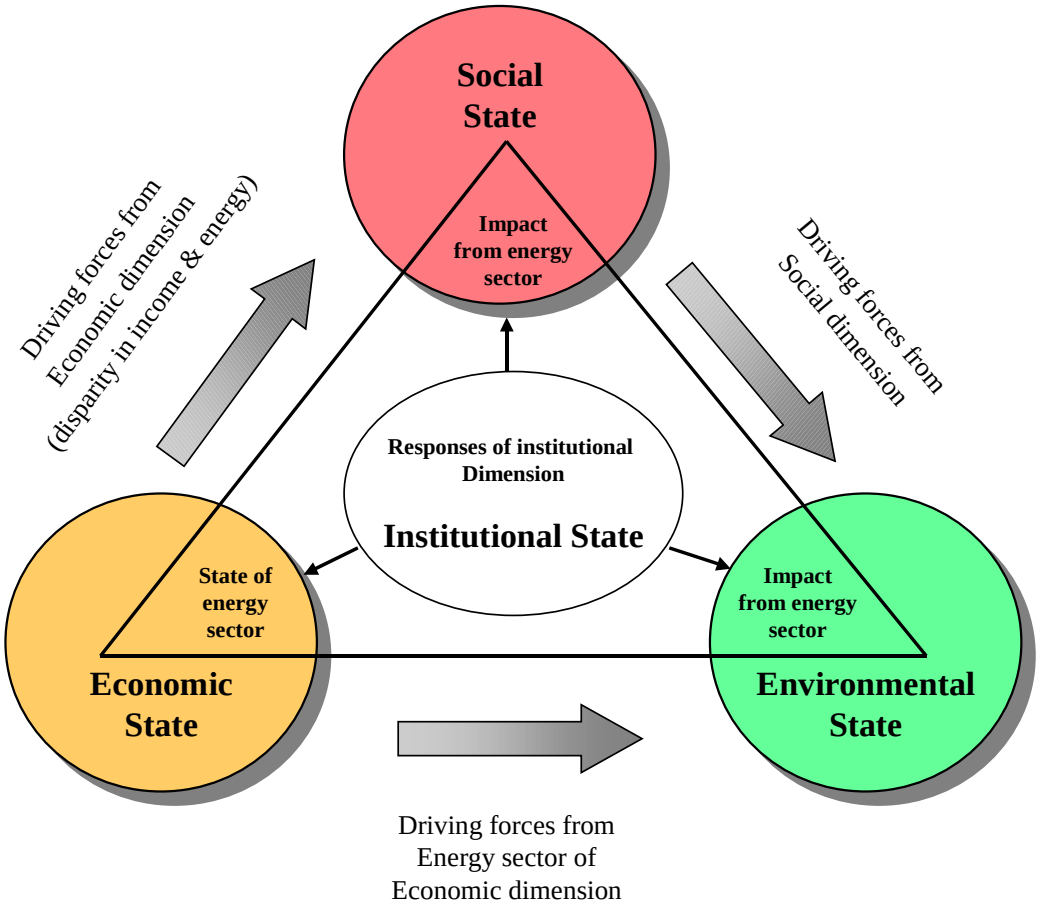
International Atomic
Energy Agency

International
Energy Agency

Indicators for Sustainable Energy Development



Indicators for Sustainable Energy Development

Energy in the Context of Sustainable Development

Agenda 21, the Rio Declaration on Environment and Development, was adopted by the United Nations Conference on Environment and Development (UNCED: the *Earth Summit*) in Rio de Janeiro, Brazil in 1992. The theme of this document is sustainable development as a focus for addressing the pressing problems of today and preparing the world for the challenges of the next century. Agenda 21 covers all issues that have significant bearing on one or more of the four key dimensions of sustainability, namely social, economic, environmental and institutional. One of these significant issues is energy.

Energy is an essential input for social development and economic growth. It provides basic needs and services such as heating, cooling, cooking, lighting, and transportation and is a critical production factor in virtually all sectors of industry. At the same time, the production and use of energy cause environmental degradation at all levels - local, regional and global. For example, combustion of fossil fuels and fuelwood leads to indoor and outdoor air pollution by particulates and oxides of sulphur and nitrogen; hydropower often causes environmental damage due to the submergence of large areas of land; and global climate change associated with the increasing concentration of greenhouse gases in the atmosphere has become a world-wide concern today. Natural resource depletion, accumulation of wastes, deforestation, water pollution and land disturbance are further examples of energy-related environmental concerns.

Moreover, there are large disparities in the level of energy consumption, not only among different countries, but also among the rich and poor in the same country. It is noteworthy that nearly 1.6 billion people still have no access to electricity or other forms of commercial energy and that the richest 20% of the world's population use 55% of primary energy, while the poorest 20% use only 5%. Globally, the demand for energy is increasing in consonance with socio-economic development. While the sustainability of the supply capacity of the earth's fossil fuel resources is not an issue for the foreseeable future, the security of supply and continued uninterrupted availability of imported energy is an immediate concern for countries short of indigenous energy sources, particularly those that are heavily dependent on oil and gas imports.

Thus the provision of adequate energy services at affordable costs, in a secure and environmentally benign manner, and in conformity with social and economic developmental needs, is an essential element of sustainable development. This was recognised by Agenda 21. In this connection, Chapter 9 of the Agenda clearly states:

> *"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."*

The 19th Special Session of the UN General Assembly held in 1997 (Earth Summit + 5) emphasised the importance of sustainable energy development in meeting the objectives of Agenda 21, selecting Atmosphere/Energy as the sectoral theme and Energy and Transport as the economic sectors/major groups, for the 9th session of the United Nations Commission on Sustainable Development to be held in April 2001 (CSD-9).

Although the objectives of sustainable development are very broad, one still needs a set of quantifiable parameters (*indicators*) to measure and monitor important changes and significant

progress towards the achievement of these objectives. Accordingly, ever since the publication of the *Brundtland Report,* "Our Common Future," in 1987 by the World Commission on Environment and Development (WCED, 1987), various international and national organisations have been developing sets of indicators that would measure and assess one or more aspects of sustainable development. These efforts received a major boost following the adoption of Agenda 21 by the Earth Summit in 1992, which specifically (Chapter 40) asks countries and international governmental and non-governmental organisations to develop the concept of Indicators of Sustainable Development (ISD).

Starting in 1995 the United Nations Work Programme on Indicators of Sustainable Development (WPISD) produced a core set of ISD covering the environmental, social, economic and institutional dimensions of sustainable development, including several energy related indicators. (UN, 1996; DSD, 2000) It also devised the Driving Force/State/Response (DSR) framework now widely applied for indicators (UN, 1996). Several energy-related indicators have been also developed as part of the Organisation of Economic Cooperation and Development (OECD) (OECD, 1993; OECD, 1998; OECD, 1999; OECD, 2000) and EUROSTAT (EC, 1999a; EC, 1999b; EEA, 1999) work on environmental indicators. Supplementing these efforts is the work of the International Energy Agency (IEA) of the OECD on disaggregated indicators of energy use and efficiency in various economic sectors and the corresponding carbon emissions (IEA, 1997a, IEA, 1997b; Schipper *et.al.*, 2000; Unander and Schipper, 2000). And a few indicators specifically referring to the energy sector were identified by the Division of Sustainable Development of the United Nations Department of Economic and Social Affairs (DSD/DESA) (DSD, 1998).

But these and other national efforts, as described more fully below, focus on the environmental dimension of sustainability, and even that information is scattered. None of these efforts has focussed on indicators for sustainable energy development (ISED). A comprehensive treatment of the energy sector encompassing all four dimensions of sustainability is needed. This need is further underscored by the emphasis placed on the energy sector in the 'Programme for the Further Implementation of Agenda 21' adopted by the Earth Summit + 5 in 1997, together with the decision that energy issues will be a main theme/sector of the 9th session of the CSD in 2001.

Development of ISED

In view of the need for a comprehensive set of indicators specifically addressing the energy sector, a project on "Indicators for Sustainable Energy Development" (ISED) was initiated by the International Atomic Energy Agency (IAEA) in 1999. The project is part of the Agency's work programme on Sustainable Energy Development and has the following main objectives:

1. to supplement the general indicators of sustainable development (ISD) being developed by WPISD by
    - identifying the main issues to be addressed in connection with sustainable energy development,
    - deriving a set of appropriate indicators for measuring and monitoring these issues so far as they relate to sustainable energy development, and
    - assigning them *Driving Force* and *State* character in close conformity with the DSR framework, and identifying a set of desirable *Response Actions* for improving the sustainability of energy sector development; and.
2. to allow the use of ISED for
    - making necessary modifications to the relevant IAEA databases and analytical tools so as to make them more responsive to sustainable energy development issues, and
    - structuring assistance to Member States in the formulation of their energy strategies in conformity with the objectives of sustainable development.

These objectives have been and are being pursued with the help of experts from various international organisations (IEA, NEA/OECD, EC, DSD/UN-DESA, UN-ECE, UNEP, UNESCO) and Member States (France, Germany, the Netherlands, India, Pakistan, Russia, Switzerland, USA).

Main Issues

The following 16 topics have been identified as the main issues to be addressed in connection with sustainable energy development under different dimensions of sustainability:

Social dimension:

- Energy disparities
- Energy affordability and accessibility

Economic dimension:

- Economic activity levels
- Energy production, supply and consumption
- Energy pricing, taxation and subsidies
- End-use energy intensities
- Energy supply efficiency
- Energy security

Environmental dimension:

- Global climate change
- Air pollution
- Water pollution
- Wastes
- Energy resource depletion
- Land use
- Accident risks
- Deforestation

Institutional dimension:

- All of the above issues taken individually as well as collectively

Figure 1 is a simplified illustration of the interrelations between these various sustainability dimensions of the energy system. The environmental state associated with the energy system results from the impact of driving forces originating from the economic and social dimensions of the energy system. The social state of the energy system is, in turn, influenced by certain driving forces originating from the economic dimension of the energy system. The institutional dimension can affect all three other dimensions - social, economic and environmental – through corrective response policy actions affecting the sustainability of the whole energy system.

Model Framework

A new conceptual model, specifically tuned to the energy sector, was developed to identify and categorise ISED in a framework consonant with the environmental models of the OECD, the EC, and the IEA. The new model is based on the “cause, symptom, and solution” approach, in close conformity with the DSR framework, and incorporates all the four dimensions of sustainable development. It provides a systematic scheme for identifying the cross linkages among various indicators of sustainable energy development (IAEA, 2000).

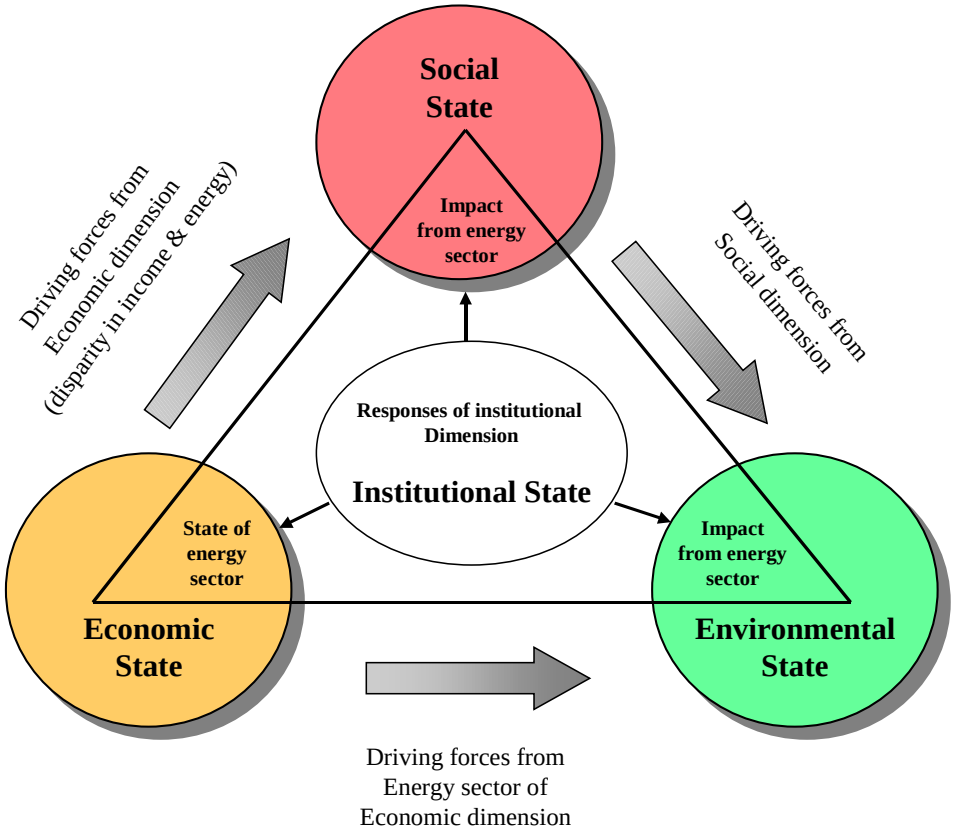


Figure 1: Interrelations between sustainability dimensions of the energy sector.

Figures 2 and 3 show the conceptual ISED model, which arranges the identified DSR indicators and the links among them according to the economic, social and environmental dimensions of sustainability. The indicators identified for the institutional dimension are classified only as corrective policy measures or Response Actions, determined by the indicators of the State of the institutional dimension, together with the State indicators of the other three sustainability dimensions.

The *Driving Force* indicators in this framework have been split into two sub-categories: *Direct Driving Forces* and *Indirect Driving Forces*. This allows a distinction to be made between the factors which have a direct influence on the *State* indicators (*Direct Driving Forces*) and those (*Indirect Driving Forces*) which affect the *State* indicators indirectly by influencing one or more *Direct Driving Forces.* Besides providing a better understanding of the inter-linkages among various indicators, this approach is helpful in keeping the number of *Direct Driving Force* indicators limited for each dimension of sustainability. The model also helps identify for each *Response Action* (with a few exceptions) the primary target *Driving Force* indicator of the corresponding sustainability dimension as well as the set of other *Driving Force* and *State* indicators on which the *Response Action* would have a positive impact.

List of ISED

The effort to identify and categorise ISED went through several iterations. A provisional list of ISED was discussed at the International Workshop on CSD Indicators of Sustainable Development held in Barbados from 6 to 8 December 1999. Later on the list was subjected to an informal testing by volunteering groups of energy system analysts in 15 countries. The teams participating in this exercise were from Argentina, Bulgaria, China, Croatia, Cuba, Germany, the Netherlands, Indonesia, Lithuania, Mexico, Pakistan, Russia, Slovakia, Turkey and the USA. For this exercise, several of the ISED were disaggregated, as necessary, into a number of component indicators and the country teams were asked to provide data for the year 1995 for about 200 indicators. The aim was to determine what could be achieved with reasonable effort. The response was encouraging. On average the participating teams filled in

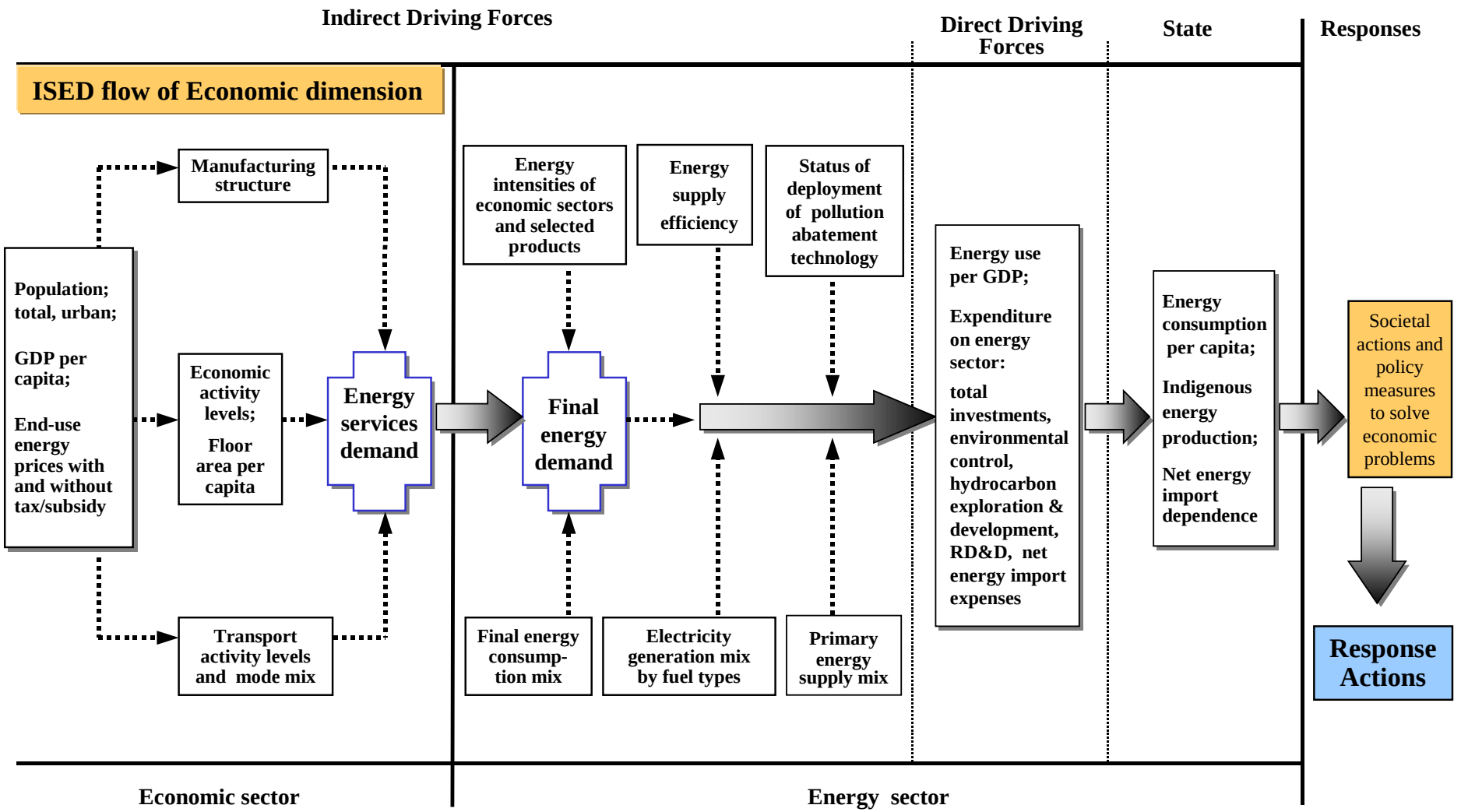


Figure 2: Conceptual framework identifying ISED linkages of Economic dimension

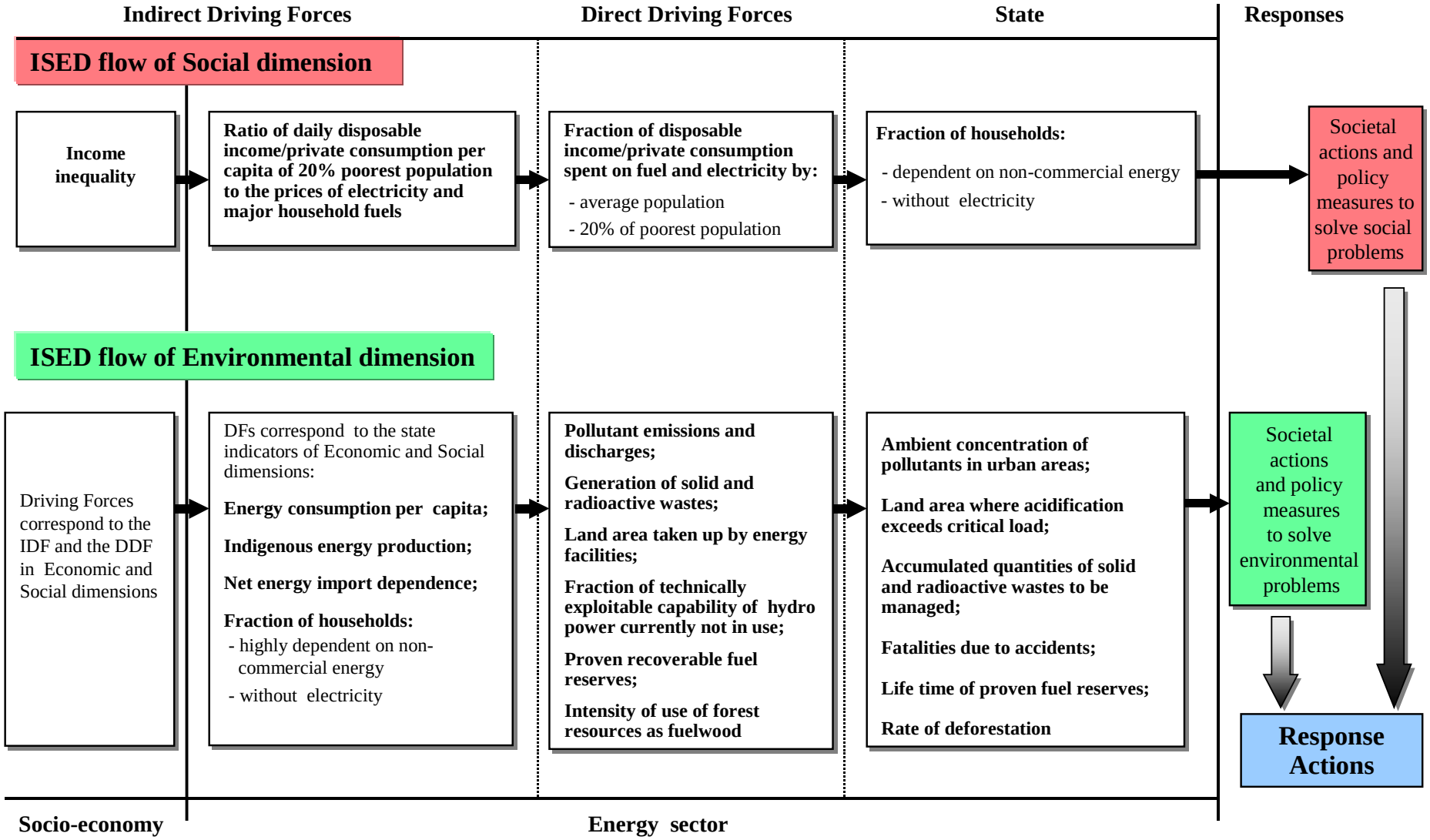


Figure 3: Conceptual framework identifying ISED linkages of Social and Environmental dimensions

67% of the required entries, with the maximum being 82%. The average was the same (67%) for the five OECD countries (Germany, the Netherlands, Mexico, Turkey and the US) as well as for the remaining ten non-OECD countries. The country teams also provided comments and suggestions about the clarity and conformity of the indicators with available national data sources. In light of these responses the provisional list of ISED was revised in line with the criteria used by WPISD in the selection of the more general ISD.

A compact version of the ISED list is given in Box I.

Box 1: List of ISED: compact form (Core ISED in bold font)

1. Population: total; urban ⊕ ♥
2. GDP per capita ⊕ ♥
3. **End-use energy prices with and without tax/subsidy ♦ ♥ ♠**
4. Shares of sectors in GDP value added ⊕ ♥
5. Distance travelled per capita ⊕ ♦ ♥ ♠: total, by urban public transport mode
6. Freight transport activity ♦ ♥: total, by mode
7. Floor area per capita ⊕
8. Manufacturing value added by selected energy intensive industries ⊕
9. **Energy intensity ⊕ ♦ ♠ : manufacturing, transportation, agriculture, commercial & public services, residential sector**
10. Final energy intensity of selected energy intensive products ♦ ♠
11. **Energy mix ⊕ ♦ ♠: final energy, electricity generation, primary energy supply**
12. **Energy supply efficiency ♠: fossil fuel efficiency for electricity generation**
13. Status of deployment of pollution abatement technologies: extent of use, average performance
14. **Energy use per unit of GDP ⊕ ♦ ♥ ♠**
15. **Expenditure on energy sector: total investments, environmental control ⊕ , hydrocarbon exploration & development, RD&D ⊕, net energy import expenses**
16. **Energy consumption per capita ⊕ ♦ ♥ ♠**
17. **Indigenous energy production ♥ ♠**
18. **Net energy import dependence ♠**
19. Income inequality ⊕
20. Ratio of daily disposable income/ private consumption per capita of 20% poorest population to the prices of electricity and major household fuels
21. **Fraction of disposable income/ private consumption spent on fuel and electricity by: average population ♦ ; group of 20% poorest population**
22. **Fraction of households: heavily dependent on non-commercial energy; without electricity**
23. **Quantities of air pollutant emissions ⊕ ♦ ♥ ♠ (SO_2, NO_x, particulates, CO, VOC)**
24. **Ambient concentration of pollutants in urban areas ⊕ ♥ : SO_2, NO_x, suspended particulates, CO, ozone**
25. Land area where acidification exceeds critical load
26. **Quantities of greenhouse gas emissions ⊕ ♦ ♥ ♠**
27. Radionuclides in atmospheric radioactive discharges ♠ ♣
28. Discharges into water basins ♥: waste/storm water, radionuclides, oil into coastal waters ⊕ ♠
29. **Generation of solid waste ⊕ ♦ ♥ ♠**
30. **Accumulated quantity of solid wastes to be managed**
31. **Generation of radioactive waste ⊕ ♥ ♣**
32. **Accumulated quantity of radio-active wastes awaiting disposal ♣**
33. **Land area taken up by energy facilities and infrastructure ⊕**
34. **Fatalities due to accidents with breakdown by fuel chains**
35. **Fraction of technically exploitable capability of hydropower currently not in use**
36. **Proven recoverable fossil fuel reserves ⊕**
37. Life time of proven fossil fuel reserves ⊕
38. Proven uranium reserves ⊕
39. Life time of proven uranium reserves ⊕
40. **Intensity of use of forest resources as fuelwood ⊕**
41. Rate of deforestation ⊕ ♦ ♥ ♠

⊕ marks ISED which correspond to ISD in the UN-CSD Working list/Core list;
♦ marks ISED which correspond to ISD in the DSD/DESA Provisional list for Chapter 4 of Agenda 21;
♥ marks ISED which correspond to OECD Core Set of Environmental Indicators and related Socio-economic Indicators;
♠ marks ISED which correspond to EC list of Environmental Indicators and Indicators for Integrating Environmental Considerations into energy Policies;
♣ marks ISED which correspond to IAEA Indicators for Radioactive Waste Management.

Table I assigns each of these 41 ISED as appropriate to the economic, social and environmental dimensions, organised in the DSR framework on the basis of the conceptual model shown in Figures 2 and 3. It comprises 15 Indirect Driving Force indicators, 14 Direct Driving Force indicators and 12 State indicators. The indicators written in bold in Box 1 and Table I are considered most significant from the point of view of sustainable energy development and may be taken as the core ISED. Thus there are 23 core ISED of which 4 are Indirect Driving Force indicators, 10 Direct Driving Force indicators and 9 State indicators.

Indicators are primarily important as a guide for policy making and for measuring progress in policy implementation. Linking indicators to relevant policy responses is therefore an important and particular aspect of the ISED. Table II lists a number of identified Response Actions and their primary targeted Driving Force indicators. The Response Actions targeting indicators No. 1-15 correspond to the economic dimension and those targeting indicators No. 29-40 correspond to the environmental dimension The last four Response Actions, for which there is no clearly identified targeted Driving Force indicator, relate to the institutional dimension. The last column of the table lists the indicators other than the targeted indicator, that are also likely to be positively affected by any particular Response Action.

Response Actions

Figure 4 shows schematically the multilevel linkages among the ISED (identified by their serial numbers in Box 1 and Table I) and the tie-in of appropriate Response Actions to the targeted Driving Force indicators. As is illustrated, the identified Response Actions are targeted on a few selected key Driving Force (DF) indicators, among which the sensitive points in the economic dimension are DF-3 (pricing indicator), DF –4,5,8 (economic activity levels), DF–9,10 (end-use energy efficiency), DF-11 (fuel mix), DF-12 (energy supply efficiency), DF-13 (status of abatement technology), and DF-15 (expenditure on energy sector). Some Response Actions have a purely environmental character and are targeted on Driving Force indicators of the environmental dimension: DF-29 (generation of solid waste), DF-31 (generation of radioactive waste), DF-33 (land area taken up by energy facilities) and DF–40 (intensity of use of forest resources as fuelwood).

Figure 5 illustrates how a particular Response action (in this case introduction of taxes on polluting fuels) targeted on an individual indicator (in this case energy prices) could positively affect a number of other indicators, of the same as well as other dimensions, through a chain of influences.

Other Relevant Work

The development of the ISED has built in part on the work of other institutions also responding to the objectives of Agenda 21. These are described below highlighting their relevance to the development of ISED.

IEA

The work on ISED and work by the International Energy Agency (IEA) of the OECD are highly complementary. Since 1995 the IEA has been engaged in analysing indicators of energy use and efficiency in its Member countries and linking them to carbon emissions (IEA, 1997a; IEA, 1997b; Schipper *et.al.*, 2000; Unander and Schipper, 2000). A notable feature of the IEA approach is that the sectoral intensities of energy use and CO_2 emissions are analysed at a very disaggregated level, thereby helping to understand the link between energy and human and economic activities and that between energy and CO_2 emissions. This also shows how economic and technical driving factors, like energy prices, economic growth and new technologies shape energy use, and therefore determine CO_2 emissions. The IEA has also

Table 1: List of ISED: Economic and Social dimensions (core ISED in bold font)

Driving Force			State
Indirect	**Indirect within energy sector**	**Direct**	
Economic Dimension			
1. Population: total/urban ⊕ ♥ 2. GDP per capita ⊕ ♥ **3. End-use energy prices with and without tax/subsidy ♦ ♥ ♠: for households, industry, automotive fuels** 4. Shares of sectors in GDP value added ⊕ ♥: manufacturing, transportation, agriculture, commercial & public services 5. Distance traveled per capita ⊕ ♦ ♥ ♠: total, by urban public transport 6. Freight transport activity ♦ ♥ : total, by transport mode 7. Floor area per capita ⊕ 8. Manufacturing value added by selected energy intensive industries ⊕	**9. Energy intensity ⊕ ♦ ♠: manufacturing, transportation, agriculture, commercial & public services, residential sector** 10. Final energy intensity of selected energy intensive products ♦ ♠ **11. Energy mix ⊕ ♦ ♠ : final energy consumption, electricity generation by fuels types, primary energy supply** **12. Energy supply efficiency ♠: ratio of TFC to TPES, fossil fuel efficiency for electricity generation, losses in gas transportation and electricity transmission , percentage of CHP in electricity generation, oil refining efficiency** 13. Status of deployment of pollution abatement technologies: extent of use, average performance	**14. Energy use per unit of GDP ⊕ ♦ ♥ ♠ : total primary energy, primary conventional energy, electricity** **15. Expenditure on energy sector: total investments, environmental control ⊕ , hydrocarbon exploration and development, RD&D ⊕, net energy import expenses**	**16. Energy consumption per capita ⊕ ♦ ♥ ♠ : total primary energy, automotive fuel, CRW, electricity** **17. Indigenous energy production ♥ ♠: total primary energy, shares of fuel types and CRW, electricity** **18. Net energy import dependence ♠: total primary energy, total conventional energy, fossil fuels by type, electricity**
Social Dimension			
ENERGY ACCESSIBILITY AND AFFORDABILITY 19. Income inequality ⊕	20. Ratio of daily disposable income/private consumption per capita of 20% poorest households to the prices of electricity and major household fuels	**21. Fraction of disposable income/ private consumption per capita spent on fuel and electricity by:** • **average population ♦** • **group of 20% poorest population**	**22. Fraction of households:** • **heavily dependent on non-commercial energy** • **without electricity**

Table 1 (cont'd): List of ISED: Environmental dimension (core ISED in bold font)

Driving Force		State
Indirect	**Direct**	
Environmental Dimension		
The relevant indicators are covered in the subsets of Driving Force and State indicators of the Economic and Social dimensions	AIR POLLUTION: **23. Quantities of air pollutant emissions ⊕ ♦ ♥ ♠ : SO_2, NO_x, particulates, CO, VOC** **26. Quantities of greenhouse gas emissions ⊕ ♦ ♥ ♠ : total, from electricity generation, from transportation** 27. Radionuclides in atmospheric radioactive discharges ♠ ♣ WATER POLLUTION: 28. Discharges into water basins ♥ : waste/storm water, radionuclides, oil into coastal waters ⊕ ♠ WASTE: **29. Generation of solid waste ⊕ ♦ ♥ ♠** **31. Generation of radioactive waste from nuclear power fuel cycle chain ⊕ ♥ ♣** LAND **33. Land area taken up by energy facilities/infrastructure ⊕** ACCIDENT RISKS ENERGY RESOURCES DEPLETION **35. Fraction of technically exploitable capability of hydropower currently in use** **36. Proven recoverable fossil fuel reserves ⊕** 38. Proven uranium reserves ⊕ DEFORESTATION **40. Intensity of use of forest resources as fuelwood ⊕**	**24. Ambient concentration of pollutants in urban areas ⊕ ♥: SO_2, NO_x, CO, suspended particulates, ozone** 25. Land area where acidification exceeds critical load **30. Accumulated quantity of solid wastes to be managed** **32. Accumulated quantity of radioactive wastes awaiting disposal ♣** **34. Fatalities due to accidents with breakdown by fuel chain** 37. Life time of proven fossil fuel reserves ⊕ 39. Life time of proven uranium reserves ⊕ 41. Rate of deforestation ⊕ ♦ ♥ ♠

Table 2: Response actions with targeted and positively affected ISED

Targeted indicator	Response Action	Positively affected indicators
3: End-use energy prices with and without tax/subsidy	Introduce taxes on polluting fuels	5-7,9,10,14-16,18,23-30
	Include externalities in full cost of energy	5-7,9,10, 13-16, 18, 23-39
	Eliminate energy subsidies except for the poor population	5-7,9,10,14-18,23-34,36-39
	Provide energy subsidies to the poor population	20-22, 40, 41
4, 8: Shares of sectors and sub-sectors in GDP value added	Optimise economic activity levels through reducing shares of energy intensive sectors/manufacturing industries	8,9,14-18,23-34,36-39
5: Distance travelled per capita by transport mode	Increase share of public transport in passenger travel	9,15-18,23-26,28,36,37
	Increase share of electrically driven public vehicles in passenger travel	24
9, 10: Energy intensity of economic sectors and selected energy intensive products	Decrease energy intensities through end-use energy efficiency improvement	14-18, 21-34, 36-41
11: Energy mix	Diversify energy supply	15, 18
	Increase share of renewables in fuel mix	15, 18, 20-32, 34-41
	Increase share of natural gas in fuel mix	12, 15, 23-34
	Increase share of nuclear in fuel mix	23-26, 28-30, 34, 36, 37
12: Energy supply efficiency	Increase efficiency of energy supply, in particular for electricity generation	14-18, 23-39
	Increase fraction of electricity supplied by CHP plants	14-18,23-26,28-30,33,36,37
13: Status of deployment of pollution abatement technologies	Improve performance of pollution abatement technologies	23-25
	Extend use of pollution abatement technologies	23-25

Table 2 (cont'd): Response actions with targeted and positively affected ISED

Targeted indicator	Response Action	Positively affected indicators
15: Expenditure on energy sector	Increase expenditure on hydrocarbon exploration and development	17, 18, 36, 37
	Increase expenditure on radioactive waste management	31-33
	Increase expenditure on waste management	29-33
	Increase expenditure on air pollution abatement	13, 23-25
	Increase RD&D expenditure for energy technology	9,10,12-14,16-18,21-41
29: Generation of solid waste	Decrease amounts of waste through recycling and reuse	30, 33, 36, 37
31: Generation of radioactive waste from nuclear power fuel cycle chain	Decrease amounts of radioactive waste through its recycling, treatment and conditioning	32, 38, 39
33. Land area taken up by energy facilities and infrastructure	Extend protected area as a percent of total land area	40, 41
40. Intensity of use forest resources as fuelwood	Extend managed forest area	41
	Develop National Sustainable Development strategy	1, 5-10, 12-41
	Ratify and implement global agreements	23, 26
	Strengthen environmental regulations	13, 23-32
	Strengthen safety regulations	28, 34

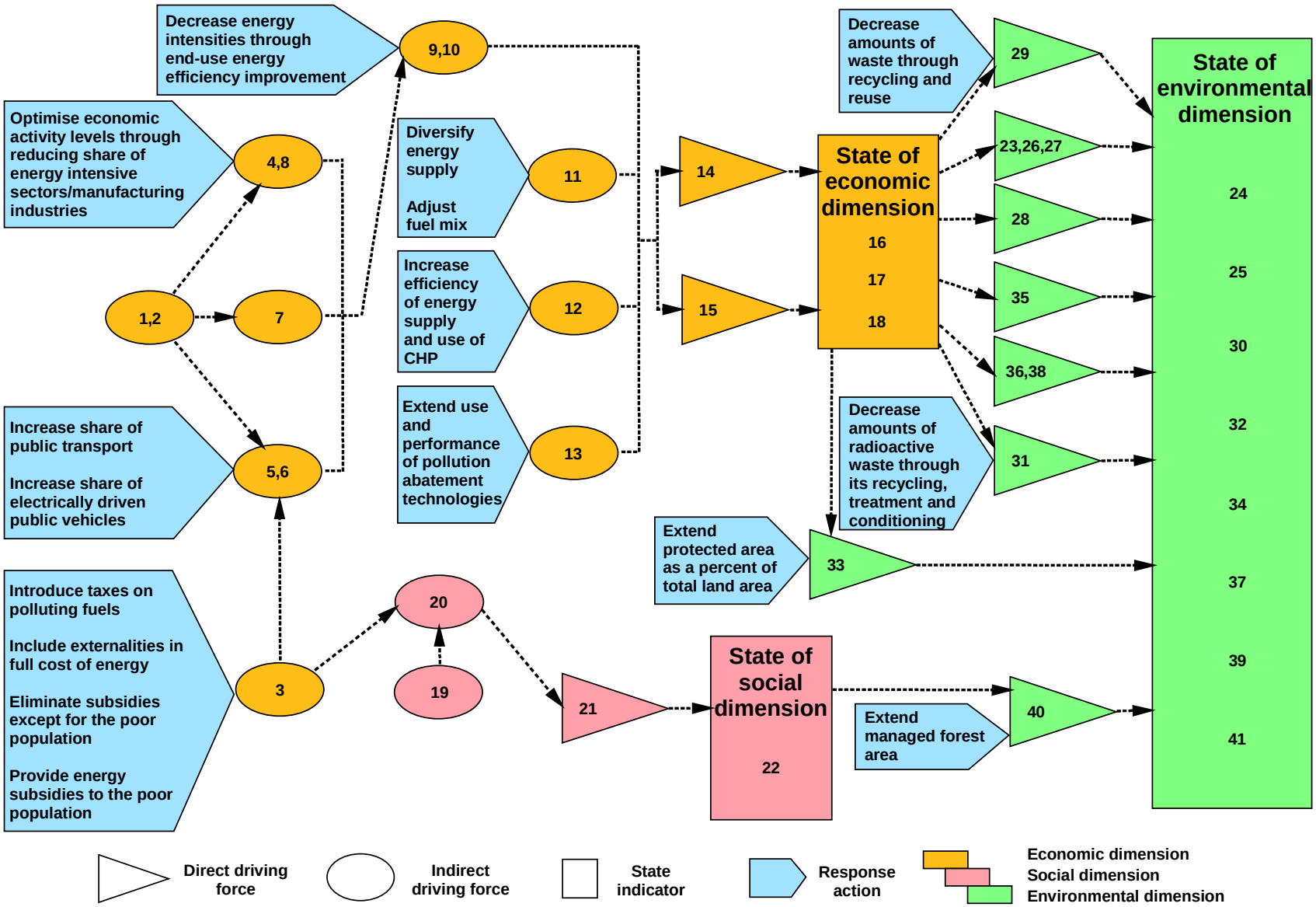


Figure 4: Linkages among various indicators and response actions

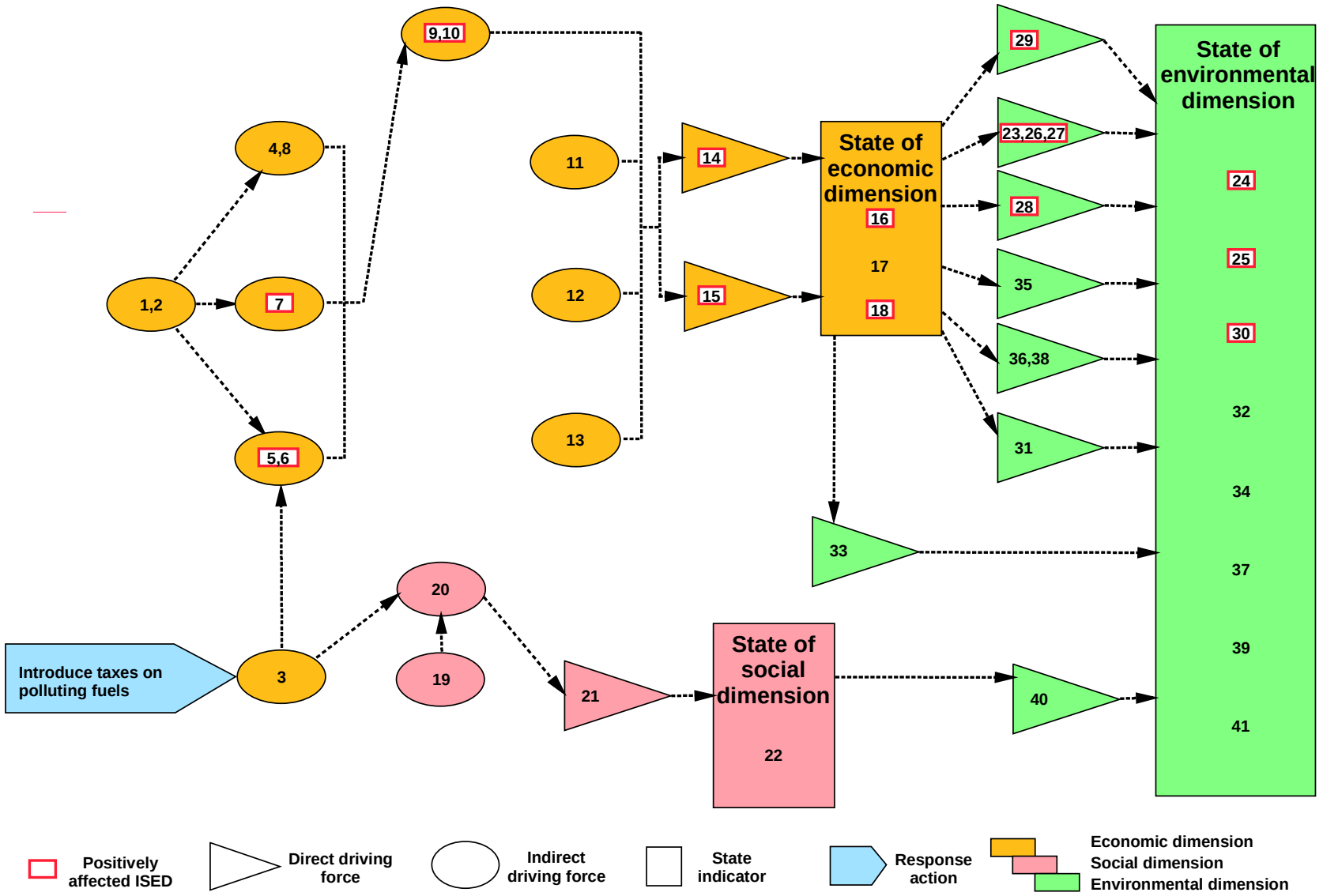


Figure 5: Example of positively affected ISED due to one response action

developed a “Model of Energy/Emissions Indicators,” which portrays the links between the general economy and the demands of individuals and companies for energy service, the energy system required to supply these services and the resulting emissions. This model has also been linked to the PSR framework to address sustainable energy development (Unander and Schipper, 2000).

The IEA has worked with many of its Member countries to develop energy indicator data and has thus developed a data base that has been quite useful for a number of analytic studies both within the IEA and by others. The IEA has also worked with many non-Member countries (see below) to determine the feasibility of developing energy indicator data. They propose to work jointly with the IAEA in subsequent phases of such projects to develop a more global data base for the analysis of sustainable energy development trends and issues. The use of ISED to develop such trends is particularly interesting.

OECD

Over the last ten years, the OECD has done some pioneering work in the area of environmental indicators. This includes: a core set of around 50 environmental indicators; indicators derived from environmental accounting; and several sets of sectoral indicators (e.g. transport-environment indicators, energy-environment indicators, agriculture-environment indicators) (OECD, 1993; OECD, 1998; OECD, 1999; OECD, 2000). The energy-environment indicators were developed to promote the integration of environmental concerns into energy policy making in OECD countries. The themes addressed by these energy-environment indicators include: (i) energy sector trends of environmental significance, (ii) environmental impacts of the energy sector with respect to pollution and natural resource use, and (iii) economic linkages between energy and the environment. Data are provided (OECD, 1993; OECD, 1998) on time trends for major indicators from a core set (for climate change, air quality, water quality, forest resources, and biodiversity) as well as selected socio-economic and sectoral indicators with environmental significance for OECD Member countries.

The OECD also developed the “Pressure-State-Response” (PSR) model for categorising the nature of different environmental indicators. In this conceptual framework the indicators for environmental *pressures* describe ‘direct’ and ‘indirect’ pressures from human activities exerted on the environment, including natural resources. The indicators for the environmental *state* relate to the quality of the environment and the quality and quantity of natural resources. The indicators for societal *responses* measure how society responds to environmental concerns through individual and collective actions and reactions. The core set of environmental indicators reported by the OECD has been categorised in accordance with this PSR approach (OECD, 1998; OECD, 2000).

The OECD also develops indicators relevant for the social and economic dimension of sustainable development. Since the OECD provides economic statistics covering national accounts, trade, prices, balance of payments and finance, it is in a good position to collect and disseminate measures of sustainability. These indicators provide a tool for assessing the need for and effectiveness of measures to improve social welfare. A provisional listing has been developed which reflects current social policy concerns and objectives – promoting autonomy, equity, healthy living and social cohesion.

In 1998 OECD started a three-year project to prepare a report on analytical issues related to sustainable development. An important part of this work addresses methods for measuring sustainable development focussing on accounting frameworks and analytical frameworks based on environmental, economic and social indicators. The final report will be published mid-2001 (OECD, 1999).

United Nations

Under the WPISD, and in collaboration with a large number of governments, intergovernmental and non-governmental organisations, the CSD in 1996 developed a preliminary working list of 134 ISD covering the various chapters of Agenda 21 (UN, 1996). Originally, the indicators were categorised using the Driving Force-State-Response (DSR) framework, which is adapted

from the Pressure-State-Response framework developed by the OECD (see above). The term "pressure" was replaced by "Driving Force" to go beyond purely environmental aspects of sustainability and to also reflect the other three dimensions of sustainable development. In this framework the "*Driving Force*" indicators encompass human activities, processes and patterns that have an impact, positive or negative, on sustainable development.

This working list of indicators was tested by 22 countries and subsequently reviewed by expert groups. The WPISD has since modified and narrowed down the list to a set of 59 core indicators but has chosen not to reflect them in the DSR framework (DSD, 2000). It should be emphasised that the WPISD does not intend to provide a comprehensive set of ISD but only a core set to which other indicators, or sets of indicators covering particular aspects of sustainable development, may be added (DSD, 1998). As such, the WPISD working list and core set of ISD do not comprehensively cover sustainable energy development and do not include many important indicators that are relevant to sustainable energy development

In connection with this effort, the IAEA developed a set of seven indicators covering the environmental issues related to radioactive waste management (Chapter 22 of Agenda 21) and categorised according to the DSR framework (IAEA, 1999).

In 1998, the Division of Sustainable Development of the United Nations Department of Economic and Social Affairs (DSD/DESA) identified a set of 43 key indicators and a provisional core set of 17 indicators for measuring changes in consumption and production patterns (IMCCPP) of all "key resources" (energy, materials, water, and land); and "consumption clusters" (mobility, consumer goods and services, buildings and housekeeping, food, and recreation) (DSD, 1998). After testing by national governments and international organisations, some of the indicators in the provisional core set of IMCCPP have been included in the WPISD's core set of ISD.

<u>European Union</u>

Environmental indicators are being developed by the Statistical Office of the European Union (EUROSTAT) and the European Environment Agency (EEA). These organisations have adapted and extended the PSR approach of the OECD into a new model called the Driving Force-Pressure-State-Impact-Response (DPSIR) model, with the definitions: *Driving Forces*: basic sectoral trends; *Pressure*: human activities directly affecting the environment; *State*: observable changes of the environment; *Impact*: effects of a changed environment; and *Response*: response of society to solve the problem (EC, 1999a, EEA, 1999). The indicators dealing with *Driving Forces, Pressure and Response* are being developed by EUROSTAT, while those covering *State* and *Impact* are being handled by the EEA.

In 1999 EUROSTAT reported historical data for two types of indicators for Member countries of the European Union. First was a set of indicators specifically focussed on integrating environmental considerations into energy policies relating to security of supply, diversity of supplies, energy efficiency, energy prices, and energy and the environment (EC, 1999b). Second was a set of 60 more general environmental pressure indicators comprising six indicators for each of the ten main themes identified in the Fifth Environmental Action Plan of the European Union (EC, 1999a). These are: air pollution; climate change; loss of biodiversity; marine environment and coastal zones; ozone layer depletion; resource depletion; dispersion of toxic substances; urban environmental problems; waste; water pollution and water resources. Some indicators included in this more general set but not in the energy-specific set, are also relevant for the energy sector.

Under the SAVE programme of the European Commission, the EU countries and Norway are collaborating to develop a set of detailed energy efficiency indicators (ADEME, 1999). EUROSTAT is co-operating with this project to collect data that will be used to establish an official set of core energy efficiency indicators for the European Union. The EU efforts are similar to those of the IEA and the two organisations are collaborating closely in harmonising data collection and reporting of energy indicators.

National Efforts

Sustainable development indicators adjusted for specific national situations have also been developed, or are being developed, by a number of countries such as the UK, the US, Canada, France, the Netherlands, and the Nordic countries. By and large, all these efforts make use of the PSR and DPSIR approaches in identifying and categorising various appropriate indicators.

Correspondence of ISED with Other SD Indicators

Table III compares the correspondence of ISED with other indicators relevant to sustainable energy development. Those ISED which are identical or nearly correspond to indicators also present in the CSD lists of ISD, the DSD/DESA set of IMCCPP, the OECD work, the EUROSTAT initiative and/or the IAEA indicators for radioactive waste management, have been identified in Box 1 and Table I with the symbols ⊕, ♦, ♥, ♠ and ♣ respectively. It is encouraging to note that for as many as 34 of the 41 ISED there exists a corresponding or a nearly corresponding indicator in the work of at least one of the five other indicator initiatives being pursued by different international organisations. The actual numbers of such correspondences are 25 with WPISD indicators, 13 with DSD/DESA indicators, 16 with OECD indicators and 16 with EC indicators, with an additional 3 being with the IAEA indicators for radioactive waste management.

Future Work

The ISED have been developed as a result of a co-operative effort among various international organisations and national experts and provide a relatively comprehensive set of indicators for sustainable energy development. The IEA and IAEA intend to work together to compile historical data on ISED for various countries, to highlight the utility of the ISED as policy tools, and to further refine the ISED as the indicators are subjected to a systematic data compilation process and used in national policy making.

This effort will build on the data bases of the IEA and OECD and, wherever possible, on the data available from other international organisations, such as the UN Statistical Office, the World Bank, EC, and UNEP. We plan to develop methodological sheets making maximum possible use of those already prepared by WPISD, DSD/DESA and other international organisations for their own sets of indicators.

Although testing by national teams has been encouraging in terms of the amount of data reported, it is important also to assess the quality of these data. Having time series with consistent and good quality data is crucial if the ISED are to be useful as analytical tools. The impact of a certain implemented response action may be misjudged if the indicator that the response action is meant to affect is based on poor, incomparable or inconsistent data. Scarce resources for data collection, which is often the case in many non-OECD countries, may result in lack of disaggregated data or data that are not consistent with internationally accepted practices. Several countries have already expressed a need to receive advice and support in establishing improved systems to collect and report data in a manner consonant with the use of ISED.

Both the IEA and the IAEA are continuously working with Member governments to address energy data quality issues and the IEA has also started similar activities in non-Member countries. It has, for example, a collaborative project with the Government of India working with various Indian institutions to assess the availability and quality of data describing energy use. The project is addressing both institutional aspects (“who is collecting what”), compliance with international standards, and the potential for improving the reporting of disaggregated data. The IEA has also established close links with Russia and China, two important energy producers and consumers, with the intention of working with those governments to improve their energy data.

Table 3: Correspondence of ISED with other SD Indicator Initiatives

ISED		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21
CDS		⊕	⊕		⊕	⊕		⊕	⊕	⊕		⊕			⊕	⊕	⊕			⊕		
UN-DESA				♦		♦	♦			♦	♦	♦			♦		♦					♦
OECD		♥	♥	♥	♥	♥	♥								♥		♥	♥				
EC				♠		♠				♠	♠	♠	♠		♠		♠	♠	♠			
IAEA (RWM)																						

ISED		22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	
CSD			⊕	⊕		⊕		⊕	⊕		⊕		⊕			⊕	⊕	⊕	⊕	⊕	⊕	
UN-DESA			♦			♦			♦												♦	
OECD			♥	♥		♥		♥	♥		♥										♥	
EC			♠			♠	♠	♠	♠												♠	
IAEA (RWM)							♣				♣	♣										

Given the importance of consistent good quality data, a priority area for future work on ISED is for both Agencies to involve more countries in capacity building activities. This can be organised as training workshops including participants from statistical offices and the governmental institutions within each country that are the most relevant users of the ISED and associated data. The workshops can be held on a country-by-country basis or with groups of countries. The training will focus on methodological issues and collection procedures relevant for the data required to establish ISED, while ensuring compliance with international standards for energy related statistics. It will also address the use of indicators as policy tools. IAEA and IEA will jointly develop and carry out these training activities and will also involve relevant regional organisations such as APEC and OLADE. The training should result in enhanced decision making capabilities in participating countries, and in the reporting of better and more detailed data to the regular databases of the IAEA and IEA. The annual data submissions for these databases will provide a useful check of progress made by the countries engaged in the training programmes.

It is hoped that the work suggested here will receive due consideration by the CSD-9 and find its full endorsement and support.

REFERENCES

ADEME, 1999: "Energy Efficiency Indicators: The European Experience" ADEME (The French Environment and Energy Control Agency), Paris, France.

DSD (Division for Sustainable Development, United Nations Department of Economic and Social Affairs), 1998: "Measuring Changes in Consumption and Production Patterns". ST/ESA/264, New York, USA.

DSD (Division of Sustainable Development, United Nations Department of Economic and Social Affairs), 2000: "Report of the Consultative Group to Identify Themes and Core Indicators of Sustainable Development". New York, USA, 6-9 March.

EC (European Commission), 1999a: "Towards Environmental Pressure Indicators for the EU", Office for Official Publications of the European Communities, Luxembourg.

EC (European Commission), 1999b: "Integration – Indicators for Energy", Office for Official Publications of the European Communities, Luxembourg.

EEA (European Environment Agency), 1999: "Material Flow-based Indicators in Environmental Reporting". Environmental Issues Series No. 14, Office for Official Publications of the European Communities, Luxembourg.

IAEA (International Atomic Energy Agency), 1999: "Proposed Indicators of Sustainable Development for Radioactive Waste Management". Vienna, Austria.

IAEA (International Atomic Energy Agency), 2000: "Tools for Tracking Progress". IAEA Bulletin 42/2/2000, Vienna, Austria 2000

IEA (International Energy Agency), 1997a: "The Link between Energy And Human Activity". OECD/IEA, Paris, France.

IEA (International Energy Agency), 1997b: "Indicators of Energy Use and Efficiency – Understanding the link between energy and human activity". OECD/IEA, Paris, France.

OECD (Organisation for Economic Co-operation and Development), 1993: "Indicators for the Integration of Environmental Concerns into Energy Policies". Environment Monographs No. 79, OECD/GD(93)133, Paris, France.

OECD (Organisation for Economic Co-operation and Development), 1998: "Towards Sustainable Development – Environmental Indicators". OECD, Paris, France.

OECD (Organisation for Economic Co-operation and Development), 1999: "Interim Report of the OECD Three -Year Project on Sustainable Development". OECD, Paris, France.

OECD (Organisation for Economic Co-operation and Development), 2000: *Energy/Environment Indicators*. In "Towards Sustainable Development: Indicators to Measure Progress," Proceedings of the OECD Rome Conference, OECD, Paris, France.

Schipper L., Unander F. and C. Marie-Lilliu, 2000: "The IEA Energy Indicators Effort: Increasing the Understanding of the Energy/Emissions Link". Contribution of the International Energy Agency to the COP-6/FCCC, IEA/OECD, Paris, France.

Unander F. and L. Schipper, 2000: "Energy and Emission Indicators: Motivation, Methodology and Applications" Published in "Frameworks to Measure Sustainable Development: Proceedings of an OECD Expert Workshop" OECD, Paris, France.

UN (United Nations), 1996: "Indicators of Sustainable Development - Framework and Methodologies", United Nations, New York.

WCED (The World Commission on Environment and Development). 1987: *Our Common Future*, Oxford University Press. London, United Kingdom.