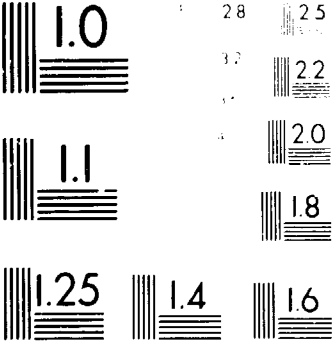


MICROCOPY RESOLUTION TEST CHART

13256

Distr.
LIMITED

UNIDO/IS.435
19 January 1984

ENGLISH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

REGIONAL ENERGY IMPLICATIONS OF THE LIMA TARGET: A TENTATIVE QUANTITATIVE ASSESSMENT*

prepared by

Global and Conceptual Studies Branch
Division for Industrial Studies

* This document has been reproduced without formal editing.

V.84-80608

TABLE OF CONTENTS

I. Introduction and Main Conclusions

The Second General Conference of UNIDO held at Lima, Peru in 1975 culminated in the Lima Declaration and Plan of Action which called for "increasing industrial production in the developing countries to the maximum possible extent and as far as possible to at least 25 per cent of total world industrial production by the year 2000".[1/]

The attainment of the target calls for, inter alia, fundamental structural changes in production and international trade, both for developing countries (DGs) and developed countries (DDs). The target has also important implications for other sectoral and development issues - agriculture, energy, transport, employment, basic needs and transfer of financial resources and technology to DGs. The purpose of this paper is to analyze quantitatively energy implications of attaining the Lima target.

The scope of the study goes beyond an aggregate assessment of energy requirements for the attainment of the Lima target for the developing countries as a whole. The study disaggregates the total energy requirements implied by the Lima target into four regional components based on a regional share scheme of the 25 per cent total which was worked out by the UNIDO Secretariat, reconciling regional targets agreed on at regional conferences held prior to the Second General Conference of UNIDO.[2/] Furthermore, with an independently estimated energy supply of each region, the study attempts to estimate possible energy gaps, i.e., production-consumption imbalance implied by the Lima target,

---

1/ See paragraph 28, UNIDO, Lima Declaration and Plan of Action on Industrial Development and Cooperation, ID/Conf.3/31, Chapter IV.

2/ Decisions taken at the Meeting of Ministers of Industry of Developing Countries in Asia and the Pacific Region, held at Bangkok on 30 October 1974, at the Latin American Conference on Industrialization, held at Mexico from 25 to 29 November 1974 and at the first meeting of the Follow-up Committee on Industrialization in Africa, held at Addis Ababa, September 1974. The reconciliation was required because the target share agreed on for the ESCAP Region of 10 per cent did not include the Middle East, and with the share agreed on for Latin America of 13.5 per cent and a 2 per cent share for Africa, this gives a total of 25.5 per cent, excluding the Middle East, see UNIDO "Modelling the Attainment of the Lima Target: the LIDO Model", Industry and Development, No.6, (UN Publication, Sales No.E81.II.B.4), p.6.

for each region[3/] and the DGs as a whole. The study concludes with an analysis of the seriousness of these energy gaps as a constraint to the attainment of the Lima target and recommendation of required policy measures to bridge them, particularly in the context of the South-South cooperation.

The growth rate of GDP of the developed countries was set at three different rates between 1980 and 2000, namely 2.5 per cent a year for scenario one (S1), 3.5 per cent for scenario two (S2), and 3.5 per cent for scenario three (S3). Corresponding to these three scenarios, production-consumption imbalances of commercial energy for all four regions in the year 2000 were calculated. The Middle East emerges with a sizeable surplus of about 50 million barrels of oil equivalent per day (mboed) under S1 and 29 mboed even under the optimistic S3. By contrast, Latin America's gap may range anywhere from 12 mboed (S1) to 25 mboed (S3) while Asia and the Pacific could suffer a shortfall of 8 mboed (S1) to 18 mboed (S3). In the meantime, the energy balance may appear promising in Africa with a manageable deficit of 1.5 mboed even under the most optimistic growth scenario 3.

The financial implications of the energy gap for certain regions are substantial. If the energy prices are assumed to rise by 2 per cent a year to $41 per barrel by 2000 in real terms, the financing requirements of energy imports for Latin America would be about $160 billion (10 per cent of GDP) per year in today's constant prices under S1, $269 billion (12 per cent of GDP) under S2, and $374 billion (14 per cent of GDP) under S3. For Asia and the Pacific, the financing needs of energy imports would amount to $120 billion (10 per cent of GDP) under S1, $180 billion (12 per cent of GDP) under S2, and $269 billion (15 per cent of GDP) under S3. If the energy price should rise faster than an assumed rate of 2 per cent per year, the financial implications for these regions could reach alarming proportions. Undoubtedly, no such major energy constraints would emerge in the Middle East and the same holds for Africa. It must be noted, however, that this aggregate figure may belie the plight of a great majority of individual oil-importing developing countries, as illustrated by the case of Africa where the lion's share of energy resources and energy production in that region are concentrated in a small number of countries such as Nigeria, Libya and Algeria.

3/ In this paper country coverage of the four regions is based on regional commission membership.

II. Description of the Methodology

A critical link between energy and industrialization is too well-known and requires no further elaboration. It merely suffices to point out that a number of developing countries and particularly newly industrializing countries (NICs) are now already going through the energy intensive phase of industrialization and many more will sson follow suit as they graduate from the first phase of industrialization characterized by the production of labour-intensive and technologically simple goods (e.g., light manufacturing) to the second phase of industrialization marked by the production of relatively energy-intensive intermediate goods and capital goods.

It is particularly notable that commercial energy consumption in developing countries is critically related to their GDP growth rates and the rate of structural transformation, which could be measured by the MVA share of GDP as its proxy variable. Of course, the energy prices will also have a significant effect on energy consumption through energy conservation and the use of energy-efficient technology, and their effects will be duly taken into account in projecting commercial energy demand in each region.

The central feature of the methodology used in this paper for energy projection is the GDP-energy elasticity. Namely, if we define the GDP elasticity of energy as

$$(1) \quad \varepsilon = (\Delta E/E)/(\Delta y/y) = \dot{E}/\dot{y}$$

where E is commercial energy consumption and y is GDP, and the dot ($\dot{}$) above the variable denotes the percentage change, then Eq.(1) can be rewritten as

$$(2) \quad \dot{E} = \varepsilon \cdot \dot{y}$$

It is now clear from Eq.(2) that given the GDP elasticity of energy, , which could be estimated from historical data, and GDP growth rates for each region implied by the Lima target, the commercial energy consumption rates ($\dot{E}$) required to attain the Lima GDP for each region can be readily estimated. It is important to note that the GDP elasticities estimated from historical data may have to be judgementally adjusted downward when they are used for projecting energy consumption. Such downward adjustments may be necessary in the light of anticipated higher energy prices and the development of energy efficient technology.

Once the energy consumption rate is estimated as above, it is quite straightforward to project regional commercial energy consumption for the Lima target year, 2000, namely,

$$(3) \quad E_T = E_0 \, (1 + \dot{E})^{T-0}$$

where the subscripts T and 0 denote the terminal year and the base year respectively.

Now it is quite obvious that a set of mutually consistent regional GDP growth rates required to attain the regional Lima targets need to be determined to estimate regional Lima energy consumption requirements. But since the Lima target and its regional distribution scheme are couched in terms of the MVA share, it is further necessary that another set of mutually consistent regional MVA growth rates should be derived and a functional relationship between GDP and MVA be mathematically spelled out so that given the Lima target MVA growth rates, the corresponding GDP growth rates may be readily calculated.

The total Lima energy requirements for the DGs as a whole is obtained by summing up the individual regional requirements. Moreover, an independent estimate of the commercial energy production in each region up to the year 2000 is derived and compared with regional energy consumption projected for the target year to estimate the production-consumption imbalance in each region and for the world.

A formal model describing the structure of relationships that exist between the economies of different regions and the interface of energy and economic growth is given in the appendix. Also presented therein is a step-by-step algorithm for solving the model to yield a set of mutually consistent regional MVA and GDP growth rates corresponding to three different Lima growth scenarios.

III. Lima Regional Growth Rates of GDP and MVA

Several key parameters of the model were exogenously determined to generate a set of consistent growth rates of MVA and GDP for each region and the DGs as a whole as follows:

1) Lima target: Π = .25, i.e., DGs' share of world MVA in the year 2000, divided into regional shares of world MVA in the year 2000: Latin America, (ECLA region), .13; Middle East (ECWA region), .03; Asia and the Pacific (ESCAP region), .07; and Africa (ECA region), .02.

2) The GDP growth rates of the developed countries (DDs):
The growth rate of GDP in the DDs was taken at three different rates between 1980, the base year of the calculations, and 2000, the Lima target year. The first one, called scenario one (S1), is an average of 2.5 per cent per annum, reflecting the continuation of the current weakened world economic conditions. The second scenario (S2) is 3.5 per cent, taking the lower end of the range of the Third United Nations Development Decade (DD III) target, which was set between 3.5 per cent and 3.9 per cent. The third scenario (S3) is 4.5 per cent, which envisages a more vigorous growth path of the world economy.

3) The growth rate of MVA share of GDP in the DDs ($\dot{b}^{nm}$):
This parameter specification was needed to calaculate the MVA share of GDP in the DDs and hence MVA of the DDs in the year 2000, since the DDs' GDP at 2000 was already determined by its exogenously given GDP growth rate. The MVA share growth rate was taken as 0.32 per cent per year, a historical growth rate of the 1975-1980 period.4/

4) The growth rate of MVA share of GDP in the DGs ($\dot{b}^{sm}$):
This parameter value was necessary to translate the Lima MVA of the DGs as a whole into its GDP equivalent. This growth rate was set at 1.27 per cent, again an estimate based on the 1975-1980 data. This rate is then disaggregated into the growth rates of MVA share of GDP for each region ($\dot{b}_i^m$) to determine each region's share of the

4/ Actually, the combined MVA share of GDP for 26 developed market economies has declined from 29.2 per cent in 1973 to 27.5 per cent in 1980 according to UNIDO data. Therefore, the positive growth rate in the MVA share of GDP shown for the developed countries as a whole during the period 1975-1980 was mainly due to the MVA share growth in the centrally planned countries in East Europe.

aggregate GDP of the DGs (a_{iT}) in the year 2000: These growth rates were estimated from historical data observed in the 1975-1980 period and they are: Latin America, 0.76%; Middle East, 4.48%; Asia and the Pacific, 1.48%; and Africa, 1.24%. Historical data on GDP and MVA by region, their average annual growth rates, each region's MVA share of GDP and regional share of world MVA for the period 1975-1980 are given in the statistical appendix.

Table 1 shows the distribution of world MVA by region and country group in accordance with the regional share scheme and the three Lima scenarios described above. Table 2 presents a similar table for GDP and Table 3 summarizes the growth rates required to attain these Lima target MVA and GDP.

Several interesting points emerge from these computational results. First, the calculated growth rate differential of MVA between DGs and DDs is around 5.5%, ignoring negligible rounding errors. In fact this differential

Table 1. MVA by Region, 1980 and 2000

(in billions of 1975 US dollars)

	1980		2000			
	MVA	%	MVA			%
			S_1	S_2	S_3	
World	2034.55	100	4251.85	5163.1	6257.87	100
Developed Countries	1825.78	89.73	3188.89	3872.3	4693.40	75
Developing Countries	208.77	10.26	1062.96	1290.8	1564.47	25
Latin America	121.93	5.99	552.74	671.20	813.52	13
Middle East	10.05	0.49	127.56	154.89	187.74	3
Asia and the Pacific	61.07	3.00	297.63	361.42	438.05	7
Africa	15.74	0.77	85.04	103.26	125.16	2

Note: S_1 assumes a 2.5 per cent GDP growth rate in the developed countries, S_2, 3.5 per cent, and S_3, 4.5 per cent.

Source: See Table 1, Statistical Appendix.

Table 2. GDP by Region, 1980 and 2000

(in billions of 1975 US dollars)

	1980		2000			
Region	GDP	%	GDP			%
			S_1	S_2	S_3	
World	6967.3	100	14042.8	17052.4	20668.16	100
Developed Countries	5867.0	84.21	9613.8	11674.1	14149.53	68.46
Developing Countries	1100.3	15.79	4429.0	5378.3	6518.63	31.54
Latin America	472.3	6.78	1842.46	2237.37	2711.66	13.12
Middle East	120.6	1.73	637.78	774.48	938.33	4.54
Asia and the Pacific	327.7	4.70	1190.52	1445.69	1752.66	8.48
Africa	179.7	2.58	758.24	920.76	1116.08	5.40

Source: See Table 1, Statistical Appendix

Table 3. MVA and GDP Growth Rates by Region, 1980 - 2000

(per cent per year)

	MVA				GDP			
	1975-1980	S_1	S_2	S_3	1975-1980	S_1	S_2	S_3
World	4.03	3.75	4.77	5.78	3.7	3.57	4.58	5.59
Developed Countries	3.82	2.83	3.83	4.83	3.5	2.5	3.5	4.5
Developing Countries	5.97	8.48	9.54	10.59	4.78	7.21	8.26	9.3
Latin America	5.00	7.85	8.9	9.95	4.88	7.04	8.09	9.13
Middle East	9.27	13.55	14.66	15.76	6.40	8.68	9.74	10.8
Asia and the Pacific	7.76	8.24	9.3	10.35	3.74	6.66	7.70	8.75
Africa	5.19	8.80	9.86	10.92	5.47	7.46	8.51	9.56

Source: Calculated from Tables 1 and 2.

is solely a function of the growth rate determined by an initial value of the DGs' share of world MVA and their Lima share (25%), which is denoted by ($\dot{\lambda}$).4/ Similarly, a constant differential exists between the GDP growth rate of the DGs and that of the DDs. But this time the differential is determined by the growth rates of the MVA share of GDP of both DGs and DDs in addition to $\dot{\lambda}$. This constant is roughly equal to 4.6%.5/ Furthermore, it should be noted that the growth rate of MVA exceeds that of GDP by a constant differential for each region and country group and this differential is solely determined by the rate of change of structural transformation in each region as given by the growth rate of MVA share of GDP ($\dot{b}_i^{sm}$).6/ Of course, the rate of change of structural transformation may vary considerably from one region to another. For instance, it ranged from 0.11 per cent for Latin America to 2.7 per cent for the Middle East in the period 1975-80. For the period 1980-2000, these differentials between MVA and GDP growth rates are projected to be 0.80 per cent for Latin America, 4.5% for the Middle East, 1.5% for Asia and the Pacific, 1.3% for Africa and 1.3% for DGs as a whole. As a result, the most rapid structural change is expected in the Middle East and the least in Latin America. This observation seems plausible in view of the fact that a massive industrialization drive has recently been launched from a base of nearly zero and accelerated in the Middle East (and particularly in the Gulf States), fueled by an abundant surplus of petrodollars. However, most of the economies in Latin America have moved far along the path of industrialization and any further industrial progress is likely to encounter increasingly difficult financial and resource constraints.

In a similar vein, the growth rates of MVA and GDP in the Middle East may appear somewhat optimistic but by no means unattainable in the absence of key twin constraints to industrialization - financial capital and energy. The same may not, however, hold for Africa. Given the gravity of fundamental economic and structural problems confronted by Africa, it may take herculean cooperative efforts both at domestic and the international scenes to raise Africa's MVA of anout $6 billion in 1980 to the Lima target range of $85 billion to $125 billion in real terms and to increase its 1980 GDP four-to-six-fold in the coming two decades. On the other hand, MVA and GDP growth rates

---

4/ From Eq.(20) in the appendix, $r^{sm} = \dot{\lambda} + r^{nm}$ and $\dot{\lambda} = 0.055$.

5/ From Eq.(20) in the appendix, $r^{s} = \dot{\lambda} + (\dot{b}^{nm} - \dot{b}^{sm}) + r^{n}$ and $\dot{\lambda} + (\dot{b}^{nm} - \dot{b}^{sm}) = 0.046$

6/ From Eq.(13) in the appendix, $r_i^{sm} = \dot{b}_i^{sm} + r_i^{s}$

required to attain the regional Lima targets in Latin America, and Asia and the Pacific appear to be well within the range of possibility, although the attainment of such regional targets under the most optimistic scenario 3 may prove to be very difficult.

Finally, Tables 1 and 2 show that the attainment of the regional Lima target shares for manufacturing output implies a greater increase in the share of GDP.7/ Thus, for example, Africa's MVA in 2000 is 2 per cent but its GDP share is 5.4, Latin America's MVA share 13 per cent with its GDP share 13.12 per cent, Middle East's MVA share 3 per cent with its GDP share 4.54 per cent. and Asia's MVA share 7 per cent with its GDP share 8.48 per cent. In aggregate, the DGs' total of 25 per cent of world MVA is accomplished by a 31.54 per cent share of world GDP.

It is obvious that the regional growth rates of MVA and GDP calculated above are sensitive to the regional share scheme of world MVA adopted, apart from the GDP growth rate of the North postulated. It appears that the regional MVA share used in the above calculations may overestimate the growth capacity of Latin America and the Middle East and underestimate that of Asia and the Pacific, particularly in view of the recent phenomenal growth performance of several newly industrializing countries (NICs) in that region. Asia and the Pacific region may continue to be one of the most dynamic growth poles in the world for a long time to come. In the meantime, severe skilled manpower shortages and technological constraints may stand in the way of the Middle East's efforts to raise its 1980 share of world MVA of less than half a per cent to 3 per cent by the year 2000. It may be also somewhat unrealistic to expect that Latin America would increase its 1980 share of world MVA of 6 per cent more than two-fold in the two decades in the light of the

---

7/ Mathematically, we have to show that the ratio variable $k = (y_i/y_w)/(y_i^m/y_w^m) > 1$ where y_i and y_i^m are the "i"th region's GDP and MVA respectively, and y_w and y_w^m are world GDP and MVA. Noting $y_w = y_n + y_s$, and $y_w^m = y_n^m + y_s^m$ and after a series of substitutions and rearranging terms, a final form of the inequality relation can be expressed as $k = (b^{nm}b^{sm} + b^{nm}b^{sm}\lambda)/(b_i^{sm}b^{sm} + b_i^{sm}b^{nm}\lambda) > 1$ or $(b^{nm} - b_i^{sm})\, b^{sm} + (b^{sm} - b_i^{sm})\, b^{nm}\lambda > 0$. Therefore, the inequality holds if $(b^{nm} - b_i^{sm}) > 0$ and $(b^{sm} - b_i^{sm}) > 0$. If $(b^{sm} - b_i^{sm}) < 0$, then the inequality holds only when the value of the first term is greater than that of the second term.

serious structural and financial problems confronted by the region. Reflecting these factors, an alternative share scheme was devised whereby Latin America's share was reduced to 11 per cent and that of the Middle East to 2 per cent, and an offsetting increase of Asia and the Pacific's share to 10 per cent, leaving Africa's share unchanged. MVA and GDP calculations based on such an alternative distribution with the assumption of a 3.5 per cent growth rate of the DDs are shown in Table 4.

It comes as no surprise that a new MVA distribution scheme reduced the MVA growth rate of Latin America slightly from 8.9 per cent to 8 per cent, since the MVA share of GDP in Latin America was postulated to grow only by 0.76 per cent per year in the period of 1980-2000 as described earlier. This is equivalent to the reduction of growth rate by less than one percentage point for two percentage points decrease in its share of world MVA. In contrast, the MVA share of GDP in Middle East was assumed to increase by about 4.5% per year in the same period and this factor was sensitively reflected in the reduction of MVA growth rate by almost two percentage points for one percentage point drop in its share of world MVA. Nevertheless, the new MVA growth rate of 12.35 per cent for the Middle East is still the highest in the world, surpassing that of Asia and the Pacific region which was calculated to be 11.36 per cent. Overall, new growth rates obtained under an alternative scheme, both MVA and GDP, appear more reasonable and plausible than those calculated under the first assumption.

IV. Lima Regional Energy Requirements and Energy Gaps

The two most critical factors in determining aggregate commercial energy consumption are the pace of economic growth and the way in which energy consumption responds to varying economic activities, of course, after properly allowing for the effect of changing energy prices on energy consumption.[8/] The first variable is usually measured by the GDP growth rate and the second by the GDP elasticity of energy consumption adjusted for the energy price effect. In the previous section of the paper, GDP growth rates for each region implied by the three Lima scenarios were calculated. The other missing element

8/ In addition to income and energy price, there are other factors affecting energy consumption such as a country's resource endowments, level of technical and economic efficiency, and government policies.

Table 4. Regional MVA and GDP Growth Under An Alternative Regional Share Scheme[1]

(in billions of 1975 US dollars)

	MVA at 2000		MVA g. r. (%)		GDP at 2000		GDP g. r. (%)	
	Reference	Alternative	Reference	Alternative	Reference	Alternative	Reference	Alternative
World	5163.1	5163.1	4.77		17052.4		4.58	
Developed Countries	3872.3	3872.3	3.83		11674.1		3.50	
Developing Countries	1290.8	1290.8	9.54		5378.3		8.26	
Latin America	671.20	567.94	8.9	8.0	2237.37	1893.16	8.09	7.19
Middle East	154.89	103.26	14.66	12.35	774.48	510.94	9.74	7.49
Asia and the Pacific	361.42	516.31	9.30	11.36	1445.69	2054.51	7.70	9.61
Africa	103.26	103.26	9.86	9.86	920.76	920.76	8.51	8.51

Note:

1. The GDP growth rate of the DDs is set at 3.5%

   Regional MVA shares:

   Reference: Latin America, 13%; Middle East, 3%; Asia and the Pacific, 7%; Africa, 2%;

   Alternative: Latin America, 11%; Middle East, 2%; Asia and the Pacific, 10%; Africa, 2%;

   1980 Share: Latin America, 6%; Middle East, 0.49%; Asia and the Pacific, 3%; Africa, 0.77%.

needed to determine regional energy consumption levels consistent with the attainment of regional Lima targets is the estimation of GDP elasticities of energy.

Table 2 in the appendix shows average annual growth rates of commercial energy consumption by region and country group during the period 1975-1980 which provided a basis for computing GDP elasticies of energy for each region for the same period as given in Table 5. It is particularly interesting to note a marked difference in the aggregate GDP elasticity of energy between DGs and DDs during the same period in which the second energy price shock occurred before the ripple effects of the first shock had subsided. It appears that the developed countries as a whole responded very remarkably to sharply escalating energy prices through conservation and efficient energy management, although part of the decline in the GDP elasticity of energy in DDs could be explained by the relatively sluggish performance of the world economy. During the period the total final consumption of commercial energy in the developed countries grew at an average annual rate of 2.13 per cent while the real GDP increased at the rate of 3.5 per cent, thus resulting in an elasticity of 0.61.

In contrast, the growth of commercial energy consumption (6.9 per cent per year) outpaced GDP growth (4.8 per cent per year) in the developing countries with an elasticity of 1.44, despite high energy costs and severe balance-of-payments difficulties encountered in the same period. Major underlying factors contributing to this strong upsurge in commercial energy consumption in the developing countries, notwithstanding rapidly rising energy prices, are higher population growth, more rapid economic growth, acceleration of urbanization, structural changes involving the development of more energy intensive industries, and replacement of traditional energies by commercial energy.

Even within the South, the elasticity varied remarkably from region to region. First, an extremely high elasticity value for Africa (2.20) may be considerably overstated, mainly because of a statistical anomoly where the growth rate has to be calculated from an extremely low base, namely 0.7 million barrels of oil equivalent per day (mboed) in 1975 which grew to 1.21 mboed by 1980, thus yielding an average annual growth of 12 per cent. It is highly

Table 5. GDP Elasticity of Energy Use

	1975-1980	1980-2000
Developed Countries	0.61	0.55
Developing Countries	1.44	1.12
Latin America	1.33	1.10
Middle East	1.71	1.40
Asia and the Pacific	1.44	1.10
Africa	2.20	1.20

Source: See Table 2, Statistical Appendix

likely that the growth rate of commercial energy consumption in Africa would decrease substantially as the quantity of commercial energy consumption steadily increases, and so would drop the elasticity. In the meantime, a relatively high elasticity value for the Middle East (1.71) may appear quite reasonable in the light of an intensified drive for energy-and capital-intensive industrialization, and the unrestrained energy consumption patterns encouraged by abundant energy supply in the region. Elasticity values for Asia and the Pacific, and Latin America may seem plausible. In fact, the value of the former is exactly the same as the mean value for the DGs, and that of the latter also deviates slightly from it.

Given these historically observed elasticities, the critical question remains as to what elasticities are to be used for projecting commercial energy consumption up to the year 2000 in different regions. As underscroed earlier, the way energy use patterns change over time depends on many factors other than GDP, and particularly an important factor is the energy price. It is a priori clear from economic theory that the effects of income and price work in the opposite directions. But the great uncertainty is the relative dominance of the two effects and the quantitative magnitude of the net effect. Ideally, an elaborate econometric model of energy consumption could enable us to isolate the price effect from the income effect and thus help estimate the relative quantitative importance of the two effects.[9/] Short of such a

9/ For instance, see A Conceptual Model for Projecting Industrial Energy Use in Developing Countries, UNIDO/IS.278, 13 January 1982. The document also contains a bibliography of most of the previous econometric studies of energy consumption in developing countries.

modelling exercise, there seems to be no alternative but to reflect the effects of price on energy use indirectly through adjustments to the GDP elasticity of energy use. Such judgementally adjusted regional elasticity values for the period 1980-2000 are given in Table 5. Now it may be useful to explain how each of these estimates is arrived at. First, the most critical assumption underlying these estimates is that the real energy prices would continue to rise steadily within a range of one to three per cent per annum in the next two decades. Given this energy price trajectory, it was further assumed for the developed countries as a group, that the energy-efficient consumption patterns established in the seventies would continue to improve through better conservation, development of energy efficient technology and structural transformation to less energy-intensive high-technology and specialized service industries away from the traditional energy-intensive "smokestack industries", such as petrochemical and basic metals industries. As a result, the GDP elasticity of 0.61 during the period 1975-80 was scaled down to 0.55, reflecting energy-saving factors mentioned above in response to an anticipated continuous but relatively modest rise in the real energy costs over the next two decades.

It is expected that the Middle East would continue to concentrate on the development of energy-intensive industries, exploiting its comparative advantage, namely abundant cheap energy and surplus capital. These considerations are fully reflected in a relatively high elasticity value assigned to this region (1.4), but it is appreciably lower than its historical value of the 1975-1980 period (1.71), recognizing the increasing importance of energy-saving measures even in energy-rich countries as the opportunity cost of energy wastes rises rapidly. For Africa, a more drastic downward adjustment from the 1975-1980 historical level (2.2) was made with an assumed elasticity value of 1.2. This was partly justified because the elasticity calculated from the 1975-1980 data may tend to overestimate its true value for the reasons explained earlier. Even if the estimate were close to its true value, it is highly unlikely that an extremely high rate of energy consumption implied by the past data could be sustained over the next two decades mainly because of inadequate financial resources, and limited technological and productive capacities in Africa.

Given a relatively broad industrial base and considerable technological capabilities in Latin America, and Asia and the Pacific, it is assumed that the two regions are better poised to respond effectively to the problems of industrialization with high energy costs by adopting energy-efficient technology and implementing vigorous energy conservation programmes. A relatively low value of elasticity given to these regions (1.1) may reflect this structural flexibility of the regions to cope with energy problems emerging from the process of accelerated industrialization.

Taking a weighted average of four regional elasticities would yield an average elasticity for the DGs as a whole equal to 1.12, which seems quite reasonable, if not underestimated. In aggregate, the response of commercial energy consumption in DGs to its GDP growth may continue to be more than proportionate as in the past, in view of accelerating trends for population growth, urbanization, energy-intensive industrialization, and substitution of commercial for non-commercial energy in DGs but considerably restrained by the rising energy costs over the next two decades.

Summarized in Table 6 are regional growth rates of commercial energy consumption, which were obtained by multiplying the GDP elasticities of energy by GDP growth rates generated by the three Lima scenarios. It is particularly noteworthy that despite the fact that the elasticity values for all regions were deliberately set on the conservative side of a possible range of estimates all substantially below the actual value observed during the period 1975-1980, the growth rates of energy consumption in all regions but DDs are still markedly high relative to their past trend values. It is, however, clear that these high energy consumption rates are influenced not so much by the GDP elasticies as the required GDP growth rates implied by the Lima target (see Table 3). But, overall, they are still well within the realm of attainability and this may be the case particularly for those values associated with scenarios 1 and 2. The projected commercial energy consumption for each region in the year 2000 corresponding to the growth ates given in Table 6 are summarized in Table 7. As expected, the commercial energy consumption of the DGs as a whole needed to attain the Lima target is quite substantial, requiring almost five times the level of 1980 consumption under S_1, slightly over 6 times under S_2, and almost 8 times under S_3. Equally dramatic is an increase in the DGs' share of world energy consumption, rising sharply from 11.5% in 1980 to about 31% under S_1, 35% under S_2, and 38% under S_3.

Table 6. Commercial Energy Consumption Growth Rates

(per cent per year)

	1975-1980	1980-2000		
		S_1	S_2	S_3
World	2.61	2.66	3.46	4.31
Developed Countries	2.13	1.38	1.93	2.48
Developing Countries	6.89	7.91	9.28	10.73
Latin America	6.47	7.74	8.90	10.04
Middle East	10.96	9.52	13.64	15.12
Asia and the Pacific	5.40	7.33	8.47	9.63
Africa	12.06	8.95	10.21	11.47

Table 7. Commercial Energy Consumption by Region, 1980 and 2000

(in millions of barrels of oil equivalent per day)

	1980		2000					
		% Share	S_1	% Share	S_2	% Share	S_3	% Share
World	107.40		181.62		215.12		249.92	
Developed Countries	95.04	(88.49)	125.01	(68.83)	139.16	(64.69)	155.13	(62.07)
Developing Countries	12.34	(11.49)	56.61	(31.17)	75.96	(35.31)	94.79	(37.93)
Latin America	5.35	(4.98)	23.76	(13.08)	29.44	(13.69)	36.25	(14.50)
Middle East	1.11	(1.03)	6.84	(3.77)	14.32	(6.66)	18.55	(7.42)
Asia and the Pacific	4.67	(4.35)	19.29	(10.62)	23.74	(11.04)	29.37	(11.75)
Africa	1.21	(1.13)	6.72	(3.7)	8.46	(3.93)	10.62	(4.25)

There are also significant regional variations in the energy requirements implied by the Lima target with the Middle East showing the fastest growth of energy consumption. However, the regional growth and relative shares of energy consumption are sensitive to the regional distribution scheme for the Lima target adopted, which was found earlier to affect significantly the relative growth rates of MVA and GDP among regions (Table 4). Table 8 illustrates such a case. More specifically, regional energy requirements in the year 2000 and their annual growth rates over the period of 1980-2000 are compared between the original Lima share scheme and an alternative version, assuming the GDP growth rate of the North to be 3.5 per cent. For the Middle East, a reduction of the Lima MVA share by one percentage point from 3 per cent to 2 per cent results in a fall in its energy requirements over 15 mboed, reducing its annual growth rate from 13.65 per cent to 10.49 per cent, a remarkable change. Likewise, although less pronounced, Latin America's energy requirements drop from 29 mboed to 25 mboed with a decrease of its growth rate from 8.9 per cent to 7.9 per cent as a result of decreasing its MVA share from 13 per cent to 11 per cent. In the meantime, Asia and the Pacific registers an offsetting gain of about 11 mboed with its growth rate increased from 8.47 per cent to 10.57 per cent, as its share of the Lima MVA increases by 3 percentage points from 7 per cent to 10 per cent. Of course, Africa remains unchanged, since its share is kept intact. This example merely underscores the importance of a regional MVA distribution scheme as a critical parameter in deriving regional energy implications of the Lima target as well as other policy implications at the regional level.

So far, we have concentrated on the demand side of the Lima energy picture, namely calculating the level of commercial energy consumption required to attain the Lima target in each region. By now, it is, however, apparent that the variable in which we are most interested is not the level of energy requirements per se, but a shortfall or surplus of commercial energy that may develop in each region, given the structure of regional energy demand determined by the Lima target. We denote hereafter this production-consumption gap as the Lima energy gap. It is, therefore, necessary to project commercial energy production in each region up to the year 2000 to estimate regional Lima energy gaps.

Table 8. Regional Energy Requirements Under An Alternative Regional Share Scheme[1]

(mboed)

	1980	2000		Average Annual g.r. 1980 - 2000 (%)	
Regions		Reference	Alternative	Reference	Alternative
Latin America	5.35	29.44	24.52	8.90	7.91
Middle East	1.11	14.32	7.35	13.64	10.49
Asia and the Pacific	4.67	23.74	34.84	8.47	10.57
Africa	1.21	8.46	8.46	10.21	10.21

1 The GDP growth rate of the North is set at 3.5%

Regional Lima MVA shares:

Reference: Latin America, 13%; the Middle East, 3%; Asia and the Pacific, 7%; Africa, 2%.

Alternative: Latin America, 11%; the Middle East, 2%; Asia and the Pacific, 10%; Africa, 2%.

1980 Share: Latin America, 6%; the Middle East, 0.49%; Asia and the Pacific, 3%; Africa, 0.77%.

An analytically sound approach to the projection of regional energy production would usually involve a detailed and comprehensive survey of commercial energy endowments by different sources in each region and an assessment of their maximum production capacities over time which are feasible within general social, economic and technological constraints. Such an indepth study is, of course, beyond the scope of this paper. Instead, this study relies on a simple extrapolation of the recent trends with a proper allowance being made for each region's known reserves of selected commercial energy and possible production bottlenecks.

The average annual growth rates of commercial energy production by region over the periods 1970-1980 and 1980-2000 are given in Table 9 and those of the 1980-2000 period primarily reflect the continuation of the 1970-1980

Table 9. Commercial Energy Production by Region, 1980 and 2000

(mboed)

	1980	2000	g.r. 1970-1980 (%)	g.r. 1980-2000 (%)	Cumulative Production 1980-2000 (billions of barrels)
Latin America	7.62	11.32	1.89	2.0	67.59
Middle East	17.87	57.31	5.88	6.0	239.96
Asia and the Pacific	5.66	11.26	-0.91 1/	3.5 2/	58.42
Africa	6.14	9.12	0.78	2.0	54.49
Developing Countries	37.28	89.01	2.80	4.45	420.46
Developed Countries	80.74	132.3	2.45	2.5	1259.54

1/ Negative growth rate is due to a sharp fall in Iran's oil production by about 4 mboed between 1978 and 1980.

2/ Assumes the restoration of Iran's oil production to the 1978 level.

Source: Table 3, Statistical Appendix, UN Yearbook of World Energy Statistics, 1981-1983.

period growth rates with a few exceptions.[10/] In Latin America and the Middle East, the trend growth rates are assumed to continue at the annual rate of 2 per cent and 6 per cent respectively. In Asia and the Pacific, the trend growth rate was corrected for a sharp fall in Iran's oil production by about 4 mboed between 1978 and 1980 by assuming that Iran's oil production would be restored to the 1978 level. In Africa, the trend growth rate of 0.78 per cent was raised to 2 per cent in view of the region's considerable development potentials of various sources of energy including hydro and recent intensified efforts in the region, both domestic and international, to accelerate their development.

10/ It is worth noting that the energy supply response would definitely be influenced by its excess demand pressure and consequent rising energy prices. It would be, therefore, more realistic to adjust the extrapolated growth rates of energy production according to the different growth rates of energy use implied by the three Lima scenarios. But without a formal model of supply and demand in the energy market, it would be extremely difficult to quantify the supply adjustment in response to the excess demand pressure.

Using the growth rates derived above, each region's energy production in the year 2000 was projected. Commercial energy production for the DGs as a whole more than doubles between 1980 and 2000. Furthermore, there are marked variations in the regional production between 1980 and 2000, ranging from less than a two-fold increase in Latin America and Africa, slightly over a two-fold increase in Asia and the Pacific, and over a three-fold jump in the Middle East.

To make a rough check on the reasonableness of production figures estimated above, the cumulative production totals for all regions up to the year 2000 were calculated and compared against their currently known reserves of selected commercial energies. Such reserve figures for oil, natural gas and coal are given in Table 10. Since geographic grouping in Table 10 does not coincide with the Lima regional grouping given in Table 9, one must be careful in reading these figures. In particular, North Africa's portion of the combined reserve figures for North Africa and West Asia should be transferred to Africa's reserves to make the two tables comparable. Likewise, reserve figures for Indian Subcontinent and East Asia could be combined to yield roughly equivalent reserves in Asia and the Pacific. After making such appropriate adjustments, it becomes clear that the cumulative production total estimated in Table 9 are well within the combined reserve limits of three commercial energy sources shown in Table 10. There is no doubt that the actual total reserves could be considerably greater when other sources of commercial energy such as hydro are included in the reserve estimation. In short, the regional growth rates of energy production specified above seem reasonable, if not underestimated.

Now we can readily calculate the Lima energy gap for each region from the two separate estimates of production and consumption of commercial energy in the year 2000. Table 11 summarizes production-consumption imbalances corresponding to three Lima scenarios for all four regions in the year 2000. First, it is not surprising to find that the Middle East emerges with a sizeable surplus of about 50 mboed under scenario 1 and 29 mboed even under the most optimistic growth scenario 3. By contrast, both Latin America, and Asia and the Pacific are likely to encounter serious stumbling-blocks erected by energy shortfalls to the path of industrialization prescribed by the Lima target. Latin America's gap may range anywhere from 12 mboed (scenario 1)

Table 10. Selected Commercial Energy Reserves in the Developing Countries, 1980

(billions of barrels of oil equivalent)

	(1) Oil*/	(2) Natural Gas*/	(3) Coal**/	(1) + (2) + (3)
Latin America	58	24.91	53	135.91
Africa, South Sahara	20.6	7.22	34	61.82
North Africa and West Asia	403.0	156.07	5	564.37
Indian Subcontinent	2.8	6.09	163	171.89
East Asia	14.4	8.40	10	32.8
Developing Countries	498.8	202.69	265	966.49
World	654.9	442.47	3032.	4129.37

Source: UN Yearbook of World Energy Statistics 1981, N.Y. 1983.

* Statistical Review 1980, Energy Economics Research Ltd.

** World Energy Resources 1985-2020, Reports to the World Energy Conference, 1978.

Table 11. Commercial Energy Production-Consumption Gaps by Region

(mboed)

	1980	2000		
		S_1	S_2	S_3
Latin America	2.27	-12.44	-18.12	-24.93
Middle East	16.76	50.47	42.99	38.76
Asia and the Pacific	0.99	-8.03	-12.48	-18.11
Africa	4.93	2.4	0.66	-1.5
Developing Countries	24.94	32.4	13.05	-5.79
Developed Countries	-14.3	7.29	-6.86	-22.83
World	10.64	39.69	6.19	-28.62

Sources: Tables 7 and 9.

to 25 mboed (scenario 3), while his Asian counterpart could suffer a shortage of 8 mboed (scenario 1) to 18 mboed (scenario 3). In the meantime, the energy balance may appear promising in Africa with a manageable deficit of 1.5 mboed showing only under the optimistic growth scenario 3. However, this aggregate figure may belie the plight of a great majority of energy-resource poor countries in Africa, since the lion's share of energy resources and energy production in that region are concentrated in a handful of countries such as Nigeria, Libya and Algeria. Equally misleading is the balance sheet for the DGs as a whole because of a dominant surplus position of the Middle East.

In the meantime, the energy balance for the developed countries as a whole seems to shed some light on the nature of interactions between the income effects and the price effects mentioned earlier. Under the low growth scenario 1, the effects of energy conservation and improved energy use efficiency, a phenomenon which has become increasingly important since the energy price-hikes in 1973, continue to dominate over the growth-induced increase in the energy demand. As a result, the supply shortfall of about 14 mboed in 1980 would turn into a surplus of slightly over 7 mboed by 2000. But under the higher growth scenario 2, the growth-induced factor in the energy demand would overtake the forces of conservation and efficiency and results in a negative production-consumption gap of about 7 mboed in 2000 and this gap would be further widened to approximately 23 mboed under the more vigorous growth scenario 3.

Looking at the global production-consumption balance figures, it becomes apparent that the figures presented in Table 11 are a rough first approximation to the production-consumption gaps which are most likely to develop in different regions of the world by 2000. This is because any global disequilibrium between production and consumption cannot be sustained over time and is bound to generate upward or downward pressures on the energy prices, and hence production and consumption adjustment until an equilibrium between supply and demand at the global level is established. However, without the aid of a simulation model of the global energy markets, which allows for production and trade among regions, it would be almost impossible to arrive at a set of regional energy production and consumption values consistent with a global equilibrium level of output.

le 12. CHINA'S TOTAL FINAL CONSUMPTION AND PRODUCTION OF COMMERCIAL ENERGY, 1970-1980

(in thousand metric tons of oil equivalent)

	1970	1975	1978	1979	1980	Average Annual g.r. 1970-1975	Average Annual g.r. 1975-1980	Average Annual g.r. 1970-1980
nsumption								
TFC	204796	302645	397670	408084	399424	8.12	5.71	6.91
ina's share of World	(4.92)	(6.43)	(7.60)	(7.53)	(7.46)			
mboed	(4.10)	(6.07)	(7.98)	(8.18)	(8.01)			
oduction	206445	318145	418277	430012	422616	9.03	5.84	7.43
ina's share of World	(4.51)	(6.16)	(7.33)	(7.18)	(7.18)			
mboed	(4.14)	(6.38)	(8.38)	(8.62)	(8.47)			
oduction-Consumption Gap								
mboed	0.04	0.31	0.4	0.44	0.46			

urce: 1981 International Yearbook of World Energy Statistics, United Nations, New York, 1983.

te: Numbers in parentheses are China's share of world total final consumption of commercial energy and millions of rels of oil equivalent per day (mboed).

mmercial Energy: Commercial energy comprises solids, liquids, gas and electricity.

otal Final Consumption of Commercial Energy: Total final consumption is the sum of consumption by the different end-se sectors and is equal to total energy required less transformation and distribution losses.

Until now, one of the most important developing countries in terms of the quantity of commercial energy consumed and produced, namely China, was left out of the picture mainly because of the unavailability of China's MVA data needed for computing its MVA growth rates required to attain its share of the Lima MVA. Nevertheless, the exclusion of China from an analysis of energy problems in the developing countries could seriously distort the overall energy balance of the DGs and the world for that matter, since China accounted for more than 7 per cent of the world commercial energy consumption (8 mboed) in 1980 and its share of world production amounted to about the same percentage (8.5 mboed) in the same year, as shown in Table 12. It is, however, worth noting that China's production has kept apace with its consumption with a net result of near zero balance in the period of 1970-1980 (see Table 12). Therefore, to the extent that this production-consumption equality continues to prevail in China during the Lima target period, the basic results obtained earlier regarding the regional energy implications of the Lima target could remain invariant whether or not China was included as a part of the study group. Of course, when it comes to the issue of South-South cooperation on energy to facilitate the attainment of the Lima target, China could play a vital role in view of its rich energy resource endowments and its significant share of world commercial energy consumption. This would be one of many points to be elaborated in the following section on policy implications.

V. Policy Implications

The conclusions and policy implications drawn from this analysis are valid only for the particular values specified for various key parameters of the model such as regional share of world MVA in the year 2000, the growth rate of the North, the rate of structural transformation, GDP elasticity of energy, the growth rate of energy production, etc. An alternative set of these parameters may produce different results, and perhaps variant conclusions and policy implications. This limitation has to be kept in mind in analyzing the following results.

First and foremost, the financial implications of the energy gap for certain regions, particularly Latin America, and Asia and the Pacific, are staggering. Suppose for simplicity the crude oil price is a reasonably accurate barometer of the general energy price movements and its real price rises at a modest rate of 2 per cent per year from $29 per barrel in 1983 to $41 per barrel by 2000. Then, a 12 mboed shortfall in Latin America under scenario 1 means its foreign exchange needs of about $180 billion (10 per cent of GDP) per year in today's constant prices to import energy needed to realize the Lima target. An equivalent financial deficit on account of energy imports alone for Latin America would balloon to $269 billion (12 per cent of GDP) under the scenario 2, and to a whopping $374 billion (14 per cent of GDP) under the scenario 3, all measured in today's constant prices. Also in Asia and the Pacific, the same story holds but somewhat on a smaller scale. The financing needs of energy imports for Asia and the Pacific would amount to $120 billion (10 per cent of GDP) under scenario 1, $180 billion (12 per cent of GDP) under the scenario 2, and $269 billion (15 per cent of GDP) under the scenario 3 in the 1983 prices. It must be stressed that these financing requirements of energy imports are projected on the assumption that the energy prices would increase at a slower pace of 2 per cent per annum in real terms. If the energy prices should rise faster, which may be a strong likelihood in the light of the current fragile demand-supply balances in the oil markets, as many experts predict, the financial implications could be alarming. For instance, let us assume a 4 per cent increase a year of the real energy price, which is not entirely an unrealistic assumption. Then, the real energy price would rise to $56.45 per barrel by 2000, 1.37 times the price level attained by a 2 per cent per annum increase, and hence would swell oil import bills in Latin America by the same factor, ranging from $247 billion (13 per cent of GDP) per year under the scenario 1 to $515 billion (19 per cent of GDP) a year under the scenario 3.[11/]

Whatever assumptions may be made with regard to the future course of energy price movements, low or high, the resultant financing requirements of energy imports for the attainment of the Lima target are likely to be highly problematic in most regions of the South with a major exception of the Middle East, and this energy financing problem would be acutely felt particularly

---

11/ As stressed earlier, the energy gaps derived under the high growth scenarios and particularly the scenario 3 may tend to overstate their true magnitudes, when the price effects on supply as well as demand are fully taken into account. With increasing energy shortages, the rate of increase in the real energy prices may exceed the assumed rate of 2 per cent a year in the first case or 4 per cent a year in the second case. As a result, energy consumption will grow slower and at the same time energy production will increase faster than at the rates assumed in the study.

in Latin America, and Asia and the Pacific. The energy shortfall could indeed pose a key constraint to the realization of the Lima target in these regions, apart from other priority problems such as industrial financing, strengthening technological capacities and human resource development. It is particularly disquieting to note that the current extremely pressing debt problems faced by many developing countries in Latin America and some in Asia and the Pacific could be exacerbated as the energy gaps of these countries widen in the course of their drive toward the Lima target. Thus, the balance-of-payments problems induced by energy imports and accompanying mounting debt burdens loom critical all along the way to the attainment of the Lima target.

There is, obviously, the urgent need for formulating effective policy measures to remove this energy obstacle to the Lima industrialization path. The fundamental question is then how these energy gaps could be eliminated or at least narrowed to a manageable propotion. In the following we propose to put forward some promising but untested ideas to mitigate energy problems faced by the DGs in their endeavour to accelerate their industrialization.

Basically the energy production-consumption gap could be narrowed by a two-pronged attack on demand reduction or supply expansion. On the demand side, there is considerable scope for conservation and efficient energy management, and especially in the industrial sector which is the most important user of commercial energy in the DGs. It must be, however, ensured that energy conservation is not achieved at the expense of economic growth. Despite the importance of energy conservation in the DGs, the major burden of bridging the energy gap may have to fall on the supply side.

Regional energy balance sheets given in Table 11 emphatically point, inter alia, to the urgency of a close cooperation between the Middle East and the rest of the regions in the South. The Middle East region will be likely to have a fairly large positive balance, a surplus more than enough to make up for the energy deficiencies of the rest of the regions in the South. It would, however, be unrealistic and even naive to expect that the surplus energy of the Middle East would automatically be transferred to the deficit regions of the South without a concomitant drastic improvement in the financial resources of the deficit regions to import energy therefrom. For any cooperative scheme between the Middle East and the remaining regions of the South to be viable and sustainable, it must be based on the idea of mutual benefits. Therefore, what is most needed here is an imaginative and bold plan for an interregional industrial complementation scheme based on the quid pro quo arrangements of trade and production among regions. For instance, developing countries in Latin America, and Asia and the Pacific would guarantee a secure market for the Middle East's exports of fledgling energy-based industrial products in which they have a comparative advantage, such as petrochemicals and other intermediate goods. Furthermore, these two regions where all industrially advanced developing countries are situated could provide technology and a wide range of capital goods needed for the energy-based industrialization of the Middle East region. In return, the Middle East could guarantee an assured supply of energy needed to attain the Lima target in the two regions.

In the meantime, a different form of industrial cooperation may be needed to be mapped out for Africa, mainly because of its embryonic stages of industrialization with abundant supply of labour at low wages. In consideration of factor intensity and resource endowments, Africa may be suited to the development of labour-intensive industries, shifting locational incidence of production of labour-intensive goods from more developed DGs in Latin America and Asia to low-income countries in Africa - a form of South-South industrial redeployment. In this regard, Latin America and Asia will export capital goods and technology to Africa which they need for the build-up of basic infrastructure and an industrial base. The Middle East would provide the necessary energy, financial capital and intermediate goods. In fact, this may take the form of a tripartite joint venture with the Middle East providing the finance and energy, Latin America and Asia the capital goods and technology; and Africa labour and raw materials. Furthermore, it is essential that rapidly industrializing DGs in the Middle East, Latin America and Asia should provide expanded market opportunities for labour-intensive goods produced in Africa.

The concept of a tripartite cooperative scheme involving the energy-rich Middle East, industrially advanced Latin America and Asia, and relatively under-developed Africa - should go beyond an industrial complementation scheme described above and also be extended to the expansion of various forms of energy sources in all regions. In this context, capital-surplus countries in the Middle East could participate in the exploration, exploitation, and production of all sources of commercial energy. Toward this end, it is imperative to establish a proper mechanism for facilitating capital surplus countries' investments in energy development in all regions. Toward this end, it is imperative to establish a proper mechanism for facilitating capital surplus countries' investments in energy development in all regions. What we have in mind is something comparable to the Energy and Mines Guarantee Fund proposed by the Inter-American Bank (IDB) to ensure both equity and debt financing against political risks and specific financial and commercial risks. Furthermore, a more automatic mechanism for recycling a portion of petrodollar surpluses in the Middle East specifically earmarked for energy investments in energy-deficient DGs would go a long way to closing the energy gaps in energy-deficient regions.

Finally, there is equally wide scope for the intra-regional cooperation on energy. One of the obvious examples is the development of a large-scale hydropower station which may require the pooling of resources of several countries and their joint production and consumption to take advantage of the economies of scale. A less obvious example is the possible cooperation potentials which could be exploited by a rational use of different sources of energy. Coal is a case in point. China (473 billion barrels of oil equivalent) and India (163 billion barrels of oil equivalent) together account for over 86 per cent of coal deposits in the South. This has one important energy strategy implication for Asia and the Pacific whose oil import requirements to fill its energy gap are quite substantial as emphasized earlier. To the extent that these two giants with a combined population of over 1.7 billion rely on coal as a primary source of energy for industrialization, the demand pressures on other forms of energy, particularly oil, will be considerably relieved; and most important of all, as a result of domestic substitution of coal for oil, China could become a major oil exporter to its neighbouring oil importing developing countries.

Appendix

METHODOLOGY

I. Determination of Lima Regional Growth Rates of GDP and MVA

North

(1) $y_t^n = y_o^n e^{r^n t}$; r^n exogenous

(2) $y_t^{nm} = b_t^{nm} y_t^n$; $\dot{b}^{nm}$ exogenous

(3) $r^{nm} = \dot{b}^{nm} + r^n$

South

(4) $y_t^s = y_o^s e^{r^s t}$

(5) $y_t^{sm} = b_t^{sm} y_t^s$

(6) $r^{sm} = \dot{b}^{sm} + r^s$

"i" th Region in the South; i = 1, 2, 3, 4

(7) $y_{it}^s = y_{io}^s e^{r_i^s t}$

(8) $y_{it}^{sm} = b_{it}^{sm} y_{it}^s$

(9) $y_{it}^s = a_{it}^s y_t^s$

(5), (8) and (9) give

(10) $$y_{it}^{sm} = b_{it}^{sm} y_{it}^s$$

$$= b_{it}^{sm} a_{it}^s (y_t^{sm}/b_t^{sm})$$

$$= \left[(b_{it}^{sm} a_{it}^s / b_t^{sm}) \right] y_t^{sm}$$

$$= \phi_i y_t^{sm}$$

where $\phi_i = (b_{it}^{sm} a_{it}^s)/b_t^{sm}$

= "i"th region's share of South MVA

but from (10)

$$\sum_i y_{it}^{sm} = \sum_i \phi_i y_t^{sm} = y_t^{sm}$$

and hence

Identification of Variables

y_t^n = North GDP in period "t"

y_o^n = North GDP in the base period "o"

r^n = North GDP growth rate

y_t^{nm} = North MVA in period "t"

b_t^{nm} = North MVA share of GDP in period "t"

r^{nm} = North MVA growth rate

$\dot{b}^{nm}$ = growth rate of North MVA share of GDP

y_t^s = South GDP in period "t"

r^s = South GDP growth rate

y_t^{sm} = South MVA in period "t"

b_t^{sm} = South MVA share of GDP

$\dot{b}^{sm}$ = growth rate of South MVA share of GDP

r^{sm} = South MVA growth rate

y_{it}^s = GDP of "i"th region of the South in period "t"

r_i^s = "i"th region GDP g.r.

b_{it}^{sm} = "i"th region MVA share of GDP in period "t"

a_{it}^s = "i"th region share of South GDP

r_i^{sm} = "i" region MVA g.r.

$\dot{b}_i^{sm}$ = "i" region MVA share of GDP g.r.

$\dot{a}_i$ = "i" region share of South GDP g.r.

T = year 2000

Π = Lima target, 25%

λ = South MVA as per cent of the North MVA

$\dot{\lambda}$ = g.r. of λ

(11) $\sum_i \Phi_i = \sum_i (b^{sm}_{it}\, a^{s}_{it})/b^{sm}_{t} = 1$

Therefore,

(12) $\sum_i b^{sm}_{it}\, a^{s}_{it} = b^{sm}_{t}$

(13) $r^{sm}_i = \dot{b}^{sm}_i + r^{s}_i$

(14) $r^{s}_i = \dot{a}^{s}_i + r^{s}$

substituting (14) into (13) and rearranging will give

(15) $(r^{sm}_i - r^{sm}) = (\dot{b}^{sm}_i - \dot{b}^{sm}) + \dot{a}^{s}_i$

which represents "differential growth rates of MVA in different regions within the South.

Lima Target Equations

(16) $y^{sm}_T = \Pi\,(y^{sm}_T + y^{nm}_T)$; $\Pi = .25$

or

(17) $y^{sm}_T = \lambda\, y^{nm}_T$

where $\lambda = \Pi/(1-\Pi) = 1/3$

Substituting (2) and (5) into (17) will give

(18) $y^{s}_T = \{(\lambda\, b^{nm}_T)/b^{sm}_T\}\, y^{n}_T$

or directly from (5)

(19) $y^{s}_T = (1/b^{sm}_T)\, y^{sm}_T$

where y^{sm}_T is given by (17)

(20) (a) $r^{sm} = \dot{\lambda} + r^{nm}$

(b) $r^{s} = \dot{\lambda} + \dot{b}^{nm} - \dot{b}^{sm} + r^{n}$

Algorithm

1) Given a GDP growth rate of the North for the period of 1980-2000 and the initial value of North GDP in 1980, Eq .(1) will give the North GDP in the year 2000 (y^{n}_T).

2) With an independently estimated MVA share of GDP for the North in the year 2000, b^{nm}_T, substituting y^{n}_T obtained in the previous step into Eq.(2) will yield a North MVA in the year 2000 (y^{nm}_T). An estimate of b^{nm}_T was obtained by using

the North MVA-share-of-GDP growth rate observed in the period 1975–1980.

3) Given the values of y^{nm}_T and the Lima target share $\lambda = 1/3$, Eq. (17) will provide the South Lima target MVA (y^{sm}_T).

4) The value of the South Lima GDP can be solved either in terms of y^{sm}_T obtained in the last step, using Eq. (19) or in terms of y^n_T using Eq. (18). The two approaches should provide the identical solution. But either solution requires the parameter value of South MVA share of GDP (b^{sm}_T), which has to be independently estimated.

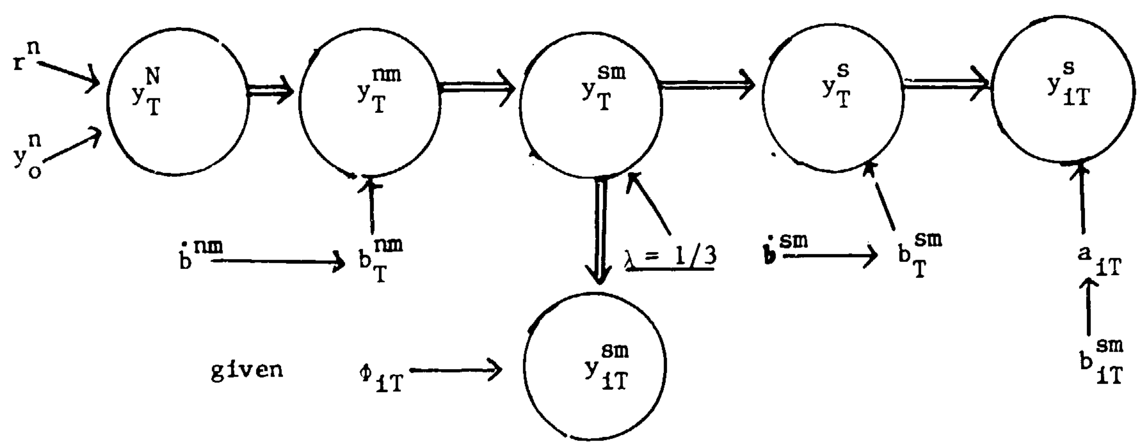
5) It is now straight forward to calculate each region's Lima target MVA since each region's share is given, i.e., Africa, 2%; Middle East, 3%; Latin America, 13%; and Asia, 7%.

6) Finally, the calculation of each region's Lima target GDP is in order. First, each region's GDP share parameter (a_i) needs to be estimated for this purpose from Eq. (10), $\phi_{iT} = (b^{sm}_{iT}\, a^{s}_{iT})/b^{sm}_{T}$ or $a_{iT} = \phi_{iT}\, b^{sm}_{T}/b^{sm}_{iT}$.

   But two variables in the numerator, "i"th region's share of Lima target MVA, ϕ_{iT} and South MVA share of Lima GDP (b^{sm}_T) are already known. Therefore, once each region's MVA share of Lima GDP (b^{sm}_{iT}) is estimated, GDP share parameter (a_{iT}) can be determined. The parameters b^{sm}_{iT} were estimated from historical values (1975-80) of the growth rate of MVA share of GDP for each region.

7) Now that the initial values (year 1980) and terminal values (year 2000) of MVA and GDP for each region, South, North and the world are respectively determined, the corresponding growth rates can be readily derived.

The above algorithm can be summarized in the following schematic form.



II. Regional Energy Requirements for the Attainment of the Lima Target and the Lima Energy Gaps

Let the GDP elasticity of energy be defined by

$$(1)\quad \varepsilon = (\Delta E/E)/(\Delta y/y) = \dot{E}/\dot{y}$$

where E is commercial energy consumption and y is GDP. Then we can derive from (1)

$$(2)\quad \dot{E} = \varepsilon \cdot \dot{y}$$

and

$$(3)\quad E_t = E_o\,(1 + \dot{E})^t$$

For regional energy production

$$(4)\quad P_t = P_o\,(1 + \rho)^t$$

where P is energy production and ρ is the production growth rate. Then the Lima energy gap is defined by

$$(5)\quad G = P_T - E_T$$

$$= P_o\,(1 + \rho)^{20} - E_o\,(1 + \dot{E})^{20}$$

where the time subscripts o and T denote the years 1980 and 2000 respectively.

Appendix

Table 1. GDP and MVA by Lima Target Region, 1975-1980

REGION	Gross Domestic Product (in millions of 1975 US dollars) 1975	1976	1977	1978	1979	1980	Average Annual Growth Rate
Developed Countries	4939162	5190183	5391695	5602888	5778932	5867015	3.50
	(30.65)	(31.53)	(31.97)	(31.85)	(32.06)	(31.12)	
Developing Countries	871049	925476	980331	1017240	1070648	1100297	4.78
	(17.94)	(18.17)	(18.11)	(18.57)	(18.85)	(18.97)	
Latin America	372251	389722	407034	423523	446443	472339	4.88
ECLA Region	(25.67)	(25.88)	(25.63)	(25.59)	(25.75)	(25.81)	
Middle East	88443	92790	99767	107466	119318	120633	6.40
ECWA Region	(7.29)	(7.53)	(7.65)	(7.94)	(7.69)	(8.33)	
Asia and the Pacific	272695	295733	316012	322210	331455	327666	3.74
ESCAP Region	(15.41)	(16.19)	(16.57)	(17.97)	(18.83)	(18.63)	
Africa	137660	147231	157518	164041	173432	179659	5.47
ECA Region	(8.88)	(8.30)	(8.40)	(8.64)	(8.81)	(8.76)	

REGION	Manufacturing Value Added (MVA) (in millions of 1975 US) 1975	1976	1977	1978	1979	1980	Average Annual Growth Rate
Developed Countries	1513752	1636527	1723899	1784252	1853046	1825784	3.82
	(90.64)	(90.68)	(90.46)	(90.42)	(90.18)	(89.73)	
Developing Countries	156231	168164	177575	188944	201803	208770	5.97
	(9.36)	(9.32)	(9.34)	(9.58)	(9.82)	(10.26)	
Latin America	95542	100862	104331	108372	114943	121933	5.00
ECLA Region	(5.72)	(5.59)	(5.49)	(5.49)	(5.59)	(5.99)	
Middle East	6447	6988	7631	8529	9179	10045	9.27
ECWA Region	(0.39)	(0.39)	(0.40)	(0.43)	(0.45)	(0.49)	
Asia and the Pacific	42023	47875	52378	57864	62399	61056	7.76
ESCAP Region	(2.52)	(2.65)	(2.75)	(2.93)	(3.0)	(3.0)	
Africa	12219	12439	13235	14179	15282	15736	5.19
ECA Region	(0.73)	(0.69)	(0.70)	(0.72)	(0.74)	(0.77)	

Sources: United Nations, Handbook of World Development Statistics, New York, 1982 (PPS/QIR5); SLANG Printout (J4163 W).

Numbers in parentheses are MVA share of GDP and regional share of World MVA

Note: The following countries are excluded because of data unavailability

Developed Countries: Iceland

Latin America: Cuba

West Asia: Bahrain, Lebanon, Oman, Dem. Yemen, United Arab Emirates, Yemen and Qatar

Asia and the Pacific: Solomon Islands, Brunei, China, Mongolia, Tonga, Samoa, Tuvalu, Vanuatu, Vietnam, Bhutan, Cook Islands, Kiribati, Maldives, Nauru, Niue, and Pacific Islands

Africa: Sao Tome and Principo. Seychelles, Southern Rhodesia and Zaire

Table 2. **TOTAL FINAL CONSUMPTION OF COMMERCIAL ENERGY BY REGION, 1975-80**

(in thousand metric tons of oil equivalent)

Region	1975	1978	1979	1980	TFC Average Annual Gr. Rate (1975-80)	GDP Average Annual Gr. Rate (1975-80)	GDP Elasticity of Energy (1975-80)
World	4709592	5235693	5416846	5357722	2.61	3.70	0.71
	(94.40)	(104.93)	(108.56)	(107.40)			
Developed Countries	4268455	4684476	4829567	4742242	2.13	3.50	0.61
	(85.55)	(93.84)	(96.80)	(95.04)			
Developing Countries[1]	441137	551217	587279	615480	6.89	4.78	1.44
	(8.84)	(11.05)	(11.77)	(12.34)			
Latin America	194955	234081	253065	266767	6.47	4.88	1.33
	(3.91)	(4.69)	(5.07)	(5.35)			
Middle East	32963	44350	51480	55444	10.96	6.40	1.71
	(0.66)	(0.89)	(1.03)	(1.11)			
Asia and the Pacific	179095	216426	229519	232963	5.40	3.74	1.44
	(3.59)	(4.34)	(4.60)	(4.67)			
Africa	34124	56360	53215	60306	12.06	5.47	2.20
	(0.68)	(1.13)	(1.08)	(1.21)			

Source: 1981 International Yearbook of World Energy Statistics, United Nations, 1983.

Note: Numbers in parentheses are millions of barrels of oil equivalent per day (mboed)

Commercial Energy: Commercial energy comprises solids, liquids, gas and electricity
Total Final Consumption of Commercial Energy: Total final consumption is the sum of consumption by the different end use sectors and is equal to total energy required less transformation and distribution losses.
The following countries are excluded:

Latin America: Cuba

West Asia: Lebanon, Oman, Dem. Yemen, Yemen

Asia and the Pacific: Solomon Islands, Brunei, China, Mongolia, Tonga, Samoa, Tuvalu, Vanuatu, Vietnam, Bhutan, Kiribati, Maldives, Nauru, Niue, and Pacific Islands

Africa: Sao Tome and Principo, Seychelles, Southern Rhodesia, Zaire and Lesotho

1 Developing countries' total was significantly reduced by the exclusion of Asian Centrally Planned Countries' (mainly China) commercial energy consumption, which accounted for almost 40 per cent of the total consumption in the developing countries with around 8.4 mboed in 1980.

Appendix

Table 3. **PRODUCTION OF COMMERCIAL ENERGY BY REGION, 1970 - 1980**
(in thousand metric tons of oil equivalent)

Region	1970	1975	1978	1979	1980	Average Annual Growth Rate (%) 1970-'75	1975-'80	1970-'80
World	4572733	5162308	5704411	5988197	5888402	2.46	2.67	2.56
mboed	(91.65)	(103.46)	(114.33)	(120.01)	(118.01)			
Developed Countries	3161549	3475795	3776857	3960651	4028292	1.91	2.99	2.45
Regional Share (%)	(69.14)	(67.33)	(66.21)	(66.14)	(68.41)			
mboed	(63.36)	(69.66)	(75.70)	(79.38)	(80.74)			
Developing Countries	1411184	1686513	1927554	2027546	1860110	3.63	1.99	2.80
Regional Share (%)	(30.86)	(32.67)	(33.79)	(35.86)	(31.59)			
mboed	(28.28)	(33.80)	(38.63)	(40.64)	(37.28)			
Latin America	315193	285460	322174	358230	380047	-1.96	5.89	1.89
Regional Share (%)	(6.89)	(5.53)	(5.65)	(5.98)	(6.45)			
mboed	(6.32)	(5.72)	(6.46)	(7.18)	(7.62)			
Middle East	503371	713343	828346	958428	891563	7.22	4.56	5.88
Regional Share (%)	(11.00)	(13.82)	(14.52)	(16.00)	(15.14)			
mboed	(10.09)	(14.30)	(16.60)	(19.21)	(17.87)			
Asia and the Pacific	309111	439418	470083	375885	282231	7.29	-8.47	-0.91
Regional Share (%)	(6.76)	(8.51)	(8.24)	(6.28)	(4.79)			
mboed	(6.20)	(8.81)	(9.42)	(7.53)	(5.66)			
Africa	283509	248292	306951	335003	306269	-2.62	4.29	0.78
Regional Share (%)	(6.20)	(4.81)	(5.38)	(5.59)	(5.20)			
mboed	(5.68)	(4.98)	(6.15)	(6.71)	(6.14)			

Source: 1981 International Yearbook of World Energy Statistics, United Nations, New York, 1983.

Note: Numbers in parentheses are regional share of world production of commercial energy, which comprises solids, liquids, gas and electricity, and millions of barrels of oil equivalent per day (mboed). The following countries are excluded for reasons of compatibility with GDP and MVA data in each region. In Africa, a few more countries are excluded because of their negligible production volumes.

Latin America: Cuba
West Asia: Lebanon, Oman, Dem. Yemen and Yemen
Asia and the Pacific: Solomon Islands, Brunei, Tonga, Samoa, Tuvalu, Vanuatu, Bhutan, Cook Islands, Kiribati, Maldives, Nauru, Niue, Pacific Islands, and centrally planned countries in Asia, except Lao People's Dem.Rep. and Democratic Kampuchea.
Africa: Equatorial Guinea, Mauritania, Sao Tome and Principo, Senegal, Seychelles, Sierra Leone, Southern Rhodesia, Swaziland, Zaire, Benin, Botswana, Chad, Comore Isl., Gambia, Guinea-Bissau, Niger, Somalia, and Upper Volta.