論 文 の 内 容 の 要 旨

論文題目　Strategy for Effective Utilization of Rice Husk in Angiang Province, Vietnam
（ベトナム Angiang 県における稲もみ殻有効利用戦略）

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Rice husks are the main agricultural residues in Angiang province, Vietnam and currently most of them are burnt in the open air or dumped into the water bodies, causing severe air and water pollution. The utilization of rice husks for energy generation can mitigate greenhouse gases (GHGs), air pollutants and also prevent local environmental problems.

In this study, potential rice husk utilization with innovative biomass-use technologies, such as gasification and pyrolysis, as well as conventional uses such as cooking and brick making was evaluated by means of Life Cycle Assessment (LCA). Taking into account the fuel allocation in the target area, GHG and air pollutant mitigation potentials for developed scenarios were evaluated. In addition, the domestic economic benefits related to the fuel change were estimated. Finally, Analytic Hierarchy Process (AHP) was applied to incorporate stakeholders' preferences into the scenario evaluation to find out the optimal rice husk use scenario to apply in the target region.

Considering the current supply and demand of rice husks, 18 scenarios for effective rice husk use were developed. The allocation of fuels, other than rice husks was decided

based on the current demand and supply of rice husks. In this study, different rice husk use technologies e.g. cooking, brick making, power generation through combustion, gasification, and fuel production by pyrolysis were taken into consideration. To prevent the bulky nature of rice husks, briquettes produced by compressing rice husks were also included in the scenarios. In the power generation scenarios, the differences between two capacities (5 MW and 30 MW) were analyzed.

From the LCA results, it was revealed that GHG and air pollutant emissions from open burning contributed largely to the current emissions in Angiang. Therefore, ceasing open burning alone had large emission mitigation potential. The use of briquettes, even though GHGs are emitted during the production stage, can still contribute to GHG emission mitigation as the production was more efficient than rice husk burning or dumping. The scenario where rice husk briquettes were used in large-scale combustion power plants (30 MW) keeping current rice husk demand showed the highest GHG emission mitigation potential among the all scenarios. The small scale gasification using excess rice husk also showed larger mitigation potential. In pyrolysis process, the scenario using excess rice husk gave larger GHG emission reduction in comparison with the case when all supplied rice husks were used. From the viewpoint of GHG emissions, the optimum option was to use excess rice husk for large-scale power generation by combustion or gasification keeping current demand.

From the viewpoint of NO_x and SO_x emissions, the scenario where rice husk briquettes produced from the all generated rice husk were used for large-scale combustion power plants (30 MW) showed the highest NO_x emission mitigation potential among all scenarios. The scenario where all rice husks were allocated to pyrolysis showed NO_x reduction but SO_x increase. The scenario keeping current demand showed higher SO_{2eq}

emission mitigation potential.

From the results of life cycle cost analysis, it was revealed that substitution of current fuels, such as coal, LPG, or fuel wood by rice husks or briquettes could provide considerable cost savings. Similarly, the sale of generated electricity to the national grid could lead to large cost savings. In relationships between the estimated cost mitigations and the GHG mitigation potentials, the scenarios showing larger GHG mitigation potentials, such as large-scale gasification and large-scale briquette combustion, were not the better options from the viewpoint of cost reduction. The pyrolysis scenarios also showed cost increases from the baseline although they showed relatively large potentials for GHG mitigations. The win-win scenarios that achieved both large GHG mitigation and cost reduction were cooking, large-scale combustion of rice husk, and small-scale gasification. Prioritizing cost over GHGs, the scenario where all rice husks were used in cooking would be the best scenario. When the priority was placed on GHG mitigation, the scenario where surplus rice husks were used in large-scale combustion power generation keeping current domestic use was the best one. The scenario where all rice husks were allocated to small-scale combustion power generation showed the least GHG mitigation and a relatively small cost reduction, and was therefore not an attractive scenario.

To incorporate the stakeholders' preferences, AHP procedure was modified and applied to the scenario evaluation. When comparing the important aspects from the viewpoint of effective rice husk use, the safety indicator was given the highest priority by rural and urban households and governors. The cost indicator was given the least priority by governors and local households, while it was the most important feature for rice mill and brick kiln owners. The environmental indicators were not given high priority.

The scenarios were ranked by using LCA results and the weights gained by AHP. The results showed that there were different preferences on the rice husk use technologies for each stakeholder. It was found that rural households, rice mill owners and brick kiln owners still wanted to use rice husk with conventional methods, while urban households preferred rice husk gasification. Governors and scientists revealed the preferences on combustion power generation, which were completely opposite to residents' ones.

This study provided the clear picture of effectiveness of each technology by mean of LCA, and the methodology to incorporate the stakeholders' preferences into the scenario evaluation.