Assessing small hydropower potential in Indonesia: from environmental and economic perspectives

(インドネシアにおける小水力発電の可能性評価: 環境性・経済性の観点から)

北海道大学大学院　環境科学院

環境起学専攻　国際環境保全コース

Naufal Rospriandana

With the increasing attention to the national energy security and climate change mitigation issues, renewable energy (RE) has become an attractive option for electricity generation in Indonesia. Furthermore, the implementation of feed-in tariff (FIT) policy has been designed to enhance more and more investments in the RE development. One of the most promising and highly promoted REs in Indonesia is small hydropower (SHP). This study intends to assess the SHP potential development in Indonesia, and to examine to which extent its economic feasibility of investment and environmental benefits and trade-offs is, particularly in regard to climate change, for the future SHP development.

Choosing an analogical study area of a hilly watershed zone in Sub-Ciwidey, Upper Citarum Watershed, West Java, Indonesia, this study first identified the hydrology of the study watershed using Soil Water Assessment Tools (SWAT) hydrological model in order to assess the SHP potential. The SWAT hydrological parameterization was done to minimize the model-data misfits. Observational data of streamflow for the period of 2009-2010 were used for the calibration, in which the model showed a good performance with the validation data for the period of 2011-2012 with the Coefficient of Determination (R^2) = 0.74-0.76 and the Nash-Sutcliffe Efficiency (NSE) of 0.67-0.80. Further, according to the head calculation with criteria higher than 10 meters and Flow Duration Curve (FDC) analysis at 60% streamflow dependability, 9 SHP potential sites were identified with total of 1.72 MW can be harnessed. Within 75% plant availability or capacity factor, the SHPs in Upper Citarum are estimated to produce 368-4277 MWh electricity.

Cost-Benefit Analysis (CBA) was also done towards the SHP case in the study area to assess how feasible the SHP investment would be. Under the recent FIT regulated in Indonesia, the SHP was considered to be suitable and feasible with positive Net Present Value (NPV) of USD 260,315 for 20 years, Internal Rate of Return (IRR) of 16.1%, Benefit Cost Ratio (BCR) of 1.14, Discounted Payback Period (DPP) of within 9-10 years. Thus, it can be concluded that economically the SHP is one of the promising energy development solutions in Indonesia.

However, with regard to the environment and climate change, this study found both benefits and tradeoffs that should be considered. While the Carbon Emission Reduction (CER) analysis came with the idea that the SHP development can reduce CO_2 emission by up to 9,300 t-CO_2 annually, the SHP is also vulnerable due to climate change, particularly in terms of change in future precipitation. Using the Intergovernmental Panel on Climate Change 5th Assessment Report (IPCC AR5)'s climate change scenarios of Representative Concentration Pathways (RCP) 2.6, 4.5, 6.0, and 8.5 scenarios, the annual electricity production by the SHP in the study area was predicted to decline at least by 1.10 and 4.32% in 2050s and 2070s, respectively.

Finally, considering the environmental and economic perspectives, this study argued that the SHP is one of the best practices in maintaining energy supply in Indonesia in. However, as the potential energy generated is mainly controlled by the amount of water, good water resources management should be more considered, especially in accordance with climate change.