

Sustainability Indicators related to Energy and Material Flow

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This study analyzed energy and material flows in different regions and industrial sectors to evaluate regional and industrial sustainability. Several life cycle approaches that are used to quantify environmental efficiency related to energy and material flows were investigated as applications of life cycle tools in emerging markets, including the service industry and the public sector. The regions included all 47 Japanese prefectures and the data for each prefecture considered 16 industrial categories based on the national physical distribution census and national input-output tables for 1995.

When using life cycle carbon dioxide emissions as a typical environmental loading item, sustainability indicators related to energy and material flows can be extracted using the following equation,

$$CO_2 = \frac{CO_2}{energy} \times \frac{energy}{flow} \times \frac{flow}{GDP} \times GDP$$

where CO_2 is the carbon dioxide emission (direct or life-cycle); $energy$ is the energy consumption or primary energy supply; $flow$ is the total material input or total material flow; and GDP is the gross domestic product or amount of industrial product.

This is a way to identify energy and material flows in a regional economic system. The energy flow consists of the primary energy supply and the recycled energy recovery, since the material flow consists of primary and recycled resources. A reduction in CO_2 with economic growth (increasing GDP) needs remarkable reductions in “ $CO_2/energy$ ”, “ $energy/flow$ ”, and “ $flow/GDP$ ” as an advanced sustainability indicator. These ratios were compared in each region and industrial category.

The ratio of the primary energy supply to the total material input for service industries ranged from 0.1 to 0.5 [TOE/10³ton] for the 47 prefectures. Ultimately, several relationships between “ $energy/flow$ ” and regional or industrial characteristics were obtained, such as regional population, distance from major markets, and so on.