# Intra and Inter Country Energy Intensity Trends

Ramachandra T.V., Yves Loerincik and Shruthi B.V.

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**ABSTRACT**

Energy is essential for economic and social development of a region or a country. However, consumption of fossil fuels is the major cause of air pollution and climate change. Improving energy efficiency and delinking economic development from energy consumption (particularly of fossil fuels) is essential for sustainable development of a region. Trends in overall energy use relative to GDP (gross domestic product) indicate the general relationship of energy consumption to economic development and provide a rough basis for projecting energy consumption and its environmental impacts with economic growth. For energy policy-making, sectoral or sub-sectoral energy intensities would be useful. The energy intensity indicates the total energy being used to support economic and social activity. It represents an aggregate of energy consumption resulting from a wide range of production and consumption activities. This paper presents intra and inters country trends in energy intensities by comparing the energy consumption per capita and energy consumption per GDP for various countries. The energy consumption per GDP for the energy sector gives the efficiency. Developed countries generally have very low value indicating a higher efficiency compared to the developing countries.

Asiatic countries like South Korea, Israel, Kuwait, United Arab Emirates, Singapore and Japan, have GDP per capita higher than 10,000 US dollars and energy consumption per capita ranging from 100 –550 giga joules. European countries like Norway , Denmark and Switzerland have a GDP per capita of 15,000 US dollars. African countries like Libya , Gabon , South Africa , Mauritius , Tunisia and Algeria have GDP per capita higher than 1,000 US dollars, and energy consumption per capita ranges from 25-120 giga joules. The values of the GDP per capita are well spread between 0 and 8000 US dollars in South and Central American countries. Energy consumption per capita ranges from 40-250 giga joules. Oceanic countries like Australia and New Zealand have GDP per capita in the range of 15,000-20,000 US dollars. Energy consumption per capita ranges from 175-250 giga joules. This energy analysis highlights the scope for energy conservation in many parts of the globe, especially in developing countries.

**key words**: Energy, GDP, and Energy Intensity.

## INTRODUCTION

Energy has always been a major component in the day-to-day life of humans. More than 1billion people in the industrialized countries (about 20 percent of the world's population) consume nearly 60 percent of the total energy supply, whereas about 5 billion inhabitants in developing countries consume the other 40 percent. The 2 billion low-income individuals ($1,000 annual income or less percapita) scattered in rural areas and shanty

towns, use only 0.2 tons of oil equivalent (toe) of energy per capita annually; the I billion or so "rich" people ($22,000 annual income or more per capita) use nearly 25 times more per year-5 toe per capita.[1] Overall, energy consumption has never been as high as today. Every country is trying to achieve economic growth with energy-intensive paths. Energy intensities are valuable indicators in describing the energy consumed in entire production chains. The combination of sectoral energy intensities and the demand for sectoral outputs provides insight into an economy's total energy use. Changes in energy consumption reflect the combined effects of changes in energy intensities in various sectors and changes in the volume and structure of demand. Energy needed per unit of production (referred to as energy intensity or specific energy consumption) shows the sensitivity of products or sectors to changes in energy prices. Temporal analyses or historical studies of energy intensities provide information about changes caused by energy price changes and their effects on total energy use.[2]

The paradox when dealing with energy is that it is needed for man to live and develop and, at the same time, unplanned developmental activities focusing on fossil fuels are affecting the environment in which he lives. Moreover, the evolution of the societies, the economic growth, and the way countries develop lead to an increasing demand for energy. Two problems arise with expanding energy consumption: first, pollution associated with energy usage increases, leading to unknown changes in world climate that could have tremendous repercussions; second, the fossil fuels commonly used are not renewable. Even if people are concerned about the future of the planet, the power of money and the need for economic growth dominate the debate. Studies have been made on the different fossil fuel resources, nuclear power, and the more environmentally benign energies like solar and wind in order ultimately to replace the fossil fuels and generally nonrenewable energies.[3] On the other hand, efforts are being undertaken to increase efficiency and, therefore, conserve energy.

Initially, the energy use per capita was used as an index of a region's development; it is quite low for developing countries and high for developed nations. However, this approach does not reveal any picture of development or efficiency of usage. To achieve this goal, it is necessary to look at the energy intensity, that is, the energy consumed per unit of output, which is the inverse of the energy efficiency of any process (the output per unit of energy consumed). The impact of more efficient energy use in reducing energy demand and the overall prospects for restraining energy demand growth are important issues in the context of environmental policy. Energy intensity is directly related to price signals, whereas energy efficiency depends more on the diffusion of the most cost-effective technologies. It is important to point out where the losses of energy are the highest in order to reduce them. Some developed countries have lower or similar energy consumption per capita and a much higher per-capita gross domestic product (GDP) thancertain developing nations. Energy services will be fulfilled only if GDP grows in a sustainable manner. Such economic growth will require the provision of corresponding energy-related services at an affordable price with no reasonable expectation to break the linear relationship between GDP growth and the increase in the energy demand that has been experienced so far.[4] Understanding the situation is an essential step for initiating appropriate conservation measures. This paper compares the energy consumption of most

countries of the world. Using indicators like energy consumption per capita and energy intensities (energy consumption per GDP), it is possible to offer an analysis that would help in optimal resource planning.

## OBJECTIVES

The objectives of the study are to (1) compare the energy consumption per capita and energy consumption per GDP for various countries and (2) analyze, describe, and explain the differences found in the energy consumption indicators in an uncomplicated manner.

## LITERATURE REVIEW

Harry C. Wilting et al. studied the energy intensity trends for 56 Dutch economic sectors for a period of20 years (1969-1988).[5] The intensities were calculated by using input-output analysis. Energy intensities have error margins due to uncertainties in the parameters of the input-output model. Uncertainties in energy intensities for any year are less than 8 percent for most sectors. The effects of energy price changes were examined. More than half of the economic sectors show significant declines in energy intensities as a result of increasing energy prices. The results estimate that there was an 18-percent decrease in the ratio of domestic primary energy use and the GDP (energy intensities) for the period 1973-1987. Energy intensities decreased in 40 of the 56 sectors; in 30 of these sectors, the decrease was greater than 10 percent.

Kees Vringer and Kornielis Blok analyzed the changes in energy consumption patterns of Dutch households for a period of 48 years (1948 to 1996) in order to discover whether these changes have influenced the energy intensity of the society.[6] Due to the rise in consumption, the total household energy requirement per capita grew an average of 2.4 percent annually over the 48 years. In the same period, the total energy intensity of households fluctuated but on average changed from 5.6 to 6.3 megajoules/1995 Dutch guilder (MJ/NLG), an increase of 0.25 percent per year. By excluding the direct energy consumption, there is a slight decline in the indirect energy intensity, from 3.8 to 3.6 MJ/NLG (-0.14 percent per year). No significant trends to lower energy intensity are found, and there is no indication of dematerialization of the consumption patterns.[7]

T. V. Ramachandra et al. have studied the energy prospects in the industrial sector for Karnataka state in India.B In the industrial sector, energy per state domestic product is 10 to 20 times higher compared to that of the industrialized countries. This implies inefficiency in energy utilization. Detailed investigation of the industrial sector, through analysis of specific (industry and sector) energy consumption for a period of seven years reveals that about 28 percent of energy could be saved in the industrial sector, which amounts to 2.25 million toe of energy or 1,541 million kilowatt-hours (kWh) of electrical energy per year in Karnataka. This savings is equivalent to the energy output of a 300-megawatt (MW) electric power-generating unit (hydro/thermal)[9]

Zhong Xiang Zhang studied the changes in energy consumption in China's industrial sector in the 1990s, based on the data sets of value added and end-use energy consumption for the 29 industrial sub sectors using the newly proposed decomposition method of giving no residue.[10] Results show that 88 percent of the cumulative energy savings in the industrial sector for the period 1990-1997 was attributed to real intensity change, with approximately 80 percent of such savings from the four main energy-using subsectors. The contributor to the decline in industrial energy use in the 1990s was the decline in energy intensity. The trend of energy-intensity decline that took place during the 1980s (at the double-digit level) was maintained during the 1990s.[11]

Fridtjof Unander et al. examined residential energy use in the Scandinavian countries (Denmark, Norway, and Sweden) for a period of 26 years (1973-1999).[12] They employed a decomposition approach to investigate the differences in the residential energy demand structure and end-use intensities. The results show that, in contrast to Denmark and Sweden, Norway saw a growth in total residential energy use between 1973 and 1999. But the analysis also indicates that Denmark and Sweden achieved significant reductions of residential energy intensities between 1973 and 1990, while the reductions in Norway were negligible. After 1990, however, there was a strong decline in residential energy intensities in Norway and a high rate of energy savings compared to most other countries, while energy savings in Denmark and Sweden almost halted.

## DATA USED & METHODOLOGY

The general data on the countries such as population, land area, density of population, growth of population, share of rural population, GDP, GDP composition, temporal data, and energy consumption share were compiled from the literature.[14] The energy consumption share by sector, GDP per capita, energy consumption, and traditional fuel consumption values were computed. The information on the traditional fuel consumption and resources in the Asian countries was collected from the Regional Wood Energy Development Program in Asia.[15]

## DATA ANALYSIS

**Computation of energy consumption indicators**:

Two indices have been computed for each country to compare the status of energy consumption, energy consumption per capita and energy consumption per GDP (i.e., energy intensity). These values are plotted versus the GDP per capita. The energy consumption used includes the traditional fuels like fuel wood, biomass and charcoal.

**Energy analysis by type of resources:**

Percentage of the total energy consumption by fuel is plotted. Emphasis is given on the percentage of traditional fuel consumption.

**Temporal Analysis of the energy consumption indicators:**

Temporal analysis of the energy consumption per capita and the energy consumption per GDP is plotted for sample countries for each continent.

## RESULTS & DISCUSSION

**General Considerations:** Figures1 and 2 depict the energy consumption per capita and energy consumption per GDP for all the countries. Each continent was considered separately for further analysis and comparison. When a country is said to be more energy efficient than another, it means that it uses less energy to erform the same task compared to the other. At each step in energy production and utilization, loss can occur. Therefore, in order to point out where the losses are found, further analysis was carried out. Initially, energy consumption was compared with a country's gross domestic product. Later, per-capita energy consumption for many countries was plotted against GDP per capita. In order to make a quantitati ve estimate of the response of energy consumption per capita to GDP per capita, regression analysis was carried out for the set of the database. Both linear and nonlinear regression analyses were effected based on the lowest percentage of error and best correlation coefficient, and the best-fit relationship for this set of data was found to be a power law of the form,

$$EC = A * GDP_{pc}^{B}$$

where

EC = energy consumption per capita in kilograms of oil equivalent and
$GDP_{pc}$= grossdomesticproductper capitain U.S.dollars.
$EC = 0.9184 * GDP_{pc}^{0.8939}$

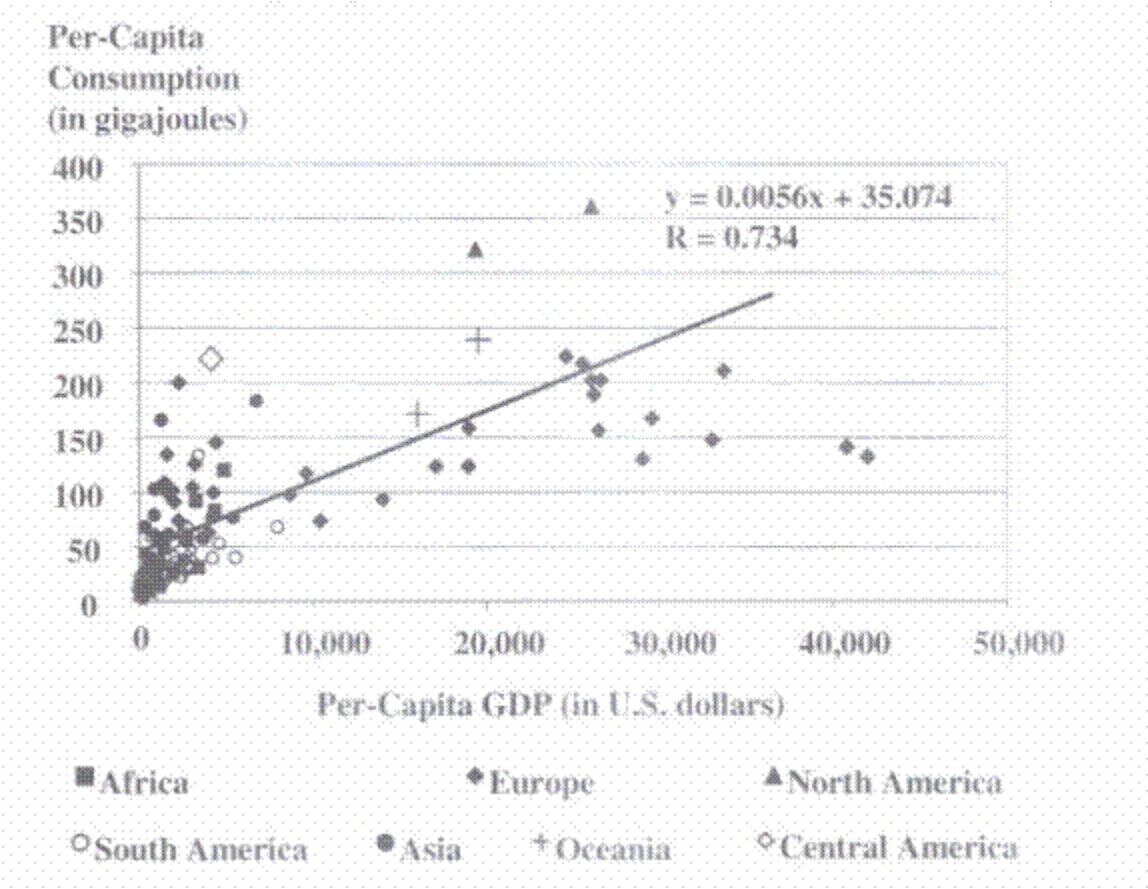


FIGURE 1 **:** THE PER-CAPITA ENERGY CONSUMPTION VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR ALL THE COUNTRIES CONSIDERED, 1995[a]

**[a]R =correlation efficient.**

The energy consumption per capita increases as the per-capita GDP increases, until it reaches a threshold. This is illustrated in figure 1 where countries on the left side have higher energy consumption per capita than those on the right side. This indicates higher energy consumption for a lower GDP per capita.

The countries seem to spread in figure 1 from the origin (no energy consumed, no GDP) in almost all the directions like a cone. There does not seem to be any limit on the amount of energy consumed per unit of GDP, and it appears that a minimum amount of energy is needed to produce a certain amount of GDP. That leads to an area on the bottom of the figure where no countries are found. For values of GDP below U.S. $2,000, the relationship etween the GDP per capita and the minimum energy consumption seems to be linear. After this value, saturation occurs for an energy consumption of about 125 gigajoules (GJ).

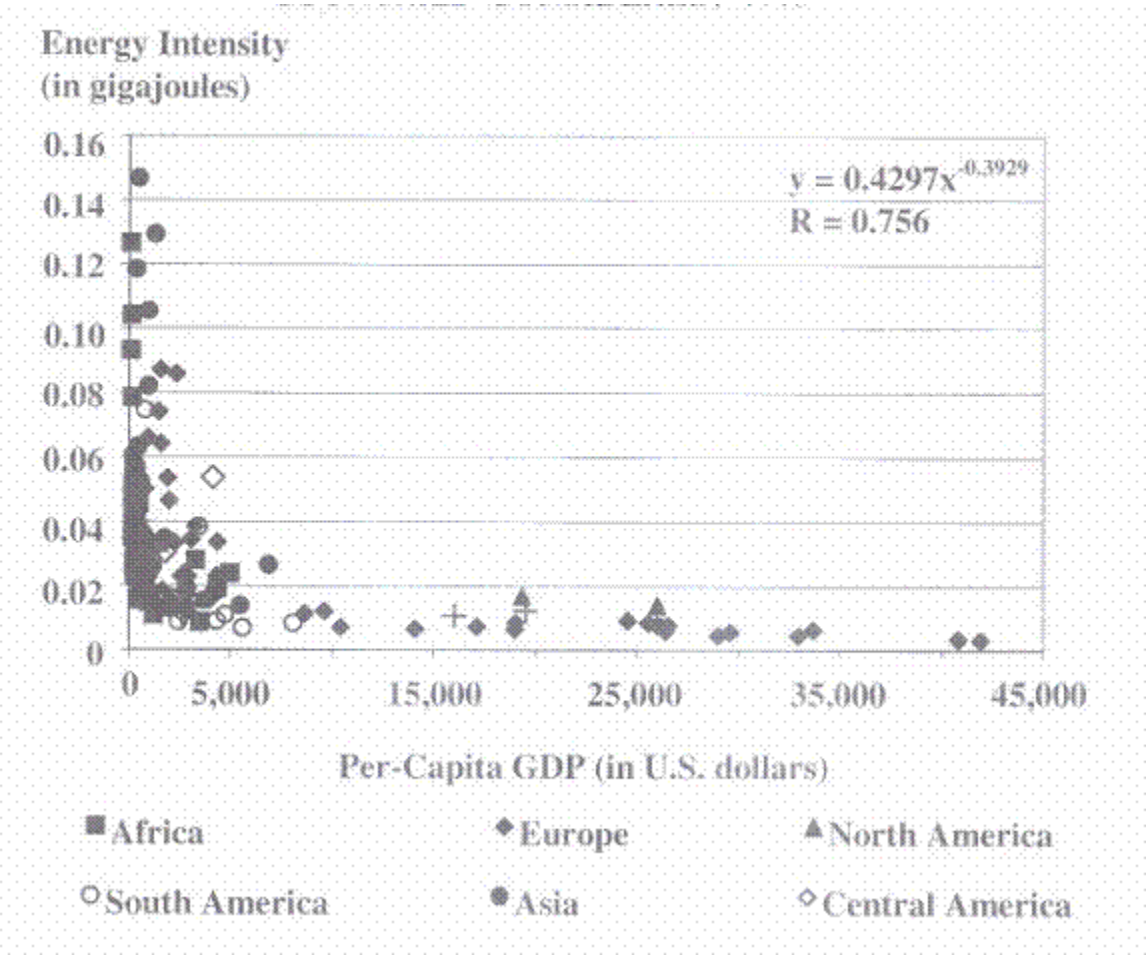


FIGURE 2 : THE ENERGY CONSUMPTION PER GROSS DOMESTIC PRODUCT (GDP)-ENERGY INTENSITY-VERSUS THE PER-CAPITA GDP FOR ALL THE COUNTRIES CONSIDERED, 1995[a]

**[a]R =correlation efficient.**

Three distinct groups emerge from figure 1. The developed countries are spread on the right of that figure. They have high energy consumption per capita, between 100 and 350 GJ, and high GDP per capita, between U.S. $10,000 and $43,000 (consisting of Western European countries and North American countries, Australia, and New Zealand). Second, on the lower left corner the developing (African, some Asian, and Central and South American) countries are found. They have very low energy consumption per capita, up to 75 GJ and low GDP per capita, up to U.S. $6,000. Third, all the countries between the first and the second group form the third group. It is composed of nations that have a GDP per capita between U.S. $6,000 and $10,000 and countries that have a GDP per capita of less than U.S. $6,000 but energy consumption per capita higher than 75 GJ (composed of North African, East European, and Middle East countries, plus some countries of Asia and South and Central America).

Variability is observed in per-capita energy consumption for similar GDP per capita, for both developed and developing countries. It can be explained partially by the fact that not all the energy consumed is taken into account in the GDP. Transport and home heating or cooling, for instance, need energy to be performed. Therefore, the energy consumption of a country does not depend only on the outcome but also on the climate and the way people live.

It is possible to evaluate the efficiency of energy consumption in a country. In a region (state), apart from the industry, agriculture, and service sectors, which participate in the GDP and consume energy, people of the country use energy for cooking, heating, and for different tasks in their day-to-day life. A country very efficient in all the domains will have very low energy consumption per GDP. That does not mean that the energy consumption per capita is low. On the contrary, high efficiency is generally associated with high technology and a high standard of living, leading to lower energy consumption per capita. Countries with high energy consumption per GDP and low energy consumption per capita are poor and inefficient. Most of the energy is used by industry and the GDP is low, indicating low efficiencies. Industrial composition and end-use efficiencies have to be taken into account in order to make a good comparison. Sectors like cement or paper, for example, are high-energy industries. Nevertheless, high energy consumption per GDP is generally associated with inefficient countries, especially ifthe energy consumption per capita is low.

Figure 2 clearly shows that countries with a high GDP per capita also have low energy consumption per GDP. On the other hand, having low energy consumption per GDP does not imply a high GDP per capita. In order to have more disposable energy, two paths can be followed. The first is to increase the energy production. Supposing that the GDP will increase if the energy production expands; the country will then have an energy-intensive path. The second possibility is to increase the efficiency or to minimize the loss. That also leads to a situation where more energy is available. Regarding figure 2, the second possibility is certainly the best. If a country wants to increase its GDP per capita, it will have to reach high efficiencies. Improving efficiency can save vast amounts of energy. This is illustrated with two examples.

**Energy Efficient Lighting:** It is estimated that 15 percent of the electric power production was used for lighting consumption. Improving the energy efficiency of lighting had a tremendous impact on a country's energy consumption.[16] The analysis shows a national savings potential of 40 percent by shifting to lamps with performance characteristics typical of current western practice (without changing the market share of various lamp types), and a 60-percent savings by adopting the best commercially available lamps.

**Rain Effect in Building Energy Estimation:** Rain has been found to affect the thermal performance of any building by cooling the surface during rain and by evaporation of the absorbed moisture from porous materials after rain. Studies have shown that the heat gain by the porous building wall can be reduced by up to 50 percent on rainy days, in favorable countries or regions.[17]

In order to make the analysis more precise, each continent is studied separately. Figures 1 and 2 are plotted with countries of each continent.

Asia

The Asian countries are grouped based on GDP per capita as shown in table 1. Among this group, Japan is the best performing, with a higher GDP per capita (U.S. $40,846) and very low energy consumption per capita (150.4 GJ). Kuwait, the United Arab Emirates, and Israel have relatively high and similar GDP per capita but their respective energy consumption per capita is very different and much higher than that of Japan. Countries of the former Soviet Union are found to have very high energy consumption per capita and very high energy consumption per GDP when compared with the Group 3 Asian states (table 1). Energy data are used to compute two interesting values. First, the energy consumption per GDP for industry can be calculated since the share of energy consumption ofthe industrial sector and the share of industry in the GDP composition are known. It gives an idea of the efficiency of the industrial sector of the country. Second, the energy consumption in households per capita also can be calculated with the energy share of the households. The average number of persons per household varies from one country to the other. This indicates the standard of living in a country.

The results for a sample of Asian countries are presented in table 2. The energy consumption per capita yields an idea of the average standard of living. The value for Azerbaijan is quite surprising, especially when compared with Turkmenistan. Since the two values given are very high, it is possible to imagine that the energy production is very inefficient. As expected, the low value ofIndia, Cambodia, and Sri Lanka indicates a poor average living standard. The higher density of population probably can explain the fact that India is lower than Cambodia and Sri Lanka Japan has the highest value, followed by Israel.

The energy consumption per unit of GDP (for the industrial sector) shows that Azerbaijan has a higher value compared to Japan, which has energy-efficient industries. India has the second least-efficient industries among the nations in table 2. The poor efficiencies of Turkmenistan, Azerbaijan, and United Arab Emirates (U.A.E.) explain their high energy consumption per-capita values, as found in figure 3.

Asia-Group 1: Kuwait, the U.A.E., and Israel, with similar climate and resources, have a very similar GDP per capita, but their energy consumption per capita is very different (figure 4). The six group-l countries have a high density of population and a low percentage of rural population. Kuwait and the U.A.E. have an energy consumption per

| TABLE 1: SELECTED ASIAN COUNTRIES IN GROUPS BASED ON PER-CAPITA GROSS DOMESTIC PRODUCT (GDP), 1995 | | | |
|---|---|---|---|
| **Group** | **Countries** | **Per-capitaGDP(in US $)** | **Per-capita Energy consumption(in giga joules)** |
| Asia 1 | South Korea , Israel , Kuwait , United Arab Emirates , Singapore and Japan | 10,000 | 100–550 |
| Asia 2 | India , China , Cambodia and Vietnam | <2000 | <50 |
| Asia 3 | Iran and the former U.S.S.R. states such as Turkmenistan and Uzbekistan | 2,000-10,000 | >50 |

| TABLE 2: PER-CAPITA HOUSEHOLD ENERGY CONSUMPTION AND INDUSTRIAL ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP) FOR A SAMPLE OF COUNTRIES IN ASIA, 1995 | | |
|---|---|---|
| **Country** | **Per capita Household Energy consumption [in gigajoules]** | **Energy consumption/unit of GDP for Industry [in gigajoules per US $]** |
| India | 1.8 | 0.095 |
| Cambodia | 4.6 | 0.021 |
| Sri Lanka | 5.4 | 0.011 |
| Azerbaijan | 17.1 | 0.454 |
| Turkmenistan | 4.1 | 0.060 |
| UAE | 6.0 | 0.029 |
| Israel | 22.8 | 0.011 |
| Singapore | 8.1 | 0.011 |
| Japan | 23.8 | 0.005 |

GDP much higher than other states of this group. At the same time, their energy consumption per capita is also higher. The GDP composition shows that for these two countries, the share of industry is similar to the share of services, i.e., industry at 55 percent and services at 45 percent in Kuwait with industry at 55 percent and services at 45 percent in Kuwait with industry at 55 percent and services at 42 percent for the U.A.E. In the other countries considered, the share of services is higher than the share of industry (e.g., Japan 60 percent, South Korea 51 percent, Israel 81 percent, and Singapore 72 percent). The services sector needs less energy

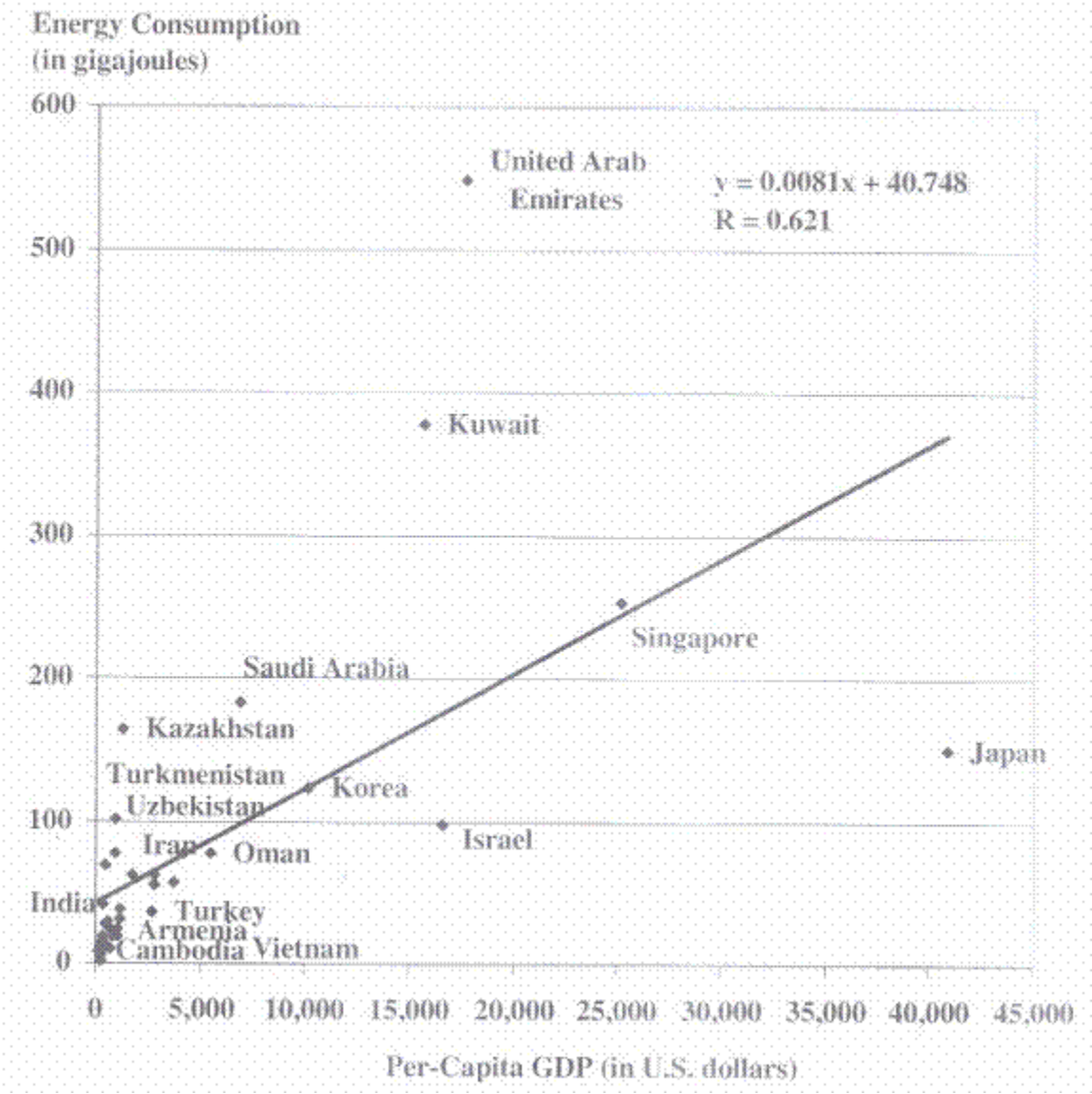


FIGURE 3 : PLOT OF THE PER-CAPITAENERGYCONSUMPTIONVERSUSPER-CAPITAGROSS DOMESTICPRODUCT(GDP) FOR SELECTEDASIAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

for a similar GDP than industry. The type of fuel used does not seem to have a strong influence. Japan and South Korea use different fuels, with liquid fuels dominant (around 50 percent). Kuwait, Israel, and Singapore use mainly liquid fuels and the United Arab Emirates uses mainly gas. Japan is certainly the most efficient of these countries. Usage of different kinds of fuels permits the country to employ the most appropriate one for a task, that is,

resource-task matching. Singapore uses only liquid fuels and its energy consumption per capita is higher than that of Japan.

Asia-Groups 2 and 3: The same two indicators have been plotted with the countries that have a per-capita GDP of less than U.S. $10,000 (figures 5 and 6). It is then possible to see the countries falling between the developing and the developed countries: Saudi Arabia, Lebanon, Oman, Malaysia, Turkey, and Thailand.

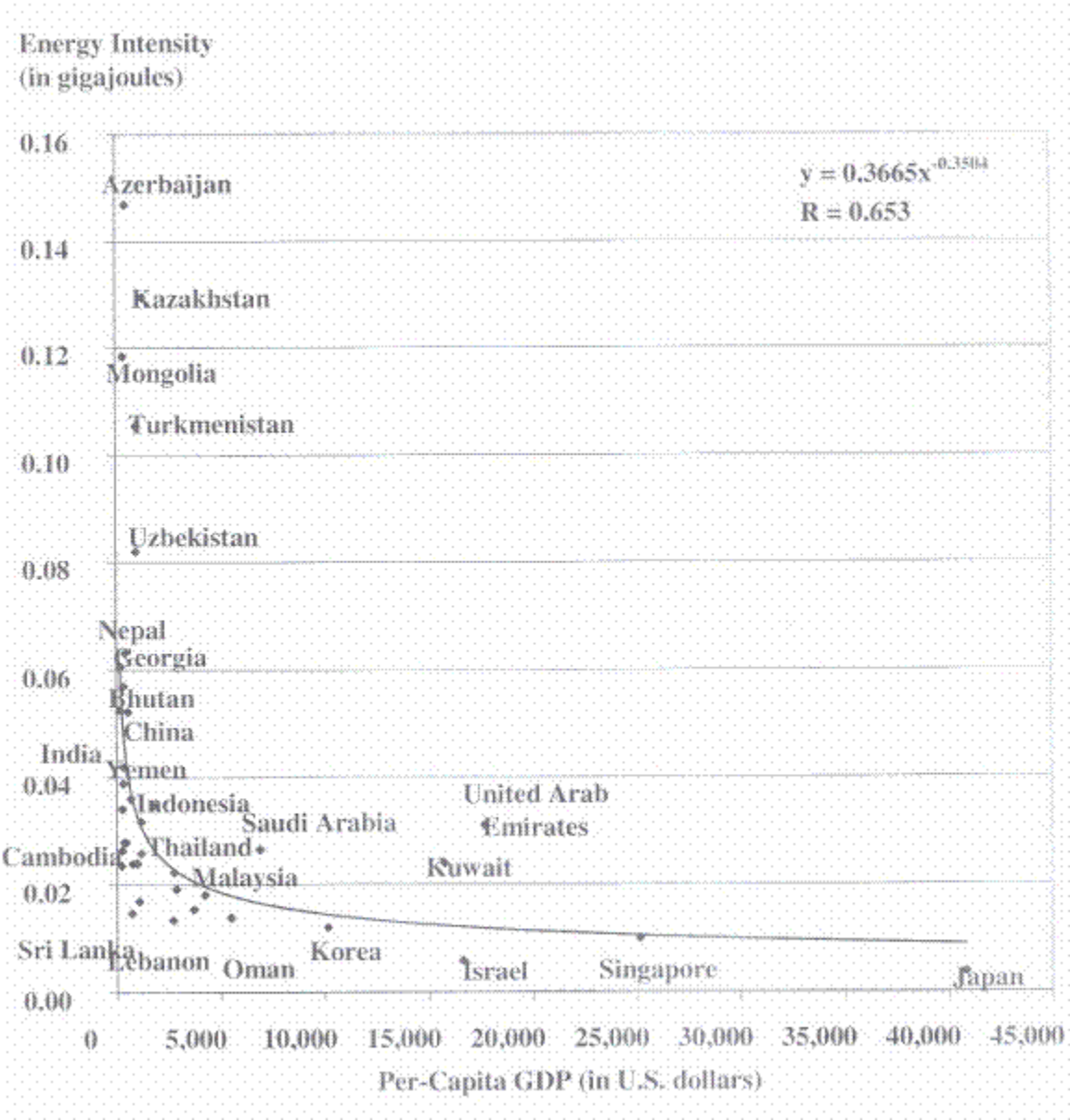


FIGURE 4: PLOT OF THE ENERGY INTENSITY VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR SELECTED ASIAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

With some former Soviet Union countries (Azerbaijan, Kazakhstan, Turkmenistan, and Uzbekistan) and Iran, they form the Asia 3 group. Other countries on figures 5 and 6 comprise the Asia 2 group. Low-income countries of the Asia 2 group are Sri Lanka, Laos, Cambodia. and Vietnam, with very low energy consumption per capita and very low energy consumption per GDP. They use mainly traditional fuels (figure 7), and agriculture

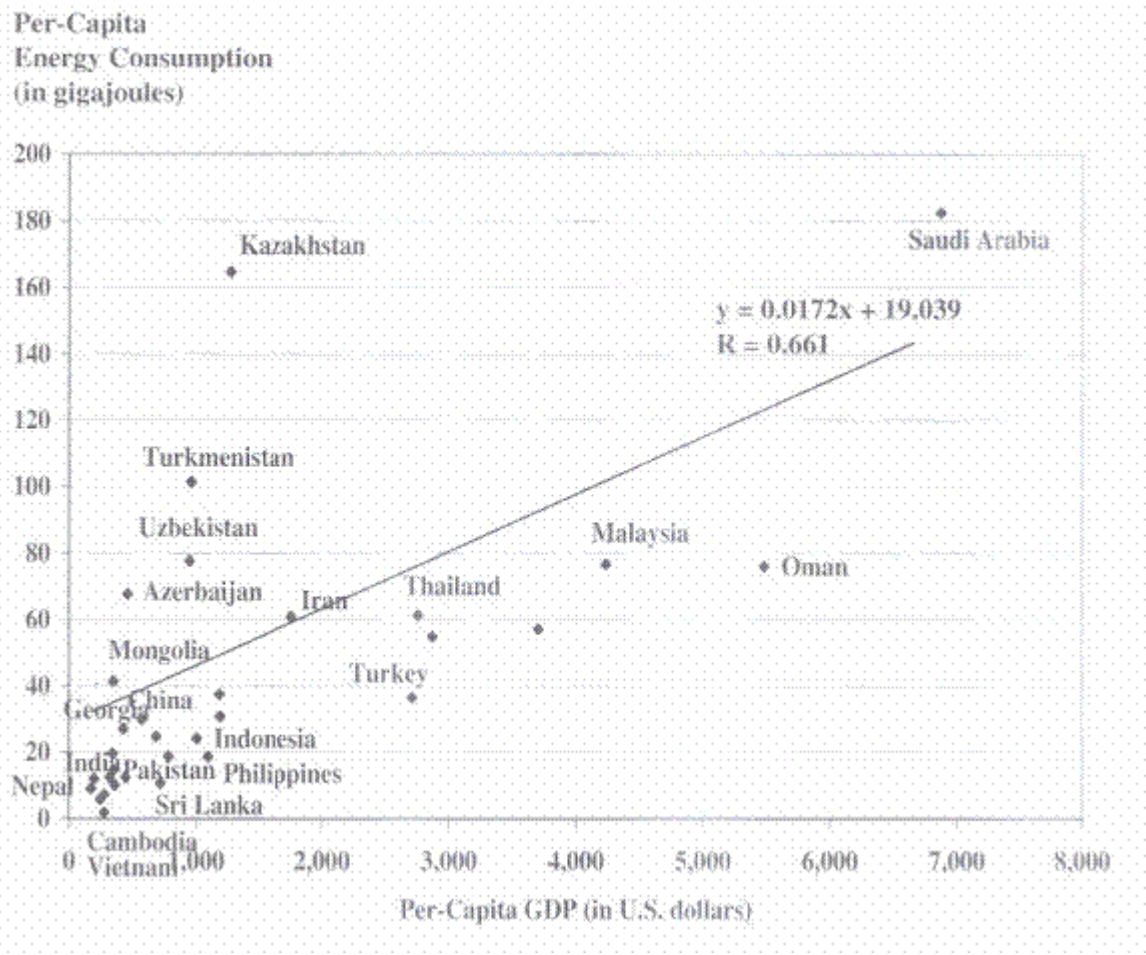


FIGURE 5: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR GROUPS 2 AND 3 OF SELECTED ASIAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

plays an important role in their economies. These countries are poor but not necessarily inefficient. Their industry is not well developed, but the fact that their energy consumption per capita is low is "encouraging." Some other nations, e.g., India, China, Georgia, or Nepal, have similar GDP per capita and energy consumption per capita, but higher energy consumption per GDP. In China and India, the main consumption of energy is by the industrial sector (66.2 and 53.7 percent. respectively); in return, the share in the GDP is 49 and 30 percent, respectively. In comparison, Japanese industry uses 42.7

percent of the energy consumed and its contribution to the GDP is 38 percent. Chinese and Indian industries are not that efficient. In Nepal, the energy consumption is more or less equally divided between industry (29.9 percent), transport (30.5 percent), and services (20.3 percent).

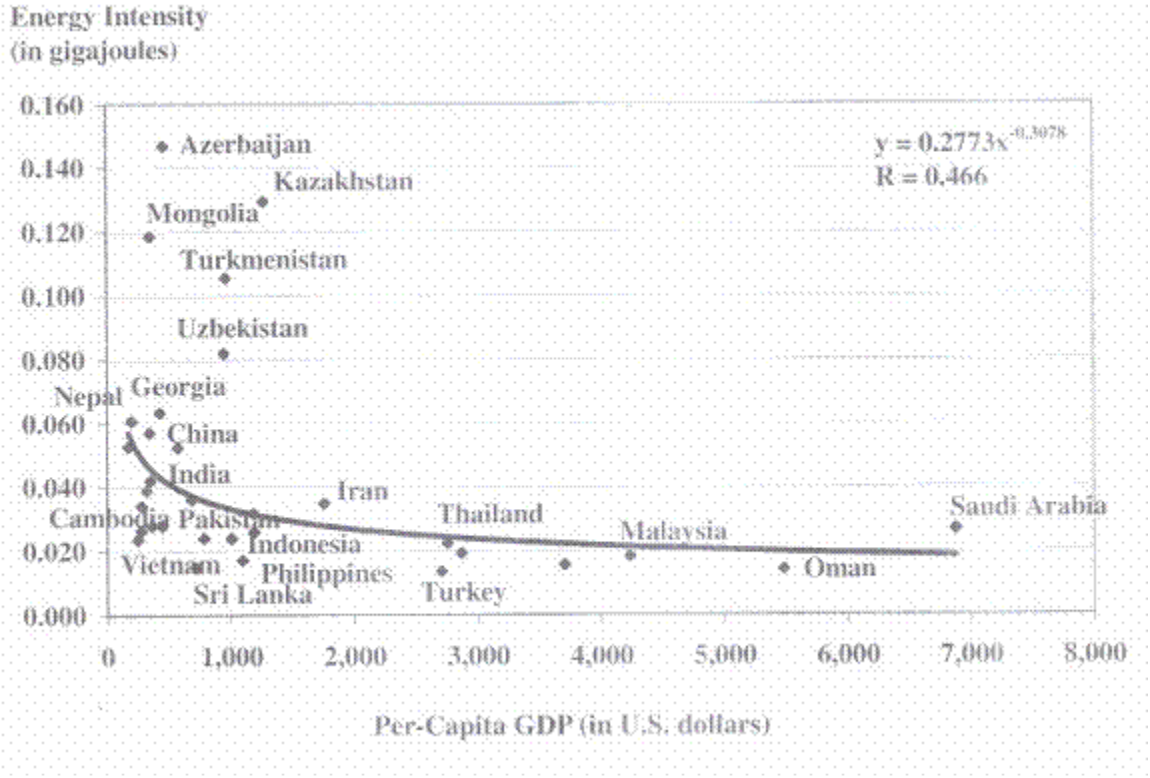


FIGURE 6: PLOT OF THE ENERGY INTENSITY VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR GROUPS 2 AND 3 ASIAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

Agriculture is the main contributor to GDP, indicating poor industry and services efficiency. Kazakhstan, Turkmenistan, Uzbekistan, and Azerbaijan are nations that have very high energy consumption per capita and very high energy consumption per GDP. Among these countries, Azerbaijan in particular has high energy use per GDP and low per-capita energy consumption; its industry consumes 55.6 percent of the nation's total energy but contributes only 18 percent to the GDP, which indicates very low efficiency (table 2). Kazakhstan and Uzbekistan have similar situations. Their industries use 58.3 and <1-6.1percent of the energy, respectively, and their respective shares in the GDP are 32.6 and 27 percent. Turkmenistan offers statistics that appear very different since its industry seems very efficient, consuming 28.5 percent of the energy and accounting for 50 percent of the GDP; transportation is a large energy consumer.

7.5 Traditional Fuel Consumption: In developing countries, traditional fuel plays a major role. Most of the people use fuel wood, agricultural residue, animal waste, and the like for cooking and heating.

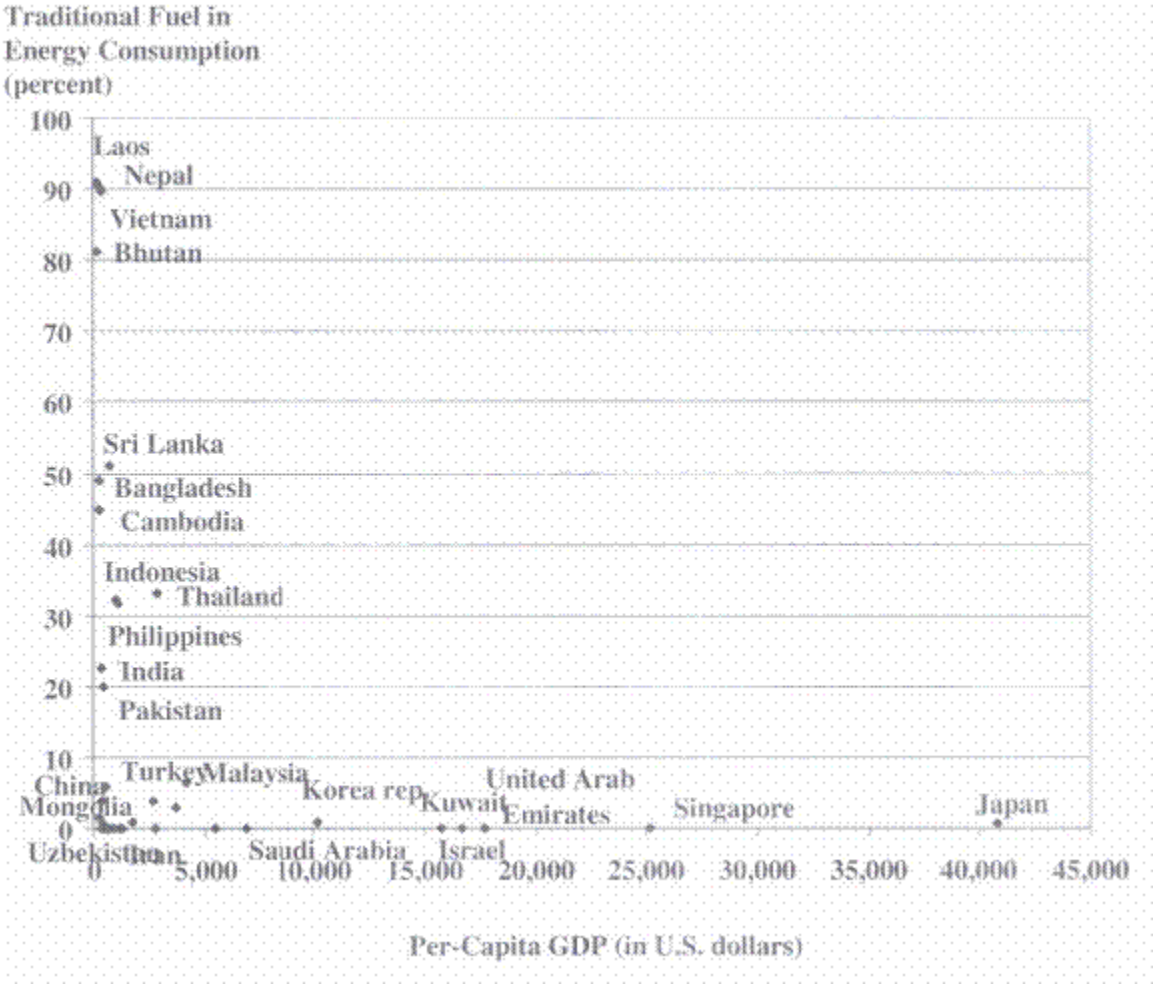


**FIGURE 7: PLOT OF THE PERCENTAGE OF TRADITIONAL FUEL IN ENERGY CONSUMPTION VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR ASIAN COUNTRIES, 1995**

Estimates of fuel wood consumption vary from 30 to 80 percent of the total energy consumption for most of the Asian countries. In all the member countries of the Regional Wood Energy Development Program in Asia (RWEDP), fuel wood consumption still is growing.[18] The role of these fuels is important in the energy consumption pattern. Biomass will remain the major source of energy for the rural populations, coupled with niche renewables,

provided they are affordable and reliable. With 72 percent of the Indian population still in rural areas, there is tremendous demand on bioresources such as fuel wood and agricultural residues to meet the daily fuel requirements. Dependence on bioresources to meet the daily requirement of fuel, fodder, etc. in rural areas is more than 85 percent,

while in urban areas the demand is about 35 percent.[19] Transition to other fuel types is a slow process due to economic affordability and other constraints; replacement is not easy and is not obligatory. A study of the share of traditional fuel is essential when dealing with energy policies.

Figure 7 shows the percentage of traditional fuel consumption versus the GDP per capita. Traditional fuel consumption is difficult to evaluate; therefore, much care has to be taken while using these values. For example, there is a huge difference in the values given for a few countries by the World Resources reports and the RWEDP[20]

It is noted that the countries with high GDPs have very low traditional fuel consumption. This is easy to understand since traditional fuel is used mostly for cooking. Countries like Japan and Singapore have other fuels that substitute for the traditional fuels. For example, gas is more efficient and convenient than fuel wood. Electricity, which also is widely used for cooking, is more convenient and saves time but is not more efficient than the improved stove designed for traditional fuel. Moreover, in developed nations, electricity and gas are available in almost 100 percent of the households. That is not the case in developing countries; switching over to either gas or electricity may not be a viable option for low-income nations. For instance, in Bangladesh a fraction of the population (25 percent of urban and 10 percent of rural) has access to electricity. In the rural area, fuel wood is probably more convenient and the initial cost for kerosine and liquefied petroleum gas (LPG) is too high for most of the fuel wood users. More efficient stoves are probably the best solutions, even if this depends on the country and situation. Using less fuel for cooking and heating, especially in the rural area, would have a positive impact on the energy consumption per capita of the low-income Asian countries. This also would lead toward sustainable use of renewable resources.

A study of potential biomass fuel conservation in selected Asian countries highlights that improving the efficiency of biomass energy utilization can save large amounts of biomass; domestic cooking is the single largest component. responsible for about 90 percent of the total biomass energy consumption.[21] Increasing the efficiency also means decreasing the amount of fuel needed for cooking and heating. This will save time and energy for the rural population-less time will be required to collect the wood with a decrease in the deforestation rate and the amount of greenhouse gas injected into the atmosphere. In order to achieve success in the efficient use of energy, a large-scale campaign is needed. Information, help, and better education also aid in a wider understanding of renewable energy techniques and energy conservation.

Figure 7 indicates that a few countries have a very high percentage of traditional fuel consumption. The Asia I group (Laos, Bhutan, Nepal, and Vietnam) has a percentage of traditional fuels consumption ranging between 80 to 95 percent compared to their neighbors (Sri Lanka, Bangladesh, Cambodia, India, or Pakistan) that show a lower share of traditional fuel consumption. It is valuable to attempt to explain the large gap between 50 percent and 80 percent in the share of traditional fuels.

Traditional fuel is used for cooking in almost every household in the rural areas of the developing countries. To explain the gap, the first value to be checked is the share of rural population in these countries. No relationship between the share of rural population and the percentage of traditional fuel could be derived. Laos, Cambodia, India, and Thailand, respectively, have 77 percent, 77 percent, 72 percent, and 78 percent of population living in rural areas. The traditional fuel consumption per capita is plotted in order to see if there is any relationship between the percentage of traditional fuel and the consumption per capita. Most likely, the relatively lower percentage of traditional fuel consumption is due to an increased quantity of commercial energy (because of industries). However, it is noticed that in these countries consumption of traditional fuel has remained the same during the last three decades (1965-1995) while consumption of commercial sources of energy is steadily increasing (figure 8). The nations that have a high percentage of traditional fuels have low energy consumption per capita. The amount of traditional fuel used per capita is similar in the states of south Asia. All the countries that have high energy consumption per GDP have a very low percentage of traditional fuel, as is the case of Azerbaijan, Turkmenistan, Uzbekistan, Kazakhstan, Mongolia, China, and Georgia.

**Europe**

In the present study, the United States and Canada are included in the European countries because it was found to be more accurate to compare the United States with the European nations than Central and South American countries. Two groups can be categorized from figure 9. First are the countries having a per-capita GDP higher than U.S. $15,000 (Europe group I). Second, nations having a GDP per capita lower than U.S. $15,000 form Europe group 2. However, a few states have a GDP per capita near U.S. $15,000 and it is difficult to classify them. The poor efficiency of the Eastern European countries can be seen in figures 9 and 10. They have low energy consumption per capita and high energy consumption per GDP, indicating low efficiency. A few low-income nations of Western Europe are found in the Europe 2 group (Greece, Portugal, and Spain). However, they have higher GDPs and similar per-capita energy consumption to the Eastern European countries. The United Kingdom, Ireland, and Italy are found to be a bit behind the other western countries. Norway, Denmark, and Switzerland have the highest GDP per capita. Half of the Western European states have a higher GDP per capita and lower per-capita energy consumption than the Russian Federation. This indicates the difference in the efficiency of the economy between the west and the east. In addition, Canada and the United States have higher energy consumption per capita compared to the European countries.

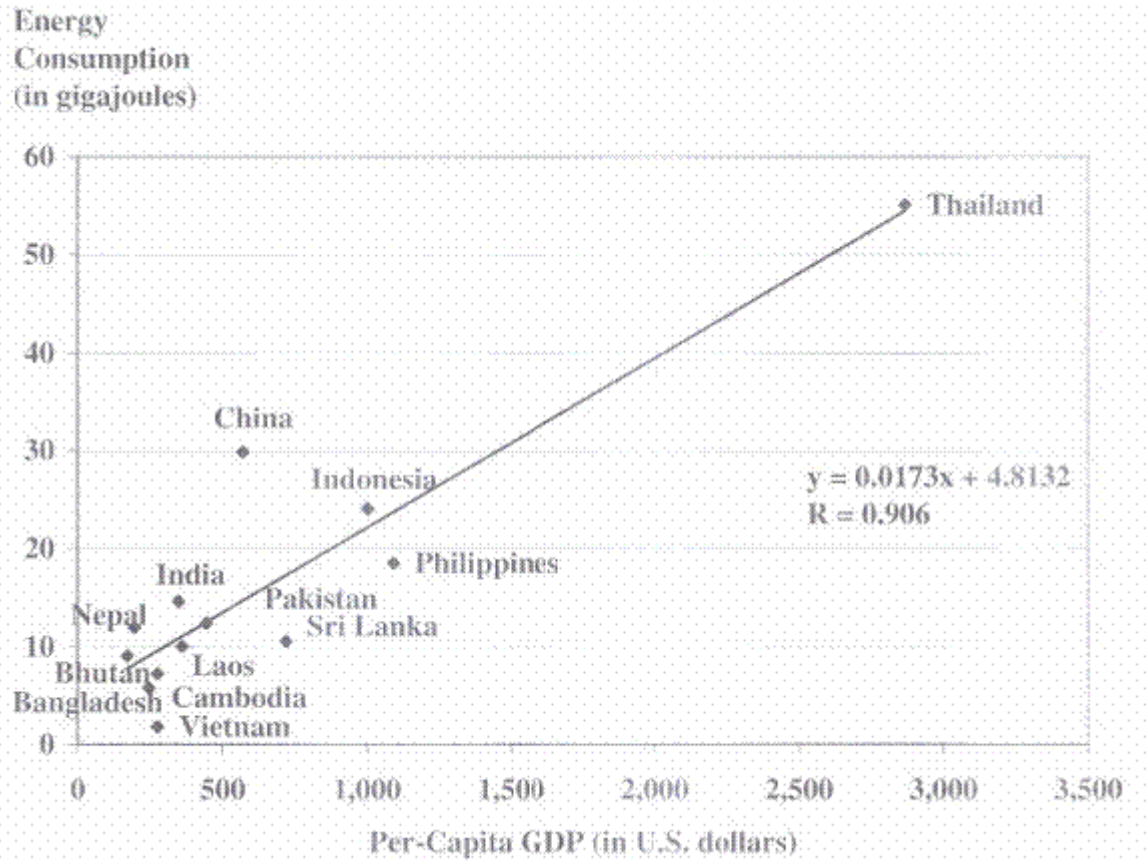


FIGURE 8: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION FOR THE ASIAN COUNTRIES HAVING A HIGH PERCENTAGE OF TRADITIONAL FUEL. 1995[a]

**[a]R =correlation efficient.**

The two groups also can be well distinguished in figure 10. The high energy consumption per GDP and low energy consumption per capita of the countries of Eastern Europe indicate a low efficiency in their economy although since 1992 they have tried to catch up with the west. Figure 9 for Europe has a different pattern than that of Asia. Most of the countries are found either at the lower right corner or the upper left corner, whereas for Asia most of the nations were found in the lower left corner. It is observed that for a few countries (Romania, Moldova, Macedonia, Bulgaria, Albania, and the Belarus Republic), the main portion of the GDP comes from services. This is the case with the Western European countries as well. In more industrialized western economies, the share of industry's energy consumption is similar to the share of the GDP coming from the industry.[22] In a few countries, industry's share of energy consumption dominates: Bulgaria (58.8 percent), the Czech Republic (48.1 percent), Finland (45.9 percent), Romania (57 percent), Slovakia (52.7 percent), and Ukraine (48 percent). In other nations. the share of the different sectors is very similar.

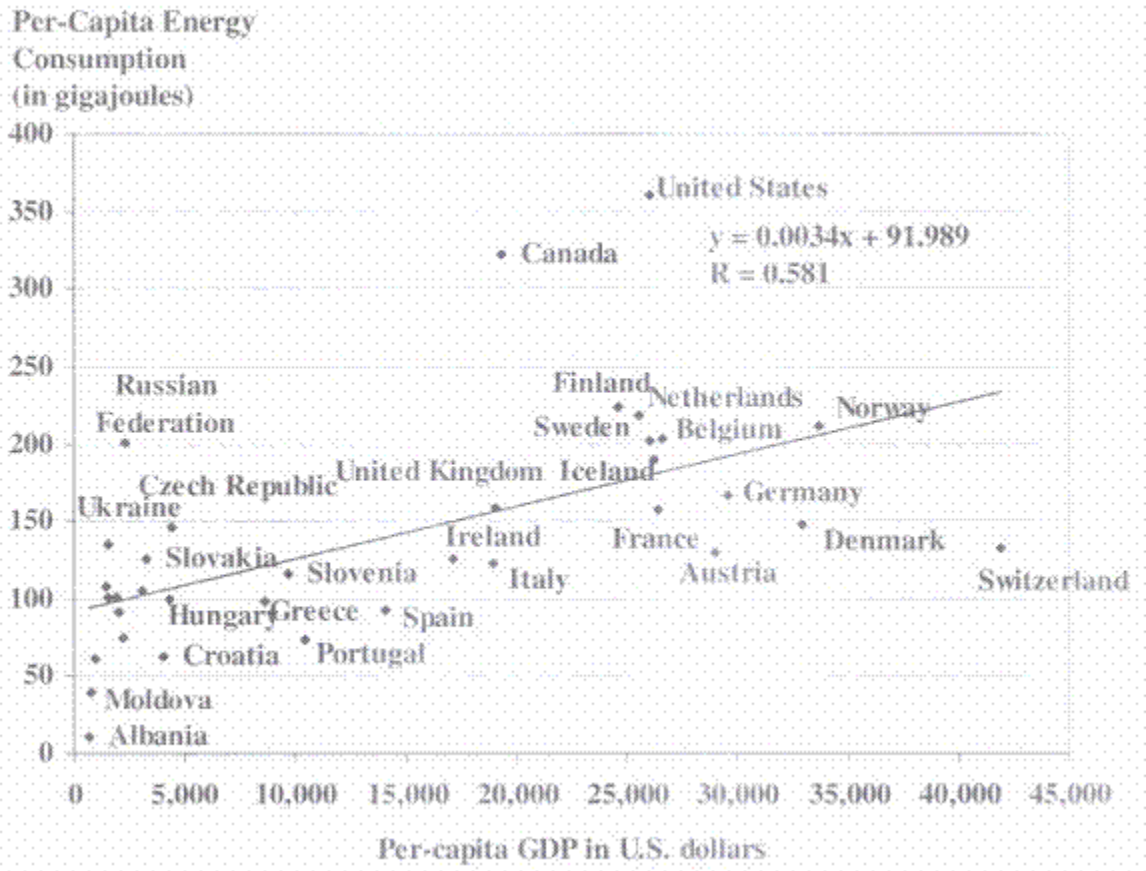


FIGURE 9: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS THE PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR EUROPEAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

Most of the European countries use a variety of fuels, although some are more widely consumed than others. For example, there is a dominance for primary electricity in Switzerland, Sweden, and Norway. These countries have good hydroelectric resources. Romania, the Russian Federation, and the Netherlands use more gas than other countries. Poland consumes substantial solid fuel (e.g., coal), whereas Portugal, Italy, and Greece use predominantly liquid fuels. The same calculation of energy consumption in one household per capita and the energy consumption per unit of GDP for industry has been made for selected European countries; the results are presented in table 3. The per-capita energy consumption indicates the standard of living in a country; at least, the values given above and the difference between the countries correspond to the subjective idea of the living standards in these nations. Nonetheless, it seems improbable that the standard of living of the Russian Federation is almost as high as that in France or in the United Kingdom. However, the energy consumption in households also depends on the climate and can be more or less efficient. The United States has a higher variation in the household energy consumption per capita, indicating a low efficiency. This difference is

because of the fact that use of gasoline for the car is included in the household while public transportation is not.

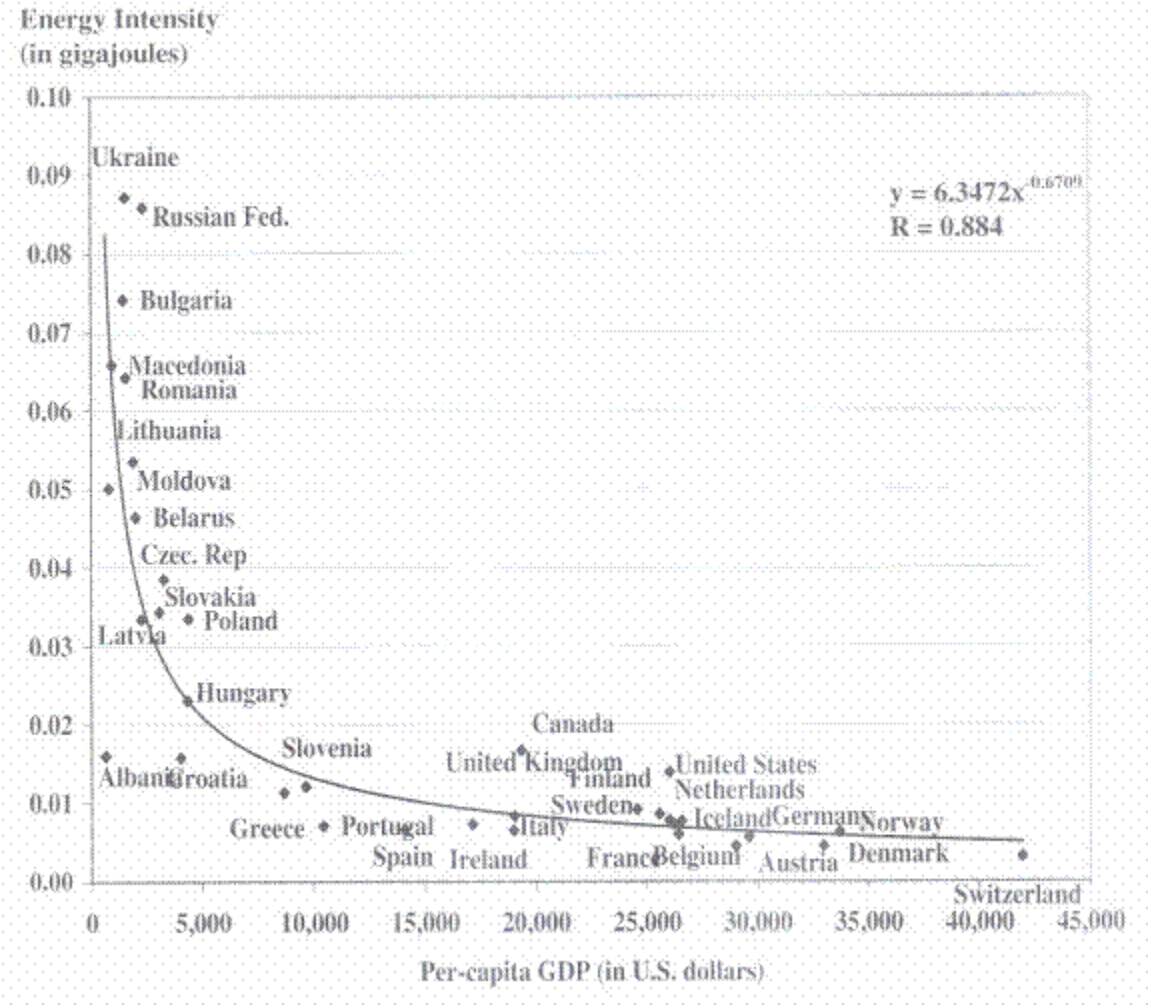


FIGURE 10: PLOT OF THE ENERGY INTENSITY VERSUS PER-CAPITA GROSS DOMESTIC
PRODUCT (GDP) FOR THE EUROPEAN COUNTRIES, 1995[a]

[a]R =correlation efficient**.**

The difference between the Western and Eastern European countries can be seen with the values of the energy consumption per unit of GDP for industry. The Russian Federation and Poland have more inefficient industry than France or the United Kingdom; Poland has a greater number of inefficient industries than Russia.

**Africa**

Africa is recognized as a low-income continent, composed mainly of developing countries. In the last few years, many conflicts and changes in governments have occurred.

| TABLE 3: PER-CAPITA HOUSEHOLD ENERGY CONSUMPTION AND INDUSTRIAL ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP) FOR A SAMPLE OF EUROPEAN COUNTRIES, 1995 | | |
|---|---|---|
| **Country** | **Per-Capita Household Energy Consumption (in gigajoules)** | **Industrial Energy onsumption per Unit of GDP (in igajoules per U.S. dollar)** |
| Norway | 46.9 | 0.011 |
| Russia | 34.8 | 0.141 |
| USA | 70.2 | 0.023 |
| Greece | 21.1 | 0.017 |
| France | 37.5 | 0.008 |
| UK | 39.4 | 0.010 |
| Poland | 20.0 | 0.081 |

| TABLE 4: SELECTEDAFRICANCOUNTRIESIN GROUPS BASEDON PER-CAPITA GROSS DOMESTICPRODUCT(GDP), 1995 | | | |
|---|---|---|---|
| **Group** | **Countries** | **Per-Capita GDP(in U.S. dollars)** | **Per-Capita Energy Consumption(in glgajoules)** |
| Africa 1 | Libya, Gabon, South Africa, Mauritius, Tunisia and Algeria | >1,000 | 25 – 120 |
| Africa 2 | All the other countries | < 1,000 | <25 |

Most of the African nations are unstable and resources are concentrated in some countries. Table 4 shows the group based on GDP per capita in U.S. dollars for African countries. Figures 11 and 12 are similar to that of Asia; hence, these countries have been divided into two groups. However, the difference between the highest GDP per capita (Libya) and the majority is very different. It is possible to distinguish the two groups in figure 12. Four countries in the Africa 2 group (Mozambique, Tanzania, Ethiopia, and Malawi) have high energy consumption per GDP. Since their energy consumption per capita does not seem greater than for the majority in this group, they might have poor efficiencies. Nevertheless, most of the countries are found in the lower left corner, having low GDP per capita and low energy consumption per GDP.

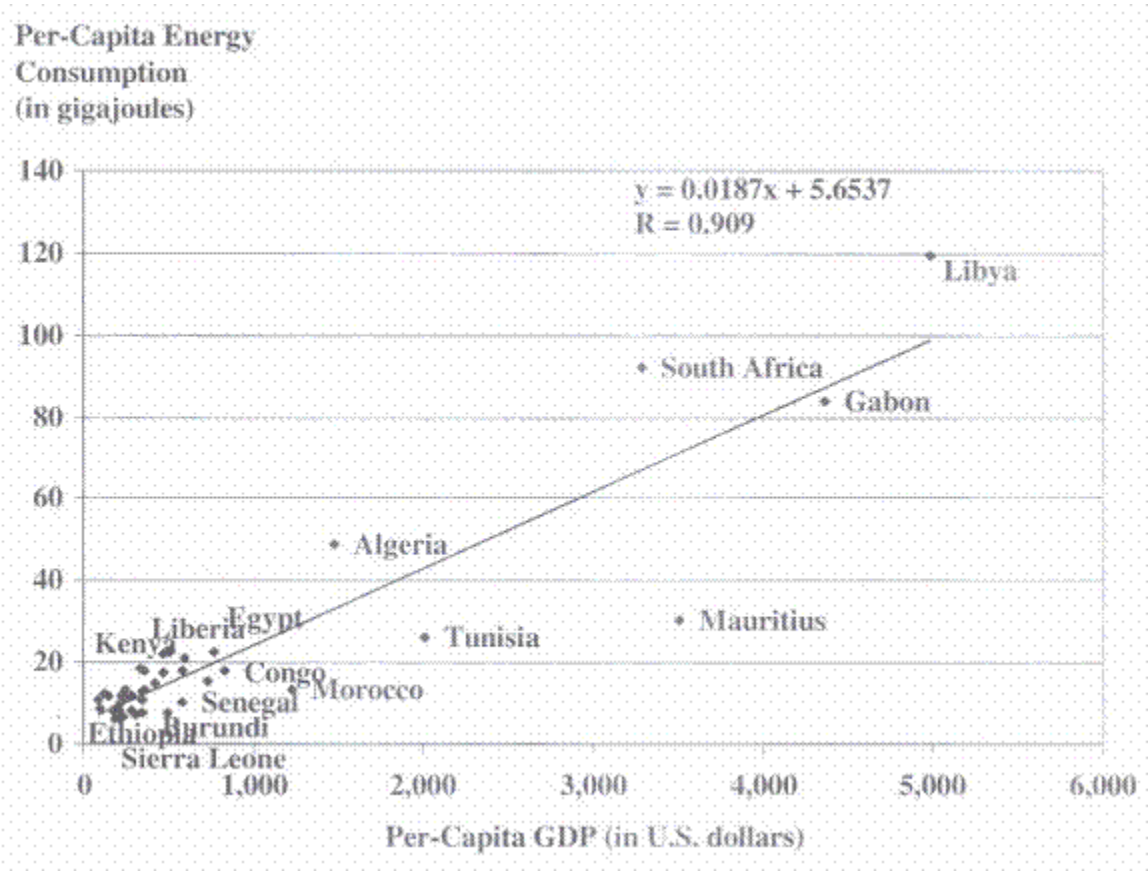


FIGURE 11: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR AFRICAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

The same calculation of energy consumption by household per capita and the energy consumption per unit of GDP for industry have been made for selected African countries; the results are presented in table 5. The value of energy consumption in household per capita is low for Angola and Ghana (Africa 2 group), indicating a low living standard. Algeria, Libya, and South Africa (Africa 1 group) have higher values. Cameroon has a very high and Morocco a very low value of energy consumption in household per capita compared to their place in figure 11. The energy consumption per unit of GDP for the industry does not have any relationship with the Africa 1 or Africa 2 groups. Angola has a very low value (like Libya), and Cameroon and SouthAfrica have a very high value even if they do not belong to the same group.

Africa-Group 1: The countries with a higher GDP percapita than U.S. $1,000 are spread on the right side of figure 11. They have very different energy consumption per capita, ranging from 25 to 30 GJ for Algeria and Mauritius to 120GJ for Libya. Mauritius and Tunisia have similar energy consumption per capita, but Mauritius has a much higher GDP per capita.

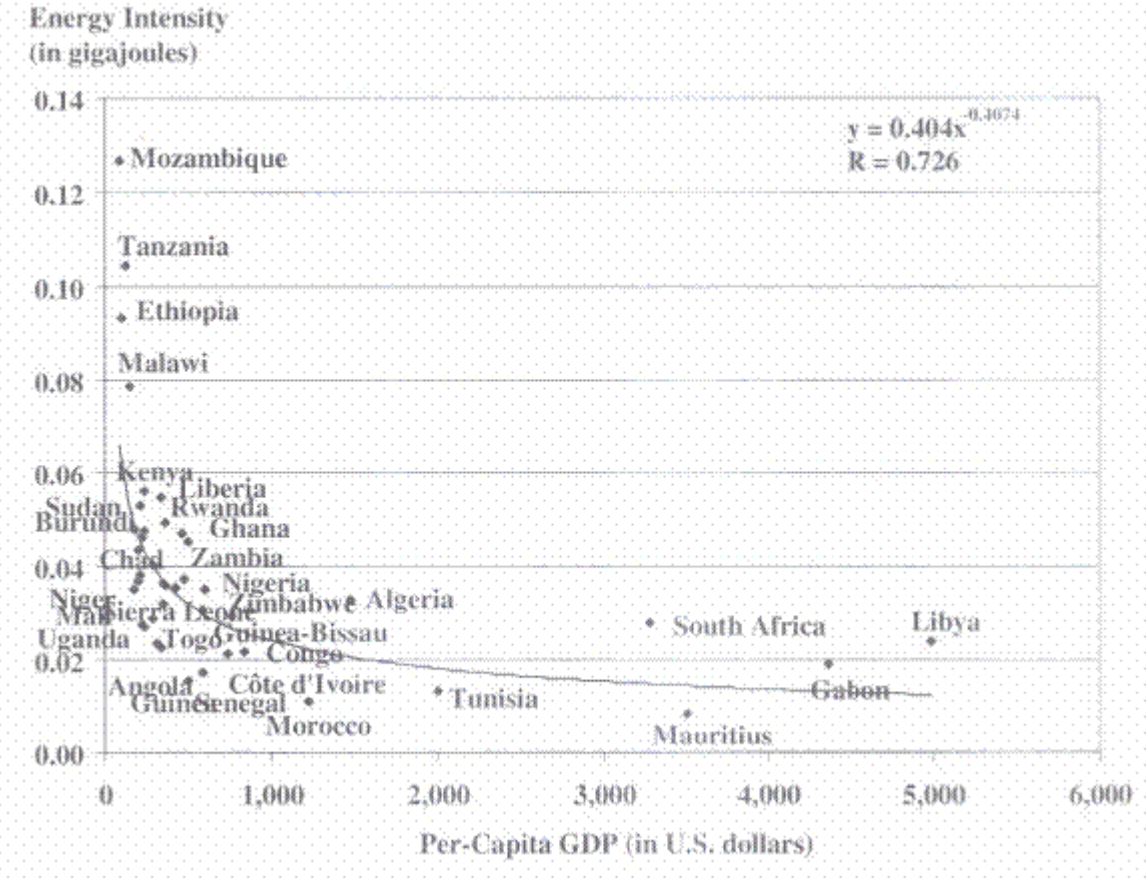


FIGURE 12: PLOT OF THE ENERGY INTENSITY VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR AFRICAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

TABLE 5: PER-CAPITA HOUSEHOLD ENERGY CONSUMPTION AND INDUSTRIAL ENERGY CONSUMPTION PER GROSS DOMESTIC PRODUCT (GDP) FOR A SAMPLE OF COUNTRIES IN AFRICA, 1995

| Country | Per-Capita Household Energy Consumption (in gigajoules) | Industrial Energy Consumption Per Unit of GDP (in gigajoules per U.S. dollar) |
|---|---|---|
| Algeria | 11.4 | 0.031 |
| Angola | 1.3 | 0.016 |
| Cameroon | 12.7 | 0.048 |
| Ghana | 3.4 | 0.189 |
| Libya | 6.8 | 0.021 |

| | | |
|---|---|---|
| Morocco | 3.3 | 0.012 |
| South Africa | 14.9 | 0.039 |

At the same time, South Africa has a similar GDP per capita as Mauritius but much higher energy consumption per capita. The Africa 1 group can be separated in to two subgroups: four countries have higher energy consumption per capita than the others (Libya, South Africa, Gabon, and Algeria). This also is seen in figure 12**.** These four nations lie above the trend line, while Tunisia, Morocco, and Algeria are found below it. Two explanations can be given. First, the four countries noted have an economy based more on industry than the other three; the share of energy in GDP composition is 51 percent for Algeria, 67 percent for Gabon, 55 percent for Libya, and 39 percent for South Africa.[23] For the other three, the value for the same is 29 percent for Mauritius, 33 percent for Morocco, and 28 percent for Tunisia. Moreover, table 3 gives a higher value for the energy consumption per GDP for industry for Libya, Algeria, and South Africa than for Morocco. Lower efficiency and the predominance of industry could explain the higher energy consumption per GDP of these four countries.

A significant difference is seen in the share of GDP composition between the countries of the African 1 and 2 groups. In most of the Africa 2 countries, agriculture's share in the GDP is much higher than for those in Africa 1. Somalia, for example, relies on agriculture for 59 percent of its GDP. That seems to indicate a lower industrialization level than for the countries of the Africa 1 group, which could explain both the lower energy consumption and lower GDP per capita. The fuel type consumption patterns also are very different. Except for Zimbabwe, Congo, and Mauritania, all the nations of the Africa 2 group use more than 50 percent of traditional fuel while in most of the Africa 1 group it accounts for a small portion.

Africa-Group 2: Figures 13 and 14 represent only the countries of the Africa 2 group; this permits a more precise study of them. The difference in energy intensities for the four countries-Mozambique, Ethiopia, Tanzania, and Malawi-can be noted in figure 14, indicating very low energy efficiencies. Lack of data does not permit computation of values like energy consumption per GDP for a specific sector that would be essential to find an explanation. In fact, the available information on these four countries and, for instance, Burundi and Central African Republic is very similar. The share of agriculture in the GDP composition is between 40 and 55 percent and these countries use mainly traditional fuel (accounting for over 90 percent of total fuel usage). All the countries of the Africa 2 group have similar characteristics and, in figure 11, form a small cluster. However, it is possible to distinguish two subgroups. Figure 13 shows that some nations detach themselves from the low-income category, which is the case with Egypt, Cameroon, Zambia, Mauritania, Zimbabwe, Cote d'Ivoire, and the Congo. These countries are spread to the right in figure 13 and have lower energy consumption per capita (as can be seen in figure 14). As noted earlier, the Africa 2 group exhibits very similar characteristics. Agriculture's share in the composition of the GDP is between 30 and 55 percent for the majority of these countries (e.g., Lesotho, Eritrea, Angola, and Botswana), with a high percentage having values around 40 percent.

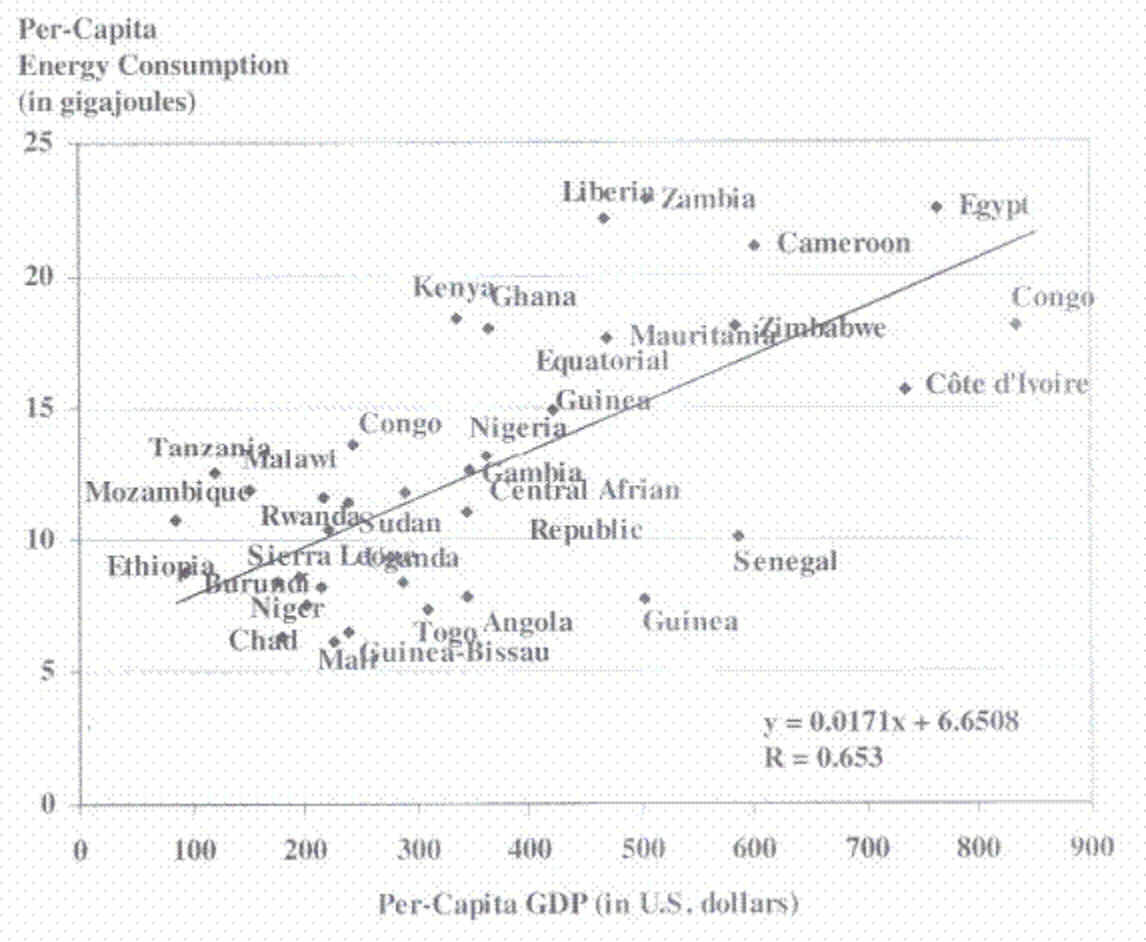


FIGURE 13: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS PER-CAPITA GROSS DOMESTICPRODUCT(GDP) FOR GROUP2 AFRICANCOUNTRIES,1995[a]

[a]R =correlation efficient.

This value is very high compared to the other continents, showing the low level of industrial development or the high percentage of traditional fuel used by the industries in Africa. As can be seen in figure 15**,** the percentage of traditional fuel used by many African countries is very high. Most of the states found in the second group (except Mauritania, Zimbabwe, Congo, and Senegal) show the share of traditional fuel use above 60 percent. Moreover, the majority of these states has a value higher than 80 percent. Improving the efficiency of traditional fuel devices would help to improve the situation.

**South and Central America**

Two groups could be distinguished in South and Central America although the value of GDP per capita is more equally spread than for Asia or Africa. Nevertheless,six countries form a cluster with the remainder falling into a second group (table 6).

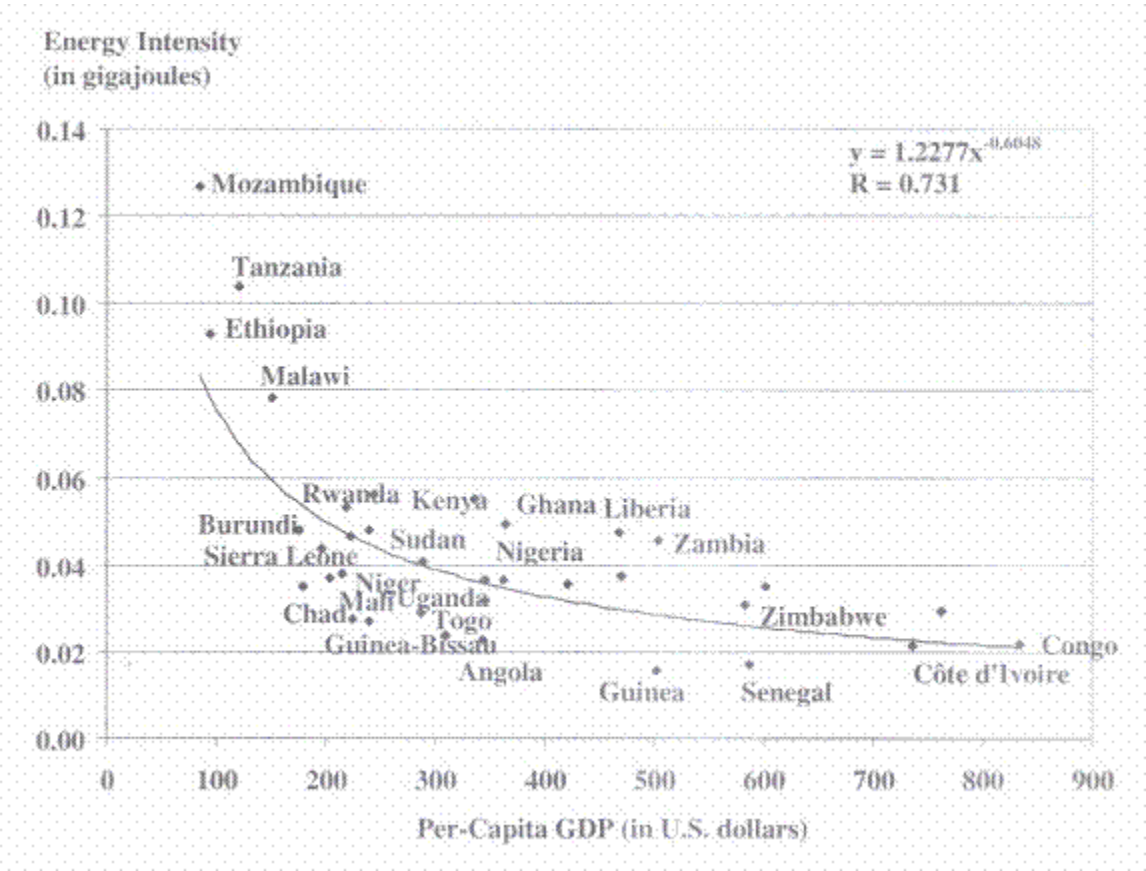


FIGURE 14: PLOT OF THE INTENSITY VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR GROUP 2 AFRICAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

six countries form a cluster with the remainder falling into a second group (table 6). Figure 16 is plotted for all the South and Central American countries; figure 17 is re-plotted without Trinidad and Tobago, Venezuela, Suriname, Jamaica, and Mexico.[24] Values of the GDP per capita are well spread between U.S. $0 to $8,000 in South and Central America. The relationship found in figure 17 is then used to forecast the energy consumption per GDP in figure 18. This linear relationship tends to show that the South and Central American countries, despite differing stages of development, follow much the same path. While each has a different value of energy consumption and GDP, they all more or less have the same energy consumption per capita if they have the same per-capita GDP. The high value of energy consumption per capita in Trinidad and Tobago is because of the large share of energy consumed by the industrial sector. It uses 85 percent of the energy and its share in the GDP composition is 44 percent, indicating low efficiencies in this sector.

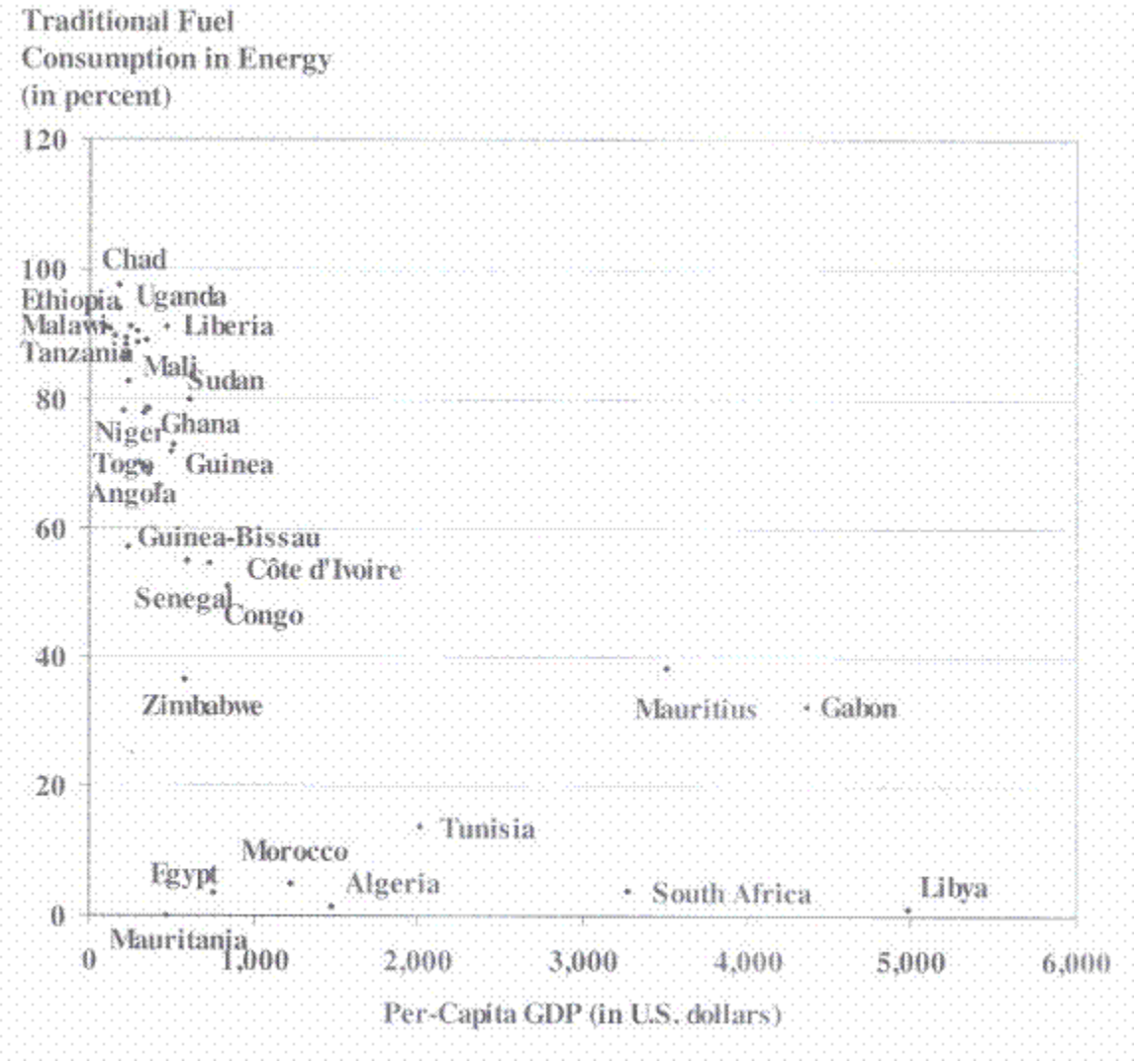


FIGURE 15: PLOT OF THE PERCENTAGE OF TRADITIONAL FUEL CONSUMPTION FOR AFRICAN COUNTRIES, 1995

TABLE 6: SOUTHAND CENTRALAMERICAN(SCA) COUNTRIESIN GROUPSBASED ON GROSS DOMESTICPRODUCT(GDP) PER CAPITA, 1995

| Group | Countries | Per-Capita GDP (in U.S. dollars) | Per-Capita Energy onsumption (in gigajoules) |
|---|---|---|---|
| SCA 1 | Trinidad , Tobago , Argentina , Uruguay , Chile , Brazil and Venezuela | 3,500-8,000 | 40-250 |
| SCA 2 | All the other countries | 400-3,000 | 10-70 |

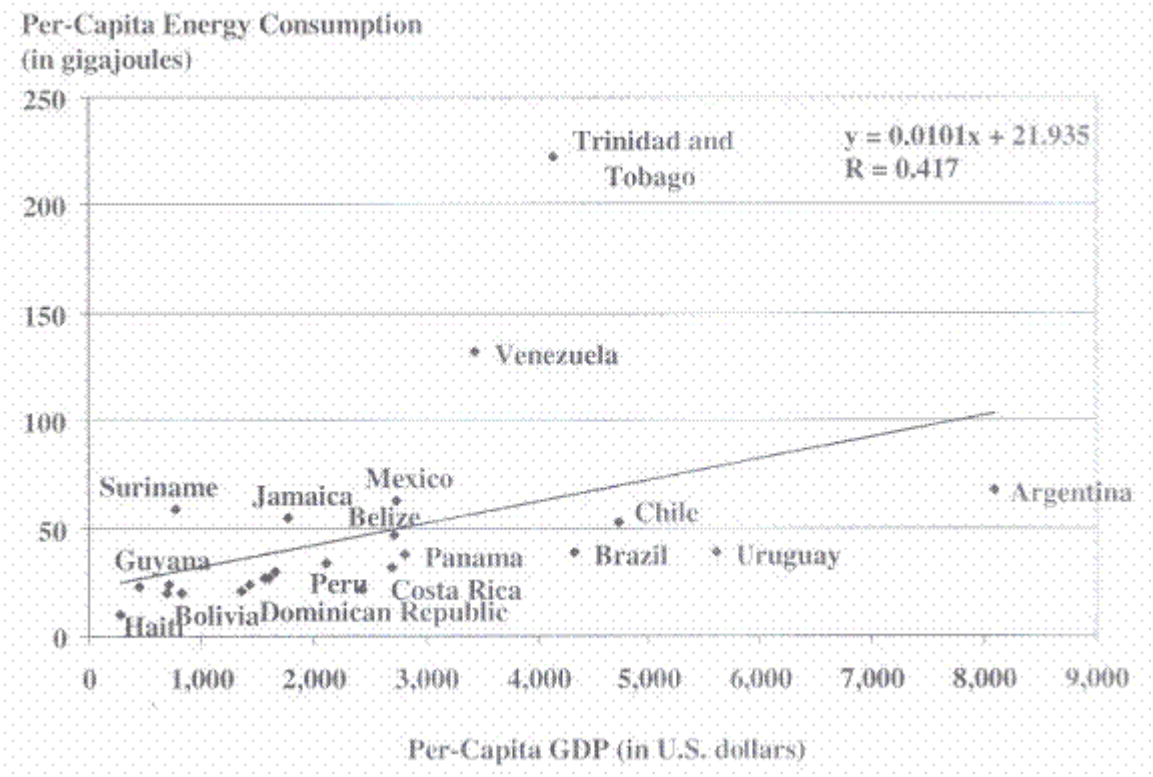


FIGURE 16: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR SOUTH AND CENTRAL AMERICAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

Venezuela and Mexico have relatively high energy-consuming industries. The share of traditional fuel in total energy consumption in South and Central America is between 30 and 70 percent, with the exception of Mexico, Jamaica, Argentina, Panama, Trinidad and Tobago, Suriname, and Venezuela. The agricultural share in the GDP tends to decrease when the GDP increases. For instance, this value is 42 percent for Haiti, 22 percent for Belize, 6 percent for Chile and 7 percent for Argentina. This may not always hold, for example, in the case of Belize, because other factors have to be taken into account. The same calculation of energy consumption in one household per capita and the energy consumption per unit of GDP for industry have been made for South and Central America; the results are presented in table 7**.** The indicators show fewer differences among the countries of South and Central America than for the other continents (tables 2, 3, and 5). The energy consumption in household per capita goes from 5.9 GJ for Brazil to 13.8 GJ for Argentina. The same observation can be applied to the energy consumption per unit of GDP for the industrial sector.

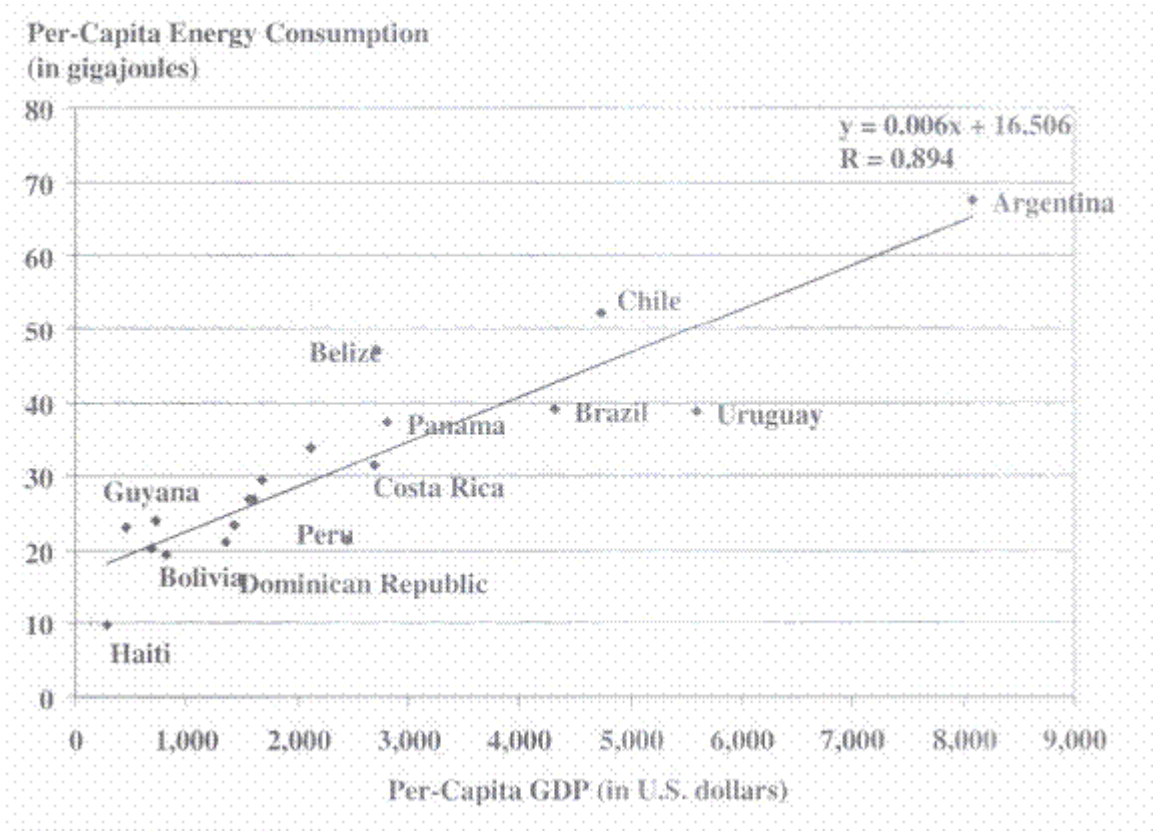


FIGURE 17: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR THE SOUTH AND CENTRAL AMERICAN COUNTRIES EXCLUDING TRINIDAD AND TOBAGO, VENEZUELA, AND SURINAME, 1995[a]

[a]R =correlation efficient.

Figures 16 and 18 show that few countries do not follow the same linear relationship. Mexico and Venezuela, where energy consumption is quite high, have high values for both indicators, which indicates high energy consumption and possible poor efficiencies.[25]

**Oceania**

Table 8 shows the groups in Oceania countries based on GDP per capita. Five countries have been selected and compared: Australia, New Zealand, Fiji, Papua New Guinea, and the Solomon Islands. Figure 19 shows a linear relationship between energy consumption per capita and per-capita GDP. For Oceania, the value is eight times lower than for South and Central America, that is, the energy consumption per GDP throughout Oceania issimilar, which can be seen in figure 20. Except for Papua New Guinea, all the other values are close. Two main differences are seen between the countries of the two groups of Oceania. Fiji, the Solomon Islands, and Papua New Guinea (group 2) have apercentage

of traditional fuel between 55 and 65 percent, while for Australia and New Zealand (group 1) it is less than 3 percent.

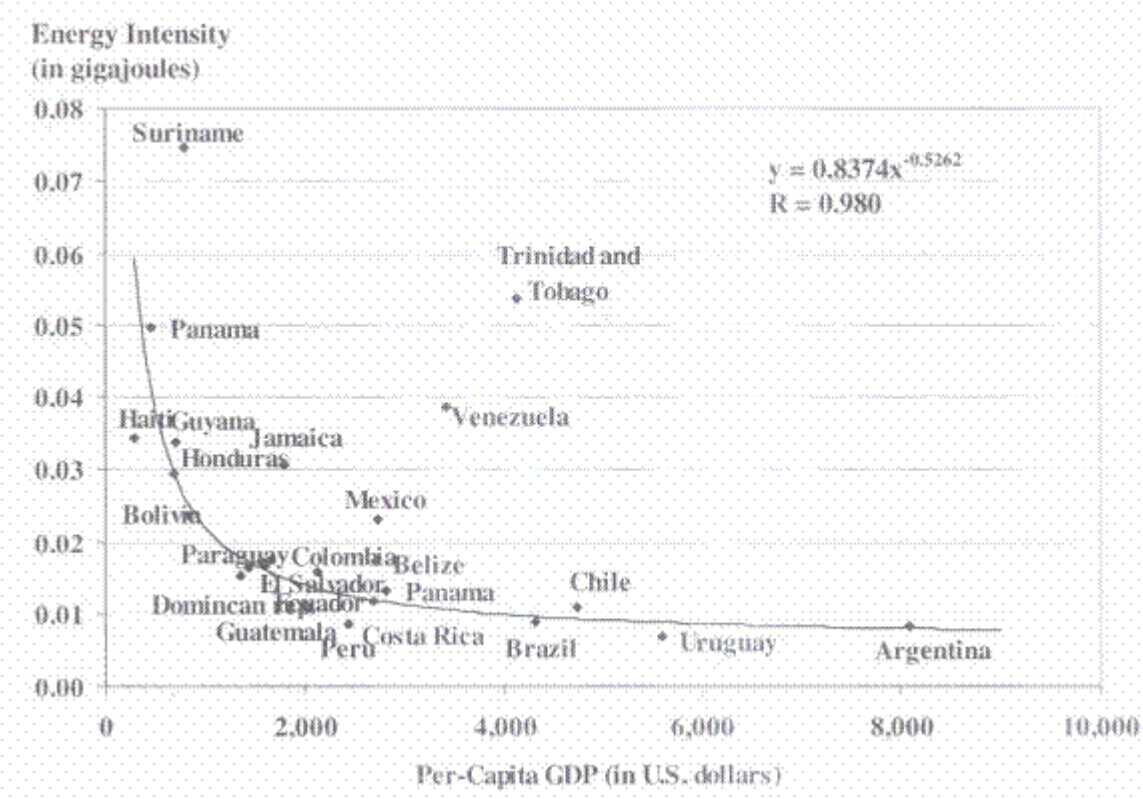


FIGURE 18: PLOT OF THE ENERGY INTENSITIES VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR SOUTH AND CENTRAL AMERICAN COUNTRIES, 1995[a]

[a]R =correlation efficient.

TABLE 7: PER-CAPITA HOUSEHOLD ENERGY CONSUMPTION AND NDUSTRIAL ENERGY CONSUMPTION PER GROSS DOMESTIC PRODUCT (GDP) FOR A SAMPLE OF COUNTRIES IN SOUTH AND CENTRAL AMERICA, 1995

| Country | Per-Capita Household Energy Consumption (in gigajoules) | Industrial Energy Consumption Per Unit of GDP (in gigajoules per U.S. dollar) |
|---|---|---|
| Argentina | 13.8 | 0.010 |
| Ecuador | 7.0 | 0.013 |
| Brazil | 5.9 | 0.013 |

| | | |
|---|---|---|
| Colombia | 7.5 | 0.028 |
| Bolivia | 6.0 | 0.035 |
| Mexico | 10.2 | 0.048 |
| Venezuela | 12.0 | 0.037 |
| Peru | 7.9 | 0.009 |

TABLE 8: OCEANIA C GROUP BASED ON GROSS DOMESTIC PRODUCT (GDP) PER CAPITA, 1995

| Group | Countries | Per-Capita GDP ( in U.S. dollars) | Per-Capita Energy Consumption (in gigajoules) |
|---|---|---|---|
| Oceania 1 | Australia and New Zealand | 15,000-20,000 | 175 – 250 |
| Oceania 2 | Papua New Guinea , Fiji and Solomon Islands | < 3,000 | <30 |

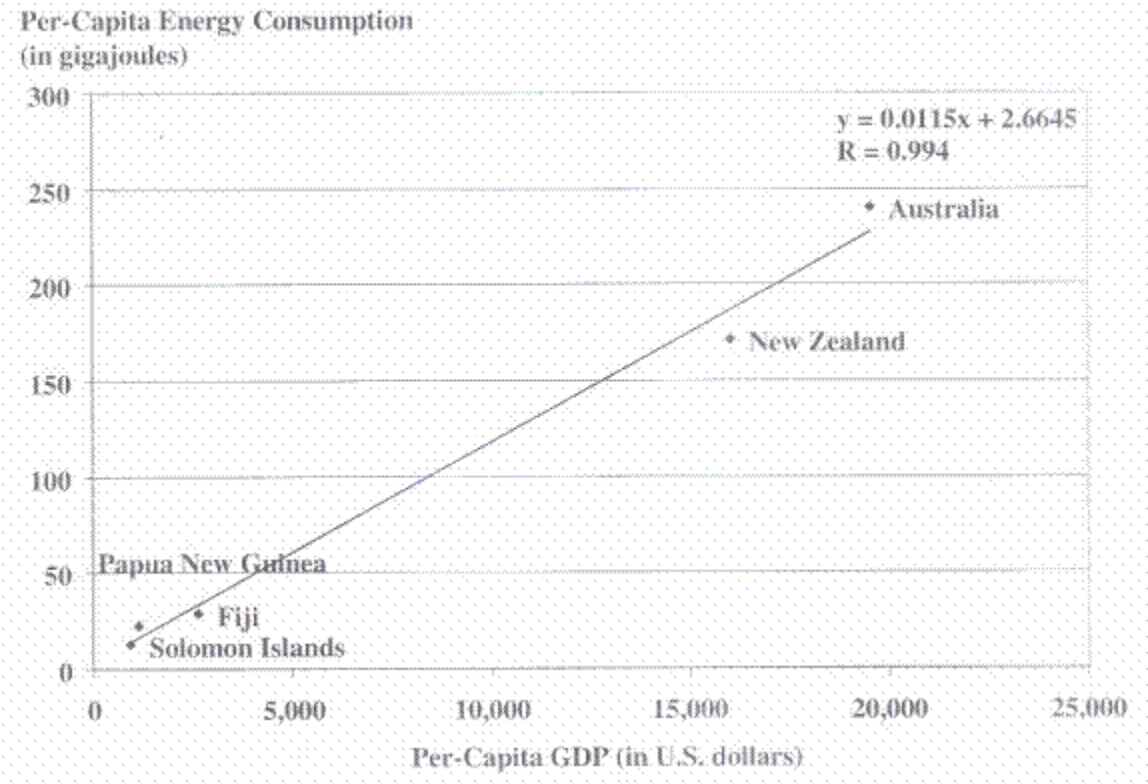


FIGURE 19: PLOT OF THE PER-CAPITA ENERGY CONSUMPTION VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR THE COUNTRIES OF OCEANIA, 1995[a]

[a]R =correlation efficient.

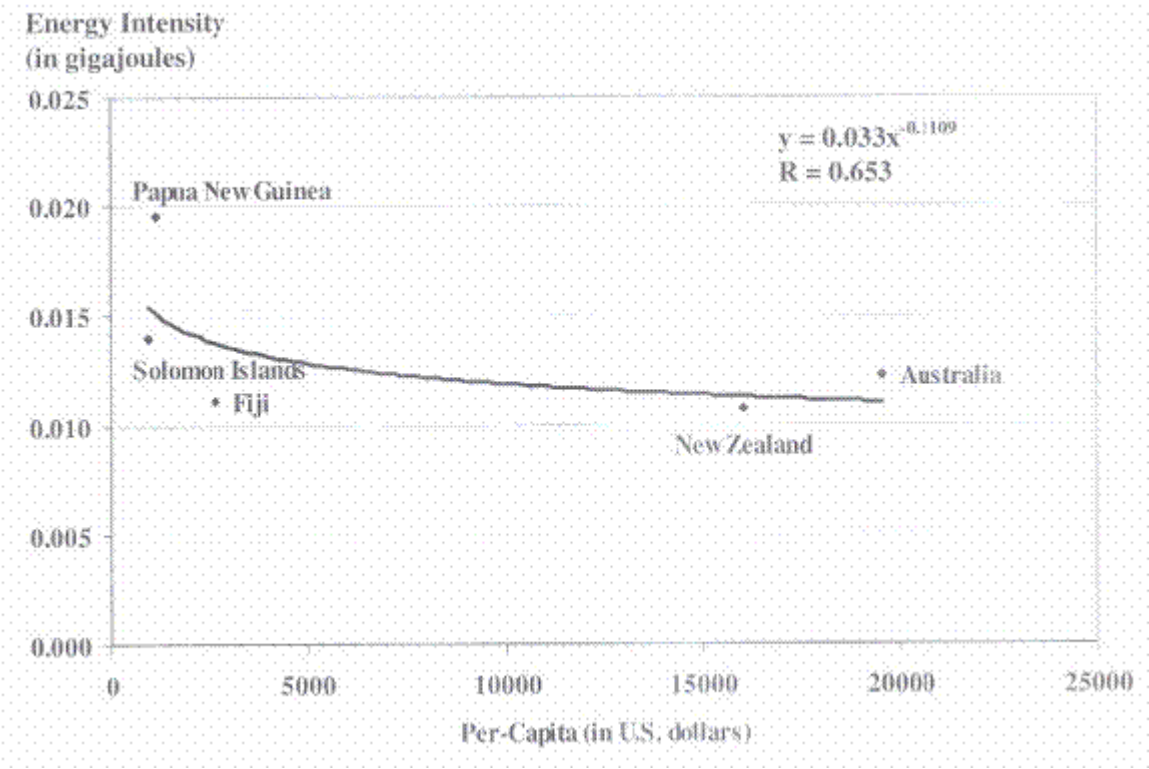


FIGURE 20: PLOT OF THE ENERGY INTENSITfES VERSUS PER-CAPITA GROSS DOMESTIC PRODUCT (GDP) FOR THE COUNTRIES OF OCEANIA, 1995[a]

[a]R =correlation efficient**.**

The agricultural share in the GDP composition is between 20 percent and 30 percent for Fiji and Papua New Guinea and below 9 percent for Australia and New Zealand. Since the energy consumption per GDP is similar, it suggests that the industry and service sectors are not as well developed in the Oceania 2 group as in the Oceania 1 group, leading to lower energy consumption per capita, lower outcome from these sectors, but similar energy consumption per GDP.

**Temporal Analysis**

The analysis performed above gives an idea of the energy consumption and GDP for each country, but it is also important to understand the variation-whether these values are decreasing or increasing over time. Therefore, the values of the two indicators for the last 20 years are plotted for a sample of countries chosen to offer a good representation of the different groups noted earlier.

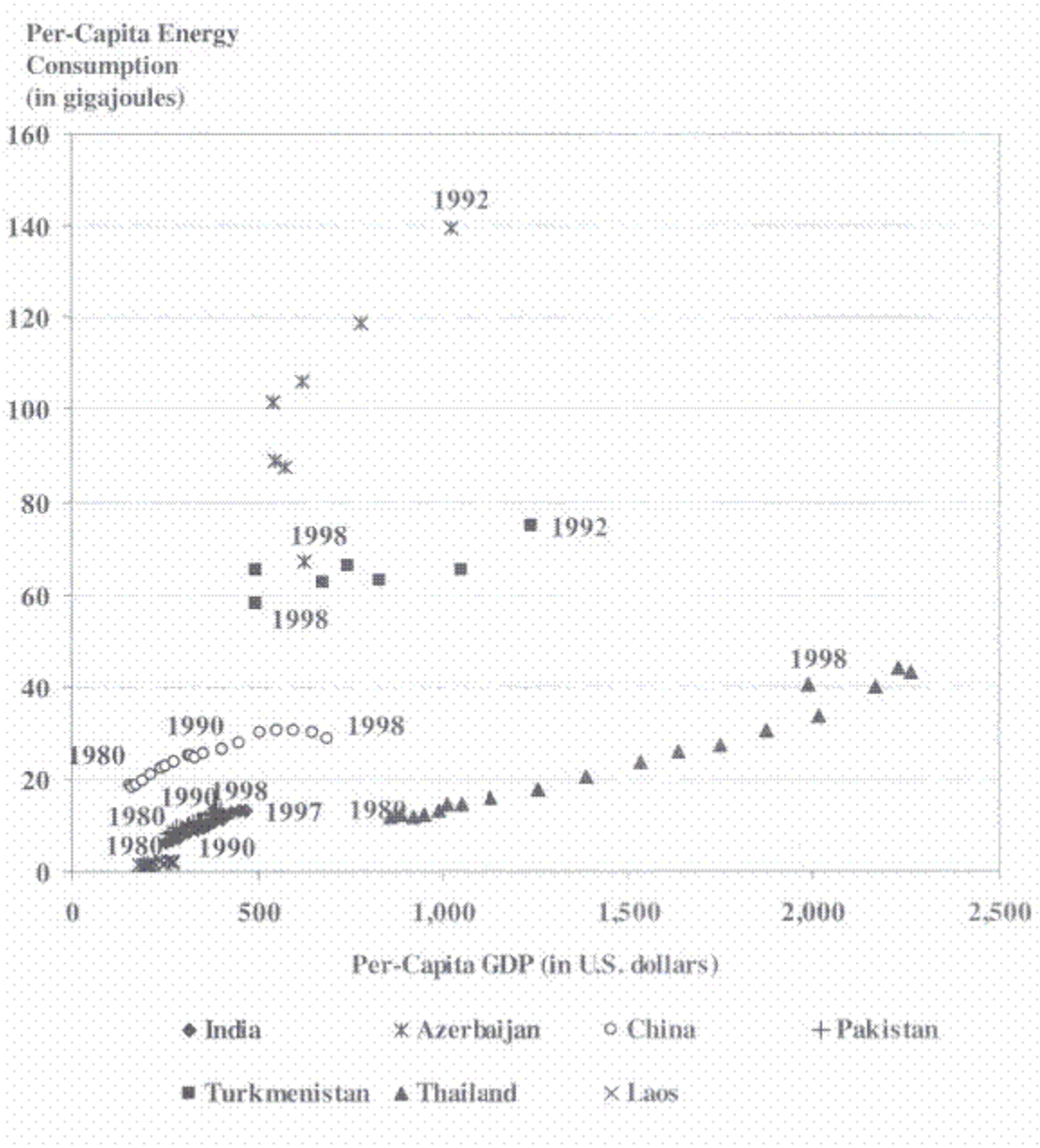


FIGURE 21:TEMPORAL ANALYSIS OF THE PER-CAPITA ENERGY CONSUMPTION FOR A SAMPLE OF ASIAN COUNTRIES, 1995

***Asia:***

Countries like Azerbaijan and Turkmenistan, which became independent only in the early 1990s, have data since then for temporal analysis. The energy consumption used in figures 21 and 22 is primary energy, excluding the traditional fuels. An increase in the energy consumption is expected in Thailand, China, India, and Pakistan. The analysis shows a rise in both energy consumption per capita and per-capita GDP. China has the most impressive growth and Laos the smallest. India and Pakistan have the same

development. For Turkmenistan and Azerbaijan, the recent independence seems not to have had a great influence on growth. BothAzerbaijan's energy consumption per capita and the GDP per capita have declined. It is interesting to notice that in the early 2000s Azerbaijan's GDP is increasing but the energy consumption is still falling.

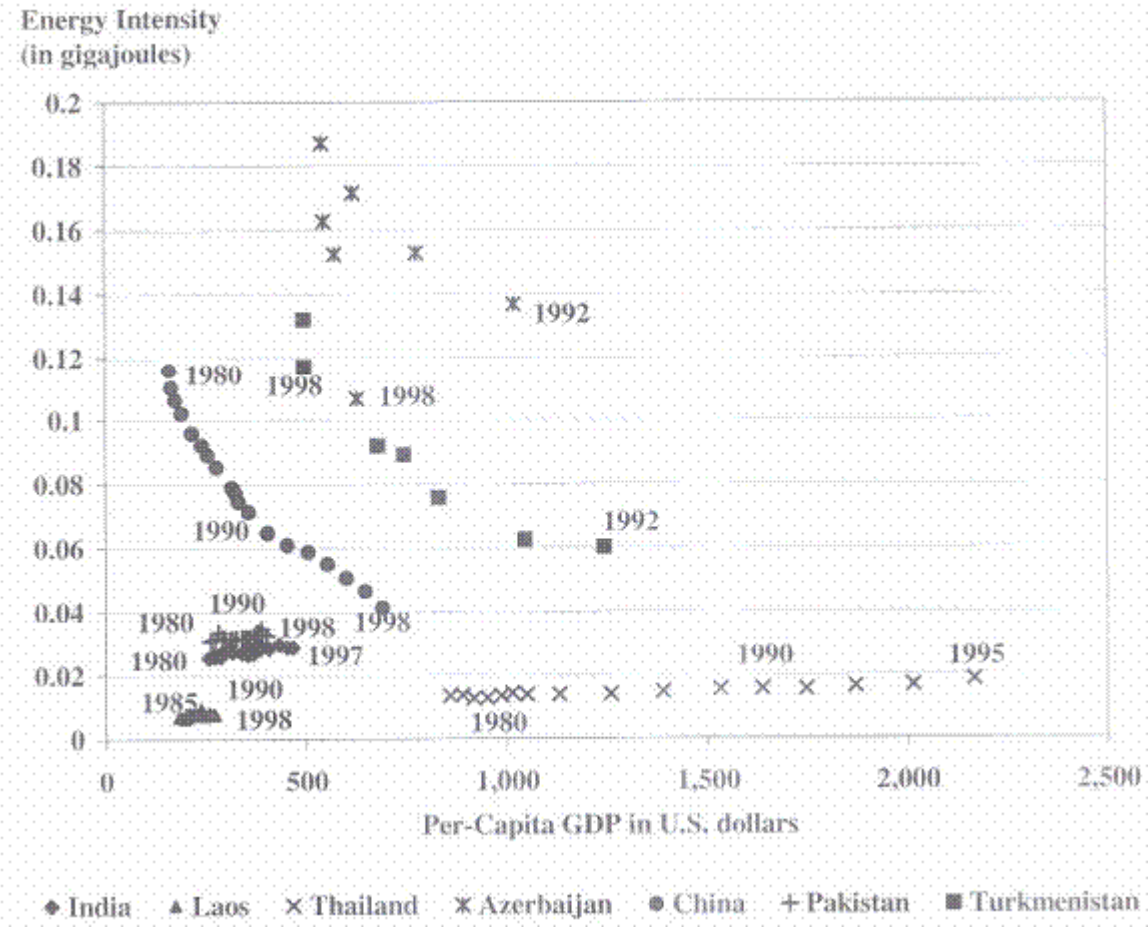


FIGURE 22:TEMPORAL ANALYSIS OF THE ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP)-ENERGY INTENSITY-FOR A SAMPLE OF ASIAN COUNTRIES, 1995

Figure 21 shows that Thailand, India, Pakistan, and Laos increased their GDP per capita with stable per-capita energy consumption. Among them, Thailand has better growth for the past 10 years (1985- 1995); China shows a major improvement in efficiency where energy consumption per GDP decreased significantly. Figure 22 shows the energy consumption per GDP for a sample of Asian countries. Europe: Temporal analysis of the energy consumption per capita for selected sample European countries is shown in figure 23. It is decreasing in the eastern nations of Europe, prominently for Russia, Ukraine, and Romania. For Hungary, the drop seems to have stopped. Analysis shows the difficulties that countries ofthe former Soviet Union encountered with independence and the economic liberalization. The energy intensity of sample European countries is shown in figure 24

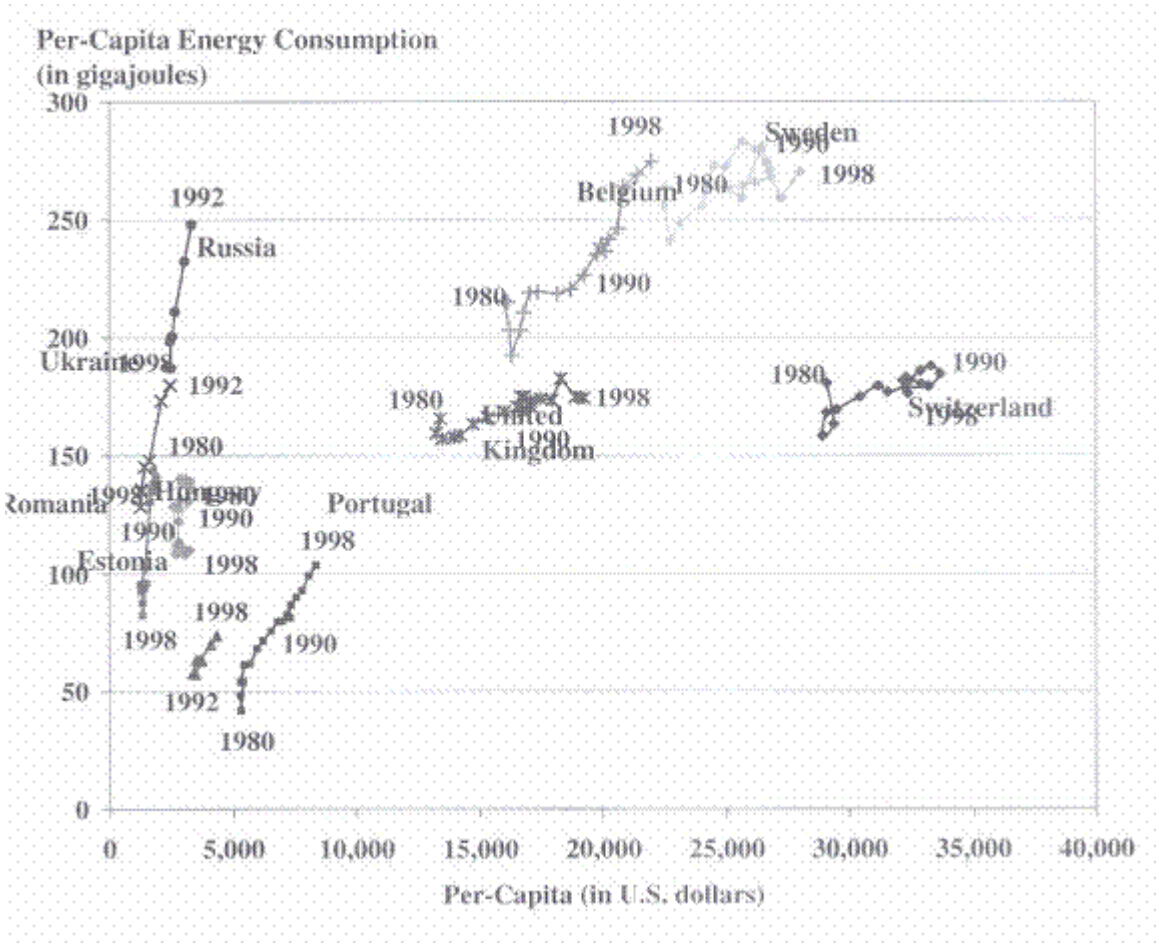


FIGURE 23**:** TEMPORAL ANALYSIS OF THE PER-CAPITA ENERGY CONSUMPTION FOR A SAMPLE OF EUROPEAN COUNTRIES, 1995

The slopes of the development of the Europe 2 group are quite steep compared to the Europe 1 group. It is difficult to say if the slopes of the Europe 2 group countries will decrease when they reach higher energy consumption levels. If so, that would be a positive direction. It is possible to observe that countries having a low GDP per capita have a tendency to increase energy production rather than energy efficiency. The reason for the high slope is due to a:decrease in efficiencies that could be explained, for example, by a lack of maintenance in the main power plants. Switzerland encountered a reverse with a decrease in the GDP per capita in the early 1990s. Africa: The plot of the energy consumption per capita versus the GDP per capita for the past 20 years has been divided in two figures (25 and 26) because the temporal analysis was not possible otherwise. Except for Zimbabwe, the countries presented in figure 25 are from the Africa I group; figure 26 presents the same plot for nations of the Africa 2 group.

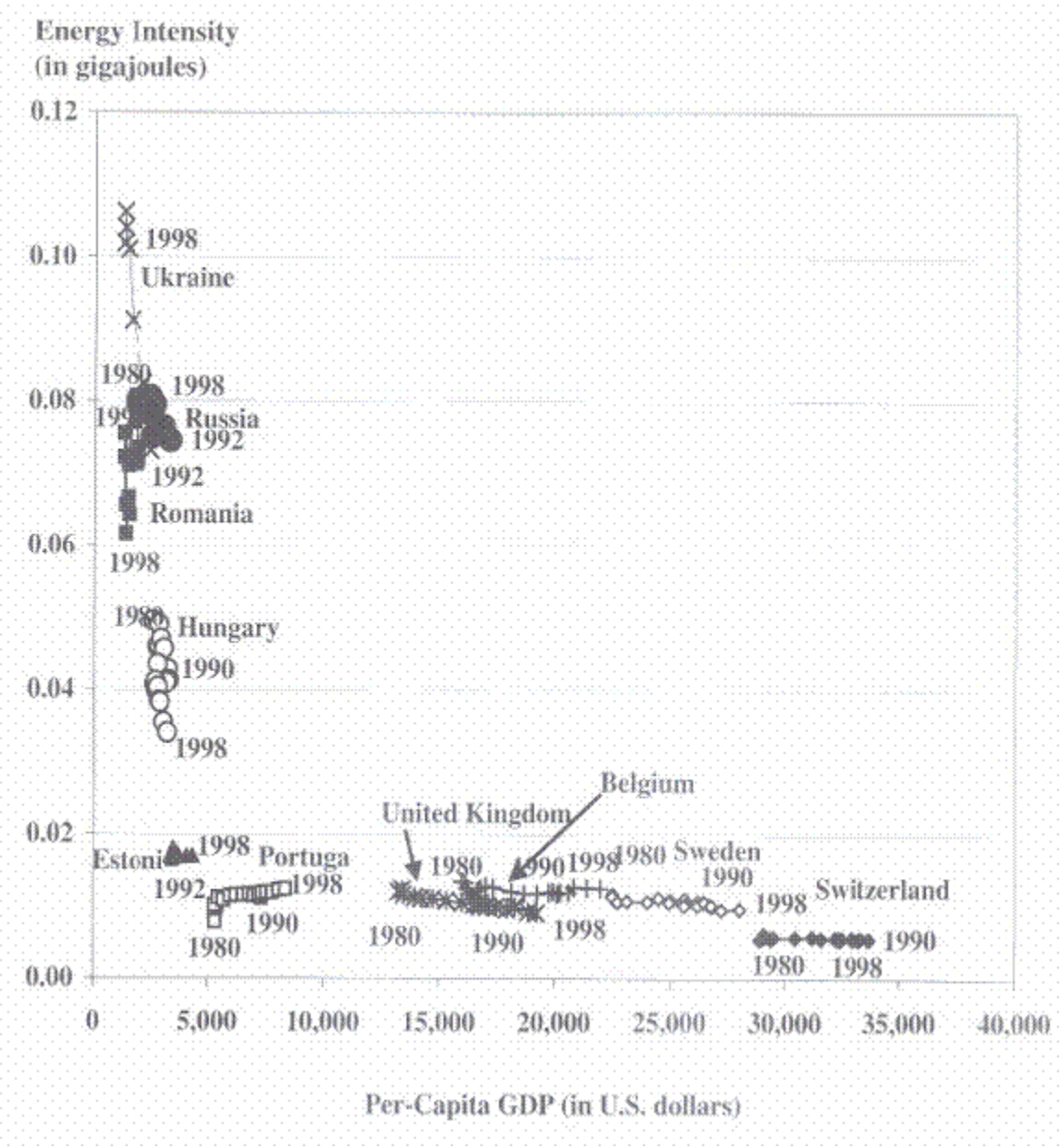


FIGURE 24: TEMPORAL ANALYSIS OF THE ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP)-ENERGY INTENSITY-FOR A SAMPLE OF EUROPEAN COUNTRIES, 1995

Figures 25 and 26 show a different variation of that for Europe and Asia. If the North African countries of Morocco and Algeria have seen an increase in GDP during the past 20 years, it is not at all the case for the others. Figure 25 indicates that South Africa has been experiencing a decline in its GDP per capita for the past 20 years; Zimbabwe appears unchanged with but a very small increase.

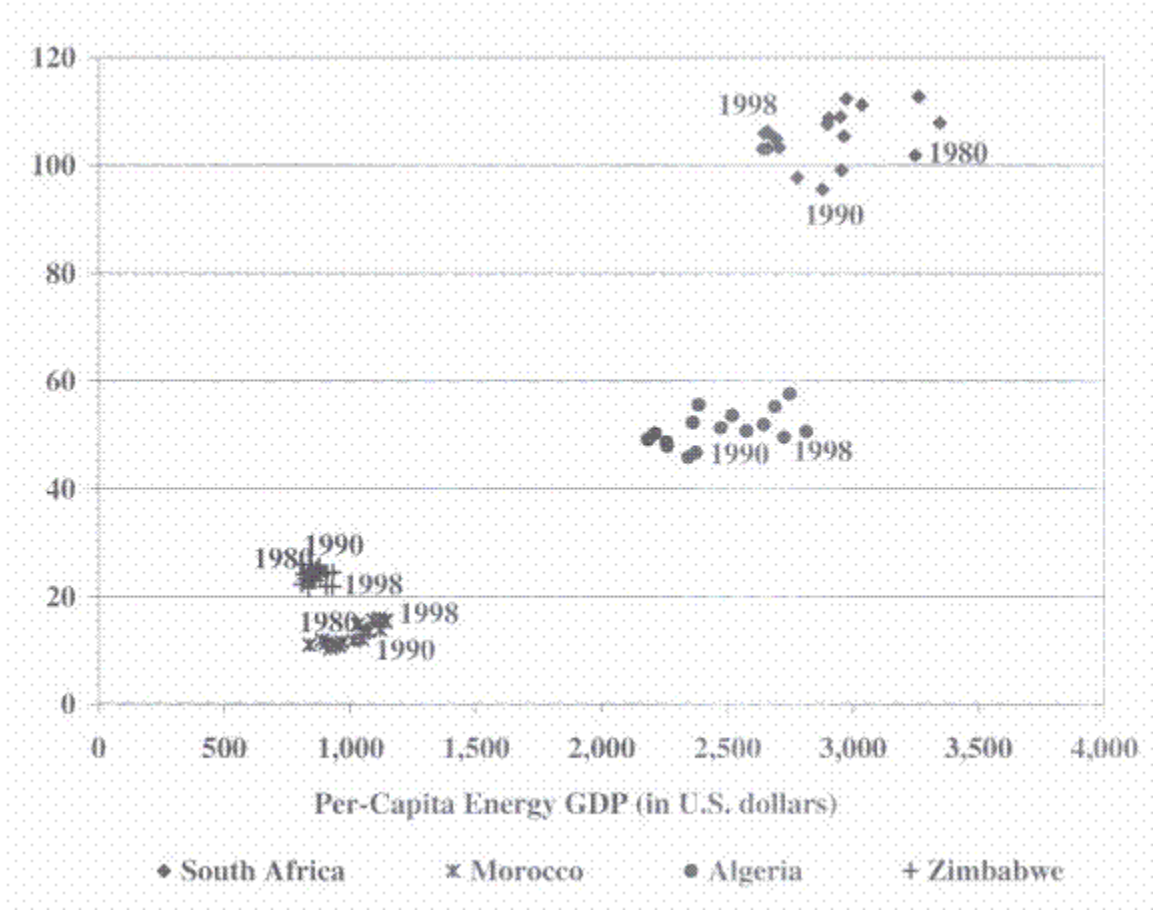


FIGURE 25:PLOT OF THE EVOLUTION OF THE PER-CAPITA ENERGY CONSUMPTION OVER TWO DECADES FOR A SAMPLE OF AFRICAN GROUP 1 COUNTRIES, 1995 (in gigajoules)

In the Africa 2 group, the development of the countries differs. Mali has improved, even if the values for the past seven years (1988-1995) are not available. During 1980 and 1991, its GDP per capita increased without an increase in its energy consumption (seen in figure 26). Sierra Leone, for instance, saw its GDP decreasing for the past 20 years and its energy consumption per capita more or less constant. Tanzania and Ethiopia had only slight changes; nonetheless, after two decades their situations appear unchanged. Figure 27 shows energy intensities for the past 20 years for a sample of African countries. In Asia and Europe, the temporal analysis of the countries showed perhaps two or three different behaviors, generally depending on the group to which a nation belonged. This does not appear to apply in Africa. Additional analysis probably could explain these trends; some factors to consider would be political changes, wars, and the consequent political and economic instability.

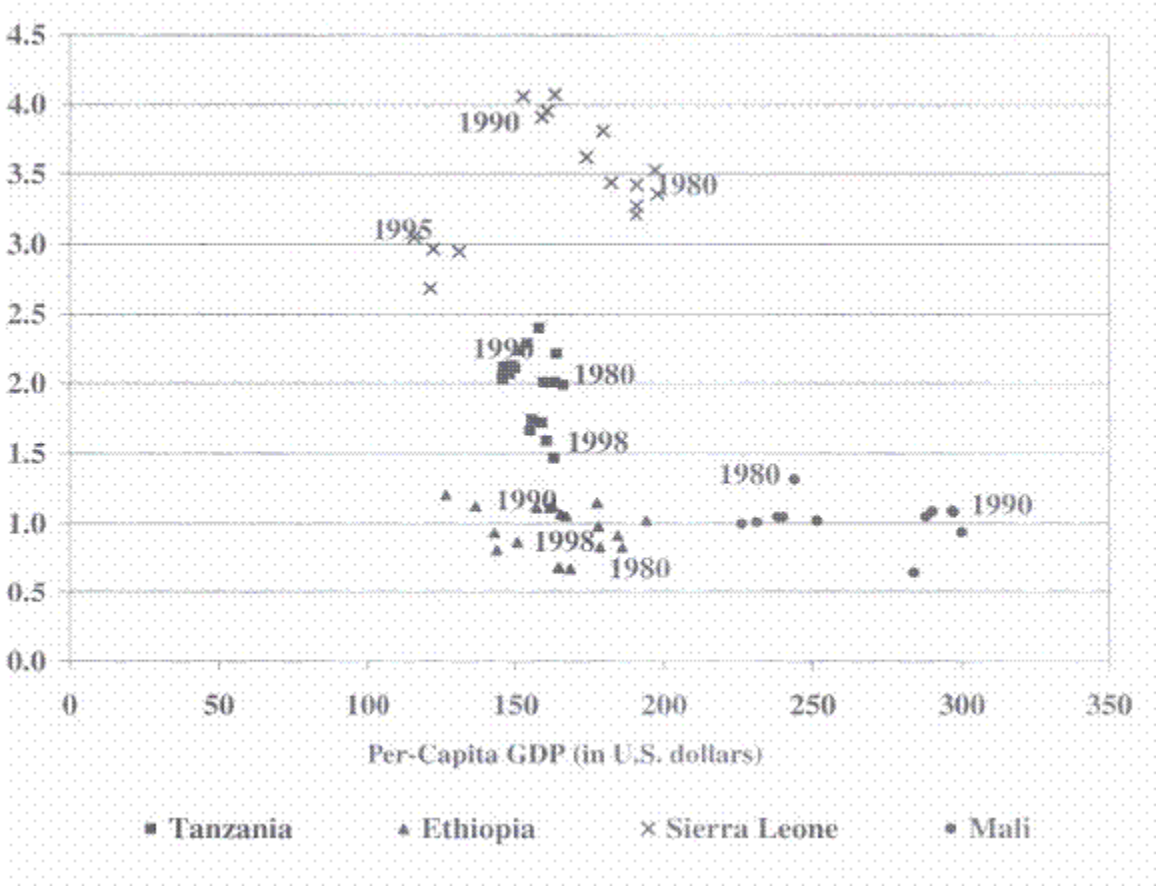


FIGURE 26: PLOT OF THE EVOLUTION OF THE PER-CAPITA ENERGY CONSUMPTION OVER TWO DECADES FOR FOUR POOR COUNTRIES OF AFRICA GROUP 2, 1995 (in gigajou1es)

South and Central America: A plot of the evolution of the energy consumption per capita for the past 20 years for a sample of South and Central American countries is shown in figure 28. The temporal analysis shows that an increase or decrease in the GDP occurs at the same time in most of the countries, except for Haiti, which is the lowest income in the region. From 1980 to 1990, the GDP per capita and the energy consumption per capita decreased for all the countries presented in figure 28; after 1990, it started to increase again for all these countries. As noted earlier, the evolution of the countries follow a similar path, with different intensities. In figure 29, it is also possible to see that a decrease or an increase in GDP occurs at the same time for the countries.

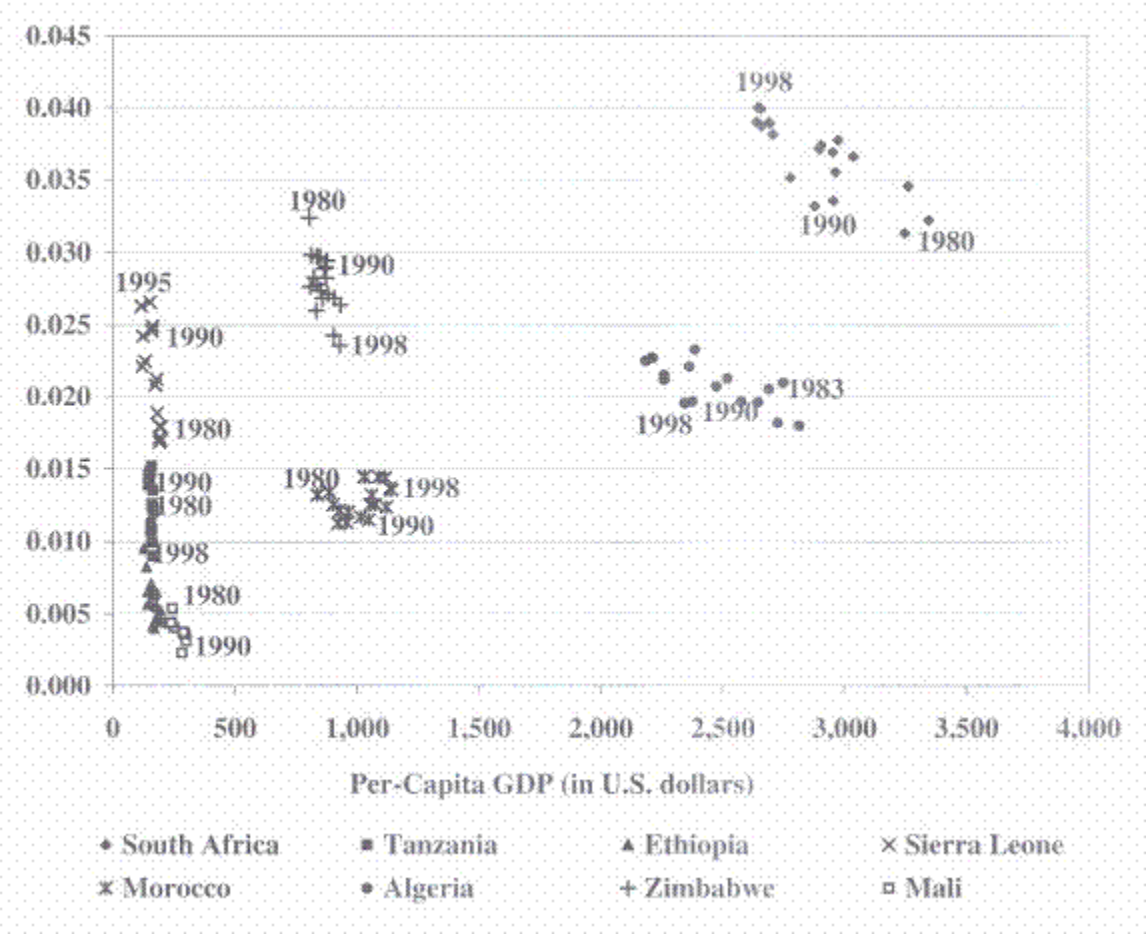


FIGURE 27: PLOT OF THE ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP)-ENERGY INTENSITY-OVER TWO DECADES FOR A SAMPLE OF AFRICAN COUNTRIES, 1995

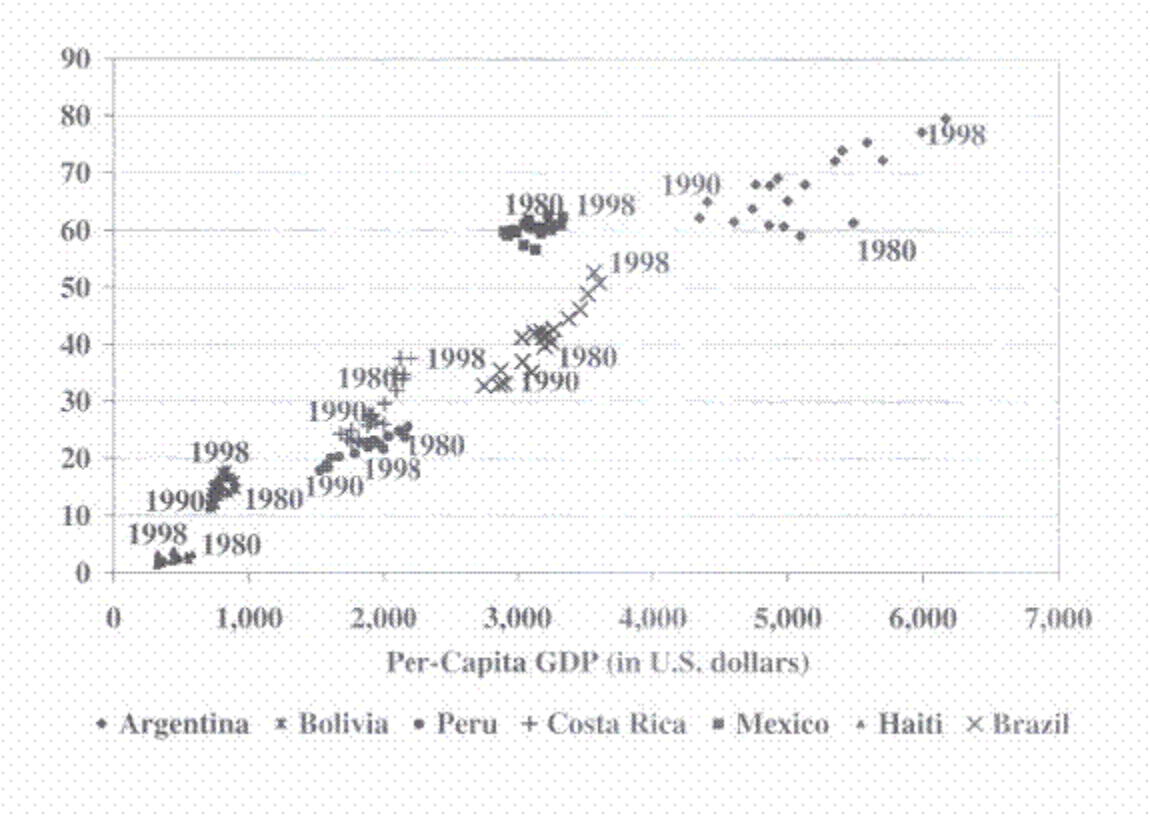


FIGURE 28:PLOT OF THE EVOLUTION OF THE PER-CAPITA ENERGY CONSUMPTION OVER TWO DECADES FOR A SAMPLE OF SOUTH AND CENTRAL AMERICAN COUNTRIES, 1995 (in gigajoules)

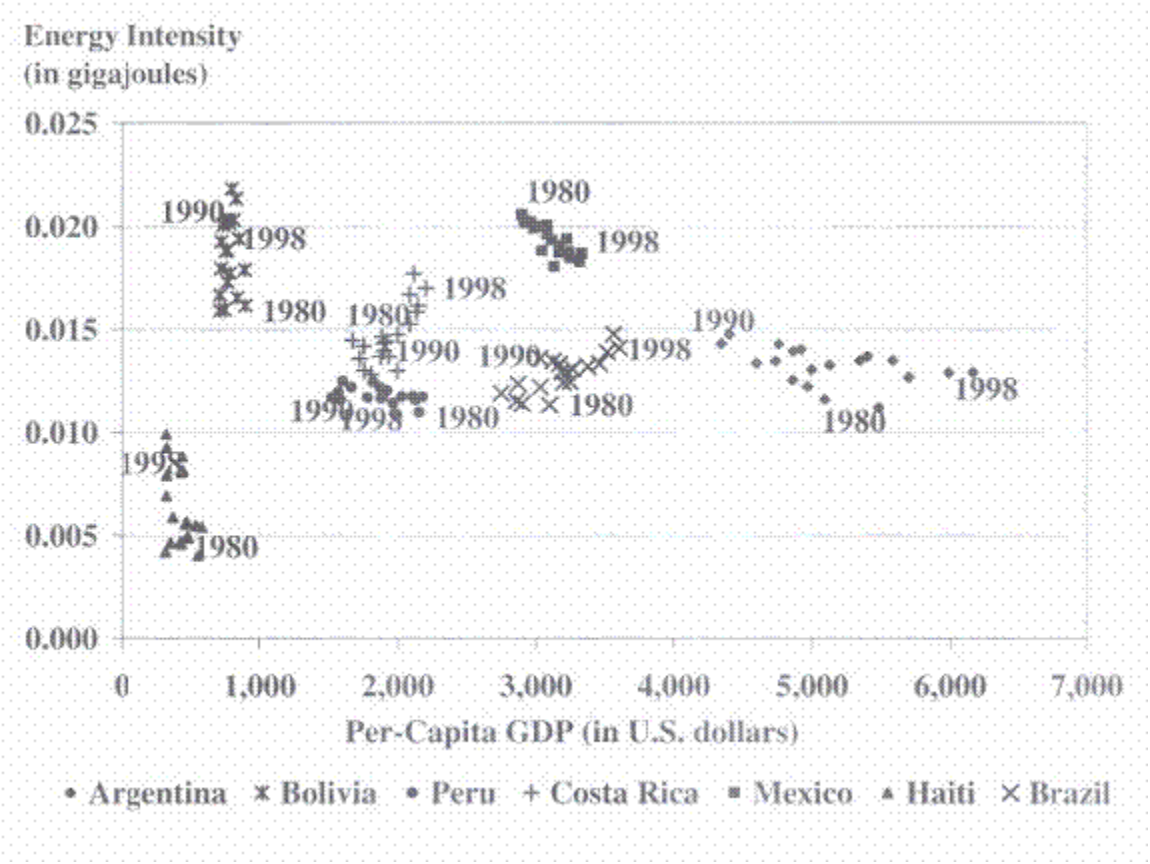


FIGURE 29: PLOT OF THE EVOLUTION OF THE ENERGY CONSUMPTION PER UNIT OF GROSS DOMESTIC PRODUCT (GDP) OVER TWO DECADES FOR A SAMPLE OF SOUTH AND CENTRAL AMERICAN COUNTRIES, 1995

**CONCLUSION**

Energy utilization in developing countries varies radically from that of the developed nations. To compare the status of energy consumption between countries, energy consumption per capita and energy consumption per GDP (energy intensity) are computed. Plotting these indicators for all states gives an idea of the efficiency, the standard of living, or the development stage of a country.

However, the analysis reveals that the situations are very different from one continent to the other. It has been seen that similar characteristics generally are associated with a region. For instance, the two groups within Europe can more or less be divided into the eastern and the western subgroups. The countries of North Africa have different characteristics than the rest of the continent, probably due to the differences in the climate and their proximity to Europe. North America (Canada and the United States) also appears detached from the rest of the hemisphere. For different reasons, vast differences in energy consumption and similar GDP per capita, or the opposite, are found. Characteristics such as industry type, climate, or living standards must be studied to

understand these differences. However,the indicators computed show significant variation in energy efficiencies.

The energy consumption per GDP for the energy sector computed for a sample of countries of each continent gives a good idea of this efficiency, even if the industry type should be taken into account. Developed countries generally have a very low value, indicating a highly efficient industrial sector; the developing nations encounter greater problems. Some developing countries, nonetheless, seem to have efficient industry. This indicator does not permit a precise conclusion and detailed analysis should be performed; still, it gives an estimate of the efficiency. In general, the energy consumption increases with higher GDP. Oceania countries have the highest GDP per capita (less than U.S. $3,000 to $15,000) and the energy consumption per capita ranges from 30 to 250 GJ. The African countries have the lowest GDP per capita (less than U.S. $1,000 to more than U.S. $1,000) and the energy consumption per capita ranges from less than 25 to 120 GJ. The share of traditional fuel consumed offers an idea about not only the amount of traditional fuel used but also the potential for conservation or for the transition to other sources in the energy ladder. Most developing countries continue to rely principally on traditional fuel with evidence of lower end-use efficiencies.

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**22.** Industry's share of energy consumption and its contribution to GDP for the European group in this study includes: France, 29.1 percent energy use and 28.4 percent of GDP; Germany, 32 percent and 33.1 percent, respectively; Switzerland, 18.5 percent and 31.1 percent, respectively, and Hungary, 23.9 percent and 30.3 percent, respectively. These indicate good efficiency.

**23.** Mining is included in the industry sector and thus the high GDP consumption in Libya, Algeria, and Gabon.

**24.** Mexico, Venezuela, and Trinidad and Tobago are major oil and gas producers that have been included in the GDP; refining was excluded.

**25.** The position of Venezuela and Mexico as major oil producers impact this element.

**AUTHORS**

| Ramachandra T. V.<br>cestvr@ces.iisc.ernet.in | Yves Loerincik<br>energy@ces.iisc.ernet.in | Shruthi B.V.<br>shruthi@ces.iisc.ernet.in |
|---|---|---|


Energy & Wetlands Research Group (EWRG),
Centre for Ecological Sciences (CES),
Indian Institute of Science (IISc),
Bangalore 560 012,
India.