An Economic Evaluation of Multilateral Approaches to Nuclear Fuel Cycle

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(1) Overview

A realization of compatibility between use of nuclear energy and non-proliferation includes the multilateral approaches to nuclear fuel cycle. Many research groups have considered the multilateralization of nuclear fuel cycle so far (Meckoni et al., 1977; IAEA, 2005; LaMontagne, 2005). These works have shown that multilateral nuclear fuel cycle approach has some benefits such as non-proliferation and cost effectiveness. Especially, due to larger output than that of an indigenous facility, they have shown that there exist economies of scale for the facilities of the MNA. However, in previous works, the economics of the MNA taking into account both front end and back end have not been quantitatively analyzed. There exist various evaluation models of nuclear fuel cycle, uranium fuel cost and reprocessing plant as in previous works. In these works the closest work on economics of the MNA to our work include LaMontagne (2005). LaMontagne (2005) makes a comparison between indigenous fuel cycle development and multilateral nuclear fuel cycle approach with respect to cost effectiveness. The cost of indigenous enrichment is an order of magnitude more expensive than multilateral supply at market-based prices. Therefore the MNA has an economic merit compared to indigenous approach. However, LaMontagne analyzes the front-end only, and mentions no transportation cost. On the other hand, IAEA (2005) mentions the maritime transport of nuclear fuel for the MNA. In IAEA (2005), it is shown that the number of sites decreases due to larger facilities, and then opportunities of maritime transport increases. Additionally, it is anticipated that possibilities of accidents for transport increases. Therefore we consider that the transport cost for the MNA may be larger than that for indigenous approach.

In this work we consider an economic evaluation for the MNA taking into account both front-end and back-end. We analyze effects of transport cost and delay in operating the reprocessing. Especially, we compare to the indigenous approach, and show the relationship between transport cost and economic merit for the MNA. Additionally, we examine some scenarios for transportation of spent fuel.

(2) Methods

In this work we use a cost evaluation model that is based on that of JAEC (2011). In JAEC (2011), there exist three models such as reprocessing model, direct disposal model, and state-of-the-art model. In this work, we develop a cost model taking into account temporary storage, reprocessing, and MOX fuel fabrication by modifying the state-of-the-art model in JAEC (2011).

As previous works, we assume that there exists scale economies for each facility in the MNA compared with the indigenous approach. In particular we consider scale economies of reprocessing facility as in Schneider et al. (2009). The reprocessing cost for any capacity in the indigenous approach is derived by means of a relational expression for scale economies in Schneider et al. (2009). Since the capacity of the reprocessing facitlity in the MNA is larger than that in the indigenous approach, a unit cost of the reprocessing (yen/tU) in the MNA is smaller than that in the indigenous approach. On the other hand, since facilities such as uranium enrichment, reprocessing, and temporary storage in the MNA is installed in different countries as shown in IAEA (2005), transport costs of fuels in the MNA is larger than that in indigenous approach.

Furthermore, we analyze three scenarios for transport of spent fuel (SF). In this scenario analysis, we assume that a facility of temporary storage is in somewhere in central Asia and that start point is in somewhere in Asia. Scenario CR, which is a current route for UO_2 transport, is a route from somewhere in Asia to somewhere in central Asia through Saint Petersburg. Likewise, scenarios of AR1, AR2, and AR3 are routes through Saint Petersburg with the Northern Sea, Vostochny and Lianyungang, respectively. For each scenario, a maritime transport is used on the route from start point to each port, and a rail transport is employed on the route from each port to the facility of temporary storage.

In this calculation, we must obtain transport costs per unit distance. For maritime transport cost, we can estimate by means of data in JAEC (2011). For land transport cost, we can use Fairlie (2000) which shows cost data of spent fuel transport from Germany to France for each company.

(3) Results

In this calculation, we use unit cost data of uranium fuel, MOX fuel, Reprocessing, SF transport, temporary storage, and HLW disposal for the case of 3% discount rate in JAEC (2011).

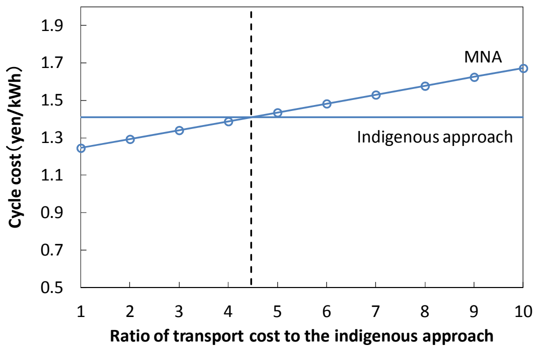

Figure 1. Comparison with the indigenous approach

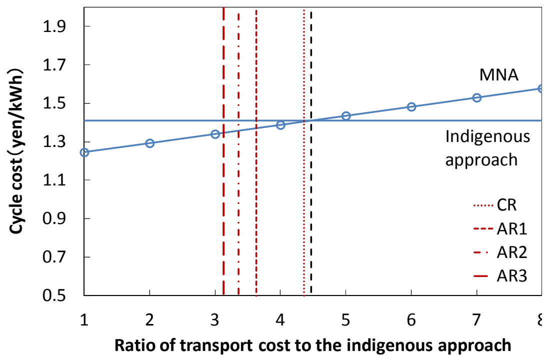

Figure 2. Cycle cost for each scenario

Fig. 1 shows a comparison of cost for the MNA with that for the indigenous approach. We consider a case in which the reprocessing cost in the indigenous approach is 60% larger than that of the MNA due to economies of scale. The horizontal axis is a ratio of transport cost for the MNA to that for the indigenous approach, and the vertical axis is cycle cost. In this figure, the line and dots show costs for the MNA, and the straight line shows costs for the indigenous approach (1.410 円/kWh). The break-even point is dependent on unit cost of each project for the MNA such as unit cost of reprocessing and temporary storage. For the base case in this calculation, a break-even point is 4.47. Therefore when the ratio of transport cost is smaller than 4.47, the MNA has an economic merit compared to the indigenous approach. In addition, when the ratio of transport costs for four scenarios are embedded in Fig. 1, we obtain Fig. 2. As shown in this figure, there exist all scenarios on the left hand of the break-even point. Therefore it is found that for the base case, all four scenarios have economic merit. However as a unit cost of land transport is large, the economic merit becomes small. For example, when the unit cost of land transport is twice that of the base case, the scenario CR only has no economic merit whereas when the unit cost of land transport is three times that of the base case, the cost for all scenarios is larger than that of indigenous approach.

(4) Conclusions

In this work, we develop an evaluation model of nuclear fuel cycle cost and analyze the effect of transport cost and delay in operation on the cycle cost. Especially, we show the economic merits of the MNA with respect to the transport cost, and the break-even point of the MNA. Additionally, we analyze the scenario for transport of spent fuel taking into account distance and cost of land and maritime transports. We find that for base case all scenarios have an economic merit compared to the indigenous approach. For the MNA, the cost allocation for the host country and other countries is one of important problem. Thus one direction for future work focuses on the decision method of the cost allocation.

Acknowledgments

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