

## The Eight Indicators

### Environmental sustainability

#### ► Indicator 1: Per capita energy sector carbon dioxide emissions

Mongolia, having undergone transformation from a socialist to a democratic form of government and from a centrally planned to a free-market economic system since 1990, is at a turning point in its history.

Until 1990, Mongolian economic development's growth and GDP were increasing slowly. From 1990 economic development faced serious challenges due to the transition period and industrial development was almost "stopped".

According to this situation, energy production and combustion decreased sharply. In 1990, energy sector used 6,654,000 tonnes of coal, 1,249,000 tonnes of liquid fuel per year. But in 2000, energy sector used 5,185,000 tonnes of coal and 524,000 tonnes of liquid fuel per year. However, during this period (1990-2000) electricity production was relatively stable. 95-97% of electricity production was produced by power plants and the rest by diesel generators of rural area. The main reasons for the reduction of CO<sub>2</sub> emissions are that the national industry's "stopped" and energy rates increased rapidly. In the last decade, a lot of efforts were done to increase the productivity of energy sector's at the Government's initiative. Also, foreign investments to implement and renew the big-sized power plants contributed to the reduction of fuel combustion.

*Note: CO<sub>2</sub> emissions from biomass fuels are not included in the calculation.*

| Fuel type           | 1990             |                                    | 2000             |                                  |
|---------------------|------------------|------------------------------------|------------------|----------------------------------|
|                     | Combustion<br>Kt | Emissions,<br>CO <sub>2</sub> , Kt | Combustion<br>Kt | Emission<br>CO <sub>2</sub> , Kt |
| • Coal              | 6654.0           | 9604.9                             | 5185.0           | 7000.0                           |
| • Gasoline          | 541.2            | 1731.9                             | 272.1            | 871.0                            |
| • Jet fuel          | 34.0             | 108.0                              | 30.0             | 96.0                             |
| • Diesel            | 554.7            | 1719.6                             | 191.7            | 590.0                            |
| • Residual fuel oil | 63.4             | 183.9                              | 30.6             | 90.0                             |
| <b>Total</b>        | <b>7847.3</b>    | <b>13349.0</b>                     | <b>5709.4</b>    | <b>8647.0</b>                    |

In 1990, Mongolia's total emissions of carbon dioxide were 3.64 MtC and population was 2 097 700 people. So, 1990 carbon dioxide emissions per capita = 1735 kgC/cap.

In 2000, total emissions of carbon dioxide = 2.64 MtC; population = 2.407 millions. 2000 carbon dioxide emissions per capita = 1096.8 kgC/cap.

#### **Vector Value calculations:**

2000 vector value =  $(1096.8 \text{ kgC/cap} - 339 \text{ kgC/cap})/791 \text{ kgC/cap} = 0.958$

1990 vector value =  $(1735 \text{ kgC/cap} - 339 \text{ kgC/cap})/791 \text{ kgC/cap} = 1.765$

The energy sector is the largest contributor to GHG emissions in Mongolia. Activities in this sector include fuel combustion at power and heat plants, coal production, coal and biomass combustion in private houses for heating process. The energy sector produces around 60% of the country's CO<sub>2</sub>.

The main type of fossil fuel used in Mongolia is coal. Natural gas is neither produced in Mongolia nor imported for domestic consumption. Oil products are imported and used for transport, power and heat plants. Consumption of fossil fuel is the greatest source of carbon dioxide in Mongolia. The decreased value of CO<sub>2</sub> per capita in the last decade is due to the almost “stopped” condition of country’s industrial sector.

Along this period of time most manufactures and plants, except food processing industry, closed their doors because of the economical crisis.

The main cause of reduction CO<sub>2</sub> emissions is the diminution of energy combustion. The industrial sector is one of the largest energy users, consuming about 70% of the electricity and 30% of the heat produced. New technology and equipment have not used in energy producing and its consumption activities in period of 1990-2000.

## ►Indicator 2: Most significant Energy-Related Local Pollutant

SO<sub>2</sub> emissions are given according to the country's statistical data of fuel consumption.

**Fuel consumption and emissions of SO<sub>2</sub> in Mongolia**

|                     | 1990          |   |                                     | 2000          |   |                                     |
|---------------------|---------------|---|-------------------------------------|---------------|---|-------------------------------------|
|                     | Consumption   | Emissions SO <sub>2</sub> of tonne fuel | Total SO <sub>2</sub> emissions, kt | Consumption   | Emissions SO <sub>2</sub> of tonne fuel | Total SO <sub>2</sub> emissions, kt |
| * Coal              | 6645.0        | 5.0                                     | 33.20                               | 5185.0        | 5.0                                     | 25.9                                |
| * Gasoline          | 582.0         | 2.7                                     | 1.56                                | 302.1         | 2.7                                     | 0.8                                 |
| * Diesel            | 554.7         | 19.8                                    | 10.96                               | 191.7         | 19.8                                    | 3.8                                 |
| * Residual fuel oil | 63.4          | 4.8                                     | 0.36                                | 30.6          | 4.8                                     | 0.15                                |
| <b>Total</b>        | <b>7845.1</b> | <b>32.3</b>                             | <b>46.1</b>                         | <b>5709.4</b> | <b>32.3</b>                             | <b>30.65</b>                        |

The average percentage of SO<sub>2</sub> in the atmosphere of Ulaanbaatar, capital city of Mongolia, is calculated as 9-10 mg/c.m by the study. As in other countries, energy production and consumption in Mongolia has a wide range of local environmental impacts from air quality and water use to degradation of land, water and forest resources. Unlike many developed countries however, some of the most critical problems occur at the household level- from the consumption of the coal for cooking, heating- rather than mainly from large size industrial use. Similar to many developing countries, exposure to hazardous levels of indoor air pollution outstrips outdoor air pollution as a potential cause of illness.

### Vector value calculations:

Mongolia's 1990 total emissions of SO<sub>2</sub> in metric tonnes from fossil fuel combustion: 46.1\*10<sup>3</sup> tonnes; for 2000, 30.65\*10<sup>3</sup> tonnes

Population in 1990 = 2.0977 millions; in 2000 = 2.407 millions

Mongolia's 1990 SO<sub>2</sub> emissions per capita = 22.2 kg SO<sub>2</sub>/capita; in 2000 =12.8 kg SO<sub>2</sub>/capita.

X(2000) = 12.8 kg SO<sub>2</sub>/capita.

W = 22.2 kg SO<sub>2</sub>/capita in 1990

Y = 2.22 kg SO<sub>2</sub>/capita.; Z = 19.98 kg SO<sub>2</sub>/capita.

I (2000) = (12.8-2.2) /19.98 = 0.53

I (1990) = (22.2-2.2)/ 19.98 = 1.00

Although, country's SO<sub>2</sub> per capita is low, the concentration of SO<sub>2</sub> in atmosphere of Ulaanbaatar, capital city of Mongolia, reached level to damage in human health. This is relevant to old cars and many households' emissions in city. Currently, in Ulaanbaatar there are 80 000 stoves and 50 000 cars (most of them old).

## **Social sustainability**

### **►Indicator 3: Households with Access to Electricity**

In Mongolia, 70% of all households, including urban and rural areas, had access to electricity at the end of 2000 and 85% in 1990.

Mongolia has 335 soum centers and villages and to date 125 of these have been connected to the central power system. Mongolia is planning to connect 40 soum centers to the central electricity system (CES) by 2005. Currently soum centers that are not connected to the VES do not receive an adequate supply of electricity due to difficulties in delivering electricity to rural areas.

In the past, diesel generators have been installed to meet the demand for electricity in soums. Unreliable supply and price increases of diesel oil have caused electricity production to decrease. In many places, diesel generators are not in operation due to lack of financial resources to purchase fuel.

From 1990, during privatization of the domestic livestock industry, the number of herdsmen has increased in the last few years. Because of Mongolian herdsmen's nomadic life, the connection to CES is impossible. However, almost all households in urban areas are connected to CES.

While the number of herdsmen was 74 710 in 1990, in 2000 this number increased 2.6 times. The main reason for the reduction of households with access to electricity is the increased number of herdsmen.

A few herdsmen use wind ventilators, or sun devices for lighting purposes.

#### **Vector value calculations**

For this indicator, the value for 1 on the vector is 0% access, while the value for 0 is 100% access. The vector value for Mongolia in 2000 is therefore 0.30, and 0.15 for 1990.

Vector values for 1990: 0.15 and for 2000: 0.30

Almost all citizens of larger cities and rural centers have access of electricity. Mongolia is closer to the sustainability target on the indicators for access to electricity (0.3). There is a National Programme for herdsmen to use solar and wind mobile equipments. In 2001, a programme to build central electric systems in all of Mongolia was approved by the Government.

It is necessary to improve the technology of burning fuels and to improve effective control on it. Our actions are not sufficient in this field. The number of families which are connected to the electricity grid decreased because of the proportion of people who live in countryside. This is the main cause to decrease the indicator's value. In the next 10-15 years it will stay unchanged. It is better to supply the nomads with renewable energy sources in Mongolia.

### ►Indicator 4: Investment in clean energy

This indicator is a substitute for job creation since investment in energy efficiency and renewable energy create proportionally more and better jobs than centralised sources. Currently, for Mongolia, there is no other financial resources except governmental investments (local investments made by Government). There is no private sector, nor direct foreign investment in the energy sector. The energy sector is wholly under the supervision of Government. That is why there is no investment from the private sector.

For period 1995-2000, USD300 millions were invested in the energy sector by foreign countries and international organisations. This investment was spent only for renewing, repairing old techniques, equipments and implementing automatic control systems. The situation, that no dollar was spent to introduce modern techniques and technologies, is very strange. It means that foreign investment efficiency is very low.

Relative little local investment was made in the energy sector and spent for goals to repair and renew equipments. The situation, that there is no foreign investment in energy sector is maybe relevant to country's unstable legal and economic environment.

Although many Government programs required certain initiative be taken to implement and develop clean energy, there is no real results of these measures. For example, in 2000 USD30000 from Government (local), USD400000 of foreign investment made done to implement and develop clean energy.

However, in the next 3 years there is a probability that about USD100 millions will be invested in this sector.

#### Vector value calculations

For this indicator:

2000 non-renewable energy investment made by government is USD74.6 millions, for 1990 is USD 20 millions. Note that, it was impossible to calculate 1990 investment by present value.

1990 and 2000 clean energy government investment:

USD200 millions and 430 millions

$W = \text{US\$ } 200.0 \text{ thous} / \text{US\$ } 20.0 \text{ mln} = 0.01 = 1\%$

$X (2000) = \text{US\$ } 430 \text{ thous} / \text{US\$ } 74.6 \text{ mln} = 0.0057 = 0.57\%$

$Y = 95\% \text{ of the investment of the energy sector}; Z = 1 - 95 = -94\%$

$I (2000) = 0.57 - 95\% / -94\% = 1.004$

To develop or obtain the technology and equipment which are saving it is necessary to develop a standard on energy usage. The investment in renewable energy sector is increasing but indeed it is still low. There are a lot of resources in renewable energy. But we almost do not use these opportunities. The economic condition does not allow to make a progress in this sector.

## **Economic sustainability**

### **►Indicator 5: Energy Resilience: Energy import**

Mongolia, a country of rich resource of coal, does not import this kind of fuel. Currently, there are about 20 coal mines in Mongolia. Also, from 2001, Mongolia is planning to export coal to Russia.

All kinds of liquid fuels are imported from Russia and China. By today, there is no oil extraction or refining.

Usually, mazout and diesel fuel are used for energy production and also some for railway and road transport.

Gasoline is used only for air and road transport. Mongolia imports some electricity and does not export any kind of energy.

*Note: The consumption of liquid fuels in transportation was indicated as energy sector's consumption.*

#### **Vector value**

For this indicator, the value of the vector 1 is 100% non-renewable energy exports share of total imports, while the value for 0 on the vector is 0%.

Total imports of non-renewable energy in Mongolia in 1990 were 32.62 PJ (132.80 PJ minus 100.2 PJ renewable energy) and were dropped to 19.98 PJ (92.58 PJ minus renewable energy 72.60 PJ) in 2000 by 12.64 PJ.

Total consumption of non-renewable energy in 1990 was 132.82 PJ. In 2000, it was 92.58 PJ.

Thus, the value of vector in 1990 for Mongolia:

$$I = 32.62 \text{ PJ} / 132.82 \text{ PJ} = 0.246$$

The vector value in 2000:  $I = 19.98/92.58 = 0.216$

The vector value: in 1990 was 0.246 and, in 2000, it was 0.216.

Liquid fuels are only imported from Russia and China. Mazout is only used in power plants. Diesel is used in the transportation sector and also in diesel electric stations, which produce 5% of the gross supply of electricity nation-wide. Since 1992, when the demand of the electricity was cut, the import of liquid fuel decreased also. According to the study, it is likely that the need of liquid fuel will increase in the road and air transportation sector by a major amount in the next 20 years. In future we need to import and to supply transportation and energy sector with domestic liquid fuels. For this reason survey of oil deposits are made in Mongolia.

## ►Indicator 6: Burden of energy investment

In 1990, Mongolia had a socialist system and any investment made in the energy sector were done from state budget. This situation is similar today. After the 1990 democratic revolution, the economic potential of our country decreased rapidly. Due to this problem, the Government cannot make large investments in the energy sector.

In the last few years, the condition of coal mining, large size power plants and electrical and heating plants worsened and became unable to perform regular work. Because of these urgent problems, all kinds of investments had to be used for repairs and to renovate major equipments in the energy sector.

The Mongolian Government took discounted loans, large amount of aids from the World bank, the Asian Development Bank and the Japanese Government for purposes to renovate large plants such as the 3<sup>rd</sup> and 4<sup>th</sup> power plants of Ulaanbaatar City, the power plant of Choibalsan City, the heat network of Darhan City, coal mining in Baga Nuur and Shivee Ovoo.

### Vector value calculation

The value for 1 on indicator 6 is 10% of the government investment in non-renewable energy as a fraction of GDP, and 0 is 0% of the same.

For this indicator, 2000 total government investment in energy sector is USD74.6 millions, USD27.2 millions of which is allocated to fuel. 10 percent of total investment, USD7.6 millions is local investment. USD40 millions of local investment were spent for renewing power plants and building new heat networks. GDP of 1990 and 2000 were USD1400 millions and USD1044 millions. In 2000, 33.44% of GDP were allocated to agricultural sector and 23% to industrial sector.

1990 vector value is  $I = 10 \cdot 20.0 / 1400 = 0.14$

2000 vector value is:  $I = 10 \cdot 74.6 / 1044.0 = 0.715$

In the period of 10 years related to the study, the investment in the energy sector increased 3 times. But the GDP only increased by 40%. It shows that the efficiency of the investment is bad. In Mongolia, the investment is mostly provided to the restoration and maintenance of the old plants and equipments, instead of building new efficient plants and obtaining new technologies friendly to the environment. This mistake must be corrected in the future.



### ►Indicator 8: Renewable energy deployment

Herdsmen are generally not provided with electricity. There are several ways to solve this problem. It is possible to construct small capacity hydro power plants, which are without adverse impacts to the environment, in order to supply some local centers. Also, there are over 40 hot springs with a temperature range of 21-96C. Mongolia has 2250-3300 hours of full sunshine annually and the average solar energy per year amounts to 1.400 kW/sq.m. In the southern part of the country, the solar activity during the day is 4.3-4.7 kWh/sq.m. However, only about 3% of the rural herdsmen currently use solar panels of 9-40 W for lighting purposes.

The potential reserve of wind energy in Mongolia is 836.8 billion KW/h, and it is usable for a period of 3.5-4.6 thousand hours per year. The average velocity of the wind in the southeast part of the country is 4-5 m/s, has wind energy reserve of over 100W/sq.m. From 2003, Mongolia has planned to invest in the renewable energy sector and to build several hydro plants with a capacity 10-40 MWt.

#### **Vector value calculation:**

For this indicator, the value for 1 on the vector is the world average renewable energy supply as share of total primary energy supply (TPES) in 1995, which was 8.64% (HELIO International 2000). The value for 0 in the vector, which is our sustainability goal, is 95%.

Total consumption of renewable energy in 1990 was  $0.2 \cdot 10^6$  GJ; in 2000,  $0.23 \cdot 10^6$  GJ.

Total consumption of primary energy in 1990 =  $132.82 \cdot 10^6$  GJ; in 2000 =  $92.81 \cdot 10^6$  GJ.

The renewable proportion of energy is,

in 1990:  $X = 0.2 \cdot 10^6 \text{GJ} / 132.82 \cdot 10^6 \text{GJ} = 0.0015$

in 2000:  $X = 0.23 \cdot 10^6 \text{GJ} / 92.81 \cdot 10^6 \text{GJ} = 0.0025$

The vector of Mongolia for 1990:  $I = (0.95 - 0.0015) / 0.8636 = 1.098$

For 2000 it is :  $I = (0.95 - 0.0025) / 0.8636 = 1.097$