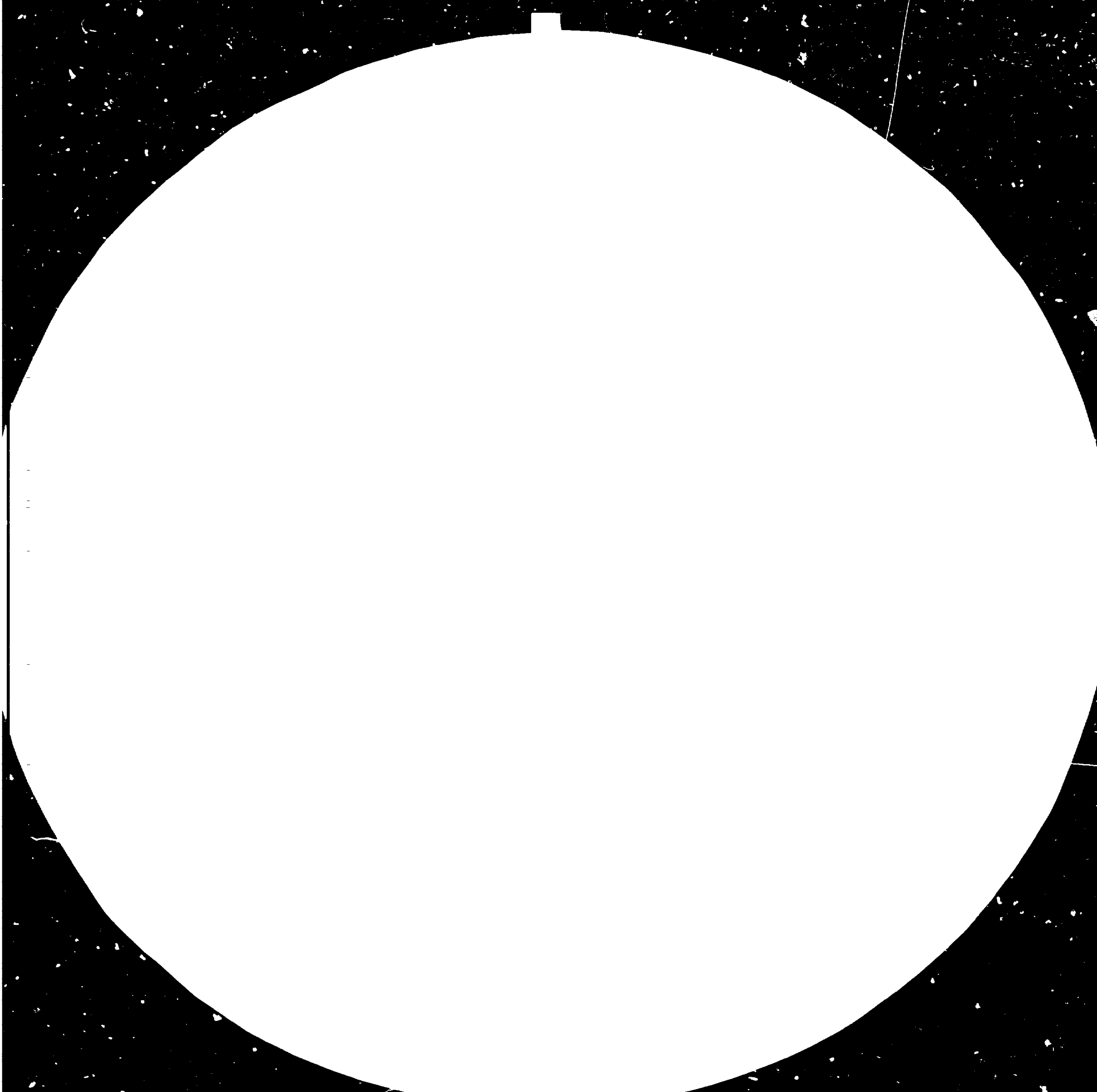
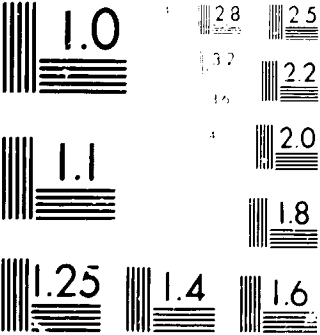
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org





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THE ECONOMICS OF, AND POTENTIAL FOR, ENERGY CONSERVATION AND SUBSTITUTION

Andrew G. Brown

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ACC TASK FORCE ON LONG-TERM DEVELOPMENT OBJECTIVES

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REPORT OF THE TECHNICAL ENERGY GROUP*

(Fourth Session, New York, 13-15 December 1982)

THE ECONOMICS OF, AND POTENTIAL FOR, ENERGY CONSERVATION AND SUBSTITUTION

I. INTRODUCTION

1. The Technical Energy Group was formed by the ACC Task Force on Long-Term Development Objectives in late 1980 to consider, with the participation of interested UN departments and agencies, various specialized areas of energy and development in which further work was envisaged within the United Nations system. Of particular importance were such areas as energy modelling and projections, energy demand and supply trends, energy development prospects and developing country energy investment requirements and sources of financing. The Task Force strongly supported the need for more intensive interagency discussion and more systematic co-operation on studies carried out in the field of energy.

2. The Technical Energy Group met for the first time from 4-6 June 1981 in New York under the chairmanship of Mr. P.N. Dhar, Assistant Secretary-General for Development Research and Policy Analysis, Department of International Economic and Social Affairs (DRPA/DIESA), to discuss energy modelling and projections and policy-related aspects. At its second session from 12-14 October 1981 in New York, the Group discussed energy investment requirements of the developing countries: problems of estimation and financing. Mr. J. L. Ripert, then Under-Secretary-General for International Economic and Social Affairs opened the meeting following which Mr. P.N. Dhar assumed the chair. At its third session from 21-23 June 1982 in Geneva, under the chairmanship of Mr. Andrew G. Brown, Director, General Analysis and Policies Division, DRPA/DIESA, the Group discussed the evolution of global energy demand and supply: problems and prospects with special reference to the developing countries.

3. This is the report of the fourth session that met from 13-15 December 1982 in New York under the chairmanship of Mr. Andrew G. Brown to consider the economics of, and potential for, energy conservation and substitution.

*This report to the Task Force was prepared under the responsibility of Mr. Andrew G. Brown, Chairman, Fourth Session, at the request of the Technical Energy Group.

4. The country classification used in this report, unless otherwise specified, is identical to that of the United Nations World Economic Survey 1981-1982, namely:

Developed Market Economies: North America, Western Europe, and Other Developed (Australia, Japan, New Zealand and South Africa).

Developing Countries:
(a) Net Energy Exporting (Algeria, Angola, Bahrain, Bolivia, Brunei, Cameroon, Congo, Ecuador, Egypt, Gabon, Indonesia, Iran, Iraq, Kuwait, Libya, Malaysia, Mexico, Nigeria, Oman, Peru, Qatar, Saudi Arabia, Syria, Trinidad and Tobago, Tunisia, Venezuela and the United Arab Emirates).
(b) Net Energy Importing (all other developing countries).

Centrally Planned Economies: U.S.S.R., Eastern Europe, and China.

5. Section II contains an overview of the meaning, rationale, potential and means of energy conservation and substitution. Section III analyses the recent experiences and prospects for energy conservation and substitution in the developed market and centrally planned economies respectively and Section IV does the same for the developing countries. Section V compares the overall energy intensities in selected groups of countries. Section VI discusses the potential for increased energy conservation and substitution in energy extraction/production and in the processing, conversion, transmission, distribution and storage of energy. Section VII analyses the experience and prospects for increased energy conservation and substitution in the major key end-use sectors (industry, transport, residential/commercial and agriculture). Section VIII discusses the economics of energy conservation and Section IX indicates measures - both domestic and international - that are needed to promote energy conservation and substitution.

II. THE MEANING, RATIONALE, POTENTIAL AND MEANS OF ENERGY CONSERVATION

6. While the term "energy substitution" is well understood, there is often confusion as to what exactly is meant by "energy conservation". The Group defined the term "energy conservation" to include:

(a) energy saved by stopping certain activities altogether irrespective of their energy content (e.g. cancelling production plans, not purchasing an automobile, turning off lights in all empty rooms).

(b) energy saved in carrying out pre-planned activities by reducing the "quality" of those activities, (e.g. lowering the thermostat in office buildings, driving at a slower speed, buying a car with a less powerful engine).

(c) energy saved in carrying out pre-planned activities in the same or better fashion while at the same time reducing energy consumption through increased efficiency of energy use (e.g. more efficient automobile engines, lowering domestic oil/gas consumption thrugh new or additional insulation in houses, utilization of waste heat generated from industrial processes).

7. While 6(a) and 6(b) as a rule do not require capital investment and thus can be implemented relatively quickly, they are often considered more "painful" since they tend to affect the standard of living and desired lifestyles. Method 7(c) covers what is normally termed increased energy efficiency and can be further disaggregated into various components such as:

(i) efficiency at the primary fuels stage covering the extraction and production of energy fuels;

(ii) efficiency at the intermediate stage - the energy sector itself - covering the processing, conversion, transmission, distribution and storage of energy;

(iii) efficiency of the mix of energy fuels delivered to the industrial, transport, residential/commercial and agricultural sectors;

(iv) efficiency in the end-use sectors or the efficiency with which operations are performed and/or finished goods produced in the four sectors referred to above.

8. The Group concentrated on category 7(iv), namely the scope for increased efficiency of energy use in the industrial, transport, residential/ commercial and agricultural sectors as being most relevant to end-consumer perceptions and also due to its feedback effects on the prior stages.

9. The rationale for energy conservation and substitution is relatively easy to come by. Studies covering developed market economies have demonstrated the substantial opportunities available to increase energy efficiency in all sectors. One study for the U.S.A. indicates that an average of 25 per cent of the energy used in the manufacturing sector could be saved by measures whose capital and related costs are less than those needed to generate equivalent amounts of energy supplies. While the potential for increased energy efficiency will vary with the specific industry and the fuel mix utilized, the net result will be lower energy consumption per unit of output. In addition to lower energy costs, increased energy efficiency reduces otherwise wasted energy and thereby both stretches out remaining fossil fuel reserves and benefits the environment through fewer emissions of waste gases.

10. While the energy to be saved through increased energy conservation and fuel substitution is greatest in the developed market economies due to their higher levels of energy consumption, energy importing developing countries can also benefit significantly since increased efficiency of energy use would lower their overall energy requirements and thus reduce their energy import bills. Several energy exporting developing countries have also realized that greater efficiency of energy use within their economies would lower their otherwise very rapid increase in domestic energy consumption, thereby allowing for higher export levels or, alternatively, prolonging the lifespan of their energy resources underground.

11. In discussing the overall potential for energy conservation and fuel substitution, the Group stressed certain views, namely:

(a) that the technical potential of improved energy conservation and substitution was significant compared to new energy supply options.

(b) that most of the existing equipment that consumes energy is not of an efficiency standard appropriate at current energy prices; that while retrofitting is economically attractive, the larger increases in energy efficiency will come from new, more efficient equipment; and that the rate at which existing equipment is replaced by more energy-efficient machinery will therefore directly influence the speed with which energy savings can occur.

(c) that the potential for energy conservation and substitution differ substantially by sector since equipment use, relative costs and technical potential differ markedly among different end-uses.

12. A hypothetical illustration of the potential for increased energy efficiency in Western Europe in 1975 by A.P. Beijdorff [1] concludes that had all energy-consuming equipment been of an efficiency standard justified by 1974/75 average energy prices, then Western Europe's primary energy consumption would have been around 15 million barrels per day oil equivalent (mbdoe) rather than the actual 21.5 mbdoe. This 30 per cent energy savings -- amounting to 6.5 mbdoe, utilizing known technology and at the average 1974/75 oil price of $11/barrel -- would in financial terms have meant a decrease of around $26 billion in Western Europe's energy bill in 1975. At current energy prices, the potential and financial implications would have been that much greater. Of the sectors considered, the largest possible energy savings were postulated for the residential/commercial sector, followed by industry, road transport and other transport in that order.

13. With their relatively less developed industrial and infrastructural base, developing countries energy savings through increased efficiency of energy use will, in quantitative terms, be far less than that in developed market economies. However, there is still considerable scope for energy savings in all sectors. There are several measures involving low-capital outlays that could be implemented relatively quickly. Examples include the insulation of service pipes and ducts carrying steam or hot water; utilization of waste heat to preheat incoming raw materials or in space heating; enhanced building design to reduce the surface area exposed to the sun and thereby reduce the need for air-conditioning; improving process control and monitoring; and more rational work schedules to reduce "no-load" periods or when the plant operates at zero efficiency. Other measures involving modified production processes, improved boilers, improved engine design/technology and modern energy-efficient equipment would, in general, require larger capital outlays and may take longer to implement. All changes resulting in increased efficiency of energy use would, however, directly reduce overall energy requirements and thus lower the cost of imported energy for energy importing developing countries. Hence, there are strong economic as well as environmental incentives for developing countries to improve their efficiency of energy use.

III. EXPERIENCES AND PROSPECTS FOR ENERGY CONSERVATION IN DEVELOPED MARKET ECONOMIES AND CENTRALLY PLANNED ECONOMIES

14. Energy consumption in the developed market economies peaked in 1979 and has since fallen. It declined by 5.8 per cent in 1980, a further 7.0 per cent in 1981 and approximately 4.4 per cent in 1982. Oil consumption of 34.4 million barrels/day (mbd) in 1982 was thus approximately 16 per cent lower than in 1979 (41.1 mbd). Individual country experiences, however, have differed significantly over the past decade. The Group discussed how much of the decrease in developed market economy oil consumption could be attributed

to lower economic growth and how much to increased energy conservation and fuel substitution. Estimates from a revised study that was originally presented at the Group's third session and which attempted to disaggregate quarterly OECD oil consumption into seasonal, cyclical and structural components show that around a third of the total decrease in oil consumption over 1979-81 could be attributed to structural change - i.e. to conservation measures and fuel substitution.

15. Table 1 is from a draft ECE study covering several country groupings in the ECE region and which attempts to decompose the decline in primary energy consumption (PEC) in 1980 into a "slowdown" effect due to lower economic growth rates and a "conservation" effect. This table vividly demonstrates existing intra-regional differences. While both North America and Northern Europe saw their PEC decline totally by 23-24 per cent, the conservation effect was more significant in Northern Europe (-11.1%) than in North America (-7.8%). Southern Europe (Greece, Portugal and Spain) showed the largest decline in PEC which was all due to the slowdown effect since its energy intensity actually increased over the period. Eastern Europe's small increase in PEC was a combination of a negative slowdown effect and a positive increase in energy intensity. Finally, in the U.S.S.R. the decrease in PEC was due to the slowdown effect alone since energy intensity rose very slightly.

Table 1

Decomposition of the Decline in Primary Energy Consumption (PEC) in 1980: Trend vs Actual

(percentage)

Country Group	Total Decline in PEC a/ PEC(1)-PEC	GDP Growth Slowdown Effect b/ PEC(1)-PEC(2)	Energy Conservation Effect c/ PEC(2)-PEC
Northern America	-22.8	-15.0	-7.8
Northern Europe	-24.1	-13.0	-11.1
Southern Europe	-27.0	-29.4	+2.4 d/
Eastern Europe	+2.0	-2.6	+4.6 d/
U.S.S.R.	-11.1	-12.1	+1.0 d/

Notes:

a/ The total decline in PEC in 1980 is the difference between PEC(1), what PEC would have been if it had grown at the former trend growth rate for 1965-1973, and actual PEC.

b/ The GDP growth slowdown effect is the difference between PEC(1), the former trend rate (1965-1973) of PEC growth, and PEC(2), the rate of growth based on lower GDP growth (1973-1980) but holding energy intensities constant (i.e. at 1965-1973 levels).

c/ The energy conservation effect is the difference between PEC(2), the rate of growth based on lower GDP growth (1973-1980) but holding energy intensities constant (i.e. at 1965-1973 levels) and the actual PEC.

d/ The opposite of the conservation effect, namely increased energy intensity.

Source: Preliminary ECE estimates presented at the fourth session, ACC Technical Energy Group, United Nations, 13-15 December 1982, New York.

16. Another paper at this session discussed the progress in energy efficiency in the Japanese economy over 1965-1980. In comparison with other developed market economies, the Japanese economy was seriously affected during the 1974-75 energy situation, but it was affected relatively little in 1979-80. Energy efficiency (proxy: Energy/GDP ratio) and oil efficiency (proxy: Oil/GDP ratio) in each of ten major sectors were analysed. The paper found that sectors with higher value added to output ratios (e.g. wholesale and retail trade, banking and insurance, real estate and the service sector) suffered less during 1974-75 than did sectors with lower value added/output ratios (e.g. metal products, industrial machinery, mining, paper and pulp).

17. While overall energy efficiency in Japan in 1975 was only 3.2 per cent higher than in 1970, it rose dramatically thereafter and was 22.4 per cent higher in 1980 than in 1975. In the transportation and communication sector, both energy efficiency and oil efficiency declined during 1974-77 but have since increased. Most industries in the large manufacturing sector, however, significantly improved both energy and oil-use efficiencies since 1975 through the introduction of more energy-efficient technology and the subutitution of labour for energy. By 1980, oil-use efficiency in the manufacturing sector was nearly double that in 1975 and, excluding petroleum and coal products, was almost three times higher than in 1975. It was found that, in general, those manufacturing industries which developed capital-saving technologies or specialized in compact, knowledge-intensive products (e.g. electronics) were able to significantly increase their share of overall manufacturing output over the decade.

18. Many developed market economies have found that their demand for energy in general - and oil in particular - is more responsive to the price of energy than earlier assumed and that the most effective policy is to ensure that market signals - in particular price developments - are passed on to final consumers with minimum delay. Energy product subsidies and other market interventions that discourage conservation and fuel substitution away from oil are being removed. In Eastern Europe, where the price of oil and natural gas imports from the U.S.S.R. are based on the average world price over the five preceeding years, the full impact of the global 1974-75 energy price increases were not fully felt until 1979 and the full impact of 1979-80 energy price increases will likely be felt only during 1983-84. This was one reason why Eastern European energy consumption during 1973-80 decreased very slightly while average energy intensity actually increased. As their energy import prices rise towards average world levels, it is quite likely that their energy consumption growth rate would decrease and the efficiency of energy use increase. There has also been, over the seventies, a significant trend in Eastern Europe towards a greater proportionate share of natural gas at the expense of oil in overall energy consumption.

19. The ECE paper An Efficient Energy Future projects that by the year 2000 the "energy conservation" scenario, that assumes widespread application of the most-efficient technology and practices now commercially available, could reduce total ECE energy demand by around 19 per cent as compared to the "trends continued" scenario which assumes only very minor improvements in recent energy efficiency efforts. The study concludes that the U.S.A. could reduce its energy demand by around 22 per cent, Western Europe by around 19 per cent, Eastern Europe by around 20 per cent and the U.S.S.R. by around 16 per cent. Potential savings by sector vary significantly depending on individual country situations and will be discussed in Section VII.

20. According to the 1982 World Energy Outlook of the International Energy Agency/OECD [2], the Energy/GDP ratio - a general indicator of progress in overall energy efficiency - which declined by 12.1 per cent over 1973-80 is expected by the year 2000 to decline by 16.5 per cent as compared to 1980 under the "high demand" scenario and decline by 20.6 per cent under the "low demand" scenario. These estimates are fairly close to the previously discussed ECE projections . The World Energy Outlook forecasts imply that if efficiency improvements do not occur, energy demand will grow 3.1 per cent rather than 2.1 per cent p.a. over 1980-2000 under the high demand scenario and 2.6 per cent rather than 1.5 per cent p.a. under the low demand scenario. The postulated additional demand in the year 2000 could amount to between 23-26 mbdoe and hence the critical contribution of energy efficiency to the future energy demand/supply balance cannot be over-emphasized.

IV. EXPERIENCES AND PROSPECTS FOR ENERGY CONSERVATION IN DEVELOPING COUNTRIES

21. It has been argued that energy conservation, in general, is an inappropriate energy policy strategy for developing countries since there is significant potential for energy conservation only where large wasteful use of energy already occurs. This argument is incorrect since it identifies energy conservation solely with the reduction of luxury consumption and ignores the possibilities for conservation through more efficient energy use. The matter can be clarified if two aspects of energy conservation are considered separately, namely, (a) the short-run prospects for energy conservation utilizing the existing stock of energy-using machinery; and (b) the long-run prospects for energy conservation as the developing economies grow and industrialize. It is in the short-run that the possibilities for conservation are more restricted, partly because comparatively few people have cars which they use for non-essential purposes. In the developing country case studies analysed by the Group, it was found that while short-run energy savings could be generated fairly easily and cheaply, the overall magnitude of these savings was likely to be small. However, the incorporation of conscious energy conservation policies into the overall energy planning framework in developing countries could result in significant longer-term energy savings and thereby cause a reduction in required oil imports or, for oil-exporting nations, an increase in the quantity of oil available for export.

22. Unlike developed market economies, many developing countries have two different economic sectors - the modernized urban sector and the traditional rural sector. While greater industrial energy efficiency and more efficient road transport are relevant considerations in the urban sector, in the rural sector more efficient wood stoves, biogas plants and water pumps for irrigation are of primary importance. As these nations industrialize, their overall commercial energy consumption will rise due to more energy-intensive production processes, increased mechanization in the agricultural sector and the tendency, as incomes rise, for fossil fuels to replace firewood and other renewable energy resources in rural areas. Increased energy efficiency, by reducing the overall growth rate of energy consumption required for the same GDP growth rate would thus, for energy-importing developing countries, reduce the level of essential energy imports or, alternatively, the same level of energy imports could result in higher economic output.

23. The Group discussed the recent experience and potential for energy conservation and substitution in Brazil, Kenya, Nigeria, the Republic of Korea and member states in the ECWA and ESCAP regions respectively.

24. Brazil is the largest oil importer in the developing world and its postwar economic growth relied, to a significant extent, on inexpensive imported oil and abundant domestic hydropower. Between 1969 and 1979, oil imports rose from 26 to 40 per cent of primary energy consumption and in 1979 Brazil was importing 85 per cent of its petroleum requirements. In 1980, however, oil imports fell from 85 to 77 per cent of total requirements and this ratio is expected to drop further. By 1985, oil imports are projected to be half those in 1979, constituting only 12 per cent of primary energy consumption. Brazil's energy strategy has at least five key elements [3] :

- increased domestic production of oil, gas and coal;
- continued expansion of large-scale hydroelectric and nuclear power systems;
- increased efficiency of energy consumption and, in particular, oil use in industry and transportation;
- increased production of ethanol from biomass sources; and
- increased use of other renewable energy sources (solar thermal and solar electric systems, wind, biogas and small-scale hydropower).

25. The projected energy mix for Brazil in 1985, as compared to 1979, calls for oil imports to fall from 34.5 to 12 per cent, domestic oil production to increase from 6 to 12 per cent, coal to double from 4.3 to 8.7 per cent, hydroelectric to jump from 28.3 to 38.6 per cent, and alcohol, bagasse, firewood and charcoal together to increase by a half. The estimated savings from energy conservation in 1985 - approximately 200,000 b/d oil equivalent - would be around 5.7 per cent of total primary energy consumption, would outrank the assumed 1985 share of the alcohol program (4.1 per cent) and would constitute about 20 per cent of total 1985 oil consumption. The Brazilian Energy Model, the central energy planning document issued by the Ministry of Mines and Energy, further postulates that around 35,000 b/d (of the 200,000 b/d figure) could be saved by reduced consumption of fuel oil in the industrial sector [3].

26. In Kenya, "commercial" energy consumption accounts for about a third of total energy use, with the remaining two-thirds consisting of firewood, biomass and other renewable energy sources. All oil and coal used are imported and the cost of these imports rose from 2 per cent of total non-energy export earnings in 1973 to 36 per cent in 1980. Transportation and industry together account for 81 per cent of total commercial energy use, agriculture for 8 per cent, the residential sector for 7 per cent and the commercial sector for 4 per cent. While the ratio of growth in oil demand to real GDP growth fell from 1.6 during 1969-73 to below 0.9 during 1973-80, it was argued that this in itself did not necessarily indicate improved energy productivity. Gasoline, jet fuel and fuel oil were the main petroleum products responsible for the reduced demand. The slower growth in fuel oil demand was attributed to increased hydroelectric production. Reduced transportation requirements that led to the decreases in gasoline and jet fuel demand did not result in the same proportional decline in economic output as would declines in agricultural or industrial activity. The Oil/GDP ratio was thus found to be an inappropriate guide to assessing changing patterns of energy use in Kenya [4].

27. The consultant study [4] concluded that savings of 20-25 per cent of present energy consumption are attainable in Kenya's industrial sector through economically attractive measures that could save around one million barrels of

oil per year. Greater proportional savings are possible in ground transport; however this potential, involving improved vehicle maintenance and traffic management, is more difficult to achieve. Electricity consumption in commercial buildings could be reduced fairly easily by around 25 per cent. It was pointed out that as Kenya's economy grows, it has the opportunity to ensure that its new capital stock - factory equipment, buildings, vehicles and appliances - is more energy-efficient. Thus future potential savings are much greater than the current potential from existing capital stock. Improved equipment maintenance programmes, better energy accounting systems, improved training and expedited import formalities for energy-conservation equipment were cited as criticially important institutional measures in this regard.

28. In Nigeria, "commercial" energy accounted for 27 per cent of total energy consumption in 1980 while fuelwood, charcoal and biomass accounted for the remaining 73 per cent which was primarily for domestic use in rural areas. The share of commercial fuels has been increasing rapidly - from 13 per cent in 1970 to 27 per cent in 1980 and is expected to continue its rapid growth in the future. The commercial energy consumption mix in 1980 was oil 75 per cent, hydropower 15 per cent, natural gas 8 per cent and coal 2 per cent. As a major oil producer, Nigeria exported around 94 per cent of total oil produced in 1980 and oil export revenues accounted for 65 per cent of total government revenues. The consumption of commercial energy grew approximately at 15 per cent per year during the seventies; in the future, efforts to complete Nigeria's ambitious development plans is likely to keep the energy demand growth rate high [3].

29. The transportation sector in 1980 accounted for 53 per cent of total commercial energy consumption and it was felt that around 20 per cent energy savings were feasible at fairly low cost, amounting to around 6.5 million barrels of oil annually. The industrial sector utilized 13 per cent of total commercial energy consumption, and savings of 20 per cent in fuel consumption and 7.5 per cent in electricity consumption could together result in a savings of around 1.3 million barrels of oil equivalent per year. Smaller savings were feasible in electricity generation. The introduction of more efficient kerosene and wood stoves, increased reliance on biogas digestors and more efficient use of charcoal could also significantly conserve non-commercial energy resources currently used in rural areas [3].

30. In the Republic of Korea, a dynamic energy conservation programme initiated in 1974 has been highly successful with the Energy/GDP ratio declining from 1.55 during 1961-73 to 0.99 during 1973-80. This decline was all the more creditable since the share of manufacturing in total GDP rose from 18 to 34 per cent over 1970-1980 with a sharp increase in the share of heavy industry. Very little non-commercial energy is consumed at present; the share of firewood to total energy consumption fell drastically from 57 per cent in 1961 to 7 per cent in 1980 and will likely continue its decline in the future. Industry consumes around 36 per cent of primary commercial energy and the overall energy intensity in the manufacturing sector declined by a third over 1970-78. While the decline during 1970-75 was mainly in light and heavy industry and occurred largely due to improved energy management, the decline during 1975-78 was more pronounced in energy-intensive industry due to energy-saving designs and economies of scale in new plant and equipment with a smaller contribution from enhanced energy management. The government has played a key role in fostering investment in industrial energy conservation [4].

31. The residential/commercial sector in the Republic of Korea accounts for 38 per cent of overall energy demand and the key feature has been the shift away from firewood and towards consumption of electricity. Government

initiatives to promote energy conservation include a ban on air-conditioning use except during 10 July - 20 August, building codes and energy efficiency labels on appliances. Transportation constitutes 12 per cent of total energy use and consists primarily of road transport. To discourage automobile travel, the tax on gasoline is 180 per cent of its cost while the tax on diesel fuel is only 7 per cent. Consumption of petroleum products in transport grew at less than 4 per cent per annum during 1973-79 after having grown at around 15 per cent per annum during 1969-73.

32. The Group considered the ECWA report Energy Conservation in the ECWA Region: Prospects and Possible Lines of Action. This report classifies member nations of the region according to their energy resource endowments, economic structure and per capita energy consumption levels and concentrates on energy conservation possibilities in energy-exporting member states. The potential for energy conservation in Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates was found to be significant. The largest potential for energy conservation was found to lie in utilization of otherwise flared natural gas. In 1979, sixty per cent of natural gas produced in the region was flared, amounting to approximately 57 million tonnes of oil equivalent. Most of the Gulf nations have plans to utilize the currently wasted gas, and the coming on stream of gas-gathering plants together with the associated fertilizer and petrochemical plants and energy-intensive industries should substantially reduce the quantity of gas flared.

33. The Group reviewed the Proceedings of the ESCAP Working Group Meeting on Efficiency and Conservation in the Use of Energy, held at Bangkok during 16-22 October 1979. The agenda included analysis of the current energy situation and the need for conservation, available technologies for improving efficiency, policy measures and international and regional co-operation. Conservation and fuel substitution developments in member states included the following:

- increased efficiency in the transport sector through a mix of higher gasoline taxes, speed limits, closure of gas stations for certain hours, etc. (India, Papua New Guinea, Philippines, Singapore, Sri Lanka, Thailand).

- increased efficiency in air-conditioning (India, Papua New Guinea, Philippines, Singapore, Sri Lanka, Thailand).

- more efficient kerosene and/or wood-burning stoves (India, Indonesia).

- enhanced use of non-conventional energy technologies (Bangladesh, Philippines).

- more diversified energy mix (India, Indonesia, Iran, Malaysia, Pakistan, Papua New Guinea, Philippines, Thailand).

- oil refinery modernization to increase processing efficiency (Bangladesh, Pakistan).

- increased efficiency in electricity generation and distribution (Afghanistan, India, Singapore).

- substitution of oil by natural gas or coal in power plants (Bangladesh, India).

V. COMPARISON OF OVERALL ENERGY INTENSITIES IN SELECTED COUNTRIES

34. While different measures are available to assess the energy intensity of an entire economy, of particular sectors or sub-sectors, or of individual factories, farms, buildings and vehicle fleets, the most common measure at the macroeconomic level is the ratio of the volume of energy consumed to the value of GDP. Despite its limitations in analysing sectoral and sub-sectoral activities, this ratio does provide an indication of the overall trend in energy intensity. Table 2, from the paper contributed by the World Bank, groups selected countries into high intensity, moderate intensity and low intensity consumers based on their consumption of energy per US $1000 of GDP at 1980 prices.

35. While the categories in Table 2 are rather arbitrary, the groupings do highlight some interesting similarities and differences. The high-intensity group, rather surprisingly, includes developing (Republic of Korea, India, Yugoslavia), centrally planned (China, Hungary, Romania) and developed market economies (U.S.A., Canada). These countries generally have highly developed, energy-intensive heavy industry sectors (e.g. steel, cement, chemicals, refineries) and all except India are temperate zone countries with space heating requirements. Most countries in this group consume a relatively high proportion of coal in their industry and power sectors and in rail transport (China, India) with the accompanying high conversion losses in each of these sectors. China, Hungary and Romania, all centrally planned economies, appear to be the highest-intensity energy consumers. Problems of conversion of net material product in national currencies into gross domestic product in US dollars may, however, tend to disturb the Energy/GDP ratio, though physical indices of energy intensity at the sectoral level are consistent with these findings. Factors which could be important in accounting for the high intensity are domestic energy prices significantly below world levels coupled with restricted technological choice.

36. India is an interesting "intermediate" case in which, although petroleum prices have generally kept pace with opportunity costs, prices for coal have not. The Republic of Korea, although well-advanced in industrial technology and reasonably progressive in energy pricing, has followed a highly energy-intensive industrial development strategy and has a substantial space heating requirement. China, the Republic of Korea and Hungary have all attached high priority to energy conservation in their energy strategies. In China, the impact of a marked shift from heavy to light industrial output and related energy conservation efforts is already evident in the 6.4 per cent decline in energy intensity from 1979 to 1980. Evidence at the sectoral and enterprise level in most high-intensity nations indicates considerable scope for reducing energy intensity especially in industry, transport and the power sector.

37. In the moderate-intensity group, little can be gleaned from macro-level data about energy intensity within sectors or the scope for efficiency improvement. However, nearly all the developed market economies (excluding Canada) have shown significant reductions in energy intensity over the 1972-80 period (reductions of 14.6 per cent in the U.S.A., 12.5 per cent in Japan, 10.8 per cent in the Federal Republic of Germany, 11.9 per cent in Italy, 8.8 per cent in France) reflecting both the relatively heavy decline of energy-intensive industries during the recent recession and also the impact of aggressive energy conservation strategies and higher energy prices. Developing countries, however, show constant or increasing energy intensities reflecting

Table 2

Primary Commercial Energy Intensity in Selected Countries: 1972-80

(tonnes of oil equivalent per US $1000 of GDP at 1980 prices)

	1972	1975	1979	1980
High-Intensity Consumers a/				
China	1.96	2.13	2.20	2.06
Hungary	1.40	1.34	1.36	1.39
Romania	n.a.	n.a.	n.a.	1.26
Canada	0.92	0.89	0.89	0.95
Korea, Republic of	0.62	0.63	0.68	0.74
U.S.A.	0.82	0.77	0.73	0.70
India	0.58	0.59	0.63	0.61
Yugoslavia	0.55	0.58	0.56	0.56
Moderate-Intensity Consumers b/				
Mexico	0.41	0.42	0.49	0.47
Turkey	0.39	0.39	0.43	0.45
Brazil	0.35	0.36	0.38	0.36
Italy	0.42	0.40	0.37	0.37
Indonesia	0.34	0.36	0.38	0.35
Japan	0.40	0.38	0.35	0.35
Germany, Federal Republic of	0.37	0.35	0.34	0.33
France	0.34	0.30	0.31	0.31
Low-Intensity Consumers c/				
Bangladesh	0.20	0.20	0.24	0.24
Ghana	0.11	0.12	0.15	0.16
Haiti	0.13	0.13	0.15	0.16
Nigeria	0.06	0.06	0.05	0.11
Nepal	0.09	0.06	0.06	0.07
Burundi	0.04	0.05	0.05	0.05

Notes:

a/ commerical energy consumption approaching or exceeding 0.6 tonnes of oil equivalent per $1000 of GDP.

b/ commercial energy consumption between 0.3 and 0.5 tonnes of oil equivalent per $1000 of GDP.

c/ commercial energy consumption below 0.3 tonnes of oil equivalent per $1000 of GDP.

Source: "Energy Efficiency in the Developing Countries", paper presented by the World Bank at the fourth session, Technical Energy Group, United Nations, 13-15 December 1982, New York.

growth in energy-intensive development in industry, transport and agriculture, but also indicating the relatively smaller impact from recent efforts to improve energy efficiency. Brazil shows a 5 per cent decline in intensity during 1979-80 while India, Mexico and Indonesia show smaller declines.

38. In the low-intensity group, increasing energy intensity is to be expected in this entirely low-income, essentially non-industrialized group, but sectoral and enterprise level data from at least some of them nevertheless indicate significant scope for improving commercial energy efficiency, particularly in the industrial, power and transport sectors. It should be stressed that the predominant energy sources in this group are fuelwood and other biomass fuels which are not reflected in the data. If such energy forms were included, the results would be very different, with the extremely high degree of conversion losses for such fuels considerably boosting the apparent energy intensity of these economies.

VI. POTENTIAL FOR INCREASED CONSERVATION AND SUBSTITUTION IN ENERGY EXTRACTION/PRODUCTION AND IN THE PROCESSING, CONVERSION, TRANSPORTATION, DISTRIBUTION AND STORAGE OF ENERGY

39. There is considerable scope for increased efficiency and conservation in most stages of the energy process - from the primary extraction/production stages to the intermediate processing/conversion and transmission/storage stages and finally in end-use applications in the industry, transport, residential/commercial, agriculture and electric power sectors. Table 3 is an overview of the average efficiency of energy resource use in the ECE area in the early seventies and possible levels of efficiency that might be attained by the early 1990s. This table was contained in the 1976 ECE report Increased Energy Economy and Efficiency in the ECE Region [5] and assumed $11/barrel oil prices together with all known geologic, economic, operational, technical and environmental constraints. At current energy prices and the recognized need to conserve energy, the average efficiency levels in Table 3 would, if anything, understate the true potential of energy conservation.

Energy Extraction/Production

40. The two main objectives at this stage are first, to increase the proportion of primary energy extracted from a given deposit thereby lowering the proportion that is abandoned/unused and second, to reduce the consumption of auxiliary energy required in the extraction process. The average efficiency of extraction of oil and coal in the ECE region was around 46 per cent in the early seventies but could rise to between 60-70 per cent by the early 1990s. The room-and-pillar system of underground coal mining has resulted in a two-thirds loss of potential coal reserves in the various deposits due to an excessive number of safety and shaft pillars, often the result of bad layout design or imperfect mining activity. The long-wall system of mining utilizes more modern mining technology, reduces the need for safety pillars without loss in overall safety requirements and reduces reserve loss from 65 per cent to between 20-40 per cent. In the future, in-situ coal gasification would provide a new dimension to exploitation of coal reserves.

41. Secondary and tertiary oil recovery methods have raised the oil recovery percentage in the ECE region to around 35-40 per cent of reserves; it has been estimated that additional waterflooding and introduction of new methods

TABLE 5

Average efficiency[a] of energy resource use in the ECE region—present situation and long-term prospects

(Orders of magnitude)

The various stages of the flow of energy	Levels of efficiency attained in the early 1970s: Level (percentages)	Levels of efficiency attained in the early 1970s: Main causes of low efficiencies	Levels of efficiency which might be attained in the early 1980s: Practically possible (percentages)	Levels of efficiency which might be attained in the early 1980s: Maximum level attainable (percentages)	Main sectors for improvement: (a) Measures fully exploited by the early 1980s; (b) Measures not fully exploited by the early 1980s	Change in percentage: From	Change in percentage: To
1. Extraction	46	Primary extraction techniques for oil; room-and-pillar mining of coal	59	71	(a) Shift towards secondary and tertiary oil extraction, long wall face mining of coal; development of hydro-power potential (b) Tertiary methods of oil extraction	+28	+54
2. Upgrading and conversion	78	Classical power generation	70[b]	70[b]	(a) Concentration of classical power generation; combined electricity/steam production; replacement of old equipment (b) New technologies such as MHD, fuel cells, gas turbines, advanced HTR, breeders, fusion reactors	−10[b]	−3[b]
3. Transport, distribution, storage	98	Electric power transmission losses, losses in transformers, compressors, underground gas storage	96[b]	98	(a) Higher voltage, better insulation (b) Increased use of direct current in long-distance transmission; cryogenic and super-conducting cables	−2[b]	±0
4. Utilization							
(a) Transport sector	20-25	Gasoline-powered internal combustion engines; modal transport pattern; sub-urbanization	23	30	(a) Smaller cars; shift of traffic from road and air to rail distribution; better traffic flow (b) New transportation and propulsion techniques; urban planning; substitution of transport by telecommunications, nearby recreation, etc.	+20	+30
(b) Industry sector							
(i) Iron and steel	55	Waste heat and waste gases	65	65	(a) Recovery of waste gases and low-grade heat; upgrading of plant size; partial integration of steel works with nuclear power stations (b) Continuous casting	+20	+20
(ii) Chemicals	50-70	Leaks	55-75	60-80	(a) Leak prevention, insulation, recycling, new technologies, plant integration into steam supply systems, concentration of operations in greater units	+10	+20
(iii) Aluminium	30	Losses of electrodes	35	35-40	(a) Increased scrap and waste heat recycling (b) New electro-chemical and chemical processes	+15	+25
(iv) Other industries	40-45	Low price elasticity	45-50	55-60	(a) Assessment of real needs; insulation; better equipment; better maintenance; recovery of waste heat; shift in energy mix; total energy schemes	+10	+30
(i-iv) Weighted average	45-50		56	60		+18	+25
(c) Agricultural sector	30	Gasoline and diesel powered internal combustion engines	33	36	(a) Improved production structure, capacity use and integration; distillation; recycling of waste; total energy systems (b) Recycling of agricultural waste, changed demand structure	+10	+20
(d) Households and other consumers .	45	Inefficient appliances, heat dissipation	50-55	60-65	(a) Insulation of appliances and buildings; total energy systems; recycling of waste and trash; district heating, reduced consumption levels; redesigned energy mix (b) Heat pumps; solar collectors; energy-conscious design of buildings	+15	+40
(a)-(d) Weighted average	42		51	55		+20	
5. Energy sector as a whole	15		20	30		+33	

Source: [illegible], table [illegible].
[a] Useful output as percentage of input or availabilities.
[illegible]
[b] [illegible]

Source: Increased Energy Economy and Efficiency in the ECE Region, Economic Commission for Europe, United Nations, New York, 1976 (sales number E.76.II.E.2).

could raise this percentage to between 40-60 per cent by the 1990s. The contribution of enhanced recovery can be enormous. For instance, in the U.S.A. a one per cent final oil recovery factor is equivalent to one year's domestic consumption of liquid hydrocarbons. If the entire volume of hydrocarbons underground could be recovered, global proved exploitable reserves would jump four-fold. Since more oil is lost during extraction than at any other stage of oil use, the potential for increased efficiency of extraction remains high.

42. The recovery factor for natural gas in the ECE region ranges from 60-80 per cent, with maximum recovery factors of between 85-95 per cent. Flaring of natural gas, however, wastes approximately 12 per cent of global natural gas production or around 160 million tonnes oil equivalent in 1979. As mentioned earlier, flared gas in the ECWA region in 1979 amounted to almost sixty per cent of production. The introduction of gas-gathering plants and associated fertilizer and petrochemical plants would significantly increase the percentage of natural gas utilized and thus reduce the quantity flared.

43. In forestry, technical improvements in wood-processing and substitution of more energy-intensive products by less energy-intensive products could raise efficiency significantly - by as much as a third in the ECE region. In developing countries where wood is harvested for direct use as fuel, suitable reforestation policies that could include the introduction of quick-growth tree farms or energy crops (sugar cane, sweet sorghums, etc.) would raise efficiencies significantly . For hydropower, the economic harnessable potential is currently around three-quarters of the technical potential and this percentage could be raised slightly.

Processing, Conversion, Transmission, Distribution and Storage of Energy

44. The intermediate stage is often referred to as Energy Sector consumption, i.e., energy consumed (a) in converting primary fuels (oil, coal, gas, biomass) into electric power in thermal power plants; (b) in converting uranium into electric power in nuclear power plants; and (c) in the transmission and distribution of electric power from thermal, hydroelectric and nuclear plants to consumers. The energy sector presents considerable opportunities for improving fuel efficiency, primarily through (i) substitution between hydro-based power and thermal power; (ii) substitution of lower-cost thermal fuels (coal, lignite, natural gas) for petroleum fuels; and (iii) reduction of losses in the conversion process (mainly in thermal plants) and in transmission and distribution.

45. Improvements in the efficiency of energy processing have been sustained by technological change induced by various economic factors. The processing of natural gas, the cleaning and regrading of coal and the oil refining process, in general, are very efficient with around 90 per cent of energy input resulting in useful output. In the generation of electricity, the highest efficiency is obtained in hydropower plants — 65-70 per cent in smaller units and up to 90 per cent in larger, sophisticated plants. Thermal power generation, however, is thermodynamically inefficient with energy losses at over sixty per cent; the average efficiency of steam power plants is between 30-40 per cent, gas turbines between 20-30 per cent, diesel power plants between 30-37 per cent and conventional nuclear power plants 30-40 per cent.

46. Improved turbine design, progress in combustion technology and improvements in metals subjected to high temperatures have contributed to past efficiency advances but further gains from these sources are likely to be

small. Cogeneration or the combined production of heat and electricity from fossil fuel and nuclear plants feeding industrial processes and district heating systems could raise average efficiency to between 70-85 per cent. Low-temperature heat obtained as a by-product during electricity generation can be utilized for residential and industrial space heating, for low temperature water heating and as low-grade industrial process heat. This is, however, more applicable to countries in temperate climates; for developing countries, many of which are in the tropics, cogeneration is useful primarily in low-heat industrial applications. While cogeneration has many environmental benefits, its constraints are the necessities for integrated urban planning and plant siting. Small gains in efficiency may be attained utilizing new technologies such as fluidized bed combustion, high temperature gas turbines, solar receptors, fuel cells and magneto-hydro-dynamic generators.

47. For the ECE region it has been estimated that the efficiency factor for the transport/distribution/storage of energy at the end of the chain as a percentage of the intake of transmission lines, pipelines, barges, etc., is very high - around 98 per cent. In several developing countries, however, the efficiency factor is only 65-75 per cent and improved system management, changes in design parameters and improved distribution systems can produce very attractive returns with benefit/cost ratios of the order of 15:1.

48. Increased energy conservation and substitution in the energy sector can, in addition, result from: (a) improved analysis and selection of hydroelectric versus thermal power options, with due regard to the different capital/operating cost proportions and the opportunity cost for fossil fuels; and (b) better maintenance and boiler operation and investments to reduce conversion losses by retrofitting thermal power plants can together lead to substantial savings with high paybacks; the efficiency and capacity of hydropower plants could be improved by 3-5 per cent and 10 per cent respectively through replacement of hydraulic turbines with improved designs and the payback period is estimated at around five years.

49. Many developing countries are responding to the potential for efficiency improvement in the power sector. China is reducing the use of oil in power plants through regulatory measures, by reconverting oil-fired plants to coal, and by restricting the length of low-voltage transmission lines. India is reducing the use of oil for flame support in coal-fired plants and re-emphasizing distribution investments. Some countries are also attempting to improve load dispatch systems (central control and monitoring) and load management techniques (spreading loads evenly throughout the day). It is also estimated that at least half of the quantity of energy consumed is produced because it cannot be stored. Current devices for energy storage, such as batteries and flywheels, have severe constraints and limited application. It was considered unlikely that a technology that would absorb and release energy quickly on demand and in sufficient quantities would be developed in the foreseeable future.

VII. PROSPECTS FOR ENERGY CONSERVATION AND SUBSTITUTION IN END-USE SECTORS: INDUSTRY, TRANSPORT, RESIDENTIAL/COMMERCIAL AND AGRICULTURE

Industry

50. Industry is, in general, the largest consumer of commercial energy in developed, developing and centrally planned economies. In 1980, industry

accounted for 31 per cent of commercial energy consumption in North America, around 40 per cent in Latin America, 38 per cent in Northern Europe, 45 per cent in Southern Europe, 54 per cent in Eastern Europe and 64 per cent in the U.S.S.R. World Bank and UNIDO estimates show that roughly two-thirds of industrial energy consumption in developed market economies can be traced to relatively few energy-intensive activities (iron and steel, chemical and petrochemical industry, cement production and non-ferrous metals production). Process heat accounts for three-quarters of industrial end-use energy with the balance consisting of mechanical power, lighting and space heating. Energy use per unit of total industrial output declined by about 14 per cent during 1973-80 and was particularly evident in the steel and cement industries where energy costs typically represent at least a third of total production costs. Energy consumption per ton of steel/cement produced during 1975-79 declined by nine/ten per cent in the U.S.A. seven/five per cent in the Federal Republic of Germany and fourteen/ten per cent in Japan.

51. These savings were achieved through a variety of measures, ranging from improved management, maintenance and control systems to the introduction of more energy-efficient technology in both new and existing plants (e.g. continuous casting in the steel industry and the dry process of cement manufacture). Much progress has been achieved through capital investment in existing plants, with rates of return more attractive in many cases than investing in additional capacity. Much of this "retrofitting" investment has contributed to removing plant bottlenecks, thus permitting increased output.

52. The scope for reducing energy intensity in the energy-intensive industries of developing countries has been identified in several countries covered under the UNDP/World Bank Energy Assessment Program, indicating the need for relevant low-cost managerial/"housekeeping" measures that have been successful in developed market economies as well as for more capital-intensive investment in retrofitting existing plants. Table 4 demonstrates the substantial scope for improved efficiency in Brazil, China and India as compared with Japan and the U.S.A.

Table 4

Industrial Energy Intensity Comparisons in Selected Countries: 1979-81

(kilograms of coal equivalent per ton of output)

	Crude Steel	Cement Clinker
Japan	650	125
U.S.A.	890	215
Brazil	920	150
China	1260	206
India	1400	215

Source: "Energy Efficiency in the Developing Countries", paper presented by the World Bank at the fourth session, Technical Energy Group, United Nations, 13-15 December 1982, New York.

53. Experiences in developed market economies since the mid-seventies and in developing countries over the last few years show that energy efficiency strategies in industry should focus on the following key areas:

(a) Promotion of detailed energy audits, feasibility studies and energy efficiency investments (utilising fuel substitution possibilities) in key energy-intensive industries (e.g. steel, fertilizers, cement, glass, pulp and paper and brick-making) where energy costs alone account for 15-50 per cent of total production costs;

(b) Special strategies for smaller industries where energy costs may be relatively lower and where decision-makers are more numerous and perhaps less sensitive to the importance of energy efficiency improvement (e.g. textiles, food processing); special surveys, audit programmes and incentives may be necessary and development finance institutions could assume a key promotional role.

(c) Enhanced supply of energy conservation equipment such as waste heat boilers, heat exchangers, instrumentation, insulation and more efficient energy consuming/conversion equipment (e.g. motor vehicles, boilers, transformers, appliances, water heaters, stoves) through impo. policies, investment incentives and licensing/joint ventures.

(d) Development of local capability to undertake energy audits and conservation programmes (promotion, education, training) through government agencies, conservation centres, private consultants and energy supply enterprises.

54. The Group felt that, over the eighties, energy savings in industry in developed market economies could approximate 15-20 per cent of present consumption, rising to 30 per cent if the period 1980-2000 is considered. In developing nations, after allowing for increasing industrial energy consumption consequent on the industrialization process, about one-fifth of energy presently consumed could be saved by the year 2000. Roughly similar savings in percentage terms could be achieved in centrally planned economies.

Transportation

55. This sector comprises all passenger and freight traffic by road, rail, air, and water as well as pipeline conveyance of liquid/gaseous fuels and coal in slurries. The growth rate of energy use in transport increased steadily in most regions over the seventies; since 1979, however, the share of transport has stagnated (Northern Europe, Eastern Europe) or fallen (North America). In developing countries, the transport sector is usually the largest consumer of petroleum fuels and the second or third-largest consumer of all commercial fuels. In 1980, transport accounted for 45 per cent of commercial energy consumption in Latin America, 35 per cent in North America, 31 per cent in Southern Europe, 22 per cent in Northern Europe, 13 per cent in the U.S.S.R. and 7 per cent in Eastern Europe.

56. While passenger traffic accounts for two-thirds of the energy consumed in transport in developed market economies, the percentage in developing and centrally planned economies is only around one-third since freight traffic is far more significant. In developing countries, on average, 65-80 per cent of transport energy is for road transport, 5-20 per cent each for air and sea transport and 1-7 per cent for rail transport. The varying structure of

transport in different countries has a dramatic impact on sectoral intensity of energy use; automobiles consume two to three times more energy per passenger-kilometre than buses or railways and trucks consume three to ten times more energy per tonne-kilometre than rail freight, pipelines or maritime transport. Oil's share in transport averaged over 95 per cent in developed market economies but only 67-85 per cent in developing countries and in centrally planned economies. The transport sector in many developing countries, however, is completely dependent on oil. Though the scope for inter-fuel substitution is limited, the potential for increased energy efficiency at relatively low cost is considerable.

57. Automotive fuel efficiency has increased considerably since 1975, primarily as a response to higher gasoline prices. The World Bank paper at this session pointed out that the average fuel consumption of new car fleets in the U.S.A. and Japan declined by 39 and 26 per cent respectively during 1975-80 and that targets for further improvement during 1980-85 range between 5-27 per cent in several developed market economies. Average gasoline consumption per automobile in 1980 in seven major developed market economies (Canada, U.S.A., Japan, Italy, France, the U.K. and Germany) was 14 per cent lower than in 1975. While the U.S.A. had the largest percentage decrease (15 per cent), its average consumption was still the highest in the group (15.15 miles/gallon) due to its existing stock of larger, less efficient automobiles. IEA/OECD assumptions of potential car stock efficiency gains to the year 2000 and based on the index 1980=100 are U.S.A. (227), Italy (149), Australia, France and Germany (138), Japan (137), Canada and the Scandinavian countries (135), the U.K. (124) and Southern Europe (118).

58. While many developing countries have followed aggressive policies on gasoline pricing and automobile import tariffs primarily to increase government revenue, increased fuel efficiency has been an associated benefit. Areas in which further attention is warranted include:

(a) pricing gasoline at world-market levels but subsidizing diesel fuel is often counter-productive; not only is the proportion of diesel fuel used very high but subsidies often provide inadequate incentive for more efficient vehicle operation, thereby hampering the development or introduction of more efficient engines.

(b) energy audits of commercial vehicle fleets (buses, trucks, taxis) could result in fuel savings of ten per cent or more through measures including operational and retrofit improvements, better batteries and improved maintenance; additional fuel savings of ten per cent or more could be obtained through more efficient driving patterns of bus and truck drivers.

(c) improved truck utilization through better fleet programming holds substantial potential for fuel saving (e.g. fewer empty backhauls, reduced idling, more optimal loading).

(d) more effective traffic management programmes have high short-term economic returns with as much as a fourth of the savings due to reduced fuel consumption (e.g. in Singapore).

(e) reduced fuel consumption due to reduced vehicle weight resulting from down-sizing and substitution of materials.

59. The energy efficiency and overall cost efficiency of rail transport is high but could be improved through improved diesel locomotive fuelling, operating and maintenance procedures, through energy audits, through improved train scheduling and operating procedures and through the electrification of main lines in countries where traffic volumes are very heavy and the capital investment justified.

60. Aviation fuel currently accounts for less than 5 per cent of global petroleum products consumption. According to ICAO paper discussed at the session, fuel efficiency improvements over the last two decades have resulted from improved engine efficiency, increased aircraft size and through operational changes including flight level assignments, cruising speeds, taxiing procedures and overall air traffic management and flow control in high traffic density areas. The result of these efforts on international scheduled services has been a 16 per cent reduction in fuel consumption per available tonne-kilometre over 1973-81. ICAO estimates that the introduction of newer, more fuel-efficient aircraft utilizing improved aerodynamic designs, the retrofitting of some aircraft with new engines and small airframe modifications would together reduce fuel consumption per tonne-kilometre by nearly 20 per cent during 1978-90. For maritime transport, as with aviation, increased fuel efficiency will result from improved fuel handling, better maintenance, operational changes, engine retrofitting and, in the longer-run, moving towards more fuel-efficient vessels.

Residential/Commercial

61. Residential and commercial energy consumption has been growing steadily in all regions since it meets the demand for space heating, air-conditioning, hot water supply, cooking, refrigeration, lighting, small appliance usage and small workshop manufacturing. The end-use efficiency of this sector is presently around 45 per cent and could gradually increase to between 55-80 per cent through improved building insulation, increased efficiency of appliances and optimum use of the available mix of energy supplies.

62. Any broad comparison between developed and developing economy experiences in this sector runs into major difficulties. While, in developed market economies, space heating requirements account for around 85 per cent of residential/commercial energy consumption and upto a third of total primary energy consumption, such demand is minimal in developing countries, most of whom are located in warmer regions. Thus, in developing countries, the commercial energy consumed by this sector is only around 10-15 per cent of total energy demand. When, however, traditional or "non-commercial" fuels are considered, the residential/commercial sector is often one of the largest consumers of energy in developing countries, its share varying between 20-50 per cent of total energy consumption. In Latin America, according to the paper contributed by OLADE, while this sector accounts for only 18 per cent of commercial energy consumption, it accounts for 29 per cent of total energy consumption, with biomass responsible for almost all the eleven percentage point increase.

63. Due to its importance and potential for energy savings and substitution, space heating has triggered significant research in developed market economies. This research attempts to satisfy several objectives simultaneously, namely, (a) rationalization of heat demand by reducing heat loss in buildings through better insulation and design and sun orientation; (b) rationalization of heat supply by limiting capacity to "real" comfort needs; (c) improving the

efficiency of the heat-generating unit (boilers, district heating, heat pumps); and (d) improving operational conditions to achieve the highest possible efficiency. Efforts have also been made towards total or partial substitution of oil and natural gas by other fuels (e.g. coal, solar energy, garbage combustion.

64. As can be seen from Table 5, there is significant scope for increased thermal efficiency in this sector. The Group found that one of the most attractive heating options for buildings was the heat pump which runs on an evaporation-condensation cycle (like traditional refrigerators) but in reverse, i.e. it absorbs low-temperature heat from the atmosphere and releases this heat at a higher temperature into the space or the water to be heated. A drawback is that when the outdoor temperature falls and the demand for heat increases, the capability of the heat pump to provide heat drops and a back-up heat source (e.g. an oil burner) is needed. This working mode of a heat pump plus a back-up heater used intermittently is termed a "bivalent" operation. A 1981 study for the Federal Republic of Germany found that replacing a traditional oil heating system in a single-family house by a bivalent heat pump saves about two tonnes of oil per year and results in both overall energy savings (less electricity used) and a significant substitution away from oil. If, for the sake of argument, all seven million one-and-two-family houses in the Federal Republic of Germany were heated thus, between 14-17 million tonnes of oil equivalent could be saved annually.

Table 5

Usage		Thermal efficiency at the point and time of conversion (per cent)
Burning of wood or coal in fireplaces	....	20
Space heating with: coal	....	45
oil	....	63
natural gas	....	75
electricity	....	95
Cooking with gas	....	37
Cooking with electricity (excluding generation and transmission losses)	....	75
Heating of water in a natural gas appliance	...	62
Heat pumps	....	85 a/

Notes:

a/ But rising to 200-250 per cent if gains from recycling are included.

Sources:

Increased Energy Economy and Efficiency in the ECE Region, E/ECE/883/Rev.1, United Nations sales publication E.76.II.E.2. Based on tables from M. Deveirman and G. Meier, "The Energy Enigma: Refiners' Dilemma", 1974 and from J. Simpson and P.H. Ross, "World Energy and Nuclear-Electric Economy," paper presented at the World Energy Conference, Detroit, 1974.

65. Suggested energy efficiency strategies for this sector included:

(a) energy audits for buildings and technical assistance programmes for improved energy management, and particularly in large commercial/institutional buildings with space heating or cooling requirements where energy savings of 25 per cent or more could be easily achieved.

(b) surveys and studies of residential energy substitution options with special reference to environmental aspects, improved metering and the possible role of energy supply enterprises in extending technical and financial assistance (e.g. for home audits, insulation, conversions, fuel substitution, and appliance and stove investments).

(c) strategies aimed at improving the distribution of more efficient cookstoves (allowing for the different problems/options in rural versus urban residences) and emphasizing the economics, marketing and commercialisation of cookstoves.

(d) improved standards and regulations for household electrical appliances and new building design (where savings could reach 40-70 per cent).

Agriculture

66. Farming methods range from traditional farming that relies primarily on human and animal power, wind energy, water power and organic matter as fertilizer to modern farming that is fairly energy-intensive, utilizing increasing quantities of fossil fuels and electricity for fertilizers, irrigation, pesticides, farm machinery and transport. It was pointed out that agricultural production itself only consumes around 3.5 per cent of total final energy consumption in developed market economies and around 4.5 per cent in developing countries. It is in the post-harvest food system that developed market economies use 15-20 per cent of final energy consumption, where the post-harvest food system (PHFS) is defined to include food processing, transport, storage, and cooking and preparation. According to the FAO paper presented at the session, energy consumption in the post-harvest food system varies greatly by country as shown in Table 6.

67. Several conclusions were drawn from Table 6:

(a) of the ten developing countries analysed, seven showed PHFS energy use constituting between 32-43 per cent of total energy use; the Ivory Coast (59 per cent), Bangladesh (76 per cent) and Tanzania (89 per cent) were significantly above the range.

(b) in general, the higher the share of PHFS energy use in total energy use, the higher the percentage of non-commercial fuels utilized. Exceptions were Brazil, Colombia and Nicaragua where non-commercial fuels accounted for between 38-51 per cent of total energy use and where non-commercial fuel use in sugar processing was exceedingly high (96-100 per cent).

(c) oil and natural gas producers (Algeria, Mexico, Tunisia and Egypt) utilize proportionately far more commercial energy in the PHFS than do non-energy producers.

Table 6

Energy Use in the Post Harvest Food System (PHFS) in Selected Developing Countries in 1980

(Per cent)

	POST-HARVEST FOOD SYSTEM			POPULATION IN URBAN AREAS	PHFS Energy Use	
	Per cent of total energy use	Per cent share: Non-commercial energy	Per cent share: Commercial energy	(per cent)	Food Processing (per cent)	Food cooking and preparation (per cent)
Colombia	32	66	34	73	40	58
Algeria	35	11	89	50	1	98
Brazil	37	81	19	62	24	72
Mexico	37	19	81	64	23	76
Nicaragua	40	92	8	57	30	69
Tunisia	40	35	65	60	6	92
Egypt	43	38	62	50	7	92
Ivory Coast	59	91	9	21	11	86
Bangladesh	76	98	2	16	2	8
Tanzania	89	99	1	20	1	98

Source: Energy and the Post-Harvest Food System in the Developing Countries: Current Use, Saving and Substitution Potential, FAO paper presented at the fourth session, ACC Technical Energy Group, United Nations, 13-15 December 1982, New York.

(d) in general, the higher the degree of urbanisation, the greater the consumption of commercial fuels in the PHFS. Exceptions again were Brazil, Colombia and Nicaragua due to their large endowments of non-commercial fuels.

(e) food cooking and preparation consumes the most energy in the PHFS, its share ranging from 69-98 per cent. More efficient cooking stoves can significantly reduce energy consumption. The share of PHFS energy use in food processing ranges from 1-11 per cent in countries that do not have signficant agricultural commodity exports and between 23-40 per cent in those that do (Colombia, Brazil, Mexico and Nicaragua).

68. Energy efficiency improvements are essential in agriculture, especially since increased mechanisation and lift irrigation are contributing to substantially higher energy consumption. In the Philippines, total mechanisation of land preparation, irrigation, threshing, harvesting and drying in rice cultivation could result in energy (diesel) consumption six or seven times higher than that used in the traditional system utilizing animal, human and solar energy. In India, mechanisation of land preparation alone roughly doubles total energy consumption per hectare for cultivation, harvesting and drying. While increased yields contribute to offsetting these

cost increases, the dramatic impact on energy demand is evident. Subsidised food prices reduce the incentive to farmers to increase outputs and yields. Subsidies may also wrongly influence the choice between, say, electric versus diesel-powered irrigation pumpsets. Improved efficiency of tractors, pumpsets and other agricultural machinery and better planning and control of fertilizer application to reduce indirect energy consumption were also stressed.

VIII. THE ECONOMICS OF ENERGY CONSERVATION

69. While the technical and environmental benefits of energy conservation are often well accepted, no real progress is possible unless the economics of energy conservation are favourable. The net economic benefit from energy conservation is obtained by comparing the initial capital investment required for a specific energy conservation measure with the discounted value of all the energy saved over the period since the initial investment must either be borrowed at the prevailing interest rate or give a return on capital.

70. It was noted that cost ranges for conservation measures are fairly wide and that as the number of roughly similar conservation measures (e.g. from double to triple glazing of windows) increases, they become less and less cost-effective. As regards the period under consideration, home insulation costs, for example, are normally spread over thirty years - the same period as a traditional home mortgage. In industry, while a process may last for twenty years, project evaluations are normally done over a 5-10 year period.

71. While a positive net economic benefit, as defined above, from a specific energy conservation measure would enable one to justify its implementation, it does not help one in the determination of how quickly investments in different energy conservation measures would pay off. This can be judged by calculation of the payback period - the number of years over which energy savings, discounted to their present value, are equal to or larger than the initial capital investment. Consumer behaviour, in general, shows a marked preference for relatively quick pay-offs, i.e. short payback periods. The payback period itself, according to Beijdorff and Stuerzinger [6], is determined using the following logarithmic formulation:

$$\text{Payback period (in years)} = \frac{\ln\left(1 - \frac{\Delta I}{\Delta E \cdot C_E} \cdot \frac{i-p}{1+p}\right)}{\ln\left(\frac{1+p}{1+i}\right)}$$

where: Δ I is the initial constant dollar investment

$\Delta E.C_E$ is the constant dollar cost of energy saved annually

(ΔE is the energy saved in energy units)

(C_E is the cost of energy)

i is the real value or constant dollar discounting rate utilized

p is the relative fuel price increase.

72. It has been found that for payback periods of upto five years, neither interest rate nor fuel price increase assumptions are very significant. Since several important energy efficiency measures fall into this category, the calculation of a simple economic indicator - initial capital investment divided by the cost of energy saved in the first year - is accurate enough. Thus discounting procedures are not essential in evaluating many energy efficiency measures and simple ratios will often suffice.

73. Assuming a conservation measure is technically feasible and economically justified, conditions that must, in practice, be satisfied before the conservation measure is implemented include the following:

(a) consumers must be aware that there is a long-run energy problem and that energy prices in future would rise in real terms;

(b) following such realization, the consumer should have some idea how to proceed. Price signals - following world-level pricing of marketed energy - are often the greatest inducement to conserve energy. Significant media exposure and related efforts including, if needed, the direct marketing of energy-efficiency equipment by governments, may be called for.

(c) the availability and cost of capital are fairly critical. Many options, other than reducing energy costs, compete for scarce, available capital. Subsidies and/or tax deductions can act as an effective inducement to enhanced energy conservation. Similarly, the higher the interest rate, the more economically attractive must conservation measures be to justify the money borrowed. For payback periods of less than five years, however, the rate of interest, as pointed out earlier, may not be a key determining factor.

(d) Conservation measures should be easy to implement with adequate stocks of the necessary equipment readily available and at reasonable installation costs.

74. The most important non-economic, non-technical consideration, however, concerns the consumer's time horizon. It has been argued that the average consumer will react only to demonstrated short-term benefits. Thus an energy consumer may either discard conservation measures which are in reality cost-effective or may choose only those measures relevant at current energy prices ignoring the fact that a slightly higher investment would make more economic sense when weighed against future (higher) energy prices. One reason for the apparent lack of consumer foresight on energy issues may lie in the fact that the capital investment in energy conservation for individual consumers is normally embodied in other types of capital assets (houses, cars, etc.). Once these conservation investments are made, they can only be traded together with the larger assets in which they have been embodied. Thus, unless energy conservation measures are generally recognized as economically worthwhile, consumers will tend to insist on very short payback periods for conservation measures while, at the same time, accepting much longer payback periods for the assets themselves (e.g. 25 years for a house) [6]. There are, however, encouraging signs that consumers recognize the long-run benefits of energy conservation and thus are willing to consider longer payback periods.

75. Table 7 presents detailed economic calculations for thirty different energy conservation measures in the industrial, transport and residential/commercial sectors respectively [6]. They have been ordered by the length of the payback period. A rough ranking based on the relative effectiveness of the conservation measures gives the following:

(A) Very Effective Measures

- improved maintenance of equipment	(industry)
- recycling of waste material	(")
- energy management	(")
- integrated design of processes	(")
- training of drivers	(transport)
- weight reduction of passenger cars	(")
- training of heat managers	(residential/commercial)
- improved control of air-conditioning	(")
- improved boilers	(")

(B) Effective Measures

- correct choice of energy and combustion technology	(industry)
- improved insulation	(")
- reduced vehicle air resistance	(transport)
- transmission improvements	(")
- engine improvements	(")
- improved efficiency of lighting	(residential/commercial)
- draught reduction	(")
- room thermostats	(")
- improved electric cooking appliances	(")
- waste heat recovery	(")
- integrated design with insulation	(")

(C) Not Very Effective or Having Certain Economic/Technical Uncertainties

- increased performance of electric motors	(industry)
- cogeneration of heat and power	(")
- reduced losses from friction	(transport)
- newly-designed engines	(")
- increased performance of electric motors	(residential/commercial)
- individual heat metering in houses	(")
- heat pumps	(")
- double/triple window glazing	(")
- insulation in houses	(")
- district heating	(")

76. It should be noted that this rough ranking system embodies considerable subjective judgement and is illustrative only. While the true effectiveness of various conservation measures will be influenced by conditions prevailing in specific nations, the ranking system does point out the relative economic attractiveness of at least twenty energy conservation/substitution measures.

TABLE 7

EXAMPLES OF ECONOMIC CALCULATIONS FOR VIABLE ENERGY CONSERVATION METHODS

ENERGY CONSERVATION MEASURE BY SECTOR	ENERGY CONSUMPTION BY MEASURE (toe p.a.)	ENERGY EFFICIENCY OPTION: Improvement (%)	ENERGY EFFICIENCY OPTION: Cost (1980$)	Investment per toe p.a. saved (1980$)	Value of improvement per unit (1980 8 per toe saved)	TIME HORIZON: Payback period (years)	TIME HORIZON: Economic lifetime (years)	Effectiveness of measure 1/
INDUSTRY								
1. improved maintenance of boilers	70.0	15	1,000	95	95	0.5	1	A
2. recycling of waste material (waste heat boiler to produce steam)	10,000.0	15	500,000	330	75	1.7	5	A
3. correct choice of energy and combustion technology	6,200.0	10	400,000	645	140	3.5	5	B
4. energy management (in electric manufacturing industry)	3,130.0	15	600,000	1,275	280	3.7	5	A
5. integrated design of processes (light metal foundry)	4,500.0	20	650,000	720	90	3.7	10	A
6. improved insulation (paper industry)	90.0	10	7,500	830	100	4.5	10	B
7. increased performance of electric motors	51.6	15	30,000	3,900	323	7.3	15	C
8. cogeneration of heat and power (chemical industry)	1,000.0	20	700,000	3,500	300	11.7	15	C
TRANSPORT								
9. training of drivers (large truck fleet)	3,500.0	10	70,000	200	70	0.4	3	A
10. reduced losses from friction (fibreglass belted tires)	1.6	2	40	1,250	440	2.1	3	C
11. weight reduction of passenger cars	1.6	5	150	1,880	270	3.3	8	A
12. reduced vehicle air resistance (wind deflectors, gap sealers for truck fleet)	140.0	3	8,000	1,900	270	3.5	8	B
13. transmission improvements	1.6	5	200	2,500	360	4.5	8	B
14. engine improvements (electronic ignition, fuel injection)	1.6	10	500	3,125	450	5.7	8	B
15. newly-designed engines	1.6	15	900	3,750	540	7.0	8	C
RESIDENTIAL/COMMERCIAL								
16. training of heat managers (swimming pool)	320.0	30	5,000	50	15	0.1	3	A
17. increased performance of electric motors	3.0	6	120	580	70	1.6	10	C
18. improved efficiency of lighting (office building)	1.1	30	535	1,640	190	2.1	10	B
19. improved control of air-conditioning (office building)	330.0	12	35,000	900	75	2.2	15	A
20. draught reduction (single family house)	4.5	10	400	880	70	2.5	15	B
21. individual heat metering (multifamily house)	36.0	20	7,400	1,050	90	3.1	15	C
22. room thermostats (public building)	20.5	20	2,560	1,250	110	3.7	15	B
23. improved electric cooking appliances	0.1	12	20	2,300	270	4.3	10	B
24. waste heat recovery (office building)	360.0	15	107,000	1,950	165	6.0	15	B
25. improved boilers (multifamily house)	10.0	25	5,600	2,230	190	7.0	15	A
26. integrated design with insulation (new single family house)	3.6	33	4,700	3,900	200	13.3	30	B
27. heat pumps (single family house, existing oil boiler backup)	5.0	58	11,500	3,950	310	13.7	15	C
28. double/triple window glazing (office bldg.)	52.0	15	33,500	4,300	220	15.1	30	C
29. insulation (single family house)	2.8	15	2,000	4,800	245	17.1	30	C
30. district heating (public buildings)	5,630.0	25	12,000,000	8,500	330	25.0	50	C

Notes:

1/ Rough ranking of the effectiveness of the conservation measure taking into account technical potential and cost effectiveness viz., A: very effective; B: effective; C: not too effective or having some technical/economic uncertainties.

Assumptions:

(a) gasoline prices of US $ 600/toe (b) heating prices of US $360/toe (c) fuel oil prices of US $ 200/toe
(d) electricity prices of US $0.05/kwh (e) real interest rate of 3 per cent p.a (f) no real energy price increase

Source: A.F. Beijdorff and P. Stuerzinger, Improved Energy Efficiency: The Invisible Resource (Appendix B), Position Paper on Energy Conservation, Eleventh World Energy Conference, 8-12 September 1980, Munich, Germany.

IX. MEASURES TO PROMOTE ENERGY CONSERVATION

77. Developed market economies have achieved considerable success in recent years in improving energy efficiency, both by reducing energy input per unit of output and through substitution by utilising cheaper fuels. Many developing countries are attempting to increase their efficiency of energy use and recent developing country experiences are also invaluable for other countries which may be faced with roughly similar economic conditions. The Group discussed obstacles to energy efficiency improvements and needed policy measures as reviewed in the World Bank paper presented at the session.

78. Obstacles to energy efficiency improvements, in general, can be categorized as follows:

(a) Lack of Awareness/Attitudes: government officials, managers, technicians, drivers, householders and the like are frequently unaware of the importance of, or opportunities for, energy conservation. Many are unaware of the cost of energy in their personal or occupational activities, that energy efficiency may be significantly affected by their own decisions/behaviour and of the impact that energy savings could have on the profitability of enterprises. They may not feel that energy-efficient behaviour or decisions deserve priority and may not consider it as attractive as increasing energy supplies or may believe that the benefits of energy-efficiency measures may not sufficiently exceed their cost.

(b) Institutions: governments often have no institutional entities with clear responsibility for designing and implementing energy-efficiency policies or programmes and there is often inadequate legislative or regulatory framework addressing such issues. Enterprises often do not have organizational units or employees specifically designated or adequately trained for energy management responsibilities.

(c) Technical: the technical know-how within governments and enterprises or on the part of individuals may be inadequate to the task of designing and implementing energy conservation measures or investments. Further, the appropriate technology together with related goods and services needed may not be readily available.

(d) Economic Attractiveness: markets may not respond rationally or quickly if the energy price charged consumers is less than its economic opportunity cost or if tariffs, taxes, interest rates or other economic policy variables restrict the availability of energy-efficient equipment and/or more efficient energy alternatives. The impact of higher energy prices may also be diluted if intermediate-stage energy consumers can easily pass on these costs through higher prices for their goods and services.

(e) Financial: individuals, enterprises or governments may have insufficient financial resources at an attractive cost to induce investment in energy efficiency methods. Alternatively, they may prefer to spend on other purposes (e.g. expansion of production) which they consider of higher priority.

79. Experience has shown that rational decision-making on energy efficiency can be induced through a mix of energy demand management strategies which could include:

- appropriate legislative and institutional frameworks
- rational pricing policies
- promotional/educational programmes
- audit, technical assistance and training programmes
- economic, fiscal and trade policies
- capital allocation or financial assistance
- development of energy information systems.

Legislative Framework

80. Most developed market economies and certain developing countries have some form of legislation dealing with energy conservation. These laws vary in scope, may designate the organisational responsibilities of a specific governmental unit for various conservation policies and programmes, may require certain practices (audits, energy managers, etc.) on the part of enterprises, and may set the framework for regulatory measures to be developed for particular sectors of the economy. Such legislation is one important sign of a government's commitment to improving energy efficiency.

Institutional Framework

81. This usually takes the form of officially-established agencies or departments with specific responsibility for national energy conservation policies and programmes. While normally part of the Ministry or Department of Energy or Power, they may, in some cases, be affiliated with the Ministry of Industry. Several developing countries are considering the establishment of such functional entities. These agencies often develop and administer informational/promotional programmes aimed at the various energy-consuming sectors and may oversee sizeable budgets for the support of industrial energy audit programmes, technical assistance, home insulation, and research and development. A few countries (e.g. Japan) have also established government or industry-supported Energy Conservation Centres providing technical assistance to energy users; most nations, however, have left such direct involvement to private firms. Certain countries have also established energy audit or technical assistance functions within or linked to energy supply enterprises (utilities, petroleum companies).

Rational Pricing Policies

82. Energy pricing should reflect opportunity costs if rational patterns of energy demand and supply are to be achieved. Governments exercise varying degrees of control over energy pricing. These controls, which may distort energy demand/supply patterns, are of three major types: (a) direct price controls; (b) indirect controls through tax policies; and (c) direct or indirect energy price subsidies. Aggregations for seven major developed market economies (Canada, U.S.A., Italy, Japan, France, U.K. and the Federal Republic of Germany), during 1970-80 show that for every 1.0 per cent increase in their imported oil price, industrial oil, residential/commercial oil and motor gasoline prices, on average, rose 0.76, 0.71 and 0.43 per cent respectively. The low pass-through for gasoline (only 0.43 per cent) increases dramatically if one adds on motor gasoline taxes which averaged 168 per cent of the gasoline price in 1973, 119 per cent in 1977 and 82 per cent in 1980 respectively.

83. In developing countries the experience is mixed. Of the twenty countries covered thus far by the UNDP/World Bank Energy Assessment Program, less than a third follow across-the-board opportunity cost pricing, over a third have a "mixed" approach (e.g. highly taxed gasoline, subsidized diesel fuel) and about a third do not follow world energy prices at all. The high energy intensities in centrally planned economies can be traced to long-run below-market energy prices. Fuel substitution possibilities are also seriously affected by distortions in inter-fuel pricing structures; while such distortions are few for industrial petroleum products or gasoline, they are widespread for power, domestic coal, kerosene and diesel fuel.

Promotional/Educational Programmes

84. The lack of awareness and attitudinal barriers to improved energy efficiency have been the target of a variety of promotional and educational programmes implemented by government agencies, energy conservation centres and institutes, consultants and energy supply enterprises. A variety of media are used, and in many countries special programmes are targeted at specific industrial or commercial groups. Some governments (e.g. Brazil, U.S.A.) have gone beyond promotion and entered into agreements with industrial groups or associations to implement energy efficiency programmes. The impact of such programmes is limited, however, without stepped-up complementary efforts involving specialised energy audits, training and technical/managerial assistance.

Audit, Technical Assistance and Training Programmes

85. Many countries have introduced or promoted the development of national programmes and capabilities to provide industrial and commercial enterprises, farmers and householders with a variety of technical services to analyse and improve their management of energy use. These services are provided through government agencies, commercial/industrial trade associations, private consultants, academic/research institutions and energy supply enterprises. Such programmes can be very effective in industrial plants, transportation firms, commercial buildings and residences and are an essential component of any national energy efficiency programme. Some countries have legislation or regulations that require energy audits for certain enterprises, and some subsidize the cost of such audits.

Economic, Fiscal and Trade Policies

86. Government policies can influence energy efficiency programmes through tariff and non-tariff policies that affect the availability of alternative forms of energy. Tariff, taxation and other regulatory policies that encourage/restrict the investment in, import of or domestic production of a variety of energy conserving, consuming or converting equipment, technology or know-how also have a significant impact. Such policies may ultimately determine whether a nation has available and makes use of more energy-efficient industrial plant and equipment, motor vehicles, other transport equipment, electrical equipment, energy control systems, solar equipment, stoves, electrical appliances, energy-efficient building materials and the like. Regulatory policy may also induce local manufacturers to improve and promote the energy efficiency of their products, as has been the case for automobiles and appliances in certain countries.

Capital Allocation/Financial Assistance

87. With capital scarce and interest rates high in real terms, investments in energy supply options need careful scrutiny. Experience has shown that governments and enterprises often do not realize that investment in energy efficiency improvements can have high economic and financial returns at a cost often much lower than that of new, incremental supply. Providing special funds for energy efficiency improvements is often a necessary incentive. Brazil has done this with some success, and the World Bank has supported energy conservation financing by development finance institutions. Such funds could be earmarked not only for energy-saving or substitution investments by energy consumers, but also for productive investment and research and development for more efficient equipment (e.g. boilers, generators, solar heaters).

Energy Information Systems

88. Few developing countries have detailed energy consumption data. Most have broad statistics by sector and by type of commercial energy although such data often "overlaps" between sectors as, for example, transport energy use in industry/agriculture or residential energy use in agriculture. Data on the energy mix in sub-sectors (e.g. in iron and steel, fertilizers, road transport) are often unavailable. Consumption data on fuelwood and other traditional fuels are extremely rough, even though in many developing countries such fuels account for over half of national energy consumption. Several countries are preparing, often with assistance, detailed energy balances to provide an information base for energy planning and demand management. Energy audit programmes in larger industrial plants facilitate the creation of enrgy consumption data banks at enterprise levels. The long-run goal is normally a national energy information system adequate to effectively monitor energy use patterns so that demand management and supply strategies can be developed, assesed and revised in a dynamic, systematic manner.

89. Table 8 is an attempt to rank certain policy measures according to their relevance by sector.

Table 8

Relevance of Policy Measures to Sectoral Energy Conservation

Sector	Financial and/or fiscal incentives	Pricing policy	Information, advice and technical assistance	Enhanced use of new and renewable sources of energy
Building insulation	A	C	C	B
Other residential/commercial	C	B	A	C
Industry	B	A	B	C
Transport	C	A	B	nil
Electricity generation	B	C	C	B
Energy-consuming equipment	A	B	B	C
Agriculture/rural use	B	C	B	A

Notes: A : immediate and direct relevance B : moderate relevance
C : not very relevant at the present time

Source: Energy Conservation in the ECWA Region: Prospects and Possible Lines of Action (E/ECWA/NR/82/2), June 1982 and presented at the fourth session, ACC Technical Energy Group, United Nations, 13-15 December 1982, New York.

Regional and International Co-operation

90. The Group felt that there was need and scope for increased regional co-operation since exchanges of experiences through seminars, conferences and studies lead to a deeper understanding of regional energy problems and possibilities for co-operation. In Latin America, for instance, the Latin American Energy Co-operation Program (PLACE) was approved at the OLADE Ministerial session in November 1981 and among the areas specifically mandated for increased regional co-operation were development and use of energy resources, rationalization of the use of energy, technological co-operation, human resources training, energy information and dissemination, and financial co-operation. Other initiatives in Latin America include the Mexico-Venezuela energy co-operation programme for Central America.

91. In the ESCAP area, a working group meeting on efficiency and conservation in the use of energy was held at Bangkok in October 1979 and was attended by nineteen ESCAP member nations, and by several UN and non-UN international organizations. Reference has already been made to ECWA's recent comprehensive study on energy conservation in the ECWA region (June 1982). The ECE has been a pioneer in this area with its 1976 study on increased energy economy and efficiency in the ECE region and its 1980 report on recent experience and prospects for energy conservation in the ECE region.

92. On the international sphere, the Group commended the efforts of several of its member bodies in their promotion of energy conservation and substitution activities. The World Bank, in addition to the ongoing UNDP/World Bank Energy Assessment Program covering 60 countries, has made several loans for purposes that include technical assistance for energy audits, retrofitting in existing plants, establishment of energy conservation centres, improved power system management and distribution systems, development of more efficient woodstoves and urban traffic management projects. A research project to investigate the impact of various conservation policy options has also been proposed.

93. UNIDO's work in energy conservation and substitution comes under its industrial energy management programme. The need for an industrial energy information system, especially in developing countries, was stressed to enable proper consideration of energy efficiency options. The key role of industrial energy planning, at both national and plant levels, was also stressed. FAO is analysing the possibilities for enhanced energy efficiency and substitution in the post-harvest food system discussed earlier. UNEP is planning a workshop on enhanced rural energy efficiency and storage in September 1983 at Bangkok and UNESCO is involved in educational and training programmes to promote energy conservation and fuel substitution.

94. The Group felt that there was significant scope for the experiences of those developing countries (e.g. Brazil, Philippines, Republic of Korea) which have had notable success in energy conservation and fuel substitution measures to be applied to other developing countries and strongly supported increased technical co-operation between those developing countries that have achieved significant progress in energy conservation and substitution and those which are attempting to do so.

95. The greatest progress in energy conservation and substitution has taken place in developed market economies due to their rigorous attempts to reduce high energy consumption levels through the introduction and implementation of existing and new energy conservation technologies in most sectors. Significant

progress has also been achieved in fuel substitution away from oil. The Group felt that the developed market economies could, based on their domestic experiences, assist developing countries in their efforts to increase their efficiency of energy use in the context of their overall energy requirements during the industrialisation process. Technical assistance and training programmes, co-operation in the development of national energy information systems and financial assistance for research, development and demonstration projects were key areas that could benefit immensely from such co-operation.

X. FUTURE WORK PROGRAMME OF THE TECHNICAL ENERGY GROUP

96. It was decided that the fifth session would be held in the third quarter 1983 and that the topic to be discussed would be chosen after consultations with participating agencies, with due regard to the relevant resolutions on energy matters adopted during the 37th United Nations General Assembly.

Notes

[1] A.F. Beijdorff, Energy Efficiency, Report, Group Planning, Shell International Petroleum Company Ltd., Shell Centre, London, April 1979.

[2] World Energy Outlook, International Energy Agency, OECD, Paris, 1982.

[3] see Annex III, Technical Energy Group Fourth Session, Documentation Paper No.8.

[4] see Annex III, Technical Energy Group Fourth Session, Documentation Paper No.9.

[5] Increased Energy Economy and Efficiency in the ECE Region, Economic Commission for Europe, United Nations, New York, 1976 (sales number E.76.II.E.2. See also The Economic Commission for Europe and Energy Conservation: Recent Experience and Prospects, United Nations, New York, 1980 (sales number E.80.II.E.4 and An Efficient Energy Future: Prospects for Europe and North America, U.N. Economic Commission for Europe, Butterworths, London, 1983.

[6] A.F. Beijdorff and P. Stuerzinger, Improved Energy Efficiency: The Invisible Resource, position paper on energy conservation, Eleventh World Energy Conference, 8-12, September 1980, Munich, Germany.

ANNEXES

I. Agenda

II. List of Participants

III. Documentation

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ANNEX I

UNITED NATIONS

ACC TASK FORCE ON LONG-TERM DEVELOPMENT OBJECTIVES

Technical Energy Group
(Fourth Session, 13-15 December 1982, New York)

THE ECONOMICS OF, AND POTENTIAL FOR, ENERGY CONSERVATION AND SUBSTITUTION

Agenda

1. Opening remarks by Mr. P. N. Dhar, Assistant Secretary-General for Development Research and Policy Analysis

2. Adoption of the Agenda

3. The Meaning, Rationale, Potential and Means of Energy Conservation

4. Recent Experiences and Prospects for Energy Conservation

   (a) in developed market economies
   (b) in developing countries
   (c) in centrally planned economies

5. The Potential for Increased Energy Conservation

   (A) At the Primary Fuels Stage
      (a) hydrocarbons
      (b) renewable energy resources
      (c) other fuels

   (B) In the Energy Sector (Processing, Conversion, Transmission, Distribution and Storage of Energy)

   (C) In End-Use Sectors
      (a) industry
      (b) transport
      (c) residential/commercial
      (d) agriculture

6. The Economics of Energy Conservation

   (a) investment requirements
   (b) comparison between the unit cost of end-use energy conservation and that needed to expand energy production
   (c) environmental aspects

7. Measures to Promote Energy Conservation

   (a) domestic measures including educational, institutional, legal, pricing and related policies
   (b) international co-operation between developing countries and between developed and developing nations

8. Future Work Programme of the Technical Energy Group

ANNEX II

UNITED NATIONS

ACC TASK FORCE ON LONG-TERM DEVELOPMENT OBJECTIVES

Technical Energy Group

(Fourth Session, 13-15 December 1982, New York)

PARTICIPANTS

Chairman: Andrew G. Brown, Director, General Analysis and Policies Division, DRPA/DIESA

Secretary: Frank Pinto, Technical Energy Co-ordinator, DIESA/UNDP

Office of the Director-General for Development and International Economic Co-operation (DIEC)	Tahar Hadj-Sadok, Senior Officer
Department of International Economic and Social Affairs (DIESA)	Vladimir Pozharsky, Special Adviser to the Under-Secretary-General
-do-	Cesar Molestina, Chief, Industrial, Environment and Energy Statistics Branch, Statistical Office
-do-	Ke-chiang Wang, Chief, Economic Outlook Section, Projections and Perspective Studies Branch, DRPA
-do-	William Clive, Officer-in-Charge, Energy Statistics Unit, Statistical Office
-do-	Joseph Shaw, Economic Affairs Officer, Energy Unit, GAPD/DRPA
	Christine Kronauer, Economic Affairs Officer, Energy Statistics Unit, Statistical Office
-do-	Yuzo Kumasaka, Associate Economic Affairs Officer, Office of the Director, GAPD/DRPA
Department of Technical Co-operation for Development (DTCD)	Stanton Smith, Senior Technical Adviser, Energy Planning Section, Natural Resources and Energy Division
-do-	Yuko Yano, Associate Economic Affairs Officer, Energy Planning Section, Natural Resources and Energy Division

*/ Mr. P.N. Dhar, Assistant Secretary-General for Development Research and Policy Analysis, DIESA, opened the session on 13th December.

Economic Commission for Europe (ECE)	Klaus Brendow, Deputy Chief, Energy Division
United Nations Centre on Transnational Corporations (UNCTC)	Ahmed Rhazaoui, Transnational Corporations Affairs Officer
United Nations Conference on Trade and Development (UNCTAD)	Helen Argalias, Economic Affairs Officer, Money, Finance and Development Division
United Nations Industrial Development Organization (UNIDO)	Se-Hark Park, Senior Industrial Development Officer, Global and Conceptual Studies Branch, Division for Industrial Studies
United Nations Environment Programme (UNEP)	Yehia El-Mahgary, Chairman, Energy Task Force, Environment Management Programme
United Nations Centre for Human Settlements (Habitat)	Carlos Rodriguez, Human Settlements Officer
United Nations Development Programme (UNDP)	Mohammed Yeganeh, Senior Consultant to the Administrator
United Nations Financing System for Science and Technology for Development (UNFSSTD)	Laura Canuto, Project Development Adviser
Food and Agriculture Organization (FAO)	Saifullah Syed, Energy Analyst, Agriculture Department
International Monetary Fund (IMF)	Alphecca Muttardy, Economist, Commodities Division, Research Department
United Nations Educational, Scientific and Cultural Organization (UNESCO)	Shikon Takei, Senior Liaison Officer, UNESCO Liaison Office with the U.N. in New York
United Nations Institute for Training and Research (UNITAR)	Philippe de Seynes, Director, Project on the Future
United Nations University (UNU)	Ivan Kanterovitz, Liaison Officer, New York Liaison Office
World Bank	Harold Wackman, Deputy Division Chief, Energy Assessments Division, Energy Department
-do-	Andres Liebenthal, Energy Economist, Energy Assessments Division, Energy Department

CONSULTANTS

State University of New York (SUNY) at Stony Brook	T. Owen Carroll, Associate Research Professor, Institute for Energy Research and W. Averell Harriman College of Policy Sciences
University of Ife, Nigeria	Victor Ogunmakin, Senior Engineer (Project Planning and Development), Center for Energy Research and Development
Lawrence Berkeley Laboratory (LBL), University of California	Lee Schipper, Research Professor and Project Leader for Energy Conservation Studies, Energy and Environment Division

OBSERVERS

International Energy Agency (IEA), Paris	Henning von Wistinghausen, Head, Relations with Producer and Consumer Countries Division
International Energy Development Corporation (IEDC), Geneva	Kenneth C. Hoffman, Senior Consultant (and Sr. Vice-President, Mathtech Inc.)
International Institute for Applied Systems Analysis (IIASA), Laxenburg	Hans Holger Rogner, Leader-Designate, Energy Development, Economy and Investments Project
-do-	Claire Doblin, Research Scholar, Energy Development, Economy and Investments Project
Organizacion Latinoamericana de Energia (OLADE), Quito	Joao Pimentel, Co-ordinator, Regional and Extra-Regional Cooperation
World Energy Conference (WEC)	Charles Robbins, WEC Representative to the United Nations

Notes:

1. ICAO was not represented but contributed a paper to the session.

2. Jayant Sathaye of Lawrence Berkeley Laboratory, University of California, represented Lee Schipper of the same institution on 15th December.

ANNEX III

UNITED NATIONS

ACC TECHNICAL ENERGY GROUP

(Fourth Session, 13-15 December 1982, New York)

DOCUMENTATION

1. Energy Conservation in the ECWA Region: Prospects and Possible Lines of Action (ECWA)

2. Energy Conservation in Developed Market Economies (IEA/OECD)

3. Future Availability and Consumption of Aviation Fuel in the Transport Sector (ICAO)

4. Energy Conservation and Oil Substitution in Latin America (OLADE)

5. "An Efficient Energy Future": Summary (ECE)

6. Proceedings of the Working Group Meeting on Efficiency and Conservation in the Use of Energy (ESCAP)

7. Energy Savings and Conservation (IIASA)

8. The Potential for Energy Efficiency and Substitution in Developing Countries: Case Studies of Brazil and Nigeria (David Jhirad and Victor Ogunmakin, Consultants)

9. Energy Conservation in Developing Countries: Observations from Kenya and Korea (Lee Schipper, Consultant)

10. Energy Efficiency in the Japanese Economy 1965-80 : An Econometric Analysis (DIESA)

12. Energy Efficiency in the Developing Countries (World Bank)

13. Energy and the Post-Harvest Food System in the Developing Countries: Current Use, Saving and Substitution Potential (FAO)

14. Management and Conservation of Energy in Industry (UNIDO)

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