Sustainability performance indicators for energy and raw material use, and environmental impacts

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Keywords

- Energy efficiency
- Material efficiency
- Environmental efficiency
- Economic activity
- Sustainability indicator
- Sustainable/unsustainable performance

Minimum data requirements

Data of two variables with an assumed causal relationship, describing the same system at two time moments:

- Economic activity
- Energy consumption
- Consumption of raw material
- Environmental impact (e.g. CO_2 emissions or other emissions into air, water and soil, amount of (hazardous) waste

Intensities and efficiencies

In the EU energy policy, energy efficiency targets have been set in terms of primary and final energy consumption, and energy intensity. Energy intensity is an inverse of energy productivity. Energy productivity is a synonym for energy efficiency.

Improvement in energy efficiency has a decreasing effect on energy consumption, but the decrease may be (and often is) counterbalanced by an increasing effect of economic growth. The lesson learnt from the IPAT and Kaya identities and verified by numerous decomposition analyses is that energy intensity and economic growth are the major drivers of energy consumption. Other drivers such as structural change in the economy, change in the energy mix, and change in population have their effect as well.

In a similar way, drivers of raw material consumption and environmental impact (e.g. CO_2/SO_2/NO_x/particulate emissions, other emissions into air, soil, or water, or waste) can be identified and analysed. Major drivers are then material and environmental intensity, and economic activity (e.g. increasing production).

New indicators

The sustainability performance indicators developed in the EUFORIE project take the most important drivers into account. They combine information about changes in intensity and activity into two indicators. The performance indicators are **sustainable growth** (SG) and **sustainable intensity** (SI). The sustainability criterion is relative: energy consumption, material consumption, and environmental impacts should not increase from the reference level. SG and SI describe if the performance of the studied system between two time moments is towards sustainability or away from it. Annual changes and change after a fixed base year of the performance are typical analyses.

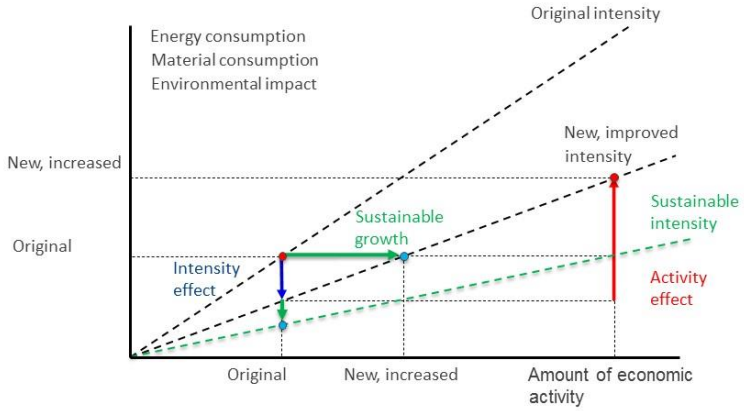

Fig. 1. Intrensity and activity effects and sustainability performance indicators.

For whom?

The new indicators SG and SI are flexible, which means they are applicable at all levels of (economic) activity fulfilling the minimum data requirements. In the productive sector (agriculture, industry, and services), the indicators can be calculated for individual products/services, specific processes, a production site, an entire company, and even a global corporation. SG and SI can be calculated also for municipalities, provinces/counties, national states, groups of countries, territories and the World. Moreover, the indicators can be calculated for any entity or system, where sufficient data is available.

What variables to include?

Calculation of the sustainability performance indicators SG and SI requires two input variables based on a pairwise choice from the following: (1) amount of production, (2) energy used, (3) raw material used, or (4) environmental impacts. Causal relationship between the chosen variables is assumed, such as:

- production explains energy use
- production explains material use
- production explains environmental impact
- energy use explains environmental impact
- material use explains environmental impact

The choice is always a challenge, especially if the activity includes several products, energy sources, raw materials and environmental impacts. Aggregated variables are therefore an alternative to a large set of disaggregated variables. Sustainability is, however, a holistic concept. It is a political concept too, because it cannot be evaluated without making choices about what to look at.

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Sustainable performance indicators

- The new indicators are based on relationship between the decomposed intensity and activity effect to energy consumption, material consumption, or environmental impact.
- **Sustainable growth** (SG)

$$SG = -\frac{I_{eff}}{A_{eff}} \times 100\%$$

- **Sustainable intensity** (SI)

$$SI = -\frac{A_{eff}}{I_{eff}} \times \frac{V_0}{V_t}$$

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Calculation of the sustainability perfomance indicators

First, the intensity and activity effects (cf. Fig. 1) to the selected explained variable (energy consumption, material consumption or environmental impact) will be calculated by a preferred decomposition method. Information about the decomposition analysis applied in EUFORIE is available in the references.

The sustainability performance indicators sustainable growth (*SG*) and sustainable intensity (*SI*) are based on the relationship between the intensity effect (I_{eff}) and activity effect (A_{eff}):

$$SG = -\frac{I_{eff}}{A_{eff}} \times 100\%$$

$$SI = -\frac{A_{eff}}{I_{eff}} \times \frac{V_0}{V_t}$$

Table 1. Cases of sustainability performance.

	Case 1	Case 2	Case 3
I_{eff}	< 0	< 0	< 0
A_{eff}	> 0	> 0	< 0
Effect size	$\|X_{eff}\|>\|Y_{eff}\|$	$\|X_{eff}\|<\|Y_{eff}\|$	-
Change of explained variable	> 0	< 0	< 0
SG (%)	0< SG <100	SG > 100	SG < 0
SI (coeff.)	SI > 1	0 < SI < 1	SI < 0
Performance	unsustainable	sustainable	sustainable

	Case 4	Case 5	Case 6
I_{eff}	> 0	> 0	> 0
A_{eff}	> 0	< 0	< 0
Effect size	-	$\|X_{eff}\|<\|Y_{eff}\|$	$\|X_{eff}\|>\|Y_{eff}\|$
Change of explained variable	> 0	> 0	< 0
SG (%)	SG < 0	0< SG <100	SG > 100
SI (coeff.)	SI < 0	SI > 1	0 < SI < 1
Performance	unsustainable	unsustainable	sustainable

SG is the sustainable share of observed activity change. SI is a coefficient telling how much the original intensity should be change to reach sustainability. Variable *V* in the calculation of *SI* refers to energy use, material use, or environmental impact explained by the decomposed effects. Subscripts *0* and *t* refer to the two time slots of the analysis.

Values of the sustainability performance indicators depend on observed changes in the included variables, and they can also be negative, depending on direction of change in the selected variables. Table 1 summarizes the possible cases.

Opportunites

The indicators can be applied to:

- all productive processes
- change at any level
- all time periods
- all causal relationships.

Challenges

The values of SG and SI are in the same range in case 1 and 5 (both unsustainable, but for different reasons), in case 2 and 6 (both sustainable, but for different reasons), and in case 3 (sustainable) and 4 (unsustainable). Empirical analysis in the EUFORIE project includes observations belonging to all six cases. Interpretation of results depends on the case, so direct conclusions cannot be drawn from the SG and SI values alone. Attempt to develop "stand-alone" and "easy-to-use" sustainability performance indicators is always a challenge.

Policy recommendations

Selected results of the EUFORIE project, including the sustainability performance indicators, will be presented and discussed in a policy-oriented roundtable on 27 September 2018 in Brussels, back-to-back the conference of European Modelling Platform for Energy (EMP-E, 25-26 September). Policy recommendations based on the roundtable will be published in a forthcoming EUFORIE deliverable.

For further reading:

Vehmas, Jarmo (2018). Report of energy efficiency at company level. European Futures for Energy Efficiency (649342 EUFORIE), deliverable D6.2.

Vehmas, Jarmo & Ameziane, Maria (2017). Report on ASA analyses of energy efficiency at company level. European Futures for Energy Efficiency (649342 EUFORIE), Deliverable 6.1.

All EUFORIE deliverables are available at the project website http://www.euforie-h2020.eu