

LBL-7808
UC-95c **C.2**
TID-4500-R66

RECEIVED
LAWRENCE
LABORATORY

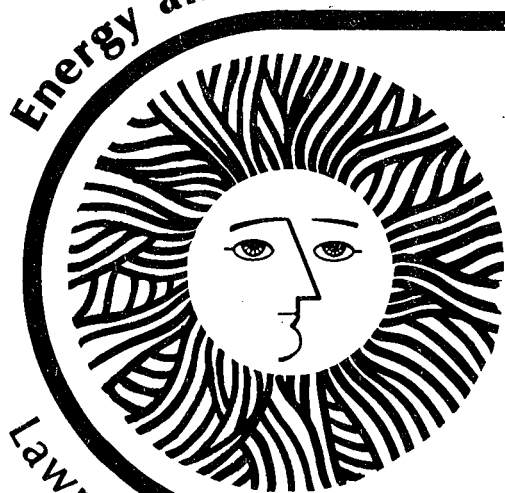
MAY 24 1978

LIBRARY AND
DOCUMENTS SECTION

TWO-WEEK LOAN COPY

This is a Library Circulating Copy
which may be borrowed for two weeks.
For a personal retention copy, call
Tech. Info. Division, Ext. 6782

Energy and Environment Division



Urbanism And Energy In Developing Regions

*Richard L. Meier, Sam Berman,
and David Dowell*

*With the assistance of
Tim Campbell, Hisham Amr Bahgat,
Hyong-kuk Kim, and Aruna Sarvate*

March 1, 1978

Lawrence Berkeley Laboratory University of California/Berkeley

Prepared for the U.S. Department of Energy under Contract No. W-7405-ENG-48
also prepared for Brookhaven National Laboratory under contract to U.S.
Agency for International Development under P A S A ERDA-TAB-995-18-76
with the U.S. Department of Energy.

LBL-7808

C.2

LEGAL NOTICE

This report was prepared as an account of work sponsored by the United States Government. Neither the United States nor the Department of Energy, nor any of their employees, nor any of their contractors, subcontractors, or their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness or usefulness of any information, apparatus, product or process disclosed, or represents that its use would not infringe privately owned rights.

Urbanism and Energy in Developing Regions

Richard L. Meier, Sam Berman, and David Dowell

With Assistance of

Tim Campbell, Hisham Amr Bahgat,
Hyong-kuk Kim, and Aruna Sarvate

March 1, 1978

Work supported in part by the U. S. Department of Energy and the Brookhaven National Laboratory under Contract to U. S. Agency for International Development under P A S A ERDA-TAB-995-18-76 with the U. S. Department of Energy.

Summary

In comparison to the cities of the industrialized countries of the world, the urban metropolitan areas of the developing countries have a much higher likelihood for encountering severely critical shortages of food, resources, and energy. This crisis situation is mostly due to the unprecedented increase in the population of these urban areas (urbanization). The promise of a better life brought about by employment and educational opportunities as well as vastly increased human interaction all provide an ever present attraction for the poor rural population to migrate to the urban areas with perceived opportunities. This migration, superimposed upon an urban birth rate that is still high in many societies leads to increases in the population of the developing urban regions from 3% to 10% per year.

While the rural dweller most often uses little marketed energy, and relies upon non-commercial forms for basic energy requirements, the situation changes markedly upon the transition to an urban environment. Cities are engines for development; therefore, increases may be expected in commercial energy use, principally for transportation, electric power, manufactured goods, and services.

The coupling of the large increases in urban populations with the sharp increase in commercial energy use means that the developing countries often expect 400% to 600% increases in energy requirements by the end of this century, although per capita the rise is still modest. This situation is in sharp contrast to the energy needs of the industrialized countries where 50% increases in energy are considered reasonable. Herein indeed lies an energy crisis with critical portent for the entire world.

A further exacerbation of the energy problem arises in considering the amount of energy exported from the cities of developing countries to the rest of the world -- mainly developed. Should the effect be as large as has emerged from the analyses of Hong Kong and South Korea, then the requirements for energy demand in the future will be notably greater than the quantities we, or any predecessors, have projected. Extrapolations of demand to 1995 could reach as much as one third of the world total, yet in the light of probable rising prices it seems unlikely to eventuate.

It is more reasonable to expect that the developing metropolises will find ways to diminish their energy use. The innovations and responses to population growth that will develop over the next several decades should cause unprecedented social, institutional, and environmental changes which could profoundly affect the developing countries and their urban settlements.

In order to illuminate the various components of urbanism and energy in the developing regions and how they might respond to this energy crisis, we have attempted to portray how typical megalopolitan regions will develop and organize themselves during the next 15-20 years (pointing to the period when present policy shifts would have maximum impact). From the pictures that emerge here some insights can be given where technical, organizational, substitutional and other techniques may be introduced that can ameliorate the impending energy crisis.

Among the many critical issues facing the developing country urban areas some of the more significant energy-related issues are:

- The importance of conservation policies in offsetting increased demand for energy intensive goods with improved efficiencies and organization.
- Resource-conserving urban design where new development can occur in physical and man-made environments which permit quality living standards with sensitive and wise use of materials, energy and space.

- Creation of institutions for transfer of appropriate technologies that propagate from the more industrialized areas to be made relevant for indigenous industry and institutions.
- The choice of nuclear or non-nuclear sources for the generation of electricity and how this choice depends on the development of both indigenous renewable energy sources and energy uses.
- The development of energy use data so that policies and planning can be carried out in an atmosphere of factual information
- The relation between energy decisions and balance of payments
- Raising the consciousness of the entire world to the interrelated benefits of international conservation of energy

The central concern will undoubtedly be focused first upon food, and then upon the electrical demand and the associated requirement for liquid fuels which make the urbanization possible. These two specific sectors will stimulate the greatest demand for energy use. In contrast to the industrialized cities which are better known to us, the social and cultural differences in the developing countries allow for varied counterintuitive approaches leading to genuinely energy-conservative urban environments.

Our vision of these approaches elaborated here, as they are adapted to the institutions and organizations of the developing urban regions, unfolds the following new energy system concepts:

- Technologies and infrastructures to alleviate critical housing shortages
- Innovative personal transportation services
- Substitution of telecommunications for personal travel
- Intensive urban agriculture and urban hydroponics
- Novel waste utilization for high protein food production
- Proliferation of simple solar applications
- Development of urban institutes of science and technology which integrate with the social and business structure of their host community

FIGURES

Fig. 1. Prospective Global Urban Population	9a
Fig. 2. Trend Changes in Energy Consumption Levels	9b
Fig. 3. Agglomeration Processes Currently Operative in an LDC Metropolis	12
Fig. 4. Time Scale for Projects in Appropriate Urban Technology	16
Fig. 5. Total Energy Consumption in Cities	17
Fig. 6. Competition in the Forthcoming Global Urban System	25
Fig. 7. Interaction in the World Urban System	26
Fig. 8. Reorganized Passenger Transport	43
Fig. 9. Slow-ways for Aid-to-walking Vehicles	45
Fig. 10. Hydroponic Installations in Lebanon	47
Fig. 11. Protein from Waste Recycle	50
Fig. 12. Plant Protein Foods	50
Fig. 13. Substitution in Materials.	53
Fig. 14. Solar Applications Needed for Domestic Use	55
Fig. 15. Institutions for Urban Technology Transfer	61
Fig. 16. Creation of Resource-Conserving Organization	63

TABLES

Table One	Major Urban Regions -- 1978	13
Table Two	Major Urban Regions -- 1995	14
Table Three	Energy Uses by Domestic Functions In Typical LDC Cities	23
Table Four	Domestic Consumption of Fuels in Indian Cities	29
Table Five	Energy Matrix - Hong Kong, 1971	30
Table Six	Energy Component in Commodities and Services Important for Urban Living (U.S.)	39
Table Seven	Foci for New Urban Settlement: 1978-95 .	66

Introduction

A great deal more is known about cities, and the process of urbanization, than has been recorded. We were asked to address tasks for which information is poorly recorded in the countries themselves, and even more imperfectly gathered by institutions in this country. Moreover, a large proportion of the information presented, particularly in the quantitative form, may be regarded as convenient fictions. In all but a few of the metropolitan areas we discuss, there is no quality control over the basic data offered, but even graver difficulties are encountered with what is left out.

We have the anomaly then of seeing international aggregate data presented by official agencies being privately disavowed by the responsible professionals in the respective areas. Moreover, leading professionals in the respective areas in most, but not all, LDC metropolises do not see any way out of their local predicament. We have agreed upon a different outlook; it is assumed that solutions will be found if there are explicit precedents somewhere in the world where problems of that type and of equivalent dimensions have been solved. We are even more hopeful that further investigation and intensive organization can bring new knowledge to the crucial problems facing cities in developing countries, but obviously cannot predict the results in advance.

If macro-economic models cannot be trusted for anything more than dimensional scaling, what then can be done? We have depended upon our powers of observation. Within the team assembled for this study more than forty cities in the developing world have been visited for purposes other

than tourism, and many lived in for much longer periods. All through this assessment of issues we have attempted to go to the nub of the problems as experienced at various levels of analysis. When statements are made without attribution to authority about conditions in LDC cities, the reader must assume that it rests upon the experience of the team. The investigators are ourselves, and the written sources are a long list of working papers and unpublished reports or dissertation drafts, but an even larger fraction of the basic data draws upon memorable experience. Very little in library literature covers the period since 1971, whereas the bulk of our experience has been accumulated since then. These sources are not citable because they primarily treat energy as a minor issue in complex urban affairs; they draw upon arguments made about water, or self-help housing, or food, sometimes even recreation, which have significance for energy use.

We have introduced some of the available published data as samples showing the huge amount of variation from one city to another, and have added our reservations about their meaning for the future. The important outcome is the specification of options, the things that can be done to save resources, particularly energy, thus postponing the time that new production capacity needs to be introduced. We have also taken a closer look at the highest growth regions to see if the demographic projections, based upon the most dependable data available, are reliable. Can those numbers be sustained in that region?

The task we undertook was sixfold; it was completed with varying degrees of thoroughness, but much additional material was added. Our first intension was to "identify specific energy demand components." The data available suggested tenfold and greater variations not only in components, but also in totals; however, much more often nothing at all is

reported. Therefore, one cannot propose policies which depend upon either local or aggregate data; very different approaches must be originated. The second intention was to "characterize different patterns of urbanization according to energy intensity along with opportunities for reduced energy use." The most significant differentiation is by size, since growth in population and area requires superimposition of new kinds of energy-dependent infrastructure.

The third was to look at "lifestyles and energy use patterned by culture." This was accomplished only qualitatively, as in Table 3, which shows the kinds of variations observed in five different LDC metropolitan areas. The principle of diversity is fundamental, because it shows how one needs to proceed in further research and action. When analyzing the forthcoming global urban system (Figures 6 and 7) we are able to foresee some kinds of cultural convergence, at least in the central districts, brought on by shared telecommunications and air traffic. The fourth intention on "food and water supply...waste disposal" led only to qualitative generalizations, but very promising opportunities were suggested that could introduce considerable savings in the future.

The fifth asked for policy recommendations. This is a time for constructive change in aid-giving relationships, so it is possible to offer a rich set of promising institutional arrangements sponsoring energy substitution and conservation. The sixth intention asked for specific projects; we have responded with eight non-routine categories which seem to have the highest priority if we are to prevent future disasters, including those arising from a severe shortage of energy.

We have gone on to identify eleven foci for the most rapid urban settlement between now and 1995. The specific opportunities available to each of these must be studied thoroughly, first for the feasibility for accomodating the population pressure, and then for the most propitious means for coping with the demand for energy (Table 7). Some brief hints as to the varying outlooks for several of these most rapidly growing metropolitan regions are provided in the appendices.

This seven week study was started at a time when all research assistants normally available had already been hired, and the libraries and laboratories were due to be shut down for the holidays. We could solve the personnel problem by finding Third World graduate students who were allowed to work a quarter time on scholarships -- if it was relevant to their studies. We had very restricted access to the repositories of knowledge and data. Given the quality of the information, this difficulty was turned into an advantage -- it forced us to use a broader range of knowledge resources.

Justification for Extrapolations

A roundabout procedure for estimation has had to be applied in order to attach some dimensions to what were first formulated as intuitive semi-quantitative relationships. A thorough assessment of the world energy market (excluding Communist areas) has recently appeared from the Massachusetts Institute of Technology Workshop on Alternative Energy Strategies (WAES) with contributors from fifteen countries (Wilson, 1977). In the appendix they prepared a special analysis of the supply and demand for energy from developing countries. The units they employed were millions of barrels per day of oil equivalents (2.2×10^{18} joules/yr or 2.1 "quads" per year or 530×10^{12} kilocalories/yr).

In 1972, which was the last full year at the old prices for petroleum, the developing countries consumed about 15% of the world's energy. By the year 2000 it was expected that this group (which includes OPEC countries) would use 25% and would still be expanding rapidly. The WAES subdivided the developing category into three groups, for which independent projections were made:

1. Lower income countries with annual per capita incomes under \$200 at current prices. These twenty countries include only India, Pakistan, Bangladesh, and Ethiopia with million size cities. Of their estimated 1005 million population in 1975 (83% in South Asia) about 20% is urban.
2. Middle income countries range from \$200 to \$2000 per capita income at current prices. These fifty-three political units (the largest of which are Brazil, Mexico, Ghana, Turkey, and South Korea) contained about 632 million people (25% in East Asia, 30% in Africa, and the remainder almost entirely in Latin America). Their urbanization ranges from 20-80% not counting city states, but the average is around 50%.
3. OPEC countries with a wide range of per capita incomes. There are thirteen altogether, counting the United Arab Emirates as one. Countries with million size cities are Algeria, Ecuador, Indonesia, Iran, Iraq, Nigeria, and Venezuela. Their total population was 292 million in 1975. The average level of urbanization approximates 30%, but is rising much more rapidly than any other grouping.

Thus, for all of these developing economies the WAES estimates 1929 million people in 1975, as compared to 732 million for the industrialized economies. Our estimates suggest that there are roughly equal numbers of urbanites in both categories at 600 millions apiece. If we make the reasonable assumption that surplus people from rural areas in these societies will be urbanized, the industrialized metropolises would add about 40% to their population by the year 2000 while those in developing countries would almost quadruple (rising to 2,300,000,000) and still be growing at a rapid rate.

The WAES study left out of account in their supply and demand estimates all the non-commercial energy sources (wood, agricultural waste, cow dung, etc.). Therefore, about 90% of energy used in developing countries that they do consider will be expended in cities and in transport between them. This is not really different from that of the industrialized countries, since the heavy energy-using industries (other than aluminum and fossil fuel production) are urban, and urban residents have higher incomes than the rural consumers. Income growth is what the WAES projected from 1960 through the present to the year 2000, according to a "high" and a "low" rate of growth for the world economy. They then hypothesized changes in the income elasticity of demand for energy for each category of economy (which ranged from 1.12 for OPEC countries to 1.90 for lower income African countries in the 1960-72 period, and 1.28 overall, based upon World Bank data) which causes the demand for energy to grow only a little more rapidly than income, assuming the price of oil goes up another 50% after 1985.

The estimated energy requirements for all developing countries would rise about 500% by the year 2000, remaining 90% urban over this period by our own judgement, thus per capita consumption calculated in the manner of the WAES would rise only 35%. However, much of the energy consumption would take place as petrochemicals and metallurgicals production in the richest OPEC countries, which by then would be highly industrialized. After making that adjustment we come to the conclusion that for non-OPEC developing countries per capita demand should rise 15-20% over the remainder of the century. That fits very well with our preconception of what can be achieved between now and then.

The WAES study goes on to make heroic estimates about the supply of energy. The non-OPEC countries would need to be net importers of 1-2 units (10-20% of their requirements) throughout this period. The alternatives for the respective metropolitan areas are to import OPEC petroleum or to build nuclear power plants. The actual demand for nuclear power generation cannot be calculated from this aggregated analysis, but must start from the possibilities open to each power grid for meeting local demand. The WAES study suggests a three-fold range in nuclear capacity by the end of the century.

Significantly, the WAES estimates of energy requirements for the developing countries are likely to be on the low side since they did not distinguish between urban growth and overall population growth, which proceeds at roughly double the present growth rate in the countryside. This is likely to incorporate a significant bias in their energy use calculations, since in developing countries the energy sources (wood, agricultural waste, cow dung, etc.) are primarily non-market. In the estimates of energy demand the appropriate growth rate should be the urban growth rate, or something possibly even greater, because many of these cities will be producing manufactures for export to developed countries. The point is appropriate in any future which presumes that the countryside retains approximately the present total population, with the urban regions absorbing the increases in population through migration.

This "massive migration" scenario is highly probable, since most rural areas are clearly overcrowded already, and most cities actually have the capacity, based upon available land and presumably available infrastructure, to absorb the surplus being created by the population increase. We have discovered some metropolises where that pressure is not likely to be sustained, but then alternative urban settlement programs appear feasible. Even with per capita urban energy consumption in developing countries remaining what it was in 1972, total consumption would then reach some 70 quads in 1995, nearly 25% larger than the WAES prediction based upon current conditions.

Statement of the Problem

Approximately 80% of the energy, and of the commodities with high energy content, are consumed in the cities of the world -- even though they possess only 40% of the population. In the future both proportions will be higher. Because surplus people now being born in the countryside find sources of livelihood most often in urban regions, the cities will take almost all the future expansion in world population.

The future expansion of world urban population three to four generations hence implies an increase by 300-500% in demand for urban residence (Fig. 1). Calculations suggest that this outcome is technically feasible; quite a few more than eight billion people could be provided an adequate living in cities, despite the exhaustion of fossil fuels (Meier, 1974, 1976a). The cities of the future will need to be physically organized quite differently from present arrangements, but the essential qualities of urban life can be maintained and probably improved. A number of resource-conserving technologies and institutions will be required by the cities in the presently developed areas of the world, as well as the less developed, in order to meet these expectations (Fig. 2). These technologies need to be created over the next several decades, if they are to be ready at the time petroleum and gas supplies decline rapidly (2000-2020?).

People use more marketed energy in the cities than in the countryside -- although this differential disappears as societies mature, reaching a steady state in population and economic opportunity. Therefore, the anticipated growth in urbanization generates an intense demand for more energy substitutes. Fortunately the bulk of the new growth in urban population is expected to occur in semi-tropical and tropical regions, mostly along coastal

PROSPECTIVE GLOBAL URBAN POPULATION

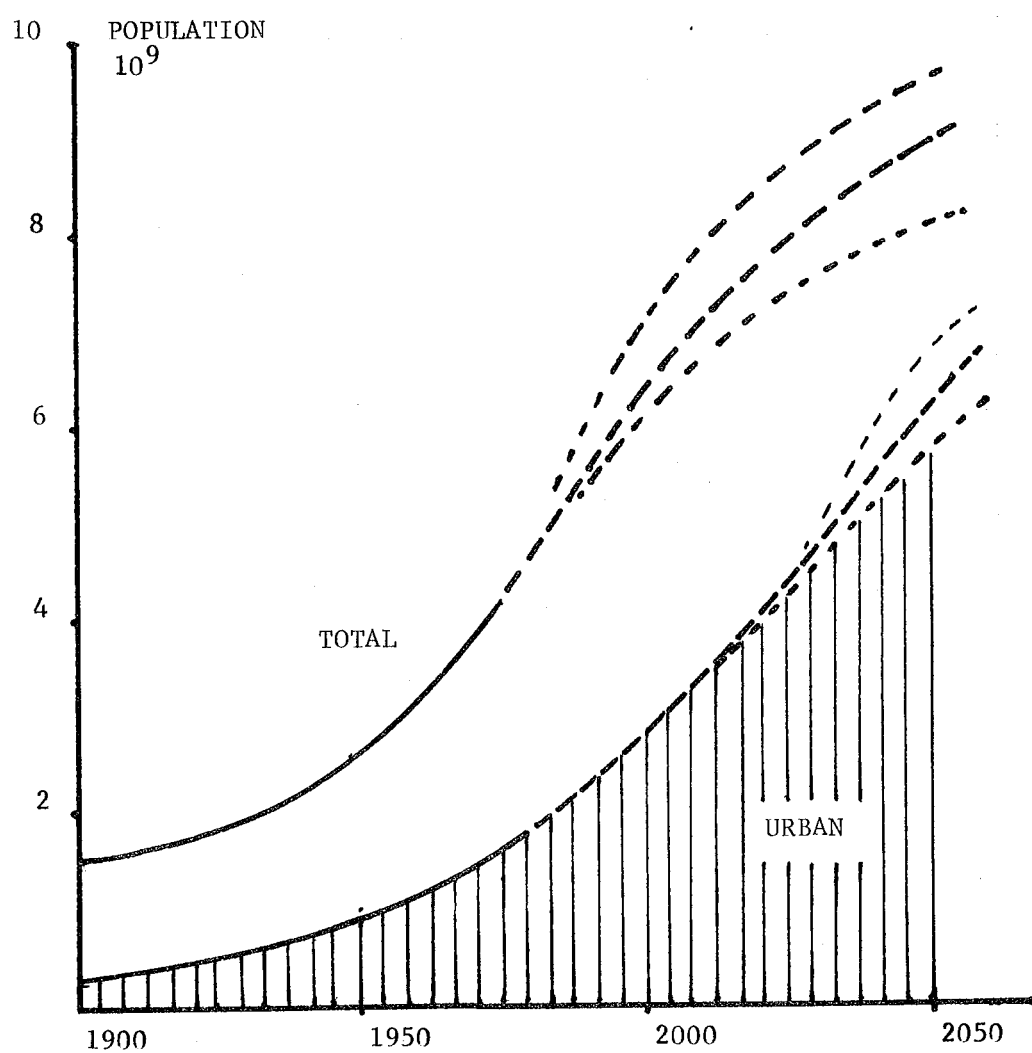


Fig. 1. Prospective Global Urban Population

TREND CHANGES IN ENERGY CONSUMPTION LEVELS

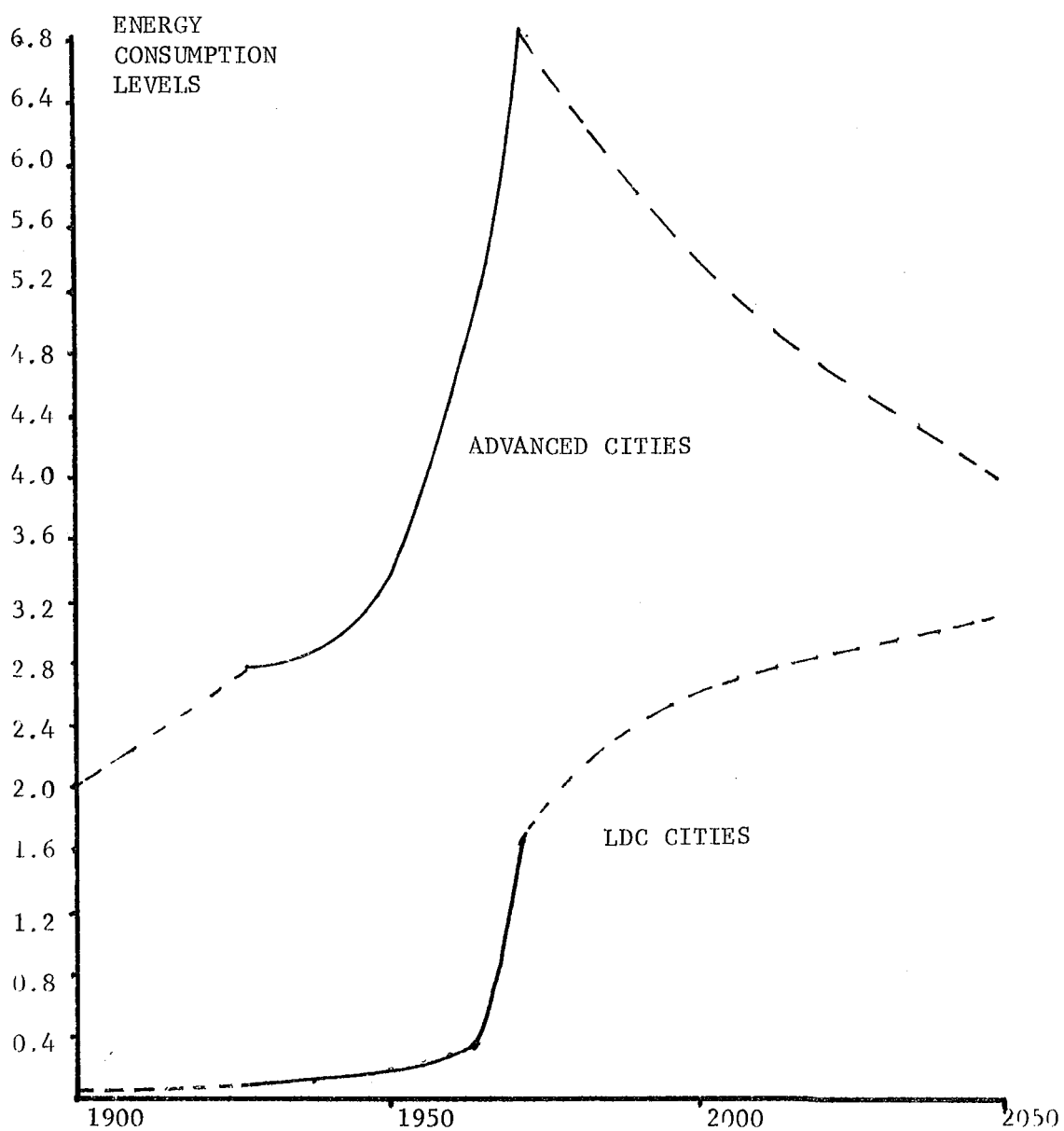


Fig. 2. Trend Changes in energy consumption Levels
(metric tons of coal equivalent per capita per year)

strips, where requirements for comfort and transport are more economical to meet than in the temperate zone where the Industrial Revolution first took hold. Transport and energy-intensive materials are more substitutable than food or thermal comfort, which demand greater inputs in colder climates.

Too often it is claimed that fuels expended in urban living are lost. The energy flows to the surroundings in the form of heat -- eventually it is radiated back to outer space as infra-red waves producing a huge increase in entropy in the process. However, cities simultaneously accumulate negentropy; the potential quantities retained are much more than what the same people could save if they are distributed throughout the countryside. This negentropy takes the form of artifacts, of communications, and of distributed knowledge recorded in various forms. People organize themselves into firms, cooperatives, associations, communities, schools, clubs, and service groups to take advantage of the potentials created by the accessibility and specialization present in the city. A rich diversity of cultural output can arise from that kind of organizational foundation, but it can fail to appear if the city is crippled by resource scarcities or internal conflict.

The task with which human civilization as a whole is confronted involves finding a transition to a resource-conserving urban structure which allows the complex, productive life to be lived in a few hundred most favorable regions, recognizing that the simple life, attuned to nature, will remain available to a minority scattered throughout the habitable areas. Given the energy demands upon future energy resources, the problem is the prospective cost increase in resource availability. The application of knowledge of all kinds to the development of new arrangements appears likely to find solutions. Developed societies will find it advantageous to consume less

energy; less developed societies will need to learn much earlier how to get the most (whether welfare, capital, negentropy or human organization) from the energy available.

Mobilization of Human Potential for Development

People are attracted to cities as long as opportunities there are superior to those in the countryside (Fig. 3). The degree of attraction varies greatly from region to region and from stage to stage in the demographic transition (from high fertility and high mortality to low mortality followed by low fertility). Added pressures include strain on the carrying capacity of the hinterland for human population, politico-religious conflicts, cultural centralization, and several other influences important for a few restricted parts of the world (Findley, 1977). Thus, we have tried to estimate the present accumulation of population for the largest agglomerations, developed and underdeveloped (Table One). The sources are United Nations reports, Rand McNally Atlas estimates, and occasional recent reports from administrators in the respective metropolitan areas who are knowledgeable about reporting errors and enumeration problems. The demographic dimensions in Table One should be regarded as reasonable approximations of the numbers of residents within territories equivalent to the Standard Metropolitan Statistical Areas in the United States. A second list proposes a set of estimated sizes, based upon as many variables as relate to the available data, for 1995 (Table Two). It will be noted that some of the urban regions are growing together and forming supercities or megalopolises.

The concern for the future around 1995 is based upon the observation that decisions taken now will require at least until 1980 to gain acceptance

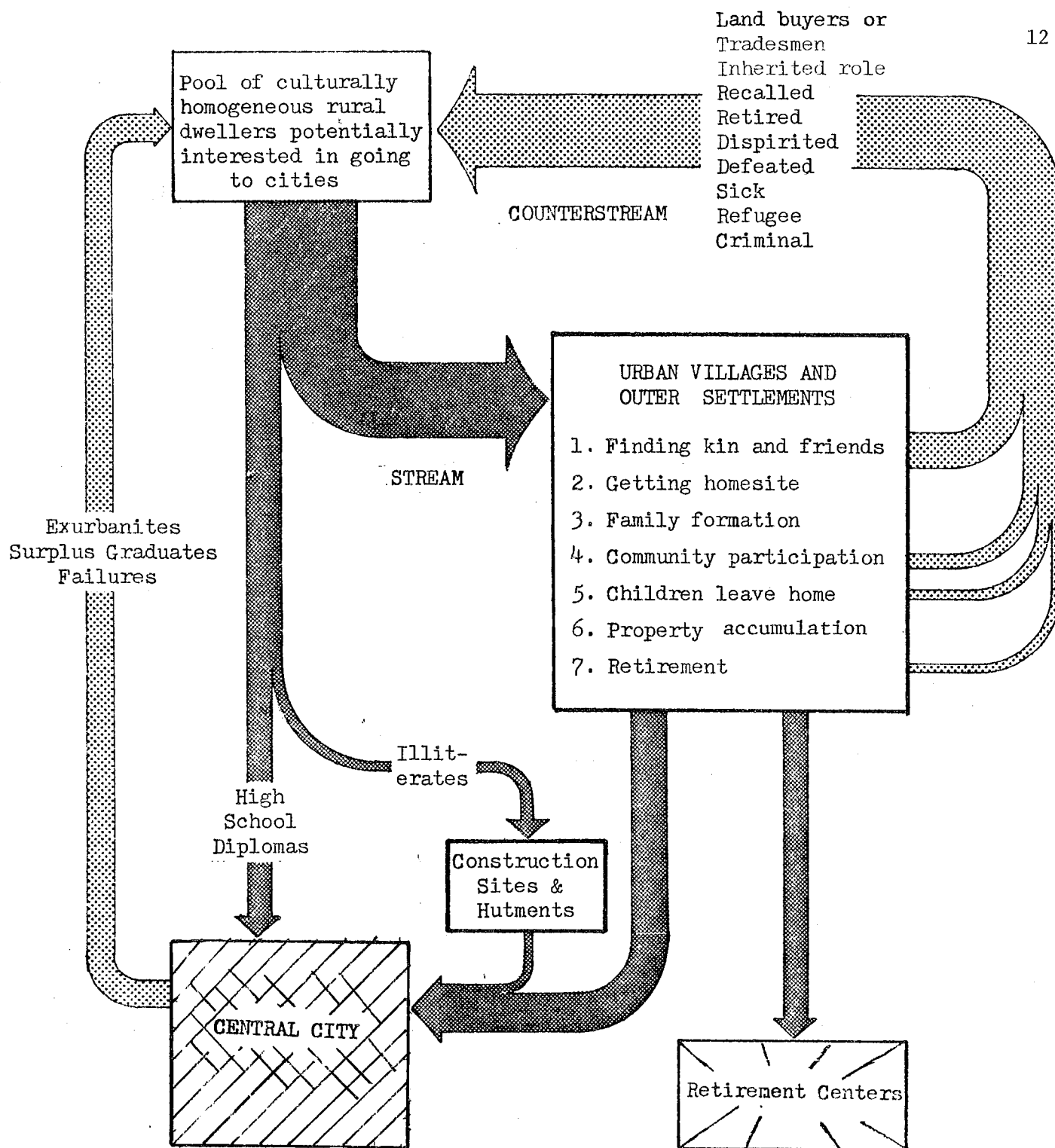


Fig. 3. Agglomeration processes currently operative in an LDC metropolis. Net immigration and excess fertility contribute to growth in the range of 3 - 10% per year. Drawn from field in a dozen countries and organized according to schema combining E.S. Lee (1966) with E.B. Brody (1970).

Table One
MAJOR URBAN REGIONS -- 1978

<u>Urban Region</u>	<u>Estimated Population</u> <u>(millions)</u>
	24.0
Tokyo-Yokohama	24.0
New York	18.5
Osaka-Kyoto-Kobe	14.0
*Mexico City	12.6
Moscow	12.0
London	11.8
*Cairo	11.5
*Sao Paulo	11.4
Paris	10.3
Los Angeles	10.2
*Calcutta	10.2
*Buenos Aires	9.9
*Seoul	9.8
*Rio de Janeiro	9.2
*Shanghai	9.0
Chicago	8.4
*Bombay	8.0
*Manila	6.8
*Jakarta	6.5
*Delhi	6.0
*Peking	5.5
Philadelphia	5.5
Leningrad	5.4
Detroit	5.2
Ruhr	5.1
San Francisco-Oakland-San Jose	4.9

* An LDC region, and growing rapidly

Table Two
MAJOR URBAN REGIONS -- 1995

<u>Urban Region</u>	<u>Estimated Population</u> <u>(millions)</u>
Tokaido (Tokyo, Nagoya, Kyoto, Osaka, Kobe)	50
*"Paulo-Janeiro" (Sao Paulo, Rio de Janeiro)	45
"Boswash" (Boston, Hartford, NY, Phila, Balt, Wash)	43
*Nile Delta (Cairo, Alexandria)	40
*Mexico City	28
*Calcutta-Kharagpur-Haldia	22
*Shanghai	20
Moscow	20
"CalSouth" (Los Angeles, San Diego, Tijuana)	19
*Bombay	19
*Jakarta	18
*Manila	17
*Delhi	17
Seoul	16
Buenos Aires	14
Paris	14
*Karachi	13
London	13
*Bankok	12
*Peking	12
*Lima	11
Chicago	11
Leningrad	10
*Wuhan	10

* still growing rapidly due to immigration

by the Office of Management and Budget and by Congress -- our dominant proposers and disposers. It would take two more years to carry out pilot tests with contractors, recruit core staff, and establish working relations with officials in a number of key LDC metropolises, followed by the initiation of a few early projects. Two more years at least are needed to build "assembly lines" for hundreds of projects that would bring together tens of thousands of professionals (there and here). Because these projects are innovations for the most part when carried out in the respective environments, more than half of them should fail within two years (if this "infant mortality" for projects is not recorded, it will be because the overall program was designed so timidly it could not possibly deal with the scale of the problems). Surviving projects normally turn the corner into some path to success in two or three years and show maximal return to society five or so years after that (Fig. 4).

Therefore, the whole resource-conserving program for cities of the world should be addressed to conditions anticipated about 1995, rather than those described in recent field reports (mostly written in the 1970-5 period).

Because of the huge increase in numbers in the course of this transition, the total consumption of the LDC cities must continue to increase. The alternative is to fall below subsistence levels, with unprecedented human suffering and eventual loss of life. In the long run the needs in LDC's are expected to exceed those of advanced cities, even though some LDC cities graduate from that category to join the advanced group (Fig. 5). The Japanese cities have done this recently, and Teheran, Singapore, and Caracas are undertaking it at present.

TIME SCALE FOR PROJECTS IN
APPROPRIATE URBAN TECHNOLOGY

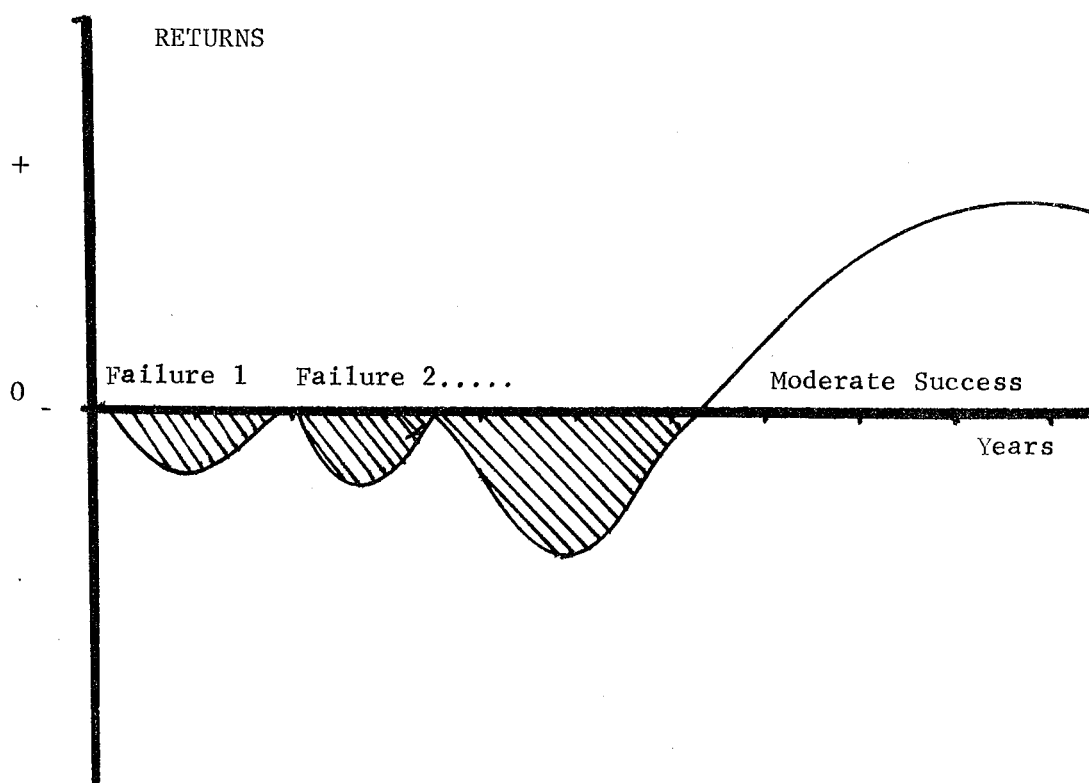


Fig. 4. Time Scale for Projects in Appropriate Urban Technology
(An algebraic model for optimizing investment in search for
appropriate technology and prototype development is provided by
R.E. Evenson and Y. Kislev "A Stochastic Model of Applied Research,"
Journal of Political Economy 84, 1976, 265-81.)

TOTAL ENERGY CONSUMPTION IN CITIES

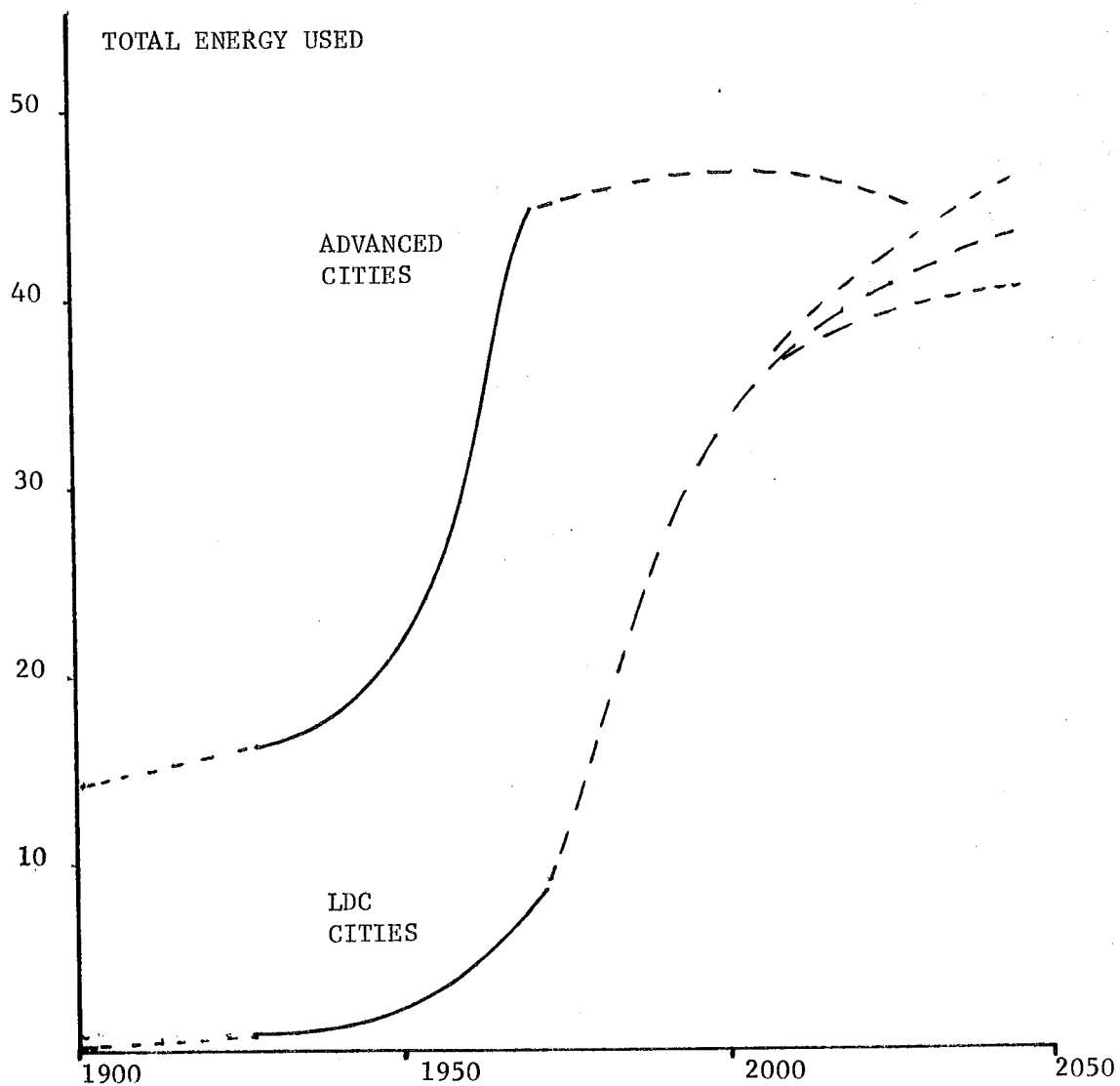


Fig. 5. Newly developing urbanization may eventually need more energy than presently developed metropolitan areas. (millions of barrels per day of oil equivalent, MBDOE).

Issues and Opportunities

The issues and opportunities facing present American foreign policy regarding energy uses in rapidly growing LDC cities include the following:

1. Conservation policy. By general agreement, based upon recent evolution of measurement techniques, efficiency improvements apply to a production process; they answer the question of "how to get more output from less input." Concepts of conservation suggest that it is possible to "obtain more satisfactions from the available outputs." This can be done by eliminating waste at the point of consumption, by appropriate recycling, or by shifting cultural values. Because salvage is necessarily quite efficient in LDC urbanization, the net savings from conservation are expected to be small. At the same time such cities will have large numbers of people recently arrived from the poorest rural districts attempting to rise above subsistence. They will inevitably consume more energy on the average even if the price is high, as they become fully urbanized, although they would consume much more if they patterned themselves after present advanced urbanites. Thus moderate savings in such cities will be counterbalanced by the increased equity in energy distribution. We see in Table Two that significant increases in per capita consumption are expected, in contrast to marked savings, mainly from conservation procedures, in the advanced cities. These savings attributed to conservation should show up primarily in fossil fuels and electric power, and much less in the utilization of biomass, since conservation of biomass is achieved most often through the use of well-tested traditional methods available within the culture.
2. Resource-conserving urban design. The appropriate technologies will be needed as quickly as possible for burgeoning LDC cities; an important fraction of such technologies may then be fitted into the reconstruction of

mature, developed cities. Population pressures, climatic conditions, natural hazards, cuisine preferences, and local politics combine to require many variants in design.

3. Institutions for the transfer of appropriate urban technologies.

Existing international institutions, such as the World Bank and the multinational corporations, are production-oriented. They are ill-fitted to the development of projects designed to enhance the efficiency of consumption. Quick-acting alternative organizational forms are required.

4. Dependence upon nuclear fuels. The demand for electrical power built up in LDC cities will depend very heavily upon procedures for installing efficient nutrition, domestic appliances, transport, and intermediate scale manufactures. The demand that exceeds local hydro, geothermal, and miscellaneous local sources will appear as a demand for nuclear power and imported fossil fuel.

5. End use data in energy. Improving the overall utilization efficiency for human purposes requires the collection of quite new kinds of urban data. For their planning and rationing the respective countries and regions will want to collect information about (a) the energy flows through a city, (b) the installed capacities for consuming energy, and (c) the inequities in distribution of goods and services created by inadequate supply. What information to collect, and how to assemble it with promptness and reliability, will be a joint enterprise to be carried out with other countries for years to come.

6. Balance of payments. Although the balance of payments issues are very pressing at the moment, and the ultimate effects of resource-conserving urban design will contribute to the achievement of balance, other equilibrating forces have much more immediate effects. This point need not be

pursued further at this time.

7. Overriding justification for making grants in aid. Given the world market in energy, any amount that is conserved elsewhere in the world helps us as well as those who save energy. With reduced world demand the pressure to raise prices is reduced, so monopolistic collusion is threatened, and the price the United States is expected to pay for its imports would be less.

Conceptual Model of Urban Growth --
Patterns of Urbanization

Since data for the consumption of energy in various metropolitan regions are scattered and almost universally out of date, a mode of stage-wise development helps focus the strategies for energy conservation. All cities accumulate special facilities and services as they grow and evolve, irrespective of culture, geography or political preferences.

Cities over five million people are singled out for special attention because they have special infrastructure requirements competing for capital and attention. A short list of their needs includes:

(Those that demand extra energy are rated +, conserve energy -, and indifferent are 0)

- (+) a fully equipped international airport
 - (0) rail mass transit (principal corridors)
 - (-) high volume telecommunications centers
 - (-) top rank professional schools
 - (-) major R & D laboratories
 - (+) a center for multinational corporation and banking headquarters
 - (+) a shopping district with multiple major department stores
 - (0) pacemaking cultural facilities (museums, etc.)
 - (-) mass production higher education
 - (+) an enclave of residential hotels (high-rise)
 - (0) high volume containerized cargo handling
 - (0) oil and LNG processing and storage
 - (-) industrial estate for continuous flow processes
 - (+) a market for distribution of perishable and exotic foods
 - (+) high voltage electrical grid
 - (0) power plant sites at a safe distance
- etc.

Many smaller metropolises have acquired most of these features, but urban settlements with more than five million residents are under extraordinary pressure to install all of them; the local influentials keep pressing for such infrastructures because the absence of them reduces their capacity to compete with their counterparts in other metro regions. The largest metropolises will link up with lesser centers to justify the highest level services; in the process they form a megalopolitan strip. Then air shuttles, high speed rail lines (rivalling the Japanese Shinkansen), convention centers, data processing networks and world headquarters for multinationals are superimposed upon the ordinary metropolitan services, to integrate a sequence of urban centers and form a megalopolis.

Isolated smaller metropolises, say in the two to five million population range, can be operated competitively over the next decade by installing the following: .

- (-) transit system with express buses
- (0) "world class" export industry
- (-) regional produce market
- (+) first class central business district
- (+) downtown cosmopolitan apartment district
- (+) medical specialties training center
- (-) high performance telephone system
- (-) dependable power grid (multiple stations)

etc.

These middling metropolises normally support smaller proportions of professionals and multilingual workers. A number of primate cities in Africa and the less dense parts of Asia will expand in this way over the next two decades.

Below the two million size we encounter an increasing number of highly specialized cities. In the LDC's today each of these lesser cities is expected to possess a major transport terminal, a major organized market, a wholesaling district, a college, a hospital, a central religious edifice, a water supply grid, a source of electric power that operates at least until 10 p.m., and a steady fuel supply system for households and artisans. Most people live in neighborhoods or enclaves with an organization resembling that of a village, but some of these face-to-face communities exhibit true urban character (master craftsmanship, entrepreneurship, cosmopolitan values, etc.). The members of such communities have demonstrated their capacity to find secure niches in any city of the world open to them. All projects in appropriate urban technology are expected to be initiated locally and supported by this fully urbanized stratum of the population.

Until now there has been only one comprehensive study of energy use. The metropolitan structure of Hong Kong was analyzed in consistent detail from the point of view of the urban ecosystem (Newcombe, 1975, 1977). The questions concerning specific activities, locales, sub-groups involved, and timing of fuel and power consumption are basically ecological. In the work underlying this paper we have reviewed contemporary observations of the energetics of Seoul (where the data are the most complete), Jakarta, Cairo, Delhi, Bombay, and Rio de Janeiro. Conversion into waste heat, or maximum rates of entropy production, served as the signal for consumption, rather than purchase by, or transfer to, the ultimate consumer. The destinations of commodities (mainly building materials and foodstuffs) created at the sites for maximal entropy production were also noted. These observations are summarized in Table Three.

Table Three
ENERGY USES BY DOMESTIC FUNCTIONS
IN TYPICAL LDC CITIES

City	Shelter, bldgs & climate control	Food distribution and cooking	Transport	Infrastructure & other uses
Cairo	significant use of sun dried mud and kiln-fired red brick; propane space heating; kerosene for heat and light in outskirts; electric room heaters growing.	animal carts for inner city deliveries; some shortage in staples. electric refrigeration spreading. cooking: propane predominates; kerosene as substitute.	few highways and subways; busses extending routes; electric rail; cheap taxis, growing use of radio dispatch. micro Japanese vans, hand and animal carts for deliveries.	low per capita water use; growing use of electrical appliances, e.g., individual propane hot water units. kerosene delivered by carts (horse-drawn or pedal powered); trucks and tricycle for propane.
Bombay	average of 3-4 stories; plastic sealers in hutment roofs. electrical lighting, hot water, air conditioning and fans for industry and middle class.	serious food scarcity, transported by train, 1 ton truck, taxi and hand; sold in very small quantities. 2 meals, no refrigeration. cooking by charcoal, kerosene+ & wood; LPG popular among middle class but scarce.	electric trains crowded but most dependable; busses used for shorter trips; heavy foot traffic. cars and taxis are plentiful but very expensive.	water very scarce and service intermittent; LPG distributed by small vehicle; other fuels hand carried. Express lunchbox system for industrial workers.
Jakarta	tile roofs, bamboo plaster walls; no heating required; room air conditioning for elites, central for offices.	processed foods sold from handcarts in very small units. one hot meal plus snacks; cooking: wood used by very poor, charcoal used for meat; LPG in shpps and restaurants.	heavily pedestrian & personal coolie portage. Also 3 wheel jitneys and small trucks with pedicabs on the outskirts of town.	except for central city water carriers used on all scales; water supply situation worsening; some sewage collected by hand. hawkers distribute kerosene.
Seoul	cement block and steel for 2/3 of bldgs; central heating increasing; 70% briquette, 30 % petroleum; room air conditioners increasing.	refrigeration in 20 % of households. briquettes used by 70 % (subsidized++); 30 % use propane gas and kerosene.	bus carries over half of traffic; subway growing; pedestrian 1/3; private vehicles and taxis under 10 %.	industrial water use to expand by five times in next 20 yrs., households by 1.5. fuels delivered by hand, scooter and truck.
Rio de Janeiro	largely steel and cement; 10-15 stories. electrical room and some central air conditioning.	high proportion of canned and processed foods; some refrigerated storage. cooking by LPG and kerosene, briquettes among poor; few electrical cookers in middle classes.	extremely rapid growth in gasoline combustion vehicles; extensive bus system; new metro service, limited range; hand carts.	high proportion served with water and sewerage; large new communities with little or no infrastructure. electricity and water piloted by some squatters.

Notes:

This table notes departures from typical patterns in developing cities, e.g., modern central sections are found in most cities, with high rise, cement and steel construction, some central but mostly room air conditioners; less permanent buildings in squatter settlements and outlying areas. Food is in adequate supply although there are occasional shortages; limited storage requires daily turnover. Downtown arteries are congested, high incidence of gasoline powered vehicles in the centers. Water systems reach one half to two thirds of the population; sewerage reaches less than half. Electrical service is provided in most central areas.

+ Fuel consumption can vary greatly in different cities of the same country. Firewood, coke and coal for instance are more heavily used in Delhi, while charcoal, kerosene and electricity are more important in Bombay.

++ Certain fuels are subsidized and so opportunities for substitution are obscured. Kerosene is subsidized by the Indian government for instance and briquettes by the Koreans, although a plan was recently announced to substitute LPG for briquettes to reduce the solid waste problem in Seoul.

The uniquenesses of the respective metropolises stem from the underlying cultures maintained by their population and their recent politico-economic history. It will be noted, however, that all the elites of these fairly representative metropolises are intent upon achieving the highly energy-consumptive features of American-European-Japanese living arrangements. A very considerable amount of information, education, persuasion, taxation, and exemplary conduct will be required to change the perceptions of these elites; some progress has been evident over the last year or so, but it is only a beginning. "Appropriate consumption" is prerequisite to the choice of appropriate technologies.

It should be recognized that urban elites now compete with each other in a manner similar to that of the large multi-product firms, even though cities are rooted to a site. The principal exports from cities meet with shifting demand; cities must continually develop new products to prevent obsolescence of their present sources of livelihood, a loss of capital, and emigration of their best talent (Fig. 6). Cities with one dominant export industry are particularly vulnerable. If international trade continues to expand more rapidly than internal commerce, as it has over the past three decades, the visible circle of competitors for each major city becomes worldwide (Fig. 7). The leading elements in metropolitan society then learn as much from examples set at great distances as they do from their neighbors, but very differently from the period of colonialism.

COMPETITION IN THE FORTHCOMING
GLOBAL URBAN SYSTEM

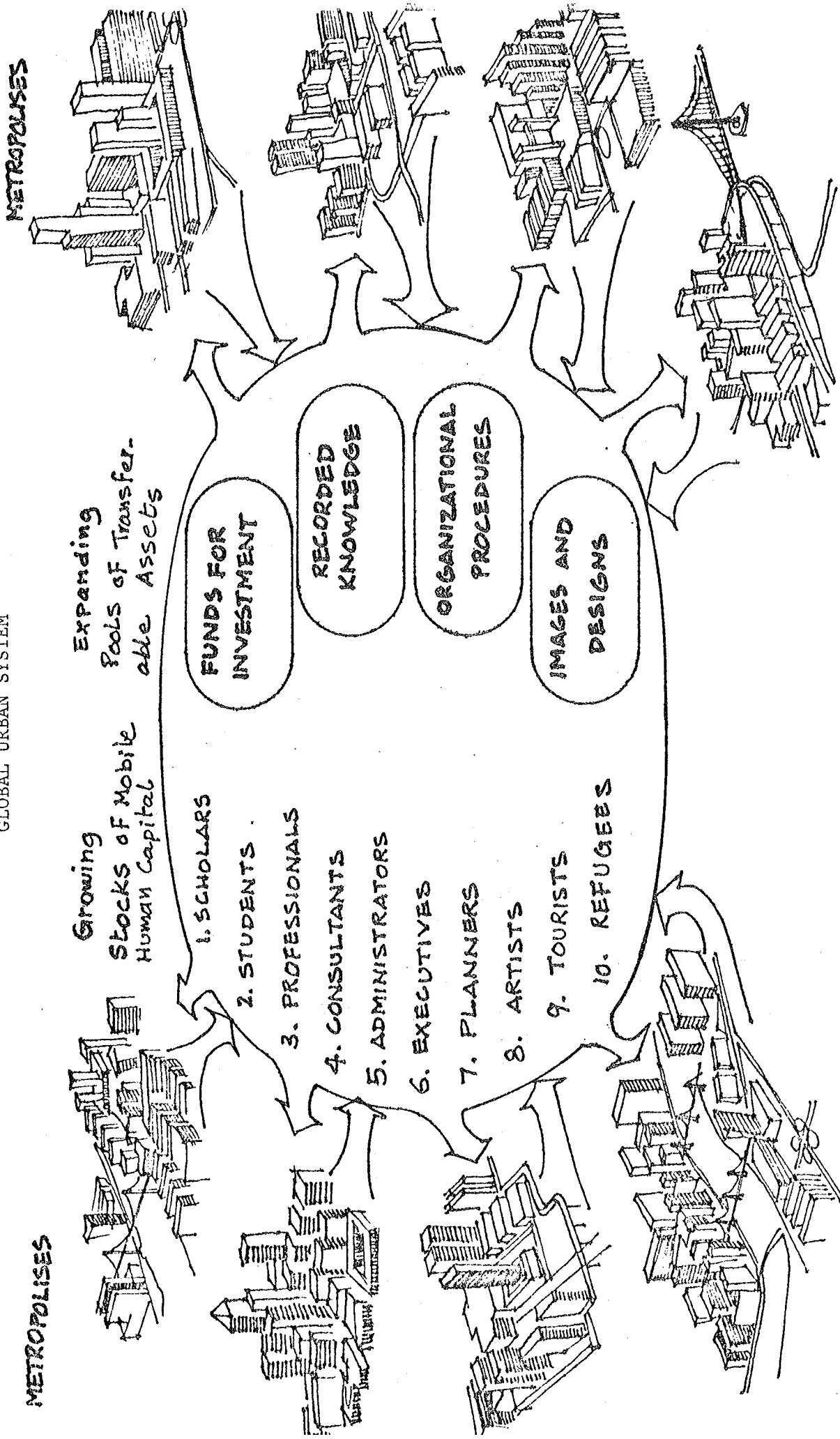


Fig. 6. The more developed metropolitan areas must continue to improve the quality of life for their citizens, otherwise more of these mobile assets will diffuse into the global stock than can be attracted.

INTERACTION IN THE WORLD URBAN SYSTEM

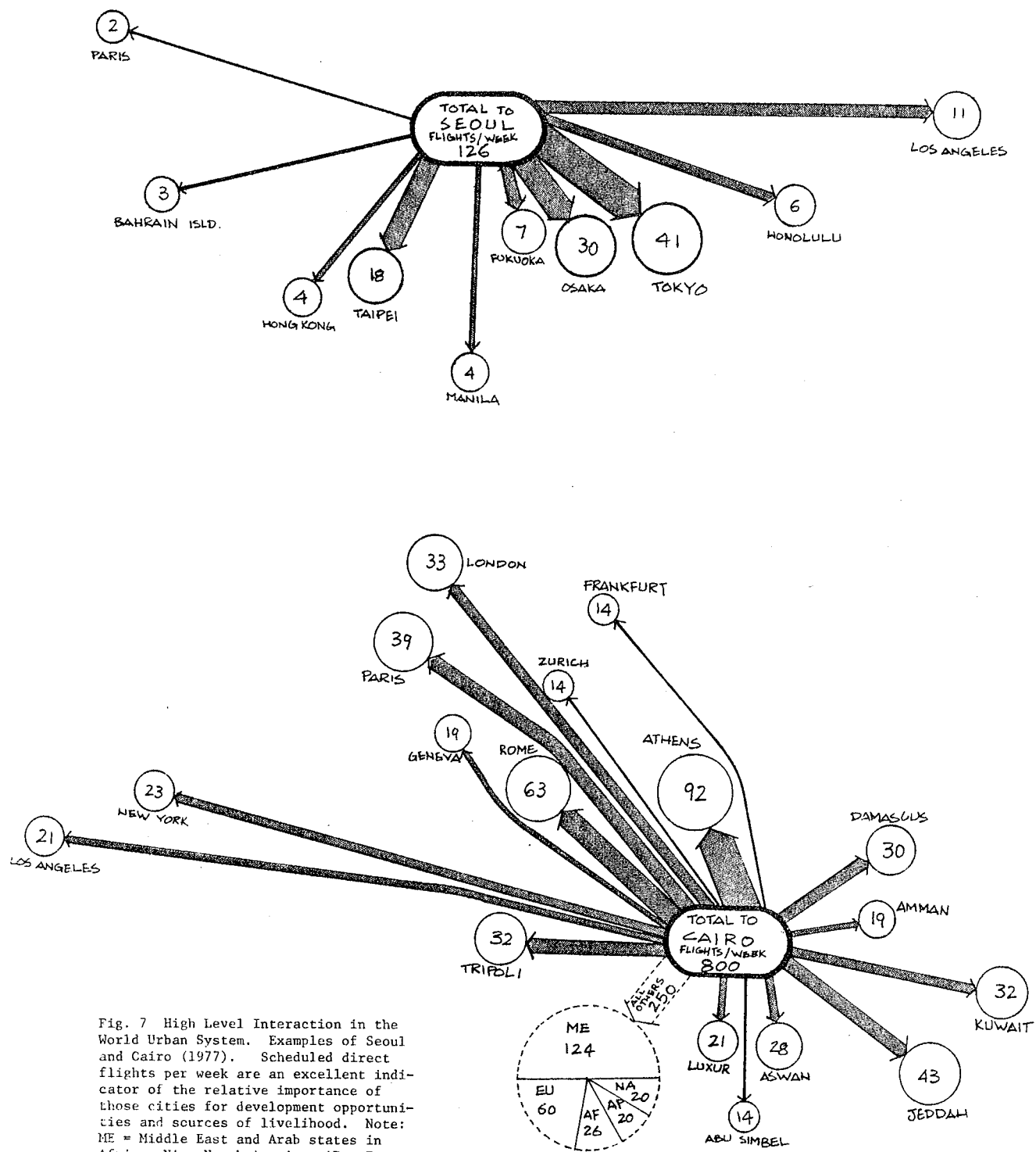


Fig. 7 High Level Interaction in the World Urban System. Examples of Seoul and Cairo (1977). Scheduled direct flights per week are an excellent indicator of the relative importance of those cities for development opportunities and sources of livelihood. Note: ME = Middle East and Arab states in Africa; NA = North America; AP = East and South Asia and Pacific; AF = Africa; EU = Europe.

Energy Distribution in Growing Urban Regions

Most growth pains felt by metropolises throughout the Third World are either directly or indirectly attributable to energy scarcity. The following symptoms prevail in most places:

- emergency food supplies increasingly depend upon the world market
- increasing losses of perishable foods before consumption
- water reservoirs prove inadequate to emergencies
- too few places are available in the schools, at all levels
- deterioration of the environment along principal corridors
- alarms about potential epidemics
- fantastic congestion at bridges and other bottlenecks
- overcrowded hospitals and polyclinics
- land speculation cycles with sharp booms and breaks
- proliferation of informal, poorly controlled settlement
- brownouts and power cuts during peak periods
- shortages of taxis and other personal transport
- some complete breakdowns in public services
- neglect of the arts causes increasing complaints
- vices seem to flourish (with a wink from top officials)

Other things also go wrong -- sometimes catastrophe strikes in the form of flood or fire. Yet the damage never seems to be fatal because the cities return to normal within weeks or months -- which means that growth is resumed and the previous complaints are again voiced. The capacity to reorganize -- to meet local requirements and adapt to resource constraints -- is greater than most people (even planners) imagine.

Certain aspects of the extraordinary variation in patterns of energy consumption described in Table Three are underscored quantitatively for key Asian cities in Tables Four and Five. Although it should be noted these data antedate the 1973 price increases, and therefore do not reflect current economizing, they do illustrate the range in volume and the proportions of energy consumed in different urban sectors. For example, Hong Kong went over to producing large amounts of desalinated water after the energy price rise, which very much changes the per capita energy consumption, but in a direction opposite to what would be expected from the price change. Also in the case of Hong Kong, for which the most complete (but again outdated) information is available, the domestic sector figures least importantly among major categories of use, whereas in India the domestic sector is the most important consumer of energy (Sarkar, 1976). At the same time, the domestic energy consumption (in joules per capita) for Hong Kong is slightly more than ten times the value for Bombay and for Delhi. The tables further point up the idiosyncracies in energy resource availability (see note in Table Four on local adaptation to available fuels) and in the case of Hong Kong, to the importance of exported energy. Assuming conservatively that 60% of the industrial production and 90% of the bunkers in Hong Kong are exported, nearly half of the total energy used by the city is exported to the outside world.

Electrical connections are highly regarded by urban establishments and households; new customers often wait for years for the power to be turned on. Almost all systems use the European 220 volt, 50 cycle standards, usually overloaded. Production levels are low, even for cities with millions of residents, so the new generators most often installed are in the 25-100 MW range. A few societies, like India and China, can produce

Table Four
DOMESTIC CONSUMPTION OF FUELS IN INDIAN CITIES
(per capita 1975)

<u>Fuels</u>	<u>Bombay</u>		<u>Delhi</u>	
	amount	energy- equivalent	amount	energy- equivalent
Charcoal, kg.	2.07	60.0 MJ	0.81	23.3 MJ
Soft coke, kg.	0.36	5.9	2.42	39.7
Hard coke, kg.	2.03	46.4	1.37	32.0
Coal, kg.	-	-	2.14	71.6
Firewood, kg.	2.85	52.7	4.68	86.4
Dungcakes, kg.	1.62	25.5	0.66	10.3
Kerosene, l.	1.53	56.3	0.44	16.0
Low pressure gas, kg.	0.50	24.4	0.21	10.4
Electricity, kwh.	0.01	0.1	0.16	0.6
Others, kg.	0.60	9.0	2.32	35.0
TOTAL		280 MJ		325 MJ

Data obtained from household surveys. Although offered as representative the low level of electrical usage and high consumption of wood suggests that the households come from "jhuggi" communities (self-constructed) in Delhi and hutments in Bombay (similar income levels, but built to cope with a different climate). Overall domestic consumption of fuels will be greater, but still considerably less than reported for Hong Kong in Table Five. Source: P.K. Sarkar, et al., 1976.

Table Five

ENERGY MATRIX - HONG KONG, 1971
MJ x 10⁸

<u>Fuel Item</u>	<u>Domestic</u>	<u>Commercial</u>	<u>Industrial</u>	<u>Local Transport</u>	<u>Bunkers</u>	<u>Export</u>	<u>Total (a)</u>
Firewood	4.49						4.49
Charcoal	3.91	3.13	0.79				7.83
Coke		1.31	1.31				2.62
Coal		0.46	8.84			0.10	9.40
Motor Spirit				51.76		1.96	53.72
Kerosene	64.60	12.38	0.62				80.51
Aviation Turbine Fuel				2.41	195.32	2.91	197.73
Aviation Spirit				0.21	1.05		1.26
Gasoils, Diesel Oil & Distillate		69.51	27.23	161.17	42.57	16.79	317.27
Fuel Oil		11.14	118.70	0.56	270.04	1.35	401.79
Liquefied Petroleum Gas	16.74	4.13	1.33				22.20
Electricity (f.o.e. & d.o.e.)	157.38	234.70	267.15	2.02			661.25
Electricity Sold	(42.78)	(63.99)	(72.79)	(0.56)			(180.12)
Town Gas (f.o.e. & d.o.e.)	10.27	7.32	1.76				19.35
Town Gas Sold	(5.41)	(3.85)	(0.93)				(10.19)
TOTAL including conversion losses	257.39	344.08	427.73	218.13	508.98	23.11	1779.42
Subtracting conversion losses	119.46	174.18	195.19	1.46			490.29
TOTAL END-USE	137.93	169.9	232.54	216.67	508.98	23.11	1289.13

Sources: Department of Oil Supplies, pers.comm. A.J.S. Lack and R.J.J. Purves; Department of Census and Statistics, pers.comm. H.K. Yip; 'Trade Statistics, Imports' and 'Trade Statistics, Exports and Re-exports,' December 1971, Hong Kong Government Printer; Hong Kong Monthly Digest of Statistics, 'Releases from Bond Tables,' January - December 1971, and January 1972, Hong Kong Government Printer; Air Pollution Control Unit, Public Works Department, pers.comm. D. Newbury and F. Chan; China Light and Power Co., pers.comm. Mr. Laufer; Hong Kong Electric Co., pers. comm. C.P. Man; Additional sources of information as listed under tables referring to the analysis of Industrial, Commercial and Transport sectors (see Tables 5, 6, and 13).

Footnotes: f.o.e. = fuel oil equivalent, d.o.e. = diesel oil equivalent; (a) Charcoal, Coke and Coal totals came from import data; Firewood is the addition of import data and 2.5% of conifer logs; imports to compensate for scavenging of scrap bunker and unaccounted local production; petroleum based fuels are from 'Releases from Bond' data rather than imports since the former gives a more accurate representation of actual use in 1971, with the exception of Gasoils, Diesel Fuel & Distillates where investigation produced greater confidence in Shell Co. data on usage in 1971. (Source: Newcombe, 1975)

virtually all the components needed for electrification internally, but most of the Third World metropolises import generators and cable from Europe, Japan, or America, while they buy switches, meters, and wiring from each other. Power poles in those cities are most often constructed with concrete and steel.

What uses for electricity warrant being first in the queue, or will pay the highest prices? Lighting is almost universally foremost -- for commercial buildings first, then for principal streets, and later for homes. Radio and television can be equally important in those countries where the programming is relatively uncensored. It, too, is introduced first into commercial establishments earliest, and homes thereafter. Interestingly, the poor are usually able to gain access to these media as rapidly as the middle class because those who are lucky in the lottery obtain sets which they share with relatives and neighbors. The playing of records and tapes becomes popular some time after extensive contacts with radio and T.V.

Among the other domestic uses ventilating fans have a high priority, since most cities are in the tropics, or suffer from a continental climate. Electric hot plates are common early purchases wherever homes are made of combustible materials; in brick or mud houses people stick with kerosene or wood. Refrigerators are widely desired, but not necessarily to preserve food. Initially refrigerators are regarded as status symbols, so retailers acquire them first, followed by the rising middle class.

Elsewhere in the city, as electrical capacity is expanded, the artisans' shops and smaller factories gradually re-equip themselves with motor-driven machines for many of their tools. After a decade or two electrical power becomes as necessary for the small industries back of the bazaar as

it is to operate installations in the industrial estate at the edge of settlement. Often the water supply, a most crucial service, uses substantial amounts of power to pump into holding tanks and inner reservoirs. Only slightly less critical is the electric railway, or tram, which is usually built so as to produce most of the power it needs.

The aggregate demand for electricity in LDC cities is not readily deduced from the occasional statistics which can be found. Quite a few cities harbor export industries which are heavy users of electrical power; the per capita figures they report will be too high to apply to all urban settlement. Unfortunately, it is just such cities with well developed electrical grids that are likely to publish statistics. If LDC cities are defined as those with less than \$2,000 GDP per capita per year, we should expect local demand to fall in the range of 100-500 kwh(e) per capita per year. The very poorest people, often also the latest to arrive from the village, are observed to be rarely connected to the distribution system (Table Five). When the household income reaches a level that is above \$1,000 per year (for an average of five persons) and reasonably secure, a threshold is overcome, since many will then subscribe to a one-ampere non-metered connection -- a typical arrangement.

It is also possible to ask the question: For what level of electrical demand should LDC cities plan, given maximum conservation efforts due to a shortage of fuel and capital? This estimate presumes a stable urban livelihood has been achieved and access to a wide range of conveniences is offered, although not as private possessions. A minimum adequate standard of living (calculated to yield as much discretionary time for its participants as exists in the most developed metropolis) for tropical environments

was estimated to require 12 kwh/capita/month in the household and an equal amount for urban services outside (Meier, 1974). Thus, an adequate "no waste" level of consumption is set at around 300 kwh/capita/year. Principal export industries are extra, and highly variable (in 1971 Hong Kong added 70%, but its industrial composition has changed remarkably since then).

Gas works often serve only the central areas of the city -- a relic of colonial days. Manufactured gas is used in metal working and food processing. Cities fortunate enough to have nearby gas fields (not uncommon for estuarine sites) will have converted their distribution system to natural gas. Fertilizer grade ammonia production is generating a rapidly growing demand for gas.

Liquid fuel is sold to the bulk of the population by hawkers and small shopkeepers for cooking, light vehicles, and lighting. It is much preferred over coal, charcoal, and wood because it is cleaner and more convenient. Some cities organize solid fuel distribution in the form of briquettes or carbide. The auto-oriented elite and the long distance haulers depend upon a limited number of petrol stations. Therefore, the range in consumption of liquid fuels from city to city is even greater than for electric power.

Food may account directly and indirectly for as much as half of the energy expenditure in Third World cities. In the case of Hong Kong, the imported fuel was traced to the points of consumption, showing that the locales with the greatest expenditure of calories were the kitchens of the large public restaurants. Companion studies to this one will document that the energy costs for fertilizer, harvest, drying, and transport of cereals amounts to several times the caloric food value, at least at the margin, for the Third World cities. Many LDC governments develop a basic quota of

staples (grain, cooking oil, sugar, tea) at around 2,000 cal/capita/day, which is made available at cost or even less, thus allowing food rationing to be introduced very quickly in emergencies.

One of the features of energy distribution most remarkable for Western observers is the subdivision of the commodities down to very small dimensions -- kerosene by the beer bottle full, grain products by the half kilogram, other food by the individual fruit or handful. Shopping is day-to-day, almost meal-to-meal. This arrangement does not take very much time because street vendors and corner shops are convenient and open for business at all hours (McGee, 1977). This pattern of supply means that inventory is held by middlemen and government, not households. Thus, breakdowns in distribution can have very serious effects within a few days.

Increases in the demand for energy in Third World cities are expected to arise in two sectors primarily. The electrical grid will be drawn upon heavily by the expansion in small scale manufactures, raising its efficiency and quality of output up to that of the world competition. In most places (South Asia may be the exception) food processing and preserving is expected to be the major category of activity seeking more electrical power. The other growing sector is transport, which should evolve many services to deal with the increasing size of the cities and the enhanced value of human time. In most places the greatest expansion of demand will be for the 6-20 passenger jitney (A.K. Meier, 1977). Savings on present uses of energy in transportation will be achieved through the reduction of waste, rationalization of routes, and by taking greater advantage of economies of scale.

The most significant change in the forthcoming decades will occur for the transport substitutes, especially telephone and the computer software

that eliminates the necessity for a trip or shipment. Proposals for "telepost," and for "open universities" and secondary schools using T.V. lectures and examinations, could save more trips (Goldmark, Craig, and Eginton, 1977). (Movement to the schools is responsible for 20-40% of the morning peak in vehicular traffic in many metropolises.) Demonstrations of the economic feasibility for decentralized office employment appeared in 1977, thus introducing the concept of telework (Harkness, 1977). The message unit levels in telecommunications are expected to grow at rates of 15-35% per capita per year whenever the equipment is installed that adds to capacity. Although electric in nature, the new solid state components for telecommunications require no significant quantities of power. The primary effect is to improve the promptness of provision of services, add to the quality of work performed, and expand the range of services offered, without resort to increases in the consumption of energy.

Changing Functions of Great Cities

The social function of a developing metropolis in the period ahead is to accept the surplus workers from the countryside, find ways of assuring nutrition, shelter, and freedom from epidemic disease, while educating their children. The metropolitan environment must propagate productive organizations to create jobs and a variety of quality institutions which stimulate further development of talent. It must also offer opportunities to outside organizations producing exotic goods that are appreciated by its citizens, enabling the establishment of affiliates or branches, and expediting those homegrown industries and cultural groups which wish to do likewise elsewhere in the world by maintaining intercity communications and transport services.

After the flood of immigrants from the hinterland reduces to a trickle the city proceeds to construct a service society in rough equilibrium with other parts of the world. An effective metropolis will draw capital and entrepreneurs, managers and technicians, information and scholars, cultural productions and artists, prestige and tourists (the "stocks" and "pools" of Fig. 6) away from the others. Advanced metropolises are increasingly involved in this competition. Until very recently the most effective strategy included the provision of an infrastructure allowing extravagant use for automotives, appliances, and diet. Henceforth, however, cities will be searching for substitutes for energy-rich styles of consumption in order to achieve excellence in this competition.

This very brief depiction of the urban system presently coming into existence has been introduced because it suggests counterintuitive approaches to urban development. If the most attractive cities in the developed world emphasize knowledge, culture, and personality growth as substitutes for display of consumption levels, the aspirants from the Third World will note the changing rules of the status game and shift their strategies accordingly. Top executives and technologists still reflect the values of the era during which they rose to positions of eminence, so they find it difficult to imagine how conservation techniques can add to the attractiveness of urban environments, although theoretically they can perceive the advantages accruing to those cities that plan and bring off major savings without reduction in the experienced quality of life.

Table Two (pg. 14) reveals a number of urban regions where the population growth has come to a virtual halt and the economy also will be settling into a stable slow-growth state (e.g., Tokaido, "Boswash," London, Chicago). These are conditions with which urbanists have not yet had experience in modern

times; they must therefore learn how to identify the social indicators that reflect the new norms and promise to guide the restoration of stability when undesired shifts occur. Under such conditions the consumption per capita of physical goods would be held constant or even diminish, while knowledge acquisition and cultural achievement could flower.

These agglomerations must evolve ways of transforming their existing social and physical capital so as to produce human satisfactions for an increasingly sophisticated population. Thus, they remain centers for personal striving, vigorous competition between images, concepts, and styles, struggles for attention, influence, and power, and the build-up of stresses that precede reorganizations. The energy allocation institutions will be under greatest strain.

Technologies Appropriate for Energy Conservation in Food, Water and Waste

When installing modern infrastructure the cities of the LDC countries normally purchase a complete system with specifications that have been developed for an advanced metropolis, or enabled it to achieve that ranking. A few standards may be adjusted for climate, differences in stature of the residents and language, but basically the system is transferred as a unit. The opportunities for misfit are very great, with the result that waste occurs at unexpected places. The losses may continue for many years because so often it is not possible to make modifications but only peripheral extensions.

In the energy-consuming sectors the misfits have been greatest in the choice of standards for personal transportation. Large size American autos lead very soon to a necessity for extensive street widening and road building

programs, the separation of shopping from the neighborhoods, and the need for expensive boulevards and freeways for the principal routes. The latter are delayed not only because so many people need to be moved to make way for the vehicles, but the capital required must be borrowed.

The air conditioned highrise office building introduces a new level of efficiency for some modern management practises, but the transfer to housing in the form of elevator apartments fits only a few cultures. If the electric power distribution system is reliable, and peak demands for power are met consistently, a decent fit has been achieved. However, a sufficiency of power -- when all sources of demand are expanding so rapidly -- is a rare achievement for an LDC metropolis. Even for the best organized it lasts only a few years. One of the crucial indicators for emergency into the "more developed" category (MDC's in the United National parlance) is the dependability of electric power.

Transport, food production, manufacturing, and domestic requirements compete strongly with each other for their share of the energy budget. The enhanced significance of energy as a commodity means that such budgeting will need to be instituted either at the national level or in the principal urban regions. The rapid rates of change and transformation in a growing LDC metropolis (e.g., 70% of all addresses, 50% of all nodes in networks, and 60% of the names of residents typically change in a "normal" decade -- Meier, 1975) suggest that Western administrative approaches based upon census procedures and formally authorized studies requiring several years to complete are also inappropriate to the conditions that prevail. LDC metropolises depend upon external energy, with storage capacity of only a few weeks to a few months, and with a significant likelihood of interruption of supplies due to such factors as earthquakes, strikes, boycotts,

Table Six

ENERGY COMPONENT IN COMMODITIES AND SERVICES
 IMPORTANT FOR URBAN LIVING (U.S.)
 (KJ per dollar of final output in U.S. in thousands)

<u>Commodity or Service</u>	<u>1967</u>	<u>1978 Estimates*</u>
Sugar	123	54
Cooking Oil	92	63
Flour	73	31
Poultry	76	40
Beef-Pork	69	34
Dairy	66	36
Fish	63	33
Vegetables	45	23
Fertilizers	183	172
Water	114	56
Cement	506	261
Bricks	360	207
Paper	212	108
Aluminium Products	147	150
Steel Products	132	59
Wood Products	51	28
Air Transport	203	112
Rail Transport	82	47
Bicycles	77	51
Local Transport	71	34
Motion Pictures	35	18
Banking	19	15
Communications	18	14

* 1967 figures were adjusted to reflect anticipated 1978 price levels. Price indexes are both wholesale and consumer, as available.

revolutions, or local wars. The new statistics should be useful for both management and planning.

At present the standard Census of Manufactures and Census of Commerce survey urban activities. Electric power consumption has been routinely included in the former, but it is often not available in the latter. Special surveys superimposed upon such censuses have permitted the construction of an input-output matrix. Because the various sources of energy have been separated out as independent economic activities (e.g., coal, petroleum, natural gas, hydroelectric) it has been possible to calculate the "energy content" per unit of money value in as many as 480 categories of activity, but the data manipulation effort required many years. The current energy requirements have been greatly changed in those activities undergoing rapid technological change as compared to the deductions made from the input-output table (Table Six). Inflation has affected the list unevenly, and cartel prices have been based upon the arbitrary use of market power rather than supply-demand interaction. For example, in 1978 the energy content of a dollar's worth of fuel oil, a major input into the matrix and so not represented in Table Six, is about one quarter of what it was at the time of the last input-output calculations. Other categories, such as communications and banking, have effected major technological changes -- including energy economies -- in the last decade, but reductions in prices for some increasingly popular services (such as credit cards and long distance calls) cause the services to remain in line with trends for the overall economy.

If the energy content for a commodity or service in an LDC region were to be calculated, we expect the "modern" goods and services to have similar requirements to those in the United States, and the goods and services

required for growth to be even more similar, because the technologies have been borrowed. Traditional goods obtained from the countryside may have sizable labor inputs (food as the fuel), which are not recorded as energy in these input-output tables, so energy content will appear small as compared to the more developed world. Much of this may be ascribed to the invisibility of the food input. Given this outlook for energy use in LDC urban areas, we can identify the activities most susceptible to conservation through technological change:

1. Reduction of Cruising and Backhaul in Urban Transport. *Jitney drivers, cab drivers, and light haulage operators report 20-40% savings in mileage running empty when they introduce radio dispatching -- a feature just now entering Third World metropolises. However, convenience to the user is still not sufficient in such cities because the telephone systems are highly inadequate. Very soon the new solid state components should make possible a readily portable and economic telephone set (wallet or wrist-watch size, costing no more than a bicycle) that would allow the owner to call for transport assistance from any location in the urban region. The "personal telephone" would evolve many other uses felt to be even more valuable (in America the forerunners were obtained by politicians, executives, salesmen, and organisers of the vices) so that they would be sufficient to pay for most of the cost of operation, including the fairly elaborate backup system required.*

The device itself amounts to only a tenth of the total innovation. In most countries such devices are illegal, so major legislation is prerequisite. Accompanying the introduction we expect a number of new roles for people who act as intermediaries between expressed demand and

the delivery of service. Each interface must evolve software that promotes satisfaction with the service provided. New procedures must develop in the urban milieu which jointly optimize between the needs of the urban resident and the requirements set forth for the overall system of transportation and communications. Experience accumulated in North America with various forms of "dial-a-ride" suggest that "demand responsive" transportation should be particularly suitable for societies that have found it necessary, whether for lack of circulation space or foreign exchange, to restrict the use of personal automobiles (Fig. 8).

Travelers must learn how to use the various transport modes (i.e., scheduled trains and buses, jitneys, taxis, and lightly powered vehicles such as scooter rickshaws, mo-peds, electric cars, and delivery vans) for their convenience. Although the geography and institutions of each metropolis result in unique transport systems, it is possible to transfer a number of concepts which speed up the economizing on energy.

2. "Slow-ways" to Enhance Aid-to-Walking Vehicles. The expected proliferation of intermediate transport technology in developing urban regions precipitates a demand for segregating slower vehicles in the city from buses, trucks, taxis, jitneys, and limousines on the principal street and highway network. People seem to prefer light transport over the auto only if the former is definitely more convenient, quieter, and cleaner. This means that the "unfinished" cities anticipating heavy immigration must design the substitute for the freeway that is suited to higher density settlement. A "slow-way" is an Australian term brought to California in 1977; "aid-to-walking" characterizes a family of small simple vehicles that can be designed to move people about on longer trips in their community with much less friction than the private automobile (Fitzhardinge, 1977).

REORGANIZED PASSENGER TRANSPORT

For a typical trip:

XXXXXXXXXXXXX 00000000000 XXXXXXXX
 walk wait ride walk

Cost (1978): fare - \$0.10 - 0.20
 human time - \$0.20 - 1.00
 energy - 100,000 joules

with communications backup:

!!!! XX 000000000000 XX
 ring wait walk ride walk

Cost (198?): fare - \$0.25 - 0.50
 human time - \$0.15 - 0.70
 energy - 70,000 joules

Fig. 8. The delivery of urban services occurs largely through non-commute trips. A typical trip using the transport system will take about one hour and the distance is 10 - 15 km. It should be noted that people may engage in extra energy-using activities during the time they "save".

The challenge to be met is a procedure for designing and redesigning broad paths or light roads which allow light vehicles to flow unimpeded to shops, schools, small manufacturing establishments, and intensive gardens in urban districts without disturbing pedestrians and minimally conflicting with heavy duty traffic. It must expedite mo-peds, scooters, and light delivery vans at a maximum speed of 30 kmph (20 mph), at the same time that bicycles, hand carts, and skateboards are served, and pedestrians feel safe (Fig. 9). Though the design of the way itself, and the associated signals, the slow-way must selectively retard and encourage the drivers so as to reduce the nuisances and risk of injury. It should "fly over" or pass under heavy traffic and connect the interiors of adjacent neighborhoods. If it is as heavily used as planned, the management of the landscape and the view-from-the-way are likely to open up serious controversies which can only be addressed by much experimentation.

3. Greater Yields from Fertilizer and Water at the Consumers' Back Door.

The serious losses in fertilizer and irrigation water occurring in modernized "Green Revolution" agriculture add to energy requirements even more rapidly than the population growth. Transport to the point of consumption also increases more than proportionally. All these losses could be reduced by sponsoring the most intensive photosynthesis within the urban region itself. The aquaculture of higher plants (hydroponics and mariculture) produces the highest recorded yields per unit of input, including real estate. The savings should be sufficient henceforth to pay for the higher land rents in urban areas.

The largest scale existing production in America is in the South and West, where the most popular crops are tomatoes and flowers. A number of well-publicized experiments originating from the Arizona-California

SLOW-WAYS FOR AID-TO-WALKING VEHICLES

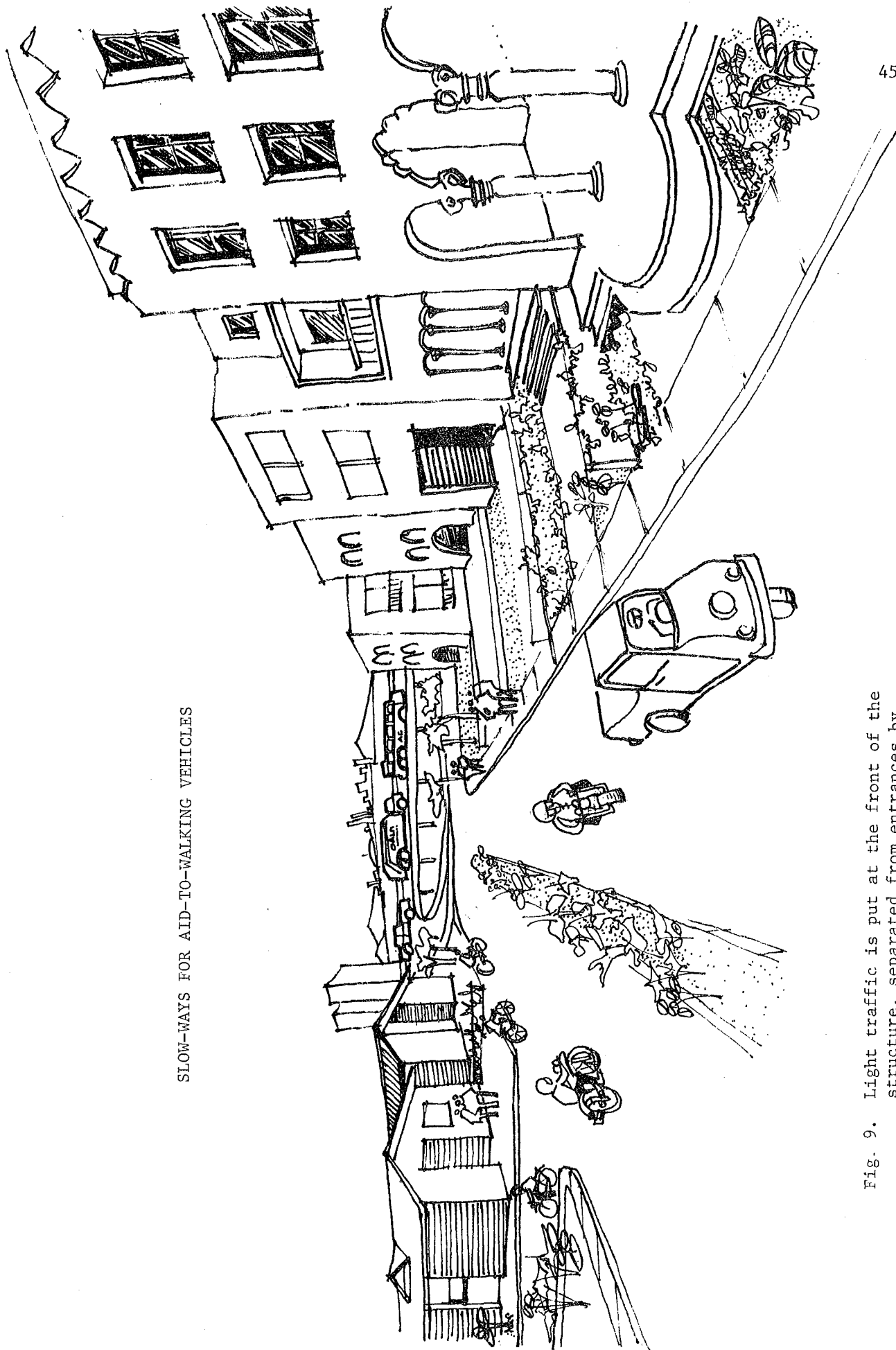


Fig. 9. Light traffic is put at the front of the structure, separated from entrances by intensive gardens, while trucks and buses operate on the periphery of the neighborhood

experience have been conducted in the settlements along the Arabian Gulf, but others have been undertaken elsewhere. However, American technology is based upon a thoroughly dependable power supply; the interruptions so common in Third World metropolises could kill a whole planting. Shellfish are affected by pollution of coastal waters. Moreover, American capital costs are extravagant; a more labor intensive design for a wider range of crops is to be preferred -- as has evolved outside of Tokyo but may no longer fit the affluence of its economy.

The accomplishment of savings in energy consumption and overall cost are equally dependent upon improved marketing techniques, since typically half of the perishables spoil before that are consumed (or else they are moved on successive days to ever poorer neighborhoods) and refrigeration or freezer preservation is exceedingly energy-intensive in the tropics. Ways should be found for utilizing surplus production, either through food products manufacture or through animal feeding. The linkages between such enterprises must be explored in a number of different directions. The hydroponics field is poorly documented because agricultural experiment stations have not been involved, and the technologists and the grower-marketers have held their trade secrets very closely, especially the formulas for the prevention of plant disease (Fig. 10). Every metropolis contains one or more such prototypes; later a special craft is expected to come into being.

4. Intensive Gardening on Urban Fringes. Most of the world, especially America, has a lot to learn from the commercialized techniques of intercropping and replanting as practised by the Japanese and the Chinese (Kambe, 1974). Although this form of agriculture has become increasingly energy intensive (Newcombe, 1977) as the wages of agricultural labor

الخيار الذي نأكله شغلنا جواراً

علماء، فإن منذ عدة عام ونيف، ولم تستعمل في المدى الأوسع كما اليوم إلى حين انفجرت أزمة توفير الطعام للجيد والضمي وأزمة تكاثر السكان، إلى القصص المائل في كميات المياه الصالحة للري، أضيفت إلى هذه العوامل الحاجة المتزايدة إلى الفاكهة والخضر في أقاليم أجمع.

ويضيف كامبل: «إن خيرا ومهتمين من الدول العربية سافروا إلى أريزونا في الولايات المتحدة واطلعوا على إنجازات شركة فينيكس في ميدان البيوت الخضراء، وأتوا مكلف من الشركة دراسة حاجيات الشرق الأوسط في هذا المجال». ويقول خالد نحوي: «نحن أخوة ثلاثة ورثنا بساتين واسعة هنا في عدلون (قرب صور) وترعرعنا على الزراعة وحسب الأرض، كما والدنا كل واحد أحب إضافة شيء إلى الورثة، وأنا سافرت إلى أريزونا وتعرفت على إدارة البيوت الخضراء، ثم عدت وأنشأت مع السيد كامبل أربعة بيوت. هذا الموسم هو الثاني لكثف الأول في الشتاء، ونبيع الكيلو، في أرضه، بالبرتين، في المستقبل سنزرع خضرا وفاكهة متنوعة ولا نركز الآن على الخيار كتجربة ولا نسهل التسويق إذ بلغت تكاليف البيت الواحد 20 ألف ليرة وتتمتع المضافة بأكثر».

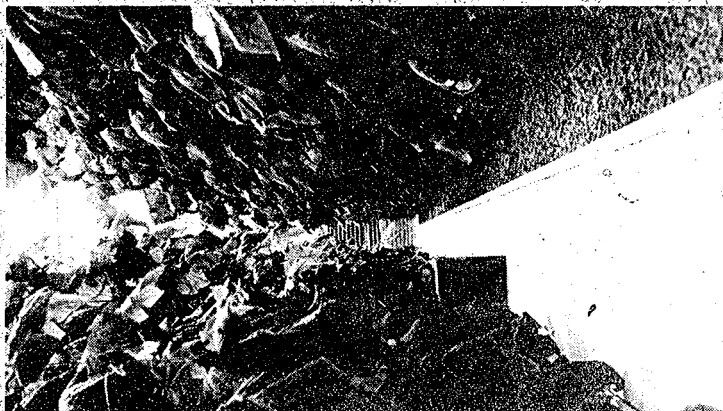
في المستقبل سيكون في إمكانه صيد في أن تصبح مينا أخضر على

إنهاء النبات بواسطة ميساه تحتوي عناصر مختبرية توازي عضوية التربة، هذه تدعى في المختص، هيدرونيك. وفي العربية أنها الزراعة، علميا نري علم، لا تعترف بالفصول أو بمزاجات المناخ، وعلى حداتها النشرة الجوية وفيضان الأنهر، تابع تعرف، يا صديقي.

لا شك رأيت في السوق ومع الباعة نوعا من الخيار، ثمرة طويلة ذات خضرة غامقة، وربما تكون اشترت والسيدة حرك فرمتها لك سلطة، أنت وذوقك.

هذه الخيارات ليست شغل برء كما خيل إليك، أنها من إنتاج بيت أخضر (غرين هاوس) يعتمد طريقة الانماء «هيدرونيك»، لتتصف لك البيت الأخضر أولا، جدرانها وسطحة من بلاطير غلاس لا تستطيع الأشعة الشمس، إذ تخرقه، أن تغير لونه الأبيض المسكي، كتلة واحدة نصف مستديرة، قاعدتها من البلاستيك والخشب والحدن مثبتة في الاسمنت، لا نوافذ سوى مسارب متحركة للهواء، وفي الداخل، إلى آلات التكيف، خزان المحتول المائي يوصل القنينة إلى الفتحات في أنابيب، ولا حمة تراب في الأنابيب، بل كسر حصى من حجارة، يازالته لا تؤثر فيها المواد الكيميائية.

قبل أن نلقاء خالد، والخضوع، والأميركي الذي البيوت الذي أول، يقول دوتش انماء الطعام، تصور في



من داخل.

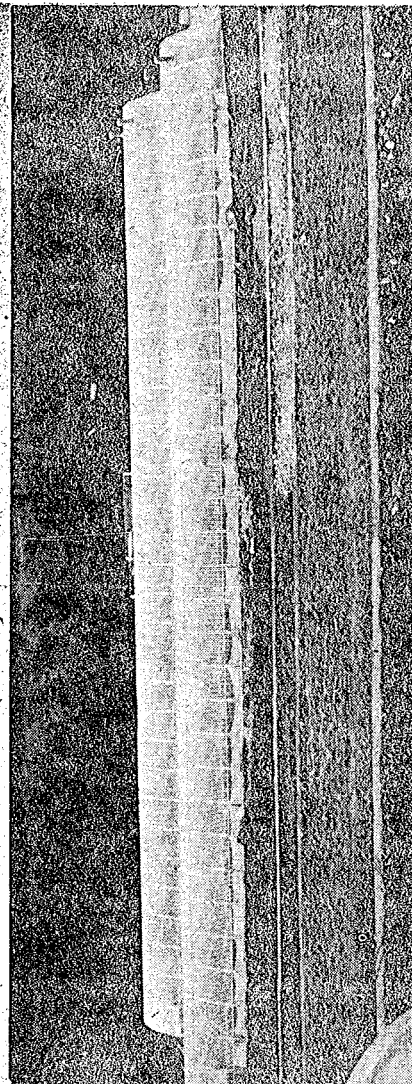


Figure 10. Hydroponic Installations in Lebanon

These American designed facilities are too vulnerable to power interruptions, too energy consuming, and too expensive to introduce elsewhere. Newer, local modifications are better.

have increased, the diversity of the output has been greatly extended. Around Hong Kong and Singapore a wide variety of leafy vegetables have displaced much of the tonnage of Chinese cabbage, a staple. Poultry, hogs, dairy and fish farming have all become integrated with vegetables over the past few years (Newcombe and Bowman, 1977; Newcombe and Nichols, 1977).

Always here the emphasis must be placed upon marketing, but direct imitations of the West in places like Manila and Jakarta have resulted in colossal failures. Rationalization of distribution must be thought through all the way to the consumer's pot. The Chinese culture has had an advantage, because it has a number of highly developed cuisines and a large proportion of the urban population congregates in the restaurants, each of which possesses a skilled buyer. Households take advantage of the standards and services imposed upon the market by these knowledgeable buyers. There is little excuse for malnutrition in such a city, since something is produced for every taste.

Few vegetables are included in the diet of very poor people. One of the effects of urbanization should be the extension of the range of their cuisine in this direction, rather than toward meat-eating -- the traditional status symbol -- which multiplies by three to ten the number of original calories to be produced. Seasoned vegetable snacks, bought from street vendors, have already found a place in the diet of the poor in many tropical metropolises. Quality and variety, along with the vitamins, must be enhanced to compete with the newly internationalized hamburger and chicken fast food shops. Plastic film bags make possible new standards of purity along the streets frequented by recent immigrants; bags prevent spoilage, so they are well worth the ten calories or so of energy involved.

All the farm advisory and food processing procedures developed for extensive modern agriculture need to be reconstructed to promote the efficient use of the free land in the urban region.

5. Protein and Recycled Nutrients from Aquaculture. Sewage can be transformed into algae (Chlorella or blue green spp.) and aquatic plants as a form of secondary treatment; the product can be fed to fish or animals. By such means valuable fixed nitrogen and phosphate can be returned to the urban ecosystem (Oswald, 1977). At least a half dozen pathways can be proposed for development and testing at the prototype scale. Because the meat and fish are readily salable, the marketing in this instance will take care of itself, so attention must be concentrated upon flexible trouble-free processes (Fig. 11).

These methods of recapturing effluent nutrients still encounter serious losses, so extra plant protein will be needed to fill minimum adequate diets. A source with promise of very high productivity is offered by an unpublicized Japanese technology for growing *Chlorella* from soluble fertilizer and sunlight in open ponds for direct human consumption. The centrifuged algae are presently converted into yogurt, protein supplement pills, and "soy" sauces; in the future various textured forms of protein are desirable. They could serve as direct substitute for meat and fish in sausages, filets, and fast foods. Yields of protein per unit area under cultivation are five to ten times greater than any reported for soy beans, peanuts, or other legumes; in addition, otherwise unproductive low-lying land might be adapted to commercial algae ponds. In this case both processing economies and marketing factors are crucial because virtually no precedent exists to draw upon. When the products become popular items in the diet this process would constitute by far the most economical

PROTEIN FROM WASTE RECYCLE

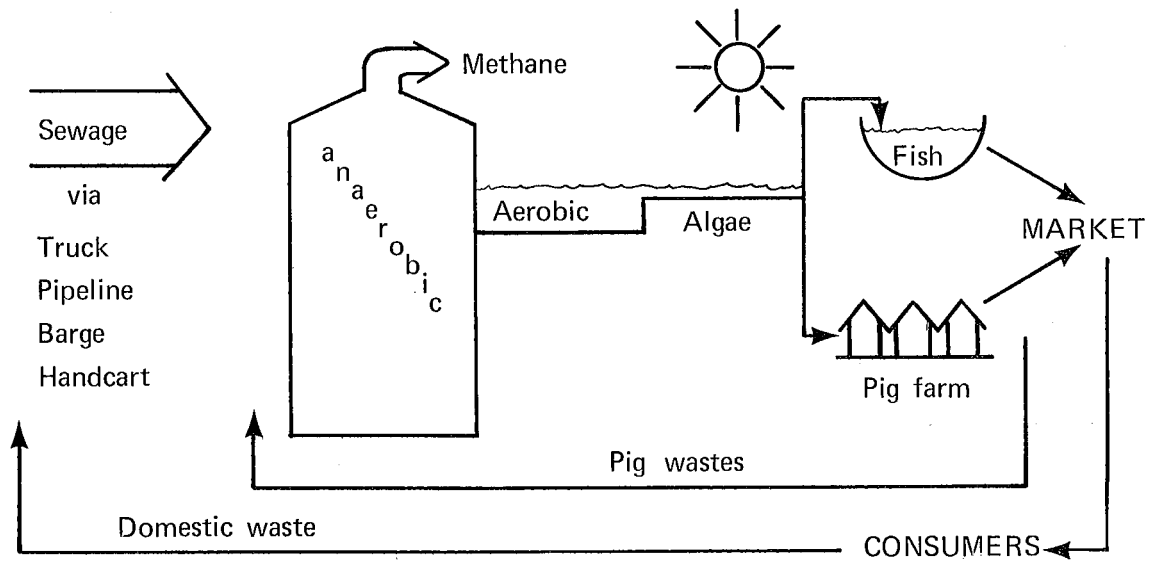


Figure 11. Fixed nitrogen retention can be very much enhanced over present practice. Algae ponds, fish farms, and pig farms should be placed on low valued land.

PLANT PROTEIN FOODS

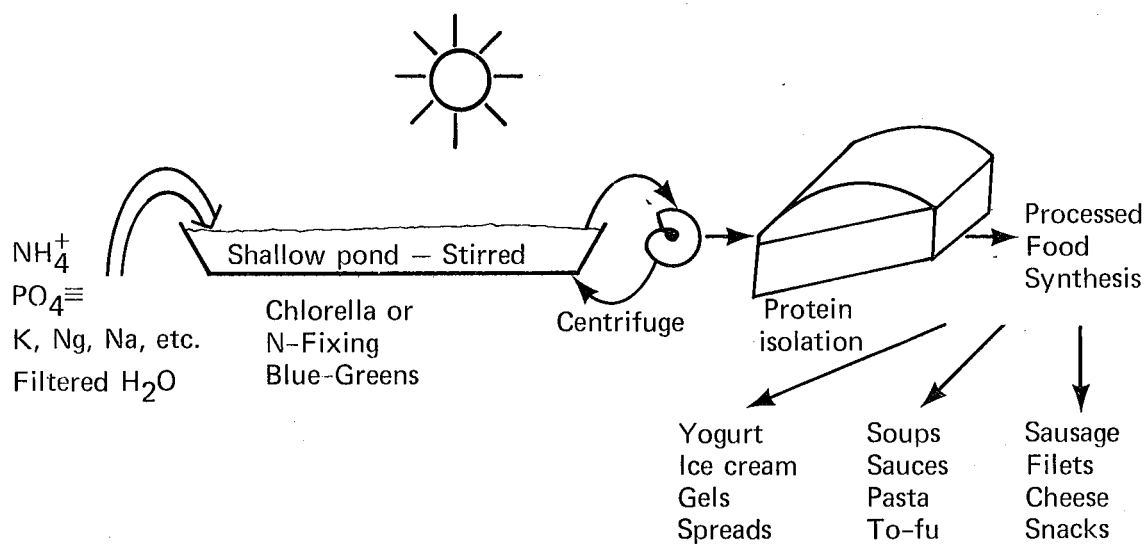


Figure 12. System for the mass production of high quality foods within urban regions.

way for converting energy-rich fertilizer into human nutrition, so it deserves very close attention (Fig. 12). The Japanese process has been exported to Taipei, and most recently to Singapore, so experience with it is broadening while it remains an as yet high priced specialty.

A number of other approaches to "single cell" proteinaceous foodstuffs look promising for regions possessing byproducts such as molasses, cellulose, or even methanol. All of them should fit very well into industrial complexes sponsored by metropolises, enabling them to synthesize the high-valued components of their own food -- a capacity useful in any part of the world as it faces threat of famine.

6. Promoting Self-Help Informal Construction that is both Economic and Comfortable. The AID generated a promising revolutionary proposal long ago which is now ready for introduction into rapidly growing metropolises. The University of Michigan team (Paraskevopoulos, 1966) identified polyurethane foam as the most promising building material to replace wood, brick, and some applications of concrete. The lightness of the panels and the continuous sheet makes it particularly suitable for self-help construction and furnishing. Although the resin itself is energy-intensive per unit weight, it is used so sparingly in rigid foam that it comes out far ahead of its competitors. It is in addition very high performance insulation, and therefore contributes to comfort over the life cycle of the building.

Initially objections were made overseas that Americans were not using the innovation themselves, so how could they expect even more conservative Third World builders to accept the technique? Since that time the material has been introduced, most often in a sandwich panel, in Europe and America, but it is rarely publicized in the architectural journals because it is

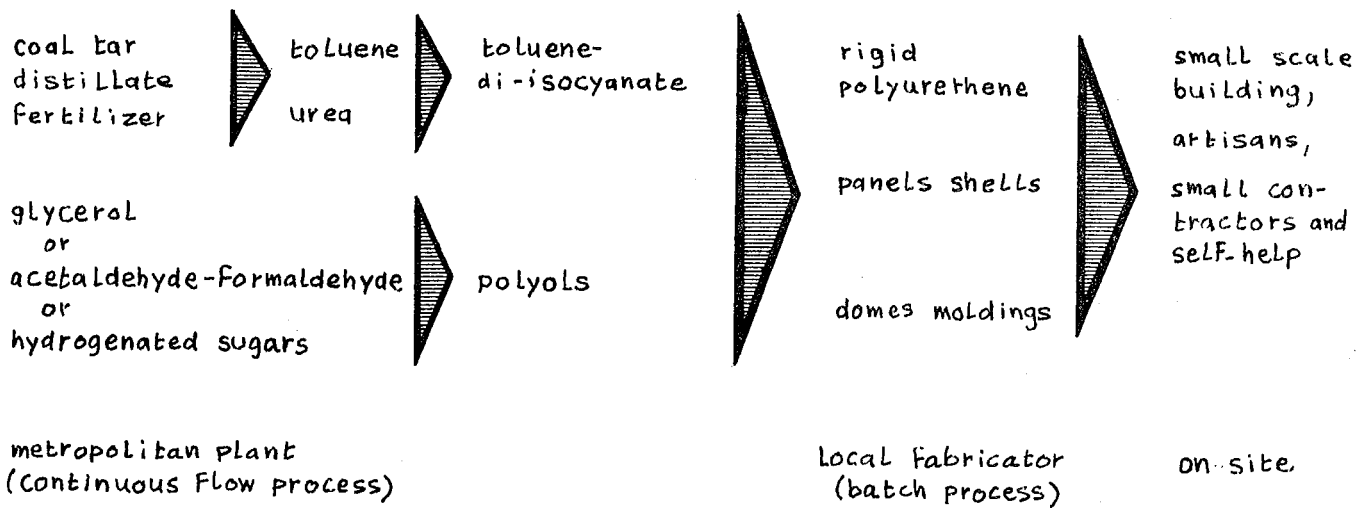
employed in the most economical construction. The material is already available in the LDC metropolises, primarily in the soft flexible form used in mattresses and cushions, but as a premium product that is high priced due to low volume production.

In the interim a scare was raised about fire hazard. Untreated polyurethane surfaces flash much faster than most, thus presenting difficulties in the evacuation of burning structures. However, a skin was developed which is so effective that polyurethane is now preferred as the raw material for prestige office furniture and for TV sets. Wood grain can be photographed and applied to the surface, so it serves as a "synthetic wood." Nevertheless, the application to site-and-services and other low cost building techniques lags.

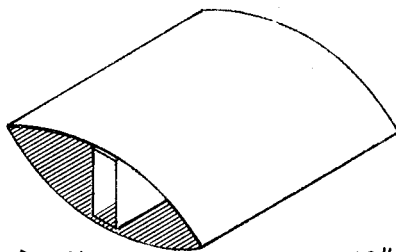
The challenge is to find easy methods of self-help construction that evolve into permanent urbanization (Turner, 1977). People could learn how to be urbanites while building their own house, while the demand for such energy-consuming materials as corrugated galvanized iron, brick, and cement is diminished. Often sites and rudimentary services are provided by government; later other options will be offered (Laquian, 1977). The insulation is increasingly appreciated as urban activities are pursued (Fig. 13).

7. Solar Domestic Appliances. The past few years of the intensified "energy crisis" have brought to light many proposals for the domestic use of solar energy. Hot water heating, space heating, cooking, drying, desalination, refrigeration, and a number others are mentioned, but in most cases they cannot match the flexibility and economy of electricity at 5-10¢ per kwh in major cities. However, rates often run higher in Third World cities, and inconvenience costs less, so some of these

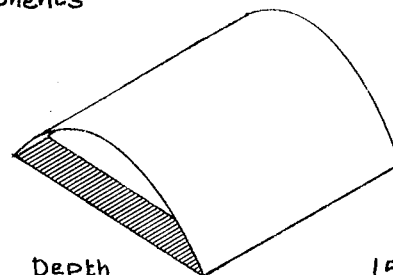
SUBSTITUTION IN MATERIALS



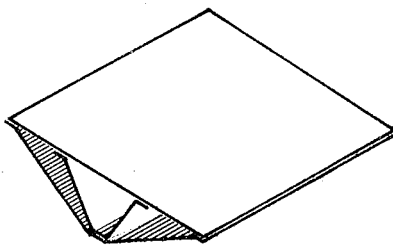
Building Components



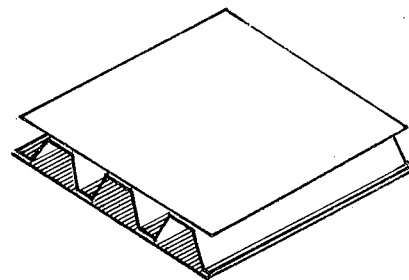
Depth 12"
Width 48"
Moment of Inertia 90"
Ultimate Span 13' 6"



Depth 15"
Width 36"
Moment of Inertia 134"
Ultimate Span 14' 3"



Depth 12"
Width 48"
Moment of Inertia 90"
Ultimate Span 13' 6"



Depth 7"
Width (variable)
Moment of Inertia 16"/ft.
Ultimate Span 15' 0"

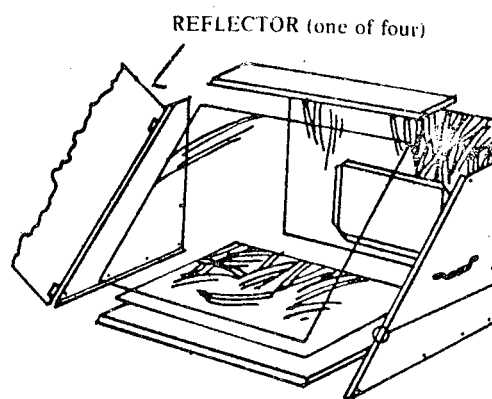
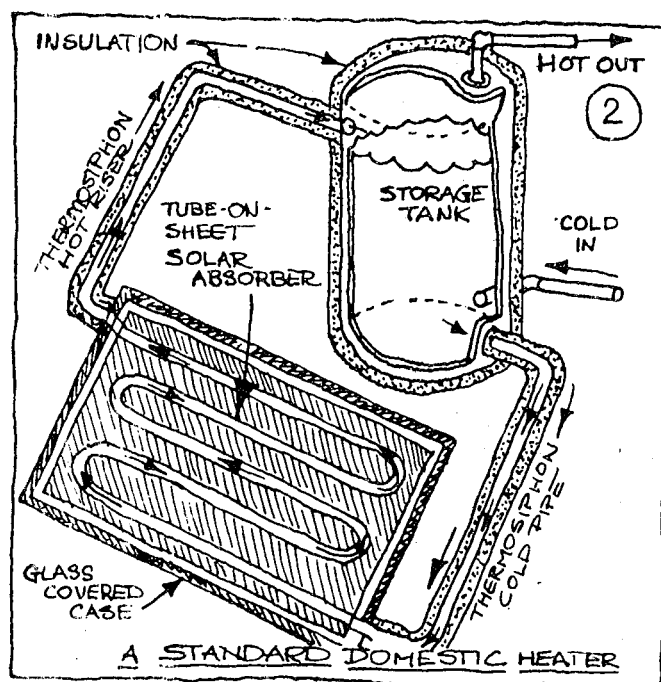
Fig. 13. The principle competitor for wood, cement and bricks is also first class insulation, so life cycle energy requirements will often show considerable savings

inventions should find niches earlier in LDC urbanization, where they promise substantial improvements over present conditions (Fig. 14).

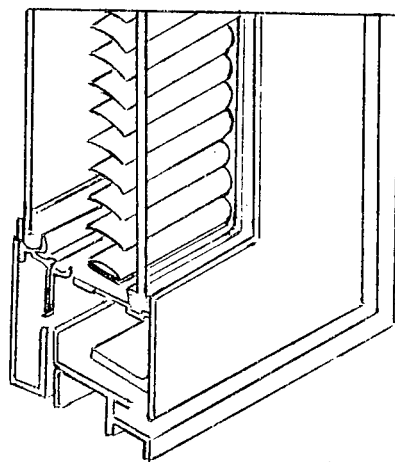
What such introductions could offer, besides refinement of the invention, is a way of achieving economies of scale in manufacture for everyone. The scattered world demand could be supplied at a reasonable price. Sunny parts of America, frustrated by the high labor costs in their vicinity, could then look elsewhere in the world for economic energy-saving solar gadgets.

The Indian Government attempted to pioneer in such technical developments, but it has consistently failed to get into production. Except perhaps for water heaters in Israel being imitated in Florida, no intermediate solar technology has moved out of the gestation phase from the developing world over the past twenty years. If the prepossessing problems of cost reduction, introduction, and maintenance are to be solved, joint efforts appear to be required.

SOLAR APPLICATIONS NEEDED
FOR DOMESTIC USE



A SIMPLE SOLAR OVEN



double pane windows with venetian blinds

Fig. 14. Hundreds of alternative designs compete for our attention; scores deserve full scale tests. Perhaps only a dozen will survive.

It is interesting to note that no such stimulation is required for one kind of industry that expedites energy conservation -- the design and production of appropriate garments. The urbanizing process quickly introduces the new immigrant to non-traditional designs for clothing that insulate effectively in cold weather and other styles that contribute to thermal comfort in hot weather. People will adopt such clothing first for informal participation in public activities (since for formal settings the conventional dress, whether comfortable or not, is appropriate). Therefore, the upwardly mobile people in the city ask the tailors and seamstresses in their neighborhoods to produce the new styles. Some of the craftspeople learn to cater to tourists as well, and use these contacts to build up an export market. Therefore, almost all low income cities with substantial numbers of foreign visitors have by now created garment and shoe industries quite capable of expanding to engage in large scale exports. Hong Kong, Seoul, Taipei, the northern border cities of Mexico, Jamaican cities, Malta, Mauritius, Singapore, Bombay, and similar cities are setting the pace at present. The more stylish garments and shoes are sufficiently high valued to be shipped by air freight. Other exports from these cities, particularly electronics, are building up a parallel demand for air freight. Garment manufacture for energy conservation is so vigorous it does not need official promotion, at least not in the direct manner proposed in the preceding pages.

A New Transfer Process

A new and promising development has appeared in the technical assistance circles over the past eighteen months. We are beginning to see published statements advocating a two-way exchange of socio-technical ideas

and experience. Always before this concept seemed to be no more than a tantalizing possibility suggested by one or two happy occasions where the developed society found it useful to adopt productive innovations originating in less developed countries. Everyone recognized that the unidirectional emphasis in technology transfer breeds resentments and misunderstandings that make the effort increasingly difficult over time. In India, for example, responding to a number of interchanges between universities and local counterparts, the term of "academic imperialism" was invented in the early 1970's. Equivalent sentiments were felt, but not expressed so vividly, elsewhere in the world.

The mutual interest in expediting conservation of increasingly scarce resources, especially energy, should lead to interchanges of experience with the developed nations, and soon some direct borrowing of technology evolved first in the poorer societies should offer significant savings for developed metropolises. Always before the flow of knowhow, frequently backed with hard currency, moved from the powerful to the weak or from the scientifically advanced to the traditional societies. These have been the circumstances since the days when colonialism was the dominant relationship.

The American Chemical Society, largest among the world's scientific societies and most enterprising among them in matters concerning the organization of the various strands of scientific knowledge, commissioned an article which proposed that a more symmetric relationship was possible in the future. Editors could foresee that developed countries will have need in the foreseeable future of the kinds of knowledge and detailed experience most economically produced in developing regions (Morgan, 1977).

Already in the professional activity of urban administration, and the delivery of urban services, this reverse flow has begun. The Council for International Urban Liaison (818 18th St., N.W., Washington) initiated an international information clearinghouse in 1976, and began publishing Urban Innovation Abroad. It notes improvements of value to the United States and Canada, regardless of origin. Now that the stage of rapid urbanization is being entered by many more cultures, a practised eye encounters many creative responses to the problems presented that appear likely to be feasible elsewhere. As compared to rural development -- the present pre-occupation of American foreign aid (along with that of many other countries) -- city-to-city transfer is easier. A much larger number of persons in both kinds of societies can be recruited for projects of the kinds already discussed here.

Successes should come somewhat easier and more quickly if projects are aimed at stimulating resource-conserving behavior in any part of the urban population, not only the poor. Then the project survival rate should be as high as 20-30%. That is the expected proportion worth continuing beyond two years groundwork and introductory effort.

Experienced stimulatory institutions are required to obtain such performance. They must be able to learn the technology quickly, appraise marketing opportunities, find entrepreneurs and inventors, engage in all kinds of troubleshooting, justify the extension of credit, get production rolling, and be willing to walk away from a promising operation, leaving it in local hands. The reward for Americans as a social group would be three-fold: (1) reduced worldwide prospective energy demand, (2) reduced worldwide plutonium production, and (3) additions to the range of

technologies available for Americans as they search for life styles that fit into a steady state society at home. Therefore, there is no apparent need for miserly accounting or retention of equity in the successful enterprises, thereby generating fears of "creeping imperialism."

A good model for an urban institution capable of operating in this fashion is the Korea Institute of Science and Technology (KIST) in Seoul. It was originally set up to accept contracts from local governments, firms, and international sources (foreign governments, multinational firms, and international agencies), to use scientific data and technological experience to promote economic and social development. Now a little more than ten years old, and extraordinarily successful, it has already undertaken energy conservation studies on behalf of public and private industries. It could mount a much larger and systematic program to stimulate conservation in cities. Because it is an institution used to working very rapidly, expanding as it proceeds, it would also be able to supply consultants to other countries working in parallel directions.

Very few other countries have organizations with competences approaching those assembled by KIST; many million-size metropolises have nothing at all that is equivalent. However, adaptations might be worked out in a manner much the same as that by which KIST was formed. At the time of its origin a non-profit American research organization, the Battelle Memorial Institute from Columbus, Ohio, was given a contract to assist in the birth of an organization to be called KIST. One member of the board of directors was shared with Battelle; he also supervised a periodic evaluation. Fortunately, the existence of Battelle is not unique, the United States has a number of institutions parallel in structure, and drawing upon a similar

variety of talents, that could undertake the stimulation of overseas institutes. Most of these have already had overseas experience, and some have ties with R & D organizations similar to those developed by Battelle with KIST. Therefore, it is possible to launch a program quite rapidly (Fig. 15).

Speed of organization in the field is essential. Too often American international assistance is hampered by second and third thoughts regarding the allocation of personnel and funds. Existing appropriate technology programs have been badly damaged by this apparent indecision. Standard methods of administration cannot cope with programs of this complexity in the time indicated. The methods for speed-up to be considered resemble solutions previously worked out by the Department of Defense and NASA, but they are adapted to the kinds of suspicions existing among the elite in Third World cities.

The key spending agency with discretion, looked at from the point of view of the recipients of funds, is the local laboratory unit of the (National) Institute of Science and Technology. Its small collection of managers, technologists, and economists work on contract with a joint U.S.-National Commission (a typical formula would provide for equal numbers of directors, but the performance of such devices since the Marshall Plan should be reviewed). Ideas, instruments for measurement, and technical people are to be found locally, but unfilled posts are filled from other developing metropolises or from America. The goal would be "viable production units" that promise to shift the overall urban ecosystem so that energy will be conserved without loss to welfare.

From the point of view of Americans a grant-giving agency could be set up that utilizes existing American capacity for consulting overseas, even

INSTITUTIONS FOR URBAN TECHNOLOGY TRANSFER

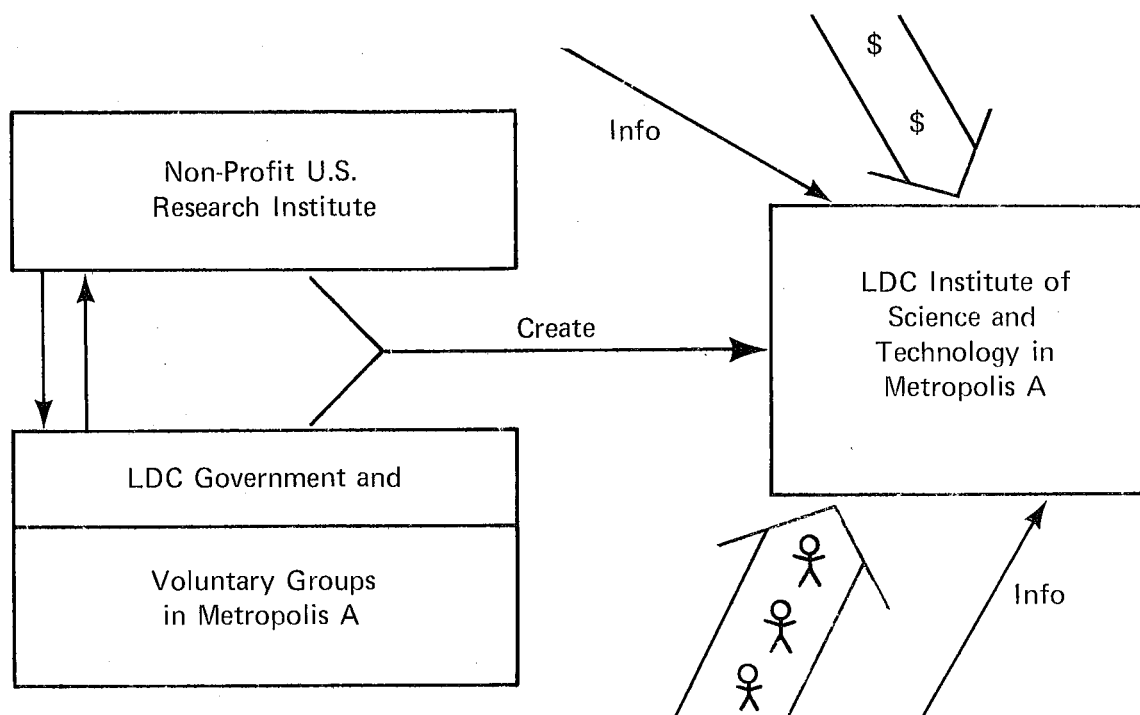


Figure 15. The institution information process parallels that for the Korea Institute of Science and Technology more than a decade ago.

to "getting one's hands dirty" in the expediting of prototypes, if that would make a difference. Together with their professional, trained counterparts in the LDC's, they fit knowledge to a willingness to act in such a way that the critical energy pinch, now projected to start in the 1995-2000 period when worldwide petroleum production is expected to halt its expansion, is noticeably reduced in intensity and the path to full dependence upon continuous supplies (primarily solar) has been worked out.

The projects should be worked upon twenty or more at a time because the expected frequency of failure is so great. With ordinary processes of dissolution and bankruptcy much valuable experience would be lost, and morale would suffer. With the aid of the "law of large numbers" the few successes can still outweigh the losses (Fig. 16).

The necessity for evaluating projects according to their contribution -- as well as economizing upon whatever else may be scarce, such as capital, foreign exchange, budgetary allocations, land, water, and necessary skills -- suggests that a flow of current data should be generated. This is a function that fits very well into the terms of reference of an Institute of Science and Technology. Energy data so far assembled in America and Europe are ill-suited to policy-making, so it is not reasonable to transfer present methods of data gathering to the rest of the world. Instead, we and they need to consider the conditions likely to be encountered in the 1990's and thereafter, and what information would be needed to address the foreseeable exigencies.

Data development and assembly projects can be organized in the same manner as those intended to develop appropriate resource-conserving technology. The successful project is one that leads to adoption of one or

CREATION OF RESOURCE-CONSERVING ORGANIZATION

Developed Countries

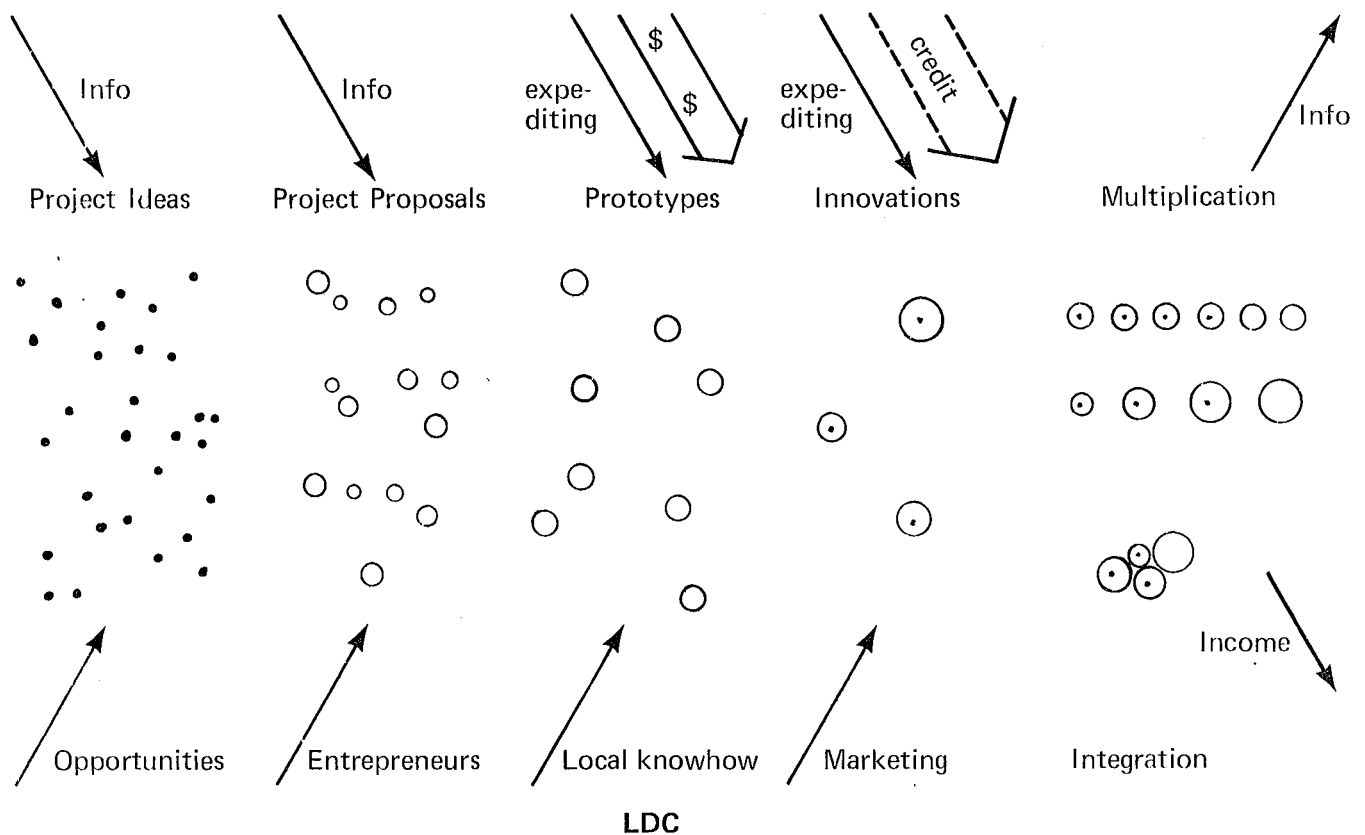


Figure 16. The project ideas are very often unique to conditions prevailing in a city. The process of collaborative project development should lead to multiplication, scale-ups, or integration of autonomous units (dotted circles) quite rapidly in a favorable urban environment.

more series of indicators by official agencies, by professional associations, or by groups of industries. The program can be discussed in a manner parallel to the others.

8. Energy Utilization Indicators in Urban Settlements. Henceforth a body of current data covering energy importation and consumption should have the following desirable features:

(a) It should permit estimation of the efficiencies of fuel use, according to the principles of the Second Law of Thermodynamics as well as the First Law, for principal activities in the urban region, because the waste of very high grade fuels can then be prevented.

(b) This body of information should be treated in such a fashion that it can be linked to nutrition in man and animals, since a combination of direct and indirect requirements suggests that food may account for as much as half of the aggregate demand for energy in some LDC metropolises.

(c) The information should relate directly to consumption (from the point of view of citizens and administrators) and therefore suggest reasonable approaches to the rationing of food and fuel, very likely reflecting a hierarchy of locally held values that distinguish a given metropolis from others.

(d) The information should contribute to variable pricing at peaks, according to daily, weekly, and seasonal cycles.

(e) Quick, cheap, routine methods need to be devised for collecting snapshot data on energy use, such as earth satellite infrared photos and counting total volume of moving transport, which simultaneously reveal conversion to waste heat (signalling entropy increase), but also the obverse, by identifying areas devoted to solar energy collection.

(f) *Appropriate instruments are needed which yield instantaneous feedback information on use of power and high energy content fuels which allow machine operators and managers to economize as they work.*

(g) *Linkages with the rate of social transactions, telecommunications transmission, and computations volume, as well as gross domestic product (GDP), should be established in order to obtain indicators of various kinds of urban system efficiency.*

Priorities for Action

Where should such a program start? The most logical answer is that it should begin wherever the urbanizing pressure is the greatest and the patterns of newest settlement can be pushed into resource-conserving forms. Urbanizing pressure can be gauged by looking at the respective metropolitan regions and estimating the masses to be urbanized in the 1978-1995 period (Table Seven).

What the list in Table Five reflects is the failure of the population policies of the 1950's and 1960's. Unwillingness to take a stand on family limitation was often combined with an inability to comprehend the impact of the human flood loosed upon the cities, when no decisions were taken. At some time during the 1970's, the official policies in all the national governments managing the affairs of these metropolises did become more enlightened. In many cases, it is still too timid, so that a basis for highly organized information dissemination combined with convenient contraceptive service has not yet been established, or even authorized. Yet this decade also reveals some of the backlash from proceeding too aggressively with simplistic procedures for birth control, as in India after

Table Seven

FOCI FOR NEW URBAN SETTLEMENT: 1978-95

<u>Urban Region</u>	<u>Settled Population to be added by 1995</u>
"Paulo-Janeiro" (Sao Paulo, Rio de Janeiro)	22 millions
Nile Delta (Cairo, Alexandria)	20
Mexico City	15
Calcutta (Kharagpur, Haldia)	12
Shanghai	11
Bombay	11
Jakarta	11
Delhi	11
Manila	10
Karachi	9
Bangkok	8
"CalSouth" (Los Angeles-San Diego-Tijuana)	8
Moscow	8
Wuhan	7

(Populations in 1978 are subtracted from those anticipated in 1995, with appropriate adjustments for megalopolis formation, and rounded to the nearest million.)

the "Emergency," and might take another form in Shanghai over the next few years. (In India, according to private reports from clinicians, people have lost confidence in the family planning programs; similar reports from Chinese-speaking travelers in Chinese cities claim that the family is reasserting its primacy in Chinese society, and it may soon demand more heirs.)

Each culture has its own pace for changing the fundamental social relationships affecting procreation, but it is exceedingly difficult for political leaders to sense what the limits upon pressures to change may be. The principal relevant appropriate instrument the United States for gauging attitudes has developed is that of survey research technique. However, these methods have already been installed in almost all of the rapidly growing urban regions for purposes of marketing, and are increasingly used to guide public policy, so little more effort is required. The technology for a still more diverse set of safe contraceptives promises to be a profitable business, so that part of the effort is already being pursued with vigor and imagination, needing little further help.

Because a modern society -- the kind these metropolises are headed toward -- is committed to plan for the adequate provision of services, including energy, for each infant added to the population, fertility restraints are of the utmost importance for energy conservation over the long run. However, they have their principal effects well into the twenty-first century. The predominant share of the immigrants accounted for in the 1995 projected growth have already been born in 1978; by migrating they are merely putting in a bid for their share of services. Because population planning issues have a different impact from those of urbanization,

they require separate analysis. This paper merely reveals their significance, without suggesting appropriate kinds of action.

Once the locales for the greatest urbanizing pressures were identified, we studied maps and interviewed planners from those places. Was it physically possible for these hordes to be accommodated? What needed to be done between now and then? What else should be done to deal with the pressures after 1995? Relevant information is exceedingly fragmentary, even in the cities concerned, and much less is available on short notice. Nevertheless, an evaluation of the situation in several of the locales under extraordinary pressure suggests that the problems of accommodation are soluble over the next two decades. The projected growth is likely to occur because the conditions in the cities, although distressing, appear to be better than those at home in the countryside or the towns.

Conclusions

The pace of urbanization must continue, because in most parts of the world the surplus population in the countryside has nowhere else to go. The world is about 40% urban now and apparently headed for the 80-90% share of the total population presently exhibited by the developed countries. Thus, the 1,600,000,000 urban dwellers in 1978 would become about three billion in 1995 -- if major catastrophes can be avoided.

The very large metropolitan areas now under heavy migration pressure are generating a number of unprecedented situations. Integrated megalopolitan complexes are expected to form in at least five locations. Three or four metropolitan regions are expected to exceed the population of Tokyo before the end of the century, and will be still growing. Scores of other multi-million size settlements will have added population to the point where major capital-intensive, energy-consuming infrastructure must be superimposed to provide transport, water, food, and housing.

Simultaneously a new, highly competitive world urban system is coming into being. Stimulated by the growth of international trade, especially the flow of fuels, the metropolitan areas must compete for mobile human capital of many varieties, investment funds, the presence of multinational enterprises, and the use of knowledge and designs. Telecommunications and airlines are the connecting links responding most rapidly to the new system structure. This competition reduces the freedom of choice in metropolitan development -- if cities fail to improve internal security and quality of life, their assets will flow to cities that appear more effective. To hold onto these mobile assets cities will have to extract more satisfactions from the increasingly scarce commodities, such as energy, mainly through substitution and conservation strategies.

Per capita consumption of energy is expected to increase gradually in LDC cities, even when allowing for a 50% price rise and 15-20% savings achieved by conservation and substitution. Meanwhile, per capita consumption in the industrial countries is expected to rise for a while, level off, and then start retreating toward a more manageable level around the end of the century. Total energy demand for LDC cities is expected to match that of the developed, early in the twenty-first century.

How much electric power is required in the LDC metropolitan areas? The present range for the largest of these is 100-500/kwh/capita/year for internal consumption. Export industry requirements are additional, and still more variable, but they diminish with megalopolis formation. An efficient, planned provision of modern urban services, including local transport and commerce, has been estimated to require about 300 kwh/capita/year in tropical climates.

Because the diversity of the respective metropolitan regions is so great, and the prospects for future growth so problematic, the only means for determining nuclear demand is to study the options available to the larger settlements independently. Such an analysis has been recently reported for the metropolitan grids of South Korea, and 11-14 reactors at 1000-2000 MW were deemed to be needed by Seoul and its export industries, depending upon decisions yet to be made regarding the splitting of central government activities from business and cultural affairs.

Developed countries, such as the United States, can speed up the search for better resource-conserving technology by collaborating with research, development, and promotion institutions in the respective metropolises. The most promising existing model for such an institution is

the Korea Institute of Science and Technology in Seoul. It accepts contracts and grants and undertakes to improve processes for the production of food, shelter, transport, materials, appliances, and information gathering. A broad distribution of urban technologies appears ripe for testing. The best of such experience should be applicable in North America a decade or so later. This form of aid-giving also helps the donors, if it succeeds, by reducing the upward pressure on fuel prices paid by donor nations.

Feasibility assessments for Sao Paulo-Rio de Janeiro, Calcutta, Cairo-Alexandria, and Mexico City are presented in the appendices. This analysis-from-a-distance is insufficient to judge how much extra installed electrical generating capacity is required before 1995, the added refining capability for liquid fuels, or the uses for new LNG and coal imports due to be arranged. It is evident that energy (and perhaps also water in most regions) planning is the major determinant of the manner in which these urban areas will adapt to the extraordinary pressures for new settlement. The current round of planning in such metropolitan areas has been addressed to solving traffic congestion problems, and reorganizing land use in central districts, as the most pressing issues. Since energy sources and distribution systems now affect the largest and most crucial investments in urban growth it is to be expected that future metropolitan planning may concentrate upon energy efficiency. Energy supplies must be planned to meet requirements set by locally dominant values regarding human services and the environment.

The only locales in which we have found this kind of planning has begun within the less developed countries are in Korea. For that reason

we also add in the Appendices a brief analysis of future Seoul development, even though recent successes in population control have greatly reduced the numbers it attracts from the countryside, making its task considerably easier than it is for the leaders we have identified.

APPENDICES

I. Prospects for Sao Paulo and Rio de Janeiro

Almost everyone in Brazil would like to see a levelling of the growth in these two huge metropolitan areas. Very recently the national government expressed its intentions to deflect expansion to other locales. However, direct and indirect measures for restraining urban dynamism have delayed impact (unless massive rustication is employed, as in Shanghai and Phnom Penh), so the present momentum will absorb large numbers of immigrants. The population anticipated in 1995 (according to Table Six) assumes that such policies will succeed to some extent before that date. They also assume that family planning will become more prevalent, especially in urban areas. The attractive force of a per capita income two and a half times the average for the rest of Brazil explains why migration will continue despite the official hurdles put in its path.

The topography of Sao Paulo suggests two directions of least resistance for physical growth at the periphery. One is to the south and east toward the coast and another into the interior to the southwest (toward Curitiba). Major additions to Rio seem likely to be in suburban watersheds made accessible through expensive improvements in mass transport systems. The preferred watersheds for accommodating the brunt of the growth lie between the two urban centers. The Paraiba Valley, in particular, has already provided sites for chemical, food, and metallurgical industries.

The most severe restraints upon growth reported by planners are presently felt in matters of pollution, the supply of fresh water, and the provision of transport. The existing waste disposal system has been swamped by heavy industry (mainly Sao Paulo), and the Paraiba Valley is already severely affected. However, new immigrants are rarely deterred by such conditions.

The inadequacy of passenger and goods transport may hold back some growth on the periphery of both cities (squatter settlements are appearing close to the new freeways), but the bus transport system still offers considerable opportunity for improvement in efficiency.

Brazil expects to dominate auto production in Latin America, as well as providing the largest single market. Its cities need to plan for circulation space and parking at least proportionate to the growth in the number of vehicles, otherwise the congestion will prevent the bus systems from serving all their patrons. Public rail transit systems are necessary, and the anticipated expense is unprecedented, but they can supply only a minor portion of the need (present rail lines are being taken over by freight movements). An expanded freeway program, perhaps similar to that of Japan, will allow a more dispersed industrialization, with new favelas springing up near new plants, but it too will cost more than can be afforded. It appears from this distance that Sao Paulo will need a complete subway network that connects with a very fast railway to Rio, but it is doubtful that either will be ready by 1995.

If the infrastructure is not ready the land rents in the present cities are likely to rise to levels as high as those in Tokyo. The poor would be the most severely affected; most would be squeezed out to the periphery. The appearance of megalopolitan infrastructure may be postponed by combinations of disasters afflicting this region. Not to grow is the more painful alternative.

II. Prospects for the Calcutta Metropolitan District

Fabled Calcutta is maligned by journalists. After Bombay it is for Indians the most successful metropolis in India, because it offers employment for men of the village who support many millions of people with their remittances. This explains the large surplus of males, and accounts for much of the disinterest in maintaining the built-up core of Calcutta, which was once the British capital of colonial India and is still the reception area for visitors. Urban Calcuttans maintain an exceedingly lively cultural life, conducted in almost all the Indian languages, and appearing as drama, literature, cinema, and music. The political ideologies are indigenous, although the labels may be borrowed, and the violence or paralysis created by their interaction has postponed some of the growth arising from industrialization and immigration.

The greatest constraint upon growth has been attributed to problems with water supplies and associated sewage, drainage, and environmental hygiene. The overriding fear has been cholera, which is endemic. However, since those plans were made, a simple, very cheap, curative approach to cholera has been proven and is slowly gaining acceptance. Recognizing that tube well technology has also advanced greatly in the last decade, it is apparent that ad hoc solutions to water and drainage problems will be feasible, and thus well within present administrative capabilities.

Internal traffic flow is hopelessly bottlenecked by an insufficiency of bridges across the Hooghly River, the eastern mouth of the Ganges, and complicated by the need to use the river for the principal port for all of India for cargo from the east. The silting of this harbor, and the intrusion of salt water into the aquifers, is to be deferred by flow

manipulation of the Ganges (Farakka Barrage), according to a recent long delayed agreement with Bangladesh. Dredging of the channel fills nearby Salt Lakes and low lying areas, which eventually become buildable land in highly accessible parts of the district (Lubell, 1974).

Haldia, the new deep water port, is just now coming into operation. It is the obvious site for capital-intensive industry (petroleum refining, petro-chemicals, fertilizer, minerals processing, flour, sugar, etc.). Since Haldia is better connected with the rail junction city of Kharagpur, 130 km east of Calcutta, much of the forthcoming urban growth will appear along this corridor. Another strip will be along the road to Calcutta, especially the ferry terminal areas (C.M.P.O., 1971). Upstream the expansion of industry is already evident; it is associated with the rail connection with the coalfields and Delhi.

Thus, over the next several decades Calcutta is likely to extend beyond its present planning district, moving ribbonlike through the estuary. The constricting effects of traffic congestion are therefore greatly diminished. The nearby rural area is gradually being reorganized by the urban markets for produce and the introduction of light manufacturers into the villages.

Grave difficulties will continue to be experienced with the inner city. The subway being built with the aid of the Russians seems to go on interminably, so that Calcuttans despair of ever seeing it in operation. Even then only a small part of the commuter demand would be met. The connection of the two major rail termini by a tunnel under the Hooghly would be a great rationalizing step for Indian Railways, as well as for Calcutta; it would be a major item of infrastructure that could set new expansion patterns into operation.

Most of the housing added in the last three decades has been of the kutcha, or semi-permanent, type in communities called bustees which are well-suited to the climate (especially after bustee improvement programs are implemented), but do not contribute to civic pride. When the gradual process by which bustees are converted into pukka urban settlement is recognized and expedited, most of the housing impediment to growth will have been overcome. Calcutta should be able to accommodate the many, many millions who wish to find their fortune in its diverse communities.

III. The Cairo-Alexandria Megalopolis

In Cairo urbanization is rapid, uncontrolled, and unplanned. It is a city that operates continuously on the brink of disaster. Basic staples of life and transport services are heavily subsidized, and the subsidies are funded from sources outside Egypt, and therefore not dependable. Transport capacity is so limited it often appears that large numbers of people in the central city will not get home at night. Housing is so scarce and costly (when it is not subsidized) the poorest half of the population is crowded one or more households (average nine members) per room. The postal delivery service takes weeks, so most of government and commerce uses its own couriers; the telephone system is completely over-taxed during working hours. The nation has recently decided it will stop payments on its debts to its leading creditor, and whatever action the creditor takes (the U.S.S.R.) will have its primary impact upon the capital city. Fuel for its overloaded power plants and railways is obtained in part on short-term credits.

Recent attempts to introduce first steps toward economic realism, as demanded by the International Monetary Fund and other creditors, triggered spontaneous riots in Cairo and Alexandria, so the original subsidies have been restored. Meanwhile, the gap between consumption and production widens, and increasing amounts of foreign aid must be pumped in.

Cairo's economic and physical condition is more desperate than that of any other Third World metropolis in the multi-million category. If the present imaginative leadership should falter, the city is likely to lapse into the pre-Nasser forms of chaos, with potentials for urban guerrilla activity reaching ten times the scale of Beirut in the 1975-77 period.

Foreign aid is being pumped in as fast as feasible projects can be devised for absorbing it, but a large share passes through Cairo to be expended around the Suez Canal -- a major source of future income.

Perhaps half the population of Cairo copes with these conditions well enough to live noticeably above subsistence. Industrial, white collar, military, and professional classes that make up this sector are responsible for the preponderant share of the energy consumption. Automobile registration is only 9/1000 of the population, but automobiles are in very strong demand and the numbers are growing more than twice as fast as the population. The number is growing because the educational system is expanding and an important fraction of the graduates do not fly off to take employment in the Arab OPEC countries.

Most of the population growth comes in the form of complete families from surplus population in rural areas, some of which are the most thickly settled in the world at more than 10 persons per hectare (2500/sq. mile). Egyptian population growth rates are estimated to be close to 3% per year, so the present 40 million is expected to be something like 54,000,000 in 1995, with almost all the extra population attempting to settle in the 200 km ribbon of urbanization connecting the southern limits of Cairo with Alexandria along the rail lines through the Delta, or in the Canal Zone region. Cairo's annual population increase continues at 4.5% per year.

Cairo has long needed a subway system, and several surveys have been made. Very soon Alexandria will need one also. The basic difficulties are not technical, but financial. It would take five years to re-map the underground utilities before a start can be made. A partial alternative -- a waterway system of mass transport -- does not seem to have been explored.

Its technical feasibility is very recent -- only since the downstream adaptations to the regulation of the Nile following the filling of the Aswan dam have begun. The connecting railway system, once a prestige agency in Egypt, could be reconstructed to serve the growing inter-city traffic, but an expanding bus system would appear to handle the bulk of the traffic economically.

For building materials -- a major energy-using industry in Cairo -- the urbanizing population must abandon fired brick made from silt and switch to building block filled with desert sand or pre-stressed concrete. Apartments in buildings two to five stories high at the edges of present urbanization will continue to predominate. Therefore, the densities of settlement created will remain very high, judged by global standards. The crowding is justified among Cairenes by the shortage of fertile land. Domestic consumption of energy is likely to be restricted to a bit of kerosene for cooking, and electric power for lighting and television for the more fortunate fraction. Local transport would be pedestrian, using handcarts for deliveries, switching to buses and trucks for longer movements. Tourism may introduce some summertime peaks in demand for power, due to air conditioning. It focuses upon the center of Cairo and the Alexandria waterfronts and will probably generate important amounts of investment, permitting the central business districts of both cities to create over time a full set of modern metropolitan services.

Very likely the major demand for energy by 1995 will be most affected by industry. The law attracting industry to Egypt had to be revised and was only beginning to work at the end of 1977. If this low cost labor can be mobilized institutionally (i.e., joint firms, banking, taxation,

moderate levels of corruption, etc.), a very rapid overspill of light industries from the Common Market countries is predicted. Products would be marketed in the Arab countries with rapidly rising incomes. Tanta, in the mid-Delta, already exhibits such industrialization pressures.

Increases in productivity involved in such a transition are sufficient to overcome the need for subsidies. The slowness of the required institutional change, and delays in the introduction of such infrastructure as bridges and telephones, introduce strong doubts.

To conclude, it is physically quite feasible for this vast increase in urban settlement to occur, but the political risks are high, and the rate of institutional change required is unprecedented for that part of the world.

IV. Mexico City

Within the short period of time allowed to us it has been impossible to find a feasible future for Mexico City that allows it to continue to grow as projected to 1995. The new migrants who hope to live there have already been born, so the demand for places in the metropolis already exists, but the supply is uncertain.

Drawing from verbal reports of planners who visit the city frequently, the cost of providing potable water is rising exponentially much faster than the population. If the capital cost of water supply for each person added to the population of the metropolis exceeds his marginal contribution to output the city quickly runs short of funds for any other kind of infrastructure. When costs become much higher than other cities, credit becomes unobtainable. Even if the country is fortunate with respect to the current oil discoveries, the wealth would only last for decades while a water system must be planned for centuries.

Transport poses problems almost equally imposing. The demand for housing also appears overwhelming. The location of the Mexican capital city on a marshy plain at a high altitude makes it relatively expensive to meet basic human needs.

If the possibilities for growth do not exist, the Government has other options. It could, for example, buy a communications satellite and establish the best possible communications with several other cities that can accept the urbanizing pressures more readily -- Monterrey and Mexicali come to mind, although they, too, encounter water problems. There might also be some new city which needs to be created to manage the petroleum development in Chiapas, far to the south. Institutions must be launched

which promise to be of the same quality as in Mexico City. Other countries, such as Korea and Nigeria, are actively considering the splitting of capital functions for many of the same reasons.

V. Seoul

From 1960 to 1975 Seoul was the fastest growing million-size metropolis in the world. Population was added at the rate of 9-11% over most of these years. Although the effects of this hyper-urbanization are still evident, almost miraculously the expansion was quite well balanced (Meier, 1970). Record rates of economic development were matched by equivalent rates of social development. Most of the planning and management over this period was the responsibility of the Seoul municipal government, but henceforth the initiative will be taken by the national agencies.

The Seoul city government is almost unique among cities in less developed countries because it publishes for internal consumption a comprehensive yearbook with current statistics and estimates; its coverage ranges from a listing of land parcels owned by the Government to consumer price indexes, to the distribution of "superstition" in the form of geomancers, mantra chanters, etc., as well as more standard categories.

The city government also found a number of ingenious solutions for meeting the housing shortage. In the 1960's it offered rights to floorspace in unfinished apartments to the squatters on its land; they moved willingly because the accessibility of the new buildings was better than for their huts, and they could get legitimate titles. In 1970 a satellite city was started for blue collar workers, who built it virtually out of the soil upon which it rests; by 1978 about 700,000 have been settled by means of such programs. Shortly thereafter a self-help program for houses and neighborhoods transformed the poorest areas of the city itself (Meier, 1974). Now the emphasis is placed upon highrise apartment communities for the rapidly expanding middle classes.

The national government proposes that a new capital city will be created nearer the center of population to accommodate administration. It will be connected by high-speed electric railway some time in the 1990's, thus accelerating megalopolis formation along the Pusan-Seoul corridor. By 1995 it is expected that over 40% of the national population will be concentrated along this line.

Korea as a whole has become a transformer of imported raw materials into standard, low-priced exported manufactures (Asia Yearbook, 1978). Seoul generates more manufactures than any other metropolitan area, but it specializes in those requiring high technology and more highly skilled labor. A very large share of the energy consumed in the metropolis nevertheless is imbedded in the exported manufactures. Electrical power consumption is projected to reach 3000 kwh per capita by 1997, five times the level in 1977. The national plan is to construct 46 nuclear power stations by the year 2000, of which eleven to fourteen (1000-2000 MW capacity) would be needed by Seoul.

The present plan for reconstructing Seoul assumes that pollution-free fuels (kerosene, LNG, and electricity) will replace the briquets now employed in the household; this should reduce loss of life due to carbon monoxide poisoning and the nuisance of disposing of briquet ash. Private cars with fuel economizing engines are expected to become much more numerous in greater Seoul, about one for every 10 persons in 1995 as compared to one for 170 in 1975 (Korea Development Institute, 1978).

Korea is now able to accumulate foreign exchange in the same manner as Japan, though not at the same scale, so the odds are increasingly in favor of its being able to acquire the necessary capital. The National Planning Board projects that about 80% of the country's power should be derived from nuclear fuels, and only about 2% from hydroelectric, with the remainder

mainly from coal. The threat of air pollution in the lower Han River basin around Seoul suggests that coal-fired generators be kept at a distance. Because cold and cloudy weather is expected through winter and spring, Seoul cannot make economic use of solar energy.

On the whole the future can be projected with greater confidence for Seoul than for any other of these metropolises. Its evolution into the Seoul-Pusan megalopolis in the 1990's, containing more than 25,000,000 population, seems inevitable.

BIBLIOGRAPHY

- Asia Yearbook - 1978, Far East Economics Review, Hong Kong, January 1978.
- Calcutta Metropolitan Planning Organization, Haldia Region Interim Strategy Plan, Government of West Bengal, Calcutta, 1971.
- Currie, Lauchlin, "Interrelations of Urban and National Economic Planning," Urban Studies, 12, 1978, pp. 37-46.
- Dong-A Ilbo (Daily News), Seoul, January 21, 1978.
- Economic Planning Board, Korea Statistical Yearbook, Seoul, 1975.
- Evenson, R.E. and Y. Kisler, "A Stochastic Model of Applied Research," Journal of Political Economy, 84, 1976, pp. 265-81.
- Findley, Sally, Planning for Internal Migration: a review of issues and policies in developing countries, U.S. Government Printing Office, Washington, D.C., 1977.
- Fitzhardinge, Richard, "Housing for the Imperial Valley: USA and Mexico," unpublished report, Department of Architecture, University of South Wales, Sydney, Australia, March 1977.
- Freika, Tomas, The Future of Population Growth, John Wiley, New York, 1973.
- Goldmark, Peter C., Bonnie Craig and Andrea Equinton, "Communications for Survival," Habitat 2, 1977, pp. 13-35.
- Harkness, Richard C., "Technology Assessment of Telecommunication-transport Interaction," Habitat 2, 1977, pp. 33-48.
- Hirschman, Albert O., Development Projects Observed, Brookings, Washington, D.C., 1967.
- Kambe, Masashi K., "New Opportunities in Fresh Fruit and Vegetable Marketing in Metropolitan Agriculture," in H. Sowthworth (ed.), Some Studies in Fresh Fruit and Vegetable Marketing in Asia, Agricultural Development Council, Singapore, 1974, pp. 106-132.
- KIST Annual, Korea Institute of Science and Technology, Seoul, 1969.
- Korea Development Institute, Research Report, Vol. 75, Seoul, Korea, 1975.
- Korea Development Institute, Fifteen Year Perspective Socio-economic Development Plan: 1977-2000, Seoul, January 1978.
- Laquian, A.A., "Whither Sites and Services?," Habitat 2, 1977, pp. 291-302.
- Lubell, Harold, Calcutta: Its Urban Development and Employment Prospects, International Labour Office, Geneva, 1974.

- McGee, Terry, Hawkers in Southeast Asia, IDRC, Ottawa, Canada, 1977.
- Meier, Alan K., "Becaks, Bemos, Lambros and Productive Pandemonium," Technology Review, January 1977, pp. 56-63.
- Meier, Richard L., Urban Futures Observed -- In the Asian Third World, 1978 (in press).
- Meier, Richard L., "A Stable Urban Ecosystem," Science 192, 1976a, pp. 962-8.
- Meier, Richard L., "Urban Futures Observed -- In the Asian Third World," Working Paper No. 264, Institute of Urban and Regional Development, University of California, Berkeley, May 1976b.
- Meier, Richard L., Planning for an Urban World: Design of Resource Conserving Cities, M.I.T. Press, Cambridge, 1974a.
- Meier, Richard L., "Seoul 1974: The Urban Dynamics of Accelerated Development," Working Paper No. 238, Institute of Urban and Regional Development, University of California, Berkeley, July 1974b.
- Meier, Richard L., "Exploring Development in Great Asian Cities: Seoul," Journal of the American Institute of Planners, November 1970, pp. 378-92.
- Morgan, Robert P., "Technology and International Development: New Directions Needed," Chemical and Engineering News, November 14, 1977, pp. 31-9.
- Newcombe, Kenneth, "Nutrient Flow in a Major Urban Settlement," Human Ecology, 1977 (in press).
- Newcombe, Kenneth, "Energy Use in Hong Kong," Urban Ecology 1, 1975, 87ff.
- Newcombe, Kenneth and K. Bowman, "Intensive Animal Production at the Crossroads: The Potential of the Urban Fringe," presented at the Anzaas Congress, Melbourne, Australia, August 1977.
- Newcombe, Kenneth and E.H. Nichols, "An Integrated Ecological Approach to Agricultural Policy-making with Reference to the Urban Fringe," Draft, Hong Kong, October 1977.
- Oswald, William J., "Determinants of Feasibility in Bioconversion of Solar Energy," in Amleto Castellani, ed., Research in Photobiology, Plenum, New York, 1977.
- Paraskevopoulos, S.C.A., "Structural Potential of Foam Plastics for Housing in Underdeveloped Areas," Architectural Research Library, University of Michigan, Ann Arbor, Michigan, 1966.

Sarkar, D.K., Bhaduri, T.J. and M. Bhargava, "Scope of LTC Projects in India," Institution of Engineers Journal, India, Vol. 57, October 1976, pp. 53-58.

Turner, J.F.C., Housing by People: Towards Autonomy in Building Environments, Pantheon, New York, 1976.

Wilson, Carol, Workshop on Alternative Energy Strategies: Energy Supply-Demand Integrations to the Year 2000, M.I.T. Press, Cambridge, 1977.

Yashiro, Takachi, Chlorella: Fundamental Knowledge and Application, Gakushukenkyosha, Tokyo, 1971 (in Japanese).

This report was done with support from the Department of Energy. Any conclusions or opinions expressed in this report represent solely those of the author(s) and not necessarily those of The Regents of the University of California, the Lawrence Berkeley Laboratory or the Department of Energy.

TECHNICAL INFORMATION DEPARTMENT
LAWRENCE BERKELEY LABORATORY
UNIVERSITY OF CALIFORNIA
BERKELEY, CALIFORNIA 94720