Transdisciplinary Approach to Regional Planning by Using Renewable Energy Cluster

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***ABSTRACT*:** This paper aims to address the impacts of introducing of biomass technology to the local economy of the area by using input-output analysis. The hybrid input-output enables us to correlate the individual industry and the local economy in both physical world and monetary world. In order to implement a downstream cut-off, cut-off rate is found to be a potential parameter. The price rate of physical world and monetary world can be set individually in single input-output table. By-products from biomass power plant are also modeled as an input to local economy.

KEYWORDS: Transdisciplinary, input-output analysis, renewable energy

1. INTRODUCTION

When the new technology has been introduced to community, it brings economic growth as well as civilization and on the other hands, it also causes the pollution and environment deterioration to the community. To develop the community sustainably, deployment of renewable energy might be the answer in term of energy generation technology. One of renowned renewable energy technology is biomass energy. This technology meets with the requirements to apply to Kochi prefecture because of its high wood resource capacity. From the benefit of introducing biomass technology, energy generation and carbon neutral, the community can supply their own power and becomes green community with cleaner environment. The power plant can contribute the positive impact on image of the community along with the change in local people lifestyle approached to the adaptation of renewable energy society. Indirectly, it may result in, for example, an increasing of immigrants and attracting more tourists. In consequence, with rising of local income might also grow the community satisfaction. To describe all these phenomena systematically, transdisciplinary knowledge is necessary for solving economic, social and environmental aspects.

Since the biomass technology is introducing to society, it is questionable whether what are the impacts on local economy or sectors in economy, positive or negative, and what is the magnitude of impacts. The hybrid input-output analysis has potential to evaluate the relationship among the individual industry and economy.

1.1 Objectives

The purposes of this paper are first to observe the detailed process of material flows in biomass energy technology from existing power plant. Secondly, it aims to demonstrate how hybrid input-output analysis and life-cycle assessment are used to analyze the impact of individual industry to the local economy. Lastly, it probably enables us to study the relationship of the indirect benefits of recycling of by-products and re-input as a resources to economy.

2. METHODOLOGY

2.1 Input-Output Analysis

The basic conceptual framework, input-output analysis developed by Leontief (Leontief, 1970), is briefly described in this section. The input-output model begins with the recorded transaction of each sector in economic system. Let us introduce the basic structure of input-output model (Miller, R.E., Blair, P.D., 2009), the table of transaction matrix Z which Z_{ij} represents the amount of monetary flow of inter-industry from consumer sectors (j) to purchase the goods or services producer sectors (i). Apart from this region, there is still remaining consumption demand from other such as household, private, government, export and import so called the final demand (f). Also, industry has to purchase labor, capital consumption and taxes which is excluded from inter-industry in order to produce goods and services. It is grouped as value added. Let the total production (X) be the summation of row vector or column vector, therefore, the mathematical theory starts with the assumption that the ratio of consumption from producer to consumer is constant. This ratio is technical coefficient (A_{ij}) presented in following equation,

$$A_{ij} = \frac{Z_{ij}}{X_j}$$

It means that when X changes through the period of time, the product of goods and services is changed accordingly to X, but the ratio of product of producer consumes by consumer is remain the same, known as the constant returns to scale. Thus, the relationship of input-output table is described,

$$X = (I - A)^{-1} f$$

From Leontief's basic equation, it leads to the other application which in this paper focusing on is hybrid input-output analysis.

2.2 Hybrid Input-Output Analysis and Life Cycle Assessment (IOA-LCA)

One of the outstanding application of input-output analysis is the hybrid model with life cycle assessment. Let us define shortly of the different between IOA and LCA, IOA basically deals with the buy-sell relationship in monetary term among sector in economy, but LCA is focus to analyze the physical flows of materials in individual industry. The hybrid IOA-LCA accomplished by Suh S. (Suh, 2004) and re-discussed in the comment (Peters, G.P., Hertwich, E.G., 2006) and reply (Suh, 2007). The paper is aimed to find an environmental intervention value by connecting inputs and outputs between individual industry and economic sectors. By Suh's methodology, the input-output table is created in both physical flows and monetary flows given,

$$\begin{bmatrix} g \\ g_{***} \end{bmatrix} = \begin{bmatrix} A & -C^D \\ -C^U & I - A_{***} \end{bmatrix}^{-1} \begin{bmatrix} f \\ f_{***} \end{bmatrix}$$

where g, A, C^D and f are in physical term, and g_{***}, C^U, $I\text{-}A_{***}$, f_{***} are in monetary term. Focusing on the coefficient matrix I-A which is applied from Leontief model, A is material flows within the industry and $I\text{-}A_{***}$ is the monetary flow in economy. C^U is the upstream cut-off or the consumption of individual industry taken from economy. C^D is production of individual industry that is consumed by economy.

2.3 Relationship of Physical and Monetary World

In this paper, our aim is to seek the intervention of individual industry to the local economy in both physical and monetary terms. Starting with making an assumption that there is an introducing biomass power plant which is consumed the wood product as a resource and it produces electricity that consumes by the local economy. Let define the material flows of biomass power plant as physical world (P) and the

monetary flows in local economy as monetary world (M). In real phenomena, P produces goods and services in physical unit as an input to the economy as well as it consumes the resources from M, the economy, which is necessary for production. Since wood is locally produced, the wood that the biomass power plant needed is then the cut-off from economy in monetary terms or upstream cut-off (M/P). Besides, the electricity and by-products produced by the biomass power plant are also the cut-off from the economy or downstream cut-off (P/M) because the electricity demanded from the economy is not changed due to the introducing of biomass power plant. Meaning that the biomass power plant takes the resource, which is previously consumed by other sectors. Moreover, it takes the demand of electricity in economy from elsewhere industry previously belonged.

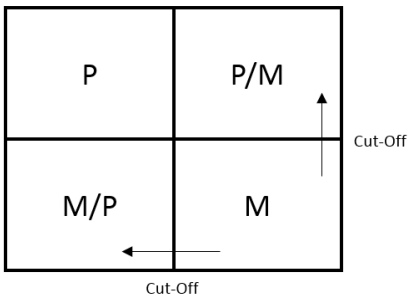

Figure1 Relation of physical and monetary world

2.4 Indirect Contributions of Biomass Power plant

In this point of view, the other industries may reduce it production and the total economy is remain as if the point where biomass power plant is not constructed. The direct benefit is only the electricity produced by biomass power plant to sustain the economy demand. However, the attention must be paid on the contributions of biomass power plant that (1) wood and woodchip is purchased at higher price (2) electricity produced by biomass is sold to the economy at the higher price (3) by-products, ash and CO2, are considered as an recycling materials that are re-input to the economy. The biomass power plant gives the value added to residual woods such as leaves, branches and also the residual from furniture manufacturing process. More than half of ash is sold to forestry sector as a fertilizer and the rest is used for paving the temporary road for construction. We assume that the CO_2 emission is consumed by forestry and agricultural sectors equally. CO_2 is necessary for energy production process of forest or tree so that it can be considered as a carbon neutral process. Likewise, by the study of Blom on carbon dioxide in greenhouse, increasing of CO_2 in greenhouse also increases the photosynthesis rate (Blom, T.J., Straver, W.A., Ingratta, F.J., Khosla, S., Brown, W., 2012).

2.5 Integrated Model

Once the condition of physical world, monetary world and cut-off is set and the direct and indirect benefits are identified, we are ready to apply this as a function to input-output analysis method. Physical and monetary world incorporated with Leontief function gives,

$$\begin{bmatrix} X_P \\ X_M \end{bmatrix} = \begin{bmatrix} P & P/M \\ M/P & M \end{bmatrix}^{-1} \begin{bmatrix} f_P \\ f_M \end{bmatrix}$$

which X is total production and f is final demand, in monetary and physical terms. Rearranging the equation gives,

$$\begin{bmatrix} X_P \\ X_M \end{bmatrix} = \begin{bmatrix} P & P/M \\ M/P & M \end{bmatrix} \begin{bmatrix} X_P \\ X_M \end{bmatrix} + \begin{bmatrix} f_P \\ f_M \end{bmatrix}$$

If we investigate in detail of physical and monetary world or inter-industry region, it is found by multiplication of matrix operation that,

$$PX_P + (P/M)X_M + f_P = X_P$$

$$(M/P)X_P + MX_M + f_M = X_M$$

Downstream cut-off is multiplied by X_M gives the result in physical unit. Likewise, upstream cut-off is multiplied by X_P renders the result in monetary unit.

2.6 Cut-Off Rate

According to downstream cut-off or mainly electricity generated from power plant, introducing of biomass power plant does not rise in consumption demand and does not increase in total electricity generation either. Since downstream cut-off unit is physical and monetary world is in monetary, the conversion is required. Cut-off rate (β) is the matrix with similar size to monetary world that indicates the cut-off ratio (β_*), which is the deduction of total electricity production in economy (M_*) by electricity production of individual industry (P_*) in physical unit. Cut-off ratio represents by,

$$\beta_* = 1 - \frac{P_*}{M_*}$$

where P* by M* is the ratio electricity production from biomass power plant of total production. The cut-off rate is applied to the integrated model given,

$$PX_P + (P/M)X_M + f_P = X_P$$
$$(M/P)X_P + (M\beta)X_M + f_M = X_M$$

which is now made the cut-off process complete. There is another reason why the cut-off rate is compiled in physical unit that is no price influence in the cut-off portion. As a result, the price rate of electricity in physical world and monetary world is now separable. For instance, if the price of electricity in monetary world is set at 16¥/kWh, the price in physical world does not has to be similar, which in real life, the price of electricity produced by renewable energy technology is set higher at 32¥/kWh. Thus, the result of applying cut-off rate can be utilized to observe how the change in unit rate of product contribute to the input-output table.

3. DISCUSSIONS AND FUTURE WORK

Integrated input-output table can describe the relation among physical world and monetary world, individual industry and local economy functionally. Cut-off rate is required in case that the input-output is mixed-unit type and different price rate between physical and monetary world is necessary to indicate. Furthermore, by-products of industry are also modeled as a recycle materials to economy. However, the simulation is now progressing and input parameters are carefully identified.

For future work, we are aiming to address the benefit caused by 'the image' which is influenced by introducing of biomass power plant. Such that, occupying clean energy technology may give a positive indirect effects to the economy such as the price of real estate of local area rise because of the good environment, energy security and image of the area. The new biomass power plant also provides a job opportunity for local people. Moreover, it may attract more tourism to the area. Hence, the income of people local area increase. This relationship is connectible among variety of economic sectors and is required systematically model to evaluate the impacts.

Another application that this hybrid input-output analysis is able to model is the impact on climate change. The connected of physical world and monetary world allows us to measure the physical flows of greenhouse gases produced by the individual industry and transferred to the economy.

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