SUMMARY OF MASTER'S DISSERTATION

Student Identification Number	80933122	Name	Keita Kato

Title

Optimization Model for Global Portfolio of Clean Energy Vehicles Considering Metal Resources and Evaluation for Copper Resource Constraint

Abstract

Environmental measures in the automobile sector are needed because of car ownership trends especially in developing countries. Various types of Clean Energy Vehicles (CEV) have been developed to reduce CO2 emissions and move our economics away from petroleum in transportation. To make an innovation of these technologies and introduce them into the market effectively on a budget and resource, it is important to analyze cost effectiveness of each CEV, an optimal portfolio of CEV, CO2 reduction effects and total social cost in the future, for a guideline of a decision-making of governments and companies. Meanwhile, CEV contain some metals that have supply risks because of the reserves and political availability. Therefore, an introduction strategy of CEV under supply constraints of the metal resources is needed. However, previous researches have analyzed only cost-effective portfolio and not taken the metal resource problems into account.

In this paper, firstly, we developed the optimization model by linear programming for CEV portfolios by 6 regions of the world, considering metal resource usage of CEV.

Secondly, as a case study, under the definition that the objectives are minimizing total social cost or copper resource usage, and the constraint is CO2 emission reduction target, we clarified an optimal CEV portfolio of the world. In case of minimizing total social cost, mainly, EV (Electric Vehicle) and PHEV (Plug-in Hybrid Electric Vehicle) were selected. On the other hand, in case of minimizing copper usage, not PHEV but FCV (Fuel Cell Vehicle) and CDV (Clean Diesel Vehicle) were selected and the optimal portfolio was different between both cases.

Thirdly, the relationship between CO2 emission target and copper usage to achieve it is clarified. For example, when achieving 15% emission reduction in 2050 compared to 2005, about 4 million ton of copper is going to be needed at least in 2040.

Finally, we evaluated copper resource constraint. When achieving 15% reduction, about 1.7 million ton of copper (equal to 33 million units of EV) might be in short supply. The governments need to acquire these amounts of copper for automobile sector and companies need to develop an alternative technology to achieve the reduction target.

Key words: Clean Energy Vehicle, Sustainable manufacturing, Portfolio, Optimization, Copper