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للأستاذ الدكتور محمد عبد الفتاح شامة

Published Papers (1994-2005)

on Energy and Environmental Protection

by Prof. Dr. M. A. Shama

1- "A Projection on the Future Demands and Capability of Offshore Technology" A.M.R.J. (Egypt-1976), Shama, M. A.,. (100%)

2- "A General Outlook to Offshore Technology", Egyptian Society of Marine Engineers and Shipbuilders, Forth seminar, Alexandria, April, (Egypt-1983), Shama, M. A., (100%)

3- "Costs of C02 Abatement in Egypt Using Both Bottom-Up and Top-Down Appr", Energy Policy, (USA-1994)Yehia El Mahgary, A. F. Ibrahim, M. A. F. Shama, A. Hassan, M. A. H. Rifai, M. Selim, I. Abdel Gelil, H. Kokor, Anhar Hegazi, A. Amin, F. Bedewi and Juha Forsstrom, (8%)

4- "Estimation of GHG Emissions in Egypt Up to the year 2020", World Resource Review, Vol. 6, No. 8, (USA-1994), Yehia El Mahgary, VTT-Energy, A. I. Abdel-Fattah, M. A. Shama, Alexandria, Faculty of Eng., M. Selim, I. Abdel Gelil, Anhar Hegazi, NREA, Egypt, M. A. Rifai, Azhar University, A. Amin, F. Bedewi EEA, Egypt, and J. Forsstrom, (11%)

5- "Technical Evaluation of Transport- Related GHG Abatement Techniques", AEJ, April. (Egypt-1995), Shama, M. A., and Hassan, A. (50%)

6- "Ship Casualties Types, Causes and Environmental Impacts", AEJ, April. (Egypt-1995), Shama, M. A. (100%)

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8- "GHG Emissions Inventory for Egypt and Emission Mitigation Options",VTT, Energy, (Filand-1995), Yehia El Mahgary, VTT-Energy, Finland, M. A. Shama, A. F. Ibrahim and A. Hassan, Alex. University, Egypt, M. A. Rifai, Azhar University, Egypt, I. Abdel Gelil, M. Selim and H. Kokor, ECPO, Egypt, Anhar Hegazi, NREA, Egypt, A. Amin, F. Bedewi EEAA, Egypt, and Juha Forsstrom, VTT-ENERGY,Finland, (8%)

9- "The problem of corrosion of ship structures", MARINES 96, Second Conference, Cairo, October, (Egypt-1996), Shama, M. A., (100%)

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11- "Energy and Env. in Eng. Education", AEJ, Vol.36. (Egypt-1997), Shama, M. A. (100%)

12- "Energy and Environment Dimension in Ship Manufacturing Processes", PRAD's 2001, Sept., 8th Int. Conf. on Practical Design of Ships and other Floating Structures, (China-2001). Shama, M. A., (100%)

13- "Life Cycle Assessment of Ships", Alexandria Engineering Journal, AEJ, (Egypt-2004) Shama, M.A. (100%)

14- "Life Cycle Assessment of Ships", IMAM 05, Sept. International Maritime Association of Mediterranean Sea, (Portugal-2005), Shama, M. A. (100%)

15- "Environmental Dimension in the Ship's Life Cycle", MARDACON 9, December, Int. Con. "Towards a Cleaner and Safer Maritime Context", (Egypt-2005), Shama, M. A. (100%)

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Costs of CO_2 abatement in Egypt using both bottom-up and top-down approaches

Yehia El Mahgary, A-F Ibrahim, M A-F Shama, A Hassan, M A-H Rifai, M Selim, I Abdel Gelil, H Korkor, Anhar Higazi, A Amin, F Bedewi and Juha Forsström

Within the frame of UNEP's project on the Methodologies of Determining the Costs of Abatement of GHG emissions, a case study on Egypt was undertaken by the Technical Research Centre of Finland (VTT) in cooperation with the Egyptian Environment Affairs Authority (EEAA), together with an expert team from different Egyptian organizations. Both bottom-up and top-down approaches were used. Several measures/technologies, including energy conservation, fuel switching, use of renewable energy and material replacement, were considered to decrease CO_2 emissions. It was found that most of the measures were cost-effective, as a considerable potential for energy conservation exists in Egypt. The impact of energy conservation measures on the economy of the country was found to be positive using a macroeconomic model

Keywords: Greenhouse gas; Abatement costs

This paper summarizes the case study on Egypt undertaken to determine the costs of the abatement of GHG. It consists of an inventory of the GHG emissions mainly, but not exclusively, from energy production in Egypt in the year 1990; and an estimation of the GHG production up to the year 2020 in the business as usual scenario. It also includes the estimation of the abatement costs for decreasing the CO_2 emissions in the year 2020 by 25% and 50% with respect to the base scenario. The economic sectors were divided into seven main areas – petroleum production, power production, heavy industry, light industry, household and commerce, transport and agriculture, and domestic waste.

The total commercial energy demand of Egypt has increased from about 130 PJ (3 Mtoe) in 1950 to about 677 PJ (16 Mtoe) in 1980–81 and to 1069 PJ (25 Mtoe) in 1989–90 with an average annual growth rate of 6.3% in the 1980s.[1] Hydro power played a significant role in satisfying Egypt's energy needs in the 1970s by providing more than two-thirds of the electricity demand. In the late 1980s the situation was completely reversed, with oil and gas providing more than two-thirds of the electricity demand.

The pattern of energy supply by source in Egypt in 1990 is shown in Figure 1; primary energy consumption by sector is shown in Figure 2. The electric power sector used in 1990 about one-third of the total oil and gas con-

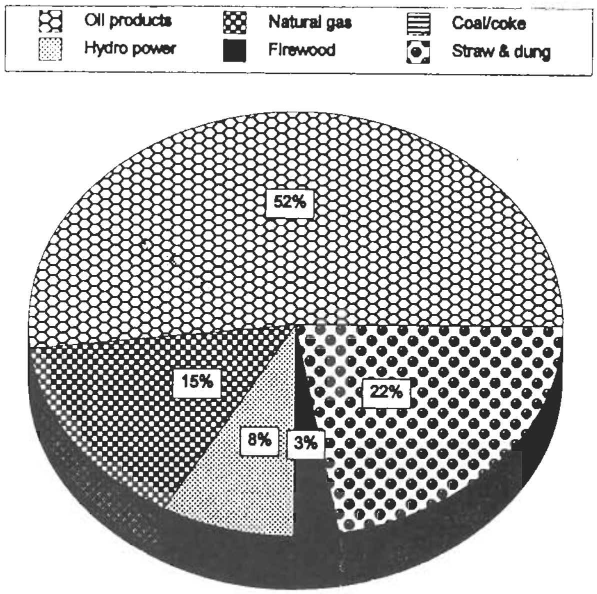

Figure 1. Energy supply by source in 1990 in Egypt.

Yehia El Mahgary and Juha Forsström are with the Technical Research Centre of Finland (VTT-Energy), Espoo, Finland. A-F Ibrahim, M A-F Shama and A Hassan are with Alexandria Faculty of Engineering, Egypt. M A-H Rifai is with Al-Azhar Univ, Cairo. M Selim, I Adbel-Gelil and H Korkor are with Energy Planning Organization, Cairo, Fax: 202-617623. Anhar Higazi is with New & Renewable Energy Authority, Cairo. A Amin and F Bedewi are with

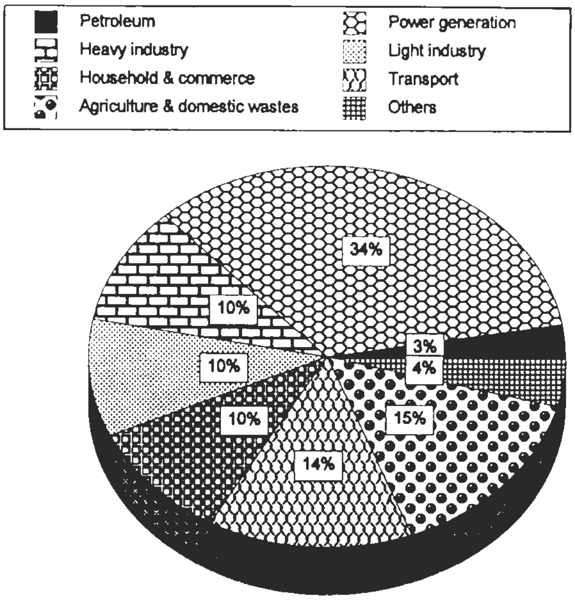

Figure 2. Distribution of primary energy consumption by sector in Egypt in 1990.[a]

[a]Non-commercial sources are included in the agricultural sector.

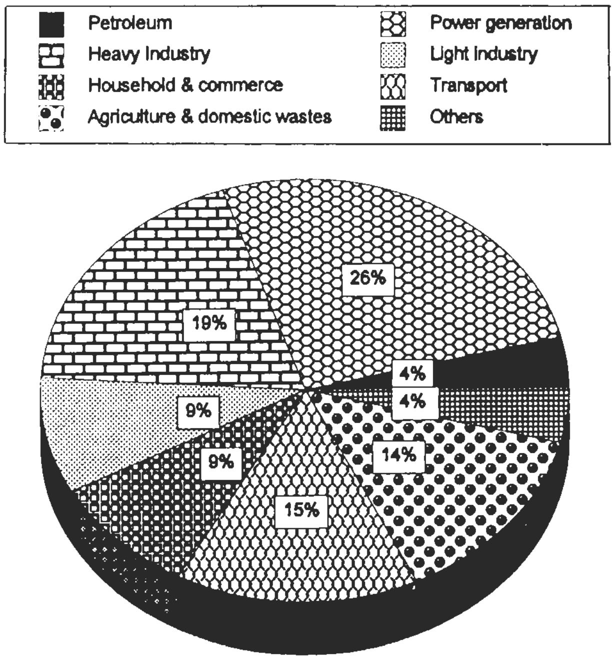

Figure 3. Corresponding GWP of the different sectors in 1990.

sumption of Egypt, as thermal power plants burned in 1990 about 360 PJ of natural gas and petroleum products to generate about 33 TWh. Hydropower generated in the same year about 10 TWh.[2] The current fuel mix of thermal electricity generation consists of 51% fuel oil, and 49% natural gas.[3]

Energy consumption and GHG emissions in 1990

A summary of the energy consumption of the different sectors and the corresponding GHG emissions, mainly but not exclusively, from energy activities, in Egypt in 1990 is given in Table 1. Both the LEAP model and spread sheets were used in this bottom-up approach.[4] As can be seen from Table 1, electricity generation, industry and transport sectors are the major producers of CO_2. Rice paddies are, on the other hand the main producer of CH_4. They are responsible of over 80% of methane production in Egypt. Finally, nitrogenous fertilizers and road transport are the main sources of nitrous oxide.

Table 1. Summary of GHG emissions in Egypt, 1990.

Sector	Energy/emissions Energy (PJ)	CO_2 (Mt)	CH_4 (kt)	N_2O (kt)
1. Petroleum	43.50	3.1	51.906	0.121
2. Power production	464.63[a]	24.75	0.073	0.890
3. Heavy industry	144.41	18.81	0.032	0.399
4. Light industry	138.59	9.30	0.024	0.351
5. Household and commerce	134.57	9.34	2.635	0.370
6. Transport	196.6	13.46	9.934	7.091
7. Agriculture and domestic waste	212.12[b]	0.67	424.22	33.25
8. Others[c]	58.82	4.08	1.127	1.579
Total	1393.24	83.51	489.95	42.63

[a]Generated energy of hydropower was obtained by assuming an equivalent efficiency equals the average thermal efficiency in that year, ie about 33%.
[b]About 202.71 PJ of non-commercial energy sources are included.
[c]Government offices, services etc (electricity consumption not included).

The different GHGs have different greenhouse warming potentials (GWP). Nitrous oxide, N_2O, has the highest GWP among the three gases and CO_2 has, fortunately, the lowest GWP. The distribution of GHG emissions, taking into account the GWP of each gas, is given in Figure 3. It is of particular interest to compare Figure 2 and Figure 3. The share of the power production sector is less in the GWP sources than in energy consumption thanks to the effect of hydropower. The share of heavy industry has, on the other hand, increased, mainly because of additional CO_2 emissions from construction industry and also because of the coal used in metallurgical industry.

The share of petroleum industry in GHG emissions is more than its share in energy consumption mainly because of gas leakage. The shares of the other sectors have roughly remained the same or changed slightly. The GHG emissions from transport sector are totally caused by burning of petroleum fuels, whereas those of the agricultural sector are mainly caused by N_2O from

Table 2. Energy and CO_2 emission factors for some countries in 1990.

Country	China	Egypt	Brazil	Poland	Finland	France	Japan	USA
GJ/capita	22.3	25.3	55.6	108.5	246.7	156.1	146.5	320
kg CO_2/GJ	76.5	59.18	34.91	66.8	42.4	41.64	58.32	60
t CO_2/capita	1.71	1.5	1.94	7.24	10.46	6.5	8.55	19.2

Sources: China, Poland, Finland, France, Japan and the USA: Annual Energy Review, 1993, in *Energy in Europe*. Brazil: L Pinguelli *et al* in *Energy Policy*, March, 1993. Egypt: present study.

nitrogenous fertilizers and CH_4 from rice paddies. Emmissions from biomass burning were not included as it is mainly caused by emissions from straw burning, which is being taken up again by new plantations.

CO_2 production of Egypt compared to other countries

Table 2 summarizes energy and CO_2 emission factors of selected countries. The first row of Table 2, the primary energy consumption per capita, is affected by the country's stage of development, effectiveness of energy efficiency and particular weather conditions. Industrialized countries have higher energy consumption per capita than developing countries. But the higher energy consumption per capita also indicates a low energy efficiency in case of similar GDP and weather conditions. Finland, for example, has a relatively cold climate and it needs more heating in winter; but its energy consumption per capita is still lower than that of the USA.

The second row of Table 2 has been mistakenly used by some authors to indicate the efficient use of energy. This is not the case as one tonne or one GJ of primary energy of a certain fuel will produce the same amount of CO_2 irrespective of the efficiency of the process used.

The second row indicates more or less the energy mix of the country. Brazil has considerable hydro power resources of over 40 GW, in addition to an effective programme of using renewables to substitute for gasoline (Figure 4). France covers a great part of its energy needs by nuclear energy. Finland has a good mix of hydro, nuclear and fossil plants, each type providing roughly one-third of the energy demand. In Egypt renewable energy sources (hydro plus non-commercial) provided about 23% of the total energy demand in 1990; they have a pronounced effect on the CO_2 per unit energy. China and Poland seem to have the highest share of fossil fuels in their energy mix. The third row of Table 2 is a mixture of the effects of the two preceding rows; the effect of the level of energy consumption per capita is more pronounced.

GHG emissions of Egypt up to the year 2020

The next and most important step was to establish, to the best of our present knowledge, a realistic scenario of

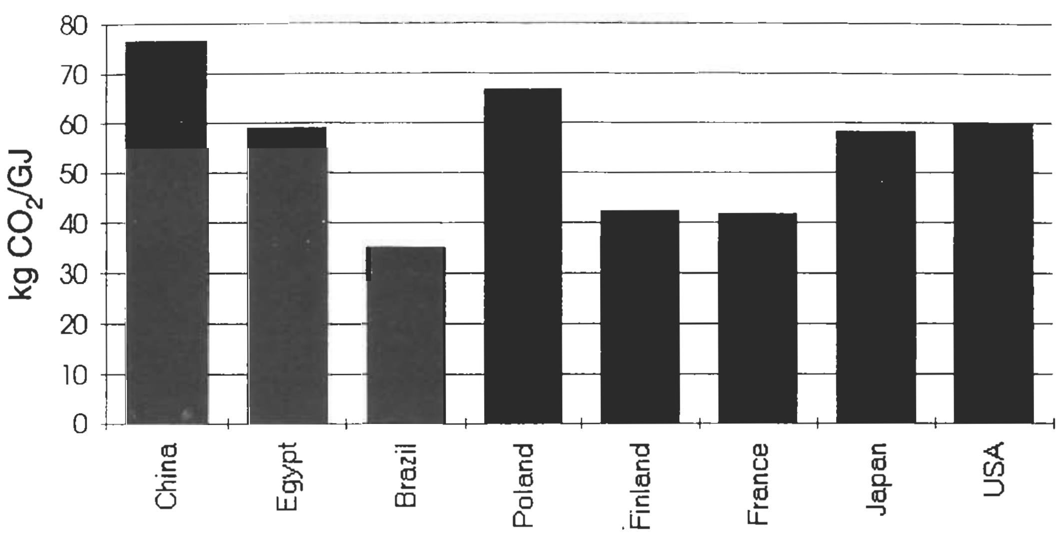

Figure 4. Carbon dioxide production per GJ of primary energy in different countries.

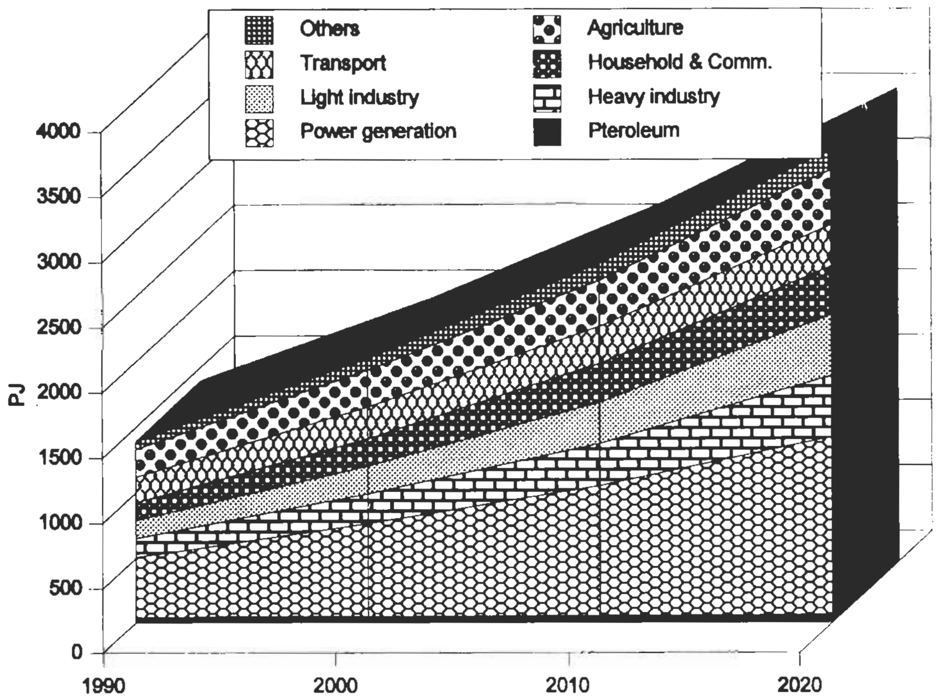

Figure 5. Primary energy consumption of Egypt by sector in the base scenario.

the energy demands of the different economic sectors and that of the whole country, and to satisfy these demands using available sources up to the year 2020. Fortunately, a number of energy forecasting studies of that type have been undertaken in Egypt using several international models. This made the problem a little easier.

In the year 2000, natural gas production was estimated at 15 Mt, increasing to 23 Mt in 2010 and to 27 Mt in 2020. Oil production was, on the other hand, assumed to increase at a much lower rate in view of the dwindling oil resources of Egypt. Oil consumption was assumed to reach 28 Mt in 2000, 31 Mt in 2010 and 35 Mt in 2020. If oil consumption outstripped local oil production, it was assumed that the balance would be imported.

The energy consumption of the different sectors in the base scenario is shown in Figure 5. It should be noticed that power production is treated here as a separate sector. When power generation, the largest energy consumer sector, is distributed among the other economic sectors, industry gets the lion share, followed by the residential and commercial sectors. They both consume huge amounts of energy.

The primary energy supply by source is shown in Figure 6. In spite of oil fuel substitution by natural gas, which causes a decrease in the dependence on oil from 54% in 1990 to 46% in 2020, oil consumption in this scenario is increasing very fast.

According to current forecasts of the National Committee of Egypt, nuclear energy is not considered among the energy sources in the base scenario, but renewable energy is assumed to play an important role. By the year 2020 renewable energy should produce roughly as much energy as hydropower. Coal, on the other hand, was introduced to limit a fast growth in oil consumption.

The corresponding GWP of the GHG emissions are shown in Figure 7. It should be noted that the sector emitting the largest amount of CO_2 is heavy industry, although its share from energy consumption is much less than that of eg the electricity production sector. This is because CO_2 emissions from processing in cement and lime industries are included in the heavy industry sector, and because of the great deal of natural gas used in the electricity sector. This reduces the total emissions of the latter.

In Figure 7, the GWP of the GHG emissions by other sources such as N fertilizers, rice paddies and landfills are also given in million tonnes of CO_2 equivalent. N fertilizers produce a lot of N_2O, which is a high potential GHG. The consumption of N fertilizers has increased in Egypt drastically after the construction of the High Dam. Rice paddies and landfills are, on the other hand sources of CH_4. The CH_4 emissions from

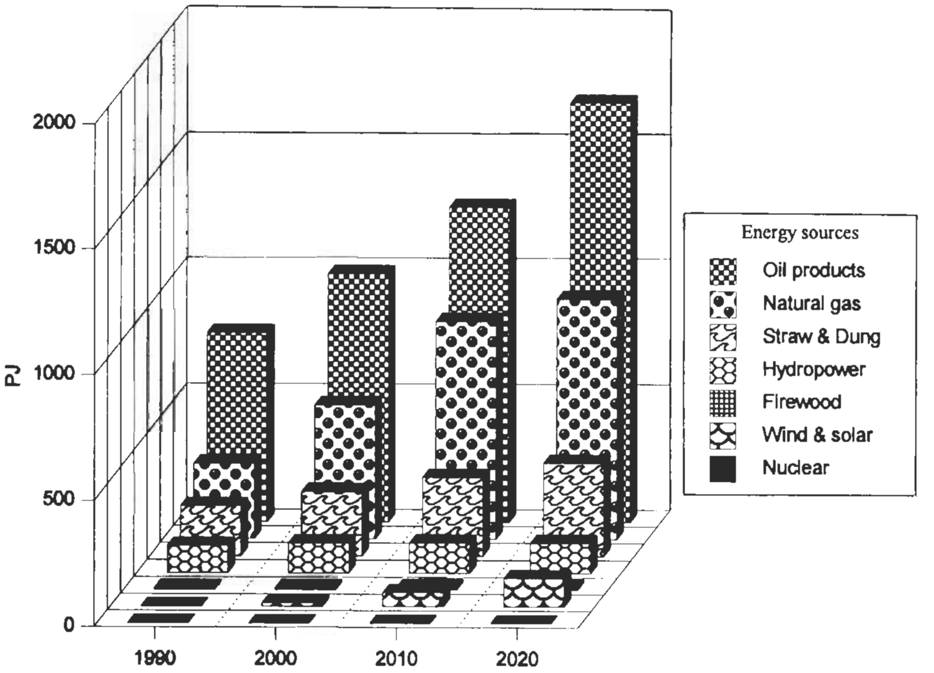

Figure 6. Energy supply by source in the base scenario.

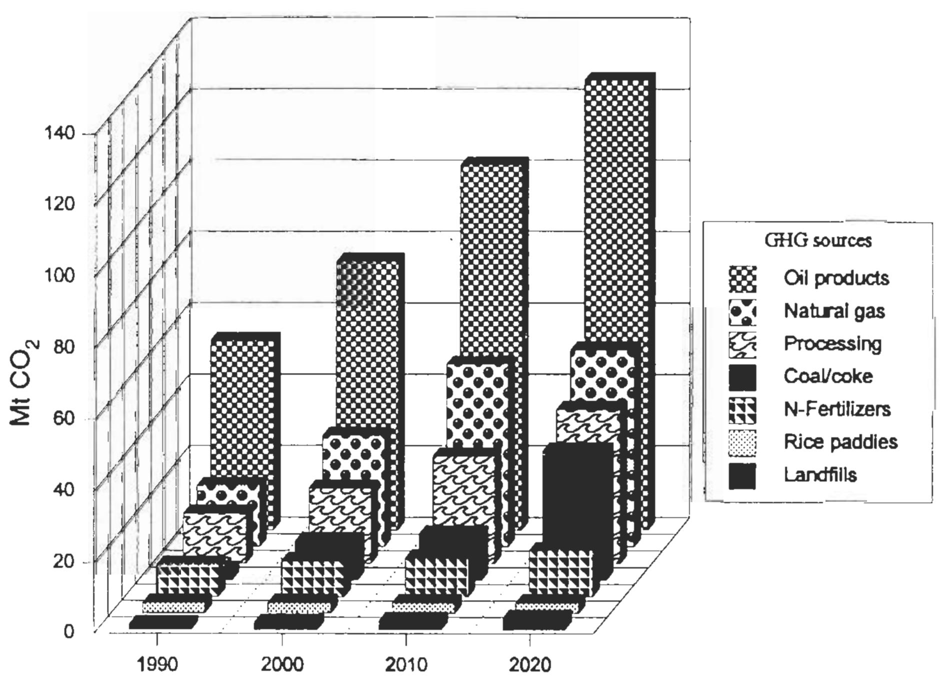

Figure 7. GWP in Mt of CO_2 of the main GHG sources in the base scenario.

rice paddies were kept constant, assuming no further increase in the area cultivated by rice. On the other hand, CH_4 emissions from natural gas leakage were added to CO_2 emissions of natural gas combustion.

Abatement scenarios

Two abatement scenarios were considered; the first A1, to decrease the GHG emissions in the year 2020 to 25%, and the second A2, to reduce them to 50% of their value in the year 2020 in the base scenario. In each of the economic sectors, a number of measures/technologies were deliberated for decreasing the GHG emissions. These technologies were based on one or more of the following techniques:

- energy conservation;
- fuel substitution;
- use of renewables;
- material replacement;
- increasing of GHG sinks.

A great deal of attention was focused on energy conservation, particularly in industry, power production and transport sectors, as its potential and cost-effectiveness in these sectors is high. Fuel substitution was primarily limited to replacing coal and petroleum products by natural gas, insofar as natural gas reserves permit.

Use of renewable energy was applied mainly in power production, household and agriculture sectors. Nuclear/import electricity was introduced in scenario A2 only. If the giant hydro power project of Zaïre does not materialize, a nuclear power plant of about 800 MW should be in operation in 2010 and a similar one in 2020 in order to avoid using imported coal or oil in thermal power plants. Material replacement was meant to decrease dependency on, and hence involve less production of, present construction materials (cement and lime) and to replace them by iron and glass. Replacement of N fertilizers by fertilizers from sludge/compost obtained in biogas plants using municipal and societal wastes were included under the material replacement item. Finally, increasing of GHG sinks was applied to agricultural sector through tree and crop plantation. Both fuel tax and CO_2 scrubbing were considered but dropped later because of their irrelevance to social and economic conditions in Egypt. A list of all the measures considered in the two abatement scenarios is given in Table 3.

The summary of the energy consumption patterns and GHG emissions in the three scenarios are shown in Figures 8 and 9. The decrease in GHG emissions (counted in their GWP) in scenario A1 in the year 2020 in comparison to the base scenario is about 27%, which corresponds to a decrease of about 25% in energy production with respect to the base scenario. In the abatement scenario A2, the corresponding figures for the decrease in the GHGs and energy consumption with repsect to the base scenario were about 50% and 42%. The percentage increase in the GWP of the GHGs emissions in the year 2020 with respect to the actual emissions in 1990 was 180% in the base scenario and only 43% in abatement scenario A2. The corresponding increase in energy consumption was over 160% in the base scenario and only 50% for abatement scenario A2.

Abatement costs using bottom-up and top-down approaches

Bottom-up approach

The cost curves of the different measures and technologies for the abatement of CO_2 are shown in Figure 10 and Table 3, in which the measures are arranged according to their costs. A number of measures are cost-effective or have what is called 'negative costs'. These costs are not a free lunch, as many erroneously try to claim. They are the economic profits gained from the application of energy conservation measures. There may be some hidden costs which are difficult to estimate at this stage, but the cost-effectiveness of these actions is positive. To argue about this issue is to say that all energy conservation measures which took place in industrialized countries, including waste heat recovery, power factor correction, efficient motors and engines, recycling, cogeneration and decrease of heat losses were not cost-effective. This argument contradicts all basic energy text books, reports, references and statistical figures and information.[5]

The determination of the exact value of the implementation/hidden costs of the energy conservation measures necessitates the undertaking of a comprehensive analysis, as institutional, social and political factors/barriers have to be considered.

This was beyond the scope of the present study; instead, a value for the implementation/hidden costs was assumed in the range of 25% the investment costs of each measure. This is shown as dotted line in Figure 11. The measures are regrouped in this figure according to their type.

The results of the top-down approach

The macroeconomic models used in Egypt have been described elsewhere.[6] The top-down model was used to investigate the short-term impact of two different actions; first the energy conservation measures introduced in the different sectors in the bottom-up approach and, second, the increase in fuel prices from subsidized prices in 1990 to international prices in 1995. The horizon of the model was the year 2002. In the present paper

Table 3. List of different CO_2 abatement measures (see Figure 10).

	Measure	Sector
1	Fuel substitution LPG with NG (natural gas)	Household
2	Fuel substitution oil with NG	Petroleum
3	Industrial processes: substitute batch with continuous	Light industry
4	Blast furnace energy conservation	Heavy industry
5	Efficient electric motors	Light industry
6	Efficient gas compressors	Ligh industry
7	Upgrading steel properties	Heavy industry
8	Efficient energy use in construction	Building industry
9	Combined heat and power production (cogeneration)	Light industry
10	Preventive maintenance	Building industry
11	Correction of power factor	Heavy industry
12	Fuel substitution kerosene with NG	Household
13	Energy conservation: programme A	Transport
14	Material recycling	Light industry
15	Correction of power factor	Light industry
16	Recovery of aluminium	Heavy industry
17	Combustion control	Light industry
18	Waste combustion	Heavy industry
19	Energy conservation: programme B	Transport
20	Use of NG instead of electricity in fertilizer industry	Light industry
21	Improved insulation	Light industry
22	Upgrading of refinery efficiency	Petroleum
23	Waste heat recovery	Building industry
24	Waste heat recovery	Light industry
25	Waste heat recovery	Heavy industry
26	Ladle treatment	Heavy industry
27	Fuel substitution: petroleum fuels with solar energy	Light industry
28	Import of electricity/construction of nuclear plants	Power industry
29	Introduction/upgrading of quality control	Building industry
30	Recycling and processing of scrap	Heavy industry
31	Steam network improvement	Light industry
32	Fuel substitution oil with NG	Building industry
33	Fuel substitution oil with NG	Light industry
34	Fuel substitution gasoil with NG	Others (service buildings)
35	Material replacement	Building industry
36	Electric heating reduced by NG heating	Light industry
37	Efficient lighting	Light industry
38	Use of natural gas in drying processes	Light industry
39	Efficient appliances	Household
40	Use of renewable energy in electricity production	Power production
41	Energy conservation: programme C	Transport
42	Closed cycle heating	Light industry
43	General efficiency improvement	Others
44	Group of energy conservation measures	Power production
45	Cogeneration using low grade heat	Light industry
46	Efficient rural stoves	Household
47	Quality control of raw materials	Building industry
48	Introduction of heat pumps	Light industry
49	Use of DC arc furnaces	Heavy industry
50	New glass melting equipment	Light industry
51	Recovery of low grade heat	Light industry
52	Efficient lighting	Household
53	Use of solar cooling	Light industry
54	Production of limestone instead of classic bricks	Light industry
55	Heat recovery by spraying	Light industry
56	Use of wind energy in water pumping	Agriculture
57	Improved maintenance of agricultural machines	Agriculture

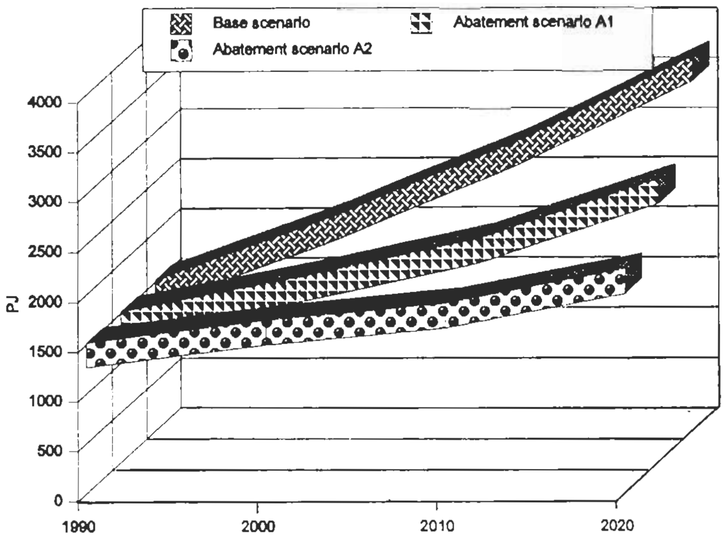

Figure 8. The pattern of energy consumption in the three scenarios.

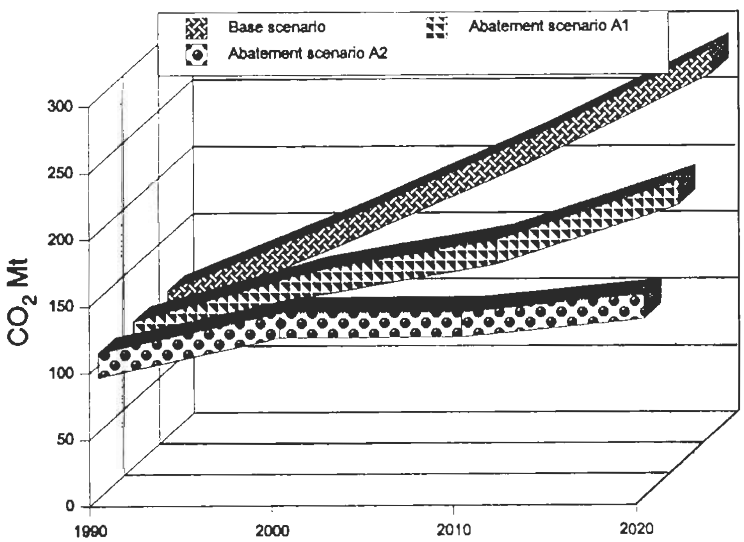

Figure 9. The GWP of the GHGs emitted in the three scenarios.

only the effect of the energy conservation measures on the welfare, investment and GDP of Egypt will be reported. This is shown in Figure 12. In this figure no account was made for the hidden/implementation costs. As should be expected, the three parameters increase steadily with increasing the percentage of energy conservation.

When the implementation/hidden costs were assumed to form 25% of the investment costs (as in the case of the bottom-up approach), the annual growth rate in the GDP dropped only by about 10%, which was unexpectedly small. This is shown in Figure 13, where the values of the lower curve were extrapolated from the results of 20% and 30% energy conservation measures.

These results appear to be in complete contrast to those obtained earlier by Blitzer *et al*[7] using possibly a different version of the present macroeconomic model from that used in this top-down approach. It should, however, be remembered that although the same top-down approach was used in the two studies, the measures and technologies assumed were completely different in the two cases. Blitzer *et al* assumed a number of conventional and new technologies (not mentioned explicitly in their paper) to decrease the GHG emissions in Egypt, and they counted the corresponding impacts of these technologies on the Egyptian

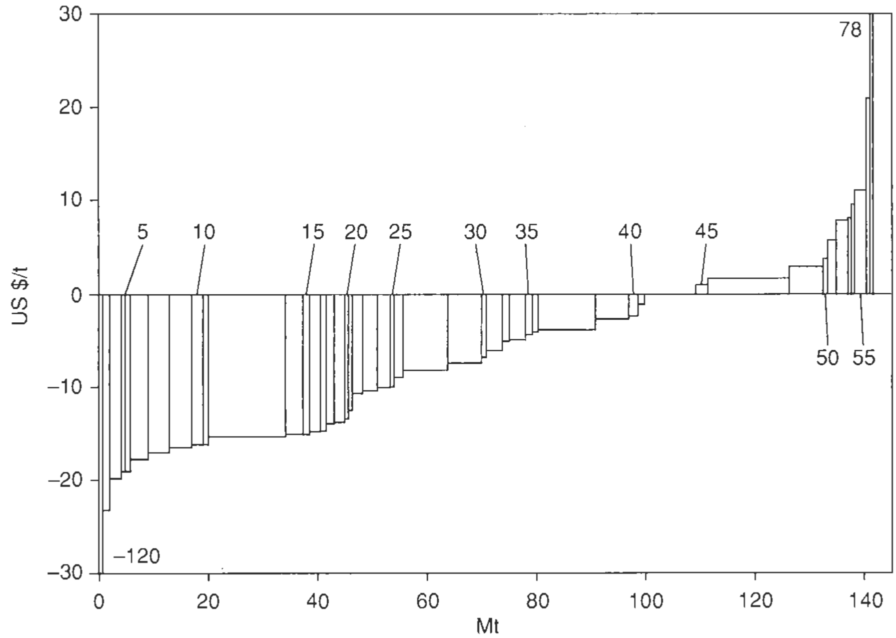

Figure 10. Marginal cost of CO_2 reduction in 2020 (see Table 3).

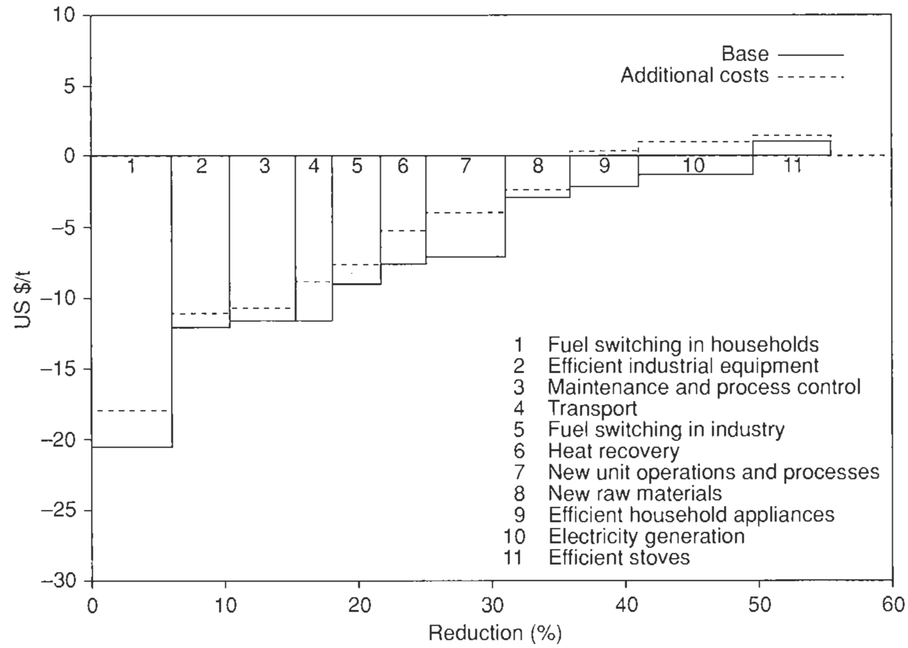

Figure 11. Impacts of additional implementation costs.

economy. The results obtained are shown in Figure 14, together with the results of the present study. The reduction in GDP was found to be 25% in the year 2007 for no more than 20% reduction in CO_2 emissions, and a record of about 43% in the same year 2007 for decreasing CO_2 emissions by 40%.

The difference between these results brings us face to face with the original purpose of undertaking the whole exercise of the case studies in different countries. It also brings to mind the situation at the end of the 1980s and beginning of the 1990s when the first estimation of the costs of GHG abatements were made in USA and announced by the Chairman of the President Council of Economic advisers, claiming that more than US$200 billion per year would be needed to meet Toronto CO_2 goals. Canadian own estimations

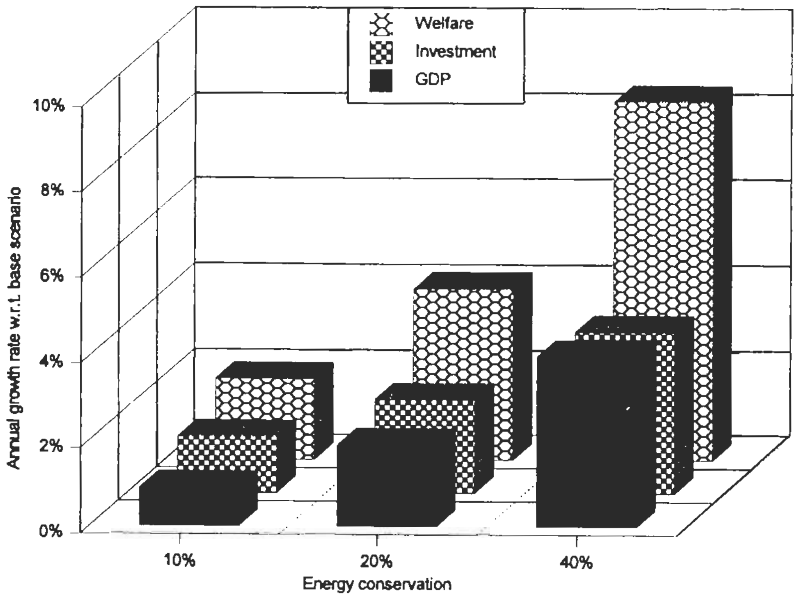

Figure 12. Annual growth rates with energy conservation measures (top-down approach).

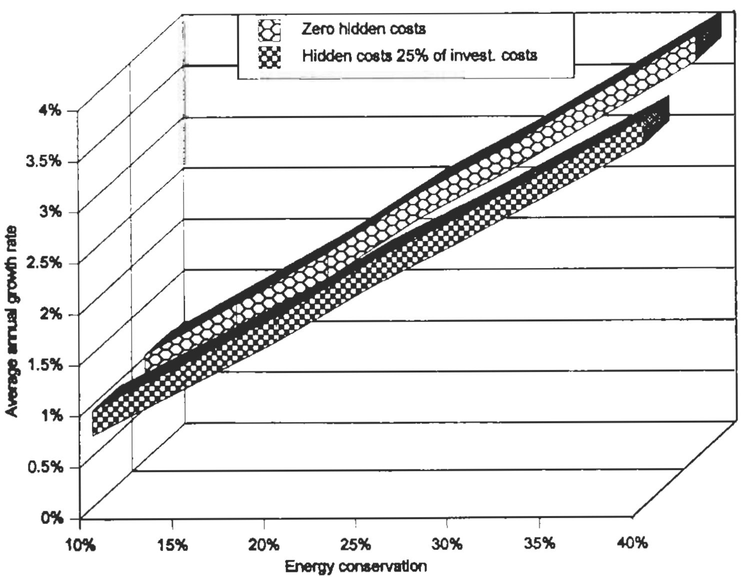

Figure 13. The effect of the hidden costs (25% investment) on GDP (top-down approach).

indicated that the amount estimated by the former US administration was in fact about right but that the *sign was wrong!* Efficiency and energy conservation gains were estimated to save the US economy roughly US$200 billion per year.[8] Studies undertaken by several investigators have confirmed this concept.[9] Along these lines, the DOE has recently estimated that the cumulative potential benefits from 1994 to 2010 of applying in the industry sector the new administration's Climate Change Action Plan, which encourages energy-efficient technologies, would be about US$80 billion.[10] This would result in a reduction of 19 Mt of carbon equivalent in the GHG emissions by the year 2000.

As mentioned above, the results of Blitzer *et al* are the outcomes of assumptions made, technologies and measures selected and costs used. There exist better and cheaper ways of doing it, by improving energy efficiency and considering energy conservation measures. It also seems that the costs of the back-up technology they used were rather high and that no account was taken of the cost-effectiveness of the new technologies. Hence, the main reason for the contradiction between the results

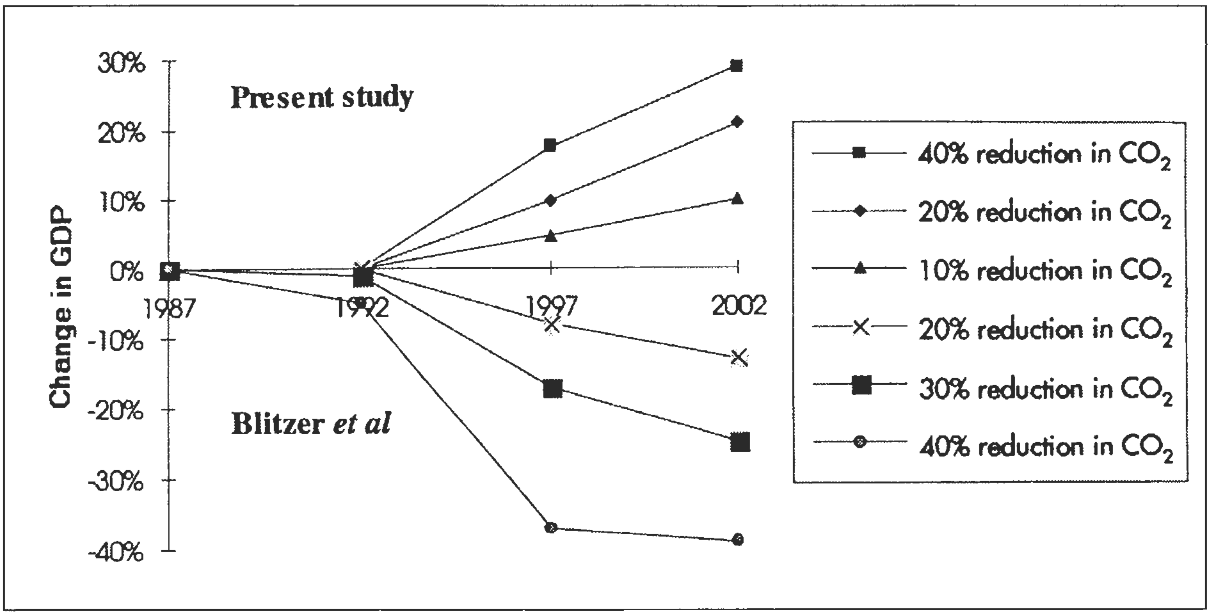

Figure 14. The contrast between the results of Blitzer *et al* and the present study using the top-down approach.

of the present study and those of Blitzer *et al* was not that one used the bottom-up approach and the other the top-down, as was thought earlier,[11] because we are comparing here the results of nearly the same model, or perhaps more accurately, two versions of the same model.

The main reason for the contradiction are the measures and technologies selected, the costs used and the assumptions made. It is clear from Figures 12–14, that the different measures and technologies considered in the present study led to different percentages of energy conservation and consequently to a positive effect on the GDP of Egypt. Another important factor which has magnified the differences in the results of the two studies is the availability of funds needed for the investments in the energy sector. Blitzer *et al* have included financial constraints on the availability of funds in a developing country like Egypt. This was the case, again, because of the capital intensive and the high net positive costs of the technology they used. In the present study, this was not the case because the energy conservation measures selected were cost-effective, and their cost-effectiveness dropped only slightly when it was assumed that implementation costs would be in the order of 25% the investment costs, hence there was no need to include financial constraints.

It could be argued that funds should be first made available to implement the energy conservation measures; hence it is necessary to accept the financial constraints of the model before assuming an economic profit from energy conservation measures. This is the dilemma of almost all developing counries. Practical solutions were offered to solve this problem through, eg donations, revolving funds or soft loans. It is also the responsibility of international funding bodies as GEF, UNDP, WB and others, to make sure that the donations, revolving funds and soft loans are made available to set the ball rolling. These projects on GHG abatement through energy conservation measures should be given the highest priority, not only because of their positive impact on the climate change policy, but also because of their economic attractiveness and positive effects on the economy and the welfare of the country.

Conclusion

Both the bottom-up and the top-down approaches were applied to study the costs of abatement of GHG emissions in Egypt. The bottom-up approach necessitates a thorough analysis of the economic sectors of the country; hence it gives quite accurate results, although the interaction between the different sectors is difficult to trace. The effect of certain actions, measures or technologies on the economic indices of the country such as GDP, welfare, investment, etc, were studied using the top-down approach.

Assuming that the base scenario selected represents fairly well a forecast of the business as usual scenario for Egypt, it was found that Egypt has considerable potentials for energy conservation measures which Egypt should start with, in view of their cost-effectiveness as verified by the bottom-up approach, and their positive impact on the economy, confirmed in the top-down approach.

This strategy is recommended to other countries, particularly developing ones.

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