called problem shifting, where environmental issues from one life cycle phase are merely shifted toward others phases, rather than eliminated, by the introduction of the new technology. Figure 1 illustrates the generic life cycle of an electric vehicle.

In the environmental assessment of electric vehicles, materials have a significant contribution to the overall environmental performance of a vehicle [2]. This is particularly important in battery-powered electric vehicles. In addition to materials in extra electronic components, electric motor and the battery itself, which are not present in traditional vehicles, novel materials in other components might be present due to inherent characteristics imposed by the design of EV. For example, some designs require lightweight materials to be utilized in the vehicle structure due to the additional battery mass. These additional materials may change the overall environmental performance of electric vehicles, not only due to their characteristics during usage, but also during raw material extraction and end-of-life phase.

The main objective of this work is to give an overview on various materials that may be present in electric vehicles and their corresponding potential environmental impact. Furthermore, as a part of the MOLINA project, this work also illustrates the current development of ecodesign tools at Mechanical Production Engineering research group at ITB.

Materials in electric vehicles

Electric vehicles have significant amount of materials similarities with traditional vehicles. Most differences are due to unique components which less prevalent or even non-existent in traditional vehicles. These include the battery pack, electric motor, power electronics and lightweight structure materials. Figure 2 gives an illustration on how these components contribute to the embodied emissions of electric vehicles. It also shows comparison between different vehicle types.

Figure 2. Embodied emissions for different vehicle designs and contribution from various components [3]

It should be noted that Fig. 2 indicates embodied emissions, i.e. total emissions from cradle-to-gate, no to be...