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SUSTAINABLE ENERGY WATCH (SEW)
INDICATOR SELECTION AND RATIONALE

INDICATOR SELECTION

I. INTRODUCTION[1]

The objective of this section is to help the user understand how to carry out the indicator calculations. The results of these calculations form part of the report on the sustainable development of a country's energy sector.

The methodology behind each calculation is presented. Instructions for completing the Excel table that graphically transcribes the indicator data into a star are also included. It is important that the indicators are calculated according to the instructions below and using established data. Generally available data must be used so that the results can be compared with subsequent years and across countries.

In order to equally measure the four components of sustainable development, two indicators have been chosen for each component. Although measurements are often different units, e.g. Joules, kgC/capita, $/capita etc., (even within a particular calculation the same measurement is not necessarily the same) this does not pose a problem as comparison between indicators is relative not absolute. The Excel spreadsheet for constructing the "star" also accounts for this.

By plotting the information on the same scale allows for visual representation of an indicator's progression towards or regression away from sustainable development in relation to the base year, e.g. 1990 (the reference year for climate change negotiations) through to the present year. Estimates about the level of sustainability for each indicator can also be made

The following convention is used when determining whether an indicator is moving towards or away from sustainability:

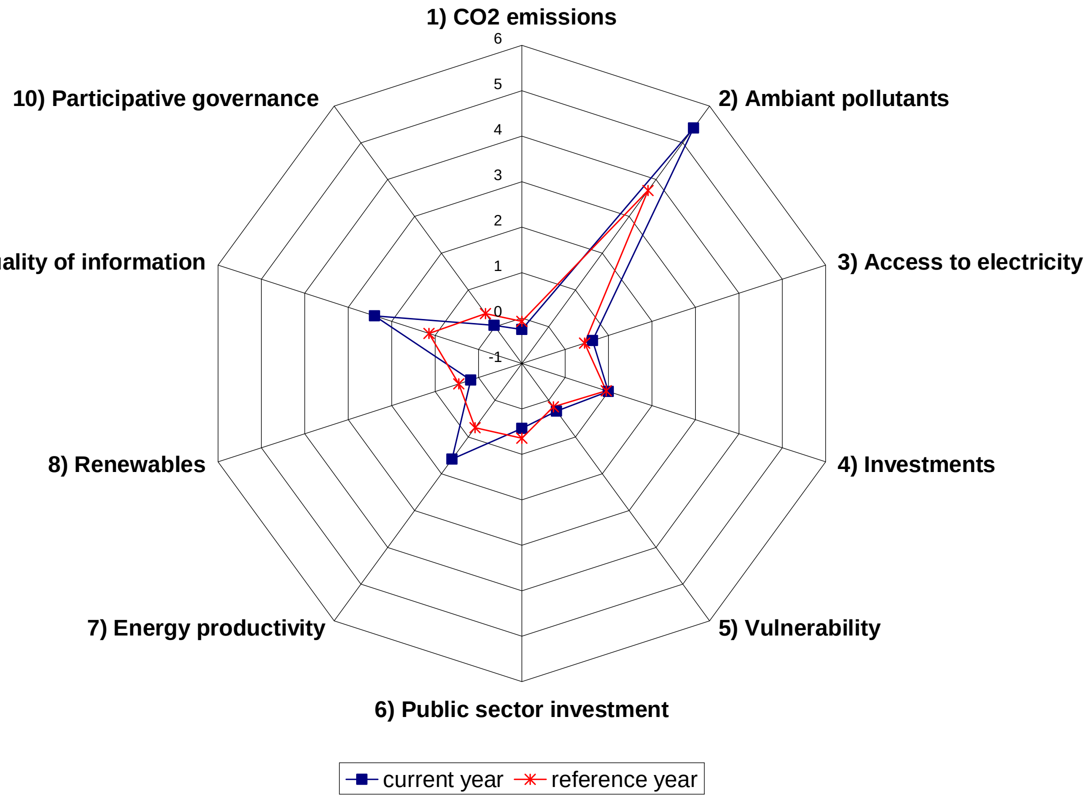
- when the indicator has a value of one or high the observed parameter is not sustainable; and
- a negative value indicates a decreasing impact relative to the base year

However how can the total evolution of indicators be measured when one indicator is moving positively and the other negatively? As the indicators carry the same weight with regards to their contribution to sustainable development it is possible to compare them within the same data set; **relative** values of the indicator are compared not **absolute** values. The

[1] This section was prepared by Ricardo Cunha da Costa, Associate researcher with the Energy Planning programme, Federal University, Rio de Janerio

comparison between the area of the star for the base year and that of the current year is a proxy for the evolution of the indicators. **A decrease in the total area of the star means that the energy sector of that country is on a trajectory towards sustainable development.**

Ten Sustainability Indicators



The star not only helps to see changes in a country's progression towards or regression away from sustainability but permits comparison between energy sectors across comparable economic levels. For international comparisons it is best to use the monetary value of Euros in terms of Purchasing Power Parity (PPP).

This section presents:

- generic formula that is the basis for all the calculations
- step-by-step instructions for calculating the eight indicators and accompanying examples
- Excel table formula and instructions for graphically representing the data
- example of a completed Excel table and resultant star

Below is the generic formula used to calculate the ten indicators. Only four variables are used to calculate each indicator with the definitions of these variables remaining the same for each indicator.

The generic formula is written as:

$$I = (X - Y) / (W - Y)$$

Where:

- I = the value of the vector (in relative terms)
- X = the value (in absolute terms) of the environmental, economic social or technological parameter
- Y = the objective of sustainability in absolute terms and corresponds to the value 0 of the vector
- W = the value (in absolute terms) which corresponds to value 1 of the vector
- Z = the value of the segment (in absolute terms) which goes from 0 to 1 on the vector.

The X value varies over the long-term while values W and Y are constant. Thus, once the difference (W-Y) has been calculated it can be kept as the denominator when calculating both the base and current years. Therefore:

$$Z = W - Y$$

Where:

- Z = the value of the segment (in absolute terms) which ranges from 0 to 1 on the vector (in relative terms)

The formula for the indicator calculation therefore becomes: $I = (X - Y) / Z$

One can see in these two equations the importance of clearly defining the Y value, which corresponds to the sustainability objective, and W, which corresponds to a state of unsustainability. As the value between Y and W increase, the impact of variation of the variable (X) becomes less.
The next section presents the equation for each indicator as well as illustrative examples

II. SUSTAINABILITY INDICATORS AND PRACTICAL EXAMPLES

The indicators cover the following aspects:

- environmental
    - CO_2 emissions per capita (global pollution)
    - ambient energy-related emissions (local pollution)
- social
    - guaranteed access to electricity
    - investments in clean energy
- economic
    - energy resilience
    - burden of public energy investments
- technological
    - energy intensity
    - renewable energy deployment

- civic
    - o ***quality of information***
    - o ***participative governance***

Two indicators are used for each aspect of sustainability.[2] The selected indicators are presented followed by examples. In order to observe the progression of indicator 1990 is to be used as the reference year.[3]

It is recommended to review the examples carefully, not only to understand the equations but also to understand how the parameters are used in each of the equations.

INDICATOR DESCRIPTION

Indicators for Environmental Sustainability

Indicator 1 – Per capita energy sector carbon dioxide emissions

Parameters

X = emissions for current year and those for 1990
W = 1130kgC/capita (world average for 1990)
Y = 339 kgC/capita (3/10 the world's average for 1990)
Z = 791 kgC/capita

Equation: $I = (X - 339) / 791$

Example

- United States, 1995
  X = 5602 kg of carbon emitted per capita

  Indicator value "I" = (5602 – 339) / 791 = 6.654

  Given than per capita emissions are way above the world average in the majority of industralised countries and are the most elevated in the US, it is not surprising that the calculated value is so high. It also indicates that energy balance that is unsustainable

- Albania, 1995
  X = 141 kg carbon per capita emission

  Indicator value "I" = (141 – 339) / 791 = -0.250

[2] Sometimes it is necessary to use more than one parameter to calculate an indicator, as in the case with Indicator 2. In this instance, the final indicator value will be the average of two intermediary indicators.
[3] Signatories countries to the Kyoto Protocol agreed to limit their greenhouse gas emissions, relative to the levels emitted in 1990

Since this value is negative, it is already within the target of SEW. Albania therefore will be able to increase its emissions by continuing its economic growth or, better still, extend its economy without increasing its emissions. With the latter, the country has an asset or which could be "sold" on the international market via through negotiable permits or Joint Implementation projects.

Indicator 2 – Energy-related local pollutant

Parameters

X = selected pollutant for current year and for 1990
W = 1990 value
Y = 1/10 of 1990 value
Z = W – W/10 = 9W/10

Equation: I = (X – 0.1W) / 0.9W

Example

- United States, 1996 – single pollutant

  X(1996) = 42.8 kg of SO2 per capita
  W = 57.2 kg of SO2 per capita
  Y = 5.7 kg of SO2 per capita (equal to 1/10 of 1990 value)
  Z = 57.2 – 5.7 = 51.5 kg of SO2 per capita

  Indicator value "I" = (42.8 – 5.7) / 51.5 = 0.720

  The US reduced its sulfur emissions through trading of credits which reduced emissions at a faster rate and with lower anticipated costs.

Example

- China, 1995 - using the concentration of ambient pollutants and combining two pollutants to calculate an indicator.
  - combine the concentration of particulates in an urban area with the sulfur dioxide concentrations in Beijing
  - change the metric of the indicator so that
    - 1 = 100% of the World Health Organisation (WHO) maximum level for each pollutant
    - 0 = 20% of WHO maximum levels

WHO maximum levels for total particulate suspension:
W(PTS) = 50 µgr/m^3
W(SO_2) = 60 µgr/m^3

Objective:
Y(PTS) = 20% x 50 = 10 µgr/m^3
Y(SO_2) = 20% x 60 = 12 µgr/m^3

Ambient pollution levels in Beijing:
X(PTS) = 377 µgr/m^3
X(SO_2) = 90 µgr/m^3

Z(PTS) = W(PTS) – Y(PTS) = 50 – 10 = 40 µgr/m^3
Z(SO_2) = W(SO_2) – Y(SO_2) = 60 – 12 = 48 µgr/m^3

Vector value "I(PTS)" = (377 – 10) / 40 = 9.175
Vector value "I(SO_2)" = (90 – 12) / 48 = 1.625

Giving equal weight to each pollutant:

Indicator value "I" = (9.175+ 1.625) / 2 = 5.4

Social Sustainability

Indicator 3 – household access to electricity

Parameters

X = percentages of households who have access to electricity in current year and in 1990
W = 0% of households that have access to electricity
Y = 100% of households have access to electricity
Z = -1

Equation: I = (X – 100%) / -1

Example

- Brazil

37% of rural households have access to electricity.

Indicator value "I" = (37.017% - 100%) / -1 = 0.630

Indicator 4 – Investments in clean energy

Parameters

X = the ratio between investment between clean energy investment and the total investment in the energy sector
W = the value of X in 1990
Y = 95% of energy sector investment
Z = W – 95%

Equation: I = (X – 95%) / (W – 95%)

Example

- Elbonia, 1998

An imaginary country ELBONIA invested 10 billion euros in the energy sector in 1990 and 13 billion euros in 1998. Its investment in clean energy (renewable energy and energy efficiency) was 560 million euros in 1990 and 820 million euros in 1998.

W = 560 million euros/ 10 billion euros = 5.6 %
X (1998) = 820 million euros / 13 billion euros = 6.3%
Y = 95 %
Z = 5.6% - 95% = -89.4%

Indicator value "I" = (6.3% - 95%) / -89.4% = 0.992

Economic Sustainability

Indicator 5 – Energy resilience

Parameters - country that is a net importer of energy

X = ratio between imports of non-renewable energy and the consumption of non-renewable energy (in Joules)
W = 100%
Y = 0%
Z = 1

Equation: I = (X – 0%) / 1 = X

Parameters - country that is a net exporter of energy

X = ratio between the export of non-renewable energy and the value of all exports (in monetary value)
W = 100%
Y = 0%
Z = 1

Equation: I = (X – 0%) / 1 = X

Example - country dependent on energy importations

- United States, 1997

The imports of non-renewable energy were raised to 23.51EJ in 1997 (23.66 EJ minus 0.15 J of hydroelectricity imported from Canada). Energy consumption of non-renewable energy rose to 82.53 EJ.

Indicator value "I" = 23.51 / 82.53 = 0.285

Example - energy exporting country

- Norway, 1998

In 1998, Norway exported 17 billion euros of crude oil, petroleum products, natural gas and 2.6 billion euros of hydro-electricity. The total value of all these exports was equal to 47 billion euros. The ratio between the export of non-renewable energy and the value of all exports:

Indicator value "I" = 17 billion euros / 47 billion euros = 0.362

The indicator value of .362 illustrates that Norway's dependency on fossil fuel is low. By improving its national electric efficiency, via its hydroelectric capacity, Norway would be also be able to increase its renewable electricity exports.

Example - energy exporting country

- Saudi Arabia, 1997

This country exported 43.8 billion euros of oil and petroleum products while total level of exports topped 50.1 billion euros.

Indicator value "I" = 43.8 billon euros / 50.1 billion euros = 0.874

This vector value indicates a high vulnerability to price and demand fluctuations.

Indicator 6 – Burden of energy investments

Parameters

X = ratio between public investment in non-renewable energy and GDP
W = 10%
Y = 0%
Z = 0.1

Equation: I = (X – 0%) / 0.1 = 10X

Example

- India, 1995
  The Indian government invested 13.7 billion euros (this included multi-lateral aid) in building nuclear power and coal fired power stations, developing coal mines, performing research and development, developing oil and gas fields, refining, and energy transportation. India also invested an addition 3.4 billion euros in major hydroelectric and wind projects (these numbers are not part of the 13.7 billion). GDP of India in 1995 was 319.7 billion euros.

  Dividing 13.7 billion euros by the GDP = 13.7 billion euros/319.7 billion euros = 0.0429 or 4.29%

  Indicator value "I" = 10X = 10 x 0.0429 = 0.429

Technological Sustainability

Indicator 7 – energy productivity (energy consumption/GDP)

Parameters

X = ratio between energy consumption and GDP
W = 10.64 MJ/euros which corresponds to the average world consumption of primary energy per unit of GDP in 1990
Y = 1.06 MJ/euros which corresponds to 1/10 W
Z = 10.64 – 1.06 = 9.58

Equation: I = (X – 1.06) / 9.58

Example

- Canada, 1995
  Canada's energy productivity was X=16.39 MJ per euro of GDP

  Indicator value "I" = (16.39 – 1.06) / 9.58 = 1.600

  This is considerably higher than the 1990 world average of 10.64 MJ.

Example

- Israel, 1995
  In Israel, energy intensity was X = 6.12 MJ per euro of GDP, far lower than the world average of 10.64 MJ, but still higher than the sustainable level for energy productivity.

  Indicator value "I" = (6.12 – 1.06) / 9.58 = 0.528

Indicator 8 – Renewable energy deployment

Parameters

X = ratio between renewable energy consumption and total primary energy consumption
W = 8.64% which corresponds to the ratio between global consumption of renewable energy and total global consumption of primary energy for 1995
Y = 95%
Z = 8.64% - 95% = -0.8636

Equation: I = (X – 95%) / -0.8636

Example

- Cameroon, 1995

  Cameroon consumed 278 PJ of primary energy, of which 222 PJ is supplied by "renewables", primarily biomass.

  The proportion of renewable energy is X = 222 PJ / 278 PJ = 0.7986 or 79.86%

  Indicator value "I" = (79.86% - 95%) / (-0.8636) = -0.1514 / -0.8636 = 0.175

  This is a value close to the desired objective (of zero)

Example

- Japan, 1997

  Primary energy production in Japan was around 23.387 EJ with renewable energy production around 1.001 EJ.

  The proportion of renewable energy: X= 1.001 EJ/23.387EJ = 0.0428 or 4.28%

  Indicator value "I" = (4.28% - 95%) / (-0.8636) = -0.9072 / -0.8636 = 1.050

  This value is well above the sustainability level of zero so therefore unsustainable.

Indicators for Civic Sustainability (Governance)

Indicator 9 – quality of information

Measured by the early dissemination of quality information allowing the equality of participation by independent bodies and energy agents (as demand and supply sides)

Vector:

- 1: 1990 budget of local/national environmental NGOs
- 0: Information and PR budget of energy agencies are equal to the budget of local/national NGOs

Indicator 10 – participative governance

Measured by the number of independent bodies and ENGOs on the boards of energy agencies

Vector:

- 1: 1990 proportion of independent members on energy agencies Boards of Administration
- 0: equal number of both shareholders and independent members