# ANALISI QUANTITATIVA DELLO SVILUPPO SOSTENIBILE[1]

***Introduzione***

Già oggi le statistiche nei paesi OECD coprono aspetti del benessere sia economico che sociale delle popolazioni, anche se non sono spesso inserite nello stesso contesto, ma quali di queste hanno a che fare con lo sviluppo sostenibile? cosa accade oltre i confini nazionali, oltre gli orizzonti dei paesi OECD?

***Oggetto e metodi dell'analisi***

Cosa significa *bisogni*? Cosa si richiede perché questi siano soddisfatti? Rispondere a queste due domande è un passo importante nella comprensione di cosa implica *misurare* lo sviluppo sostenibile, ma, prima di affrontare la definizione del campo e del livello dei bisogni, bisogna identificare le condizioni necessarie per assicurare uno sviluppo sostenibile.

In senso stretto la produzione dipende dai beni strumentali disponibili, in particolare dal capitale prodotto (risultato delle attività umane), dal capitale umano e dalle materie prime. In senso largo la produzione dipende anche dalle tecnologie, dall'armonia sociale e dal governo politico, oltre che dal funzionamento delle istituzioni e della regolamentazione. Sebbene la produzione (o il reddito) per abitante non costituisca un indicatore totalmente soddisfacente del benessere umano, la nozione che i beni strumentali determinino la capacità di produzione può essere applicata al problema del soddisfacimento dei bisogni, per cui, porre come condizione che le generazioni future siano in grado di soddisfare i loro bisogni vuol dire porre come condizione che dispongano di un livello di ricchezza sufficiente.

Non sapendo di sicuro quali saranno i bisogni futuri, la condizione necessaria per la sostenibilità "debole" è espressa sotto forma della *regola del capitale costante*, secondo la quale l'evoluzione del patrimonio nazionale pro capite non deve essere negativa ("il maggior grado di incremento del benessere si ha quando si riesce a consumare il massimo senza intaccare il capitale"[2]). Anche se è difficile definire con precisione, e a maggior ragione valutare in termini monetari, caratteristiche come l'armonia sociale o il buon funzionamento delle istituzioni, l'obiettivo principale della riflessione sullo sviluppo sostenibile è proprio quello di comprendere queste caratteristiche nel quadro della ricchezza nazionale.

Da un punto di vista statistico ciò vuol dire fare dei bilanci che evidenzino gli apporti e le detrazioni al patrimonio oltre che le entrate ed uscite attuali, per mettere insieme sviluppo odierno e sviluppo a lungo termine. Diversi Paesi, e la Banca Mondiale per i diversi Paesi, hanno cercato di includere nei bilanci nazionali la valutazione delle risorse naturali ed ambientali, tenendo conto del loro consumo e della loro degradazione, ma non riescono a tener molto bene in conto dei capitali ambientale, sociale e, specialmente, umano, per la difficoltà di valutarli e confrontarli compiutamente in termini monetari.

Anche se si riuscisse a compilare una lista dei bisogni umani accettata da tutti o quasi, sarebbe comunque molto difficile individuare per ciascuno di essi l'importanza relativa e il grado di soddisfacimento compatibile con la sostenibilità, che dipendono dal tipo di società e di individuo.

Quello che in pratica è possibile fare nelle statistiche, e che potrà comunque aiutare a prendere le decisioni del caso, è dare una valutazione di massima delle tendenze e dei progressi.

Per riuscire a render conto del progresso dello sviluppo sostenibile in termini statistici, bisognerà:

- Fare bilanci sulla base di una nozione estesa di ricchezza nazionale, includendo non solo il capitale generato dalle attività umane, ma anche il capitale naturale, umano e sociale

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[1] OECD - *Sustainable Development: Critical Issues, Cap. 3, p. 44 (2001),* <http://oecdpublications.gfi-nb.com/cgi-bin/OECDBookShop.storefront/EN/product/032001032P1>

[2] Weitzman, Martin L., "On the Welfare Significance of National Product in a Dynamic Economy", The Quarterly Journal of Economics", 90 (1976).

**Componenti della sostenibilità ambientale**

| Component | Logic |
|---|---|
| Environmental Systems | A country is environmentally sustainable to the extent that its vital environmental systems are maintained at healthy levels, and to the extent to which levels are improving rather than deteriorating. |
| Reducing Environmental Stresses | A country is environmentally sustainable if the levels of anthropogenic stress are low enough to engender no demonstrable harm to its environmental systems. |
| Reducing Human Vulnerability | A country is environmentally sustainable to the extent that people and social systems are not vulnerable (in the way of basic needs such as health and nutrition) to environmental disturbances; becoming less vulnerable is a sign that a society is on a track to greater sustainability. |
| Social and Institutional Capacity | A country is environmentally sustainable to the extent that it has in place institutions and underlying social patterns of skills, attitudes, and networks that foster effective responses to environmental challenges. |
| Global Stewardship | A country is environmentally sustainable if it cooperates with other countries to manage common environmental problems, and if it reduces negative transboundary environmental impacts on other countries to levels that cause no serious harm. |

- Seguire l'evoluzione di questi bilanci in modo da assicurarsi che il valore nazionale netto non diminuisca
- Monitorare il soddisfacimento dei bisogni attuali o, più in generale, i fattori che contribuiscono ad aumentare o diminuire la ricchezza nazionale o il valore dei suoi elementi costitutivi

Vari sforzi, sia a livello nazionale che internazionale, sono stati messi in atto per riuscire a raggiungere questi obiettivi[3].

In Allegato è riportato un quadro di indicatori particolari (nel dettaglio quelli energetici) consigliati nel 2001 dall'ONU per analizzare il livello di sviluppo sostenibile raggiunto dai vari Paesi.

Servono anche indicatori economici, sociali e ambientali per valutare in modo sintetico e complessivo se davvero ci si sta muovendo verso un progresso sostenibile.

Fra quelli ambientali si possono citare:

- L'indice "Impronta ecologica" (EF, Ecological Footprint)[4] di WWF è ottenuto dalla superficie boschiva necessaria per assorbire le emissioni di $CO_2$ pro capite, più la superficie necessaria per nutrire una persona, più quella edificata. Dal punto di vista ecologico, ogni abitante della Terra ha a disposizione 1.9 ettari di produttività biologica media (funzione del livello tecnologico), ma ne consuma 2.3; ciascuno degli abitanti dei paesi a più alto reddito ne utilizza, nella media, più di quattro, mentre quelli dei paesi a più basso reddito meno di uno. In un confronto mondiale di quest'orma, sono gli Stati Uniti che occupano il primo posto fra i Paesi con più di 3 milioni di abitanti: ciascun abitante di questo paese consuma quasi 10 ettari con una capacità biologica di più di cinque ettari e, quindi, con un deficit ecologico di più di 4 ettari. Il più alto deficit compete al Belgio/Lussemburgo con più di 5 ettari (esclusi gli Emirati Arabi che hanno meno di 3 milioni di abitanti, un'impronta di più di 10 ettari e un deficit di quasi 9 ettari). Un italiano consuma 3.8 ettari con un deficit di 2.7.[5]

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3 OECD, Sustainable Development Indicators: Proceedings of an OECD Workshop, Paris (1998).
OECD, *Towards Sustainable Development: Indicators to Measure Progress*, Proceedings of the OECD Rome Conference, Paris (2000).
http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm

4 http://www.wwf.it/ambiente/attenzione/13.pdf

5 WWF, Living Planet Report 2002. <http://www.panda.org/downloads/general/LPR_2002.pdf>

- Gli indici "Sostenibilità ambientale" (ESI) e "Prestazioni ambientali" (EPI, Environmental Performance Index) sviluppati da World Economic Forum, Columbia and Yale Universities sono indici del progresso verso la sostenibilità ambientale[6]; il primo, molto vasto, basato su 20 indicatori che si riferiscono a 68 variabili per monitorare i componenti della sostenibilità ambientale a lunga scadenza (vedi tabella), il secondo limitato a considerare le caratteristiche dell'aria, acqua, terra e clima per valutazioni a breve scadenza delle azioni intraprese in campo ambientale.
- L'indice "Richiesta totale di materiali"[7] (TMR) del World Resources Institute è un indicatore altamente aggregato che esprime la massa totale di materie prime naturali consumate a causa delle attività umane.

Altri indici aggregati tengono conto degli aspetti economici e sociali:

- L'indice "Prodotto interno lordo" (PIL)[8] (GDP, gross domestic product) è il più noto e misura la quantità di beni e servizi prodotti in un anno all'interno dei confini di un Paese, a differenza del PNL Prodotto nazionale lordo (GNP) che è la somma dei redditi percepiti dai residenti e dalle imprese di un Paese, indipendentemente dal luogo geografico in cui si trovano gli impianti. Per tener conto di alcuni aspetti dello sviluppo sostenibile è stato sviluppato il "PIL verde".
- L'indice "Sviluppo umano" (HDI) combina indicatori di salute, istruzione e reddito procapite (vedi box 2.2 e 1.1).

BOX 2.2

### Human development—the concept is larger than the index

Ironically, the human development approach to development has fallen victim to the success of its human development index (HDI). The HDI has reinforced the narrow, oversimplified interpretation of the human development concept as being only about expanding education, health and decent living standards. This has obscured the broader, more complex concept of human development as the expansion of capabilities that widen people's choices to lead lives that they value.

Despite careful efforts to explain that the concept is broader than the measure, human development continues to be identified with the HDI—while political freedoms, participating in the life of one's community and physical security are often overlooked. But such capabilities are as universal and fundamental as being able to read or to enjoy good health. They are valued by all people—and without them, other choices are foreclosed. They are not included in the HDI because they are difficult to measure appropriately, not because they are any less important to human development.

*Source:* Fukuda-Parr 2002.

da UNDP, "Human Development Report 2002"

[6] http://www.ciesin.columbia.edu/indicators/ESI/
[7] http://www.wri.org/materials/why_measure.html
[8] Mezzetti Giulio, "La globalizzazione dell'ambiente mondo", La Nuova Italia, Firenze (2002)

BOX 1.1

## Measuring human development

*Human Development Reports,* since the first in 1990, have published the human development index (HDI) as a composite measure of human development. Since then three supplementary indices have been developed: the human poverty index (HPI), gender-related development index (GDI) and gender empowerment measure (GEM). The concept of human development, however, is much broader than the HDI and these supplementary indices. It is impossible to come up with a comprehensive measure—or even a comprehensive set of indicators—because many vital dimensions of human development, such as participation in the life of the community, are not readily quantified. While simple composite measures can draw attention to the issues quite effectively, these indices are no substitute for full treatment of the rich concerns of the human development perspective.

### Human development index

The HDI measures the overall achievements in a country in three basic dimensions of human development—longevity, knowledge and a decent standard of living. It is measured by life expectancy, educational attainment (adult literacy and combined primary, secondary and tertiary enrolment) and adjusted income per capita in purchasing power parity (PPP) US dollars. The HDI is a summary, not a comprehensive measure of human development.

As a result of refinements in the HDI methodology over time and changes in data series, the HDI should not be compared across editions of the *Human Development Report* (see indicator table 2 for an HDI trend from 1975 based on a consistent methodology and data). The search for further methodological and data refinements to the HDI continues.

### Human poverty index

While the HDI measures overall progress in a country in achieving human development, the human poverty index (HPI) reflects the distribution of progress and measures the backlog of deprivations that still exists. The HPI measures deprivation in the same dimensions of basic human development as the HDI.

*HPI-1*

The HPI-1 measures poverty in developing countries. It focuses on deprivations in three dimensions: longevity, as measured by the probability at birth of not surviving to age 40; knowledge, as measured by the adult illiteracy rate; and overall economic provisioning, public and private, as measured by the percentage of people not using improved water sources and the percentage of children under five who are underweight.

*HPI-2*

Because human deprivation varies with the social and economic conditions of a community, a separate index, the HPI-2, has been devised to measure human poverty in selected OECD countries, drawing on the greater availability of data. The HPI-2 focuses on deprivation in the same three dimensions as the HPI-1 and one additional one, social exclusion. The indicators are the probability at birth of not surviving to age 60, the adult functional illiteracy rate, the percentage of people living below the income poverty line (with disposable household income less than 50% of the median) and the long-term unemployment rate (12 months or more).

### Gender-related development index

The gender-related development index (GDI) measures achievements in the same dimensions and using the same indicators as the HDI, but captures inequalities in achievement between women and men. It is simply the HDI adjusted downward for gender inequality. The greater is the gender disparity in basic human development, the lower is a country's GDI compared with its HDI.

### Gender empowerment measure

The gender empowerment measure (GEM) reveals whether women can take active part in economic and political life. It focuses on participation, measuring gender inequality in key areas of economic and political participation and decision-making. It tracks the percentages of women in parliament, among legislators, senior officials and managers and among professional and technical workers—and the gender disparity in earned income, reflecting economic independence. Differing from the GDI, it exposes inequality in opportunities in selected areas.

**HDI, HPI-1, HPI-2, GDI—same components, different measurements**

| Index | Longevity | Knowledge | Decent standard of living | Participation or exclusion |
|---|---|---|---|---|
| HDI | Life expectancy at birth | 1. Adult literacy rate<br>2. Combined enrolment ratio | GDP per capita (PPP US$) | — |
| HPI-1 | Probability at birth of not surviving to age 40 | Adult illiteracy rate | Deprivation in economic provisioning, measured by:<br>1. Percentage of people not using improved water sources<br>2. Percentage of children under five who are underweight | — |
| HPI-2 | Probability at birth of not surviving to age 60 | Percentage of adults lacking functional literacy skills | Percentage of people living below the income poverty line (50% of median disposable household income) | Long-term unemployment rate (12 months or more) |
| GDI | Female and male life expectancy at birth | 1. Female and male adult literacy rates<br>2. Female and male combined primary, secondary and tertiary enrolment ratios | Estimated female and male earned income, reflecting women's and men's command over resources | — |

da UNDP, "Human Development Report 2001"

Altri indici economici tengono conto di un ancora più ampio insieme di variabili, perché legate al soddisfacimento delle necessità presenti e future, opportunamente pesate o monetizzate: il "Genuine Progress Indicator"[9] (sviluppato da Redefining Progress insieme all'indice Impronta Ecologica), il simile "Indicator of Sustainable Economic Welfare"[10,11], per misurare la "felicità" tenendo conto del Welfare e dell'ambiente, l'"Index of Economic Well-Being"[12], ecc.

Fra questi il "Genuine Savings"[13,14,15], sviluppato dalla World Bank, si basa sulla nozione che lo sviluppo sostenibile richiede di creare o mantenere il patrimonio totale (economico + ambientale + sociale) ed è = Risparmio lordo (ovvero il PIL detratto dai consumi) + spese per l'istruzione (ovvero investimenti in capitale umano) - consumo di capitali fissi (immobilizzati) - esaurimento di minerali, foreste, energia - danneggiamento da $CO_2$. Un suo valore positivo indica solo una condizione necessaria per la sostenibilità debole ma non misura il tasso di crescita del patrimonio complessivo.

Le misure aggregate sono utili per sintetizzare grandi insiemi di informazioni, ma più sono aggregate più sono soggette a problemi di esaustività, sovrapposizione e bilanciamento, che vengono risolti obbligatoriamente in modo soggettivo e discutibile, per cui è necessario riesaminare continuamente definizioni e metodi di valutazione.

In generale, poi, difficilmente esistono analisi attente sulla precisione dei dati di partenza e su quella dei risultati dei processi di aggregazione (valutazione degli errori e della propagazione degli errori), in modo che perplessità e dubbi esistono sui numeri offerti. Il loro significato appare intermedio tra una valutazione qualitativa e una rigorosamente quantitativa; comunque, le stime che da essi si possono trarre sulle loro variazioni nel tempo (anche se il modo stesso di calcolare gli indicatori può cambiare di anno in anno!) sono preziose per giudicare la correttezza degli interventi fatti o per mettere in evidenza le situazioni più critiche.

Un pericolo può derivare da una insufficiente consapevolezza della imprecisione ed approssimazione del valore di un indice di sostenibilità e da una sopravvalutazione del suo ruolo: sulla base di questi indici si costruiscono graduatorie tra Stati o tra comunità all'interno di uno Stato e si è tentati, perciò, a dare giudizi su "buoni" e "cattivi", per un verso spronando positivamente le classi dirigenti a politiche più accorte e responsabili, ma anche, negativamente, inducendo a intraprendere azioni rivolte più a migliorare l'indice che a percorrere seriamente la strada dello sviluppo sostenibile.

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9 http://www.rprogress.org/projects/gpi/

10 OECD, Composite Indicators of Sustainable Development, Document No. STD/NA(1998)17. <http://www.oecd.org/dataoecd/52/26/2681727.pdf>

11 http://www.foe.co.uk/campaigns/sustainable_development/progress/templates/storyintro.html

12 http://www1.oecd.org/els/pdfs/EDSCERIDOCA006.pdf

13 http://lnweb18.worldbank.org/ESSD/essdext.nsf/44DocByUnid/F532AB178FA17E7685256B75006F6134/$FILE/GenuineSavingsRatesinDevelopingCountries1998.pdf

14 http://econ.ucsd.edu/~sferreir/GenuineSavings.pdf

15 http://www.brettonwoodsproject.org/topic/environment/gensavings.pdf

# ALLEGATO

## 58 INDICATORI (2° EDIZIONE) INDIVIDUATI NEL 2001 DALLA COMMISSIONE ONU PER LO SVILUPPO SOSTENIBILE E NEL 2007 SUPERATI DALLA 3° EDIZIONE[16]

| SOCIAL | | |
|---|---|---|
| **Theme** | **Sub-theme** | **Indicator** |
| Equity | Poverty | Percent of Population Living below Poverty Line |
| | | Gini Index of Income Inequality |
| | | Unemployment Rate |
| | Gender Equality | Ratio of Average Female Wage to Male Wage |
| Health | Nutritional Status | Nutritional Status of Children |
| | Mortality | Mortality Rate Under 5 Years Old |
| | | Life Expectancy at Birth |
| | Sanitation | Percent of Population with Adequate Sewage Disposal Facilities |
| | Drinking Water | Population with Access to Safe Drinking Water |
| | Healthcare Delivery | Percent of Population with Access to Primary Health Care Facilities |
| | | Immunization Against Infectious Childhood Diseases |
| | | Contraceptive Prevalence Rate |
| Education | Education Level | Children Reaching Grade 5 of Primary Education |
| | | Adult Secondary Education Achievement Level |
| | Literacy | Adult Literacy Rate |
| Housing | Living Conditions | Floor Area per Person |
| Security | Crime | Number of Recorded Crimes per 100 000 Population |
| Population | Population Change | Population Growth Rate |
| | | Population of Urban Formal and Informal Settlements |

| ENVIRONMENTAL | | |
|---|---|---|
| **Theme** | **Sub-theme** | **Indicator** |
| Atmosphere | Climate Change | Emissions of Greenhouse Gases |
| | Ozone Layer Depletion | Consumption of Ozone Depleting Substances |
| | Air Quality | Ambient Concentration of Air Pollutants in Urban Areas |
| Land | Agriculture | Arable and Permanent Crop Land Area |
| | | Use of Fertilizers |
| | | Use of Agricultural Pesticides |
| | Forests | Forest Area as a Percent of Land Area |
| | | Wood Harvesting Intensity |
| | Desertification | Land Affected by Desertification |
| | Urbanization | Area of Urban Formal and Informal Settlements |
| Oceans, Seas and Coasts | Coastal Zone | Algae Concentration in Coastal Waters |
| | | Percent of Total Population Living in Coastal Areas |
| | Fisheries | Annual Catch by Major Species |
| Fresh Water | Water Quantity | Annual Withdrawal of Ground and Surface Water as a Percent of Total Available Water |
| | Water Quality | BOD in Water Bodies |
| | | Concentration of Faecal Coliform in Freshwater |
| Biodiversity | Ecosystem | Area of Selected Key Ecosystems |
| | | Protected Area as a % of Total Area |
| | Species | Abundance of Selected Key Species |

[16] http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm

| ECONOMIC | | |
|---|---|---|
| **Theme** | **Sub-theme** | **Indicator** |
| Economic Structure | Economic Performance | GDP per Capita |
| | | Investment Share in GDP |
| | Trade | Balance of Trade in Goods and Services |
| | Financial Status | Debt to GNP Ratio |
| | | Total ODA Given or Received as a Percent of GNP |
| Consumption and Production Patterns | Material Consumption | Intensity of Material Use |
| | **Energy Use** | **Annual Energy Consumption per Capita** |
| | | **Share of Consumption of Renewable Energy Resources** |
| | | **Intensity of Energy Use** |
| | Waste Generation and Management | Generation of Industrial and Municipal Solid Waste |
| | | Generation of Hazardous Waste |
| | | Generation of Radioactive Waste |
| | | Waste Recycling and Reuse |
| | Transportation | Distance Traveled per Capita by Mode of Transport |

| INSTITUTIONAL | | |
|---|---|---|
| **Theme** | **Sub-theme** | **Indicator** |
| Institutional Framework | Strategic Implementation of SD | National Sustainable Development Strategy |
| | International Cooperation | Implementation of Ratified Global Agreements |
| Institutional Capacity | Information Access | Number of Internet Subscribers per 1000 Inhabitants |
| | Communication Infrastructure | Main Telephone Lines per 1000 Inhabitants |
| | Science and Technology | Expenditure on Research and Development as a Percent of GDP |
| | Disaster Preparedness and Response | Economic and Human Loss Due to Natural Disasters |

Gli indicatori energetici sono rimasti sostanzialmente gli stessi anche nella 3° edizione del 2007.

# Indicatori energetici 2001

| ANNUAL ENERGY CONSUMPTION PER CAPITA | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name**: Annual energy consumption per capita.
b) **Brief Definition**: The per capita amount of energy - liquids, solids, gases and electricity – available in a given year in a given country or geographical area.
c) **Unit of Measurement**: Gigajoules.
d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/ Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: The indicator is a widely used measure of access to and use of energy, individual and industrial energy consumption patterns and the energy intensity of a society.
b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): Energy is a key factor in industrial development and in providing vital services that improve the quality of life. Traditionally energy has been regarded as the engine of economic progress. However, its production, use, and byproducts have resulted in major pressures on the environment, both from a resource use and pollution point of view. The decoupling of energy use from development represents a major challenge of sustainable development. The long-term aim is for development and prosperity to continue through gains in energy efficiency rather than increased consumption and a transition towards the environmentally friendly use of renewable resources. On the other hand, limited access to energy is a serious constraint to development in the developing world, where the per capita use of energy is less than one sixth that of the industrialized world.
c) **International Conventions and Agreements**: UNFCC and the Kyoto Protocol call for limitations on total greenhouse gas emissions, which are dominated by $CO_2$ from the combustion of fossil fuels.
d) **International Targets/Recommended Standards**: The Kyoto Protocol sets targets for total greenhouse gas emissions for Annex I (developed) countries.
e) **Linkages to Other Indicators**: The indicator is closely linked with other indicators of the economy, with environmental indicators such as climate change, air quality and land use, and also with social indicators.

**3. METHODOLOGICAL DESCRIPTION**

a) **Underlying Definitions and Concepts**: Gross inland consumption of energy is a key aggregate in the energy balances. Consumption of energy refers to “apparent” consumption and is derived from the formula that takes into account production, exports, imports and stock changes. Production refers to the first stage of production. International trade of energy commodities is based on the “general trade” system, that is, all goods entering and leaving the national boundary of a country are recorded as export and imports. Bunkers refer to fuels supplied to ships engaged in international transport, irrespective of the carriers’ flag. In general, data on stocks refer to changes in stocks of producers, importers and/or industrial consumers at the beginning and the end of the year.
b) **Measurement Methods**: The indicator is calculated as the ratio of total energy requirement and mid-year population. Total energy requirement (gross inland consumption) is calculated from the following formula: Primary production + Imports – Exports – Bunkers +/- Stock changes = Total energy requirement.
c) **Limitations of the Indicator**: Apparent consumption may in some cases represent only an indication of the magnitude of actual gross inland availability. The actual value of the indicator is strongly influenced by a multitude of economic, social and geographical factors. When using it as an indicator of sustainability the indicator has to be interpreted in connection with other indicators of economic development and energy use, as smaller or larger values of the indicator do not necessarily indicate more or less sustainable development.
d) **Status of the Methodology**: The indicator is in widespread use, but without a standardized methodology. International recommendations are available.
e) Alternative Definitions/Indicators: None.

**4. ASSESSMENT OF DATA**

a) **Data Needed to Compile the Indicator**: Energy commodity data for production and consumption (energy balances) and mid-year population estimates.

b) **National and International Data Availability and Sources**: Energy commodity data for production and consumption, and population data are regularly available for most countries at the national level; and for some countries, at the sub-national level. Both types of data are compiled by and available from national statistical offices and country publications.

**5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR**

a) **Lead Agency**: The lead agency is the United Nations Department of Economic and Social Affairs (DESA). The contact point is the Director, Statistics Division, DESA; fax n. (1 212) 963 9851.
b) **Other Contributing Organizations**: Other organizations involved in the indicator development include the International Energy Agency of the Organisation for Economic Co-operation and Development (OECD/IEA), and Eurostat.
c) **Data References**: United Nations: Energy Statistics Yearbook. United Nations: Energy Balances and Electricity Profiles.

**6. REFERENCES**

a) Readings:
   - Concepts and Methods in Energy Statistics, with Special Reference to Energy Accounts and Balances. United Nations, 1982.
   - Energy Statistics: Definitions, Units of Measure and Conversion Factors. United Nations, 1987.
   - Energy Statistics: A Manual for Developing Countries. United Nations, 1991.

b) **Internet site**: United Nations Statistics Division: http://www.un.org/Depts/unsd

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| SHARE OF CONSUMPTION OF RENEWABLE ENERGY RESOURCES | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name**: Share of consumption of renewable energy resources.
b) **Brief Definition**: The percentage of a country’s total energy consumption supplied from renewable energy sources.
c) **Unit of Measurement**: %.
d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/ Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: This indicator measures the proportion of energy mix between renewable and non-renewable energy resources.
b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): Chapter 4 of Agenda 21 calls for an improvement of efficiency in the use of energy sources and for a transition towards the environmentally friendly use of renewable resources. Energy is a key aspect of consumption and production. Dependence on non-renewable resources can be regarded as unsustainable in the long term. Renewable resources, on the other hand, can supply energy continuously under sustainable management practices and their use in general create less environmental pressure. The ratio of non-renewable to renewable energy resources represents a measure of a country's sustainability.
c) **International Conventions and Agreements**: None.
d) **International Targets/Recommended Standards**: None.
e) **Linkages to Other Indicators**: Interpretation of this indicator is enhanced when combined with annual energy production, annual energy consumption per capita, and lifetime of proven energy reserves. It is also closely linked to some of the environmental indicators such as greenhouse gas emissions.

**3. METHODOLOGICAL DESCRIPTION**

a) **Underlying Definitions and Concepts**: The elements comprising this indicator are consumption of renewable resources and total energy consumption. Renewable energy sources refer to energy collected from current ambient energy flows or from substances derived from them. This definition includes energy derived from geothermal, hydro, solar, tide, wind and wave power, and biofuels, such as fuelwood, bagasse, charcoal, animal and vegetal wastes, and other (industrial and municipal) wastes. Consumption refers to "apparent consumption".

b) **Measurement Methods**: This indicator is computed by calculating the ratio of consumption of energy from renewable resources over total energy consumption. Apparent consumption is calculated by the following formula: Primary production + Imports – Exports – Bunkers +/- stock changes.

c) **Limitations of the Indicator**: Due to the large variety of forms of renewables and their uses, data collection is difficult. Comparability of national data is limited due to the lack of standardized methodologies.

d) **Alternative Definitions/Indicators**: None.

**4. ASSESSMENT OF DATA**

a) **Data Needed to Compile the Indicator**: Consumption of energy from renewable resources; total energy consumption.

b) **National and International Data Availability and Sources**: National data and estimates on renewable resources are available from national statistical offices and country publications for many countries. The United Nations Statistics Division, and the International Energy Agency of the Organisation for Economic Co-operation and Development compile data and estimates based on information from national and international sources.

c) **Data References**: United Nations, Energy Statistics Yearbook and Energy Balances and Electricity Profiles; International Energy Agency, Energy Balances of OECD Countries, Energy Balances of Non-OECD Countries; World Energy Council, Survey of Energy Resources.

**5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR**

a) **Lead Agency**: The lead agency is the United Nations Department of Economic and Social Affairs, Statistics Division.

b) **Other Contributing Organizations**: The agencies involved in the development of this indicator are the World Energy Council (WEC), the International Energy Agency of the Organisation for Economic Co-operation and Development (OECD/IAE), Eurostat, and the Economic Commission for Europe.

c) **Data References**: World Energy Council: *Survey of Energy Resources*. United Nations: *Energy Statistics Yearbook.*

**6. REFERENCES**

a) **Readings**: See 5(c)

b) **Internet site**: United Nations Statistics Division: http://www.un.org/Depts/unsd

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| ENERGY USES PER UNIT OF GDP | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name**: Energy Use per unit of GDP.

b) **Brief Definition**: Ratio of total energy use to GDP.

c) **Unit of Measurement**: Megajoules per $ (MJ/$).

d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/ Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: Trends in overall energy use relative to GDP indicate the general relationship of energy consumption to economic development and provide a rough basis for projecting energy consumption and its environmental impacts with economic growth. For energy policy-making, however, sectoral or sub-sectoral energy intensities should be used.

b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): Energy is essential for economic and social development, but consumption of fossil fuels is the major cause of air pollution and climate change. Improving energy efficiency and delinking economic development from energy consumption, particularly of fossil fuels, is essential to sustainable development.

c) **International Conventions and Agreements**: UNFCC and its Kyoto Protocol call for limitations on total greenhouse gas emissions, which are dominated by $CO_2$ from fossil fuels.
d) **International Targets/Recommended Standards**: No specific target for energy intensity. The Kyoto Protocol sets targets for total greenhouse gas emissions for annex I (developed) countries.
e) **Linkages to Other Indicators**: The ratio of energy use to GDP is an aggregate of sectoral energy intensity indicators and is thus linked to the energy intensities for the manufacturing, transportation, commercial/services and residential sectors, for which separate methodology sheets have been prepared. This indicator is also linked to indicators for total energy consumption, greenhouse gas emissions and air pollution emissions.

## 3. METHODOLOGICAL DESCRIPTION

a) **Underlying Definitions and Concepts:** The ratio of energy use to GDP is also called "energy intensity". The term "energy intensity" is better used for sectoral or sub-sectoral ratios of energy use to output. The indicator could be called "aggregate energy intensity" or "economy-wide energy intensity". The ratio of energy use to GDP indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a wide range of production and consumption activities. In specific economic sectors and sub-sectors, the ratio of energy use to output or activity is the "energy intensity" (if the output is measured in economic units) or the "specific energy requirement" (if the output is measured in physical units such as tonnes or passenger-kilometers). Due to the limitations described in section 3 (c) below, total energy use should be disaggregated into components, by sector (manufacturing, transportation, residential, commercial/services, industry, agriculture, construction, etc.) or sub-sector. For each sector or sub-sector, energy use can be related to a convenient measure of output to provide a sectoral or sub-sectoral energy intensity. Examples include energy use for steel-making relative to tonnes of steel produced; energy consumption by passenger vehicles relative to passenger- or vehicle-kilometers; energy consumption in buildings relative to their floor area. (See separate methodology sheets for manufacturing, transportation, commercial/services, and residential sectors). The energy intensity of a process (energy consumed per unit of output) is the inverse of the "energy efficiency" of the process (output per unit energy consumed).
b) **Measurement Methods:**
   - **Energy Use**: Total and sectoral energy consumption is obtained from national energy balances. Household and services/commercial consumption should be carefully separated, and manufacturing (ISIC D, formerly 3) should be separated from other industrial uses (ISIC C and F, formerly 2 and 5) and agriculture (ISIC A and B, formerly 1).
     **Unit**: Energy is measured in terajoules (TJ, $10^{12}$J), petajoules (PJ, $10^{15}$J), or exajoules (EJ, $10^{18}$J).
   - **Output**: Components of GDP should be deflated to constant dollars by chaining each component, not simply by deflating each component by the overall GDP deflator.
     **Unit**: GDP is measured in US dollars, converted from real local currency at purchasing power parity for the base year to which local currency was deflated.
c) **Limitations of the Indicator:** The ratio of aggregate energy use to GDP, often called "energy intensity" or the "energy ratio", is not an ideal indicator of energy efficiency, sustainability of energy use, or technological development, as it has been commonly used. The aggregate ratio depends as much on the structure of the economy as on the energy intensities of sectors or activities, and changes in the ratio over time are influenced almost as much by changes in the structure of the economy as by changes in sectoral energy intensities. Measurement and interpretation of energy intensities are complicated by differences among products within a category, such as size (e.g., automobile weight or refrigerator capacity), features (power steering and automatic transmission in cars, freezer compartments in refrigerators), and utilization (hours per year a stove is used, vehicle occupancy if passenger-km is the measure of output). Comparison among countries of the ratio of energy use to GDP is complicated by geographical factors. Large countries, for example, tend to have high levels of freight transportation as many goods are distributed nationwide. Compared with countries with moderate climates, cold countries may consume as much as 20 per cent more energy per capita due to demand for space heating, while hot countries may use 5 per cent more energy per capita, due to demand for air conditioning. Countries with large raw materials industries may use twice as much energy per unit of manufacturing output compared to countries that import processed materials, due to the high energy intensity of raw material processing. Canada, for example, has a high ratio of energy use to GDP, due in part to that fact that it is a large, cold country with a large raw materials processing sector. In Japan, the climate is milder, raw materials are limited, and high population density results in smaller residential units and less distance travelled, contributing to a lower ratio of energy use to GDP. Interpreting the ratio of energy use to GDP in terms of environmental impact or sustainability is also complicated by differences in environmental impact among energy sources. Canada, for example, has substantial hydropower, nuclear power and natural gas, all of which have lower environmental impacts than coal or oil. Given the large number of factors that affect energy consumption, the ratio of total energy consumption to GDP should not be used as an indicator of energy efficiency or sustainability for policy-making purposes.
d) **Status of the Methodology:** The ratio of energy use to GDP, as well as sectoral and sub-sectoral energy intensities, are in widespread use, but without a standardized methodology.

e) **Alternative Definitions/Indicators:** The ratio of sectoral or sub-sectoral energy use to the output or activity of the sector or sub-sector provides a more useful indicator of energy intensity. Four separate methodology sheets have been prepared for manufacturing, transportation, commercial/services, and residential sectors.

**4. ASSESSMENT OF DATA**

a) **Data needed to compile the indicator**:
- Sectoral energy consumption;
- Real GDP in US dollars.

b) **National and international data availability and sources**: The International Energy Agency maintains the most thorough set of energy balances and energy accounts, based primarily on national data or data collected from reliable regional agencies. For OECD countries, the OECD maintains the most reliable set of national accounts with a breakdown of GDP by sector and sub-sector. IEA energy data now cover virtually all developing countries. GDP and value-added by industry are published in the United Nations National Accounts Statistics. The IMF "International Financial Statistics" provides nominal and real GDP for most countries. Data on components of GDP are often available from regional development banks or national sources.

c) **Data References**:
IEA: Energy Balances of Member Countries
Energy Balances of Non-Member Countries
Eurostat: Energy balances
Latin American Energy Organization/ Organizacion Latinoamericana de Energia (OLADE)
Asia Pacific Energy Research Centre (APERC)
UN: National Accounts Statistics
IMF: International Financial Statistics

**5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR**

a) **Lead Agency**: The lead agency is the International Energy Agency (IEA).

b) **Other Contributing Organizations**: Virtually every national and international energy agency uses the ratio of total energy use to GDP, often inappropriately. Key agencies involved in more detailed development of sectoral and sub-sectoral indicators, including energy intensity and energy efficiency indicators, are Eurostat and the Directorate-General for Energy and Transport of the European Commission. The IEA has a parallel effort with a particular focus on non-EU countries. Work is also being done by APERC, with a focus on the Asia-Pacific Region, and OLADE for Latin America.

**6. REFERENCES**

**Internet site**: International Energy Agency: http://www.iea.org/

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| INTENSITY OF ENERGY USE: COMMERCIAL/SERVICE SECTOR | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name**: Intensity of Energy Use in the Commercial/Service Sector.

b) **Brief Definition**: Energy consumption per unit of commercial/service sector output or per unit commercial/service sector floor area.

c) **Unit of Measurement**: Megajoules per US$ (MJ/$) or megajoules per square meters ($MJ/m^2$).

d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: This indicator is used to monitor trends in energy consumption in the commercial/service sector, which is the largest sector of most economies.

b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): The service sector is less energy intensive than manufacturing, and the growth of the sector relative to manufacturing contributes to the long-term reduction in the ratio of total energy consumption to GDP. The sector, however, is a large consumer of electricity, generation of which contributes to many local or global environmental problems.

c) **International Conventions and Agreements**: There are no international agreements. Some countries are promulgating energy-efficiency standards for lighting, office equipment or other devices, while others are negotiating voluntary agreements to reduce energy consumption per square meter of floor space.

d) **International Targets/Recommended Standards**: There are no international targets or standards. Many industrialized countries have previously set targets for reducing the space-heating component of service-sector energy consumption per unit of floor area. Now, many countries are trying to reduce electricity consumption for cooling, lighting, and information systems.

e) **Linkages to Other Indicators**: This indicator is one of a set for energy intensity in different sectors (manufacturing, transportation, commercial/services and residential), with the indicator for energy use per unit of GDP as an aggregate energy intensity indicator. These indicators are also linked to indicators for total energy consumption, greenhouse gas emissions, and air pollution emissions.

## 3. METHODOLOGICAL DESCRIPTION

a) **Underlying Definitions and Concepts:** Energy consumption per unit of value added or per unit of floor area in the commercial/service sector is one way of measuring energy requirements and trends in the sector. As with the manufacturing sector, the commercial/service subsectors are diverse and difficult to classify. They include subsectors that require a great deal of electricity per unit of output (retail trade), those that use large quantities of fuel for water and space heating (health care establishments), and those that by their nature consume little energy (warehousing, parking). Energy efficiency in this sector is more directly related to the efficiency of general energy services (lighting, ventilation, computing, lifting, etc.) than to the efficiency of the particular sectoral activities. But there are almost no data on actual energy service outputs per unit of energy input (lumens of light, cubic meters of air moved, computing power or use, tonnes raised in lifts, etc.). Hence, the usual measure of energy intensity, megajoules per unit of output in economic terms (MJ/$), can be a useful indicator provided it is clear that this summarizes many processes and types of buildings. Because of the differences in processes, it is very important to separate electricity from fossil fuel and purchased heat. An alternative indicator is energy consumption relative to floor area (in sq. meters), which is a good measure of the total amount of physical activity for the sector. In warmer countries, built area is a less accurate proxy for the total amount of activity, since a substantial amount of business activity occurs outdoors. In low-income countries, substantial activity takes place in front of homes that also serve as stores. It is often difficult to measure and interpret energy intensities per unit of value added within subsectors (private services, public service, etc.) because different activities often take place in the same building, hence, the real partition of energy use between activities is uncertain. In such cases, intensities expressed per unit area disaggregated by building type may be more easily related to real energy efficiencies. However, these have the similar problem that a variety of activities may take place in a particular type of building. A hospital, for example, will contain space for food preparation or laundry services, as well as for health care.

b) **Measuring Methods**:

- **Energy Consumption**: Energy consumption is usually measured at the point of use, i.e., the building or enterprise. Data for buildings must be collected through surveys of building owners, operators, or tenants, while data for enterprises are usually collected through the enterprise’s normal accounting of expenditures or consumption of energy. Note, however, that the correspondence between enterprise and building type can be very loose. In a few countries, energy consumption in buildings is measured or imputed by surveys of actual buildings (United States, France and Japan, and Sweden for space and water heating only). Where these data exist, they can be used to represent real efficiencies. Heating energy consumption per sq. meter of floor area heated is an important example of such a measure. Electricity use per sq. meter is important to measure, but it is difficult to disaggregate into heating, cooling, water heating/cooking, lighting, etc., without recourse to detailed surveys. Some colder countries (e.g., Norway) have very high energy intensities, which are clearly dominated by electric heating, while others (e.g., Canada, Finland) have very high intensities, yet do not have much electric space heating. Similarly, warmer countries have substantial amounts of space that are fully air-conditioned. For many countries, the amount of air-conditioned space is unknown. Despite all these uncertainties, fuel intensities (plus district heating) and electricity intensities recorded separately give useful indicators of space/water heating/cooking on the one hand and electricity services on the other. Primary energy use should be used to aggregate electricity and fuel consumption (see methodology for manufacturing sector).

  **Unit**: The preferable unit is a multiple of joules, usually terajoules ($10^{12}$J), petajoules ($10^{15}$J), or exajoules ($10^{18}$J).

- **Output.** There are different approaches to measuring output in the commercial/service sector, with value added as the most direct measure of economic output. However, for estimating energy efficiency, physical area is preferred because most energy services (heating, cooling, lighting, etc.) are related to the floor area and size of the building. Surveys of floor area by building type have been carried out in many IEA countries. Often, the building type is specifically related to the activity of the enterprise, e.g., school (education), hospital (health care), or restaurant (food services). However, in many cases, particularly for offices and restaurants, buildings contain a mix of activities and enterprises, each with its own energy system and with considerably different energy use patterns. An alternative measure of output that may be useful for measuring the economic impact of the entire sector and its energy use is energy consumption of the sector relative to its GDP share. In this case, it may be desirable to remove the contribution of transportation services as well as the contribution of "implied value of household mortgages and rents", as transportation is considered as a separate sector and mortgages and rents do not directly involve energy use. However, using service sector energy consumption relative to its share of GDP means that the resulting intensity should not be associated with energy efficiency. As with manufacturing, care must be taken in deflating sectoral GDP to the desired base year.

**Unit:** Constant US dollar. Market value of output in real local currency is deflated to a base year using GDP deflators corresponding to each branch. Local currency is then converted to a common international currency, normally US dollars, preferably using purchasing power parity for the base year. For floor area, sq. metres of built space is usually the unit, but in some colder countries, sq. meters of occupied or heated space is recorded. The difference, which can be significant (up to 10%), reflects unheated spaces, garages and stairwells, etc.

c) **Status of the Methodology**: The methodology is in use in many developed countries.

d) **Alternative Definitions/Indicators**: It has become increasingly desirable to measure $CO^2$ emissions per unit of production. IPCC Coefficients can be used to convert each fuel consumed to $CO^2$ emissions. For electricity and heat, the broad rules suggested for primary energy can be followed, but the same uncertainties exist. Since in many countries more than half of all final energy consumed in this sector may be in the form of electricity, accounting for the emissions from electricity generation is extremely important.

## 4. ASSESSMENT OF DATA

a) **Data Needed to Compile the Indicator**:

- Energy use in the commercial / service sector;
- Real output (value added) of the commercial / service sector; and/or
- Built areas or occupied space (sometimes, heated space).

b) **National and International Data Availability**: Value added or GDP in one-digit service sector branches is available for almost every country. More detailed data exist for OECD countries, both from national sources and from the OECD national accounts. Energy consumption data at the sector-wide level are available from almost all OECD countries and most others, but there are some important caveats. First, one must check the residential sector data from the same source to determine whether liquid and solid fuels have been divided between these sectors. In many of the IEA time series, this division is not done, and one sector or the other has all of the liquid or solid fuels. For developing countries, this split is a problem for gas as well, which is often entirely allocated to either residential use or services rather than being split. Second, one must ascertain whether the commercial/service sector contains data from other sectors. Data from western Germany for the sector ("Kleinverbraucher") contained significant amounts of both agriculture and construction through the early 1990s. Other countries may include street lighting and even non-energy utilities like water and waste disposal. Some countries include anything that cannot be classified elsewhere. Reliable time-series energy data disaggregated at the subsectoral level exist for only a few countries, namely, the United States, France, Japan, and Sweden (heating only). IEA sent a questionnaire to OECD countries asking for data on floor area and energy use, but few responses on floor area were received. The IEA will pursue this and expects to report data for floor area in its future energy indicators.

c) **Data References:**

IEA: Energy Balances of Member Countries
Energy Balances of non-Member Countries
Eurostat: Energy Balances
The Latin American Energy Organization / Organizacion Latinoamericana de Energia (OLADE)
Asia Pacific Energy Research Centre (APERC)
UN: Industrial Statistics
OECD: STAN database (structural analysis database)
EU: NACE system

## 5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

**Lead Agency**: International Energy Agency (IEA).

## 6. REFERENCES

a) **Readings**:

Krackeler, Tom and Lee Schipper, 1998. "Carbon Dioxide Emissions in OECD Service Sectors. The Critical Role of Electricity use". *Energy Policy* (February).
Schipper, L., and Steve Meyers, 1986. "Energy Use in the Service Sector. An International Comparison". *Energy Policy* (June).

Meyers, S., Ed., 1986. *Electricity Use in the Service Sector. Report of An International Workshop*. Palo Alto, CA: Electric Power Research Institute.

b) **Internet site**: The International Energy Agency: http://www.iea.org/

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| INTENSITY OF ENERGY USE: MANUFACTURING | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name**: Intensity of Energy Use in Manufacturing.
b) **Brief Definition**: Energy consumption per unit of manufacturing output.
c) **Unit of Measurement**: Megajoules (MJ) per unit output of the manufacturing sector in constant US dollars.
d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: The manufacturing sector is a major consumer of energy. This indicator is a measure of the efficiency of energy use in the sector that can be used for analysing trends and making international comparisons in energy efficiency, particularly when the indicator can be disaggregated to specific branches of manufacturing.
b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): Sustainable development requires increases in energy efficiency in order to reduce fossil fuel consumption, greenhouse gas emissions and related air pollution emissions.
c) **International Conventions and Agreements**: UNFCCC and its Kyoto Protocol.
d) **International Targets/Recommended Standards**: Although there are no specific international targets regarding energy use or energy efficiency, many industrialized countries have targets for reducing energy use and carbon emissions from manufacturing branches.
e) **Linkages to Other Indicators**: This indicator is one of a set for energy intensity in different sectors (manufacturing, transportation, commercial/services and residential), with the indicator for energy use per unit of GDP as an aggregate energy intensity indicator. These indicators are also linked to indicators for total energy consumption, greenhouse gas emissions, and air pollution emissions.

**3. METHODOLOGICAL DESCRIPTION**

a) **Underlying Definitions and Concepts**: Energy consumption per unit of value added is one way of measuring energy requirements and energy efficiency in manufacturing. While energy consumption per unit of physical output is a better indicator of energy efficiency in specific manufacturing processes, energy use per unit of economic output is more useful both for relating energy efficiency to economic activity and for aggregating and comparing energy efficiency across manufacturing sectors or across the entire economy.
b) **Measurement Methods:**

- **Energy Use:** Energy use is usually measured at the point of consumption, i.e., the factory or establishment. “Own energy” (including internal use of hydropower, biofuels, or internal waste heat) should be combined with purchased energy at useful heating values. For combined production of heat and electricity, no simple method exists for dividing the total energy consumed between these two outputs. Where excess heat or electricity is sold or provided to outside establishments or a grid, the energy required for this out-going supply should not be allocated to the product of the establishment or branch and the income or apparent value added from these sales should be excluded from output value.
  In some cases, it may be preferable to measure total primary energy consumption, including losses incurred in the external production and distribution of the purchased electricity and heat, since these losses would occur if the establishment or branch used the primary energy directly. Primary energy consumption is a better measure of the total energy burden on the economy of a unit of output from an industry. Generally, the energy loss from converting primary energy to electricity is estimated by the average ratio for electricity production in the economy.
  Complications in interpreting energy intensity data arise from the fact that some branches of manufacturing may be concentrated in regions of a country rich in certain kinds of power or heat sources, such that those branches constitute a lower energy burden on the economy than the indicator would suggest. Interpretation is also complicated when a particular branch has significant internal energy resources, such as captive hydro,

biofuels or coal. There are various conventions for calculating the primary energy corresponding to electricity produced by nuclear, hydro or geothermal sources.

It is also possible to measure total energy consumption, internal and external, for any final product by using input-output tables to measure the energy embodied in materials and intermediate products. This is much more data intensive, because the input-output tables are complex. Such tables are not produced regularly, so this approach is difficult to follow, except at long intervals.

**Unit**: Preferable units for measuring energy are multiples of joules, usually terajoules ($10^{12}$J), petajoules ($10^{15}$J), or exajoules ($10^{18}$J).

- **Output.** There are different approaches for measuring output in manufacturing. For some purposes, physical output would be preferable, but this is not possible using the energy consumption statistics available in many countries, and there are many sectors for which aggregate physical output cannot be easily defined.

  There are two basic alternatives for measuring economic output. In either case, we use real local currency, deflated by the deflator for the sector or branch to a base year. This step is crucial, so that the weight of each sector or branch reflects the correct weight in the base year. The value of output is then converted to a common international currency, usually US dollars, preferably using purchasing power parities (PPP). One alternative is to calculate the total value of production or shipments. This measures literally the total output from an industry, and is defined for most countries. The other alternative is to calculate the value-added or contribution to GDP, representing only the increase in economic output produced by the sector or branch in question.

  The total value of output tends to be more stable over time, but has the disadvantage that it cannot be aggregated to total output, because of double counting: inputs to one branch may be the outputs of another branch. Value added can be aggregated, but may have greater fluctuations from year to year if input costs or output prices change, which is common for many basic raw materials, particularly crude oil. Unfortunately, there is no simple correspondence between the two measures of output.

  **Unit:** Constant US dollars. Market value of output in real local currency deflated to a base year using GDP deflators for each sector or branch. Local currency is converted to US dollars, using purchasing power parity for the base year.

c) **Limitations of the Indicator:** The aggregate indicator for the manufacturing sector reflects both the energy intensity of various branches of manufacturing and the composition of the manufacturing sector. Changes in the aggregate indicator can therefore be due either to changes in energy intensity or to changes in relative branch output. Similarly, differences between countries may be due either to differences in energy efficiency or differences in the structure of the manufacturing sector. A country with large energy-intensive industries, such as pulping, primary metals or fertilizers, for example, will have a high energy intensity, even if the industry is energy efficient. For this reason, it is desirable to disaggregate energy intensity by branch of manufacturing.

Detailed calculations such as total energy consumption for particular products, using input-output tables, while desirable, are very data intensive and difficult to update regularly.

d) **Status of the Methodology**: The methodology is in use in many developed countries.

e) **Alternative Definitions/Indicators**: In the context of climate change, it has become increasingly desirable to convert energy consumption to carbon emissions per unit of production. The fuels consumed can be converted to carbon emissions using IPCC coefficients. Carbon emissions will therefore change both with changes in energy efficiency and changes in fuel type.

## 4. ASSESSMENT OF DATA

a) **Data needed to Compile the Indicator**:
- Energy consumption by manufacturing sector and branches
- Real output of the sector and branches

b) **National and International Data Availability and Sources**: Value added in manufacturing at the three and four digit ISIC level for most OECD countries is now compiled by OECD as part of its STAN data base. The United Nations compiles value added at the two or three digit level for developed and developing countries. The European Union produces data on value added at the two and three-digit level in the NACE system, and suitable bridges exist to translate NACE into ISIC.

One persistent data problem at the aggregate level is distinguishing between "industry" (ISIC C, D, F and even E) and manufacturing (ISIC D). Some countries also lump agriculture, forestry and fishing (ISIC A, B) in the aggregate "industry" classification. For these reasons, it is strongly recommended that data be checked to ascertain exactly what sectors are covered. Manufacturing is the preferable aggregate, since inclusion of the other sectors mentioned can distort time series analysis and comparisons among countries.

c) **Data References**:

IEA: Energy Balances of Member Countries
Energy Balances of non-Member Countries

Eurostat: Energy Balances

The Latin American Energy Organization / Organizacion Latinoamericana de Energia (OLADE)

Asia Pacific Energy Research Centre (APERC)
UN: Industrial Statistics, National Accounts
OECD: STAN database (structural analysis database)
EU: NACE system

## 5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

a) **Lead Agency:** The lead agency is the International Energy Agency (IEA).
b) **Other Contributing Organizations**: OECD and IEA have collected detailed value added and energy consumption data at the four-digit level in the ISIC database. Less detailed two-digit data are also available. IEA now collects two-digit energy consumption data for manufacturing for about half of the developing countries as well.

## 6. REFERENCES

(a) **Readings:**
*Energy Policy*, June/July 1997 issue, Elsevier Science Limited, various articles in this issue discuss the physical and monetary measures of output and various problems associated with indicators of manufacturing energy use and intensity.
Phylipsen, G.J.M, Blok, K., and Worrell, E., 1997. *Handbook on International Comparison of Energy Efficiency in the Manufacturing Industry***.** Utrecht: Dept. of Science, Technology, and Society.
IEA, 1997. *Indicators of Energy Use and Energy Efficiency***.** Paris. OECD.
(b) **Internet site**: International Energy Agency: http://www.iea.org

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| INTENSITY OF ENERGY USE: RESIDENTIAL SECTOR | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

## 1. INDICATOR

a) **Name**: Intensity of Energy Use in the Residential Sector.
b) **Brief Definition**: Amount of energy used per person or household in the residential sector.
c) **Unit of Measurement**: Gigajoules (GJ) per capita or GJ per household.
d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/Energy Use.

## 2. POLICY RELEVANCE

a) **Purpose**: The indicator is used to monitor energy consumption in the residential sector.
b) **Relevance to Sustainable/Unsustainable Development** (theme/sub-theme): The residential sector is a major consumer of energy with a distinctive pattern of usage. Reducing energy consumption contributes to reducing air pollution and climate change. Many policies addressing energy efficiency and savings have been formulated for this sector. In colder countries, for example, the space heating component has been the focus of many energy-saving policies, while in almost all countries, the electric-appliance and lighting component is still the focus of many policies.
c) **International Conventions and Agreements**: None specifically for this sector.
d) **International Targets/Recommended Standards**: None as such. However, thermal standards for new homes are in effect in almost all OECD and Eastern European countries, China and some other countries in colder climates. Efficiency standards for boilers are also important in many countries. Efficiency standards on new electrical appliances are important in the United States and indirectly in Canada, and voluntary programmes have been important in Japan and Europe.
e) **Linkages to Other Indicators**: This indicator is one of a set for energy intensity in different sectors (manufacturing, transportation, commercial/services and residential), with the indicator for energy use per unit of GDP as an aggregate energy intensity indicator. These indicators are also linked to indicators for total energy consumption, greenhouse gas emissions, and air pollution emissions.

## 3. METHODOLOGICAL DESCRIPTION

a) **Underlying Definitions and Concepts**: Household or residential energy use encompasses energy used in residential buildings, including urban and rural free-standing houses, apartment dwellings, and most collective dwellings such as dormitories and barracks. These energy uses typically include cooking, water heating, space heating and cooling, lighting, major appliances for refrigeration, washing and drying, TV and communications, computers, conveniences like food machines, vacuum cleaners, etc., as well as a myriad of small appliances. Household or residential energy use should exclude energy for farm processes, small businesses or small industry. The household sector must be separated from the commercial/services sector, although data for many IEA countries did not separate these two sectors in the past. The energy sources should include not only purchased energy, but also gathered energy such as fuelwood or other biomass and miners' coal.

b) **Measurement Methods**:

- **Energy Use**: Purchased energy for residences/households is usually recorded in the energy statistics of a country with data provided by electric, gas, or heat utilities according to customer definitions that correspond to "households". Data on purchases of LPG, other oil products, coal or similar fuels and wood are not always recorded correctly since suppliers may not know where or how these fuels are being used.

  Alternatively, household/residential energy use can be measured through household surveys. The most direct surveys collect detailed information on both fuels consumed and energy-consuming equipment owned or used. The most accurate surveys also obtain permission from households to ask energy suppliers for quantities consumed, or they leave fuel-use diaries for households to record what they consume. They measure usage in a variety of appliances and in heating equipment using miniature data loggers. Less detailed surveys estimate the use of each fuel for each major purpose through regression analysis over a large number of households.

  **Unit**: Energy is measured in megajoules (MJ) or gigajoules (GJ) (net calorific value). In most cases, electricity and purchased heat are counted at final or delivered value. In some cases, primary energy is recorded. (See methodology for manufacturing sector).

- **Residential unit**: Energy consumption is calculated on a per capita or per household basis. In general, energy consumption depends both on the physical size and characteristics of the dwelling and on the number of people. As the number of people in a household declines, energy consumption per household declines, while the energy consumption per capita increases. As a rule of thumb, energy use for water heating, cooking and many appliances tends to vary with the square-root of household size.

  For developing countries with large rural sectors or large numbers of homes without access to electricity, the share of homes in the urban sector and the share in each sector connected to grid electricity is an important factor in total residential energy consumption. The shares of homes using different kinds of biomass fuels are also important.

c) **Limitations of the Indicator**: When energy consumption by end-use is not known, energy use per household is a valuable indicator of energy intensity, but it does not measure energy efficiency. Some important conclusions can be drawn, however, if the average winter temperature, ownership of energy-consuming appliances, and dwelling size are known. In a country with cold winters and high penetration of central heating systems, a low total consumption of energy for all purposes, relative to total floor area and the severity of winter climate, probably implies efficient heating practices. Conversely, high energy use relative to floor area in a country with mild winters may imply inefficiencies. However, since energy consumption habits vary so much, both among countries and among end-uses, few conclusions about "efficiency" can be drawn from the indicator on "residential energy use per household". (See alternative definitions/indicators below).

d) **Status of the Methodology**: The indicator, with some variations in the methodology, is used in many OECD countries. It is not widely used in developing countries.

e) **Alternative Definitions/Indicators**:

- **Measurement of Efficiency**: A true energy efficiency can be expressed as energy use per unit of energy service. Examples of true energy efficiency would be litres of refrigerated volume at a given temperature divided by electricity use, lumens of light per watt of power consumed, or computer tera-flops per second divided by power consumption. In practice, these are not measured for large populations. Specific energy requirements for particular services, taking into account equipment efficiency and the time the service is used, are easier to estimate since these can be summed for a given household and compared with actual consumption.
- **Output (services provided)**: Ideally, output units would be in energy services delivered, such as lumens of lighting, meals cooked, area and time heated, litres of hot water provided, litres refrigerated, kilogrammes of clothes washed, etc. In practice, such data are rarely available, even for individually metered homes. A suitable proxy for each service may be either the area heated (or lit), the number of people in the household receiving meals or hot water, and the average number of appliances, by type, per household or per capita.
- **Energy requirements**: If both energy use and equipment ownership for each major service is known, then specific energy requirements can be developed as follows:
  - Space heating: energy use per sq. meter heated or per sq. meter per degree day;
  - Energy use per capita for water heating and cooking; and
  - Energy use per year for each major appliance: refrigerator, freezer, clothes washer, dryer, dishwasher, TV, etc.

  These specific energy requirements are related to, but not identical to, energy efficiencies. They differ in that they do not measure accurately the service provided, since, for example, a large refrigerator gives more service than a smaller one.

**4. ASSESSMENT OF DATA**

a) **Data Needed to Compile the Indicator**:
- Energy use in the residential sector (as indicated in section 3(b) above);
- Number of households and/or population.

b) **National and International Data Availability and Sources**: Until the early 1980s, the residential or household sector was not well distinguished from the commercial/service sector in a majority of OECD member country energy statistics, particularly for liquid and solid fuels. In OECD countries, this distinction is now common. In developing countries, data often distinguish residential and commercial consumption of electricity and natural gas, but users of liquid and solid fuels are often not accurately identified. Many national energy balances thus fail to distinguish between the residential and commercial/service sectors. Such problems are indicated when data show electricity and natural gas consumption for both the residential and commercial/service sectors, while liquid and solid fuel consumption is shown for only one of the two sectors.
The other major challenge is to estimate the use of biomass fuels of all kinds in developing countries. This is important in almost all developing countries, even in urban areas.
Because of these two problems, aggregate national or international statistics must be used with caution.
Data on equipment are usually developed by electric and gas utilities, as well as by trade associations representing electric and gas appliance manufacturers. These have generally not been compiled in an internationally compatible form. No single agency collects all the data, except in a few IEA countries (United States, France, Netherlands) where detailed household surveys are undertaken. The World Bank has sponsored many one-time household surveys in developing countries, focusing either on rural or urban areas. As noted above, national or private energy companies often undertake marketing surveys. Oil industry sources in most IEA countries often compile data on oil-equipment sales and ownership.

c) **Data References**:
IEA: Energy Balances of Member countries.
Energy Statistics of non-Member countries.

**5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR**

**Lead Agency**: International Energy Agency (IEA).

**6. REFERENCES**

a) **Readings**:
Schipper, L., Ketoff, A., and Kahane, A. “Estimating Residential Energy Use from Bottom-Up, International Comparisons. Ann. Rev. Energy 10. Palo Alto CA: Ann. Revs., Inc. 1985.

b) **Internet sites**:
International Energy Agency: http://www.iea.org
World Bank: http://www.worldbank.org/html/fpd/energy/

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| INTENSITY OF ENERGY USE: TRANSPORTATION | | |
|---|---|---|
| **Economic** | **Consumption and Production Patterns** | **Energy Use** |

**1. INDICATOR**

a) **Name:** Intensity of Energy Use in Transportation.
b) **Brief Definition**: Energy consumption for transportation relative to the amount of freight or passengers carried and the distance traveled.
c) **Unit of Measurement**: Magajoules per tonne-kilometer (MJ/tonne-km) for freight, and Megajoules per passenger-kilometer (MJ/passenger-km) for passengers.
d) **Placement in the CSD Indicator Set**: Economic/Consumption and Production Patterns/ Energy Use.

**2. POLICY RELEVANCE**

a) **Purpose**: Transportation is a major consumer of energy, mostly in the form of fossil fuels, and the share of transportation in energy consumption is generally increasing. The indicator is a measure of how efficiently energy is used for moving goods and people. The indicator can be used to monitor trends in energy consumption for transportation and for international comparisons. Separation of freight and passenger travel is essential.

b) **Relevance to Sustainable/Unsustainable Development** (theme-sub-theme): Transportation serves economic and social development through distribution of goods and services and through personal mobility. However, energy consumption for transportation also leads to air pollution and climate change. Reducing energy intensity (increasing energy efficiency) in transportation can reduce the environmental impacts of transportation while maintaining the economic and social benefits.

c) **International Conventions and Agreements**: UNFCCC and its Kyoto Protocol. The European Union voluntary agreement on greenhouse gas (GHG) emissions from automobiles (to which Japanese and Korean producers have also agreed) require reductions in GHG emissions per kilometer from new automobiles.

d) **International Targets/Recommended Standards**: Many industrialized countries have targets for reducing energy use and carbon emissions from transportation, for which these energy intensities are key indicators.

e) **Linkages to Other Indicators**: This indicator is one of a set for energy intensity in different sectors (manufacturing, transportation, commercial/services and residential), with the indicator for energy use per unit of GDP as an aggregate energy intensity indicator. These indicators are also linked to indicators for total energy consumption, greenhouse gas emissions, and air pollution emissions. This indicator is also linked to the indicator for distance traveled per capita by means of transport.

## 3. METHODOLOGICAL DESCRIPTION

a) **Underlying Definitions and Concepts:** Energy consumption per unit of transportation activity is a key measure of how efficiently transportation systems convert energy into human mobility and goods distribution. Because it is not meaningful to add freight and passenger travel, these types of transportation must be disaggregated. Separating the two activity measures is generally not difficult, but separating the energy consumption is often complicated.

b) **Measurement Methods**:

- **Energy Use**: Energy consumption should be measured for each kind of vehicle, including two-wheelers, automobiles, busses, small trucks, heavy trucks, and miscellaneous road vehicles, as well as trains, ships and aircraft for domestic transport, and even pipelines. In general, however, national energy balances are only disaggregated by fuel and broad traffic type: road, rail, water, and air. Considerable work is required to disaggregate road fuels consumed by vehicle type. It is important to take into account the different energy content and carbon emissions in different fuels and not simply add the weights or volumes of different fuels consumed (e.g., tonnes, or cubic metres in the case of natural gas). Some of the difficulties in disaggregating road fuels consumed by vehicle type are explained in Schipper et al. (1993). International air or marine transportation should not be included. Electric power consumption for rail, subway and trams, as well as electric road vehicles, should be converted to primary energy consumption, although there is no standard method for such conversion.

  **Unit**: Preferable energy units are multiples of joules, usually terajoules ($10^{12}$J), petajoules ($10^{15}$J), or exajoules($10^{18}$J), converted from weights or volumes of fuels at net heating values.

- **Output or Activity**: There are two different measures of activity. Vehicular activity, in vehicle-km, provides a measure of traffic that is important for transport policy and road and infrastructure planning. Most often, these data can be divided further into basic vehicle types. However, economic and human activity is better measured in passenger-km and tonne-km, taking into account utilisation or load factors. A bus carrying 20 passengers for 10 km (200 passenger-km) is less energy intensive (more energy efficient) than the same bus carrying 5 passengers for the same distance (50 passenger-km). Similarly, a fully-loaded truck is less energy intensive than the same truck carrying a partial load.

- **Indicators**:
  (i) **Vehicle Intensities**: Energy consumption per vehicle-km by vehicle and fuel type is an important indicator, as many standards for air pollution (and more recently, goals for $CO_2$ emissions reduction) are expressed in terms of vehicle characteristics, i.e., emissions per vehicle-km.
  (ii) **Modal Intensities**: Energy use per passenger-km or tonne-km should be disaggregated by vehicle type, i.e., two-wheeler, car/van, bus, air, local and long-distance rail, subway, tram, ship or ferry for passengers; and truck, rail, ship, air for freight.

  **Note**: Aggregate energy intensity for travel or freight is a meaningful summary indicator, the value of which depends on both the mix of vehicles and the energy intensities of particular types of vehicles. The energy intensities of train and bus transportation per passenger-km are commonly 60 to 80 per cent less than the energy intensities for cars or air transportation. For freight, rail and ship transportation are commonly 65 to 90 per cent less than the energy intensive for trucking per tonne-km. These differences between modes are of the same order of magnitude as the differences between the lowest and highest energy intensities of transportation within each mode. It should also be noted that fuel consumption per vehicle-km also depends on traffic conditions as well as vehicle characteristics.

  The energy intensity for a vehicle type depends on both capacity and capacity utilisation. A large vehicle that is fully loaded generally has a lower energy intensity per tonne-km than a fully-loaded smaller vehicle, but a small vehicle fully loaded will have a lower energy intensity than a large vehicle with the same load. Typical load factors for private cars are 1.5 people per car. Typical load factors for rail and bus vary from well below 10 per cent (e.g., United States city busses on average) to over 100 per cent of nominal capacity at peak times, and in many developing countries during most of the day. Typical load factors for trucking might be 60 to 80 per cent of weight capacity when loaded, but trucks commonly run 20 to 45 per cent of their kilometers empty, yielding a relatively low overall load factor. Under-utilized transport capacity means more pollution and road damage (and other impacts) per unit of transport service delivered, hence capacity utilisation itself is an important indicator of sustainable transportation.

c) **Limitations of the Indicator**: Data availability may limit the disaggregation of the indicator to the desired level. Considerable work is often required to disaggregate energy balances into various modes of transportation.
Some countries' transportation energy statistics include fuel consumed by domestic airlines or shipping lines in international transportation. Efforts should be made to exclude such transportation and energy consumption from the indicators.

d) **Status of the Methodology**: The methodology is in use in many developed countries.

e) **Alternative Definitions/Indicators**: An alternative, simpler, broad measure of energy intensity for transportation could be average fuel consumption per vehicle for all vehicles, but the results would be strongly influenced by the mix of vehicles, which varies enormously among countries and over time. In particular, it would be influenced by the number of two- and three-wheelers.

## 4. ASSESSMENT OF DATA

a) **Data Needed to Compile the Indicator**:
   (i) Energy consumption by mode of transportation, vehicle type and fuel;
   (ii) Distance traveled by vehicles, passengers and freight, including load factors.

b) **National and International Data Availability and Sources**: Energy use by fuel type in each branch of road transport, rail, ship, and air transport is published by most transport ministries in OECD countries. National energy balances (as well as present IEA/OECD Energy Statistics) do not disaggregate road transport by mode. Few sources of energy data separate fuel consumption for rail or shipping into that for passengers and that for freight, but national or private rail and shipping organizations often do this. Energy consumption for local electric transport (commuter rail, subways, trams) is often published separately by national authorities.
Eurostat is a lead agency for collecting data on vehicle, passenger, and tonne-kilometers in Europe. Ministries of Transport in the United States, Canada, Japan, Australia and other countries, often through their statistical agencies, publish similar data. In developing countries, fewer data are available.

c) **Data References**:
Eurostat: Transport Annual Statistics

## 5. AGENCIES INVOLVED IN THE DEVELOPMENT OF THE INDICATOR

**Lead Agency**: The lead agency is the International Energy Agency (IEA).

## 6. REFERENCES

a) **Readings**:
Schipper, L. and Marie-Lilliu, C., 1999. *Carbon Dioxide Emissions from Transport in IEA countries: Recent lessons and long-term Challenges*. KFB Meddelande 1999:11. Stockholm.
Schipper, L., Figueroa. M.J., Price, L., and Espey. M., 1993. "Mind the Gap: The Viscious Circle of measuring automobile fuel use". *Energy Policy* (October).
Samaras. Z., et al. 1999. *Study on Transport Related Parameters of the European Road Vehicle Stock*. Prepared for Eurostat and DG-7. Thessalonikai: Laboratory of Applied Thermodynamics, Aristotle University.
Schipper, L., and Tax, W., 1994. "Mind the Gap". *Transport Policy*.

b) **Internet site**: IEA: http://www.iea.org/