



 POLITECNICO DI MILANO



Socio-Economic and Energy Related Indicators

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- **Basic rules for System Analysis**
- **Socio-Economic Indicators**
- **Energy related Indicators**
- **Energy & Development: some examples**

References:

World Bank, Little green data book, 2012-14

IAEA, Energy Indicators for Sustainable Development: Guidelines and Methodologies, 2005

UNDP, HDI, 2011-14



System analysis requires

- the system
- the purpose
- the boundaries
- the environment
- the input and output flows

Engineers must focus on

- the identification of stakeholders
- the goals, based on stakeholders' analysis and interconnection, synergy and contrast
- the aims and boundaries: direct or indirect, short, middle or long time frame...
- reiteration of project's plan

IAEA indicators are designed for system analysis

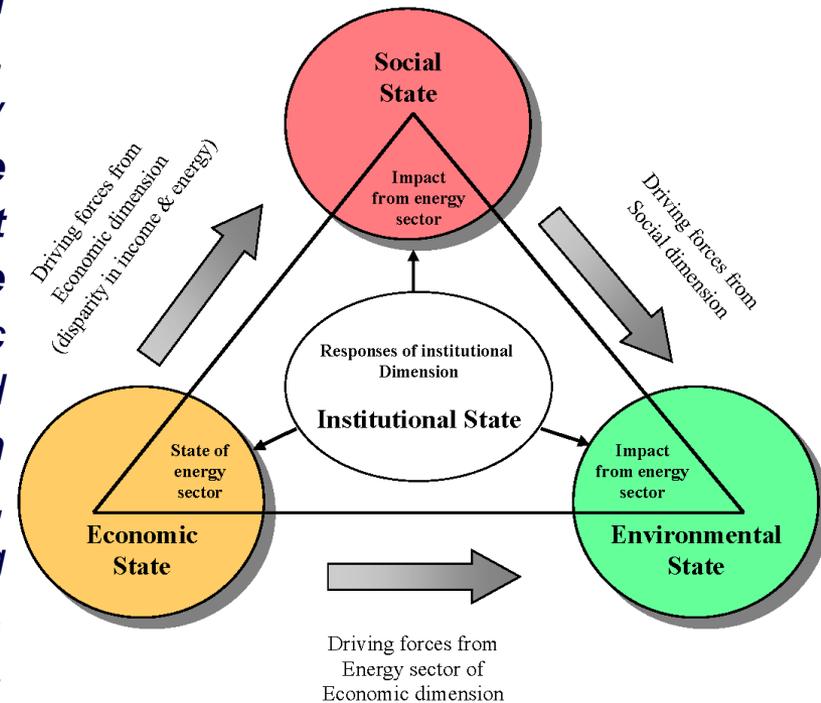


Socio-Economic Indicators

Sustainable energy development

Essential element (source Agenda 21, IAEA/IEA)

*“Energy is essential to economic and social development and improved quality of life. Much of the world’s energy, however, is currently produced and consumed in ways that **could not be sustained if technology were to remain constant and if overall quantities were to increase substantially.** The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be based on **efficiency in energy production, transmission, distribution and consumption,** and on growing reliance on environmentally sound energy systems, particularly new and renewable sources of energy. **All energy sources will need to be used in ways that respect the atmosphere, human health, and the environment as a whole.**”*





Socio-Economic Indicators

Some selected general and common indicators are here analyzed in order to give a first idea of the different **socio - economic** situations in which they can be used for a system analysis.

In this course the focus is on some socio-economic indicators closely related to energy:

- **Total population and Share of urban population**
- **Gross Domestic Product (GDP) and Gross Domestic Product per capita**
- **Human Development Index (HDI)**



Socio-Economic Indicators

Total Population and Share of urban population

Data about population are very important in the energy investigation because of the direct proportionality between the **country energy consumption and the number of persons**.

Moreover the percentage of urban population is meaningful because of the higher energy consumption per capita respect to the rural population and because of the shifting towards “modern” energy vectors.

The **urban population** has higher energy consumption rather than the rural one, so the country energy consumption is expected to rise in the next future for:

- population growth
- migration towards the urban area
- the general increasing of the living quality standards

Important: The divide between rural and urban energy vectors and consumption is stronger in the developing countries.



Gross Domestic Product

The **Gross Domestic Product (GDP)** is one of the most common and widely used economic indicator. GDP is defined as:

$$\mathbf{GDP = C + I + G + X - M}$$

where:

- C: private consumption and personal expenditures of households such as food, rent, medical expenses...
- I: defined as investments by business or households in capital (no financial products).
- G: government expenditures on final goods and services. It includes salaries of public servants, purchase of weapons for the military, and any investment expenditure by a government.
- X: gross exports.
- M: gross imports.

The level of GDP in different countries may be compared through different ways. It is possible to convert the value from the national currency according to:

- **the current currency exchange rate or**
- **the purchasing power parity (PPP) exchange rate**



Gross Domestic Product per capita

The **choice of the approach** can have an heavy impact on the relative ranking of the analyzed countries.

With the **current currency exchange rate methodology** GDP is calculated by exchange rates prevailing on international currency markets.

This can offer better indications about the **countries international purchasing power and relative economic strength**, becoming meaningful for high foreign dependency economy.

With **the purchasing power parity of each currency** relative to a selected standard (usually the United States dollar) and fixed years (for data trends).

The purchasing power parity method shows the **relative effective domestic purchasing power of the average producer or consumer within the specific economy**. This can be a better indicator of the living standards of less-developed countries because it compensates for the weakness of local currencies in world markets: **with the PPP application the disparity in GDP between high and low income countries decreases**, as compared to the current exchange rate method. This phenomenon is known as Penn Effect.



Gross Domestic Product - Limits

It is important to highlight some limitation of GDP as wellness indicator:

- does not take in account **disparity in incomes** between the rich and poor
- includes **works that do not produce net change or those resulting from repairing damage**. For example, rebuilding after a natural disaster or war may produce a considerable amount of economic activity and increase the GDP value. The same results happens when many people are sick and receive expensive treatment.
- **ignores externalities** (such as damage to the environment) and the sustainability of growth: a country may achieve a temporarily high GDP by over-exploiting natural resources.
- estimates may not take into account the black market, where the money spent is not registered, and the non-monetary economy in general.

However GDP can be used as a rough indicator of the economy situation of a country.

In the energy analysis GDP indicator is used because of the linkage between energy demand and economy growth.



Human Development Index

(Source UNDP)

Human Development is a development paradigm about the creation of an **environment** in which people can develop their **full potential and lead productive, creative lives in accord with their needs and interests**. **People** are the real wealth of nations. Development is thus much more than economic growth, which is only a means of enlarging people's choices.

Fundamental for enlarging these choices is to build **human capacities**. These core capacities for human development are:

- Enjoying a long and healthy life
- Being educated
- Access to resources that enable people to live in dignity
- Being able to participate in decisions that affect their community

Without these, many choices are simply not available, and many opportunities in life remain inaccessible and the fight against poverty only a “chimera”



Human Development Index

(Source UNDP)

This way of looking at development is not new: philosophers, economists and political leaders have long emphasized **human wellbeing as the purpose, the end, of development.**

As Aristotle said in ancient Greece, “Wealth is evidently not the good we are seeking, for it is merely useful for the sake of something else.”

In seeking that something else, **human development shares a common vision with human rights.** The goal is human freedom.

People must be free to exercise their choices and to participate in decision-making that affects their lives.

Human development and human rights are mutually reinforcing, helping to secure the well-being and dignity of all people, building self-respect and the respect of others (fostering peace!)

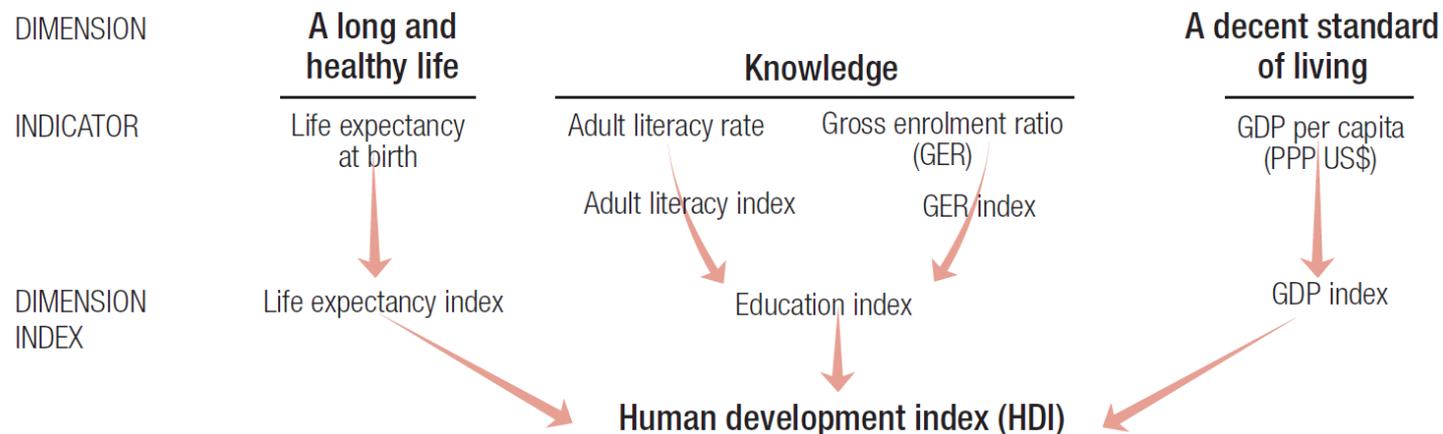


Socio-Economic Indicators

Human Development Index

One of the most meaningful social indicator is the HDI, that combines the normalized measures of **life expectancy**, **literacy**, **educational attainment**, and **GDP per capita** for **countries worldwide**.

With this index is possible to create a **rank for different level of development**. Country with a HDI higher than 0.8 are considered **High Human Developed**, a HDI between 0.5 and 0.8 are consider **Medium Human Developed** while a HDI lower then 0.5 **Low Human Developed** countries.





Human Development index

Methodology

The HDI is build up as follows:

- **Life Expectancy Index (LEI)**

- **Education Index (EI)**

Adult Literacy Index (ALI)

Gross Enrollment Index (GEI)

- **GDP Index (GDPindex)**

$$\text{Indicator} = \frac{\text{value} - \text{min value}}{\text{max value} - \text{min value}}$$

$$\text{HDI} = \frac{1}{3} \text{LEI} + \frac{1}{3} \text{EI} + \frac{1}{3} \text{GDPindex}$$

$$\text{LEI} = \frac{\text{LE} - 25}{85 - 25}$$

$$\text{EI} = \frac{2}{3} \text{ALI} + \frac{1}{3} \text{GEI}$$

$$\text{ALI} = \frac{\text{AL}}{100}$$

$$\text{GEI} = \frac{\text{GE}}{100}$$

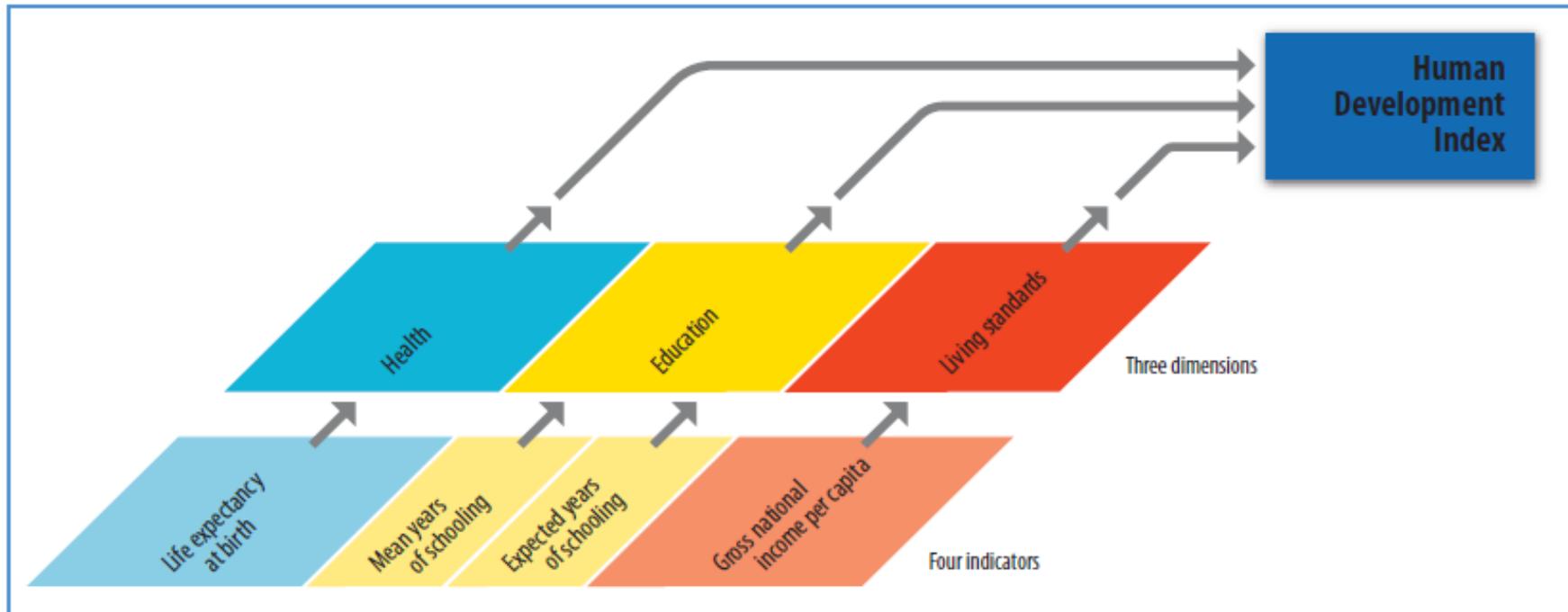
$$\text{GDPindex} = \frac{\log(\text{GDP}_{\text{ppp}}) - \log(100)}{\log(40000) - \log(100)}$$



Socio-Economic Indicators

Human Development Index

New methodology - 2010



Note: The indicators presented in this figure follow the new methodology, as defined in box 1.2.

Same dimensions BUT different indicators and different weight



Human Development Index

New methodology - 2010

The HDI is build up as follows:

➤ **Life Expectancy Index (LEI)**

$$LEI = \frac{LE - 20}{63.2}$$

➤ **Education Index (EI)**

$$EI = \frac{\sqrt{MYSI - EYSI}}{0.951}$$

Mean Years of Schooling Index (MYSI)

$$MYSI = \frac{MYS}{13.2}$$

Expected Years of Schooling Index(EYSI)

$$EYSI = \frac{EYS}{20.6}$$

➤ **INCOME Index (II)**

$$II = \frac{\ln(GNIpc) - \ln(163)}{\ln(108211) - \ln(163)}$$



Socio-Economic Indicators

Human Development index

New Methodology – 2010

The HDI is NOW built up as follows:

$$\text{HDI} = \sqrt{\text{LEI} \cdot \text{EI} \cdot \text{GNIindex}}$$

- **Life Expectancy Index (LEI)**

A key change was to shift to a geometric mean: thus in 2010 the HDI is the **geometric mean** of the three dimension indices. This method captures how well rounded a country's performance is across the three dimensions.

- **Education Index (EI)**

Mean years of schooling is estimated more frequently for more countries and can discriminate better among countries, while expected years of schooling is consistent with the reframing of this dimension in terms of years.

Mean years of schooling

Issue of quality of education is still open

Expected years of Schooling

To measure the standard of living, **gross national income (GNI)** per capita replaces gross domestic product (GDP) per capita. In a globalized world differences are often large between the income of a country's residents and its domestic production. Some of the income residents earn is sent abroad, some residents receive **international remittances** and some countries receive sizeable aid flows. GNI can also account for the national debt.

- **GNI Index (GNIindex)**



Socio-Economic Indicators: regional example

Human Development Index (HDI)

A composite index measuring average achievement in three basic dimensions of human development— a long and healthy life, access to knowledge and a decent standard of living.

Adult literacy rate

The proportion of the population aged 15 years and older which is literate, expressed as a percentage of the corresponding population, total or for a given sex, in a given country, territory, or geographic area, at a specific point in time, usually mid-year. For statistical purposes, a person is literate if he/she can, with understanding, both read and write a short simple statement on his/her everyday life.

GDP per capita

GDP (in PPP terms in US dollars) divided by midyear population life.

Life expectancy at birth

The number of years a newborn infant would live if prevailing patterns of age-specific mortality rates at the time of birth were to stay the same throughout the child's life.

Enrolment ratio, gross combined

The number of students enrolled in primary, secondary and tertiary levels of education, regardless of age, as a percentage of the population of theoretical school age for the three levels.

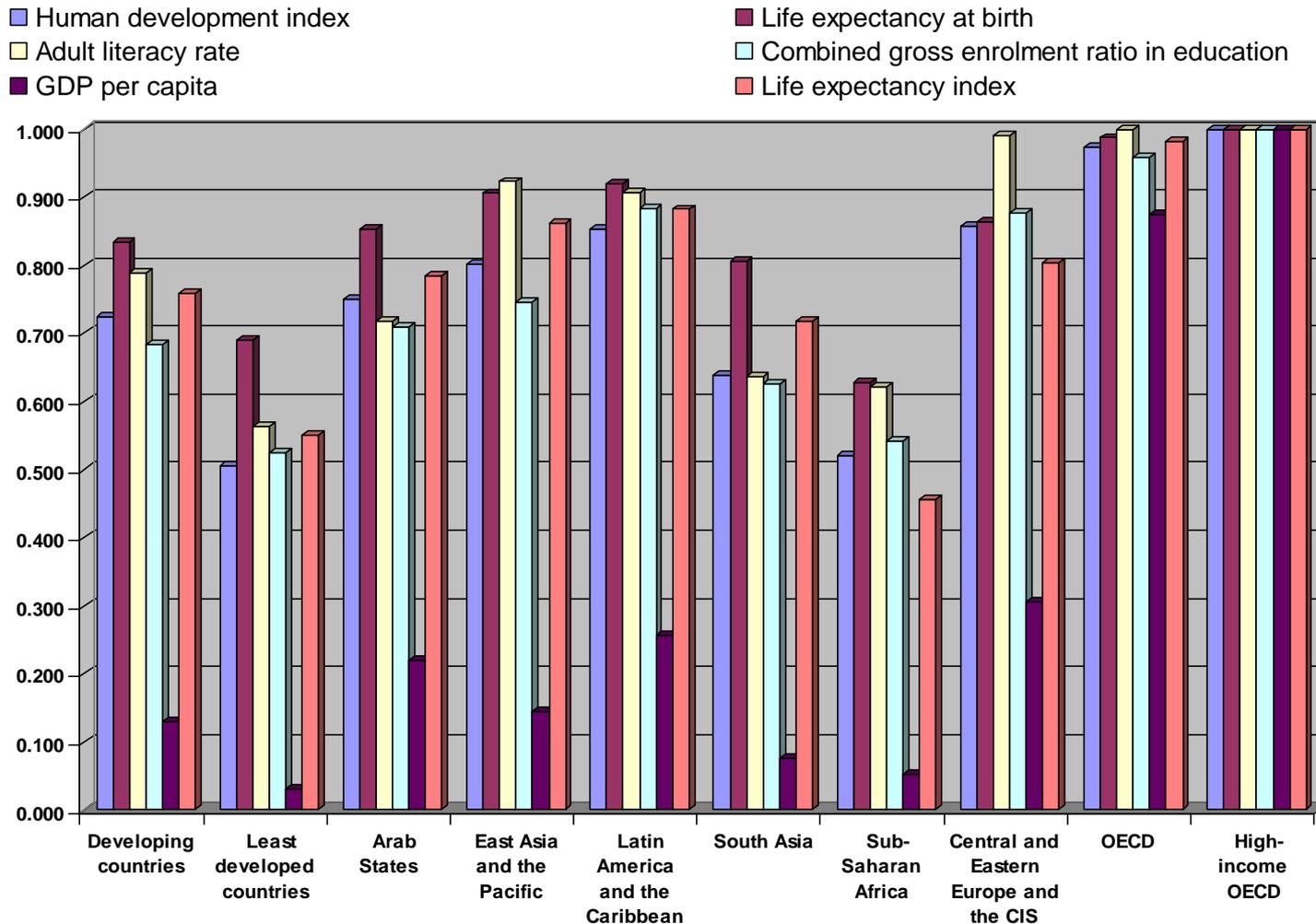
Life expectancy

Life expectancy index One of the three indices on which the human development index is built.



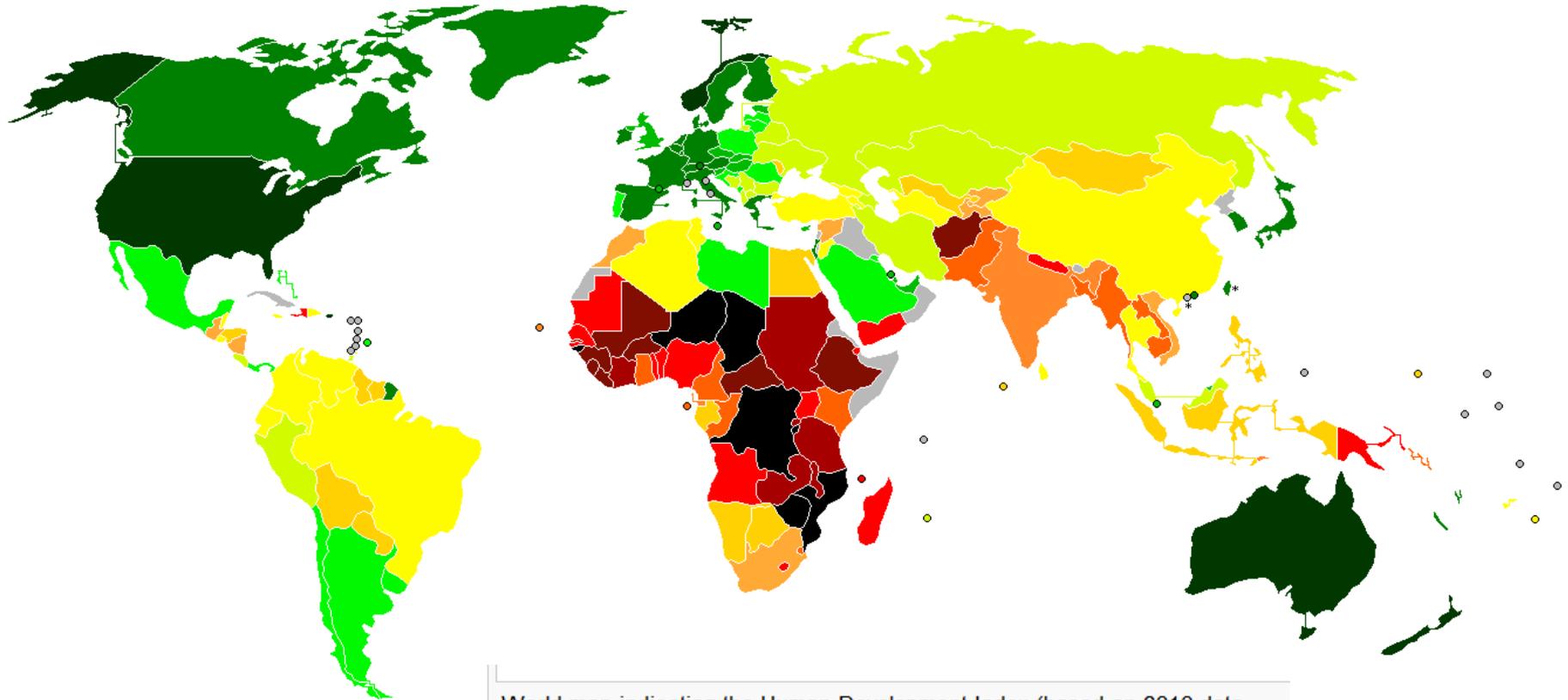
Socio-Economic Indicators: regional example

Some relevant indicators for regional comparisons

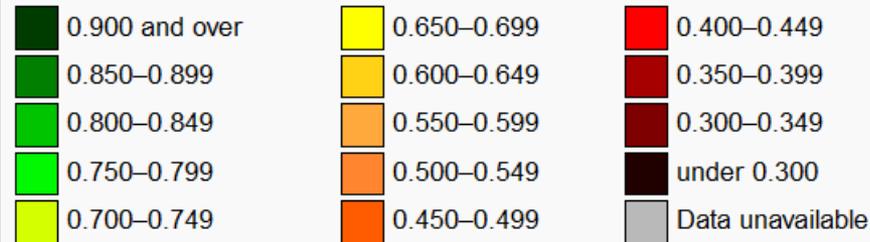




Socio-Economic Indicators: regional example



World map indicating the Human Development Index (based on 2010 data, published on the 4th of November, 2010)^[1]





Socio-Economic Indicators

Level of development, poverty and gender

Five human development indexes are nowadays commonly used for any development study, less related to energy

HDI

Poverty issue

Human poverty index for developing countries (HPI-1) A composite index measuring deprivations in the three basic dimensions captured in the human development index—a long and healthy life, access to knowledge and a decent standard of living.

Human poverty index for selected high income OECD countries (HPI-2). A composite index measuring deprivations in the three basic dimensions captured in the human development index—a long and healthy life, access to knowledge and a decent standard of living—and also capturing social exclusion.

Gender issue

Gender empowerment measure (GEM) A composite index measuring gender inequality in three basic dimensions of empowerment—economic participation and decision-making, political participation, and decision-making and power over economic resources.

Gender-related development index (GDI) A composite index measuring average achievement in the three basic dimensions captured in the human development index—a long and healthy life, access to knowledge and a decent standard of living—adjusted to account for inequalities between men and women.



Energy Indicators

Adequate and affordable energy services have been relevant in the economic development and the transition from subsistence agricultural economies to modern industrial and service-oriented societies.

Energy is a central issue to improve social and economic well-being, and is indispensable for industrial and commercial wealth generation.

However it is important to note that **energy is only a means**. The final goals are:

- **a sustainable economy**
- **a clean environment**
- **appropriate living standards**
- **prosperity**
- **good health**

that are shared theme with the United Nations Millennium Development Goals.

In **1999** the **International Atomic Energy Agency (IAEA)** introduced a set of specific energy indicator to monitor the development of a country.



Energy Indicators

The original name was “Indicators for Sustainable Energy Development (ISED)” but in 2002 IAEA decided to modify it in “**Energy Indicators for Sustainable Development (EISD)**” to avoid misunderstanding.

Besides, in the common view, “sustainable energy development” tends to refer only to renewable energy, rather than the broader spectrum of **energy choices**.

The Energy Indicators for Sustainable Development (EISD) is a set of **30 indicators**, classified into **3 dimensions** (social, economic and environmental) with further classification into 7 themes and 19 sub-themes.

A fourth dimension is currently in course of evaluation by IAEA: **the institutional area**.

Each **dimension** represents a fundamental element of **sustainability**.



Energy Indicators

Indicators are meaningful when are used to define comparisons. It is possible to compare indicators by two ways:

Spatial (among different countries)

to create a ranking among the countries.

Temporal (along years)

to compare the impact of different policies and internal/external events. Moreover, with the time comparison it is possible to extrapolate some values and to create projections.



Spatial comparisons

First level of comparisons

The first level is internal comparison among similar countries

Second level of comparisons

The second level is a world wide positioning of the country

Temporal comparisons

Punctual data over one specific year

Last available data

Trend and time series comparisons

Generally Over decades



Energy Indicators

There are **30 indicators**, classified into **three dimensions (social, economic and environmental)**. These are further classified into 7 themes and 19 subthemes.

Social Dimension

EISD in the social dimension measure the impact that **available energy services could have on living standards**. Availability of energy services has strong implications in terms of poverty, employment opportunities, education, community development and culture, demographic transition, indoor pollution and health, gender and children status and daily activities. They describe issues related to **accessibility, affordability and disparity in energy supply and demand**.

In rich countries, modern energy services (lighting, heating, cooking, etc.) are almost universally available and in those contexts the energy is cleaner, safer, more reliable and affordable with respect to the Developing Countries (DCs). In DCs, **firewood and dung collecting for cooking and heating** could take up to six hours per day, especially for women and children. Moreover, these fuels are employed inside the houses in inadequate devices with low efficiency and **heavy negative impact on human health through contribution to disease (and even death) for air pollution and fires**.



Energy Indicators

Social dimension

Social				
Theme	Sub-theme	Energy Indicator		Components
Equity	Accessibility	SOC1	Share of households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy	<ul style="list-style-type: none"> Households (or population) without electricity or commercial energy, or heavily dependent on non-commercial energy Total number of households or population
	Affordability	SOC2	Share of household income spent on fuel and electricity	<ul style="list-style-type: none"> Household income spent on fuel and electricity Household income (total and poorest 20% of population)
	Disparities	SOC3	Household energy use for each income group and corresponding fuel mix	<ul style="list-style-type: none"> Energy use per household for each income group (quintiles) Household income for each income group (quintiles) Corresponding fuel mix for each income group (quintiles)
Health	Safety	SOC4	Accident fatalities per energy produced by fuel chain	<ul style="list-style-type: none"> Annual fatalities by fuel chain Annual energy produced



Energy Indicators

Energy Indicators

Economic dimension

Economic EISD measure the **impact on economic sector of the kinds of available energy, in term of source, quantity and reliability of providing**. The focus is the long term sustainability of the energy mix.

Economic			
Theme	Sub-theme	Energy Indicator	Components
Use and Production Patterns	Overall Use	ECO1	Energy use per capita <ul style="list-style-type: none"> – Energy use (total primary energy supply, total final consumption and electricity use) – Total population
	Overall Productivity	ECO2	Energy use per unit of GDP <ul style="list-style-type: none"> – Energy use (total primary energy supply, total final consumption and electricity use) – GDP
	Supply Efficiency	ECO3	Efficiency of energy conversion and distribution <ul style="list-style-type: none"> – Losses in transformation systems including losses in electricity generation, transmission and distribution
	Production	ECO4	Reserves-to-production ratio <ul style="list-style-type: none"> – Proven recoverable reserves – Total energy production
		ECO5	Resources-to-production ratio <ul style="list-style-type: none"> – Total estimated resources – Total energy production

End Use	ECO6	Industrial energy intensities	<ul style="list-style-type: none"> – Energy use in industrial sector and by manufacturing branch – Corresponding value added
	ECO7	Agricultural energy intensities	<ul style="list-style-type: none"> – Energy use in agricultural sector – Corresponding value added
	ECO8	Service/commercial energy intensities	<ul style="list-style-type: none"> – Energy use in service/commercial sector – Corresponding value added
	ECO9	Household energy intensities	<ul style="list-style-type: none"> – Energy use in households and by key end use – Number of households, floor area, persons per household, appliance ownership
	ECO10	Transport energy intensities	<ul style="list-style-type: none"> – Energy use in passenger travel and freight sectors and by mode – Passenger-km travel and tonne-km freight and by mode



Energy Indicators

Economic dimension

Economic				
Theme	Sub-theme	Energy Indicator		Components
	Diversification (Fuel Mix)	ECO11	Fuel shares in energy and electricity	<ul style="list-style-type: none"> – Primary energy supply and final consumption, electricity generation and generating capacity by fuel type – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
		ECO12	Non-carbon energy share in energy and electricity	<ul style="list-style-type: none"> – Primary supply, electricity generation and generating capacity by non-carbon energy – Total primary energy supply, total electricity generation and total generating capacity
		ECO13	Renewable energy share in energy and electricity	<ul style="list-style-type: none"> – Primary energy supply, final consumption and electricity generation and generating capacity by renewable energy – Total primary energy supply, total final consumption, total electricity generation and total generating capacity
	Prices	ECO14	End-use energy prices by fuel and by sector	<ul style="list-style-type: none"> – Energy prices (with and without tax/subsidy)
Security	Imports	ECO15	Net energy import dependency	<ul style="list-style-type: none"> – Energy imports – Total primary energy supply
	Strategic Fuel Stocks	ECO16	Stocks of critical fuels per corresponding fuel consumption	<ul style="list-style-type: none"> – Stocks of critical fuel (e.g. oil, gas, etc.) – Critical fuel consumption



Energy Indicators

Environmental dimension

The production, distribution and use of energy influence the environment in the household, workplace and urban area, and at the regional, national, and global levels.

Environmental EISD measure the impact of energy systems on the overall environment, and in particular the determination of **positive or negative trends in land, water, and air quality.**

Such environmental impacts vary depending upon how energy is produced and used, and on related energy regulatory actions and pricing structures.

Principal issues related to the environmental dimension include **global climate change, air pollution, water pollution, wastes, land degradation and deforestation.**

Environmental				
Theme	Sub-theme	Energy Indicator		Components
Atmosphere	Climate Change	ENV1	GHG emissions from energy production and use per capita and per unit of GDP	<ul style="list-style-type: none"> GHG emissions from energy production and use Population and GDP
		Air Quality	ENV2	Ambient concentrations of air pollutants in urban areas
	ENV3		Air pollutant emissions from energy systems	Air pollutant emissions
Water	Water Quality	ENV4	Contaminant discharges in liquid effluents from energy systems including oil discharges	<ul style="list-style-type: none"> Contaminant discharges in liquid effluents



Energy Indicators

Environmental dimension

Land	Soil Quality	ENV5	Soil area where acidification exceeds critical load	<ul style="list-style-type: none"> - Affected soil area - Critical load
	Forest	ENV6	Rate of deforestation attributed to energy use	<ul style="list-style-type: none"> - Forest area at two different times - Biomass utilization
	Solid Waste Generation and Management	ENV7	Ratio of solid waste generation to units of energy produced	<ul style="list-style-type: none"> - Amount of solid waste Energy produced
		ENV8	Ratio of solid waste properly disposed of to total generated solid waste	<ul style="list-style-type: none"> - Amount of solid waste properly disposed of - Total amount of solid waste
ENV9		Ratio of solid radioactive waste to units of energy produced	<ul style="list-style-type: none"> - Amount of radioactive waste (cumulative for a selected period of time) - Energy produced 	
		ENV10	Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste	<ul style="list-style-type: none"> - Amount of radioactive waste awaiting disposal - Total volume of radioactive waste



Energy Development Index

It is the indicator compared to HDI and built up in the same way (4 dimensions, 4 indicators)

- **Per-capita commercial energy consumption E_c** : an indicator of the overall economic development of a country.
- **Per-capita electricity consumption in the residential sector EE_c** : an indicator of the reliability of electricity services and consumer's ability to pay for them.
- **Share of modern fuels in residential sector energy use $ME\%$** : an indicator of the level of access to clean cooking facilities.
- **Share of population with access to electricity $EE\%$**

$$EDI = \frac{1}{4} E_c + \frac{1}{4} EE_c + \frac{1}{4} ME\% + \frac{1}{4} EE\%$$



Energy Development Index

Indicators are calculated as follow

$$\text{Indicator} = \frac{\text{value} - \text{min value}}{\text{max value} - \text{min value}}$$

Table 8.8 • The minimum and maximum values used in the calculation of the 2010 Energy Development Index

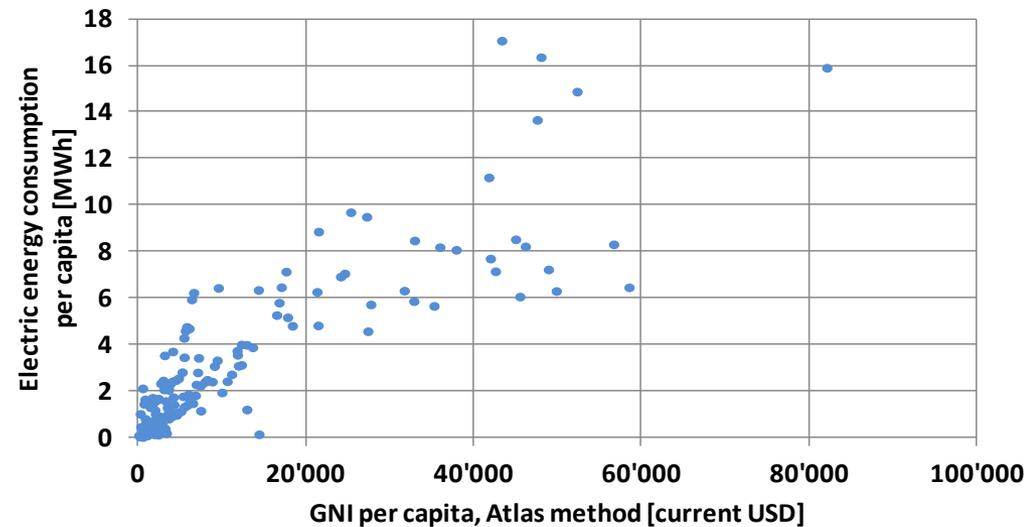
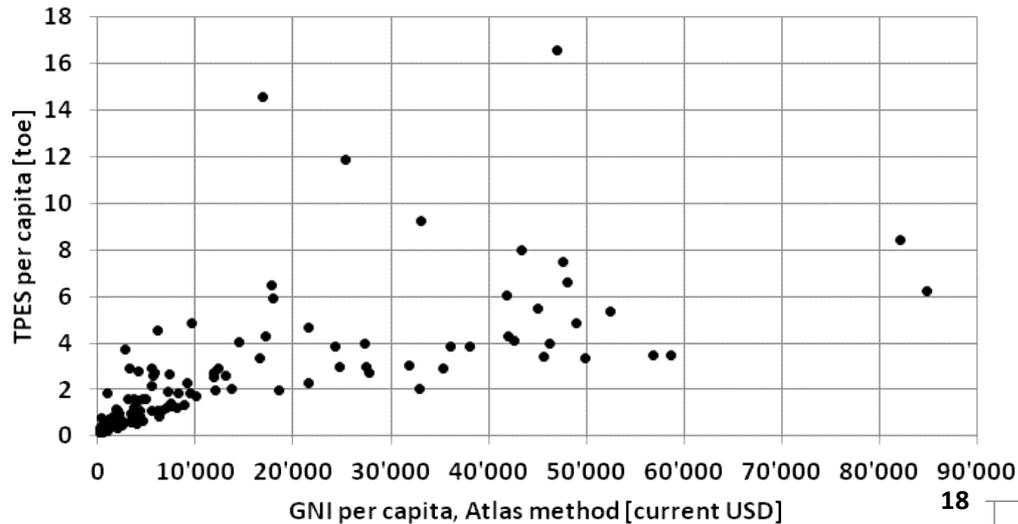
Indicator	Minimum value (country)	Maximum value (country)
Per-capita commercial energy consumption (toe)	0.03 (Eritrea)	2.88 (Libya)
Per-capita electricity consumption in the residential sector (toe)	0.001 (Haiti)	0.08 (Venezuela)
Share of modern fuels in total residential sector energy use (%)	1.4 (Ethiopia)	100 (Yemen, Lebanon, Syria, Iran)
Share of population with access to electricity (%)	11.1 (Dem. Rep. of Congo)	100 (Jordan, Lebanon)

toe = tonne of oil equivalent.



Energy & Development: some examples

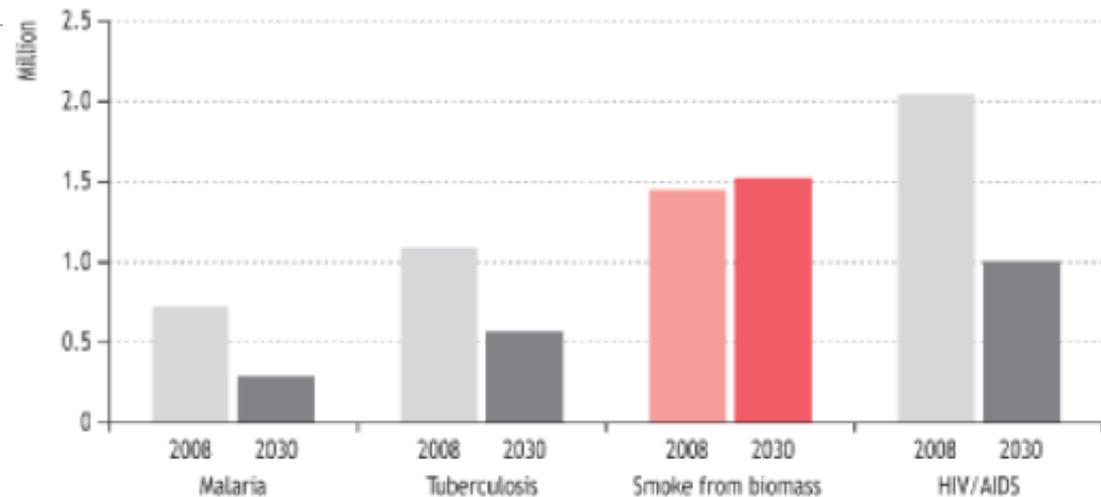
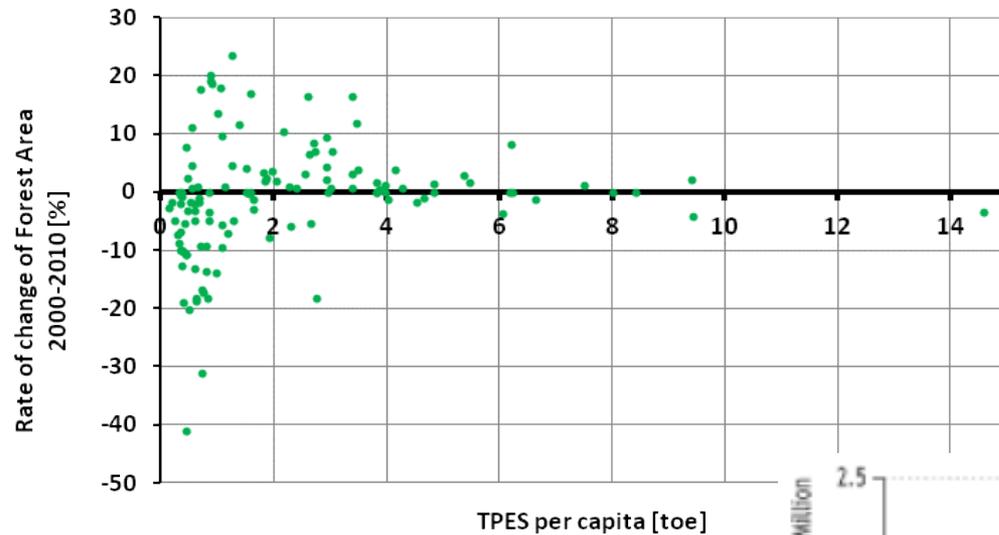
Energy and Economic development





Energy & Development: some examples

Energy and Environmental development





Energy & Development: some examples

Energy and Social development

