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ENERGY RESEARCH GROUP

MANUSCRIPT REPORTS

Energy Demand Patterns

Lutz Hoffmann;
Lee Schipper, Stephen Meyers, and Jayant Sathaye;
Yoshio Hara

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The Energy Research Group consists of eminent members of the international community of energy analysts and policymakers from developing countries. This independent Group has been set up to review energy-related research and technology and its relevance to developing countries, to assess the research capacity of developing countries, and to suggest the priorities for energy research in these countries.

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INTRODUCTION

Ashok V. Desai
Coordinator, Energy Research Group

This report brings together three papers on energy demand presented at the Energy Research Priorities Seminar held in Ottawa on 8-10 August 1983.

The paper by Professor Lutz Hoffmann suggests a framework in which energy demand studies may be organized if they are to be useful in policy-making. Although energy-demand relationships have attracted extensive investigations, the stability of the parameters they have estimated is much in question, and the use of their average values for prediction or planning remains hazardous. Hoffmann points toward disaggregation and the analysis of the chain of energy transformations as possible paths toward more stable and reliable parameters.

Professor Lee Schipper and his colleagues point to another factor that leads to instability in sectoral parameters, namely a changeover from one technology to another: insofar as technologies producing a product (or service) vary in their energy intensity, a technological shift will also change the energy intensity of the product. Rapid technological change is characteristic of some sectors in developing countries, and may well account for the high aggregate GDP-elasticities of energy consumption observed.

Dr. Yoshio Hara begins with estimates of these elasticities, which were greater than one for all the member countries of the Asian Development Bank in 1961-78. The high elasticities, together with extreme oil dependence, made them vulnerable to the drastic rise in the oil price after 1973. Dr. Hara distinguishes three diverging patterns of national experience. The oil-surplus countries naturally gained from the rise in the oil price. Among oil-deficit countries, the newly industrialized countries expanded their exports so rapidly that the oil crisis no longer worried them. For the rest, balance of payments adjustments became a prime concern of policy. Whether they dealt with the oil bill by borrowing, by import substitution, or by demand restraint, the impact of energy on their growth was unmistakable.

Thus Dr. Hara's empirical paper shows why energy-demand studies, and energy studies in general, deserve to be taken seriously. Although oil consumption among the market economies has fallen since 1979, and oil prices have been under downward pressure, it would be a mistake to think that energy supply has ceased to constrain growth in the developing countries. The present low-growth equilibrium in the energy markets tells us nothing about the growth rates that can be achieved without running into an energy-supply constraint: such a constraint is implicit even now in the case of those oil-deficit, debt-ridden developing economies that are finding it impossible to balance their payments, and their ranks would be joined by more developing countries if world energy demand were to increase faster.

ENERGY DEMAND IN DEVELOPING COUNTRIES: IDENTIFICATION OF RESEARCH AREAS

Lutz Hoffmann*

There has been a considerable amount of research about energy demand in developed and developing countries during recent years. As a result, we now know much more about the orders of magnitude involved, as well as the structure of energy demand by sector and fuel and its determinants, than we did a decade ago when the incipient oil crisis began to rock national and international energy markets. However, with the growing number of research studies, it has increasingly become apparent that there are many more open questions than originally conceived. These not only refer to basic data and empirical results, but also are closely interlinked with unresolved methodological issues.

I attempt here to identify areas where research on energy demand seems to be needed for developing countries. I hope that during the discussion a consensus on priorities will emerge.

Research for Whom?

Which of the many open questions is to be tackled first depends on the consumer of the research results. A minister responsible for energy policy in Canada is probably confronted with quite different problems and therefore wants to know different things about energy demand than his colleague in Kenya or an oil company operating off-shore from Argentina.

The first thing that must be done therefore is to define the consumer and try to identify his interest. I make the assumption that, in the context of this conference, it is the government official in a developing country dealing with energy planning and energy policy on whom we focus. When I come to identifying his interest, I must again make assumptions, because up to now we may know from particular officers in particular countries what their concerns are, but there does not exist a representative picture of the developing world as a whole or for certain regions. It should be realized that much of what we know from the literature or from conference statements about the concerns of energy planners and policymakers in developing countries is filtered by those doing the reporting, who have their own interests, such as international financing institutions, United Nations experts, or experts providing so-called technical aid. My first suggestion therefore is to conduct a survey among energy planners and policymakers in developing countries about what they consider as the most pressing issues to be researched. This would be similar to the survey undertaken several years ago, by Fred Bergsten on behalf of the Ford Foundation, about research issues in international economics.

Keeping this in mind, I suggest that the energy policymaker in a developing country needs information on energy demand to answer the following set of questions:

- In which areas is investment required for the development of indigenous energy resources;
- In which areas is investment required for inducing energy saving; and
- In which areas is it possible to improve energy saving without major investments.

*Lehrstuhl Fuer Volkswirtschaftslehre, Universitaet Regensburg, Universitaetsstrasse 29-31, Regensburg, West Germany.

To answer these questions with respect to energy demand, the policymaker must understand:

- The relationship between expected or planned economic activity and energy demand;
- The technically and economically feasible potential for reducing energy demand through energy saving; and
- The likely reaction of energy consumers to the entire range of exogenous parameter changes and of policy measures.

Relationship between Economic Activity and Energy Demand

The energy planner is often in a very difficult position. On the one hand, the macroeconomic planner supplies information on expected developments of sectoral output, personal income, and population and on the other the energy producer supplies targets for the expansion of fuel output. The energy planner's basic function then is to see whether the two are consistent and, if not, to work out proposals where adjustments could or should be made.

Analyzing the various steps of energy demand

To analyze the various steps, the energy planner first has to conceptualize the link between economic activity and energy consumption. In the past, this was often done by relating economic output to either final or primary energy consumption. The parameters estimated were income or output elasticities for final fuels, such as gasoline, kerosine, electricity, etc., or for primary fuels, such as crude oil, solid fuels, gases, and primary electricity. This approach, which was adopted by most econometric research studies, is methodologically unsatisfactory because it neglects the intermediate steps between economic output and fuel consumption. The result is not only the derivation of unreliable and opaque parameters but also a systematic neglect of how fuel demand is affected by these intermediate steps and what this implies for fuel-saving measures.

I conclude that any analysis of energy demand should explicitly consider the entire range of steps involved -- even if the data do not permit all of them to be quantified. This means that it should be made explicit that the immediate demand of a private household or a production unit is not final energy, but an energy service, measured as passenger distance or smelted iron or a warm house.

The demand for energy services leads to a certain demand for useful energy in the form of heat, motive power, or light, depending on the energy conversion equipment (Fig. 1). The important implication of these two steps is that the energy demand generated by economic activities or private households is, as such, not fuel-specific. It only becomes fuel-specific if certain technologies are assumed that convert available final energy into useful energy. Hence estimated elasticity parameters for final or primary fuels underlie the implicit assumption that conversion technologies are given, or change at best along the time trend of the past. That technologies can change due to innovations, investment decisions, government policy, etc. is not accounted for. It is therefore not surprising that, first, estimated elasticities for a particular fuel tend to show a wide range of variation over different time periods and in different countries and second, that because of this, projections based on them turn out to be highly unreliable.

Although engineers have always been aware of the different steps of energy demand, in particular the distinction between useful energy and final energy,

Concepts	Modern food preparation	Car transport	House heating
energy service	cooked food	passenger distance	warm house
	↓ pot ↓	↓ tires, body ↓	↓ insulation ↓
useful energy	required heat	required motive power	required heat
	↓ electric stove ↓	↓ engine, transmission ↓	↓ furnace ↓
final energy	required electric energy	required gasoline	required heating oil
	↓ power plant ↓	↓ refinery ↓	↓ refinery ↓
primary energy	required coal	required crude oil	required crude oil

Fig. 1. Steps of energy demand for three examples.

economists have only rarely used them as a basis for analysis. As a result we know very little about the relationship between economic activity and the demand for energy services and useful energy.

Some information for industrial countries is available from engineering analysis. However, this is certainly not sufficient and often not applicable to developing countries where either technologies are different (e.g., cooking equipment in the residential sector or transport equipment) or the same technologies are employed differently -- often less efficiently. We also have no empirical answer to the implications of engineering analysis at the industrial or sectoral level. Such answers are crucial for planning purposes, which by necessity require some sort of aggregation.

I therefore strongly suggest that, also for developing countries, considerably more analysis should be done on:

- The relationship between economic activity and the demand for energy services; and

- The relationship between the demand for energy services and the demand for useful energy.

It must, however, be realized that empirical research in this area is not straightforward. The first task, for instance, involves conceptual difficulties. The variable energy service has to be made operational: for transport, the energy service is the movement of persons or commodities over a certain distance; for the residential sector, cooking of food is also an energy service; and for the steel industry, smelting of iron ore is an energy service. These services are apparently difficult to measure. We may therefore use the immediate result of the energy service as a proxy. In the case of transport, we would use "passenger" or "tonne-distance", for cooking the "cooked food", and for smelting the "smelted ore".

There are more difficulties, however. Some of these proxies are two-dimensional, whereas for quantitative analysis one-dimensional variables are more convenient. A cool house, for instance, is a proxy for air-conditioning. It has the two dimensions, temperature and house size. To estimate the relationship between, for instance, per capita consumption and air-conditioning, quantitative measures for a cool house must be translated into a one-dimensional variable that could be regressed against per capita consumption.

The second task involves the estimation of energy intensities, defined as useful energy per unit of energy service as measured by immediate output. As data on useful energy do not exist for most developing countries, there is also no information available on energy intensities as I have defined them. We need information on the absolute levels of intensities as well as their changes over time. The absolute levels of intensities have to be known because we must generally work with some kind of aggregate, as noted earlier. The energy intensity of an aggregate can change simply due to a changing structure of the aggregate if the intensity levels of its components differ but do not change themselves. Changes over time in the intensities of the elements could reinforce or offset the impact of structural change.

Importance of different levels of aggregation

The aggregation problem gives rise to a wide area of badly needed research results. Many of the research studies in the mid-1970s -- in particular those for developing countries -- were on a highly aggregated level. The most discussed relationship was the overall income elasticity or the overall energy intensity, measured by either final or primary energy consumption per unit of gross domestic product (GDP). The poor results of many forecasts based on this relationship led to a demand for more disaggregated models. This demand certainly is legitimate. However, the tendency now is to favour analysis on the micro level. This is of value for project analysis or specific conservation measures but it is of little help for energy planning and many fields of policymaking. We therefore will continue to need energy demand analysis at various levels of aggregation.

One important point here is to find out how the stability of a parameter is related to the level of aggregation of the underlying variables. This information is very important for energy modelling and forecasting. For instance, a model builder may want to know whether it is sufficient to distinguish among the agriculture, industry, transport, commercial, and residential sectors or whether (and under which conditions) it is advisable to subdivide "industry" into energy-intensive and less energy-intensive industries and to subdivide "transport" into different transport modes, etc.

Also with respect to fuels, too fine a disaggregation of demand analysis is often more confusing than illuminating. This follows immediately from the statement that energy demand generated by economic activities or private households is, as such, not fuel-specific. It is obvious that how private households satisfy their needs for heat, light, and power depends first of all on what they can get, i.e., availability. There may be a preference for liquid fuels over solid fuels, but within liquid fuels and within solid fuels preferences will be hard to identify. A too-disaggregated projection, for instance demand for residential kerosine or liquefied petroleum gas (LPG), may then give the wrong impression that there is little choice among alternative patterns of fuel supply.

Too little research on noncommercial energy

The need for considerably more research efforts in the field of so-called noncommercial energy has been stressed by many researchers and policymakers. The data problem for noncommercial energy is still much greater than for commercial energy, although an increasing amount of data is forthcoming from various research efforts. Most of these studies refer to noncommercial energy consumption in the residential sector and only a few include information about manufacturing and agriculture. This is a gap where research is urgent, because noncommercial energy is very important for small-scale manufacturing in rural areas. With the present emphasis in development strategies on integrated rural development, the impact of such a strategy on noncommercial energy and an eventual transition to commercial fuels ought to be known.

A particular difficulty of noncommercial energy-demand analysis is the uncertainty about its determinants. For commercial energy, the hypothesis that income and prices are the most important determinants, if supply is available, is fairly well established. If we have to deal with noncommercial energy in the real sense, i.e., the fuels are not exchanged against money, then by definition, prices can have no direct impact and also monetary income becomes a dubious variable.

The question is not only what are the determinants of noncommercial fuels in general, but why do we observe differences or changes over time in the consumption pattern of specific noncommercial fuels. For instance, a change in demand from twigs to crop wastes or dung may have important implications for the supply of fertilizer and thus affect agricultural productivity. The example illustrates that, unlike most commercial fuels, the use of biomass as fuel often competes directly on the end-use level with alternative uses as fertilizer, construction material (logs), etc.

Such questions call for more field research based on very carefully designed interviews about motivations for using a certain noncommercial fuel. In addition, a comprehensive effort to assemble and to evaluate the widely scattered data and qualitative information collected by individuals, research groups, government bodies, and international institutions would be a very rewarding effort. It is time that a data bank for noncommercial energy be established somewhere whose services would be available to planners in developing countries and researchers around the globe.

Potential for Energy Saving

Energy saving may be defined for energy as a whole or for individual fuels. It can be measured by changes in energy consumption per unit of output (energy intensity). I have defined energy intensity as useful energy per energy service measured by its immediate output. However, as long as the conceptual and data problems with energy services and useful energy are not solved, the ratio of final energy or primary energy per unit of output will be used instead. It should be noted that the definition chosen can be quite important for the results obtained. The energy intensity in terms of final energy need not move in the same direction as that in terms of primary energy. It also may make a difference whether output is defined as gross output or as value added.

Identifying the sources of energy saving

The energy intensity, measured either in terms of final or primary energy, may decline due to one of the following factors:

- The conversion intensity (useful energy per unit of energy services) is reduced;
- The conversion efficiency (useful energy per unit of final energy) is increased;
- The transformation efficiency (final energy per unit of primary energy) is increased;

- The industry mix changes in favour of sectors with low energy intensity;
- The product mix within sectors changes in favour of products with low energy intensity; and
- The fuel mix changes in favour of fuels that can be utilized more efficiently.

The need for energy intensity studies seems to be realized by several researchers. The "LDC Energy Demand Study Group" concluded in its meeting on 8 June 1983 that "there is a felt need for detailed physical energy/output data for industrial processes in the form of a handbook, which could be used in energy efficiency studies. In part this need could be met by systematically collecting such data in the course of standard energy audits of the kind donors already sponsor."

The poorest information exists for conversion intensities. Conversion efficiencies come second. For both of these, even the present levels of magnitude reached in different developing countries are largely unknown. However, we also would need to know the potential and likely changes of these indicators over time. This could be done by first establishing the minimum intensity or maximum efficiency that could reasonably be achieved and then working out the path that leads to this value to determine the shape of this path and on what it depends. Econometric time-series analysis for different sectors and countries may be helpful. The function to be specified could include, as an explanatory variable, an indicator of output growth. This could serve as a proxy for the pace of autonomous capital replacement, with embodied innovation. In addition, it may include an energy-price variable for the price-induced technical change.

Up to now, information on these topics is again particularly poor in the field of noncommercial energy. On the other hand, the potential for improvements in conversion intensity and conversion efficiency seems to be quite large for noncommercial energy. Due to the heavy weight of noncommercial energy in many developing countries, this area of research deserves high priority.

Much more solid information is available on transformation efficiencies. In the field of commercial energy, improvements are limited in developing countries -- and where improvements are possible, the potential and the policy measures required are fairly well known. For noncommercial energy, the situation is different. Here again, the potential for efficiency improvement seems to be considerable and even present efficiency levels are not very well known.

Need for sectoral and structural studies

With respect to the level of aggregation on which the analysis is to be carried out, the same holds as for the analysis of the economic activity/energy relationship. We not only need information on individual processes, as the LDC Energy Demand Study Group suggests, but also research about intensity reduction or efficiency improvements on a sectoral or industry level. The energy planner or policymaker in a developing country must be able to form an idea of the extent to which the energy intensity may decline in industry or agriculture or in energy-intensive industry as compared to less energy-intensive industry. Information on individual processes is not helpful to him although it is certainly valuable for building up the relevant information for the various sectors.

It is now well known that changes in the industry mix and the product mix may have a considerable impact on energy saving. However, the extent to which this may be the case under different conditions is not well understood.

The impact of structural change on energy saving is complicated by possible feedbacks. Structural change may make certain fuels more scarce and others more abundant. This may change the structure of fuel prices: therefore the cost and price structures may change in turn and this again may change the structure of fuel demand and so on. We know rather little about this type of feedback for industrialized countries and almost nothing for developing countries. Data for a proper analysis of such phenomena are, at present, hardly available for developing countries. Because of this, and as long as we do not have corresponding research results for industrial countries that would indicate whether it is worthwhile to collect the required data, one may consider this as a research task to be taken up later.

Another closely related issue deserves high priority because of its importance for policymaking. This is the impact of alternative development strategies on energy saving, ignoring for the time being the feedbacks just mentioned. Development strategies are always structural strategies. Whether the emphasis is on import substitution or export expansion in manufacturing, or on integrated rural development, there is always a correlation in terms of the structure of output, of the size distribution of establishments, or of the rural-urban distribution of the population.

Research during the late 1960s and the 1970s has produced a considerable body of empirical information about the implications of such strategies for capital and labour intensity, but we know almost nothing about the implications for energy intensity and hence for energy saving. If energy is a scarce factor in a developing country, this fact should shape development strategies in the same way as the relative scarcities of capital and skilled labour and the abundance of unskilled labour. This cannot be done as long as the impact of a strategy on energy saving is still in the dark.

The fuel mix is likely to be affected by all the determinants of energy intensity discussed up to now. It means that changes in conversion intensity, conversion efficiency, and transformation efficiency, which differ by sector or fuel, change the fuel mix as does a changing industry mix or product mix. Whether this implies energy saving depends on how it is defined. If it is defined as fuel-specific, we will always have energy saving for the fuel substituted by another fuel. If it is measured for energy as a whole, the results depend on the levels of the intensities or efficiencies by sector and fuel. It would be worthwhile to explore in different developing countries which type of fuel substitution would have the greatest impact on sector-specific and overall energy saving. This would help planners to design policy measures that induce such substitution processes.

Reaction of Energy Consumers to Exogenous Parameter Changes and Policy Measures

The experience of the oil crisis in industrial as well as developing countries has clearly demonstrated that changes in exogenous parameters, such as the international oil price or in policy measures, can significantly influence not only the structure of energy demand but also its overall level. This is probably one of the most discussed areas of energy demand, but at the same time an area where research was least successful in producing reliable information. This is particularly true for the reaction of fuel demand to energy-price changes.

Studying transmission elasticities

A first area where insufficient information is available is the impact of international price changes, in particular for crude oil, on domestic final-energy prices in developing countries. This impact can be expressed by a transmission elasticity that measures the relative change of a domestic final-energy price with respect to the change of crude oil or other internationally traded fuels.

The transmission elasticity seems to depend on the share of the imported primary-fuel costs in the market price of the final fuel, on taxation policy, on price regulations, and on the difference between the domestic and the international price of the final fuel. To understand how prices of internationally traded primary fuels affect energy demand in developing countries, it is important to know under which conditions and to what extent price changes for primary fuels transmit themselves into price changes for domestic final fuels. This would probably require a comparative study for a number of developing countries.

The first and simplest task is to compile data on cost structures and to investigate how they affect transmission elasticities under alternative market conditions (monopolistic versus competitive markets). More difficult, but also more interesting, is to study how governments reacted to the price increases for imported fuels with tax policies and price regulations and why they did so. Was this reaction a one-time possibility, as some analysts believe, or could it be repeated?

Decomposing price reactions

The price reaction of energy demand is more complicated than many models lead one to believe. There is first a behavioural reaction in the sense that energy consumers demand less energy services if the price for energy in general increases. A private household, for instance, lowers its thermostat and is content with a less warm room because energy has become more expensive. If the energy price increase persists the household may want in addition to exchange the energy-using equipment and thereby reduce energy consumption further. It may, for example, exchange the present burner of the heating system for a more efficient one. This is certainly a different reaction from the first one: the first is behavioural and may be reversed, the second is more permanent and structural.

The distinction between the two is important. A behavioural reaction may be similar with respect to price increases and to price decreases. An efficiency reaction, on the other hand, will not be the same. It is unlikely that an efficiency improvement induced by a former price increase will be reversed if the price should decline later. By splitting up what is usually lumped under the price elasticity, one obtains a better understanding of reactions of energy demand to price changes.

It can be expected that, in this way, much more reliable elasticity parameters will be obtained and that it will become possible to predict future changes in the price elasticity. The research required in this field is considerable. Although this is a new research area for industrial as well as for developing countries, research efforts might also start in the latter because of the great importance generally attached to pricing policies.

Substitution elasticities: No cheers for econometrics

Econometric estimates of price elasticities have usually produced rather poor results. Either the signs were "incorrect" or the values obtained showed a fairly wide range of variation. This is particularly true for time-series analysis. In energy-demand modeling, it is therefore sometimes more advisable to use assumed elasticity parameters instead of taking estimates obtained from time-series. The problem then is, however, to justify a certain assumption.

An even more difficult problem is the estimation of cross-price elasticities or substitution elasticities. Not only are consistent estimation techniques complicated (simultaneous estimation techniques, Zellner algorithm), but also the results obtained up to now for industrial countries are not at all encouraging. For instance, the controversy whether capital and energy are substitutes or complementary factors of production has up to now not been resolved although many econometric estimates have already been made, some of which use very detailed micro data. This leads to the conclusion that research efforts in this direction should not be made for developing countries. Other methods should be developed to account for the reaction of relative fuel shares to changes in relative fuel prices and to measure the substitution between energy and other productive factors as a response to changes in the respective price ratios.

Producers' or consumers' sovereignty?

One factor that seems to be very important for fuel substitution in developing countries, as compared to industrial countries, is fuel availability. This has mostly been neglected in fuel-demand analysis. Several studies on residential energy consumption have revealed that the substitution of commercial for noncommercial fuels or of electricity for kerosine and LPG is largely determined by availability. If fuelwood becomes increasingly scarce, households switch to kerosine if they can obtain it, or to electricity if it is available. However, the problem may be even more complicated. Rural electricity is often not competitive with noncommercial fuels. What then usually happens is that once power plants and transmission lines have been built, electricity is supplied at heavily subsidized prices. This then leads to the switch in consumption from noncommercial fuels to electricity. It is noted that this is set in motion by the decision to have a rural electrification program and not by an "independent" decision of consumers. For energy demand forecasting in developing countries, it should therefore be kept in mind that decisions to develop domestic energy sources for local supply certainly affect the fuel consumption pattern in a significant way.

This suggests a very interesting but also highly complicated research task. It would seek answers to the question of the extent to which the energy consumers shape the future energy-consumption pattern in a developing country, or whether this pattern is mainly the result of investment decisions by the producers. Although difficult, I do not consider this question as unresearchable.

Summary of Research Tasks

The above discussion leads to the following 14 research tasks:

- Run a survey among energy planners in developing countries on what they conceive as the most pressing issues in energy-demand analysis.

- Design operational concepts of energy services and estimate output and income elasticities for energy services on different levels of sectoral aggregation. Test the stability of the parameters for the various levels of aggregation.

- Collect and analyze data on noncommercial energy consumption outside the residential sector.

- Investigate the determinants of the demand for biomass as fuel and for other uses.

- Set up a system for collecting data on noncommercial energy consumption and compile the data from the various private and public sources.

- Estimate the level of conversion intensities and conversion efficiencies and their change over time on different levels of sectoral aggregation. Test the stability of the parameters estimated for the various levels of aggregation.

- Estimate transformation efficiencies for noncommercial energy and their change over time.
- Analyze the impact of development strategies on energy demand and energy saving.
- Analyze the interdependence between structural change and energy demand.
- Investigate the impact of interfuel substitution on energy saving.
- Analyze the factors determining the transmission of international primary-fuel prices on final-energy prices.
- Study in more detail the price reaction of energy consumers by looking at behavioural and efficiency reactions.
- Investigate the reaction of relative fuel shares to changes of relative fuel prices by employing other methods than econometric estimates.
- Analyze the extent to which energy consumption patterns are determined by investment decisions for fuel supply.

ENERGY DEMAND IN THE DEVELOPING COUNTRIES: TOWARD A BETTER UNDERSTANDING[1]

Lee Schipper, Stephen Meyers, and Jayant Sathaye*

Energy is what both people and economies run on, thus the presence of adequate energy supplies is of the utmost importance to a country or other entity. Providing energy, as we have painfully grown to learn, is not so cheap any more. Whether we look at oil or fuelwood, new supplies are typically more difficult and require more resources to gather. Thus, the people whose duty it is to plan for tomorrow's energy supply need to have information as to the likely nature of tomorrow's energy demand. Having too little energy may hinder economic development or even jeopardize human subsistence; having too much means there was an unnecessary expenditure of scarce resources.

These observations apply generally, but in countries where the demand for basic human needs exceeds the present capacity of the society to meet them, it is particularly important not to unnecessarily expend resources in the energy production sector that might be spent on other areas of development. In some developing countries, this has not been a problem because the economy has been able to absorb whatever quantities of energy (particularly electricity) that producers have been able to supply. With today's higher energy prices and more uncertain economic outlook, however, this condition of open-ended demand is becoming more rare.

For some energy sources, provision of adequate supplies may be hindered by resource limits (as with fuelwood) or financial constraints (as with imported oil). It then becomes important to understand how demand for these goods is evolving so that those responsible can have a feel for just how bad the situation may be, and can better assess the steps that may be available to deal with the problem.

Several facets of energy demand are crucial to the timely development of energy supplies and their markets. First, the type of demand is important. Some countries are developing toward a heavy industrial mix that will rely on heavy oils (or coal) and base-load electric power -- South Korea is a good example. Other countries may focus more on lighter industries and agriculture, so that lighter oils will be more important. Some countries (Kenya, for example) may develop large tourist industries where solar water heating can make an important contribution to the energy balance. In others, a large demand for low-temperature process heat, such as is important to food processing or textiles, may make the large-scale use of biomass energy commercially interesting. In sum, it is important to match the available supplies economically (and physically) to the energy demands developed by a growing economy, rather than letting a limited number of supply choices shape what demands (and economic structures) are possible.

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[1] Some of the work discussed in this paper was supported by the U.S. Department of Energy (US-DOE), Buildings Energy Research Division, under contract No. DE-AC03-76SF00098. The research for the Kenya study was funded under a cooperative agreement between Resources for the Future and the U.S. Agency for International Development. The current Lawrence Berkeley Laboratory study is supported by the US-DOE and a variety of other institutions. The authors are staff scientists at the Lawrence Berkeley Laboratory, and are solely responsible for the opinions expressed here.

*Energy Analysis Program, Lawrence Berkeley Laboratory, University of California, Berkeley, California, USA 94720.

The size of energy markets in a developing country is also important to supply planning. In countries with large domestic markets, such as India or South Korea, domestic energy supplies that are expensive compared to world oil supplies today may be worth developing for national security purposes, even if these supplies could not be profitably sold on the world market. In Thailand, for example, the development of natural gas finds may be crucially dependent on development of domestic markets for the gas. On the other hand, in smaller countries, the domestic markets may not be big enough to render exploration and development of energy supplies interesting for most international companies. Gas finds could only be exploited domestically if a large, dense, distribution network could be set up, and exports of liquefied natural gas (LNG) might likewise prove unprofitable if the quantities available were small. Thus, the nature of the evolving domestic energy market may provide the key to exploration and exploitation of domestic energy reserves that would otherwise be uninteresting for the world market.

From a global viewpoint, the evolution of energy demand in the developing countries is an important unknown variable. The potential for substantial growth is there, given the size of the populations and level of industrialization. A better understanding of the underlying factors that drive growth in the industrializing countries will thus also reduce some of the uncertainty surrounding future world energy demand.

The Structure of Energy Demand in Less Industrialized Countries

The Less Industrialized Countries (LICs)[2] are a very diverse set of nations, yet it is possible to develop a logical framework with which one can describe the structure and evolution of energy demand in any of them. Table 1 illustrates such a scheme. Energy demand is broken down by the well known sectors, and each sector into a series of subsectors listed from the least to the most energy-intensive. If we could fill in the various values, we would no doubt find that they vary widely from country to country and over time. The fuels used in each sector also vary. With such a scheme as in Table 1, one can look at each subsector and assess trends in demand, as well as the prospects for renewables or for conservation in each sector. It is unlikely, for example, that cement mills could be fired by biomass because of the enormous quantities of fuel consumed, but it is very likely that appreciable reductions in energy needs of cement mills could be achieved.

The chart represents the idea that the process of development encompasses a transition within each sector as the low-energy (and low-income) activities are replaced by those demanding more energy and producing (or consuming) more output. For each economic activity, the energy use per unit of output depends on the activity (i.e., cement or paper, large or small cars) and the technology used to perform the activity. Using such a classification of an economy, one can think about future energy needs in terms of the mix of activities and the energy intensity of each activity. Of course, one must remember that it is services -- space conditioning, cooking, transportation, process heat, etc. -- that are desired by consumers, not the fuel and electricity themselves. Accounting problems are not trivial: more calories are burned cooking on a traditional wood stove than with electric cookers, including all conversion losses (i.e., wood to charcoal to boiling water, fuel to electricity to household to boiling water). Thus, the energy intensity of the more primitive activities may be higher than that of the most advanced activities. This is the case within industry, since larger facilities almost always use less energy per unit of output than smaller ones.

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[2] We feel that the term Less Industrialized Country is a more accurate and value-neutral term to describe the countries of the world with a lesser degree of industrialization and modernization than the usual term "Less Developed Countries."

Table 1. Classification of energy demand in LICs

Sector	Examples	Share of GDP	Share of energy	Trend
	Agriculture/forestry			
Primitive	Hand tools			
Animal power	Bullock			
Light mechanized	Small tractors			
Heavy mechanized	Large harvestors			
	Fishing			
Nonmotorized	Net, canoe			
Motorized	Fleets			
	Industry			
Handicraft	Baskets			
"Informal-cottage"	Buckets			
Light	Shoes			
Medium	Food processing			
Heavy	Cement			
	Transportation			
Human/animals				
Informal public	Jitneys			
Formal public	Buses, trains			
Automobiles	Private			
Light truck				
Heavy truck				
Rail				
Air				
	Residential			
Rural				
Urban				
Nonelectrified				
Electrified				
"European standard"				
	Commercial			
Rural/informal	Restaurants			
Rural services	Hospital			
Urban				
Buildings	Offices, hotels			
Nonbuilding	Communication			

One pattern that stands out among all countries is the early emergence of the transport sector, for which few economic substitutes for oil are available. As the country matures, the industrial sector tends to become the largest energy consumer, in part because manufacturing relies more on commercial fuels, in part because manufacturing increases its output rapidly compared to agriculture. Exactly how large the manufacturing sector becomes, however, depends on resource endowment because a country with much wood or mineral resources is more likely to develop primary (and energy-intensive) industries than one without. Energy use in the buildings sector, including both homes and commercial buildings, often grows the most quickly, as a country begins to trade the wealth it gained from development for consumption and tertiary services like health care and schools.

In the following sections, we give some general observations about sectoral energy demand in the LICs.

Agriculture, forestry, and fishing

These activities tend to produce the bulk of the gross domestic product (GDP) of low-income countries, but to use only a small amount of total commercial energy. In agriculture, very low income countries have few mechanized farms and little or no mechanical irrigation. As incomes grow, such subsistence farming may exist alongside large-scale agriculture. Farming can be fairly energy intensive, with energy (fertilizer, farm equipment, and irrigation) accounting for a major share of factor costs. In South Korea, for example, the amount of energy used per million won of output nearly doubled between 1970 and 1978, reflecting increasing mechanization (Kim 1981).

Fishing has a much higher energy intensity than agriculture, although the ratio of energy use to useful protein produced may not be higher than for grains and vegetables. Motorized fishing fleets in relatively small boats in particular tend to have a high energy intensity. In Kenya and the Senegal, we found that the fishing sectors were very sensitive to energy costs as long as the boats used were relatively small. Large fishing trawlers that run on heavy oil, on the other hand, probably catch a greater tonnage per unit of energy and per unit of energy cost, but such fleets are usually the domain of a few middle- and high-income countries.

Industry

"Primitive" industry such as weaving or basketmaking requires almost no commercial energy. "Cottage industries," such as implement fabrication by hand, may use very little energy directly in hand-forming buckets or other implements, but rely on "upstream" energy embodied in the metal parts they use. These cottage industries and light industries (textiles and tobacco) show great room for trade-off between labour and the bundle of capital and energy. For medium industry (food processing, fabrication and assembly, and fine chemicals), the use of process heat is important, although at low enough temperatures to make the use of biomass or even solar energy attractive. In heavy industry, few uses of energy directly replace labour, unless one blows glass by hand from wood fires or makes sun-dried mud bricks instead of concrete blocks. In most of the medium-to-heavy industries, there is very little energy to be saved by substituting labour for machines, for such savings would not save process heat, which is the dominant use for fuel in industry.

There is a great deal of structural growth -- development by another name -- that will increase the importance of industrial energy use. The increase in industrial energy use will depend on the mix of products and the technologies used to produce them. Much of this energy is imported today, embodied in products such as machines or cement. It is not clear how much steel, cement, or chemicals a country needs to consume, as evidenced by the falling quantities of these commodities consumed per unit of GDP, or in some cases per capita, in the countries of the Organization for Economic Cooperation and Development (OECD). We submit that there are no ironclad development patterns that dictate how much raw material must be produced and consumed in any country, just as there is no rule on how much energy is needed to produce a tonne of any material.

The choice of economic strategies is an important determinant of energy demand in the industrial sector. Some African countries, for example, are very dependent on exports of ores or other materials related to energy-intensive raw-material processing. For 14 African countries, mineral exports accounted for more than 50% of export earnings in 1978, but only two of these generated more than 10% of gross national product (GNP) in industry in 1976. If these countries want to increase the value-added obtained from these raw materials, they must build large processing and fabrication industries. Such development would probably tend to decrease the overall energy/output ratio for industry, as finished products generally have a lower energy/output ratio than raw materials. Whatever the overall change in the energy/output ratio, a strategy that seeks to expand downstream production will increase energy needs in a country markedly. What must be understood today are the links between the various possible industrial mixes open to a country still growing and the energy needs associated with those mixes.

Transport

The transport sector is very heterogeneous. Although human and animal power still abound in the rural areas of low-income countries, rail and road networks are crucial for the expansion of trade and the commercial economy. At low incomes, commercial and traditional transport of freight and people dominates activity and energy use. Only as incomes rise does truly private transport -- the private use of private cars -- become important. In Kenya, we noted that automobile energy use only passed that for trucks and rail combined in the early 1970s, and of the cars in Kenya, at least one-third were owned by companies or agencies. Air travel is a luxury in most developing countries and international travel dominates except in large countries such as India.

The future of transport energy use in lower- and middle-income countries is very dependent on choices made today about the road and rail infrastructure, settlement patterns, and localization of industry. Cities such as Bangkok and Caracas are choked by traffic, in the latter case reinforced by low gasoline prices. Even in Nairobi, however, traffic jams at rush hours and lunch are a daily occurrence. Much of the private transport energy is consumed by high-income consumers for whom energy prices are not important, but use of energy for freight or commercial purposes appears to be price-sensitive, as evidenced by the rapid fuel switching encountered in countries where differentials exist between gasoline, diesel, liquefied petroleum gas (LPG), or even biomass-based fuels.

Residential

The residential uses of energy are well known: space conditioning, water heating, electric (or gas) appliances for washing, motors, communications, and cleaning and cooking. In low-income countries, cooking dominates, whereas in high-income countries cooking may be the smallest energy use in most households. In many of the countries of Africa, the calorific content of biomass fuels used for cooking exceeds the amount of all other energy consumed for all other purposes.

Patterns differ sharply between rural and urban households. Among rural and periurban or urban low-income consumers, renewable fuels for cooking far outweigh uses of commercial fuels and electricity. In cities, electricity, kerosine, and LPG appear, and even natural gas where it is available. We found in Kenya, however, that the use of electricity was sharply delineated between those middle- and upper-income households with consumption patterns similar to households of comparable incomes in Europe, and thousands of marginal consumers who might have only a few lights and a radio. For poor households, kerosine serves as the source of lighting, and other energy services (except cooking) are absent.

Table 2. Saturation of home appliances (percent of homes)

	USA 1980	Sweden 1979	France 1980	Italy 1980	Taiwan 1978/9	Bangkok 1980[a]	Tunisia 1980	Kenya 1980
Dishwasher	36	17	22	17	-	-	-	-
TV	99	99	90	94	90	96	40	7
Refrigerator	100	99	95	94	85	82	20	5
Freezer	38	65	20	10	-	-	-	-
Clothes washer	75	88	80	75	73	ca.5	-	-
Air conditioner	55	0	0	1	20	15	5	-
Electric water heater	33	17	27	41	5	ca.4	ca.4	1
Gas water heater	53	-	30	15	5	-	1	-
Electric range/oven	52	95	48	2	3	-	-	1
Gas range/oven	40	5	40	95	70	-	-	3
Electric rice cooker	-	-	-	-	90	84	-	-

Sources: LBL Residential Data Base (OECD countries) and reports from individual countries.

[a] Survey of middle- and upper-income households.

It is important to realize that urban housholds all over the world seem to be adopting similar patterns of energy use in homes (excluding space heating). We have assembled (Table 2) some figures on appliance saturations from a variety of studies, including our own survey of the OECD countries (see Schipper and Ketoff 1983). Other data from Thailand and the Republic of Korea and Singapore present a similar message: as a country approaches middle-income status, probably around US$1000/person, households with electricity begin to acquire all kinds of devices, and electricity use grows very rapidly. In Korea, for example, annual growth rates exceeded 15% per household in the mid-1970s. The number of appliances doubled very rapidly. In Kenya, on the other hand, increases in consumption per household were minimal, because the real middle-class consumer has yet to emerge and the largest consumers are predominantly wealthy Kenyans or foreigners.

The greatest uncertainty in the future of the household sector is the rate of urbanization and the subsequent substitution of some or all of the renewable energies used today (dung, wood, charcoal, etc.) with commercial energy forms. In Taiwan, this process is complete, and virtually every household is electrified. In South Korea, there are still many households using wood for heating, but electrification has passed 80%. In Kenya, only 8% of all homes have electricity, although the proportion rises to 30% in areas where electricity is actually available. It is very important to watch the developments in residential energy use at a great level of detail, distinguishing among types of consumers, patterns of consumption, and location across income groups. Note that water heating is important in developed-country households, accounting for as much as 25% of the fuel consumed in the sector. There is a great potential for avoiding this fuel or electricity use by timely introduction of solar hot-water heating in sunny countries, as is occurring now in Kenya and many other countries as well.

Commercial

The commercial sector is a bit of a catch-all, containing buildings and also a variety of other energy uses such as gas and waterworks, communications facilities, street lighting, airports, and even golf courses and drive-in movies! There are many parallels between buildings in cities in the developing world and those in the OECD countries, but buildings in rural areas may be very poorly lit and ventilated with few of the amenities common to city buildings. Indeed, many "restaurants" or "stores" may be little more than tents or other simple structures with no electricity and only a wood or charcoal fire as evidence of energy use. The same contrast is true of the streets themselves, which tend to be lit in the major cities but unlit and often even poorly defined elsewhere.

To understand building energy use, it is necessary to divide buildings up by vintage, by type of equipment, by function (e.g., water heating and lifts), and by purpose (e.g., hospitals and hotels). From surveys of buildings in the USA, we know that energy requirements can differ radically depending on both the functions and the building purpose. Moreover, there is a clear progression towards greater amenities (i.e., space comfort, ventilation, and lighting) in buildings in countries with higher incomes. At the same time, however, the energy intensity of a given service may vary by an order of magnitude between two buildings.

Among the subsectors in the commercial sector, the hotel, schools, and hospitals subsectors are particularly intensive users of hot water. In Kenya and elsewhere, there are ample opportunities for using solar systems to provide much of this hot water. We have found that, in nearly every warm country, there is a clear distinction between large buildings designed with shading built into the facade elements, and large unwieldy structures with facades exposed directly to sunlight. Of all the major economic sectors, the commercial sector is likely to use more electricity, as a fraction of all energy purchased, than other sectors, and to grow the most rapidly with middle-income status. Unfortunately, the needs for air conditioning and the predominant use of buildings during daytime hours make electric power demands in this sector very peaked, causing difficulties for utilities that do not have access to reserves of hydropower to meet peak demands. A danger in many developing countries is that the problems of energy efficiency in the building sector go ignored today because that sector appears small in relation to the other sectors. Yet in only one or two decades, fuel and electricity use in the buildings sector can be four to six times what it is today. In Italy and in South Korea, for example, growth rates in both the residential and the commercial sectors were more than 10% per year for many years, while electricity use in commercial buildings in Singapore was also growing very rapidly until a conservation campaign was begun. In Tokyo, the appearance of air conditioning in the short space of only 10 years made an enormous impact on the yearly load curve of the Tokyo utility, adding a peak of about 20% to the base demand. Thus, the building sector can move from obscurity to the forefront in a very short time.

Understanding Changing Demand: Looking Behind Energy Statistics

Gaining a meaningful understanding of energy demand and how it is evolving in a country or other entity is not easy. The basic problems are all too familiar to anyone who has done energy analysis: data reliability and data nonexistence. These problems are particularly well known in LICs. Data are, nonetheless, obtainable. In small countries, the number of important energy users is few, whereas in larger countries or those that have reached middle-income status, an infrastructure that collects and even analyzes data often exists. In Kenya, our study was carried out by visiting 40 firms and obtaining sales figures for 100 others from suppliers, as well as by sorting the utility-sales data by individual customer. In the Philippines, the Bureau of Energy Utilization has put a program in place that essentially collects such data. Thus the problem is not that data cannot be gathered, but that there is a lack of resources, personnel, or interest in gathering and using it.

In this paper, we would like to address a third, and often neglected, area: data assembly and interpretation. By "data assembly," we mean the grouping of data in such a way as to give insight on things that people want to know about. That is, to allow interpretation of trends that may otherwise remain hidden behind the well known statistics.

Our central thesis is this: What is needed is less focus on aggregate energy-demand statistics and more focus on the factors that drive energy demand. One must distinguish between statistics that are important and data that are useful in increasing understanding. Total oil demand in a given year, for example, is an important statistic, but it does not really help us to understand what is going on. It provides only a weak basis for estimating what next year's oil demand will be. In the old days of forecasting by extrapolation, this was perhaps good enough. But in today's more uncertain situation, few would still rely on it as a basis for planning. We first need to know where the oil products are consumed: in factories, in power plants, in cars and trucks, in homes, etc. We are then in a position to assess what is happening within each of these areas.

The above may seem obvious. Indeed, many developing countries now have a respectable sectoral breakdown of energy consumption. In most cases, however, the work stops with this sectoral breakdown. This is not enough! Although a historical time-series can tell us about growth rates in consumption of various fuels and about the changing fuel mix, it does not shed any light on the forces that are shaping consumption patterns. These forces include such things as the number of homes, the amount of commercial floor space, the number of cars, freight traffic, and industrial activity.

Why is it important to keep track separately of these "structural" factors? It could be argued, for example, that the trend seen in the residential-sector energy consumption captures the effect of the growing number of households, so why count both? However, this supposes that growth in energy demand depends only upon growth in these "structural" factors. In fact, total energy demand (in a sector or a country) for a particular good or service is the product of the amount of that good or service demanded and the energy intensity (energy consumed per unit of good or service) with which it is delivered. Because this energy intensity can change (in response to energy prices, changes in technology, or other variables), it is important to keep separate track of the "structural" factors.

What is needed is a systematic approach to connecting energy statistics with the "structural" factors that drive energy demand. We refer to the resulting statistics, which are typically expressed as energy consumption per some unit of "structure," as indicators of energy demand.

Ratio of energy to GDP as an indicator

These indicators can be constructed at various levels of disaggregation. In general, the more inclusive the indicator, the less useful it is. The most inclusive indicator is the ratio of national energy consumption to gross domestic product (E/GDP). Although it is popular and much-debated, the E/GDP ratio is not a very useful indicator. It is difficult to interpret. Worse, it can be misleading in that it may draw the uncautious interpreter to the wrong conclusion.

It is one of our axioms that: The things that are really important are the things that the E/GDP ratio hides. Two very important factors are lumped together in the E/GDP ratio:

- Changes in the mix of goods and services in the GDP; and
- Changes in the energy intensity with which the particular goods and services are produced.

In economies in which growth and change is occurring at a rapid rate, these factors can shift relatively quickly.

South Korea provides a good example of this. Economic growth in South Korea has surpassed planners' expectations, averaging nearly 9% per year over the last 20 years. The share of manufacturing in the GDP has grown substantially -- from 18% in 1970 to 34% in 1980 (Table 3). The manufacturing sector itself has become "heavier" as the combined share of "heavy" and "energy-intensive" industry grew from 47% in 1970 to 56% in 1978 (Table 4) leading one to expect that the E/GDP ratio would have risen during the 1970s. Within each of the manufacturing subsectors, however, energy intensity declined sharply (Table 5). This drop is due both to energy conservation in factories already existing in 1970 and to the addition of new factories that were more energy efficient than the old ones. The latter occurred to such a large extent in heavy manufactures that the overall energy intensity of the subsector was reduced by over two-thirds! This was not due to massive energy conservation, but rather to the very rapid expansion (from gross output of 300 billion won in 1970 to over 4000 billion won in 1978) of the heavy manufactures subsector.

The result of these and other changes was a decline of 6% in the Korean E/GDP ratio between 1973 and 1979. Looking at the ratio alone would have alerted us that something happened, but given us no clue as to just what that was, or whether it reflected a permanent change.

Table 3. South Korea: Percentage origin of GDP[a]

	1961	1965	1970	1975	1980
Manufacturing	8.3	11.0	17.9	26.5	34.4
Mining	1.7	2.0	1.6	1.5	1.2
Agriculture, forestry, and fishing	47.0	43.2	30.4	24.9	15.9
Other	42.9	43.9	50.1	47.1	48.4

Source: Major statistics of Korean economy.

[a] Based on 1975 constant prices.

Table 4. South Korea: Composition of the manufacturing sector (as percent of gross output)[a]

	1970	1978
Light manufactures	52.6	44.2
Heavy manufactures[b]	7.5	21.7
Energy-intensive manufactures[c]	39.9	34.0

Source: Kim (1981).

[a] 1975 prices.

[b] Heavy manufacturing consists of fabricated metal products, general machinery, electrical machinery and equipment, and transport machinery.

[c] Energy-intensive manufacturing consists of paper and pulp, chemicals, coal, petroleum, nonmetallic mineral products, primary iron and steel, and nonferrous metals.

Table 5. South Korea: Energy intensity and growth in the manufacturing sector

	1970	1978
Energy intensity (t-oe per million won at 1975 prices)		
Light manufactures	0.65	0.41
Heavy manufactures	1.28	0.36
Energy-intensive manufactures	2.10	1.65
Gross output (billion won at 1975 prices)		
Light manufactures	2053	8484
Heavy manufactures	294	4158
Energy-intensive manufactures	1560	6547

Source: Kim (1981).

E/GDP "elasticity" is another over-used statistic that one sometimes encounters. E/GDP "elasticity" is typically a measure of how much energy consumption responds to a given increase in GDP. In economics, elasticity typically refers to changes in demand for some good relative to changes in the price of the good or the income of consumers. In theory, at least, both price and income are well defined quantities whose contents are not important to the relationship with demand. Such is not the case with GDP. Indeed, it is the changing content of the GDP that is of critical importance in understanding the evolution of energy demand. We cannot speak of a 1-unit increase in GDP in the same way as we refer to a 1-unit increase in price or income, for whether that 1 unit is composed of digital watches or it is composed of steel matters very much in terms of the effect on energy demand.

An additional problem is that the E/GDP "elasticity" is often calculated in a simplistic fashion without inclusion of a variable for energy price, which certainly has an effect on E (energy consumption) that should be kept distinct from the income effect.

Indicators of Energy Demand

To better understand what is going on with energy demand, it is necessary to disaggregate both total energy consumption and total GDP. The goal is to connect the various pieces of the energy pie with the "structural" factors that drive demand for each piece. For example, we would connect gasoline consumption with the number of passenger vehicles, or if the data were available, the number of vehicle-kilometres driven. The latter is closer to what actually drives gasoline demand, but may be a difficult number to ascertain. This is a common dilemma: the more accurately one tries to disaggregate both the energy and structural sides, the more difficult it is to come up with the necessary data. One must strive to represent the relationship between the energy demand and the driving forces as finely as possible, without making impossible data demands.

The first step is to disaggregate total energy consumption into the various demand sectors. Typically, these are households; the "commercial" sector, although this is somewhat of a misnomer, because the sector includes government operations; industry (including manufacturing, mining, and construction);

Table 6. Taiwan: Energy in mining and manufacturing

	1961	1965	1970	1975	1980
Commercial energy consumption (ML-oe)[a]	2374	3350	5765	8384	14448
Contribution to GDP (million 1976 NT$)	39690	65736	141237	238142	440784
E/GDP (L/1000 NT$)	59.8	51.0	40.8	35.2	32.8
Index	147	125	100	86	80

Source: Republic of China Statistical Yearbook.

[a] ML-oe = million litres of oil equivalent.

agriculture, forestry, and fishing; and transport. Properly, one should allocate energy consumed in electricity generation to the demand sectors according to their relative shares of electricity consumption. This disaggregation is not always so easy to make. For example, there is a fine line between transport of goods and routine industrial or agricultural operations. (When does moving fish or logs stop being fishing or forestry and become transport?) Often, one is able to draw the line in theory, but actually allocating energy consumption in accordance with the blueprint proves difficult.

One can develop some indicators at the sectoral level, but often this presents problems similar to those encountered with the E/GDP ratio. That is, many different items are lumped together, and the relative shares of these different items can change. For example, in the manufacturing sector one can express total energy consumption in the sector in relation to total output of goods. Because we cannot add together men's suits and tonnes of steel, however, output must be expressed in some common unit, such as dollars or pesos (corrected for inflation, of course). Table 6 shows data on energy use in the manufacturing and mining sector of Taiwan. The ratio of total energy use in the sector to sector output -- expressed in constant local currency -- fell by 20% between 1970 and 1980. The question one must examine is: Did the output of the sector shift toward less energy-intensive products? Because the ratio of energy use to output also fell continually between 1961 and 1970 -- a period in which energy prices did not increase -- it seems that, in fact, structural changes were taking place in the composition of the sector that pushed down its energy intensity.

Similar problems arise in developing aggregate indicators in the other sectors. Energy use per household is a somewhat useful indicator, but here too the average household changes with respect to both housing type and appliance holdings. For nonresidential buildings, energy consumption per unit of floor area is sometimes used, but the mix of different building types changes with time. In the transport sector, it is virtually impossible to develop a sectoral indicator, because there is no common unit with which one could aggregate the many services encompassed in the sector.

These problems do not mean that such sectoral indicators do not tell us something. It is just that they mix changes in the structure of the sector with changes in the way energy is used to produce particular goods and services.

Indicators at the subsector level

As one disaggregates further, things become more clear (and the data become harder to get!). In manufacturing, one can examine particular industries. Energy consumption may be determined by survey, and output expressed in terms of

Table 7. Philippines: Indicators of energy intensity[a] in industry (in barrels of oil equivalent per thousand 1972 pesos value-added)

	1974	1975	1978	1979	1980
Logging/Wood products	2.45	2.94	2.45	2.64	2.10
Chemicals	0.51	0.49	0.33	0.36	0.31
Food processing	0.55	0.53	0.44	0.45	0.40
Textiles	0.85	1.06	0.73	0.69	0.61
Paper	2.55	2.59	2.84	2.96	2.80
Metal industry	1.42	3.64	3.34	3.28	3.45
Mining	2.23	1.94	1.86	1.90	1.67

Sources: Bureau of Energy Utilization; 1981 Philippine Statistical Year Book.

[a] Energy consumption refers to petroleum use for direct consumption and electricity generation in each industry.

value added. Here too, the mix of outputs can change over time, but the outputs in a particular industry are much more homogeneous and tend to vary less than for the entire manufacturing sector. Sometimes, it is possible to use the actual total physical output of an industry (e.g., tonnes of steel). This is preferable to value-added, which can be complicated by changes in prices received for products. Data from the Philippines provide a good example of industry-level indicators using value-added (Table 7). In all of the cases shown, the ratio of oil-product consumption to value-added has declined since the 1979 oil price shock. These drops are certainly due in part to the government's aggressive energy-conservation program.

At the level of the individual firm, it is easier to develop indicators using actual physical output. These energy intensities are the most reliable indicators of energy conservation, although here too there may be complications. Results from our Kenyan study are shown in Table 8.

In transport, the various modes must be considered. The most important indicators are those concerning passenger and freight transport. Often, it is difficult to make a precise disaggregation of energy consumption by transport mode. Not all gasoline is used in passenger vehicles, for example. Most is, however, and a useful indicator is gasoline consumption per vehicle. Even better would be consumption per vehicle-kilometre traveled, but this indicator is usually difficult to come by. For land freight transport, one can make the rough assumption that all diesel fuel used in transport is used in freight, though this can lead one astray if a large number of diesel-fueled passenger vehicles are entering the fleet. The indicator is then the ratio of diesel-fuel consumption to a unit of freight traffic, such as tonne-kilometres. Similar indicators can be developed for air and rail transport, though the presence of bunkers (fueling by international airlines) complicates the situation with respect to air transport.

Nonresidential buildings can be grouped by different types. As with industry, energy-consumption data can be gathered through survey. Table 9 shows an example from our study in Kenya. Hotels can be an important part of the economy in countries where tourism is a major industry. Here the appropriate measure of energy intensity is the "guest-day" -- a measure of the service provided by the hotel. The indicators strongly suggest progress in energy conservation in Kenya's hotels.

In the household sector, the aggregate indicator "energy per household" may be the only one for which data are available. There are no convenient measures of the service that households derive from using energy (i.e., energy per meal), although in some cases it may be possible to develop them. Still, it is

Table 8. Kenya: Indicators of energy intensity in industry

Factory	Year	Energy use per output (MJ) Fuel	Electricity	Output unit
Vehicle assembly	1977	5000	2020	vehicle
	1979	3550	1730	
Truck assembly	1978	1950	-	vehicle
	1979	1780	2195	
Tires	1975	35600	8930	ton
	1979	19940	5760	
Tire recapping	1977	21700	3095	ton
	1979	13700	3455	
Cement (wet kiln)	1977	6200	290	ton
	1979	6020	265	
Cement (dry kiln)	1976	3950	310	ton
	1979	3980	255	
Paper/pulping	1977	47500	-	ton
	1979	38800	-	
Steel	1977	4070	2125	ton
	1979	3840	2410	
Creameries	1972	1940	170	$L \times 10^3$
	1979	1480	350	
Food processing	1975	6250	-	ton
	1978	4370	-	
Soap	1977	12760	495	ton
	1980	10700	545	

Source: Schipper et al. (1981). Based on data supplied by individual firms.

Table 9. Kenya: Indicators of energy intensity in hotels (as energy per guest-day)

Hotel	Year	Electricity (kW.h)	Fuel (MJ)
1	1975	16.1	138
	1979	14.3	102
2	1977	35.5	306
	1979	23.7	253
3	1977	33.1	-
	1979	30.1	146
4	1977	21.5	-
	1979	16.9	559

Source: Schipper et al. (1981). Based on data supplied by hotels and electricity supplier.

very important to keep track of structural changes in the household sector, as it is the growth in appliance holdings that has driven residential energy demand in the middle-income developing countries.

Using energy indicators

Indicators can be used at different levels for different purposes. Perhaps the main usefulness of indicators is simply that they shed more light on what is happening to energy demand than ordinary energy statistics. By separating out some of the effects of structural growth, they can assist analysts in assessing the impact of energy conservation, whether induced by prices or government programs. They can be used by planners or even plant managers to monitor the energy productivity of industrial operations. Used with caution, they can also allow assessment of where an industry or sector in one country stands in relation to similar ones in other countries.

Indicators can also provide a basis for forecasting energy demand. They make clear the linkage between demand for energy and the demand for goods and services, and show how the relationship changes. Although they do not take the place of formal energy-demand models, they help identify important driving forces and point out areas where data are needed.

Understanding Energy Demand in LICs: Key Issues and Directions for Research

Role of traditional fuels

The so-called "traditional" or "noncommercial" fuels -- wood, charcoal, dung, bagasse, etc. -- now make up a much smaller share of the total energy balance in the developing countries than was the case 20 years ago (Table 10). This is, in part, because of switching to fossil fuels (especially in the wealthier developing countries), but is also an outcome of the enormous growth in fossil-fuel consumption that has accompanied industrialization. Overall, consumption of traditional fuels has continued to increase and, in many if not most developing countries, most households still rely on the traditional fuels. Higher incomes permit a transition to kerosine or liquefied petroleum gas (LPG) for cooking needs and such a movement has been observed in many countries. At the same time, there has been increasing use of biomass fuels by industry in response to higher oil prices.

In general, there is a lack of good data with which one could quantify both the magnitude of traditional fuel consumption and the dynamics of the movement by households to fossil fuels. In-country research should try to address this latter issue as well as simply quantifying biomass consumption. There is also a place for international research that would analyze results from different countries and perhaps draw some general conclusions about the dynamics of energy use in the household sector.

Price and income elasticity of energy demand

The range of values that has been cited for the price and income elasticities of energy demand in LICs is wide indeed. More careful analysis of the response to the changes in energy prices that have occurred in the last decade is needed. In this analysis, it is important to differentiate among demand sectors, as the response to price changes can differ very much among them.

Table 10. Role of wood[a] as an energy source (percent of total energy consumption)

	1960	1970	1978
		Asia	
Bangladesh	-	-	73
India	69	63	57
Pakistan	-	54	50
Indonesia	62	57	49
Thailand	-	30	23
Philippines	55	38	34
South Korea	53	17	7
Malaysia	43	27	19
Asian DMCs[b]	64	54	46
		Latin America	
Colombia	-	19	16
Peru	-	30	23
Mexico	-	15	11
Brazil	-	29	25
Argentina	-	3	2
Venezuela	-	1	1
		Africa	
All LDCs	-	69	58

Sources: Asian Development Bank (1982); Latin American Energy Organization; United Nations (Africa).

[a] Includes other biomass fuels (dung, bagasse, etc).

[b] Developing member countries of the Asian Development Bank.

Complicating factors that confound the traditional calculation of price elasticities must be kept in mind. In Kenya, for example, the prices for small lots of LPG and kerosine -- fuels used almost exclusively by homes -- increased markedly between 1972 and 1979, yet demand more than doubled. The moderate increase in incomes during that period meant that more homes could afford to buy these fuels and the equipment needed for their use. However, it appears that the key factors were the pressure on the wood and charcoal supply and the migration of people to the edge of Nairobi, both of which forced up the demand for commercial fuels. The lesson here is clear: energy prices are important determinants of demand in LICs, but modeling the relationships among prices, capital stocks, and incomes is complicated.

As for the response of energy demand to increasing income (particularly household income), analysis of the experience of middle-income developing countries should provide insight into what may be in store for other countries.

Effect of "new" capital equipment on energy use

Most developing countries are in some ways lucky that the jumps in world energy prices occurred when they did, and not later. In many countries, much of the capital stock -- factories, vehicles, and buildings -- that will be used for the remainder of this century and beyond is not yet in place. The potential for building a capital stock that is attuned to today's energy prices is thus large.

Sometimes, however, "new" equipment may in fact be old equipment. Many developing countries have begun their own airlines and are using castoff equipment from the West (particularly fuel-inefficient Boeing 707s). Older automobiles abound in many countries where the cost of new cars is inflated by import duties, and entire factories that have become outmoded in the West may be dismantled and reassembled in developing countries. These moves may be economic, given the low cost of the "used" equipment, but the energy costs of operation should be evaluated.

Capacity expansion tends to push down energy intensity -- in part because of the new capital being more efficient and in part because of economies of scale. In a major hotel in Kenya, doubling of capacity brought a significant decrease in use of energy per guest-day. Examination of consumption data showed that the larger capacity saved more energy than the moderate conservation efforts of the engineer. In Thailand, the energy intensity of a bottle factory we visited was reduced significantly when the size of the factory was doubled. The new part of the plant, with computerized equipment, required only half as much energy per bottle as the old part.

There is a danger of extrapolating future energy consumption based on energy use in today's capital stock, which in many cases will account for but a small (and inefficient) share of the future capital stock. Research into the interaction between economic development and energy efficiency is needed.

Fuel switching

Fuel switching has been encouraged in many countries to reduce oil imports. Although fuel switching is often associated with the goal of saving a particular fuel, such as oil or wood, in our work we consider this as separate from energy conservation, which has to do with improved efficiency of fuel use. In large industrial and commercial establishments, we found much evidence that factories were ready to switch to the fuel that was the least costly to use, taking into account both the cost of energy and the cost of equipment and maintenance. Sometimes the fervor for switching away from oil seems to have obscured the cost of alternatives. Nevertheless, it is important to find areas where fuel switching can occur or be stimulated. Substitution of mixed renewable/oil fuels for oil -- coconut oil and diesel fuel in the Philippines or gasohol in Kenya and Brazil -- or illegal switching to LPG in cars in Thailand show that there is some flexibility in transport. In industry, there have been notable examples of switching to coal in the cement industry, but in other industries oil (or gas) is usually easier to use. Where natural gas is found, it may readily enter the domestic market and replace oil. To understand fuel-switching possibilities, a detailed description of energy end-uses, consistent with a country's development plans, must be made.

In the residential sector, the interplay between commercial and noncommercial fuels is important and was mentioned. In Senegal, the gas company has recently developed and successfully marketed a very inexpensive LPG water-heating device. It is hoped that these devices will relieve pressure on the rapidly depleting forest. Because the cost of the LPG is held down by controls, it becomes cheaper than purchased wood or charcoal for boiling water. In all countries, it is important to look more carefully at the changing patterns of residential energy use, assessing the role of relative prices and the costs of the equipment that use the various fuels.

Role of energy conservation

The effect of energy conservation in affecting energy demand in LICs often seems to be misunderstood. By "energy conservation," we mean those activities that reduce energy consumption through improved efficiency in use. This is different from "energy curtailment," though this too results in lower energy consumption and may well be an appropriate response to energy shortages. Energy conservation involves making adjustments in energy-consuming equipment or improvements in operation that permit the equivalent levels of service at less cost. Energy costs are usually but not always the major driving force behind conservation. Sometimes energy conservation occurs when it is not the major goal, as when old machinery is replaced with more modern equipment.

The important effect of new, more energy-efficient capital equipment was discussed above. This will be the major way in which LIC economies become more energy efficient, but conservation measures with existing capital stock are also important. We examined the extent of such measures in Kenya before the 1979/80 oil price shock, and a discussion of our findings is given in the Appendix. In general, the results were mixed, with some very successful examples illustrating that big savings are possible when firms put forth the effort.[3] This and other examples indicate, however, that the response of energy users to increased prices and other conditions is lagged, and hindered by slow economic growth or political instability. Thus, one cannot expect to see dramatic results overnight, although sudden price increases for some fuels can result in drastic curtailment of activities like driving or use of air conditioning.

Role of policy

Efforts to control growth in energy demand have been more aggressive in some developing countries than in the already industrialized nations, but little is known as to the actual effect of government policies. Policies can lead to more efficient energy use, to outright curtailment of certain activities in the hopes that energy savings will result, and in the long run to economic activity that is less energy intensive. On the other hand, policies that restrain prices can encourage energy consumption, as is well known.

We review a few government programs in the following paragraphs.

In Singapore, the government has restricted traffic flow in the downtown area. During rush hours, cars must either have three or more occupants or pay a special tax to drive downtown. This measure has noticeably reduced congestion and traffic. Additionally, the government has imposed a thermal standard on new office buildings, which, although under revision (through a joint project with the Lawrence Berkeley Laboratory), will ultimately reduce energy use per square metre in large buildings.

The South Korean government instituted a series of audit and energy management programs in industry, resulting in savings documented by the Korean Energy Management Association. The government has also promulgated weak thermal standards for new housing. In the area of curtailment, the government has required that elevators not be used between the first few floors in buildings. We observed, however, that most people rode elevators to the first floor at which they stopped, then walked down -- illustrating that curtailment can be difficult to enforce.

An important policy initiative in Thailand was the institution of energy audits in industry. Of course, there is no guarantee that the recommendations of such audits will be taken, as was pointed out when we visited factories in Thailand.

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[3] Barriers to conservation and ways to assist in overcoming them are discussed in the Appendix.

In Venezuela, the government instituted a voluntary program by which car owners would abstain from driving on a certain day of the week determined by the last digit of their registration plates. Our observation (in 1981) was that this policy had little effect, probably because the price of gasoline was so low. However, experience from virtually all the countries in the OECD suggests that taxes based on the weight or displacement of a car do encourage the purchase of lighter or smaller vehicles.

In the Philippines, energy audits were instituted in 17 major industries as had been done in Thailand. In addition, each industry was required to institute conservation measures and submit quarterly progress reports to the government. Along with price increases in fuels, this has resulted in a 15-20% improvement in energy efficiency in most of the energy-intensive industries.

The above examples emphasize a need for critical evaluation: if a country adopts a policy, can it be shown that it has had an effect on consumption beyond what was caused by changes in prices and incomes? In Sweden, for example, thermal standards on new homes were tightened in 1977. However, most homes built in 1975 were close to the levels of insulation demanded in 1977. It was difficult to maintain that the standards themselves caused the reduction in energy use observed in homes built after 1977. For developing countries, the need to be able to track the impact of energy-use policies is critical, because the rates of growth in capital stock are so rapid that a "mistake" -- a policy that led to unintended side effects -- that was ignored for a few years could be difficult to undo if a large amount of energy-consuming capital was built during those few years.

Concluding Observations: Assessing Future Energy Needs

Energy demand is the big uncertainty in the LICs. Supplies are generally ample (except in the case of wood), but expensive. Improving the understanding of energy demand is essential to developing the type and amount of supplies that will be needed in the future.

The rapidly changing nature of LIC economies and of energy use in them makes it difficult to use simple models built from price and income elasticities to forecast future energy needs, particularly when the nature of yet-to-be-installed capital equipment is uncertain. The transition from agriculture to manufacturing, the substitution of energy-using domestic production for imports of key finished materials, such as steel, chemicals, and paper, and other changes all have major impacts on the E/GDP relationship. A better approach to looking at the future involves assessment of the mix of future activities in the economy and the likely levels of energy intensity of those activities. A "baseline" scenario could then be compared with scenarios assuming different values for the energy/output ratios or different activity mixes.

An important element is the impact of energy conservation. Many factors are working for conservation in the developing world, including the increased size of most industrial operations over time and the potential use of more energy-efficient capital equipment. The mere process of development, which may entail the expansion of energy-intensive activities, should not be construed as "anticonservation." Our experience shows that new equipment coming on line in the 1980s and 1990s need consume only 50-75% as much energy per unit of output as existing equipment. Development assistance targeted to energy conservation could help the LICs actually achieve the potential savings. Just as economic growth allows the introduction of energy-efficient capital stock, greater energy efficiency will foster GDP growth by freeing resources that would have been used for imported fuels or expensive domestic energy projects.

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Appendix: Progress in Energy Conservation in Kenya

Kenya, like many other developing nations, was hit hard by the two big increases in oil prices. Additionally, irregular rainfalls and maintenance problems caused difficulties in the hydroelectric supply during several periods between 1973 and 1981. Thus, there were ample reasons for firms and individuals in Kenya to be interested in energy conservation. In our study (Schipper et al. 1981), which we summarize here, we found mixed results.

Nominal prices of petroleum fuels in Kenya were about four times higher in 1980 than in 1973, and nominal electricity prices had approximately doubled. When general price inflation is taken into account, however, one sees that there was only a twofold increase in the 1973–80 period, and there was practically no change in real fuel prices between 1974 and 1979. (Retail prices as of June 1980 were about US$0.63/L for motor gasoline, US$0.44/L for diesel fuel, and US$0.33/L for kerosine.) The price of electricity for residential customers in 1980 (about US$0.07/kW.h) was, in real terms, below the level prevailing in 1973.

Aggregate data on petroleum fuel consumption confirms that growth in demand has slowed considerably since 1973 and, more importantly, has been less than growth in real GDP. From 1969 to 1973, the ratio of growth in petroleum fuel demand to real GDP growth was 1.6, but from 1973 to 1980 the similar ratio fell to below 0.9. This drop is certainly significant, but it should not necessarily be taken as a sign of improved energy productivity within the major sectors of the Kenyan economy. Although demand for all fuels (with the significant exception of kerosine) showed slower growth from 1973 to 1980 than from 1969 to 1973, gasoline, jet fuel, and fuel oil were primarily responsible for the sharp fall in the overall growth rate. The slower growth in fuel-oil demand was due chiefly to increased hydroelectric production. As for gasoline and jet fuel, the reduced growth in demand was probably due to curtailment of transport activity, which does not bring with it a proportional drop in economic production to the same degree as does a decline in agricultural or industrial activity. To clarify the changes we observed, we summarize our findings from each sector.

Signs of energy conservation

Industry

Several factors complicate the assessment of conservation progress, which we measure in terms of reductions in the energy intensity of production or activity (i.e., energy use per unit of output or activity). Results of our survey of firms were given in Table 8. Capacity utilization can have a significant effect on energy intensity. Some factories in Kenya are so pressed to produce that they run in excess of rated capacity and lose energy efficiency in the technical sense, although so doing may result in greater profits. Expansion of capacity can affect energy efficiency, as large factories tend to use less energy per unit of output than smaller, and newer less than older.

Despite these difficulties, most of the reduction in energy intensity that we document here resulted from deliberate attempts to save energy. Conversely, most factories that had not attempted to improve energy use had constant or increasing energy intensities. Indeed, our interviews and examination of data on industrial energy use showed a clear distinction among firms. Some firms, notably the most energy-intensive ones (cement, oil refining, and some steel companies) showed a keen awareness of the economic benefits of energy conservation and of systematic energy accounting. Managers could pinpoint increases or decreases in energy use relative to output and, significantly, the reasons why they came about. Interviews with transnational firms, even those whose energy intensity is relatively low, revealed a similar awareness. The largest and best documented conservation gains came from a firm that is a subsidiary of a multinational firm.

The status of conservation among other firms, however, is mixed. In one firm, the engineers complained that the firm probably would not invest a small amount to fix obvious leaks, improve boiler efficiency, or "optimize" a process, even if the returns for such investments were large. One of our guides pointed out that the boilers we had just viewed were run at unnecessarily high pressures. An engineer at a metal-processing firm told us that he was satisfied simply to be able to start the equipment in the morning. The managing director of a very large and energy-intensive firm listed difficulties that held back his conservation effort: poor organization, varying oil quality, high demand for product that made high mill-capacity a more important factor than energy economies. The progress made toward more efficient energy use in his firm was slow, in spite of the increasing size of the fuel bill. In contrast, a manufacturer of food and household items had just hired an engineer who planned to make important process modifications to reduce energy use. Several firms had discovered sources of biomass scrap from other factories that would substitute for a considerable fraction of their oil use, whereas others have discontinued use of such scrap for boiler fuel because of pollution problems.

We found activities related to energy conservation scattered among the firms we visited, but no clear trend. Those firms that had made efforts to economize had generally succeeded; many firms simply had not tried. The data in Table 8 illustrate that a wide range of firms were successful in reducing the energy intensity of their operations. In general, we observed that reductions in petroleum fuel intensity were much larger than reductions in electricity intensity. This is not surprising given the relative trends in price. In some firms, we found increases in energy intensity, particularly in electricity, despite efforts to conserve energy. The data on creamery operations (nation-wide) present a striking example. Fuel intensity had fallen since 1972, but electricity use per unit output increased twofold. We believe that this increase reflects mechanization of older facilities. Of course, increased electricity intensity does not rule out the presence of conservation practices; in the case of the creamery, electricity intensity would have been even higher in 1979 had not measures been taken to reduce consumption.

The effects of capacity utilization and economies of scale need to be kept in mind when interpreting energy intensities. We noted several firms that reduced energy intensities markedly without any apparent conservation efforts. In almost every case where this was observed, the output of the firm had risen as much as fivefold over the period examined. Similarly, firms whose output fell during slack years showed increased energy intensities in spite of reported conservation efforts, some of which we observed personally. The oil refinery, for example, used more fuel per unit output in 1979 than in 1973, apparently because reduced demand for its products forced it to run well below its capacity (although a concerted conservation effort reduced energy intensity somewhat in 1979 relative to 1977).

Transport

Data limitations prevented us from forming precise indicators of energy intensity in the transport sector. There are indications of reduced activity with respect to automobiles, as total automobile vehicle-kilometres traveled (as estimated by the Automobile Association) increased by an average of 3% per year between 1975 and 1979, while the estimated number of automobiles grew at a rate of nearly 6%. Growth in gasoline demand was down significantly in the 1973-80 period, averaging 3.7% per year as opposed to 11% per year for 1969-73. Whether the fuel efficiency of the automobile fleet improved is an open question, but it is clear that its present fuel efficiency is very low, probably due to both poor vehicle maintenance and congested traffic conditions. Higher import duties on larger cars have apparently had some effect on the pattern of new-car purchases.

There do appear to be improvements in the energy efficiency of bus and rail transport. The bus company in Nairobi noted a 10% drop in energy consumption per vehicle-kilometre after a concentrated effort to improve operating efficiency was carried out, and its intercity counterpart also observed energy savings in 1980. Total energy use by the railroad was about 3.2 PJ in 1980 compared with 6 PJ in 1977. During this period, there was no significant decline in rail travel. The main reason for the dramatic decrease appears to be a rapid shift from heavy diesel fuel and fuel oil to automotive diesel fuel, which burns much more efficiently in locomotives. There was also some upgrading of the locomotive stock. Finally, the replacement of older aircraft with wide bodies during the 1970s held down the use of jet fuel relative to international passenger traffic at Nairobi's airport.

Commercial buildings

The data we collected for commercial buildings show definite signs of energy conservation among hotels (see Table 9) and mixed indications of conservation activity among office buildings. It should be kept in mind that the price of electricity, the major energy expenditure for most commercial buildings, did not increase nearly as much as did the price of petroleum fuels. We found that some of the larger hotels had considered energy-conservation opportunities carefully, and solar water-heating systems (with collectors assembled in Kenya) had been installed or were planned for many hotels. Office buildings in Nairobi showed no clear trend. Of the 10 buildings for which we had several years of electricity consumption data, two showed a significant decrease in consumption, two showed significant increase, whereas the rest stayed at about the same level of consumption.

Residences

It is difficult to characterize conservation efforts in the residential sector due in part to changes in electricity tariff classification. We could detect no discernible drop in estimated residential electricity sales (not surprising given that the real price of electricity fell by 20% from 1973 to 1978). Similar uncertainty applies with respect to residential use of petroleum fuels, although it is noteworthy that total Kenyan kerosine consumption increased at a faster rate between 1973 and 1980 than between 1969 and 1973. This trend may reflect substitution of kerosine for wood in cooking.

Solar energy in buildings

One impressive trend that may be important for all of Africa was the establishment of an active domestic solar hot-water industry in Kenya, represented by four firms by 1980 and more since. In 1976, there were only about 200 m^2 of installed collectors, according to figures from all companies then active; by 1980, there were nearly 3000 m^2 of installed collectors, saving about 9 TJ of fuel and electricity. This number has probably doubled since 1980.

Although the use of domestic hot water in homes and buildings in Kenya is low today, it is growing rapidly, particularly in middle-class housing. New units using solar energy have been installed in large developments as well as in upper-income rental and owned housing near the centre of Nairobi. If efficiency and conservation is imagined as consumption of fuels and electricity avoided, then solar energy represents an important future source of energy conservation in a fast-growing area of end use. Manufacturers include those assembling imported components, and those fashioning collectors out of domestically available materials.

Barriers to energy conservation

Although we observed, as a general rule, that concerted efforts to reduce energy costs were largely successful, there remain a number of barriers to improving the efficiency of energy use in Kenya (and similar developing countries). Lack of on-site expertise in improving the efficiency of existing equipment is a common problem, particularly among locally owned firms. Competent engineers are often preoccupied, indeed overworked, just keeping the plant functioning. There is also a lack of domestic sources of hardware to improve the energy efficiency of existing equipment. The necessity of importing some conservation equipment causes problems with import formalities and restrictions for those firms attempting to invest in conservation.

Inability to organize workers and management hinders conservation efforts. Several hotels experienced difficulty in training staff to manage lights, cooling, and hot-water equipment. Most firms that we visited had difficulty providing energy-consumption data that should be on hand in every manager's office. Lack of information on actual energy-use patterns makes it difficult to devise effective energy-management programs. We also encountered the belief that little could be done to reduce energy use in the firm's operations, as well as overwhelming management concern with other parts of factory operations.

A more subtle barrier to energy conservation is the protection of industrial outputs by tariffs and other means. We were told that, in some cases, profit margins may be so high as to make the gains afforded by more efficient energy use uninteresting to the individual entrepreneur, even though the sum of these gains would have a substantial positive impact on the overall balance-of-payments of the whole country. Thus, these government subsidies may be causing the private sector to underinvest in conservation.

Furthering energy conservation in developing countries

Although the potential for improved energy productivity in developing countries is considerable, the task of realizing it is probably more difficult in the LIC context than in the wealthier countries of the North. This is due both to the barriers discussed earlier and to the general lack of capital to make investments in energy efficiency. Further, in the often volatile political climate in many LICs, private decisions with respect to investment in energy efficiency may use a much higher discount rate than is appropriate from the longer-range perspective of national well being. Probably even more so than in the industrialized countries, where the market is relatively well equipped to respond to the demand for energy management products and services, there is a role for government involvement to facilitate efficient use of energy.

An oft-cited basic principle is the pricing of energy at or at least near its replacement cost. Without an accurate signal of the cost to the economy of using energy, firms and consumers are unlikely to make decisions that result in the wisest possible use of scarce resources.

For government action to be effective and targeted for the areas where it is most needed, a detailed understanding of the patterns of energy use in the economy is necessary. Once industrial energy use is better understood, the conservation problems and needs of individual factories or whole industries can be better addressed. Government authorities can play a key role in the establishment of thorough energy-use monitoring programs.

From our work in Kenya and observations from other countries, we see the following pressing needs that should be addressed by energy authorities, trade and professional societies within countries, and international donor organizations.

Training: Even in energy-intensive industries, where staff has always dealt with high energy costs, there appears to be a great need for training of both engineering and management personnel as well as assembly-line workers. This is particularly important for local firms without access to the resources of transnational corporations. We were reminded constantly of staff reluctance to employ the most modern energy-saving techniques because of a lack of personnel trained to monitor them.

Implementation: The investment needs of conservation technologies are not necessarily appreciated or understood by government and private authorities who control investment. Support for conservation investments is called for in many instances.

Evaluation: Better data on industrial energy use allows both managers and authorities to follow the progress toward more efficient energy use. With such information, better judgements about investment needs, and indeed future industrial energy needs, can be made. Individual firms should also be assisted in developing systems to keep better track of their energy use.

Import policies: Many important conservation technologies can only be imported into LICs. We found evidence that import licences may be refused, or that duties on imported equipment may be prohibitive. Although it is certainly desirable for LICs to develop their own "conservation industries," it seems advisable in the medium term to allow the importation of energy-saving equipment, whose benefits will be felt immediately.

Energy conservation is not a substitute for prudent development of local energy resources, but it can significantly reduce energy costs in the long run as well as provide some near-term relief to energy-related foreign exchange problems. The World Bank and other organizations have called for massive energy-related aid to low-income developing nations. We feel that serious consideration should be given to aid that enhances the efficiency of energy use. At present, it is institutionally easier to give or finance large energy-producing facilities with capital provided by donors or other lenders. Given the scarcity of such capital, however, it seems prudent to demand that contributions to LIC energy needs bring the greatest return possible. In contrast to most energy-supply schemes, investments in energy efficiency have a diffused but relatively rapid impact, and thus can be instrumental in helping financially struggling developing countries through the present hard times. A long-range energy-conservation program could considerably reduce the energy costs of development, and provide energy savings that will probably be less expensive than many of the energy-supply alternatives.

LONG-TERM EFFECTS OF OIL PRICE FLUCTUATIONS ON DEVELOPING COUNTRIES WITH SPECIAL REFERENCE TO ASIAN COUNTRIES

Yoshio Hara*

Major Economic Impacts on Developing Countries Produced by Rising Oil Prices

Energy supply and demand in developing countries in the 1970s

In the 1970s, energy consumption in Asian developing countries generally had grown sharply despite major oil price increases. The primary factor was simply the substantial expansion of their economies. For instance, in terms of gross national product (GNP) growth rate per capita between 1960 and 1977, Thailand, South Korea, Malaysia, Taiwan, Hong Kong, and Singapore had annual average growth rates of 3.6%, which exceeded the average for the middle-income countries of the world. The growth rates in Indonesia and the Philippines were 3.3% and 2.5%, respectively, which also outpaced the average for low-income countries, 1.4%. Taking these two countries as an example, it also is worth reviewing gross domestic product (GDP) growth rates in the 1960s and the 1970s. In Indonesia, the GDP growth rate, which had stayed at 3.5% per year in the 1960s, grew sharply in the 1970s reaching an average of 7.7%. In the Philippines, the rate also grew, from 5.1% in the 1960s to 6.4% in the 1970s.

Also, in terms of gross domestic investment, Indonesia, the Philippines, South Korea, and Malaysia had high growth rates, exceeding 10% per year, while Taiwan and Hong Kong also showed fairly strong growth rates, nearing 10% per year. Thus, economic development associated with sharply growing investment in the 1970s caused energy consumption to rise in Asian countries (Table 1).

As a result, taking Thailand and the Philippines as an example, their energy elasticities to GNP or GDP were 1.72 and 1.34, respectively, between 1961 and 1978 (Table 2). Limiting the period to the 1960s, the values were as high as 2.37 and 2.00, respectively. This means that their energy consumption grew at twice the speed of their economic output. Between 1970 and 1978, however, their energy elasticities declined sharply due to effects of the oil crisis.

To review the relationship between economic growth and energy consumption from a different aspect, it is useful to compare commercial-energy consumption

Table 1. Percentage growth of energy consumption

	1961-70	1970-78	1961-78
Indonesia	0.0	15.0	6.8
Thailand	19.9	7.0	13.6
Philippines	10.1	5.2	7.7
South Korea	14.7	9.0	12.0
Malaysia	10.1	8.1	9.1
Taiwan	9.9	11.9	10.8
Hong Kong	10.6	8.4	9.5
Singapore	5.0	16.6	10.3
New Zealand	4.8	4.6	4.7
Australia	5.9	4.3	5.1

Sources: United Nations (1972, 1974, 1977, 1979b).

*Chief Economist, The Institute of Energy Economics, No. 10 Mori Building, 18-1 Toranomon 1-chome, Minato-ku Tokyo 105, Japan.

Table 2. Energy elasticity in nine Pacific countries, 1961-78[a]

Country	Basis	1961-78	1961-69	1970-78	1970-73	1974-78
		Nonenergy-exporting countries				
Middle income						
Thailand	GDP	1.72	2.37	0.75	1.12	1.02
Philippines	GNP	1.34	2.00	0.73	0.89	0.99
South Korea	GDP	1.16	1.37	0.90	0.83	0.89
Taiwan	GDP	1.15	1.11	1.33	1.97	1.63
Singapore	GDP	1.25	0.32	1.48	2.58	1.23
Industrialized						
New Zealand	GDP	1.36[b]	1.19	1.42[c]	1.62	1.92[d]
		Energy-exporting countries				
Low income						
Indonesia	GDP	1.24[e]	0.06	1.84[f]	1.05	3.79[g]
Middle income						
Malaysia	GDP	-	-	1.19	1.60	0.66
Industrialized						
Australia	GDP	1.09	1.09	1.38	1.10	1.39

Sources: Energy consumption data -- United Nations (1972, 1974, 1977, 1979b); CEPD (1979). GDP data -- IMF (1979).

[a] For hydroelectric, nuclear, and imported electric power, 1 kW.h = 2.45 kcal; GDP and GNP values are as of 1975.

[b-g] b: 1970-77, c: 1960-76, d: 1974-76, e: 1960-77, f: 1974-77, and g: 1970-76.

per unit of GDP among individual countries between 1961 and 1978 (Fig. 1). The comparison produces several features of individual countries depending on stages of their economic development. As of 1961, Thailand consumed commercial energy of 0.35 kg coal equivalent (kg-ce) per US$1 of GDP: this increased to more than 1 kg-ce in 1971. Likewise, commercial energy consumption in the Philippines, which stood at 0.63 kg-ce in 1961, exceeded 1 kg-ce in 1971-72. After the 1973 oil crisis, however, commercial energy consumption turned downward in both countries. By contrast, South Korea and Taiwan have shown high growth in their commercial energy consumption throughout the 1960s and the 1970s (Table 1), although consumption levels sharply fluctuated year by year. In such advanced countries as Australia and New Zealand, trends of energy consumption per unit of GDP have been very stable (Fig. 1) due to the absence of drastic changes in their economic and industrial structures.

Energy consumption in developing countries includes a large portion of noncommercial energy, such as firewood, charcoal, straw, bagasse, coconut shells, and animal wastes. Even today, many countries in such areas as Southeast Asia (excluding members of the Association of South East Asian Nations (ASEAN)), Southwest Asia, and the South Pacific cover more than 60% of their total energy requirements with noncommercial energy. However, in the ASEAN countries, which are making remarkable progress in economic development, the ratios of noncommercial energy to total energy requirements diminished notably between 1973 and 1978. During this period, the most dramatic decline in the ratio was in Indonesia, from 60% to 40%, followed by the Philippines from 29% to 28%, Thailand 25% to 21%, and Malaysia 15% to 13%.

Consequently, the importance of commercial energy has been growing in these countries since the second half of the 1960s. Simultaneously, dependence

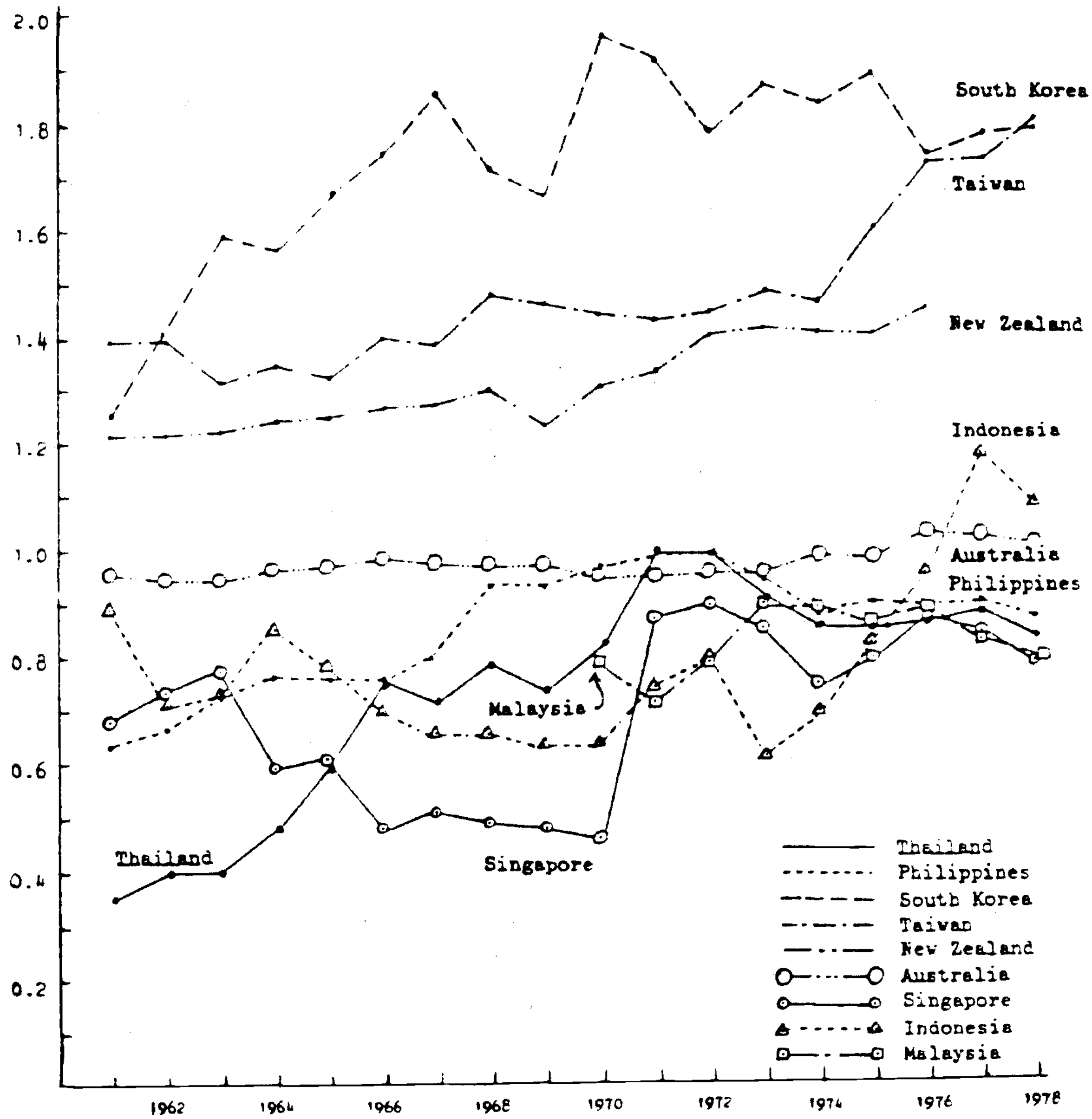

Fig. 1. Energy consumption per unit of GDP (coal-equivalent kilograms per US dollar).

on oil has grown sharply. Taking developing countries in East Asia as an example, the average ratio of oil to total commercial energy consumption, which was as low as 33% in 1960, grew to 49% in 1970 and reached 56% in 1973. Particularly noteworthy is the fact that oil dependence further increased to 58% in 1978 even after the oil crisis.

In addition, in most developing countries, excluding those with such domestic resources as coal, hydroelectric potential, and natural gas, oil dependence to cover their commercial energy needs reached nearly 80-100% during the period from the 1960s to the early 1970s.

Progress in industrialization and energy supply and demand

As indicated by Japan's history of economic growth, it is obvious that progress in industrialization contributes much to the expansion of energy consumption. Between 1960 and 1977, when developing countries made rapid progress in industrialization, the importance of industries and manufacturing industries to GDP grew by more than 10% in the so-called newly industrialized countries (NICs), including South Korea, Taiwan, and Singapore. In contrast, in such advanced industrial countries as Japan and Australia, the importance of industries and manufacturing industries has been declining, whereas that of the service sector has been increasing.

Figure 2 shows the relationship of two major light industries (food/agriculture and textile/clothing) to all manufacturing industries in individual countries. The proportion, declining in parallel with progress in industrialization, is less than 50% in South Korea, Singapore, and Malaysia. By comparison, in 1977, the ratios of industrial energy consumption to total energy consumption were 49% in South Korea, 64% in Taiwan, and 31% in Malaysia. Comparing 1970 and 1977, the ratios of industrial to total energy consumption increased by 13.7% in the Philippines, 9.5% in South Korea, and 3.4% in Indonesia.

To give a clearer picture of the relationship between progress in industrialization and energy consumption, I use energy consumption per worker in manufacturing industries by country (Table 3). In 1975, energy consumption per worker was 6-7 tons coal equivalent (t-ce) in Indonesia, Malaysia, and Taiwan, 10-12 t-ce in South Korea, Singapore, and New Zealand, and 24 t-ce in Australia. In short, the ratio between the lowest and the highest energy consumption per worker stayed at 1:3.

Effect of soaring oil prices on the economies of developing countries

As discussed so far, during the period from the 1960s to the early 1970s, the energy-consumption pattern in developing countries was characterized by apparently heavier oil dependence. Even the oil crisis in 1973 could not discourage this underlying trend of increasing oil dependence.

For instance, comparing 1969 and 1978, oil dependence increased sharply from 65.1% to 84.4% in Indonesia, from 46.5% to 61.1% in South Korea, and from 54.7% to 75.8% in Taiwan. On the other hand, three countries -- Thailand, the Philippines, and Malaysia -- showed slight declines in their oil dependence during the same period: from 96.5% to 94.7%, from 97.0% to 94.2%, and from 95.9% to 88.1%, respectively. However, the growth of their oil consumption remained high, so that the energy structure continued to depend heavily on oil.

Such being the situation, the oil crisis in 1973 produced serious impacts on the balance of payments of these countries. Table 4 contains indices of fuel imports by energy-importing countries. These indices were obtained by multiplying the index of fuel prices by the index of imported fuel amounts based on indices of fuel imports in value and in volume (index of fuel imports = index of fuel prices x index of imported fuel amounts). South Korea had the highest import indices because it increased its imports during the 1973-78 period despite soaring energy prices. In contrast, New Zealand showed the lowest indices because of gradual declines in its energy imports during the same period. However, the majority of developing countries showed greater or lesser increases in their energy imports between 1973 and 1978. As shown in Table 5, with the exception of such oil-producing countries as Indonesia and Malaysia, ratios of oil imports to value of total imports have grown sharply in individual developing countries, which intensified the pressure on their balance of payments.

For example, Thai deficits in energy trade, which had been growing year by year since 1973, were offset to some extent by favourable exports up to 1974. In 1975 and afterwards, however, the country recorded deficits in the current

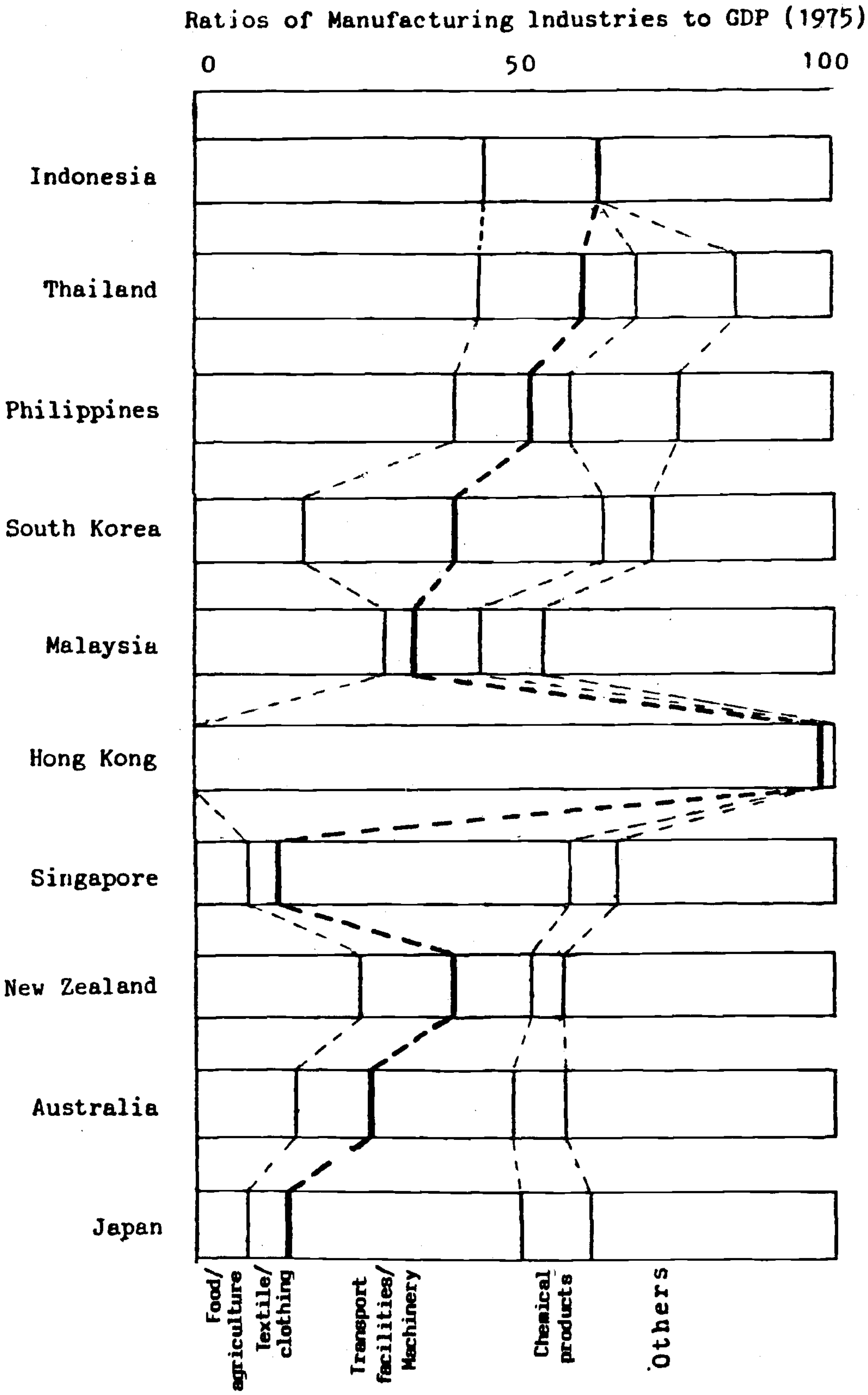

Fig. 2. Industrial structures by country 1975. (Source: World Bank 1979. Note: Food/agriculture, ISIC 311, 313-314; Textile/clothing, ISIC 321-324; Transport facilities/machinery, ISIC 382-384; Chemical products, ISIC 351-352.)

Table 3. Energy consumption per industrial worker

	Energy consumption per worker					Value added per worker in manufacturing (mid-1970 US$/person) (B)		Value added productivity of energy (US$/t-ce) (B/A)	
	Industrial			Manufacturing (t-ce) (A)					
	Yearly average (kg-ce/person)		Annual growth rate (%)						
	1970	1977	1970-77	1970	1975	1970	1975	1970	1975
Indonesia[a]	25	55	11.9	3.4	7.5	983	1960	290	261
Thailand	290	442	6.2	6.3	-	3590	-	569	630
Philippines	-	175	-	-	12.2[b]	3834	4150[c]	-	340
South Korea	262	498	9.6	9.9	10.8	1674	2384	169	221
Malaysia	149	197	4.1	8.7	6.1[d]	3056	-	351	480
Taiwan	597	1032	8.1	7.5	7.0	-	-	210	260
Singapore	-	940	-	-	10.9	3102	3284	-	301
New Zealand	944	1161	3.0	11.4	11.7	-	-	-	-
Australia	2007	2218	1.4	19.4	23.6	6562	-	338	-

Sources: World Bank (1979); United Nations (1976, 1978, 1979a).

[a] The 1970 figures for Indonesia are based on the number of workers in manufacturing companies with more than 10 employees or which introduced machines, whereas the 1975 figures are based on the number of workers in manufacturing companies with more than 20 employees.

[b] 1975 data on energy and 1974 data on labour force.

[c] 1974 data on labour force.

[d] 1974 data.

Table 4. Indices of energy imports (payment, prices, and volume[a])

		1973	1974	1975	1976	1977	1978
Thailand	Import payment	100	268	334	357	437	482
	Import price	100	278	325	436	378	410
	Imported volume	100	96	103	82	117	118
Philippines	Import payment	100	301	346	401	447	472
	Import price	100	307	338	356	377	397
	Imported volume	100	98	102	113	119	119
South Korea	Import payment	100	337	444	559	697	769
	Import price	100	303	386	425	452	433
	Imported volume	100	111	115	132	154	178
Hong Kong	Import payment	100	271	280	359	419	435
	Import price	100	266	294	289	337	325
	Imported volume	100	102	96	124	24	134
Singapore	Import payment	100	305	305	379	408	475
	Import price	100	319	380	392	418	475
	Imported volume	100	96	80	97	98	100
New Zealand	Import payment	100	273	289	307	325	298
	Import price	100	250	277	327	338	332
	Imported volume	100	109	104	94	96	90

Sources: Import payment and prices -- table 3-2-1; Imported volume -- ESCAP (1974).

[a] Volumes are in terms of coal equivalent.

account balance as serious as deficits in the balance of payments. In contrast, NICs, such as South Korea and Taiwan, have improved their balance of current account since 1974 despite growing deficits in energy trade. This was because expanding exports of industrial products allowed NICs to absorb increases in energy prices.

This can be better explained by indices of energy-import prices and indices of export prices among energy-importing countries. That is, while terms of trade have been rather worsening since 1974 for Thailand and the Philippines, the terms for such NICs as Hong Kong bottomed out in 1975-76 and started to improve.

Changes in terms of trade by country can be summarized as follows:

- In the case of nonoil-producing developing countries, such as the Philippines, three changes are noted. They are, first, in addition to growing oil-import bills, import prices of foods and others have increased sharply; second, inflation in advanced countries caused import prices of industrial products to rise; and third, business recessions in advanced countries resulted in a slowdown in the growth of export prices of primary products.

- For NICs, the case of South Korea shows, first, despite sharper increases in energy-import prices than experienced in Thailand and the Philippines and temporary deteriorations in terms of energy trade in 1974 and 1975, which were as serious as experienced by the other two countries, product export prices, backed by competent industrial capability, started to increase favourably after 1975; second, from the aspect of trade structure, the ratio

Table 5. Ratios of oil imports to total exports in developing Asian and Pacific countries during the 1973-79 period (Ratios of oil import bills to total exports in value)

	1973	1974	1975	1976	1977	1978	1979	Average 1975-78
Afganistan	6.3	4.8	10.1	9.3	11.8	12.5	16.0	10.9
Bangladesh	6.8	20.7	25.1	30.1	45.5	32.3	22.5	33.3
Burma	4.0	0.3	5.2	5.4	1.4	-	-	-
Fiji	21.0	27.9	27.1	31.2	33.0	28.2	33.8	29.9
Hong Kong	2.9	6.9	6.9	6.2	6.5	5.6	6.4	6.3
India	9.0	17.6	31.1	24.6	25.4	28.5	29.3	27.5
Indonesia	1.4	2.5	3.6	5.1	6.7	5.0	6.0[a]	5.1
Kiribati	4.7	2.4	3.3	7.7	11.5	7.1	-	7.4
Malaysia	5.3	9.8	11.1	9.7	9.2	8.6	9.5	9.7
Nepal	21.1	20.6	16.7	17.2	24.6	22.7	20.4	20.3
Pakistan	6.8	13.7	32.0	32.4	35.1	33.3	33.5	33.2
Papua New Guinea	3.7	6.4	11.9	10.2	-	-	-	-
Philippines	10.3	24.1	33.6	34.6	31.5	30.1	28.8[a]	32.5
South Korea	9.2	22.9	26.4	21.5	20.6	18.2	20.0[a]	21.7
Samoa	12.9	6.2	42.9	30.0	27.7	35.5	-	34.0
Singapore	18.0	34.5	37.1	37.7	32.4	30.7	31.2[b]	34.5
Solomon Islands	8.6	8.8	18.7	13.8	11.8	11.7	5.9	14.0
Sri Lanka	11.2	25.8	21.9	24.1	20.9	18.2	26.6	21.3
Thailand	14.5	25.2	31.4	27.5	29.3	27.5	28.0	28.9
Tonga	14.0	12.9	15.7	45.0	28.6	43.3	41.4	33.2

Source: ADB (1980).

[a] Based on the achievement during the first 11 months.

[b] Based on the achievement during the first 6 months.

of energy imports to total imports was relatively limited, which alleviated worsening terms of trade; and third, the country was able to increase exports of light industrial products, etc. primarily to members of the Organization of Petroleum Exporting Countries (OPEC).

Thus, large differences are now surfacing between nonoil-producing developing countries and NICs in their deficits in current-account balance after the oil crisis. Deficits in current-account balance can be offset to some extent by such means as official transfer, drawdown in foreign-currency reserves, and direct investment by foreign capital. Current-account deficits remaining even after these measures are taken should be financed by overseas borrowing. It is noted that the amounts of overseas borrowing required by energy-importing developing countries, rose sharply first in 1974 but continue to grow year by year.

Under such circumstances, governments have been covering growing needs for borrowing since the oil crisis by positive introduction of official funds from external sources as well as from private funds. Such countries as South Korea, Indonesia, and Malaysia, where export prices increased after the oil crisis, have been particularly positive toward introduction of private funds partly in anticipation of erosion of accumulated borrowing by inflation. However, needless to say, these borrowed funds should be reimbursed. Apart from a vicious cycle of additional borrowing to pay interest resulting from growing debts, the second oil crisis produced serious impacts on the economies of many developing countries, which are now standing in crucial positions.

Effects on Economies of Developing Countries Produced by Declining Oil Prices

Economies of developing countries after the second oil crisis

Despite the aftereffects of the first oil crisis, the world economy maintained a relatively high annual average growth rate of slightly more than 4% in the 1970s. However, stagnation in the world economy was rapidly intensified after the second oil crisis in 1979. It is thought that the world economy in 1982 resulted in a zero growth. Reflecting the economic trend, the growth of the world trade, which slowed from 6.0% in 1979 to 1.5% in 1980, declined to 0% in 1981 and further to a negative value in 1982. Moreover, in nominal terms of value basis, the world trade showed negative growth for two consecutive years, thus falling into an unprecedentedly worsening situation.

The synchronized recessions worldwide and the diminishing world trade directly hit the economies of developing countries and intensified debt crises that they had been facing since the first oil crisis.

As already mentioned, although developing countries had been taking positive stances toward economic-growth policies since the first oil crisis, many of them are now in difficult financial situations characterized by accumulated foreign debts needed to cover growing development investment and by deficits in current account balance. According to a survey conducted by the Development Aids Council (DAC) of the Organization for Economic Cooperation and Development (OECD), outstanding medium- and long-term debts among developing countries amounted to $626 billion as of the end of 1982. With short-term debts included, total debts reached $863 billion (Table 6). Furthermore, including debts liable to the USSR and East European countries, outstanding foreign debts in the world are estimated to exceed $1000 billion. This amount is equivalent to 8% of GNP in the world and 11% of that among advanced countries. Also, principal and interest reimbursed in 1982 totaled a huge $346 billion, while the debt-service ratio stayed at an unbelievable figure of 60%.

Taking the Philippines and Thailand as an example of nonoil-producing developing countries in Asia, outstanding official foreign debts liable to these countries rose 3.2 times and 3.9 times, respectively, in only 3 years, from $5.1 billion and $2.8 billion in 1979 to $16.6 billion and $11.0 billion at the end of 1982.

Here, it is worth reviewing trends of economic activities in these countries during the 1980-82 period. In 1980, oil imports as a percentage of total imports in the Philippines grew sharply to 30.4% from 24.2% in the previous year due to increases of as much as 65.3% in the oil prices of OPEC. As a result, oil-import bills also rose from $1.6 billion in 1979 to $2.5 billion in 1980. However, in the same year, the Philippine economy achieved a real economic growth rate of 5.4%, which was only slightly lower than the 6% growth of 1979. The reason for the slight decline was that exports of the country's major exports (such primary products as sugar, coconuts, and copper) increased (25.7% over the previous year) nearly offsetting an increase in imports of which oil was the centrepiece (26.2% increase over the previous year). However, real economic growth rates deteriorated sharply in 1981 and 1982 to 4.8% and 2.6%, respectively.

It is thought that poor market conditions for primary products, resulting from the stagnation in the world economy, contributed much to the sharp declines. Figure 3 shows the trends of price indices of major primary products in Asia; most indices turned sharply downward in 1980. In fact, the Philippines sugar and copper exports declined in value in 1981 by 114% and 22%, respectively, from the previous year. On the other hand, OPEC's crude oil prices rose in 1981 by 11.6% over the previous year, but finally declined by 3% in early 1982 due to sluggish oil demand. However, accounting for inflation during the period, crude-oil prices in real terms declined by 1% in 1981 and 8.6% in 1982 from the previous years. Reflecting the downward trend in crude-oil prices, the ratio of oil imports to total imports dropped to 25.6% in 1981 from 30.4% the previous year. Also, the ratio of oil imports to total trade deficits decreased from 135% in 1980 to 87.6% in 1981.

Table 6. Total foreign debts (in $1 billion, or %) of developing countries

	1979	1980	1981	1982
Outstanding medium- or long-term debts	406	465	530	626
Non-OPEC	332	385	445	520
OPEC	74	80	85	106
Official	146	166	188	218
Private	260	299	342	408
Short-term debts or official military debts	133	165	230	237
Total foreign debts	539	630	760	863
Principal reimbursed	118	147	185	255
Medium- and long-term debts	50	50	61	71
Others	68	97	124	184
Interest reimbursed	38	56	80	91
Medium- and long-term debts	26	37	49	60
Others	12	19	32	31
Principal and interest reimbursed	156	203	265	346
Debt service ratio (DSR)	34.8	34.2	45.6	59.6
DSR (excluding short-term principal)	20.7	18.7	25.3	29.2
Ratio of foreign debts to:				
The world's GNP	4.9	5.2	6.6	7.0
GNP of advanced countries	7.8	8.2	10.8	11.5
GNP of developing countries	32.9	35.8	40.0	45.4

Note: Prepared from statistics issued by the DAC, OECD, CIA's reports (some estimates included), etc. The debt service ratio was calculated by excluding service exports.

For Thailand, the real economic growth rate in 1980 was 5.8%, slightly lower than 6.1% in 1979. Although the rate rose as high as 7.6% in 1981, it declined again in 1982 to 4.5%. The trend of economic growth rates in Thailand is quite different from other ASEAN countries, where economic growth rates have declined steadily since 1980. Primary factors behind the unusual trends were that the ratio of agricultural production to GDP, which is usually around 25%, increased in 1981 by 7.5% over the previous year, and the ratio of the farm-product processing industry to GDP, which is usually about 21%, also increased in 1981 by 10.2% over the previous year. The economic growth rate again turned downward in 1982 due to such factors as the sluggish activity in the agricultural sector (a decline of 1.2% from the previous year) and a slowdown in private equipment investment, which was caused by sharp rises in domestic interest rates resulting from the worldwide trend of high interest.

Oil-import bills in Thailand nearly doubled from $1.6 billion in 1979 to $3 billion in 1980. As a result, the share of oil imports in total imports increased from 22.8% in 1979 to 31.4% in 1980. However, due to declining oil demand, the share of oil imports decreased slightly in 1981 to 29.9%. The country's deficits in trade balance amounted to $2.7 billion and $2.9 billion in 1980 and 1981, respectively.

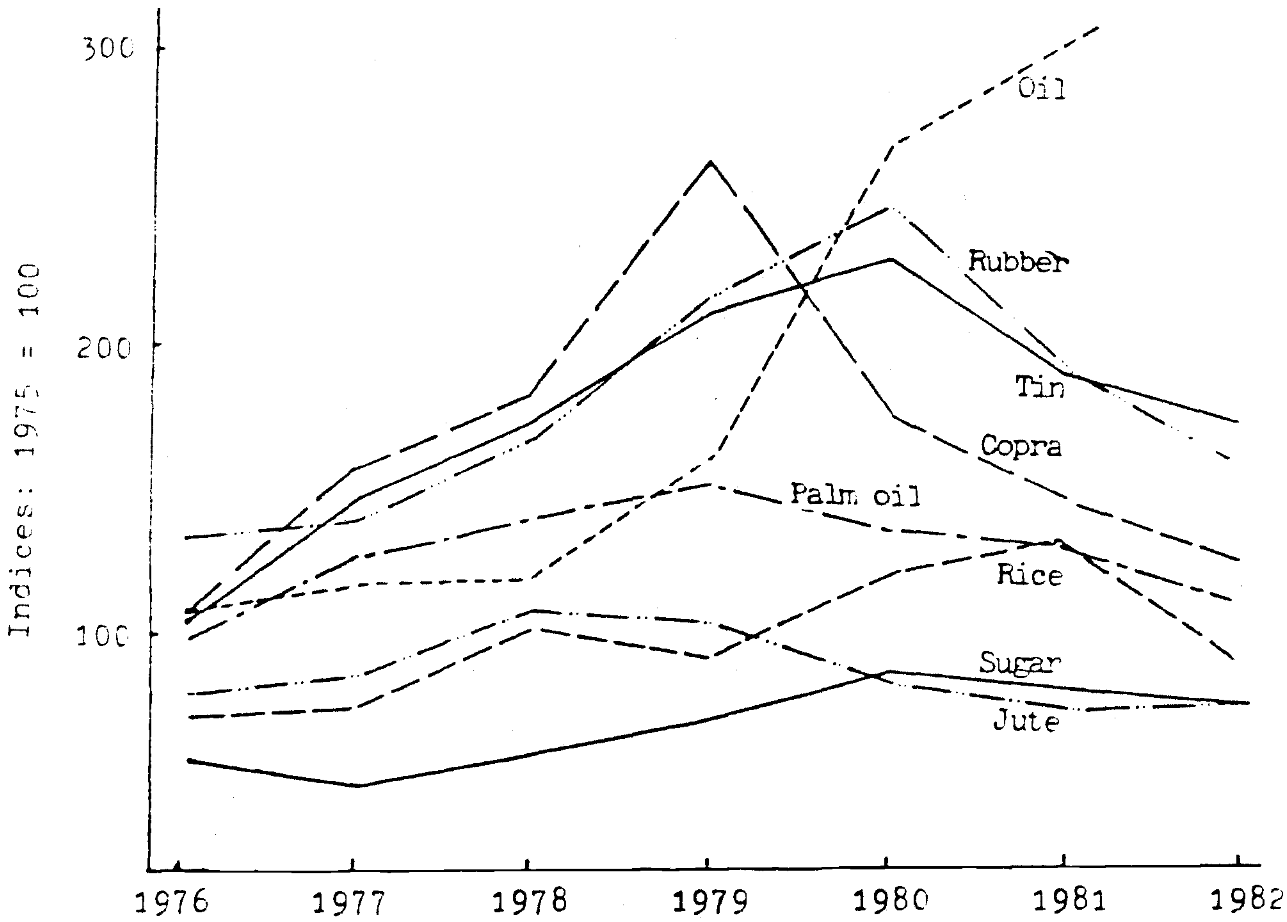

Fig. 3. Price indices of major primary products in Asia. (Sources: "Asia Trend", Institute of Asian Economic Affairs, Fareastern Economic Review.)

Based on these situations, direct and indirect effects produced by the second oil crisis on nonoil-producing developing countries can be summarized as:

- Directly affected by the sharp increases in oil prices in 1979-80, the economic growth rate was forced to drop, therefore the growing oil-import bills increased the aggravation of current-account balance.

- Since 1981, the economies of developing countries have been facing double crises due to both direct soaring oil prices and the indirect effects of the oil crisis that include considerable declines in primary product prices because of synchronized recessions in the world economy.

- Fluctuations in economic growth rates shown by individual countries during the period resulted from differences in their domestic production levels in the agricultural sector, the agriculture-related processing industry, and other industries.

- During the period, oil consumption has declined due to increasing domestic product prices, thus the share of oil in primary-energy supply decreased for two consecutive years.

Short-term impacts of declining crude-oil prices on the economies of developing countries

Unfortunately, data are not yet available that would enable us to prove the exact impact of the drop in crude-oil price decided by OPEC in March 1983. However, generally speaking, it seems certain that OPEC's recent cut in its crude-oil price can produce favourable effects on advanced countries, NICs, and nonoil-producing developing countries, although not on OPEC members. Signs of such favourable effects have already appeared. The U.S. economy finally seems to be coming out of the prolonged recession and market conditions for primary products have been showing intensified upward trends since March 1983.

Taking NICs in Asia as an example, their exports in the January-March period increased by 40% over the same period of the previous year with electronic parts, household electric appliances, and textiles as the centrepieces. At the same time, Thailand and the Philippines have also been showing higher growth of their exports, primarily in the field of primary products. Thus, the current situation implies that individual countries should record higher economic growth in 1983 than achieved in 1982. The recovery of advanced economies and resulting expansion of exports of industrial and primary products can be regarded as indirect effects produced by the cut in crude-oil price.

Needless to say, a direct effect of declining crude-oil prices is the downturn of oil import costs for individual countries. For instance, assuming that Thailand would import in 1983 the same amount of crude oil as in 1982, the country could save $400 million this year on its oil import bill, for the Philippines and South Korea, the saving would be $200 million and $700 million, respectively.

In a sharp contrast to nonoil-producing developing countries and NICs enjoying the direct favourable effect, OPEC members are now facing critical situations in their trade balance. As a result, a number of social and economic development projects, which have been promoted at a high level in oil-producing countries, will now be canceled or substantially delayed. For developing countries, these developments in oil-producing countries introduce new problems, such as reductions in their exports of building materials used in plant construction and declines in the amount of foreign currency remitted by their workers as a result of reductions in foreign labour by Middle Eastern countries. Thus, close attention must be paid to both sides of the effects produced by declining oil prices.

Another disturbing point in the short run is the problem of inflation. In many Asian countries, having suffered continuously from two-digit inflation (fueled by the second oil crisis), consumer prices finally settled in 1982. However, a return to two-digit inflation is quite probable in the course of their economic recoveries that are derived mainly by the expansion of exports.

As mentioned before, the problem of accumulated debts among developing countries has already entered an extremely serious stage. In other words, even if as a result of the recent declines in crude-oil prices the world economy could recover from the prolonged recession, the problems of financial crises and accumulated debts that confront developing countries could not be solved easily in the short run.

Declines in crude-oil prices and alternative energy development

As pointed out earlier, energy consumption in Asian developing countries, although it declined temporarily after the first oil crisis, continued to grow throughout the 1970s slightly more slowly than their GDP growth rates. However, after the second oil crisis, energy consumption, particularly oil consumption, dropped to lower than previous levels for two consecutive years in 1981 and 1982. This was because of government policies, including pricing policy, to curb consumption and because of diminishing demand resulting from recessions.

Finally, we cannot neglect the favourable effects of alternative energy policies taken by individual governments in parallel with energy conservation policies. An excellent example is the successful geothermal energy development in the Philippines. Since early 1977, when the first geothermal power plant of 3 MW was constructed in Tongonam, the country has expanded its geothermal power generation capacity so that it now exceeds 600 MW. Also, in Thailand, natural gas supplies initiated in 1981 now contribute to lowering its domestic oil consumption.

Alternative energy developments expected to be in progress in the coming years include hydroelectric power in Malaysia, coal and brown coal in Indonesia, and lignite in Thailand. Geothermal development projects planned by Indonesia and Thailand are also promising. Furthermore, Thailand and Malaysia are now considering industrial development plans to make the best use of their abundant natural-gas resources and Indonesia is also planning for a similar policy. The Malaysian plan includes production of methanol, urea, and sponge iron from natural gas and installations of new thermal power plants. Thus, it is probable that these countries will establish their own natural gas-based steel and chemical industries in the future.

These moves imply a drastic change in their attitudes from the conventional concept of exporting oil and natural gas to advanced countries as energy resources without first doing any processing. In other words, these countries have a new concept of establishing industries that produce industrial materials through effective utilization of their domestic energy resources, thus promoting both production and exports of industrial products that they had been importing previously.

Then, the problem is how recent declines in crude-oil prices will affect these moves toward alternative energy development in developing countries. To start with a conclusion, it is believed that these moves, in principle, can be further promoted in the coming years, although slight delays may be caused by the effects of declining crude-oil prices.

The reasons for the conclusion are:

- Potential energy demand in developing countries is quite strong and an upturn of energy demand will be inevitable in the course of their economic recoveries. In the long run, growing energy demand also seems to be inevitable due to such factors as population growth and expansion of their economies.

- Alternative energy development that developing countries are now promoting involves without exception conventional types of energy that are naturally competitive with imported oil to some extent.

- On the other hand, the development of new energies (solar power generation, petroleum liquefaction, etc.) carried out by advanced countries can be more seriously affected by declining oil prices, because they require huge development costs and are still at the development stage in technological terms.

- Alternative energy development in developing countries has been conducted in a direct link with their domestic industrial-development plans. It is expected that developing countries will increasingly steer their efforts in this direction in the coming years.

If any factors can cause delays in alternative energy development in developing countries, one will be the problems of current-account deficits and accumulated debts, which are likely to remain unsolved for some time and can impede the raising of required development funds.

Long-term Impacts of Oil Price Fluctuations on Developing Countries

Long-term outlook for oil prices

It is nearly impossible right now to predict the long-term trends of crude-oil price, which was officially reduced by the OPEC for the first time in March. However, considering factors that can affect oil-price levels in the future, the trend of oil demand is likely to play a much more important role than in the past as a determining factor unless a sudden accident temporarily causes drastic changes in the supply-demand relations. This means that oil will be dealt with in the market as an economic good just like other primary products. Thus the supply-demand relations will demonstrate a stronger influence than in the past in determining the price. Then, one of the two most critical factors that can determine oil-demand levels in the future is the growth of the world economy, the other is the levels of alternative energies, such as nuclear power, coal, and natural gas. In other words, future trends or levels of crude-oil prices will be based on the supply-demand relations that basically reflect these factors at any one time. It should be noted, however, that crude-oil prices will not always represent fair price levels for either the supply or the demand sides. For instance, a very sharp increase in crude-oil prices resulting from tight supply-demand relations, although temporarily and greatly benefiting the supply side, should lead to diminishing demand that, in turn, causes the price level to turn downward again. An excellent example of this case is recent declines in crude-oil prices.

Table 7 shows the long-term fair levels of crude-oil prices, which were calculated on the basis of an assumption that crude oil is one of the economic goods required to develop economic activities. It indicates the fair levels of crude-oil prices relative to the economic power of advanced countries that hold significant shares

Table 7. Fair crude-oil prices to major countries

	Japan	USA	United Kingdom	West Germany	France	Italy
Price index						
1972	63.8	68.1	62.1	79.0	71.6	55.9
1982	135.2	171.9	248.8	139.5	184.5	302.2
Ratio 1982/1972 (A)	2.119	2.524	4.006	1.766	2.577	5.406
Exchange rate[a]						
1972	303.11	-	2501.8	3188.6	5044.3	583.22
1982	242.52	-	1619.3	2418.5	6857.3	1397.7
Ratio 1982/1972 (B)	0.8	-	0.647	0.758	1.359	2.397
GNP						
1972	134.115	1489.1	98.75	1000.5	1332.5	116.489
1982	204.182	1851.2	108.84	1199.4	1743.6	151.936
Ratio 1982/1972 (C)	1.522	1.243	1.102	1.199	1.309	1.304
Fair price[b]	40.31	31.37	28.56	27.93	24.82	29.41

Source: IMF, International financial statistics.

[a] Local currency per US$.

[b] Calculated (in $) as (10xAxC)/B taking $10/barrel as the 1972 price.)

in crude-oil trade. To calculate the levels, three explanatory variables were used: inflation rates, exchange rates to US dollars, and GNP growth rates. Accordingly, if West European countries, whose economic power is relatively weaker among advanced countries, are taken as the standard, a fair level of crude-oil prices is around $28 per barrel at present.

On the other hand, to apply the same concept for developing countries requires adjustments of exchange rates, because many developing countries set the rates at levels dissociated from reality. Taking this point into account, a tentative calculation showed that a fair crude-oil price level to developing countries is around $25/barrel. Needless to say, these tentative calculations provide only a reference point. At any rate, it seems that fair crude-oil price levels in the long run will be formed by reflecting supply-demand situations as well as economic power (crude oil-purchasing power) of individual consuming countries including developing countries.

Long-term oil supply and demand outlook for developing countries

To quantitatively forecast the world energy supply and demand in the long run is as difficult as to predict oil-price trends. According to such a forecast announced by the International Energy Agency (IEA) last fall, oil consumption in OECD countries will continue to decline until the year 2000 (low-demand case, Table 8). This is because the growth rate of energy demand as a whole is expected to slow down and because the importance of nonoil alternative energies (nuclear power, natural gas, and coal) is likely to further increase. On the other hand, the IEA predicts that energy consumption, particularly oil demand, in non-OPEC developing countries will rise rapidly in the coming years. As a result, the IEA's forecast concludes that the world demand for OPEC oil will not diminish in the 1990s or afterwards. Of course, no one can guarantee that actual situations will develop exactly as predicted by the IEA. However, these forecasts are generally made based on three basic estimates: first, the growth rate of the world economy; second, growth rate of primary energy demand; and third, the rate at which alternative energies are introduced. Therefore, judging from achievements in the past, the economies of developing countries are expected to expand by achieving higher growth rates than those of advanced countries, if the world economy, supported by the recent crude-oil price cut, continues to recover at a relatively favourable pace.

It is also expected that energy demand in developing countries will continue to grow faster than their economic growth, on the average, due to such factors as progress in urbanization, promotion of the policy of industrialization, modernization of agriculture, and population growth.

Conclusions

Compared with oil-producing and oil-consuming countries, developing countries have least room for exerting influences on oil supply-demand and price trends. However, once sharp fluctuations in oil prices occur, it is developing countries that are most seriously affected. This was proved by the two oil crises in the past. So long as no one can guarantee that an unexpected fluctuation (an increase) in oil prices will never occur in the coming years, developing countries must make continuous efforts to reduce their oil dependence through such political measures as alternative energy development and energy conservation.

Alternative energy development in individual developing countries, which has been encouraged from their experiences of the two oil crises, is now producing fruitful results. As mentioned before, the Philippines and Thailand are

Table 8. Energy demand in OECD countries and world oil supply and demand in million barrels per day[ab]

	1980	1985	1990	2000
OECD				
Total primary energy demand	79.1	81-82	89-93	105-121
Nonoil energy demand	40.4	46	55-56	72-78
Oil demand	38.7	35-36	34-37	33-43
Demand for imported oil	24.2	21	20-24	18-30
World oil demand				
OECD	38.7	35-36	34-37	33-43
OPEC	2.9	4	5-6	8-9
Non-OPEC developing countries[c]	7.9	9-10	11-13	17-22
Total	49.5	48-50	50-56	58-74
World oil supply				
OECD	14.8	15	14-13	15-13
OPEC	27.5	23-26	27-29	24-28
Non-OPEC developing countries	5.3	8-9	8-11	9-13
Net exports (net imports) by communist countries[f]	1.3	1-(1)	0-(2)	0-(2)
Increases resulting from refining[g]	0.6	0.6	0.6	0.6
Total	49.5	48-50	50-52	49-53
Excess demand	-	-	0-4	9-21

[a] The lower figures are based on the oil price increases/low economic growth scenario.

[b] Rate of conversion: Million barrels/day = 48.2 million tonnes oil-equivalent, or 1 tonne oil-equivalent = 7.57 barrels.

[c] Non-OPEC developing countries (including South Africa and Israel).

[d] Including synthetic fuel oil.

[e] Forecasts for OPEC are based on "possible" output, which is estimated on not only confirmed reserves but expected additional reserves. The forecast for 1985 reflects lower demand. For 1990 and 2000, output in capital-surplus oil-producing countries, such as Saudi Arabia, Kuwait, and Abu Dhabi, is predicted to be lower than technically available output.

[f] Communist countries: COMECON countries in and outside Europe and includes China, North Korea, Laos, Cambodia, Yugoslavia, and Albania.

[g] Increases in terms of volume obtained in the refining process (which are not increases in terms of weight).

typical countries making remarkable progress in this field, the former in geothermal development and the latter in the development of natural gas and lignite. As a result, the weight of imported oil in primary energy supply and demand is expected to decline sharply in both countries. Then, even if oil prices fluctuate suddenly in the future, the resulting impact on these countries will be much less significant than in the past. Reflecting recent declines in oil prices, people around the world, including advanced countries, are calling for a review on alternative energy development from the economic aspect. However, so long as there is no guarantee that sharp increases in oil prices will never occur in the coming years, alternative energy development must continue.

Meanwhile, improved efficiency of energy use is the only measure that will enable developing countries without any energy resources to deal with increases in oil prices. However, although developing countries have followed this course as a political policy during the past decade, little progress has been made in producing tangible effects. In this light, developing countries must, in the coming years, increase their efforts for improving efficiency of energy consumption by such measures as introduction of facilities of appropriate scale when they plan to carry out new development projects.

From these viewpoints, developing countries are now certainly coming to be able to cope with fluctuations (increases) in oil prices to some extent, although they are still highly vulnerable to oil-price fluctuations.

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