Economics of Greenhouse Gas Limitations

COUNTRY STUDY SERIES

Ecuador

Ecuadorian Foundation for Energy and Environment (FEDEMA)

Ecuador.

Published by: UNEP Collaborating Centre on Energy and Environment,
Risø National Laboratory, Denmark, 1999.

ISBN: 87-550-2564-1

Available on request from:

UNEP Collaborating Centre on Energy and Environment
Risø National Laboratory
P.O. Box 49
DK 4000 Roskilde
Denmark
Phone: +45 46 32 22 88
Fax: +45 46 32 19 99

Cover photo: Tomas Bertelsen / Billedhuset

Information Service Department, Risø, 1999

TABLE OF CONTENTS

International Framework

The main trends of the international scenario for the next third of a century are discussed below. Certain analysts, like Santos (-97, references at the end of the text), consider that fundamental changes already took place, and the coming evolution will be driven by forces already present. Main feature in the plot is the globalisation phenomenon. Economic globalisation is considered irreversible by many, like the director of the World Trade Organisation (Ruggiero-97). Also the secretary of the Democratic Confederation of the French Labour Party (Cash-International-97) and an official of the World Bank (Kaji-96), hold similar views.

1 Meaning of globalisation

Globalisation is a process more than a state, leading to segmentation and planetary distribution of economic activities, as a function of competitive and comparative advantages, available in different locations.

The process assumes and reinforces the following conditions:

- Free flow of goods, services and capital, inside and across boundaries of commercial blocks, aiming to a complete elimination of national, regional and other barriers for trade.
- Access with decreasing costs, to planetary networks of communications, transport and other services, with practical elimination of overheads due to co-ordination, transactions, transport of components and so on.
- General use of (now) advanced technologies, for information handling and progressive automation of complex activities. Rapid incorporation of the results of Research & Development into flexible production, with the result of shorter product lives in the markets and improved tuning of their demands.

New markets and new forms of economic participation will induce greater diversification in the scale, life and organisation of the production units.

Globalisation through competition in an open market environment will promote specialisation, with reduction of costs and better assignment of resources. Adding the almost instantaneous access to information and, reduced costs of transaction, come close, as never before, to the assumptions of economic theory (Economist-96), with the consequent approach to a global economic optimisation. On passing, institutional limitations in developing countries may imply that enterprise diversification might be better than focalisation (Khanna & Palepu-97).

The reshaping of the economy dynamised by competition will strengthen its ability to expand its innovativeness and adaptability to new situations, providing opportunities for many. Reduction of stability, weakening of social links, worsening of distributive of inequalities and resilience to face external shocks, will generate social stresses (Adda-96). Given the diversity of initial conditions for different actors, regarding their abilities for a successful insertion in the new economy, and given the weakening of the organisative components in the new society and the world, many economically or culturally excluded will feel deprived. After multiple localised conflicts, their voice, linked to a more humanistic thinking, will mitigate the undesirable effects of unlimited competition, bringing organisative elements in a slowly emerging new social and world order.

This will merge the dynamics of a liberal economic with the human concerns of a more reflexive and concerned renewed man of the XXI century. Main issues will incorporate solidarity and sustainability, both at local and global scales. The mitigation process will take decades, to balance the drive of the purely economic concerns. On line with this trend, the Organisation for Economic Co-operation and Development (OECD) previews “a significant reduction of poverty in the world for the year 2020” (Cash-International-97).

Such and optimistic perspective is not shared by everybody. For example Singer & Wildavsky-92 anticipate a divided world between rich, enlighten democratic zones and poor, violent, conflict zones for one or two more centuries. Others like Krauthammer-97, consider that a relative decrease in the power of the USA, brought by consolidation of other commercial blocks, in ten o fifteen years from now, will lead to a society less free, more violent and unstable that the present one. This view seems pessimistic and not very likely, considering that, at least for material systems, distributed ones are more stable than over centralised ones.

2 Driving forces of the globalisation process

The following three interacting factors, have accelerated the globalisation process, since the middle of the eighties.

First among them, is the technological development, that according to Wriston (Aguirre & Rebois-94) is the builder of the new system. It gave way to an electronic massification that influenced production processes through the following means:

- Automation made feasible flexible production and accelerated processes and transactions. They result into reductions of production times, costs and where applied reduced labour demand. At the same time, it opened new demands for specialised professional services and highly paid labour.
- Massive telecommunications accelerated more transactions times and replaced certain transport demands by information flows (Negroponte-95).

These interlined means broke a critical barrier in the middle eighties, expanding rapidly a worldwide technological network. Such network provided the platform for a planetary distribution of production activities, based on the local advantages. This in turn gave way to greater specialisation and an unprecedented expansion of international trade. New development poles emerged, particularly in South East Asia and new market niches, aroused in a dynamic way.

Thus, the expanding technological platforms provided massive mobility of information. Cheaper worldwide services and explosive enhancement of production means, which besides growth implied radical restructuring of firms and governments. Second factor is the generalised competition as the economic setting for economic activities, around the world. This is bringing down trade barriers and opening markets, in an evolutionary way. Hufbauer-96 points out the role of information technology in this process, as well as the effects on the labour market. Heilbroner-96 holds that the overall balance is a reduction of jobs. Multinational firms apply strategies for the conservation and creation of competitive advantages in this setting (Adda-96). Both, specialisation and extensive competition open opportunities not only for large economies, but also for small countries like Hong Kong and Singapore for example, to grow rapidly (Thurow-97).

Third force is the drive to grow of production conglomerates, that authors like Heilbroner-96 call the “logic of capitalistic expansion”. In an environment of generalised competition, frequent immediate aims include cost reduction and market expansion.

3 Cultural and political impacts

The new techno-economic scenario was not restricted to the economic activities, but brought other influences to people lives.

In the cultural dimension, worldwide broad casting of videos, movies, music and news of concentrated sources, particularly from the USA, gave way to massive packed entertainment and information. This phenomena generated among others, cultural shocks, consumerism, diffusion of new issues, universal references provoking uniformisation, but also pointed diversities and, in a minor scale, gave opportunities for value affirmation in certain minorities and special groups (via Internet, particularly).

The cultural influences briefly mentioned, brought corresponding impacts, among others, the following. Empowered some old and new actors, particularly the editors of large information networks, who select, edit, filter and display information. Also, promoted new aspirations in the masses, generating frustration and impatience in the poor. Created new niches. Gave opportunity to integrate isolated lands.

Such social phenomena had political implications, focusing in developing countries, provided new perspectives to evaluate critically governments and society, illustrated new forms of participation, promotion of consumption, reduced the tendency to save and invest, and stressed social relations. Generalisation of economic culture, whose logic of solving conflicts is negotiation, was slowly transferred to the political arena. The new conditions, pose new challenges to governments. Also, many of them tend to weaken, as well as the feeling of nationality.

4 Empowered actors

Multinational firms (MF) had been main players in the globalisation process. They promoted it and wined considerable power, to the extent that national governments weakened. Their main mechanism has been direct international investment (DII). DII brought internationalisation of production assets and diffusion of production techniques. Main aims of MF have been market expansion, mitigation of risks and internalisation of advantages (Adda-96).

The geographic expansion of MF has been spectacular since 1985 but uneven. Main flows of investment have been Southeast Asia, some countries in Latin America like Mexico, Chile and Argentina and more recently Panama and certain Caribbean countries. Main conditions for investment appear to be a dynamic and low cost labour, communications and transport networks, stimulating laws for investment and opportunities for privatisation, loan purchase, etc. Most activities transferred overseas are branches of manufacture with higher proportion of labour and less intensity of technology.

The globalisation process is not smooth and involves conflicts that arouse by opposition of losing actors, who are many. It is advisable that the accelerated dynamics brought by such process, be led not only by the economic logic, but complemented by humane, justice and equity imperatives, that channel, organise and set certain restrictions to the economic and political play. Such organisation could be led by United Nations, particularly the United Nations Conference on Trade and Development (UNCTAD), and by the World Trade Organisation (WTO) (Santos-97).

So far however, the main actors and events limiting the process, have not arisen so much from explicit arguments and agreements, but from the political power of certain actors (unions in developed countries, particularly AFL-CIO in the USA) and by the fear to instabilities (financial and stock markets), typical of such an unrestricted system.

To dampen such instabilities and to mitigate the risks of international flows of capital, certain multinational organisations (MO), particularly the International Monetary Fund (IMF) and the World Bank (WB), have achieved new roles, monitoring economic policies and practice, and targeting of investments to developing countries. This represents a tacit shift of power from national governments.

Regarding sustainability and environmental conservation, achievements are very uneven. At local scale, developed countries have made great improvements, while developing countries are worsening their environments by growing pollution, and inadequate exploitation of natural resources, particularly forests. At the global scale, particularly mitigation of climate change, besides the European Union, no serious commitments have been made so far.

The political decision to mitigate emissions of GHG by the USA and Japan appears weak in the international conferences of 1997. They promise to reduce them to the 1990 level only in 2010.

5 Commercial blocks

The commercial blocks are sets of countries that establish preferential conditions for trade among them, approaching a free market. Such conditions entail reduction of tariffs and no-tariff barriers. Trade relations with other countries, are regulated in scope and magnitude, by governments or multilateral institutions of the block, depending on the level of integration achieved.

The consolidation of blocks can be seen as an intermediate stage in globalisation. The activity inside it promotes competition and trade with some degree of organisation, which in cases like the European Union aims to political integration. The relation with outside countries, represents an involution with regard to the generalised preference principle, defended by the GATT and now by the WTO.

The block strengthens the position of their members to negotiate, with third parties and other blocks. Also, protects them from risks and disadvantages, and mitigates the effects of phenomena like labour migration (Mexico to USA, North Africa to European Union, for example).

The consolidation of the blocks depolarises both, economic and political power in the world.

There is variety of mechanisms applied by blocks, the most frequent are agreements, and granting not shared trade advantages to their members. Among these are free markets for members and common tariffs for third countries. Advanced integration processes, like the European, incorporate the monetary union (Maastricht Treaty) scheduled for 1999. Among its expectations, brought by risk and transaction costs reduction, are to intensify trade and improve the competitiveness of the member countries. Still it is viewed as a step in a long process of political union, trough a federation scheme.

Examples of administrative instruments are those referring to semiconductors and cars in the European Union. Among barriers and protectionist measures, are protocols for subsidies, differential technical standards (like those for TV). Others forms of protectionism, applied particularly by the USA, are commercial sanctions, and subtle ones like conditions apparently protecting labour and the environment, in the partner country; others and more aggressive, like political disruption of other sub-blocks.

A wide encompassing Japanese strategy, called the "goose model" for Southeast Asia, involves a well co-ordinated trade, financial, diplomatic and co-operation policy, serving a great international industrialisation project for the whole region.

In order to ensure greater integration in international trade for the countries of Western Europe and the United States, it is expected that over the medium term there will be stable interest rates and prices and, as a rule, prospects of recovery, which also holds true for Japan, despite the uncertainty of the financial system. It is forecast that the Monetary Union of the Europe will contribute to economic and financial stability and to a greater integration of capital markets. Despite favourable growth prospects, there is not much optimism for a reduction of unemployment rates; actually the contrary is expected, since it is felt that this is not a transitory situation but rather the result of technological advances where increasingly skilled manpower is required, thus leading to an increasingly wider income gap between the skilled and the unskilled.

If this historical trend is replicated, then the gap between developed countries and the poorer countries will continue to widen, since the so-called convergence toward a standard of living similar to that of the industrialised countries has been applicable only to the newly industrialised countries of Asia (IMF)[1].

6 Situation and evolution of blocks

Three main blocks with different degrees of integration, are usually identified. The most structured and mature is undoubtedly the European Union. Presently this block applies a "reciprocity requirement" in is relations with outsiders. The other quasi-blocks are the South-East Asian, led by Japan and the Western Hemispheric one, by the USA. The power of the three is similar, leading for a three polar world in the XXI century, as the relative advantage of the USA is decreasing.

Considering a variety of factors Thurow-92 views the advantage of the European Union by the number and quality of its own market (850 million, including East European countries) as the one that will establish the rules of the game for the world in the next century. In his words "Brussels will become the new Bretton Woods". Under such premise, in the political arena, a "communitary capitalism" European style will

---

[1] In the bottom fifth, in terms of income, over the last 30 years, the number of poor countries have increased from 52 to 82. During this same period, the countries of Africa have reduced their income from 14% to 7%, compared to industrialised countries.

extend through the planet. This brand of capitalism is milder than the Anglo-Saxon version, incorporating organisative components to the market economy.

7 The Western Hemisphere block

The Western Hemisphere is not yet a block, but a collection of subregional common markets (MERCOSUR, Andean, Central American, CARICOM, 3 (Mexico-Colombia-Venezuela), NAFTA, etc.) These common markets promote trade and “open subregional” integration. Such integration aims to increase interdependencies, solidarity and competitiveness.

In practice however, due to the political and economic weight of the USA, it becomes an influence zone, where the USA sets the game rules for trade. This applies through explicit and de facto mechanisms. Among the first are multilateral and bilateral agreements and outstandingly, the NAFTA. Among the others are “commercial sanctions” mentioned, and the subtle yet powerful influence on multilateral organisations (IMF, WB, IADB, etc.).

These institutions have enlarged their agendas, monitoring macroeconomics and country periodical evaluations that influence decisively the financial flows. Recently, they are widening the scope of their conditions for loans, with subjects such as government quality and equity of social expenditures.

There were great expectations for the geographic expansion of the NAFTA treaty, particularly for a fast incorporation of Chile. Internal politics in the USA have slowed that process. The unions, in that country, are frightened for supposed job exports to Mexico in the short experience of the treaty. Their influence in the US congress delayed indefinitely approval of the “fast track”, that simplified negotiations of new similar treaties in the hemisphere.

The fast development of MERCOSUR, the success of Chilean exports and the renewed interest of the European Union and Japan to intensify relations with Latin-America have decreased the priority of NAFTA for the Southern partners. Japan views the higher endowment of natural resources in Latin America, as compared to Southeast Asia, and the political and economic maturation of the region, as important factors in the design of its international trade plans for the next decade.

Thus, for the next coming years, in absence of a mayor crisis, it is expected a rapid and continuos growth of the trade inside and among the multiple common markets, and a less rapid progress in their integration. This trends will consolidate their economies, attracting renewed interest from the European Union and Japan, to establish special trade agreements, both to profit from the consumer markets and particularly to supply the technology demands of the manufacturing and services sectors, that are expected to grow significantly.

The learning experience of the USA with NAFTA will partially dissipate fears of potential losses for its labour market. Also, the mentioned competition of other blocks, to capture the Latin-American markets, will stimulate the USA to negotiate new and more balanced trade agreements for the hemisphere.

All such progress in the hemispheric trade, will strengthen all economies involved, and given other factors, might put them in a new track for development. Progress however will not be fast nor easy.

8 World Trade Organisation

The interest of developed countries in augmenting their international trade led them to transform the GATT[2] into the World Trade Organisation (WTO) in order to regulate the international trade of goods and services (and foster trade liberalisation), capital movements, and intellectual property.

The World Trade Organisation has been qualified as a club of wealthy countries that are striving to ensure that quality and competitiveness become the ground rules for trade. In general, the advantages of eliminating or reducing taxes as applied by developed countries for the imports of developing countries is leading to a reduction amounting to 9% to 5% of all exports with customs duties of over 15%.

In the WTO, the fact that countries are obliged to dismantle the taxes and customs on the products they import is considered to be an advantage, in contrast to bilateral agreements or agreements that can be made with groups of countries, where once the term of agreement has concluded conditions may or may not be renewed. This is the case for the preference granted to the exports of Ecuadorian shrimp by the European Union. This mandatory rule considerably reduces the uncertainty attached to future profits and enables long-term objectives to be outlined for investments aimed at export products.

Environmental aspects have not been neglected in the negotiations within the WTO, and the need to incorporate into international prices those costs stemming from environmental management and the deterioration of nature, as well as to finance technological innovation to save energy and reduce pollution, is also mentioned. This objective is not so easily reached in practice, owing to the ineffectiveness of controls and the difficult of quantifying these costs and above all the eagerness to capture market niches on the basis of competitive prices. One example is the international trade of fine wood coming from primary tropical forests, for which there are no explicit requirements to replenish the resource. For international trade, however, certain quality conditions have to be complied with for given products, especially food products, such as the absence of chemicals that might affect health and also the growing preference for the use of biodegradable products in order to reduce waste elimination problems in the importing countries.

Nevertheless, protectionist measures continue to be applied to domestic production aimed at the export market; for example, the European Union's proposal to reduce subsidies to exports and domestic agricultural and livestock production is generating much resistance domestically in the member countries and it will be difficult to ensure abatement of this subsidy. In addition, there are other non-tariff restrictions such as managed trade[3] and compliance with stringent standards governing origin, sanitary conditions, and technical requirements which in practice will be limiting the possibilities of the export of products coming from developing countries[4].

Industrialised countries have considerably lowered their customs duties to imports of both manufactured products and agricultural products, which will lead to greater opportunities for trade with these countries. Thus, the customs duties on

---

2 General Agreement on Tariffs and Trade.

3 Meaning the subscription of bilateral agreements establishing quotas for the trade of certain products.

4 These practices are referred to as neoprotectionism.

industrialised products have declined from 6.3% to 3.8% and those for farm products by 37%. Tropical products are benefiting from a 43% reduction; this category includes traditional products exported by Ecuador such as coffee, cacao, oil seeds, fats, and oils. Wood, furniture, and paper imports have also benefited from tax cuts ranging from 4.6% to 1.7%, which means that there is a better chance for Ecuador to trade the first two products, a situation which can be taken advantage of as long as environmental sustainability conditions are guaranteed.

Regarding the WTO and world trade for the agricultural and livestock sector[5], which displays severe distortions, non-customs duties measures are being replaced by customs duties that will have to be gradually pared over a ten-year period for the developing countries[6], including Ecuador. Owing to the sensitivity of this sector[7], the Andean Price Band System is being applied; it involves variable customs duties for 136 products, which on the one hand require protection and, on the other hand domestic price stability, which therefore implies a "special treatment." This system will remain in force for seven years, during which time the country will have to ensure the efficiency of its agricultural and livestock sector so that it can compete with imported products. On the other hand, Ecuador consolidated its nonsensitive agricultural products, with 10 points over and above the Common External Custom Duty. In addition, it will have to comply with sanitary and phytosanitary measures.

9 Oil market

In view of the importance of oil in the Ecuadorian economy, it is advisable to outline the general characteristics of the oil market that will eventually prevail. It is expected that there are no prospects for a major increase in oil and gas prices on the international market, and therefore oil export earnings for Ecuador are not expected to rise, at least not in terms of prices, although earnings may rise as a result of production increases and higher shares of production aimed at the export market.

The elements used to substantiate this estimate, according to the International Monetary Fund's analysis[8], are as follows:

- On the supply side, world oil reserves, according to the concept of definitive recovery, which includes remaining oil and the oil whose production is economically justified, are estimated to be between 1.4 trillion and 2.1 trillion barrels, which yields a reserves / production ratio of 65 years. The increase in reserves will be coming largely from the North Sea and Latin America, although the reserves of the Middle East continue to be the most important (65% of world total in 1990). The breakthroughs in technological processes have contributed to reducing extraction costs and therefore have broadened economically exploitable reserves.
- On the demand side, since the early eighties, the world's oil demand structure has changed, with the growing importance of the share of the newly

---

[5] Espinosa Cañizarez, Christian, "Importance of WTO Agriculture Agreement for Ecuador", in *Ecuador and WTO*, Central Bank of Ecuador. 1996.

[6] 36% for the developed countries and 24% for the developing countries, op. cit.

[7] Owing to the proportion of the population involved in this activity and the sector's share of GDP, op. cit.

[8] International Monetary Fund, Economic and Financial Studies, *World Economic Outlook*, October 1996.

industrialised countries of Southeast Asia, whose oil and gas consumption has grown more rapidly than that of industrialised countries. Meanwhile, the Eastern European countries, especially Russia and other countries of the former Soviet Union, have reduced their consumption, as a result of the economic recessions and the hike in real prices. The Latin America countries have shown, since 1990, more constant growth, in contrast to the African countries whose growth is scarce. Until the year 2000, an 2% annual growth rate of oil demand is being forecast; this average is calculated by taking into account the decline in consumption of the industrialised countries (1% per year), the low growth in the countries of the former Soviet Union, in contrast to the high growth of consumption in China and the newly industrialised countries of Asia (estimated rate of 5%). The countries of Latin America, the Middle East, and Africa are expected to register a growth of between 2.2% and 2.5%.

- The growth rate for oil demand is being influenced by greater efficiency in the use of energy, especially in the developed countries and by a substitution of thermoelectric generation for hydropower generation, as well as the increasingly widespread use of natural gas for electric power generation. In addition, pressures for environmental control will be encouraging, over the longer term, the substitution of fossil fuels.

Socioeconomic Analysis and Macroeconomic Scenario

1 Evolution and principal characteristics of the Ecuadorian economy

1.1 Overview of GDP[9] evolution

The high rates of growth of the Ecuadorian economy, recorded during the oil boom, beginning in 1972[10], did not return during the eighties and nineties, as indicated in the following tables and figures. As a rule, it has been the oil sector that has been sustaining high GDP growth rates and the driving force behind the manufacturing sector up until 1981[11], as a result of the protectionist policies that favoured application of the import substitution model that turned out to be unsustainable.

During the period 1986-1997, GDP growth was highly uneven, with rates fluctuating between 2% and 5%[12], as displayed in Table 1. The highest growth of this decade was based mostly on the impetus of the agricultural and livestock sector and the oil sector, as well as the exceptional growth of the financial sector, which, although accounting for a small share of the GDP structure, is a driving force behind production activities which have benefited from modernisation efforts as a result of the incorporation of computer technology which has improved productivity.

Average GDP growth is even lower than for the eighties as a whole than for the period 1986-1997 (1.8% compared to 2.7%), with notable stagnation in the manufacturing, trade, and transportation sectors, confirming the appropriateness of the term “lost decade.”

Total GDP growth rates over the last decade have been insufficient to foster per capita GDP growth, which between 1987 and 1997, grew by a total of scarcely 4.7%, equivalent to 0.41% per year for that period. On the basis of these figures, it is estimated that, for per capita GDP to grow by 50%, total GDP must grow steadily at a rate of about 6%[13] per year for a ten-year period, similar to the average growth of the

---

9 The analysis of growth rates and structures is made on the basis of constant sucres. The dollar figures are presented only for illustration. Constant dollar figures are not used because they reflect international inflation only. Real exchange rates were not calculated. In the case of Ecuadorian economy, inflation rates have been higher than devaluation rates.

10 It is important to mention that the highest growth rate of Ecuador’s history occurred in 1973, that is, 25.3%, as a result of the insertion of the oil sector into the country’s economy. As of 1976, GDP growth began to decline.

11 The industrial recorded rates of more than 8% from 1973 to 1981.

12 Without taking into account 1988, when the GDP growth amounted to 10%, as a result of the recovery following the 1987 earthquake.

13 According the United Nations forecasts, population growth rates will be 2.09% up to the year 2000, 1.64% between 2000 and 2010, and will decline further up to the year 2025 at 1.18% per year.

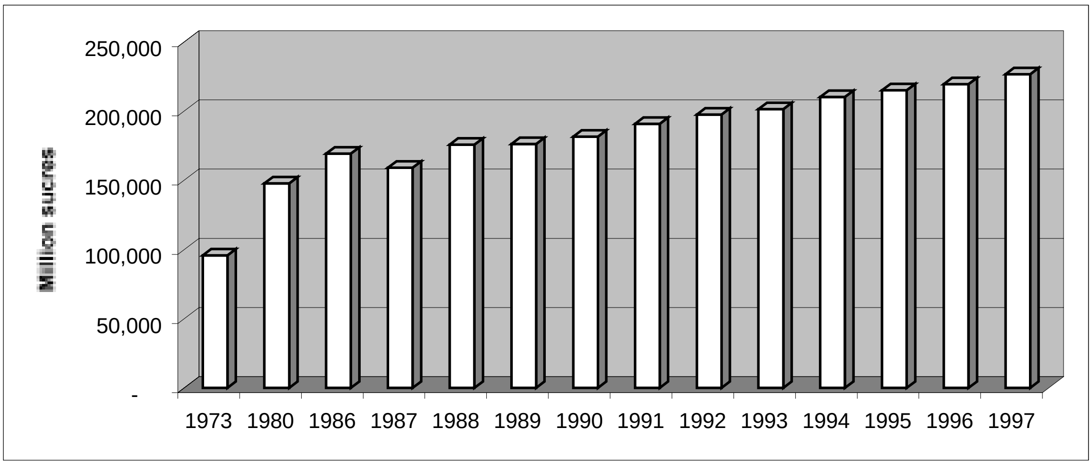
period from 1973 to 1980, during which time the determining factor was the growth of the oil sector. This scenario, however, is considered highly unlikely.

Table 1 GDP evolution
(Million constant sucres of 1975 and growth rates)

	1973	1980	1986	1990	1991	1992	1993	1994	1995	1996	1997
Constant Sucres	95.867	147.622	169.136	181.531	190.638	197.436	201.447	210.150	215.074	219.342	226.654
Growth rates	25.3%	4.9%	3.1%	3.0%	5.0%	3.6%	2.0%	4.3%	2.3%	2.0%	3.3%

Source: Banco Central del Ecuador. National Accounts.

Figure 1 GDP evolution
(Million constant sucres of 1975)



Although the instability of the economy is partially due to the country's vulnerability to external factors such as oil prices and adverse weather conditions, it is also due to the application of stopgap policies aimed at resolving transitory situations without any long-term approach, in other words, a State policy restricted to proposing and implementing a process that can be qualified as one of reform followed by conflict and then by setbacks or regression. This recurrent scheme of reform-conflict-regression is due to political conflicts fostered by unstable and fragmented political parties[14]. This instability has exerted negative pressure on the country's economic history. As a result the country has been qualified, somewhat simplistically, as a high-risk country, one that discourages investment or requires higher level of earnings to ensure adequate risk coverage.

In terms of the physical space of the economy, the country is characterised by the prevalence of regional and local interests and the lack of consensus in the entrepreneurial and business class, which has failed to provide long-term solutions to the problem and, on the contrary, has promoted conditions for the creation of powerful oligopolies that control the market.

---

[14] Larrea, Carlos, *Economía y Humanismo*, Economic Research Institute of the Pontifical Catholic University of Ecuador, Quito, page 77.

1.2 GDP structure

As for the GDP structure, on the demand side, as indicated in Table 2, a factor that deserves special attention is the low investment rate in the economy during the period 1986-1997, which is around 14%. During the period 1974-1982, the investment rate was over 20%, but in 1983, as a result of the debt crisis, the rate started declining and as yet shows no sign of recovery.

Table 2 GDP rates
(Percentages obtained in terms of constant values of 1975)

Variables/years	1973	1980	1986	1990	1991	1992	1993	1994	1995	1996	1997
GDP *	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
a. Final Consumption	69.6	83.5	78.2	79.1	76.7	75.2	75.1	73.8	73.7	73.4	72.6
b. Gross Fixed Capital Formation	16.6	23.7	15.2	13.2	14	14.4	14.3	14.3	14.7	14.7	14.9
c. Stock Variations	1.9	2.8	1.8	-0.3	2.0	0.8	0.1	0.3	0.8	-1.2	0.7
d. Exports	33.8	20.9	25.4	28.2	29.6	31.4	32.0	33.4	34.2	34.7	34.8
e. Imports	21.9	30.9	20.6	20.2	22.3	21.8	21.5	21.8	23.4	21.6	23.2
f. Opening degree of the Economy	55.7	51.8	46	48.4	51.9	53.2	53.5	55.2	57.6	56.4	57.1

* GDP=a+b+c+d-e, f=d+e
Source: Banco Central del Ecuador. National Accounts.

The economic history of countries indicates that the accumulation of capital is an indispensable condition for growth[15], especially in the early development phase, which is Ecuador's present stage of development, in contrast to industrialised countries. In the latter countries, because of their high degree of development, although the accumulation of capital is still an important factor, technology and the development of production becomes the determining factor for growth.

In addition, under the item gross fixed capital formation (GFCF) and consumption, the participation of public investment has declined as a result of the lack of state resources. Thus, in 1990 the consumption of public administration accounted for 11.8% of GDP, and it is expected that there will be decline of 8.5% for 1998, with a downward trend expected for the future. Public investment has declined from 2.9% of GDP in 1990 to an expected 2.2% for 1998.

Regarding the origin of the GFCF, it is noteworthy how, throughout the decade, the national component has been declining in importance and giving way to an imported component; as a result of this, the need for foreign currency to import capital goods is increasingly greater. Thus, for example, in 1990 the imported component of GFCF amounted to 36% and increased to 51% in 1995.

It is also relevant that, with the elimination of the anti-export bias and protectionist legislation starting in 1990, the evolution of the share of exports in GDP has shown a gradual shift of the economy toward foreign markets. With the liberalisation of the economy, the same can be observed for imports.

Regarding the impetus of GDP components, it is noteworthy that, in almost all the years considered, exports grew much more than GDP. Nevertheless, this upward

---

15 For the countries that have become newly industrialised, the investment rate is around 30%.

evolution has slowed down over the last three years. In addition, the final consumption of households has remained within growth ranges no greater than 2.7%, whereas consumption of public administration has become restricted, as a result of downsizing of the State and attempts to rationalise public spending in compliance with agreements subscribed with international organisations.

Average indicators per inhabitant, both for final consumption of households and capital accumulation, declined during the period 1986-1997, which would indicate that the economy is generating enough resources to maintain at least the same levels of consumption. The decline in consumption has been steeper for the lower-income population groups as a result of uneven income distribution. Investment growth is also lower than population growth, which means that new investment requirements will not be met, especially those to meet social needs. Alongside this, there is a higher concentration of income and deterioration in the employment rate.

1.3 External sector

The Ecuadorian economy is highly vulnerable to whatever happens abroad[16]. In keeping with the outward growth policy that has been applied over the last few years, the openness of the economy has recovered since 1990, growing from 48.4% in 1990 to 57.1% in 1997[17], and it is estimated that it will be 59% in 1998. Nevertheless, trade liberalisation is far from complete[18].

A recurring problem in the Ecuadorian economy is the negative current account balance (Table 3)[19], which has not been offset by a positive balance of trade, which is insufficient to cover the services and revenues deficit, stemming from the large share of public outlays used to pay the interest on medium- and long-term foreign debt[20].

Table 3 Balance of payments 1986-1996
Million U.S. dollars (of each year)

Concept	1980	1986	1990	1991	1992	1993	1994	1995	1996	1997
Current Account Balance	-642	-582	-360	-708	-122	-678	-681	-735	111	-743
Trade Balance	278	557	1009	643	1018	592	561	354	1220	598
Capital Balance	874	311	760	865	144	1150	1150	580	163	1005
Service Balance	-950	-1184	-1476	-1461	-1260	-1400	-1400	-1320	-1399	-732

Source: Banco Central, Statistics Information. August 1997.

The net positive capital earnings, which would be financing the current account deficit, involve mainly foreign debt flows and, to a lesser extent, direct foreign investment,

16 León, Patricio, "El Comercio Exterior Ecuatoriano: Una Trayectoria Incompleta", in *El Ecuador Frente a la OMC*, Central Bank of Ecuador, 1996, page 16.

17 Exports plus imports / GDP ratio.

18 León, Patricio, "El Comercio Exterior Ecuatoriano: Una Trayectoria Incompleta", in *El Ecuador Frente a la OMC*, Central Bank of Ecuador, 1996, page 16.

19 The year 1996 is an exception, as it recorded a positive balance of US$293 million, which contributed to increase the country's monetary reserve.

20 In 1996, the payments for services received amounted to US$2.33 billion, of which US$907 million correspond to medium-term and long-term foreign debt, the value around which this item has fluctuated through the last decade.

which although increasing since 1993 has remained between US$470 million and US$530 million, which is considered insufficient to meet the country's investment needs.

1.3.1 Exports

The growth of exports is by far greater than GDP growth rates, although unfavourable international trade price terms have persisted[21]. Thus, during the period 1986-1997, export and GDP growth rates amounted to 5.7% and 2.7%, respectively, whereas as of 1990 this difference sharpened, amounting to 6.4% for exports compared to an annual average of 3.2% for GDP.

On the basis of this information, total country exports in terms of current dollars have grown 2.2 times between 1987 and 1996[22], with oil exports growing 1.78 times[23] and non-oil exports growing 1.89 times. The so-called non-traditional exports merit special attention since their value has grown from US$150,500,000 in 1986 to US$1,104,200,000 in 1996[24], which has enabled them to account for a substantial share of total exports, 22% compared to 6.8% in 1986. This upward trend is continuing[25] but it does not as yet include an important share of exports of industrialised products, since most sales abroad are primary products, a trend which is not likely to change in the future.

It is important to emphasise the decline in relative importance of oil exports as a share of total exports. They reached a peak of 52% of total in 1990 and have been declining since then, down to 34% in 1994 and 36.5% in 1996. This has turned out to be positive for the economy, since it means a lesser dependence on oil and gas exports and has given impetus to other activities aimed at the export market, especially the agricultural and fishing sectors.

As for the geographical distribution of exports, it is noteworthy that, although the United States continues to be the most important market for Ecuadorian products, there is a clear trend toward reducing this share over time. Thus, in 1986, the United States accounted for about 60% of total and, in 1996, for close to 38%, as a result of the rapid expansion toward European markets, sales to which have grown fivefold[26], whereas sales to the North American market has grown by only 39% over this same period. This trend toward the European market is highly promising for Ecuadorian exports.

As an indicator of the degree of integration with the other economies of the region, Ecuadorian trade with the countries of the Latin American Integration Association (ALADI) has also gained importance, rising from 11% to 17.5% between 1986 and 1996,

---

21 Measured by the relationship between the export unit value index and the import unit value index. For 1996, it was 85.9, taking the year 1990 = 100 as the baseline. ECLAC, *Statistical Yearbook of Latin America and the Caribbean*, 1996 edition.

22 US$2,200,200,000 to US$4,859,700,000.

23 In 1986, a lower value for oil exports was recorded owing to the drop in international oil prices.

24 Traditional products: bananas, coffee, cacao, etc.; nontraditional products: flowers, vegetables, etc.

25 On the basis of information from January-July 1997, nontraditional exports accounted for 20.9% of total exports during this period.

26 These grew from US$207.7 million in 1986 to US$1,096,200,000 in 1996. The principal market for Ecuadorian banana exports is the European Union, which between 1990 and 1996 has grown by 11% per year in terms of volume. Ecuador is currently meeting 28% of this market's export needs and it plans to enlarge this share to 32%.

Chile being the country that accounts for the highest amount of trade within this group, that is, 25% of exports, without taking into account Colombia. In addition, exports to the Andean Community has grown from US$42.9 million in 1986 to US$430.8 million in 1996, with prospects for further growth[27]. Regarding these exports, the Colombian market is the largest, accounting for up to 72% in 1996 of all exports aimed at the subregion. It is expected that the relative share of these exports will decline as exports to Peru increase[28].

1.3.2 Imports

The production infrastructure is still highly dependent on foreign imports, as indicated by the high percentage of the external purchases of raw materials plus capital goods in total imports. This ratio is no lower than 74% and has risen to more than 85%[29] during the period being reviewed. In terms of raw materials, the most significant items are those aimed at the industrial sector, in ranges higher than 70%; likewise capital goods aimed at the industrial sector account for percentages of about 60%, an important component also being transportation equipment and, in a negligible proportion, equipment aimed at the agricultural sector[30]. Regarding this, although it is certain that protection to industry has declined, the low customs duties for inputs, machinery, and equipment help to maintain a certain effective protection.

Throughout the period, the growth of imports of durable and nondurable goods is noteworthy, since they have grown five-fold (4.8 times between 1986 and 1996), which has led to notable growth in the share of consumer goods overall, from 9.7% in 1986 to close to 22% in 1996, as a result of the decline of customs duties and the elimination of restrictions on the imports of certain goods. This has meant considerable competition for national industries.

The imports of oil products, although they have not increased systematically their share of total imports, which has been quite volatile between 1986 and 1996, are registering a growth of more than 40% owing to the insufficiency of refining infrastructure to meet domestic market needs for aviation fuel and diesel.

The dependence on imports coming from the United States is estimated to be at about 30% of total, similar to the proportion of goods coming from the member countries of the ALADI, with trade with Brazil and Mexico being the most important, whereas purchases from the Andean Subregion[31] account for between 16% and 18% of total imports, of which more than half is from Colombia, a country with which Ecuador has an unfavourable trade balance, in view of the Colombia's industrial development and the facilities that are available for introducing merchandise from this country.

---

27 According to statistics for January-July 1997, the Andean Group would be exporting in 1997 a value of more than US$700 million.

28 This has already actually occurred in the period from January to July 1997.

29 Between 1988 and 1991.

30 They account for no more than 3% of total imports of capital goods and transportation equipment in 1996, which similar characteristics throughout the period.

31 Included in ALADI.

1.4 External debt

The debt crisis developed between 1983 and 1992, after which period the Brady Plan was implemented. The magnitude of Ecuador's external debt has become a major factor undermining the country's growth. It has exerted a negative impact on its import and export capacity and has required major allocations of resources for the payment of interests and capital amortisation to the detriment of investments.

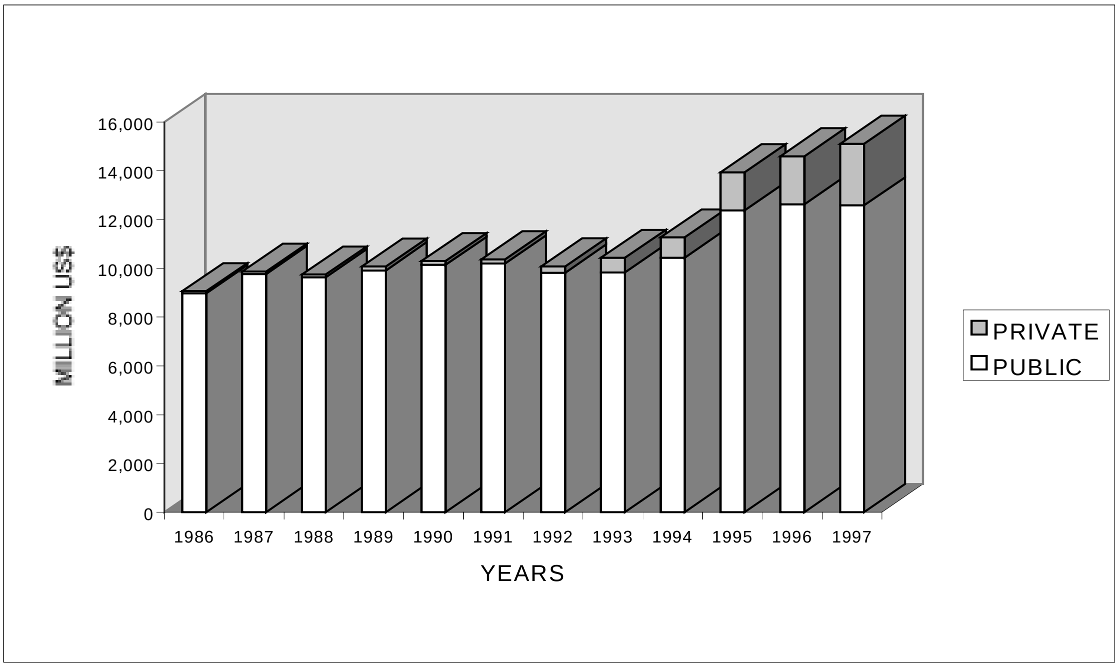
By 1996, the country was able to reduce its external debt-GDP ratio to 76% but high indebtedness persists owing to the country's need for capital to finance its current account balance or its infrastructure. It should be emphasised, however, that during the decade being examined and especially over the last few years, the private sector's foreign debt has grown rapidly, having multiplied 22-fold between 1986 and 1996 owing to the relative facility of obtaining financing from abroad and the relative confidence that there will be no major currency devaluations.

Table 4 Evolution of the external debt
(Million of US$ of each year, balance at end of year)

Year	Public	Private	Total	Debt/GDP
1986	8,977.5	85.2	9,062.7	86%
1987	9,760.3	98.0	9,858.3	104%
1988	9,630.7	119.3	9,750.0	107%
1989	9,918.5	158.2	10,076.7	104%
1990	10,134.6	163.5	10,298.1	97%
1991	10,201.4	165.9	10,367.3	90%
1992	9,823.9	254.8	10,078.7	81%
1993	9,830.3	602.7	10,433.0	72%
1994	10,440.4	828.4	11,268.8	67%
1995	12,378.9	1,555.1	13,934.0	77%
1996	12,627.9	1,958.2	14,586.1	76%
1997	12,579.1	2,520.1	15,099.2	75%

Source: Central Bank of Ecuador.

Figure 2 Evolution of external debt



In order to figure out what proportion of oil exports accounted for the payment of capital and interest of the external debt, suffice it to say that, between 1986 and 1988, this payment was greater then oil exports, where in 1996, the debt payment was equivalent to about 60% of oil exports.

Table 5 Payment of amortisation and interest of public debt
(Million U.S. dollars of each year)

Year	Disbursements	Amort.+interest payments	Amort.+int. / oil exports
1986	1234.6	1143.7	114.7%
1987	1113.9	950.6	131.3%
1988	925.7	1423.7	144.1%
1989	949.1	1138.3	99.2%
1990	575.5	1255.8	88.5%
1991	747.9	1253.1	108.8%
1992	500.0	1298.9	96.5%
1993	482.0	865.2	68.8%
1994	688.1	934.0	71.6%
1995	1064.4	1262.2	80.9%
1996	1010.3	1111.0	62.5%

Source: Central Bank of Ecuador

Concerning Central Government revenues, between 20% and over 50% of these revenues during this period were used for paying foreign debt obligations, although the proportion of revenues aimed at paying the debt has tended to decline over recent years, except for 1995; in any case, foreign debt payments continue to be slightly less than public spending for health and education combined.

1.5 Public situation

1.5.1 Income

The dependence of the nonfinancial public sector (NFPS)[32] on revenues from oil activities continues to be substantial, even though in 1995 and 1996 a decline was apparent. In 1985, these revenues accounted for 50% and in 1995 for 29%. Comparing NFPS revenues with GDP, it is interesting to note that, as of 1992, the importance of revenues coming from crude oil exports declined, giving way to revenues generated from the domestic sale of oil products, as a result of the elimination of fuel subsidies, except for LPG.

Regarding revenues coming from crude oil exports, the State has very little margin for manoeuvring, since these revenues are determined by external factors such as demand and international prices, on the one hand, and the availability of oil and gas resources and domestic demand, on the other hand.

[32] Comprised of the Central Government, Nonfinancial Public Enterprises, and Rest of General Government, which includes the Ecuadorian Social Security Institute, the State Bank, Sectional Governments, Universities, Office of the Attorney General, and other entities of lesser importance. In 1995, the relative importance of these subsectors was 56%, 23%, and 21%, respectively.

Table 6 Ratio of oil revenues of the nonfinancial public sector to GDP

Year	Oil revenues			Other revenues
	Exports	Domestic sales of oil products	Total	
1986	7.6%	0.8%	8.4%	13.8%
1987	4.9%	1.1%	6.0%	14.3%
1988	6.3%	1.4%	7.7%	12.8%
1989	7.8%	1.7%	9.5%	14.6%
1990	9.7%	1.9%	11.6%	13.0%
1991	7.2%	1.7%	8.9%	13.7%
1992	7.9%	1.7%	9.6%	13.1%
1993	5.7%	2.9%	8.6%	13.6%
1994	3.9%	3.3%	7.2%	14.0%
1995	4.0%	3.6%	7.6%	15.1%
1996	4.3%	3.9%	8.2%	13.6%

Source: Central Bank of Ecuador

Without underestimating the efforts made to increase revenues coming from the value-added tax and income tax collection[33], it is apparent that these revenues are not enough to substitute the earnings generated by oil activities. Indeed, it would be a very complex matter to find another activity that would be able to substitute oil and gas activities as a source of revenue[34] for the State.

1.5.2 Public spending and deficit

The current and capital expenditures plus budget spending for paying the interest and capital of foreign and domestic debt are currently higher than revenues. This has led to a public deficit that has been covered partially by greater domestic and foreign indebtedness[35], leading to debt balances that have remained virtually unchanged. In addition, outlays are displaying higher volatility than revenues with respect to GDP[36], since they vary depending on needs and increase as a result of inflation, exchange rate changes, etc., to a greater extent than the latter, which show a certain rigidity to meet the demand for current and capital expenditure financing.

The payment of interests and amortisation for domestic and foreign debt absorbs between 39%[37] and 55% of total expenditures and investment, with the remaining amounts left to be distributed in education, health, agricultural and livestock

---

33 Nevertheless, Ecuador continues to be one of the countries in which the share of income tax in GDP is one of the lowest, namely 1.9%. Owing to foreign trade liberalisation, taxes on imports have declined by about 50% over the last decade.

34 Difference between the cost of production and the price.

35 Thus, for example, in 1995 and 1996, the difference between outlays and current and capital income for the General Budget of the State, plus amortisation and interest payment obligations, amounted to almost 3 trillion sucres, more than 60% of which was covered by internal and external disbursements. In 1996, this difference increased to 5.4 trillion sucres, 70% of which was covered by internal and external disbursements.

36 Measured by the standard deviation during the period 1987-1996, which resulted in an index of 3.06 for expenditures and 1.15 for income.

37 Proposed Budget Pro Forma for 1998.

development, transport and communications, and other spending, which turns out to be totally insufficient with respect to unmet needs. The postponement of investments in the area of health and education jeopardises the formation of human capital that is needed for any development process.

1.6 Sector analysis

The following tables provide a sector structure of GDP and the growth rates of the major sectors of the economy for some years. From Table 7 we can observe the drastic reduction of importance of oil sector in the economy since the petroleum boom and the recuperation of agriculture, forestry and fishing, due mainly to the production oriented to the external market.

Table 7 Sectoral structure of GDP

Years	1973	1980	1986	1990	1997
Agric., forest., fish.	18.1%	14.4%	15.8%	17.7%	17.6%
Petroleum	19.4%	10.2%	13.8%	11.8%	14.2%
Industry	14.1%	18.2%	16.7%	15.5%	15.5%
Commerce	14.3%	16.8%	14.7%	15.1%	14.9%
Transport	5.0%	6.8%	6.0%	6.2%	6.2%
Financial sector	9.9%	12.0%	2.7%	2.4%	3.9%
Electricity	0.7%	0.8%	1.3%	1.5%	1.4%
Others	18.6%	20.9%	29.1%	29.9%	26.5%
GDP	100.0%	100.0%	100.0%	100.0%	100.0%

Source: Central Bank of Ecuador

Table 8 Average growth rates by sector

Sectors	1973-1980	1980-1989	1986-1997	1990-1997
Agric.,forest., fish.	2.9%	4.0%	3.7%	3.1%
Petroleum	-2.9%	3.3%	3.0%	6.0%
Industry	10.3%	0.4%	2.0%	3.2%
Commerce	8.9%	0.7%	2.9%	3.0%
Transport	11.2%	1.1%	3.0%	3.2%
Financial sector	9.3%	-14.9%	6.0%	10.8%
Electricity	8.2%	11.2%	3.1%	1.6%
Others	8.2%	6.3%	1.8%	1.5%
GDP	6.4%	2.0%	2.7%	3.2%

Source: Central Bank of Ecuador

1.6.1 Energy-economy ratio

The importance of the energy sector for the Ecuadorian economy lies in the fact that, on the one hand, the oil sector (crude oil and refining) accounts for a major share of GDP, and that, on the other hand, there are important technological and economic links between the energy sector and all the other sectors of the economy[38].

[38] The so-called forward effect of the oil sector amounted to 53,766 in 1995, which was surpassed only by the chemical products and basic minerals.

Ecuador's economy continues to be closely tied to the destiny of the oil sector since the share of crude oil and natural gas, along with refining, as of 1992, has remained stable at about 14% of GDP, in contrast to its share of about 20% at the start of oil production. Regarding the other production sectors, the oil and gas sector ranks third, in terms of magnitude, after the agricultural, hunting, and fishing sector (17%) and the manufacturing sector (about 15%).

The impact of the oil sector on the economy is decisive, especially because of its involvement in the external sector: the flow of foreign currency since the oil boom has accounted for 50% of all the country's export sales, as confirmed by the fact that the price of oil is a benchmark variable for setting up the State's General Budget.

The structure of public revenues coming from the oil sector, where oil export earnings are differentiated from earnings stemming from the domestic sale of oil products, has changed over the last few years. In 1986, oil earnings, which accounted for 36% of total NFPS public revenues, involved 31% from exports and 3% from the domestic sale of oil products. By 1986, this distribution had evolved so that oil revenues, which accounted for 29% of total public revenues that year, could be broken down as follows: 16% from exports and 14% from the domestic sale of products. This change is due to significant increases in the prices of oil products, as a result of the elimination of subsidies (except for LPG) and the marginal increase in consumption.

Regarding the electric power subsector, its importance resides in its linkage with almost all sectors of the economy, since its share of GDP is insignificant and has remained relatively stable since 1988, at about 1.5% and 1.4%. The growth rate of the subsector in the seventies was more than 8% per year, whereas in the eighties it was 10% per year owing to the implementation of large hydropower projects, but the driving force that has sustained it has run the risk of disappearing over the last few years, owing to the shortages produced by the partial shutdown of the Paute hydropower station, the largest in the country, indicating low growth rates, from 3.1% during the period 1986-1997 and 1.8% between 1990 and 1997.

1.6.2 Agricultural and livestock sector

In Ecuador's production structure, the agriculture and livestock sector, along with cattle-raising, forestry, and fishing, has remained important, accounting for about 17% of GDP, with highly variable growth rates, owing to the sector's vulnerability to natural conditions. The sector's structure is quite heterogeneous, and those production activities aimed at export markets, which are far more dynamic and involve a business-type of managerial organisation, are very different from those activities aimed at the domestic market, which usually rely on traditional campesino schemes of production and are of the utmost importance because of their social impact, since the rural areas of the country are noteworthy for their extensive poverty[39].

[39] 25% of rural inhabitants are living in critical poverty whereas another 50% are considered to be living in relative poverty (sufficient income for food, but insufficient for meeting basic needs), in contrast to the urban areas where the respective percentages amount to 20%. In addition, in the rural area, the population has less access to education and health services. Morris D. Whitake, *Evaluación de las Reformas a las Políticas Agrícolas en el Ecuador*, Vol. 1, Institute of Agricultural and Livestock Strategies, 1996, page 50.

Since 1992, there have been substantial improvements in general macroeconomic policy[40], as well as specific policies that directly or indirectly affect the agricultural and livestock sector[41]. This has led to a certain amount of modernisation and improvement in competitiveness. First of all, these policies are attempting to eliminate the bias for price controls on agricultural goods which are detrimental to the rural sector, doing away with restrictions on agricultural exports, simplifying procedures for importing farming inputs, privatising the suppliers of farming inputs, reducing the reasons for land expropriation, and establishing norms regarding the transfer of water concessions with the sale of land.

Nevertheless, the agricultural and livestock sector faces problems involving the lack of price information, stocks, quality standards and producer associations, in addition to marketing systems that channel earnings not to the producer but to a series of intermediaries before reaching the final consumer. In addition, a sound irrigation and water management system continues to be critical despite institutional changes that have already taken place.

1.6.3 Mining

This sector continues to account for a negligible share of GDP, since it does not even amount to 1% (for that reason it was included as part of “Others” in Table 7. It is undergoing a crisis as a result of declining investments in exploration and production and low productivity of traditional mining methods, which are very widely applied. One of the reasons is the lack of liquidity of foreign companies due to the fall of prices of minerals on international markets, such as gold, and due to the lack of guarantees required by investors. Foreign investment for exploration is needed, since the mineral reserves available in the country are not sufficiently well known. Another factor contributing to this stagnation are the conflicts between traditional miners and ecological foundations, arising from the widespread failure to comply with the regulatory framework for mining exploration and production, which is causing considerable environmental damage. The zone with the highest potential is located in the southern part of the country, where there are large international companies extracting gold. Nevertheless, there are optimistic forecasts for mining production, especially gold, a mineral which generated earnings of about US$100 million in 1995, and it expected that by the year 2000 this figure will have doubled.

1.6.4 Manufacturing

Manufacturing in Ecuador showed high rates of growth during the period when the import substitution policy, which turned out to be unsustainable, was implemented. The country’s industrial production is mainly aimed at meeting domestic market demands, except for the textile industry, the motor vehicle industry, and some processed foods. The sector’s structure is dominated by the food and textile branches, which together accounted for between 53% and 61% of the sector over the last decade. Nevertheless, in terms of growth, the most dynamic are the industries involved in producing machinery and transportation equipment and material, which have displayed growth rates that are higher than the sector’s average, in contrast to food and textiles that have recorded modest growth rates, which may be due to the competition

---

40 “The subsidies and incentives inherent to the import substitution model fostered neglect of agricultural activities by marginalised farmers with a shortage of resources...”, op. cit., page 52.

41 Op. cit., pages 37-52.

with imported products. Annex 4 provides the structure of the industrial sector by branch and their respective growth rates.

As a result of import liberalisation, the Ecuadorian industry faces problems in terms of competitiveness owing to its financial weaknesses, the rising prices of raw materials and inputs due to the existing intermediation process, insufficient information on recent foreign technical standards, breakthroughs, and discoveries, deficiencies in management and conservation, and slight value added, as well as the lack of automation, testing laboratories, and the application of an adequate system of weights and measures (metrology)[42]. The prospects of national industry depend on expanding business with foreign markets, to which the most efficient industries can gain access if the above-mentioned conditions are improved and if there is interest in doing so.

2 Variables considered for establishing the baseline scenario

2.1 Matrix of impacts

In order to identify the factors that will be affecting the forecast of the economy's performance up until 2015, at first, the Impact Matrix methodology was applied. In this methodology, the relationships between an inter-related set of economic, social, political, resources, and infrastructure variables were established[43]. As a result, the so-called driving variables, which influence the performance of the other variables, were obtained, and their analysis is crucial for any forecasting that is carried out.

The driving variables that were identified were: structural adjustment, government priorities, external debt, exports, country's urbanisation, and the influence of powerful economic interest groups. The variables with a lesser driving force are competitiveness of the economy and the civil society.

2.1.1 ***Structural adjustment***

The adjustment has a high grade of incidence on the economy and society. Ecuador is applying adjustment policies involving the elimination of subsidies, downsizing of the State[44], and somewhat complicated attempts to impose constraints on public spending, as well as the delegation of energy and communications sector operations to the private sector[45] and greater flexibility in labour hiring.

Future prospects for this variable involve its consolidation along with an effort to improve tax revenue collection by reducing tax evasion, curtailing expenditures, and as a result controlling fiscal deficits, as well as reforms to the income tax system for both individuals

---

42 Luis Luna Osorio, page 308.

43 Mitigation Assessment: An Approach for Screening and Evaluating Options, Risø, 1996, page 30.

44 With funding from the World Bank, the MOSTA project is being implemented by the National Modernisation Council; it envisages a redefinition of the State’s role.

45 A recent amendment to the Constitution abolished the ban on selling the electric power and telecommunications sectors to the private sector and repealed the prohibition to eliminate the possibility of holding strikes in the basic services sectors such as health and education. Regarding upgrading of the tax system, a Law was recently passed to reform the institutional structure in charge of tax collection and to create an Internal Revenue Services, aimed at curtailing political intrusiveness, on the one hand, and increasing income tax revenue yields, on the other hand, thus reducing opportunities for corruption.

and companies. Stringent management of public resources will contribute to enhancing the country's credibility both domestically and abroad, thus leading to higher investment.

It is envisaged that the social cost of adjustment will be mitigated by using the revenues generated by privatisation funds[46] and, alongside this, it is expected that management of services such as health and education will be handed over to the private sector, which will not necessarily ensure that needed coverage will expand, and therefore the State will be unable to shirk its traditional responsibilities in these areas. It will be difficult to overcome current poverty levels in the medium term, although something will be achieved from the implementation of cost-efficient community projects.

In addition, it is expected that as part of the modernisation process, the privatisation of sectors such as electricity and telecommunications will facilitate higher investments and eliminate bottlenecks, which in turn will enhance growth. Regarding infrastructure, efforts are also being made to delegate management of the country's principal road network to the private sector and thus improve road conditions and ensure a more efficient transportation system. In addition, for those roads that are not profitable for the private sector because they do not involve sufficient traffic, it is expected that their maintenance will be privatised and road funds set up, in order to relieve the State from the total burden of financing roads. This can contribute to territorial integration and exert positive effects on production.

2.1.2 Government priorities

This driving variable involves objectives that the government intends to achieve by applying different policies, especially the definition of investment priorities. This variable turns out to be one of the major driving forces, and it can be asserted that, in Ecuador, it may well be an obstacle to realising the country’s growth potential, since these priorities are determined by powerful economic and political interest groups, which are preventing the establishment of a propitious environment for governability.

2.1.3 External debt

This is another important variable that is preventing the country from growing. Over the medium term, it is not expected that there will be any substantial reduction of foreign debt obligations, because the overall amount of the debt is declining very slowly while there is a demand for new resources through further indebtedness for new investments or to cover unforeseen expenses, in view of the high vulnerability of the economy and infrastructure[47].

2.1.4 Exports

Both oil exports and non-oil exports are performing a fundamental role in the economy, and it is expected that their share of GDP will be increasing as a result of policies implemented to promote the export sector and the enlargement of the range of exportable goods from both the agricultural and the industrial sectors, the latter by the installation, albeit modest, of a sweatshop scheme (manufacturing plants that assemble components

---

[46] Creation of the Solidarity Fund.

[47] One example is the financing needs for repairing and mitigating the severe damage caused by the El Niño phenomenon (alteration of Pacific Ocean currents), especially in the coastal region of Ecuador. Financial resources from international agencies will be channelled for this purposes and, in addition, more funds will be requested. In 1998, it is expected that the General Budget of the State will be using 39% of its allocations to pay the public debt.

imported tax-free for re-export, otherwise known in Spanish as *maquila*). The trickle-down effect produced by exports will contribute to providing impetus to the economy. Exports, while showing a considerable degree of driving force, are also highly dependent and are therefore considered to be a linkage variable, subject to compliance with exogenous conditions such as the evolution and performance of foreign prices and market and the success of the domestic policies being applied, financing, and competitiveness, among others.

2.1.5 Urbanisation

This factor also plays an important role as driving variable, but at the same time it is highly dependent on government policies, especially those involving the use of land, infrastructure, and population growth. The latter indicator shows a downward trend in the coming 20 years, almost zero for the rural area, which means that cities, especially the two poles of Quito and Guayaquil, will continue to grow, albeit at lower rates, as well as intermediate cities.

2.1.6 Powerful economic interest groups

These are the principal players controlling the means of production and exerting a decisive influence on political decision-making for their benefit and interests. There is little chance that, in the future, there will be major change in this prevailing scheme of income concentration, and as a result the continued strength of these groups is virtually guaranteed.

2.1.7 Energy policy

Its influence largely comes from the use of natural resources, land, and the environment, and it exerts major impacts on the economy as a whole, either directly or indirectly. The elimination of subsidies on energy consumption will contribute to a more efficient use of energy but privatisation of the electric power sector does not necessarily guarantee the application of saving policies. In addition, the enlargement of the trans-Ecuadorian oil pipeline will facilitate the transport of large volumes of crude oil, thus improving the generation of foreign currency coming from oil exports. As for the electric power policy, liberalisation of the sector for the inflow of private-sector capital will facilitate, over the medium term, the rise in power generation.

2.1.8 Infrastructure

The driving force of this variable is relatively high, as it is the basis for development. The participation of the private sector in infrastructure for public use will help to improve current conditions and will support expansion in terms of infrastructure, transportation, communications, sanitation, energy, etc.

2.1.9 Competitiveness

Although it is a factor with a lower driving force, the influence of this variable comes from the need to maintain and improve it for exports and the economic situation of the production branches, thus making it a determining variable for their success. It is estimated that the country's conditions for competitiveness are tending to improve, as production and management systems are improved to ensure efficiency in those production activities targeting the export market.

2.1.10 Civil society

This variable shows a low driving force and at the same time low dependence, since it has not as yet taken a leading role in economic and political decision making[48]. For the upcoming 20 years, progress is expected in the awareness raising of citizens regarding their role in demanding accountability from those wielding political and economic power and in general demanding improvements in the country's conditions of governability, and to do this institutional leadership is indispensable. Governability is understood as the State's capacity to govern, taking into account the fact "the problems hampering national development are essentially political and as long as they are not resolved, the country will have trouble ensuring sustainable economic growth, much less achieve an equitable social distribution of the benefits of this development"[49] even when the application of economic policy complies with the indispensable requirement of being "rational, planned, transparent, credible, predictable, as well as legitimate and with limited discretionality."

2.1.11 Investment

This variable shows a high degree of dependence since it is influenced by many factors such as interest rate, credibility, and predictability in economic policy, political stability, and maintenance of clear regulations for private-sector involvement in public service delivery. It is expected that the investment rate of the economy will improve but is highly unlikely that it will reach the same levels as the seventies and early eighties.

2.2 Domestic factors being considered for the baseline scenario

Regarding Ecuador, although its poverty is not as extreme as that found in many African countries[50], it is necessary to establish a series of conditions so that the country can achieve growth rates that are considerably higher than historical rates. Because of this, the scenario has assumed a growth rate which, although higher than the historical rate, continues to be quite modest, namely, 4.5%[51].

2.2.1 Demographic context

According to the forecasting conducted on the basis of the last three Population and Household Censuses (1974, 1982, and 1990), Ecuador in 1995 had 10,524,000 inhabitants, of whom 60% were located in urban areas and the remaining 40% in the rural area or undefined zones. This population was comprised of a total of 2,177,000 households, with close to 61% located in the urban subsector and 39% in the rural area.

---

48 "The representatives of social movements did not attract sufficient support from the people during the last elections held to choose representatives at the National Assembly that was set up to amend the Constitution. The results of these elections gave support mainly to the political parties, despite the distrust displayed by public opinion in these parties owing to the wide gap between the "wishes of the citizens and the actions of politicians". Forrest D. Colburn, in *Ecuador: Un Problema de Gobernablidad. Armonización de Reformas Económicas con Reformas Políticas*, CORDES, UNDP, October 1996, page 82.

49 Osvaldo Hurtado, "Presentación", in *Ecuador: Un Problema de Gobernabilidad*, op. cit.

50 Nevertheless, in terms of per capita income growth, it is among the lowest, along with Cameroon and Zambia. IMF, op. cit.

51 The Central Bank has estimated an average growth rate of 4.35% per year between 1997 and 2012, with a rate starting at 3.3% in 1997 and reaching a peak of 5% in the year 2001 and thereafter a constant rate of 4.4%.

Average population growth rates for the country will amount to about 1.8% per year for the period 1995-2010 and 1.3% for the period 2010-2030, with higher rates for the urban sector than the rural sector, in line with current trends. To estimate the distribution of the population in the urban and rural areas, steady growth of urbanisation was assumed and the ratio of inhabitants per household was progressively reduced, as a result of which 71% of the population would be concentrated in the urban area by the year 2030. The figures obtained on the basis of this hypothesis are indicated in the table below:

Table 9 Forecasting of population and number of households (thousands)

	Urban			Rural			Total
Year	**Inhabitants**	**%**	**Households**	**Inhabitants**	**%**	**Households**	**population**
1995	6,343	60.3	1,324	4,181	39.7	853	10,524
2010	8,897	64.7	2,224	4,864	35.3	1,081	13,761
2020	10,775	67.8	2,694	5,117	32.2	1,248	15,892
2030	12,713	61.0	3,178	5,192	29.0	1,403	17,905

Source: Own elaboration, based on official sources and statistics

Energy demand forecasting for the residential and services sector is based on the number of inhabitants of the country, their distribution by urban and rural areas, and as a result the amount of households existing in each area. This last parameter is used to determine the energy intensity associated to each use, in terms of energy consumed by household.

In keeping with the results of the World Bank survey carried out in 1993 (ESMAP, 1994), the urban residential sector has been broken down into three subsectors. According to this survey, 73.2% of urban households are low-income or lower-middle income households, whereas 20.3% are middle-income and upper-middle income households, and 6.5% upper-income[52]. For the rural area, however, there is only one single category that includes all the households of the sector.

2.2.2 Summary of other conditions that could partially be achieved

- Rise in the physical capital accumulation rate.
- Improvement in the human capital skills[53].
- Greater liberalisation of trade and financial markets in order to contribute to a more efficient allocation of resources, along with the complementarity of policies, in order to reduce the vulnerability to abrupt international price changes.
- Decline in state intrusiveness in production and delegation of activities to private sector.
- Improvement in macroeconomic and political stability, as well as legal guarantees.

---

[52] In this study, the location of households in each category was determined by comparing the household income and the number of minimum living wages.

[53] Since there is a widespread in the social, education, and health sector, there are interesting proposals being made to overcome the crisis, involving not only privatisation which in itself does not resolve any problems, but also the application of models based on a philosophy of solidarity.

- A certain improvement in governability, in view of the historical experience which has shown the negative effects of political tension, deficiencies in public administration, etc.
- The agricultural and livestock, forestry, and fishing sector, which has modernised mainly its institutional structure by guaranteeing land ownership and facilitating marketing, will be basing its growth essentially on both traditional and non-traditional exports, the latter displaying more favourable growth prospects. As a result of WTO guidelines, the sector must necessarily become more efficient, within a seven-year period, while keeping the price bands that protect and ensure its stability. There is a tendency to revert the economy to the production of primary goods and raw materials.
- The industrial sector could recover if it improves its competitiveness, which would enable it to enlarge its access to foreign markets.
- Transportation has good prospects for growth if the country's road network is upgraded, management of important segments of the primary road network is delegated to the private sector, and private contracting is resorted to for road maintenance, which would facilitate business and trade.
- The liberalisation of the economy will help to increase the growth rate of the trade sector and internationalise financial services, and relative modernisation of the economy will give impetus to the financial sector.

2.2.3 Conditions that could be achieved in the energy sector:

- Private-sector investment will contribute to ensuring future energy supply.
- Greater efficiency in the electric power distribution utility companies, which will involve greater private-sector participation.
- Participation of the private sector in refining and marketing activities, subject to regulation, in case monopolies arise.
- Greater concern for environmental protection and ethnic groups living in oil production areas.
- Annual incorporation of reserves, equivalent to the volume being produced.
- Regarding institutional aspects, the state oil company will be autonomous and be entitled to enter into partnerships and draw up contracts, whereas the State, through the Ministry of Energy and Mines (MEM), will be in charge regulating, monitoring, and supervising activities, conducting bidding processes, and drawing up oil contracts.
- Participation of private-sector capital in marginal field projects[54].
- Development of heavy crude oil reserves[55].
- There is no intention on the part of government to apply explicit energy conservation or saving policies, nor is it expected that this will take place. The scenario assumes that basically prices will be regulating consumption. With the intervention of the private sector, there will be a widespread elimination of subsidies, which will help to restrain consumption.

---

54 Sushufindi, Sacha, Auca, and Libertador.

55 Ishpingo-Tambacocha-Tiputini.

- It is expected that crude oil exports will attain their peak in the year 2002, at which time they will begin to decline until their exportable margin is depleted by the year 2014, unless new reserves are incorporated. In keeping with this forecast, it is estimated that the oil sector will have an average growth rate of only 2% and, therefore, its share of GDP will decline notably from 14% to 9%.
- The electric power sector will be able to recover on the basis of new investments to expand hydropower and thermoelectric capacity.

2.3 Opportunities and risks of the international situation for a developing country like Ecuador

With the international landscape depicted in the first chapter of this document, there are many uncertainties regarding their influences in a country like Ecuador. Uncertainties arise not only from the ingredients of the assumed situation, but from major trends inside the country and particularly, the rate at which changes take place and the feedback to the external incidences. Thus, it is not a nature of this essay to pursue such a complex analysis, but only to identify in a list, in an admitted subjective form, the main opportunities and risks for the country.

2.3.1 Opportunities

1. Economic Interdependence provides an opportunity, since it favours economic integration by means of trade, greater financial flows, improvement of information networks, and spillovers of technology[56] incorporated into the capital goods that are imported.
2. Dispersion of production activities across the world.
3. Improved access to capital flows, if an adequate reshaping of internal conditions to attract investments, is opportunely carried out.
4. Access to information resources and advanced technologies
5. Reduced costs of sophisticated inputs, due to technical progress and competition among multiple suppliers.
6. Access at low rates, to modern service networks.
7. Reduced transaction costs and opportunities for direct relations supplier customer.
8. Dynamic generation of new market niches, by a growing world economy.
9. Opportunity to specialise in the production of components, goods and services of high value added for special markets.
10. Depolarisation of power in the world and shortening of distances and transaction times, opens new potential markets.

2.3.2 Risks

1. It was mentioned that interdependence is an opportunity, however, at the same time, globalisation can represent a risk for a weak economy such as the

56 International Monetary Fund, *World Report,* June 1997.

Ecuadorian one, which is incorporating, later than other countries, foreign trade liberalisation and economic deregulation policies.

2. Greater interdependence makes national economies more sensitive as a result of international financial market flows and technological breakthroughs. Price fluctuations on international markets heavily affect Ecuador's terms of trade with the rest of the world, especially since the Ecuadorian economy has become more open.
3. Despite of the fact that general reduction of the barriers for trade will promote exports, which play a significant roll for the economy due to limitations of the domestic market, the consolidation of blocs of countries could also lead to the creation of barriers to imports coming from other blocs and this would result in barriers to Ecuadorian exports aimed at those blocs to which Ecuador does not belong and. In any case, being a small country it would have to be subject to the rules of the predominant country in the bloc to which it does belong, thus exposing itself to a weakening of the position it takes to defend its interests.
4. Internalisation of the benefits of international trade, led by transnational companies, tends to reduce the surplus taken by national economies where these companies are located.
5. Volatility of export markets and shorter life cycles of products.
6. Substitution of export products by technological and fashion changes.
7. Underdevelopment implies a low technological platform, which provokes a handicap in a highly competitive environment for production a technologically valued goods and services.
8. Decrease of relative value of natural resources and unskilled labour.
9. Instability of international capital flows.
10. Increased monitoring roles of multinational organisms, which might by biased by the interest of countries with more power.
11. Persistence of protectionist practices with new covers.
12. Pronounced asymmetries of negotiating power for trade and technology agreements in the world.
13. Increased influence of internal politics of leading countries, in commercial and other relations with small countries.
14. Certain cultural impacts from global multimedia affect identity, values, raise expectations, frustration and social conflicts.
15. Global multimedia also promotes imported consumption, reducing resources for productive investment.

On the basis of the above, growth forecasts for the economy by sector up to the year 2015 may be summarised as indicated in Table 10.

Due to the high level of uncertainty to forecast economic behaviour for longer periods, the baseline scenario considers the same above growth rates up to 2030.

Table 10 Growth forecasts for the economy by sector

Sectors	Average growth 1997-2015	Structure 2015
Agric.,forest., fish.	5.0%	19.3%
Petroleum	2.0%	9.2%
Industry	4.5%	15.6%
Commerce	5.5%	17.8%
Transport	5.5%	7.4%
Financial sector	6.0%	5.1%
Electricity	3.8%	1.2%
Others	4.0%	24.4%
GDP	4.5%	100.0%

Elaboration: FEDEMA

Development, Current Situation and Perspectives of the Energy Sector

1 Oil and gas activities in Ecuador

1.1 Introduction

Petroleum is Ecuador's principal non-renewable natural resource and will continue to be for the next two decades. It accounts for close to 45% of current and capital revenues for the General Budget of the State, about 14.1% of gross domestic product, 31.06% of total exports and 40.06% of primary product exports. It also meets about 80% of total net domestic energy demand.

Therefore, oil reserves and oil production have a special meaning for the country, since they are at the very core of the economy and decision making in all the different phases of the oil industry is based on them.

1.2 Exploration

Since the early eighties, the need to expand investments in exploration for the discovery of new reserves, in order to ensure growth of production, meet the steady increase of future domestic demand, and obtain higher earnings for the country's development, led to the entry of countless companies into this area of oil activity. Thus, between 1982 and 1992, there were six rounds of international oil bidding processes for oil and gas exploration and production in 11 prospecting blocks: seven in the Ecuadorian Amazon Region (EAR) and four offshore in territorial waters. As a result, at present there are contracts in force with the following companies: City, Occidental, Elf, Maxus, Oryx, Arco, and Braspetro in EAR and Tripetrol on the Ecuadorian seaboard.

Amendments to the Hydrocarbons Law in January 1994 fostered new foreign investments in exploration activities, with the application of a different contracting framework, using partnership contract schemes.

The Seventh Round of Bidding for oil exploration and production, conducted as a result of these amendments and the geological interest in the oil and gas prospecting being offered, enabled various oil companies to become involved in exploratory activities in six blocks of the Amazon region, with investment commitments on the order of US$188.7 million.

In June 1995, the Eighth Round of Bidding began. This international bidding process managed to arouse the interest of three foreign companies in three blocks located in the Amazon Region, with investment commitments for the exploratory phase on the order of US$39.6 million.

In its search for venture capital and as part of its divestiture strategy, the State announced that between ten and seven fields operated by Petroproducción were marginal fields. Petroecuador estimates that, with investments amounting to US$105.7 million, these fields, which hold proven reserves of 70.7 million barrels, would be capable of producing about 20,540 barrels per day. In 1996, the bids submitted for environmental impact studies, technical inspection, and inventory of assets, facilities, and equipment were reviewed.

1.3 Reserves

A summary of original and remaining oil reserves of the EAR at January 1, 1997, drawn from the report "Oil Reserves and Oil Production Forecasts for the Amazon Region 1996-2014" issued on January 3, 1997 and prepared by the commission comprised of the National Hydrocarbons Directorate (DNH), the Contract Administration Unit of Petroproducción (ADC-Petroecuador), is provided below. The reserves belong both to fields that are currently producing and fields not in production. There are three types of reserves, depending on their reliability and degree of knowledge about them:

> *Proven reserves*, determined on the basis of reservoir studies, mathematical simulation, production plans, seismic reinterpretations, geological studies, well drilling, historical production, and update of recovery factors.
>
> *Probable reserves*, which involve only the six fields discovered by Petroproducción.
>
> *Possible reserves*, which involve the exploratory prospecting of Petroproducción, operating companies, the Seventh and Eighth Rounds, and blocks of any future rounds, which have been determined exclusively on the basis of geological correlations and seismic exploration, without any well drilling, and whose probability of success in terms of discovery is 50%. Remaining reserves are the difference between original reserves and cumulative production since the start of production.

Table 11 Summary of remaining reserves and total reserves of the EAR (at January 1, 1997)

Company	Reserves			Accumulated production	Remaining reserves	°API at 60°F
	Proven	Probable	Possible*			
	(1000 Bbl)					
Total	4934977	24835	141781	2152848	2948746	23,5
Petroecuador-City	81950	0	6800	31300	57450	22,8
Occidental	112210	0	146370	28330	230250	20,8
ELF	47430	0	25790	3360	69860	19,0
YPF-Maxus	258920	0	38540	27380	270080	17,2
ORYX	99050	0	3375	28090	74335	22,0
ARCO	162000	0	70000	0	232000	14,7
Braspetro	28000	0	10360	0	38360	12,8
Total companies	789560	0	301235	118460	972335	18,1
Total VII Round	0	0	564300	0	564300	28,2
Total VIII Round	0	0	350300	0	350300	16,8
Total other rounds	0	0	821200	0	821200	17,5
Total EAR	5724537	24835	2178816	2271308	5656881	22.0

(*) With 50% probability of success of discovery
Sources: "Reservas y Proyecciones de Producción de Petróleo de la Región Amazónica 1996-2014"; DNH, Petroproducción – Contracts Administration Unit-Petroecuador. Reserves of Bidding Rounds were obtained from Contracts Administration Unit, June 1996.

1.4 Production

Cumulative oil production at January 1, 1998 was estimated to be 2,406,700,000 barrels, since the start of production in the EAR.

In 1997, national total average production amounted to 388,000 barrels per day, which gives an annual production of 141.71 million barrels, that is, 0.9% higher than in 1996. Of this amount, 99.7% comes from the EAR and the rest from the Santa Elena Peninsula.

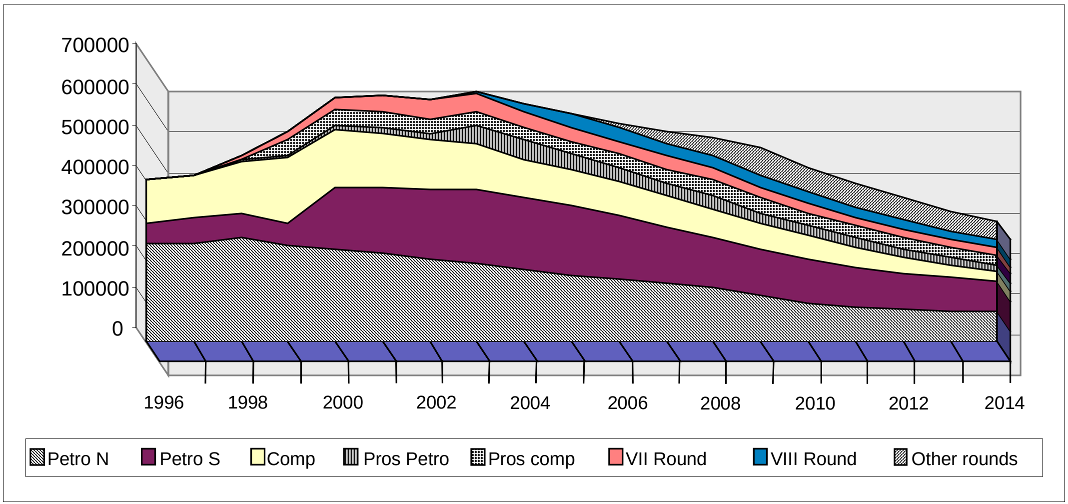
With respect to production in EAR, 79.8% corresponds to Petroproducción, which produced a total of 106.7 million barrels (that is, 292,300 barrels per day), 4.7% less than in 1996, essentially owing to budget cuts implemented by the company since August 1995. It drilled 14 wells, that is, 13 production wells and one exploratory well, which turned out to be productive.

In 1997, the foreign oil companies operating in the country produced 35 million barrels of crude oil, that is, 23% more than the preceding year.

1.5 Production forecasting

According to forecasts of an internal study of the Contract Administration Unit of Petroecuador conducted in March 1997 and taking into account scenario 4, which envisages remaining reserves on the order of 4,739,000,000 barrels and an average daily production of 434,200 barrels per day, it is expected that peak oil production in the EAR will be reached by the year 2003, in the amount of 618,000 barrels per day, with production levels remaining steady, that is, over 500,000 barrels per day for a five-year period, and then declining to 477,000 and 390,000 barrels per day for the years 2009 and 2011, 354,000 and 323,000 barrels per day for the years 2012 and 2013, and ultimately reaching a level of 297,000 barrels per day in the year 2014.

Figure 3 Oil production forecasting in the EAR (barrels per day)



To ensure that this forecasting will actually materialise, well drilling programs will have to be carried out, involving about 34 wells per year for the years 1996 to 2000, and secondary recovery in the fields of Shushufindi, Sacha, and Auca, in addition to the implementation of additional artificial surveying and prospecting projects. The companies that were awarded contracts in the Seventh Round of Bidding must also begin production in 1998 and the fields of Yuturi and Pañacocha must come onstream in the year 2000, whereas the fields of Ishpingo, Tiputini, Tambococha and Imuya, involving reserves of 720 million barrels, as well as other prospects, must become part of national production by the year 2003. The blocks that were awarded in the eighth round of bidding will come onstream in the year 2003 and other future rounds, involving a 50% chance of success, would be producing as of the year 2006.

Table 12 Oil production forecasting in the EAR
(thousand barrels per day)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014
Petroproducción north	243934	256140	238236	229213	215177	202532	190545	176828	163806	152202	142338	132931	112790	96306	85007	79316	74670	71583
Petroproducción south	59815	59822	51303	148074	165362	171127	184458	176882	170347	156921	138265	124393	113547	105004	96396	90467	82901	75918
Other companies	107078	129280	163281	146241	132979	123841	110904	98504	89752	83557	76988	70696	63850	57966	49425	36963	28456	22910
Prospection Petroecuador	0	2200	6260	11008	16726	17689	49400	44614	40467	36854	33681	30881	28396	26177	24185	22385	20758	19279
Prospection other companies	800	3200	40984	38313	35907	33600	31341	29240	27281	31456	35757	40174	36539	33263	30309	27643	25234	22955
VII Round	0	8000	16256	27807	38448	48314	44463	40920	37661	34663	31905	29368	27034	24886	22910	21092	19418	17879
VIII Round	0	0	0	0	0	0	7000	22335	33613	31610	29726	27954	26288	24721	23248	21862	20559	19334
Other rounds	0	0	0	0	0	0	0	0	0	13377	31793	46966	69120	64024	59305	54937	50893	47147
TOTAL	411627	458642	516320	600656	604599	597103	618111	589323	562927	540640	520453	503363	477564	432347	390785	354665	322889	297005
°API	25.6	25.1	24.2	22.7	22.4	22.3	21.7	21.5	21.3	21.1	21.0	20.8	20.4	20.3	20.2	20.2	20.2	20.2

Source: Petroecuador, Contract Administration Unit
Elaboration: FEDEMA

1.6 Transport problems

Since 1992, the issue of enlarging the country's capacity to transport the oil produced in the EAR in order to carry it to the Ecuadorian shoreline for export has been one of the most controversial in recent years. Opponents of the project are pessimistic about the figures for remaining recoverable reserves and the estimates of production levels that can actually be attained.

Nevertheless, there are at present considerable volumes of oil that cannot be produced due to the lack of transport facilities. Therefore the current government administration has taken the decision to go ahead with the enlargement of the Trans-Ecuadorian Oil Pipeline System (SOTE), which would increase carrying capacity from 285,000 to 450,000 barrels per day and enabling the pipeline to carry crude oils in a range of between 23 and 26 degrees API. The project would involve a total cost of US$160 million and five subprojects, namely: increasing the carrying capacity, installing additional pumps in the five pumping stations, installing a parallel pipe for 20 kilometres between the stations of Papallacta and San Juan, increasing the storage capacity in Lago Agrio and Balao, installing the new single-buoy mooring in Balao to receive ships with greater drafts (250,000 dead weight tons).

In order to develop new reserves, basically the Ishpingo-Tambococha-Tiputini-Imuya (ITTI) heavy crude oil project, a new oil pipeline has to be built for this type of crude oil, in two stages, one for the development of the central-south zone and the other which will extend to zones that will be gradually incorporating production in the Northeast, as well as production stemming from the seventh and eighth rounds and other rounds that might take place in the future. This project will be financed by private-sector capital, and its cost is estimated to be between US$500 million and US$600 million.

1.7 Investments

The contribution of the private sector for the development of the oil sector in Ecuador is urgent and imperative. It requires investments on the order of between US$1,881,000,000[57] and US$2 billion[58] for oil and gas exploration, production, industrialisation, storage and transport projects, which will help to spur economic growth. There are three main projects: construction of a new pipeline (US$500 million-US$600 million), exploration and production of ITTI (US$1.2 billion), and exploration and production of marginal fields. It is expected that bidding processes will take place at the end of 1997.

The Petroproducción investment budget[59] for the year 1997 prepared by the various units of Petroproducción amounted to US$146.5 million, of which 76.9% corresponded to new projects and 23.1% (US$33.9 million) to projects from previous years.

1.8 Forecasting for the production of associated natural gas in the EAR

DNH estimated that, at December 31, 1997, remaining associated natural gas reserves in the EAR amounted to 547.4 billion normal cubic feet[60].

---

57 Petroecuador Magazine, *Síntesis*, February 1996, and P. López, former President of Petroecuador.

58 Raúl Baca, former Minister of Energy and Mines, *El Comercio*, September 30, 1997.

59 Budget Unit, June 17, 1996.

In order to obtain associated natural gas production forecasts for the oil fields in the EAR, the following are considered: historical series of natural gas production, the historical average gas-oil ratio (GOR) for each one of the fields, assumptions of GOR by correlation of neighbouring fields for those fields not in production, and oil production forecasting assumptions.

Figure 4 Forecasted production of associated natural gas

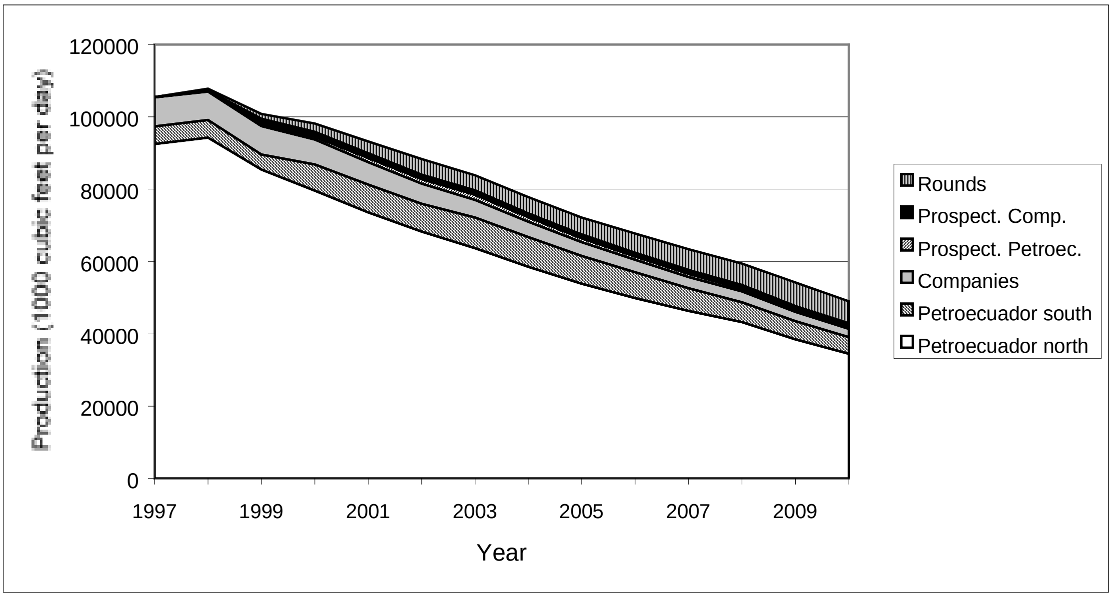


Table 13 Forecasted production of associated natural gas
(Thousand cubit feet per day)

	1997	1998	1999	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010
Petroecuador north	92446	94250	85402	79516	73537	68249	63623	58587	53830	49841	46374	43201	38452	34470
Petroecuador south	4951	4860	4142	7296	7710	7719	8528	8142	7745	7097	6195	5518	5024	4627
Companies	8035	7851	7933	6872	6141	5531	4835	4242	3811	3517	3184	2931	2518	2293
Prospective Petroecuador	0	158	451	793	1204	1274	1457	1240	1062	915	792	690	605	533
Prospective Companies	32	128	1509	1410	1321	1236	1152	1074	1002	1054	1111	1172	1075	986
Rounds	0	600	1300	2201	3290	4316	4272	4507	4710	5303	5662	5902	6488	6086
TOTAL	105464	107847	100737	98088	93203	88325	83867	77792	72160	67727	63318	59414	54162	48995

1.9 Use of associated natural gas in EAR

At present, Petroecuador, through Petrocomercial, is industrialising only associated gas produced in the fields of Shushufindi, Libertador, and Limoncocha in order to obtain liquefied petroleum gas (LPG), natural gasoline, and residual gas.

[60] Source: Energy-Economic Information System (SIEE), OLADE, March 1998.

1.9.1 Sacha Project

On the basis of joint studies by Petroindustrial and Petroproducción, it has been determined that the gas being produced in fields such as Sacha, Pucuna, and Paraíso, which produce on average about 10 million cubic feet per day, must be tapped. In addition, as of the year 2000, the Huamayacu field, with an estimated gas production of 2 million cubic feet per day, will come onstream.

The installation of a modular plant in Sacha in order to process this gas will lead to a production in this area amounting to more than 100 metric tons of LPG per day and 8 million cubic feet of residual gas per day. The cost of this project is estimated to be about US$31 million, which would include laying the pipeline up to the head of the Shushufindi polypipeline and building storage facilities (2 spheres).

For the project's implementation, the participation of private enterprise is expected using a build-operate-transfer (BOT) scheme for a 15-year period. At present, companies are in the process of being qualified, and it is expected that the inter-subsidiary (between subsidiary companies of Petroecuador) agreement will be signed in order to proceed with the submittal of bids to the qualified companies.

1.9.2 Bermejo Project

This field is characterised by its high-quality oil production (31-32° API) and its gas content potential. The current gas-oil ratio is, on average, 2,300 cubic feet of gas per barrel of oil.

According to preliminary studies, in order to tap this gas to obtain LPG, natural gasoline, and residual gas, as well as to develop the separate CO2 in order to reinject it into the formation and increase the reservoir's recovery factor, high investments are needed and as a result the project has not as yet materialised.

Another project that is highly interesting is the use of this gas over the short term in order to generate electricity, which would produce savings of between US$2.5 million and US$3 million per year, which is the amount being spent for using diesel as feedstock for this purpose.

This project, in its first phase, would consist of taking about 3 million cubic feet per day of gas coming from Calizas A and B and from Basal Tena in Bermejo Norte and Sur; this gas has a CO2 content of under 2% of the molar fraction and a calorific power of 1,400 BTU per cubic foot of gas. In addition, it includes the possible access of 1.2 million cubic feet per day of gas produced in Guanta, Atacapi, and Parahuacu.

This volume would be carried up to the Secoya station, where the liquables would be extracted in the modular plant; as a result, about 40 tons per day of LPG would be obtained, as well as recovery of about 2.5 million cubic feet per day of residual gas that would be used as feedstock for the generation of 10 MW of electricity.

The estimated investment cost for the project is about US$11 million for transfer lines, interconnections, compressors for taking and dispatching, and complementary facilities in both Bermejo and Secoya.

The second phase would involve analysing the tapping of about 5 million cubic feet per day of remaining gas from the Bermejo Field and with a content of over 40% of CO2.

1.9.3 Optimisation of gas taking in Shushufindi-Aguarico

Petroproducción and Petroindustrial are studying the possibility of implementing jointly a project aimed at the overall optimisation of gas taking at a low pressure in all the stations; as a result, about 50 tons per day of LPG and about 3 million cubic feet per day of residual gas to be used as feedstock for generating electricity would be obtained.

In addition, there is the project for taking gas to be used in burners, with a low-pressure system (8-10 psi), which would involve taking about 4 million to 5 million cubic feet per day, which would also be used for electric power generation.

1.10 Gas from the Gulf of Guayaquil

Exploration activities have been conducted in the Gulf of Guayaquil since 1948 in order to find oil and gas. To date, about eight companies have carried out 15,000 kilometres of seismic lines and drilled 19 exploratory wells. As a result, gas has been discovered in the Amistad field and traces of oil have been found in the Gulf of Guayaquil No. 1 well. The gas was identified as "dry sweet" with a high methane content (98.3%) and the absence of sulphur components.

Assessments conducted[61] estimated that proven gas reserves discovered in 1969 amount to 159.02 billion normal cubic feet[62], equivalent to a daily potential of 35 million normal cubic feet per day and reserves-production ratio of 12.6 years.

On December 31, 1997, DNH reported by means of its Reservoirs Division, that there are remaining natural gas reserves in the Gulf of Guayaquil in the amount of 264 billion normal cubic feet.

Studies on the usefulness of the gas obtained focus on the potential demand for natural gas in Guayaquil for thermal use in the industrial sector (cement works) and especially as a fuel for gas turbines generating electricity. Natural gas would replace diesel oil, which is the fuel that is currently being used and of which there is a shortage in the country.

Depending on the volume of reserves, natural gas could also be used as raw material for the potential development of the fertiliser and explosives industries, as well as its use as fuel for transportation.

The EDC Company of Ecuador, which was awarded in July 1996 the bid for the partnership contract for gas exploration and production in Block No. 3 in the Gulf of Guayaquil, which includes the Amistad Field, estimates that, on the basis of three-dimensional seismic prospecting studies conducted in 1997, there is a volume of proven reserves in this field on the order of 280.2 billion normal cubic feet, which should be confirmed by the drilling of four exploratory wells.

---

61 Gas Reserves Calculation, Amistad Field, INE-CEPE, April 1988. “The complexity of determining natural gas reserves of the Gulf of Guayaquil gas is evident in the estimates made by different companies and institutions in which notable differences in assessments can be observed.”

62 "Proven reserves fluctuate from 118 million to 296 million normal cubic feet, in other words, a 250% difference, whereas total reserves display a far greater variation, ranging from 142 billion normal cubic feet to 3.85 billion normal cubic feet, which means that the larger figure is 27 times higher than the smaller one.

Considering only the most expected values in each of the three reserves categories, the results are:

Proven reserves: 159.02 billion normal cubic feet

Probable reserves: 175.94 billion normal cubic feet

Possible reserves: 209.6 billion normal cubic feet."

Gas Reserves Calculation, Amistad Field, INE-CEPE, April 1988.

The company intends to invest in the exploratory phase (seismic surveys, installation of platform, drilling of four wells) about US$40.8 million and, in the production phase, about US$109.35 million, envisaging processing facilities for 80 million normal cubic feet per day of natural gas and associated liquids, an 80-kilometer 14-inch undersea gas line, an inland receiving station, and another 90-kilometer 14-inch land gas line to the supply sites.

It is estimated that production of this gas will begin in the year 2001, with a daily production of between 30 million and 50 million cubic feet, depending on the confirmation of the volume of reserves.

1.11 Refining

Ecuador has four refineries, with an oil processing capacity of 157,500 barrels per day, broken down as follows: Esmeraldas 90,000 barrels per day; Libertad 46,500 barrels per day (which includes the Cautivo refinery); Lago Agrio 1,000 barrels per day (used to ensure supply for consumption in the EAR fields); and Amazonas 20,000 barrels per day, which along with the natural gas processing plant, whose working processing capacity amounts to 25 million cubic feet per day of natural gas and 150 gallons per minute of liquables, comprises the Shushufindi Industrial Complex.

It was expected that, for the first months of 1998, the new enlargement of the Esmeraldas Refinery, which is to process 100,000 barrels per day of crude oil up to 23° API, which is now in the process of testing, would be operating at full capacity.

In May 1998, the new gas plant of Secoya was commissioned: it has a natural gas processing capacity of 5 million cubic feet per day to produce 40 gallons of liquid per minute, which will be sent to Shushufindi for processing, and to obtain between 60 and 70 metric tons of LPG per day, which would mean saving US$5.4 million per year as a result of a reduction of imports of about 22,000 tons of LPG.

1.12 Other projects

1.12.1 Comprehensive energy development plan for the Amazon Region

An inter-subsidiary commission of Petroecuador, comprised of Petroproducción, Petrocomercial, Petroindustrial, and the Oil Pipeline, has been working on the Comprehensive Energy Development Plan for the Amazon Region, which considers that electricity is a basic element for oil production; in addition, as the process of field production progresses, artificial recovery systems have to be implemented to maintain pressure, which means higher electric power needs to operate the equipment. Likewise, as a result of the advent of heavy oil production and the increasing production of formation water, this water has to be reinjected into the wells in order to avoid environmental pollution, which in turn also increases electric power demand.

The Plan includes Petroecuador, its subsidiaries, service companies and partnership companies working in the Amazon Region, in other words, the plan extends to the entire Amazon region. It is aimed at meeting the growing demand for electricity, reducing the cost of building new transmission and distribution lines, increasing power generation units connected to the National Interconnected System, and eliminating the scattered and under-used small-capacity electrogeneration groups. This would help to curtail the consumption of diesel, reduce maintenance work, lower stock of equipment and spare parts, avoid production losses due to electricity outages, and tap gas, reduced crude oil, and heavy crude oil for electric power generation, minimising the consumption of diesel, of which the country has a shortage.

According to electric power demand forecasting based on different projects being carried out in the EAR, the Plan envisages the following power generation, transmission, and distribution projects:

1.12.2 Gas-fired power generation station in Secoya

The Petroindustrial plant which is about to come onstream in the Secoya station will have a surplus of 2.5 million cubic feet per day of residual gas, which could in turn generate up to 8 MW, a capacity which could be used in the Libertador field and by a transmission line in Atacapi-Secoya. The project's estimated cost is US$11.1 million, which includes the project integrating the YPF and Petroindustrial power stations (US$1 million). It is scheduled for implementation between 1998 and 1999.

1.12.3 Reduced crude oil station in Shushufindi

The Amazonas Refinery in Shushufindi produces about 9,000 barrels per day of reduced crude oil (topped crude) with a rating of between 14 and 15° API, which is reinjected into the oil pipeline. If this reduced crude oil is used as a fuel, a power capacity of about 280 MW could be generated; this would cover the needs of the EAR, and oil production could increase by an amount similar to what is consumed. On the basis of the analysis conducted by the Commission, a plant of this size is not practical, unless part of this energy can be exported to the National Interconnected System, which basically depend on costs, since to enter into this System it will have to be competitive with existing power generation.

The Plan proposes a modular plan covering the needs of Petroproducción, Petroindustrial, OXY, ORYX, and the Oil Pipeline until the year 2010, starting with a power capacity of 30 MW and gradual annual increases until the required demand is met.

For this project, three scenarios with different electric power demands are being considered; investment needed is on the order of US$122.3 million, US$112.6 million, and US$221.1 million, respectively, for each scenario. The project's implementation period is from 1997 and 2003.

1.12.4 Power generation stations with heavy crude oil

Tiputini-Tambococha-Ishpingo

It is estimated that these fields will be coming onstream in 2001. Due to their distance to the Interconnected System and their environmental sensitivity, the Plan recommends power generation inside the field. It is estimated that peak demand of 80 MW be reached in the year 2008; using heavy crude oil produced in the field as fuel, an investment on the order of US$96 million is estimated.

YPF (B-16) fields, Bogi-Capirón-Tivacuno

Owing to its location in the Yasuní Park, it would not be feasible to build an aerial line for electric power transmission from Shushufindi; therefore this project is viewed as a stand-alone project. Peak demand will amount to 91.8 MW and will be attained in the year 2003. Currently, it has 37 MW. To meet demand, investments estimated at US$60 million will be required for a plant using heavy oil as feedstock.

ARCO fields, Block 10

ARCO will start up its operations in 1998; its peak demand of 20 MW will be reached in the year 2009 and will have to be met by centralised power generated using heavy crude oil. An investment in the amount of US$24.2 million is estimated.

Campos City

With a marginal demand, it is recommended that its current power generation systems be optimised by increasing its capacity by 1 MW and building distribution systems for an estimated investment of US$1.5 million.

1.13 Petroecuador's need for financial autonomy

Since oil is a nonrenewable resource, the implementation of essential actions and projects for the country's growth and development is urgent.

The state oil company Petroecuador should benefit from a suitable legal framework guaranteeing both its operating and financial autonomy and providing it with the economic resources it needs to carry out both responsibly and efficiently its operating, training, and investment activities. This would promote the deployment of efforts aimed at improving indices of productivity and efficiency and developing competitive capacity on the basis of conditions identical to those of private-sector companies. It must be free to enter into partnerships, to draw up contracts, and engage in marketing activities, while the State should define its operating areas and establish profit margins.

2 Electric power subsector

2.1 Development of the national electric power subsector[63]

Electrical energy service in the country started at the end of the nineteenth century, in 1897, with the establishment of the Electric Light and Power Company (Empresa Eléctrica Luz y Fuerza) in the city of Loja, which installed two hydraulic turbines, of 12 kW each. In Quito, the power utility Jijón Gangotena y Urrutia was established, with the installation of a capacity of 50 kW, and later it became the Quito Electric Light and Power Co. In the twenties and thirties, contracts were drawn up with American companies to supply electricity to the cities of Quito, Guayaquil, and Riobamba.

Up until 1961, electrification in Ecuador, where service started at the end of the nineteenth century, experienced chaotic growth and development, where the municipalities were in charge of supplying electricity in the geographical areas under their jurisdiction. This led to considerable fragmentation and dispersal of the system, which developed without any type of planning, with deficiencies and high operating costs as a consequence. In 1961, there were more than 1,200 power stations, and there was an installed capacity of about 120 MW. In May 1961, the Basic Electrification Law was enacted; it created the Ecuadorian Electrification Institute (INECEL) to implement the country’s electrification process, and as a result electric power service delivery became the exclusive responsibility of the Ecuadorian State.

In 1966, INECEL prepared its first National Electrification Plan which set forth as its basic premises the establishment of a National Interconnected System (SNI) and Regional Electric Power Integration. The former proposed establishing the current power generation and transmission system, which is comprised of large power generation stations connected to a basic transmission ring or loop, with connections to the load dispatch centres in the respective provinces. The latter recommended the creation of electric power distribution utilities in the provinces, which would become part of the SNI.

---

63 FEDEMA-CAAM, Estudio sobre políticas energéticas del Ecuador, CAAM, Quito, 1995.

This scheme has remained in force up to now, that is, INECEL is in charge of power generation and transmission in terms of bulk electricity, whereas the power utilities provide service to their customers by means of electricity purchases from INECEL and their own power generation.

With the reforms of the Basic Electrification Law of 1973, INECEL was granted its own legal status as a public entity, its own resources, and economic and administrative autonomy. Beginning in that year, the National Electrification Fund was allocated 47% of the royalty earnings coming from oil production revenues (a share that was reduced to 35% in 1975), on the basis of which the Institute was able to truly fulfil its duties as the agency in charge of implementing major electric power subsector projects.

Therefore, INECEL at that time began implementing large hydropower and thermoelectric generation projects and extending transmission networks. To finance the high capital investment requirements for these projects it relied on the basic contributions of the Electrification Fund and, to a lesser extent, on external loans[64]. Thus, during this period, the most important projects that were commissioned included: the country's major thermoelectric power station, the steam-driven Estero Salado Station (146 MW), the Guangopolo Station (31 MW), and the Pisayambo Hydropower Station (70 MW) between 1977 and 1978; the Esmeraldas Thermoelectric Station (132 MW) and the Santa Rosa Thermoelectric Station (51 MW) between 1981 and 1982; the Paute Hydropower Station, the largest and most important electric power infrastructure project in Ecuador, with an initial installed capacity of 500 MW (Phases A and B), in 1983; the Agoyán Hydropower Station (156 MW) in 1992; and Phase C of the Paute Project (additional 575 MW). With the commissioning of the latter, the efforts made till then had culminated, and electricity generated on the basis of oil products was replaced by hydropower, whose potential in the country is quite substantial. Alongside these projects, a 230-kV transmission ring was built with ramifying connections at 138 kV and their respective substations, in order to provide service to the entire country by means of the National Interconnected System.

The scheme that was adopted, although it enabled service expansion with the construction of large projects, converted INECEL in both judge and claimant of the subsector, because in addition to being the implementing agency of the subsector, it dictated the norms to regulate its operation, including the establishment of bulk tariffs for distribution and marketing utility companies, as well as the tariffs that the latter applied to their customers. INECEL also controls the power distribution utilities as majority shareholder.

State management of INECEL, far removed from optimal levels of efficiency, has over the years produced various anomalies in the operation of the electric power subsector, which has mainly led to low internal generation of economic resources, administrative and business management deficiencies. As a result, the electric power subsector has witnessed the decline of its operating capacity, and its prospects for development have been curtailed. Indeed, as of 1973, various Electrification Plans have been approved, but over the last 15 years, they have been severely constrained by the lack of funding. This has led to serious lags in project construction, with high cost overruns and delays in electric power generation and transmission programs. The system has been unable handle the shortages of the dry season and has had to ration electricity over the last five

[64] At present, the Electrification Fund is of no importance in terms of its contribution to financing the electric power sector, because for more than a decade the exchange rate for the dollar for transferring the royalty earnings from oil revenues to the Fund has been frozen.

years. The low-water periods since 1992 have highlighted the fragility of the electric power system, whose major hydropower stations (Paute, Agoyán, and Pisayambo) rely on only one single hydrological basin and rainfall regime.

In October 1996, the Law Governing the Electric Power Sector was passed; it permits a vertical break-up of the electric power system and provides opportunities for private-sector investment in the phases of power generation, transmission, and distribution. The new Law is aimed at providing incentives for competition in power generation activities and regulating the phases of transmission and distribution.

The same Law provides for the elimination of INECEL over a lapse of two years, as of October 1996, and this will take place in September 1998. The Law created the National Electricity Council (CONELEC) as a regulatory entity and established the National Energy Control Centre (CENACE) as the entity in charge of transactions on the Bulk Electric Power Market.

Although almost two years have elapsed since enactment of this Law, no significant changes have been become apparent in the System, because the Government has not given it the impetus it requires. CONELEC was recently established in November 1997, but the preparation of the regulations that would permit a suitable operation of the System and privatisation of the companies that are the target of the break-up have come to a standstill, and no significant progress is evident.

Meanwhile, INECEL continues to be responsible for the System's operation and has attempted to tackle energy shortages by contracting private-sector companies to supply power generation. In addition, during the transition period, it is expected that, for large hydropower and thermoelectric projects, concessions will be granted to interested companies, guaranteeing electric power purchases by means of long-term contracts.

2.2 Electric power subsector structure

As mentioned earlier, Ecuador's electric power subsector is comprised of the National Interconnected System (SNI), which involves various hydropower and thermoelectric power generation stations owned by INECEL and a major 230-kV ring-shaped transmission system, with an extension of 820 kilometres.

The following table provides various indicators for the electric power subsector in the year 1997.

Table 14 Electric subsector indicators (1997)

Installed Capacity (MW)	2970
Hydropower	1487
Thermoelectric	1483
Billing Energy (GWh)	7818
Energy Generation (GWh)	10296
Losses	24.5%
Maxim Power Demand (MW)	1951
Number of Customers	2150000
Load Factor	60.2%
Electrification rate at 1995	75%
Urban	95%
Rural	53%

Source: INECEL

Of the installed capacity of thermoelectric stations, 41% (606 MW) is owned by private-sector companies[65]. It should be mentioned that, although the majority of the regional utilities are involved only in electricity distribution, there are some that contribute their own power generation to the System, albeit only a very small share of it.

The SNI is also comprised of 1,306 kilometres of radial transmission networks at 138 kV; it has 25 substations of 230 / 138 / 69-46 kV, with a total power transformation capacity of 4,213 MVA. The ring is connected to 18 electric power distribution utilities by means of a subtransmission system with a total extension of 3,170 kilometres at 138, 69, 46, and 34.5 kV, and with a total power transformation capacity of 1,598 MVA. The electric power utilities have 22,852 kilometres of primary distribution networks and a transformation capacity of 1,925 MVA.

The demand growth rates recorded in 1990-1997 are 7.2% for energy and 6.7% for power capacity. The growth rates of energy consumption over the last two years are quite high, that is, 9.95% for 1996 and 11.5% for 1997, which could be partially explained by the energy rationing that occurred in 1995.

2.3 Problems of the Paute Hydropower Station

Paute, which is deemed to be one of the largest hydropower stations in Latin America, is one of the most important projects for the country; with an installed capacity of 1,075 MW, it is the key facility for Ecuador's electric power system. It has been operating for 12 years and at present is supplying about 50% of total demand for electricity.

One of the problems that has been constantly affecting the station's operation is the sedimentation in its reservoir. Regarding this, it is important to point out that this sedimentation process of the Paute River basin stems largely from mismanagement of farming resources in the upriver areas of the basin, a situation that already existed many years before construction of the hydropower project. A partial solution to the problem has been achieved by dredging the bottom of the dam but this operation has not yielded satisfactory results because of its sediment extraction capacity, which is less than the volume of sediment regularly entering the reservoir.

The most suitable solution seems to be the construction of the Mazar Project, a dam that would be located upriver from Paute and which would be used not only to regulate the water of the Paute River but also to contain the volume of sedimentation carried by the river. In addition, reforestation programs are being implemented in the Paute River basin, to compensate for the severe deforestation of the area as result of the extensive settlement that came in the wake of the project's construction. Efforts are also being made to improve soil and land use in the river’s upstream basin.

2.4 The new Electric Power Law and Electrification Plan

The new law governing the electric power sector, enacted in 1996, is only partially in force, since its regulations have not been as yet approved. This Law introduces various wide-ranging conceptual and organisational changes into the electric power sector, providing incentives to the private sector to participate in the operation and enlargement

---

[65] There are still various small stand-alone systems that are not part of the SNI; among the most important are the stand-alone systems of the Galápagos Islands and the power utility of Sucumbíos; it is expected that the latter will be interconnected within two years.

of the System and leaving the regulatory, standard-setting, and monitoring functions in the hands of the State, that is, the National Electricity Council (CONELEC).

Power generation, which is at present in the hands of INECEL, will be divided among various utility companies, which will be qualified as joint stock companies. The private sector will be able to participate in power generation and thus compete with the utility companies stemming from INECEL.

The Law provides for the establishment of a bulk market for transactions between generators, distributors, and large consumers, which will opt for two types of prices: those set by the National Energy Control Centre (CENACE) on a spot market and those that are freely agreed upon by the parties involved on a long-term market.

Transmission and distribution monopolies will be kept, since they are natural monopolies, and they will be handed over to interested companies by means of concessions. The transmission company will have to be independent of generation and distribution and therefore will not be able to conduct energy marketing activities.

The tariffs for end-users will be set by CONELEC and will include the weighted costs of power generation, transmission, and distribution. Power generation costs will be allocated on the basis of the short-term hourly marginal cost calculated and authorised by CENACE.

Privatisation of existing installations will be conducted by selling 39% of the shares of the companies stemming from the break-up of INECEL. In these companies, 10% of the shares are being transferred to the employees.

The tariffs, as a result, will be set on the basis of supply costs, without considering the end-use of the electricity being supplied and thus eliminating some of the cross subsidies. It is assumed that low-consumption residential customers who cannot pay their costs will be receiving a direct subsidy from the State.

Electrification in rural zones or areas that are not attractive to private-sector investment will be implemented by the State.

The Law has envisaged granting concessions for large power generation projects of over 50 MW which are included in the Master Electrification Plan; this Plan had been prepared previously by INECEL but in the future it will be prepared by CONELEC. In addition, the projects which are established as private-sector initiatives will be incorporated into the Electrification Plan after their approval by CONELEC. For projects under 50 MW, there will be no concession schemes. Although the Law does not provide for any major constraints on private-sector investors for awarding power generation concessions, the latter requirement is viewed as an obstacle to their participation in the market because there is no complete freedom of action to develop private-sector initiatives, mainly with respect to thermoelectric projects where the resource to be used for generating electric power is a tradable commodity on the markets.

The last Plan for providing electric power generation facilities that was proposed by INECEL is summarised in the Table 15. In this Plan, it is apparent that there is a large component of thermoelectric stations which did not previously exist in INECEL's power expansion plans, and this might be of interest to private-sector investors. In 1997, two thermoelectric power stations installed by INECEL were commissioned: the steam-driven station of Trinitaria (125 MW) and a gas-fired turbine (95 MW).

The Toachi-Pilatón Project (171 MW) was handed over to the Provincial Council of Pichincha so that it could proceed to conduct an international public bidding process and award the respective contract. The San Francisco Project, located downriver from the Agoyán Power Station, was the subject of a bidding process at the beginning of 1998 and will be awarded shortly. The Mazar Project was also the subject of a bidding process but the corresponding bids have not yet been submitted. Concessions are being granted for the implementation of all these hydropower projects using a build-operate-transfer (BOT) scheme, which means that at the end of the concession they will have to be returned to the State. This type of scheme is apparently contrary to the objectives of the new Law, which is aimed at ensuring that State activities will be restricted to regulation and monitoring.

Table 15 Expansion plan of electricity generation (1994-2010)

Plant	Type	MW	Year Operation
Gas Turbine (Diesel)	Thermoelectric	120	1998
Gas Turbine (Diesel)	Thermoelectric	120	1999
Daule Peripa	Hydroelectric	213	2000
Gas Turbine (Diesel)	Thermoelectric	240	2000
Steam Turbine(Bunker)	Thermoelectric	300	2001
San Francisco	Hydroelectric	230	2003
Apaquí	Hydroelectric	36	2003
Mazar	Hydroelectric	180	2004
Angamarca	Hydroelectric	50	2005
Coca Codo Sinclair	Hydroelectric	432	2006
Quijos	Hydroelectric	40	2007
Combined Cycle	Thermoelectric	100	2008
Toachi Pilatón	Hydroelectric	171	2009
Gas Turbine (Diesel)	Thermoelectric	40	2009

Source: INECEL

In addition, as part of the power generation program, hydropower stations with a medium-sized capacity (Apaquí, Angamarca, and Quijos) are being included, and they involve a major component of local resources.

As for transmission facilities, the Paute-Pascuales-Trinitaria System started up in 1997, and it is expected that by the end of 1998, Phases C and D1, enlargement of the Portoviejo substation, extension of the Milagro-Machala system and the Dos Cerritos substation will have concluded.

Phase C includes a transmission line from Ibarra to Tulcán, complemented by substations located in these two cities. Phase D1 involves a transmission line from Loja to Cumbaratza, a transmission line from Quito to Ibarra, substations in Mulaló and Babahoyo, and enlargement of the positions in the Vicentina, Loja, and Cuenca substations.

Over the medium term (until the year 2003), lines and substations for new power generation projects incorporated into the SNI will be commissioned. Over the long term (from 2003 thereafter), configuration of the SNI will be consolidated and the transmission system that joins the SNI with the Coca-Codo Sinclair station will be implemented.

As for subtransmission and distribution, the construction of 1,242 kilometres of subtransmission lines and 2,140 MVA of transformation capacity has been envisaged. This would enable the incorporation of 860,700 additional customers, 42% of whom belong to the rural sector. On the basis of these goals, it will be possible to maintain current service coverage levels, that is, 95% for the urban area and 53% for the rural area.

3 Energy supply and demand

3.1 Production of energy sources

3.1.1 Primary energy production

Hydrocarbons

The oil fields of the Ecuadorian Amazon Region (EAR) came onstream in 1972, with a volume that, by the end of that year, had reached 220,000 barrels per day. In 1973, more than 76 million barrels were produced, a figure that was surpassed only in 1979, after a certain stability in oil production was achieved with the incorporation of new medium-capacity fields.

Between 1979 and 1982, a period which was marked by notable rise in international oil prices, which hit a historical peak, production remained virtually stable; but the incorporation of the Libertador field in 1982 enabled production to substantially surpass the volumes obtained in previous years, achieving in 1983 a production of close to 85 million barrels, that is, 232,800 barrels per day.

During the period from 1983 to 1988, oil production activities displayed greater impetus (except in 1987 owing to a major earth tremor that partially destroyed the pipeline and led to a halt in production activities), reaching an inter-annual growth rate of 4.9%. Actually, the significant decline in oil prices on the international market in those years forced the country to increase its production quotas, in order to compensate for loss of foreign currency earnings as a result of low-priced oil exports.

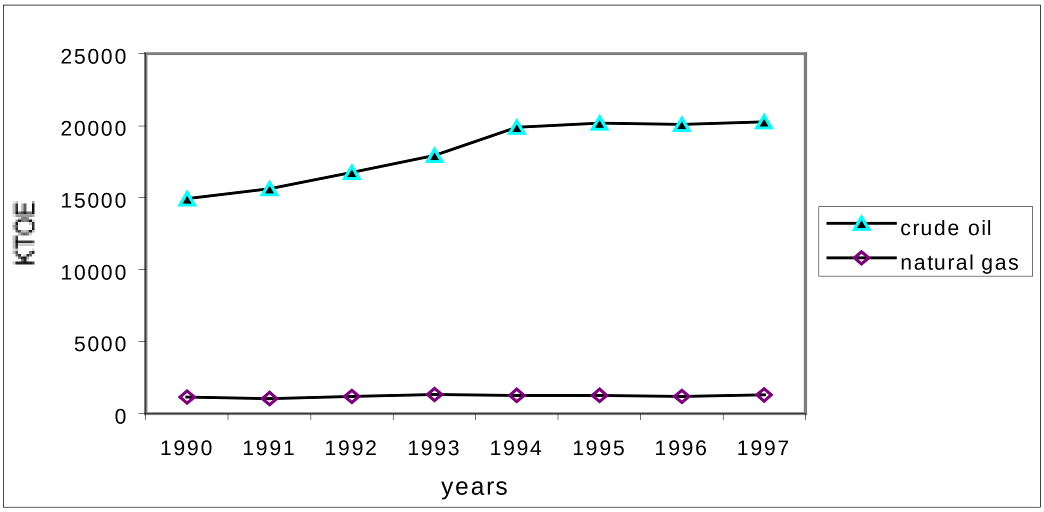
Between 1989 and 1990, the international market situation tended toward slight price increases, as a result of which Ecuador's production, in conformity with OPEC policies to stabilise the price of the barrel of crude oil, declined slightly, fluctuating between 279,000 and 286,000 barrels per day.

During the period 1990-1997, there was once again a surge of oil production, generating a steady increase of extracted volumes, so that by 1997, production attained a historical peak of 141.71 million barrels, which was equivalent to an average production of 388,200 barrels per day.

Regarding oil production and destination, it is important to emphasise that, over the last few years, there has been a positive evolution in several items, indicating in certain cases a new trend compared to what had been observed in the past decade. For example, annual average growth of oil production between 1990 and 1994, which amounted to 7.3%, was more than twice the value obtained between 1980 and 1990 (3.4%). During the period 1990-1997, it grew at an annual pace of 4.5%, whereas the average increase of crude oil inflows into refineries has remained virtually at the same levels as the first two periods: 2.6% and 2.5%, in that order, with a slight increase of 1.1% for the third period, owing to the decline of 15.6%, compared to 1996, triggered by temporary stops in the enlargement of the Esmeraldas refinery, which led to considerable increases in oil volumes aimed at export, which over the last period grew at about 5.6% per year, compared to 4.6% in the past decade.

In terms of energy supply, since 1972, when the oil boom started in Ecuador, oil has been the principal source of primary energy and has recorded an annual average growth rate of 6.6% between 1972 and 1997. Throughout this period it has maintained a similar percentage share of the primary energy source production mix. Regarding the 1997 energy balance, oil accounts for a bit more than 76% of total net primary energy supply and 86.2% of total production of this type of source, which this year amounted to 23,501 kTOE.

Figure 5 Production of hydrocarbons



Associated natural gas ranks second in terms of importance in the primary source production mix: in 1997 it accounted for a share of 5.5% and its inter-annual average growth between 1990 and 1997 amounted to 1.6%. Its production is closely linked to crude oil production in the fields of the Amazon region. Its development has not reached desired levels and is limited to being used virtually as raw material for the recovery of oil products such as natural gasoline and liquefied petroleum gas, as well as very small amounts in the fields used as fuel for pumps, compressors, and heaters and for reinjection into production wells in gas-lift projects. Nevertheless, natural gas development, without reaching the levels that could be achieved, has shown a favourable development, especially as a result of the enlargement of, and improvement in, gas taking in the Shushufindi Plant. At present, close to 28% of natural gas production is aimed at this plant[66].

Biomass

The volumes of biomass production for energy purposes are not known with any certainty. The figures used for the national energy balance are based rather on demand estimates. In the case of bagasse, its production depends on harvesting and the processing of sugar cane in sugar mills.

On the basis of the survey conducted by the Energy Sector Management Assistance Programme (ESMAP) of the World Bank and the National Energy Institute (INE) in 1993 on energy consumption in the residential sector, it is evident that, as a rule, the inhabitants of the rural sector do not fell trees to use the wood as fuel; rather they pick up branches, bushes, and the waste from trees that have been logged for the wood industry, which it is estimated taps only 40% of standing timber.

---

[66] The Shushufindi Gas Plant was commissioned in 1982, with a rated capacity to process 25 million cubic feet per day. Nevertheless, for various years, the plant has been operating far below its real capacity.

The share corresponding to biomass (firewood + plant waste) as a primary source of energy has remained at similar levels over the last few years, accounting for about 5.6% of total primary energy production, an item that is still quite significant for the country, but which has displayed moderate growth rates (3% per year on average over the last seven years). This trend is due to the increase of plant waste (basically bagasse), since the decline in firewood used for energy purposes is quite noteworthy.

Hydroenergy

Hydroenergy contributes an essential part of Ecuador's energy supply: more than 68% of electricity generated in 1997 came from this primary energy source, although this situation is not reflected in the primary energy production balance, where hydroenergy accounts for only 2.7% of the global amount. This share does not display a favourable behaviour, since hydroenergy has declined slightly over the last few years (by 2.4% in 1992 and 2.3% in 1995), with an annual average growth of 3.9% between 1990 and 1997, because it has not been possible to consolidate a process aimed at substituting thermoelectric power generation for hydropower generation, despite the considerable expansion of the power generation capacity of the Paute hydropower station in 1992.

Figure 6 Primary energy production (kTOE)

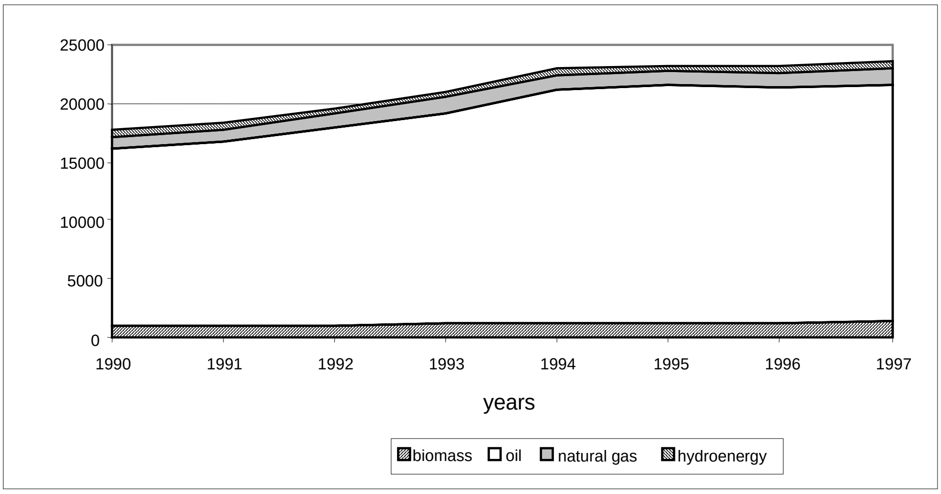


Table 16 Primary energy production (kTOE)

Source	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997***
Biomass	1071	1103	1124	1190	1183	1223	1261	1314
Firewood	868	883	909	946	965	985	1017	1061
Bagasse	203	220	215	244	218	238	244	253
Oil	14935	15642	16756	17938	19879	20185	20088	20265
Natural Gas	1161	1061	1194	1339	1267	1287	1190	1295
Hydroenergy	479	489	476	557	635	525	609	627
Total Prim.	**17646**	**18295**	**19550**	**21024**	**22964**	**23220**	**23148**	**23501**

* Provisional. Sources: INE – MEM

Basically for hydrological reasons, the effective hydropower reserve capacity is not able to meet the demand for electricity, especially during the dry season, and the country has had to resort to its thermal power generation facilities[67]. Thus hydropower production between 1990 and 1997 grew at a rate of 3.9% per year, whereas thermoelectric power generation has grown at an annual average of 12.3%.

3.1.2 Production of secondary energy sources

The total production of secondary energy for the year 1997 amounted to 8,348 kTOE (excluding nonenergy products), with an annual growth rate of 3.9% compared to the preceding year, and an inter-annual average of 4.8% for 1990-1997, an index which is hardly higher than the one for the consumption of energy products, which during this period rose by 4%.

Fuel oil is the most noteworthy energy product because of its yearly production growth of 6.8% between 1990 and 1997, a growth rate that amply surpasses the increases observed in consumption (-0.5%), which means a higher volume of fuel oil available for export. In the mix of secondary energy source production in 1997, fuel oil ranks first, accounting for 44% of total.

Liquefied petroleum gas (LPG) displayed high growth rates between 1990 and 1994 thanks to the expansion of the processing capacity for this fuel. During the period from 1990 to 1997, it grew at an annual rate of 4.1%, which was lower than the 7.8% growth of demand. Last year, that is, 1997, production declined by 21.8% compared to the volumes reached in 1996. The high levels recorded for the consumption of liquefied gas implied that liquefied petroleum gas imports would continue to growth substantially, 10.6% per year between 1990 and 1997. At present, national LPG production accounts for about half of total supply of this energy product.

Table 17 Secondary energy production (kTOE)

	1990	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997***
LPG	168	212	246	287	285	242	285	223
Gasolines	1320	1373	1407	1342	1355	1288	1325	1395
Diesel Oil1	184	136	92	86	73	79	69	85
Turbo Fuel	184	190	203	199	185	218	224	259
Diesel Oil 2	1236	1387	1321	1462	1550	1464	1683	1836
Fuel Oil	2351	2287	2154	2245	3033	3247	3661	3725
Electricity	**548**	**603**	**619**	**639**	**710**	**763**	**779**	**825**
Hydroelectricity	431	440	429	502	569	470	545	562
Thermoelectricity	117	163	190	137	141	293	234	263
Total	**6083**	**6275**	**6127**	**6363**	**7311**	**7423**	**8142**	**8457**

* Provisional
Sources: INE - MEM

Diesel production has recorded a growth of 5.8% per year during the period 1990-1997, and in 1997 the increase was 9.1% over the preceding year. This fuel also increased its contribution to the production of secondary sources, from 10.3% to 21.7% during the above-mentioned period, but demand has grown considerably more than production, at an annual average of 8.3% during the same period), and because of this it has been necessary to increase imports to meet domestic consumption needs. Something similar is

[67] Power generation from Paute is limited to 820 MW, on the basis of an installed capacity of 1075 MW. During the dry season, the effective capacity of this power station is down to only 300 MW.

occurring with aviation fuels (jet fuel), whose production growth rate of 5% has not been in keeping with the national consumption increase of 8.4%.

Average growth of annual gasoline production is virtually at the same level as the increase of consumption (0.8% per year between 1990 and 1997). This fuel also contributes considerably to the production of secondary energy sources, although its share has tended to decline; in 1990 it accounted for 21.7% of total, whereas in 1997 it accounted for only 16.5% of total.

Kerex (diesel 1) was increasingly and relatively less important in the secondary energy source production mix, in response to a policy applied in 1991 to eliminate subsidies for the consumption of this fuel in the residential sector. Indeed, both the volumes produced in the refineries and the demand for kerex have declined considerably (by an annual average of 10.4% and 27.2%, respectively, between 1990 and 1997), so that at present this oil product accounts for only 1% of secondary energy production nation-wide.

Electricity, however, accounts for 9.8% of secondary energy source production, a share that has increased slightly over the last few years. The growth rate for the production of electricity during the period 1990-1997, which was 6%, was higher than the growth rate for oil products (4.7%), but slightly lower than the increase rates of sector demand for electricity (6.2%).

3.2 Trade

3.2.1 Oil and fuel oil exports

Oil is the only primary energy source that Ecuador exports. Between 1990 and 1997, oil exports evolved, to a certain extent, in line with production, in other words, steady growth with annual average increases of 4.5% and 5.6%, respectively.

In 1997, oil sales abroad amounted to one of the highest in terms of volume, since the export figure was over 91.4 million barrels, in other words, an average of 250,400 barrels per day, 4.87% less than in 1996, bringing earnings of US$1,190,930,000 FOB, on the basis of an average weighted export price of US$15.51 per barrel, in contrast to a price of US$18.04 per barrel 1996, and because of this oil exports brought in 18.22% less earnings. As a result of this greater activity in the oil production phase, the intensity of oil exports with respect to production has increased over the above-mentioned period, going from 59.3% in 1990 to 64.2% in 1997.

Table 18 Energy exports (kTOE)

Product	1990	1991	1992	1993	1994	1995	1996	1997*
Petroleum	8860	9332	10637	11397	12414	13453	12066	13014
Diesel Oil 1 / Kerex					18	7	2	6
Jet fuel					13	21	1	
Diesel Oil 2	117	50	22	71	135	27	12	16
Fuel Oil	1354	1384	1087	1352	1977	1929	2272	2504
Total	10331	10766	11746	12820	14557	15437	14353	15540

* Provisional
Sources: INE - MEM

The export of oil products is variable in terms of products. Between 1990 and 1993, fuel oil and diesel were exported, albeit only small amounts of the latter, whereas in 1994, only fuel oil was exported. As indicated, the capacity for refining heavy fuels has enabled important exportable balances to be obtained, and fuel oil is virtually the only export item among oil products. Between 1994 and 1997, small amounts of diesel oil 1 (kerex) and low-quality naphthas were exported, whereas fuel oil exports between 1990 and 1997 grew at an annual average rate of 9.2%.

Regarding total exports of hydrocarbons (including oil) made in 1997, foreign sales of fuel oil accounted for 16.1%, whereas as a share of exports of oil products only, fuel oil accounted for more than 99.1%. On the other hand, the larger volumes of fuel oil obtained in the refineries have meant that its exports have grown considerably over the last two years, eventually leading to an annual rate of increase of 9.2% between 1990 and 1997. The problem with this fuel lies in the difficulty of placing it on foreign markets as well as its low economic value on the international market, which is far below the one obtained for other fuels.

Fuel oil exports in 1997 amounted to 8.36 million barrels, at a weighted price of US$15.6 per barrel, which generated earnings of US$130.6 million FOB, meaning a decrease not only in terms of volume (31.06%) but also in terms of price (7.73%) compared to the preceding year. There were also 1.38 million barrels of naphtha exports that generated US$27.63 million at an average weighted price of US$23.3 per barrel, that is, 2.6% lower than the preceding year.

3.2.2 Hydrocarbons imports

There are no recent records of oil imports by Ecuador, since the country stopped importing oil in 1977, at which time the Esmeraldas refinery was commissioned.

At present, Ecuador's oil refining capacity enables the country to have a certain amount of self-sufficiency in terms of domestic supply of oil products, in addition to exportable surpluses of some oil products. The same does not hold true for liquefied petroleum gas processing plants, although most of LPG is also obtained from the refineries, because the facilities that the country has available are not enough to meet market demands, which grew at an annual average rate of 10.5% between 1990 and 1997.

Therefore, regarding the import of oil products, the most important are liquefied gas imports. Over the years 1994-1997, these imports have grown considerably at an annual rate of 17.9%. Regarding total imports of oil products in 1997, LPG imports accounted for close to 51% in terms of energy products. It must be emphasised that this share declined considerably compared to previous years, owing to the steep rise of diesel imports over the last four years (in 1993, household gas imports accounted for 98% of total imports).

The country's diesel refining capacity is no longer sufficient to meet demand owing to the relatively high increase of this demand; that is why this fuel is being imported increasingly frequently. As a rule, these imports take place during the final months of each year, as in the years 1994 to 1997, with an annual growth rate of 23.1%, owing to the higher demand for this fuel for thermoelectric power generation. In 1997, diesel imports accounted for 48.6% of total secondary energy imports.

Table 19 Hydrocarbons imports (kTOE)

Product	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997***
LPG	225	227	226	214	278	395	391	456
Gasoline	15	34	51			106		
Jet fuel	5	5	4	4	4	4	3	5
Diesel Oil2	30		85		198	334	344	435
Total	**275**	**266**	**366**	**218**	**480**	**839**	**738**	**896**

* Provisional   Sources: INE - MEM, Energy Balances

In addition to the above-mentioned fuels, small amounts of gasoline and jet fuel are normally imported.

The increase in imports over the past year is also largely due to the shutdown of the Esmeraldas refinery which was in the process of upgrading its capacity.

3.2.3 Balance of production, domestic consumption, export and export of oil products

At the beginning of the country's oil boom, the country's refining capacity and structure was relatively well adapted to the domestic demand for oil products. On average, imports did not account for more than 5% of final consumption and the surpluses of heavy fuels accounted for about 10% of production. Likewise, the refining capacity increased at rates similar to those for the consumption of oil products.

Since the start of the past decade, however, there has been a marked imbalance between the production structure and the final consumption of hydrocarbons: the intensity of imports of oil products has reached higher levels, accounting at present for 19% of consumption, an indicator that has grown gradually over the last few years, except for 1993. The situation is even worse in the case of household gas, for which average purchases from abroad in 1997 amounted to 1,110 metric tons per day, a volume that will grow relentlessly in the future if the extremely high subsidies granted to gas persist.

The current production structure is characterised by a high percentage of heavy oil products (close to 41% of total production). Over the last few years, the growth of fuel oil production has been 6.7% on average for 1990-1997 and 7.1% between 1994 and 1997; its consumption has not intensified, but rather has declined in 1997 compared to the volumes recorded in 1990 (-0.5% per year). The increase in the consumption of light and medium products, however, is higher than the indices obtained for the total consumption of oil products and is far higher than the refining output for these products, with annual average growth rates of 4.5% and 3% for the period 1990-1997, respectively.

On the basis of all these figures, it can be inferred that the increases achieved in the production of oil products respond, to a large extent, to the marked growth of demand. The general balance indicates that, between 1990 and 1997, the growth in the consumption of oil products, which rose by 29.7% during this lapse of time, is clearly higher than the relative increase in production (1.4 times higher in 1997 than in 1990). On the other hand, the export-production ratio, after having declined to 25% between 1991 and 1993, is now at about 33%, a higher percentage than the one calculated for 1990, which was 26.6%.

In short, with an installed refining capacity of 157,000 barrels per day, state refineries are at present meeting most of the domestic demand for fuel, except for household gas (LPG) and lately diesel, with exportable surpluses of fuel oil and smaller amounts of other oil products. Overall, the country has a surplus of hydrocarbon supplies, with exports clearly predominating over the imports of oil products. Nevertheless, the facilities for refining heavier crude oils must be adapted to two major needs that became apparent in 1995 processing of heavier crude oils, if the volumes that have been forecast are actually incorporated, and growing demand, which cannot be met by current facility

3.3 Energy consumption

3.3.1 Characteristics of recent evolution

Upon examination of Ecuador's final energy consumption structure by energy source, it can be observed that oil and gas products provide 71% of demand, with the remaining share being distributed among energy sources stemming from biomass and electricity, in that order of importance. For more than two decades, oil products have been dominant in the energy mix, with only insignificant variations in percentage terms. This is one of the main features of the country's energy balance, and there is no clear evidence that electricity or any other energy source will be able to substantially substitute these energy sources.

Table 20 Final energy consumption by source (kTOE)

	1990	1991	1992	1993	1994	1995	1996	1997*
BIOMASS	**1071**	**1103**	**1124**	**1190**	**1183**	**1223**	**1261**	**1314**
Firewood	868	883	909	946	965	985	1017	1061
Bagasse	203	220	215	244	218	238	244	253
HYDROCARBONS	**3653**	**3819**	**3811**	**3793**	**4077**	**4348**	**4558**	**4738**
LPG	416	432	473	503	546	625	692	704
Gasoline	1326	1411	1405	1399	1354	1315	1393	1402
Diesel Oil 1	171	109	84	54	48	33	32	40
Turbo Fuel	126	148	150	124	168	183	228	222
Diesel Oil2	1043	1196	1231	1264	1491	1609	1711	1819
Fuel Oil	571	523	468	449	470	583	502	551
ELECTRICITY	**412**	**453**	**471**	**486**	**546**	**591**	**607**	**628**
TOTAL	**5136**	**5375**	**5406**	**5469**	**5806**	**6162**	**6426**	**6680**

* Provisional
Sources: INE- MEM

Owing to the importance of the use of firewood and the substantial contribution made by bagasse in the industrial sector (sugar can industry), traditional energy sources continue to account for an important item in the national energy balance despite the apparent substitution of firewood for liquefied petroleum gas as a household fuel. Indeed, until 1977, firewood's share was higher than 31.3% of total final consumption, a percentage that has declined rapidly, to such an extent that, by 1997 it accounted for only 15.9% of demand coverage. In addition, LPG as a household energy source has made substantial inroads, so that from a slight contribution of 1.0% to the energy consumption mix in 1976 it now accounts for 10.5% of total final consumption.

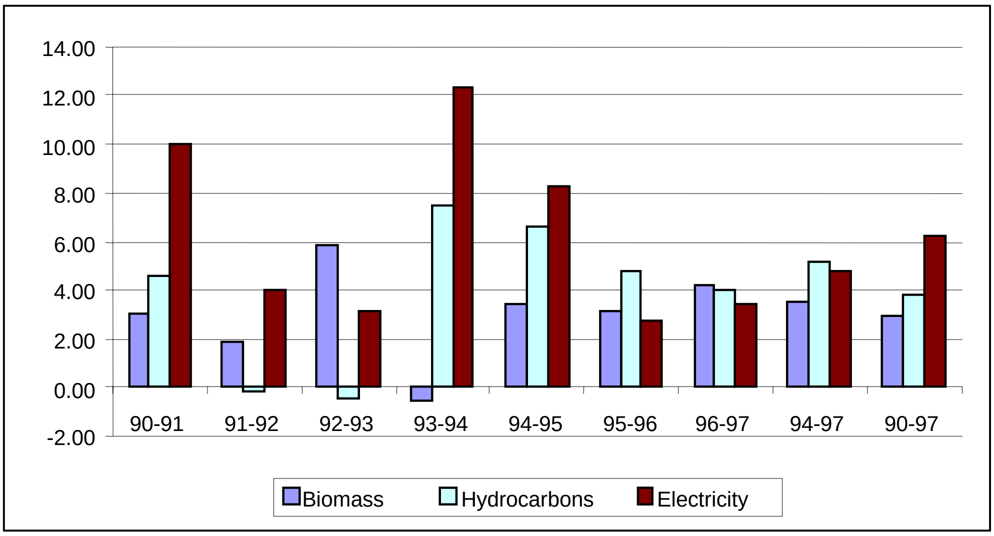
Liquefied petroleum gas is definitely the fuel that displays the highest growth levels in terms of consumption: 14.7% yearly growth during the period 1985-1990 and 7.8% between 1990 and 1997. Penetration of this fuel (of which there is a production shortage in the country) has taken place mainly in the residential and services sectors, although it is frequently used in industry.

Gasoline and diesel are the fuels most extensively used by the transportation sector: 77.5% of gasoline consumption and 58.3% of diesel consumption belong to this sector. In terms of percentage of final energy consumption, diesel and gasoline ranked first in 1994, in that order. Diesel is the fuel that shows the highest annual growth rate between 1990 and 1997, which implies that demand for this fuel has to be met by increasingly larger volumes of imports.

The decline in fuel oil consumption in 1997 is noteworthy; it has occurred in industry and sea transport. Although this fuel is exported, its placement on foreign markets is difficult, not only in terms of volume but also in terms of price, and therefore its use on the domestic market is highly advisable.

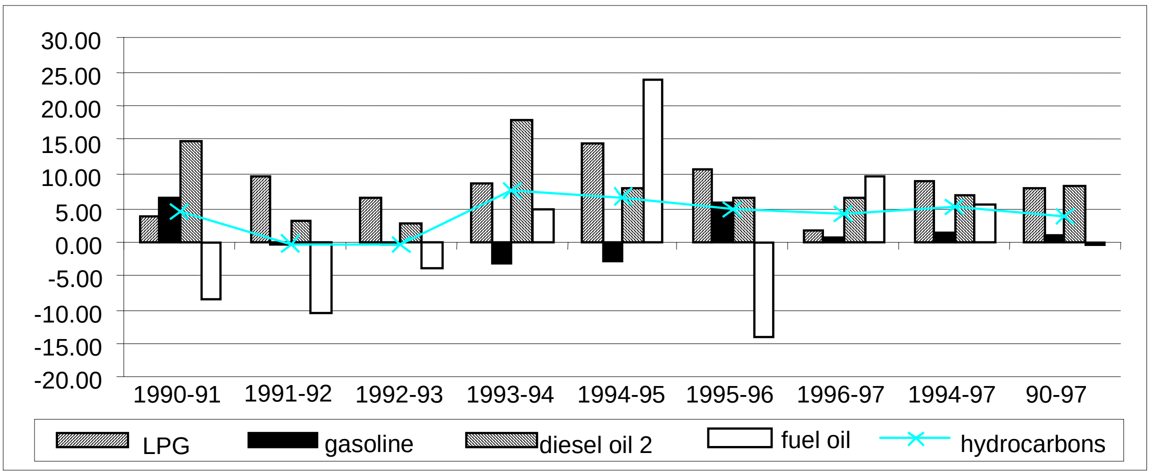
Turbo fuel is totally consumed by air transport and has displayed high annual growth rates, which is the result of higher activity recorded in this type of transport.

Figure 7 Growth rates of final energy consumption (%)



It can be observed that the annual average increase in consumption of oil products (5.1%) for the period 1994-1997 is higher than the annual average growth of total final energy consumption (4.8%) for this same period. It is noteworthy that LPG consumption growth is 8.8% per year. That is, the demand for hydrocarbons continues to grow rapidly, which means that over the medium term Ecuador could become a net importer of oil products. Indeed, between 1990 and 1997, the increase in crude oil loads to refineries for the production of oil products was, on average, close to 4% per year; part of this production is aimed at fuel exports, which during this period grew by close to 7%, which means that the increase in oil requirements to supply refineries is due mostly to the need to meet domestic demand.

Figure 8 Growth rates of petroleum product consumption (%)



It should be emphasised that the refining structure is not in line with the demand structure for oil products. Thus, in 1997, hydrocarbons accounted for 90.2% of secondary energy produced (8457 kTOE). As indicated, part of this energy is being exported (virtually the only oil product that is exported is fuel oil), and alongside this there is the import of some oil products, accounting for about 10% of total supply. Likewise, with respect to 1997, national production of light fuels was close to 50% whereas final demand was over 62.7%.

The figures for electricity demand indicate an annual average increase of 6.2% between 1990 and 1997, a value that is highly representative of the recent period and which is the result of the relatively high achievements in terms of service coverage, especially in the country's urban areas, so that this energy source is gradually increasing its share of supply for final energy consumption.

The highest share of electric power consumption is concentrated in residential use, which in 1997 accounted for 37.4% of total electricity requirements, whereas industry accounted for 32.2% and the services sector for the remaining percentage.

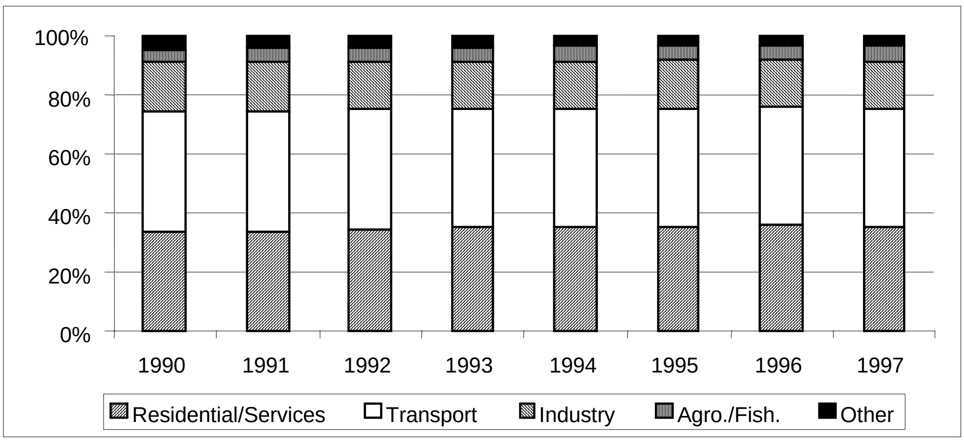
3.3.2 Energy consumption by sector

As for the energy demand structure by sector, the transportation sector accounts for close to 50% of national final energy consumption, a consumption that involves almost in its entirety oil products (gasoline 40.9%, diesel 39.9%, and other fuels 19.2%). Small amounts of electricity are used to operate the streetcar system in the capital. If only hydrocarbons are considered, this sector accounts for 56% of the country's overall requirements, reflecting the rapid growth of the passenger car fleet, the ageing of public transportation units, and the low efficiency of fuel consumption.

The demand for fuel oil in the transportation sector corresponds to the sea transport subsector, whose energy consumption has increased over the last year, possibly due to greater activity in this sector.

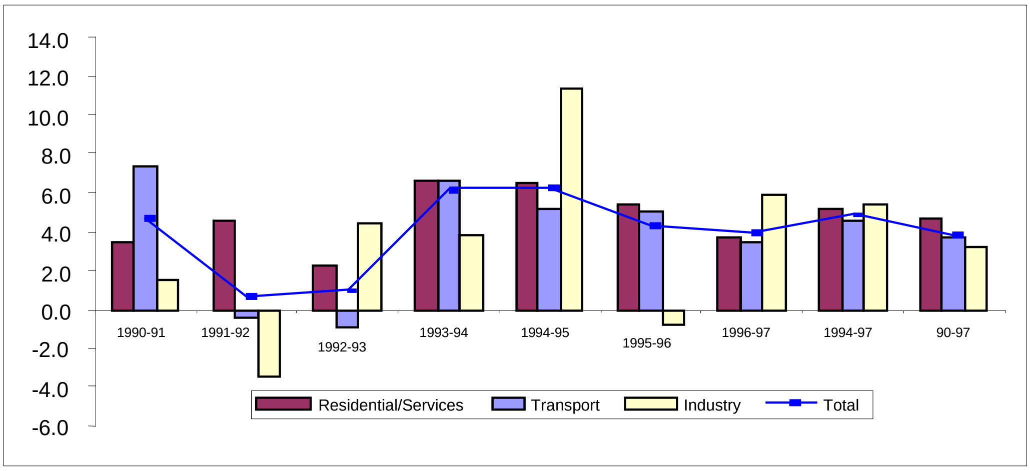
The residential sector is the main consumer of non-commercial energy, such as firewood and plant waste (41.5% of the sector's energy consumption), thus ranking second in terms of energy consumption in the overall balance. Nevertheless, as indicated previously, the relative share of these energy sources is clearly declining and because of this the sector, owing to the widespread penetration of oil products, has decreased its percentage share, which now accounts for about 28.3% of total final energy consumption. The gradual growth of the residential sector's participation in the percentage mix of commercial energy sources is therefore quite noteworthy (34% in 1985, 40.7% in 1990, and 45.5% in 1994).

Figure 9 Sectoral consumption structure (%)



LPG is the energy product with the deepest penetration in the household sector: it increased its share from 25.7% in 1990 to 32.8% in 1997 with respect to total residential consumption. This essentially due to its widespread use in urban households, which prefer this fuel for its high quality and, above all, the low sale prices that have prevailed for a long time. On the other hand, electricity meets 12.4% of residential energy demand, with a notable trend toward increasing this share.

Figure 10 Growth rates for final energy consumption (%)



The energy structure of urban residential consumption should be differentiated from the rural consumption structure due to the latter's need for firewood. In the urban residential sector, LPG consumption accounts for more than 59% of total consumption and electricity accounts for more than 29%, whereas in the rural sector, LPG accounts for only 14% of consumption and electricity hardly 1%, which is due to the fact that large segments of the latter sector have no access to modern energy sources. As a result, in these areas they have to resort to biomass use, despite all the difficulties existing in some zones of the country for ensuring supply of this type of energy sources, in addition to the fact that these fuels do not fully meet the energy needs of the users.

Table 21 Final energy consumption by sector (kTOE)

SECTOR	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997***
RESIDENTIAL/SERVICES	1726	1785	1867	1908	2035	2168	2284	2368
Residential	1425	1447	1511	1561	1635	1733	1829	1893
Services	301	338	356	347	400	435	455	475
TRANSPORT	2059	2210	2200	2179	2324	2443	2567	2657
INDUSTRY	863	876	846	883	917	1021	1013	1073
AGRO/FISH	230	253	256	258	298	314	334	354
OTHERS	248	244	237	231	224	215	228	231
Total	5126	5368	5406	5459	5798	6161	6426	6683

* Provisional
Sources: Former National Institute of Energy, Energy Balances.

The industry ranks third among energy consumers (16% of final consumption) and second in terms of commercial energy consumption, reflecting the country's relatively slight industrialisation. It is apparent that total energy consumption in industry has increased moderately between 1990 and 1997 (annual average of 3.2%), in contrast to the growth of the sector's gross domestic product, which in this same period increased by an annual average of 3%, which probably is evidence of higher energy productivity in industry (decline of energy intensity).

The industrial consumption structure shows the prevalence of hydrocarbons, which cover 50.1% of sector demand, distributed largely between diesel and fuel oil. The latter displays a behaviour that is not in line with the country's supply structure (it has fuel oil surpluses); according to the energy balances, there has been a steady decline of fuel oil demand in the sector, which is inexplicable. Electricity accounts for 18.9% of total industrial consumption, which is the energy source with the greatest penetration in the sector, substituting oil products and biomass.

Plant waste accounts for a substantial share of the energy supply for industry, with close to 31% of the sector's consumption, owing to the intensive use of bagasse as a fuel for the sugar industry. Industry also consumes liquefied gas, gasoline and kerex (diesel 1), but their contribution is quite slight compared to the four basic energy sources of the sector: bagasse, fuel oil, diesel, and electricity.

The services sector is one of the sectors with the highest annual average growth in terms of energy consumption over the last few years, and by 1997 it had increased its share of the final energy consumption mix by 1.1% compared to 1990. The principal energy sources used in the sector are diesel, electricity, and gasoline, accounting for 44.2%, 38.9%, and 7.7% of final energy consumption, respectively, but the growing contribution of liquefied petroleum gas should also be taken into account as an energy source for this sector, a fuel that covers virtually all the energy needs for cooking.

Finally, it is important to emphasise the significant participation of the item Others in the energy balance, which accounts mostly for nonidentified consumption, which is partially explained by the illegal trade of gasoline and diesel to Peru and liquefied petroleum gas to the country's neighbouring countries.

4 Energy prices

The energy pricing policy in Ecuador is noteworthy for its public revenue approach, since the government implements price adjustments essentially to cover state budget deficits. As a result, pricing policy is only peripherally linked to global economic policy, which at present is striving to stabilise the economy by means of the free play of market forces, deregulation of prices for public services, the elimination of subsidies which are deemed to be distorting the signals that the pricing system should be transmitting to the consumers, reduction of fiscal deficits, and cost recovery by means of a cost-benefit analysis. In addition, the pricing policy theoretically continues to be used as a public instrument to redistribute incomes, which in practice is partially being accomplished, since it benefits those who consume the most. At present, the State rather than the production companies is granting the subsidies. On the other hand, energy saving and conservation is relying only on the impact of prices and tariffs.

The application of this pricing and tariff-setting policy is also linked to the sector's institutional restructuring with the participation of the private sector, the break-up of state monopolies, and the promotion of competitiveness.

4.1 Electric power tariffs

According to the Basic Electrification Law, tariffs should reflect service costs, which include operating costs, reserves for depreciation, and usefulness. The tariffs are set by the Board of Directors of INECEL, on the basis of information from the electric power utilities.

The current tariff structure establishes differential rates depending on the sector: residential, commercial, industrial, street lighting, government entities, and social welfare. In addition, for the industrial, commercial, and special services sectors, additional fees are set for power capacity contracting. In addition, within each sector there are different tariff levels, which are highly progressive and benefit the lowest consumption strata, especially in the residential sector.

There is a single tariff structure for the entire country, whereas the energy sold in bulk by INECEL to electric power utility companies has different prices for each one of the utilities In 1997, the average bulk tariff was 175 sucres per kWh, equivalent to 4.3 US$ cents. Lower tariffs are charged to smaller companies, which cannot recover their costs through tariffs, because of their small markets, or to companies that are undergoing financial problems. The highest rates are paid by the large utilities and those where industry accounts for a large share of consumption. Thus, this structure generates cross subsidies between the power distribution utilities. This system was established on the basis of regional and social development considerations although it has not fostered efficiency or helped to reduce losses. The bulk tariffs are being revised periodically, in accordance with the financial situation and market structure of the power distribution utilities.

As for the tariff structure for the consumer, the residential sector has always benefited from preferential rates, which are lower than those applied to the commercial and industrial sectors and at the same time are displaying a downward trend, since the real value of residential tariffs is actually being undermined by inflation. This is the only sector that is benefiting from a financial and economic subsidy, which was recently, in 1997, reduced as a result of the considerable tariff adjustment in this sector, although residential rates continue to be slightly lower than the others. The residential sector rates are not in line with service costs, but are based on political considerations aimed at ensuring income redistribution, even though this approach is not always successful. There are subsidies for residential consumers up to 1,000 per kWh per month, which is not justified even in terms of social equity. The State has to pay for the subsidy through INECEL, an obligation that the State fails to comply with, and this leads to severe financial problems for this institution, as it prevents the availability of resources to ensure an efficient operation and maintenance of the system, much less new investments. In addition, there are cross subsidies for the benefit of the residential sector, coming from industrial and commercial consumption. In addition, the maintenance of subsidies at high consumption levels does not favour the efficient use of energy through the rational use of energy and the substitution of old appliances for efficient appliances, except for water heating where the substitution of LPG for electricity has become a common practice. The evolution of electricity tariffs is shown in Table 22.

In the residential sector, electric power consumption is highly concentrated, reflecting prevailing income distribution conditions. Thus, customers that consume up to 150 kWh account for more than 70% of the total number of customers and require only 33% of the electricity consumed in the residential sector; at the other end of the spectrum, 2.7% of the total number of customers that require 500 kWh and over are consuming 20.5% of the electricity. This situation means that the subsidy is equally concentrated and that the low-consumption customers also receive a highly reduced subsidy.

Compared to the Andean subregion countries, the residential rates for Ecuador are higher than those in Colombia and Venezuela (3.96 U.S. cents per kWh and 1.25 U.S. cents per kWh, respectively, in 1997). As for Peru, the ratio is reversed because this country has policy aimed at keeping low industrial rates (5.21 U.S. cents per kWh in

1997) and much higher residential and commercial rates (13.77 U.S. cents per kWh and 11.20 U.S. cents, respectively, for the same year). In Ecuador, however, industrial rates remain at an intermediate level between the commercial and residential rates; they are lower than those for Colombia (7.97 U.S. cents per kWh in 1997) and higher than those for Peru in 1997 (5.21 U.S. cents per kWh) and considerably higher than those of Venezuela (3.23 U.S. cents per kWh).

Table 22 Electricity tariffs by sectors

YEAR	INDUSTRIAL	COMMERCIAL	HOUSEHOLDS
1982	6.79	8.08	6.20
1990	3.67	3.55	1.94
1991	4.37	4.14	2.08
1992	5.41	5.72	2.48
1993	8.73	8.22	3.48
1994	9.00	9.00	4.00
1995	7.25	7.12	3.18
1996	5.54	5.63	2.50
1997	6.47	6.97	5.98

Source: Latin American Energy Organization (OLADE), Energy Information System (SIEE)

It is felt that the higher tariffs for the industrial sector, compared to the residential rates, which industry and commerce must pay in Ecuador, do not really undermine the international competitiveness of these sectors, essentially because the share of electric power spending in the intermediate consumption of the companies is not significant.

According to the new Electrification Law, passed by the legislature but whose regulations regarding the application of the rates have not been finished, cross subsidies for the benefit of the poor residential sectors will be established. According to the new Law, there will be competition between power generators, and distribution utilities will have to pay the real costs of bulk energy. The policy that will be applied by the State through CONELEC, which is the regulatory agency, for the power distribution companies that are at present receiving the subsidy, has not yet been decided.

4.2 Prices of oil products

The prices of oil products have been adjusted in response to specific State budget financing needs, as indicated by the high share of total budget revenues stemming from oil products.

As a result of the Hydrocarbons Law, in January 1998, the prices of oil products were liberalised; until then they had been set on the basis of production costs plus a reasonable profit. The pricing scheme has freed MEM from discharging this responsibility, which was transferred to the Ministry of Finance. For this purpose, the benchmark that was used was 90% of the average price for Gulf Coast oil products, the price of crude oil exports, the U.S. dollar rate on the free market, plus a custom duty. In order to determine the consumer price, according to the corresponding legal provision, a maximum profit margin of 18% for the distributors, calculated on the basis of price at the terminal and depot, is allowed.

Thus the trading of fuels was liberalised, and this has promoted the formation of marketing companies that have their own distributors; theoretically at least competition between these distribution companies should prevail. In practice, it should be observed that there are signs of collusion, as the prices for all the distributors are virtually the same.

In order to keep revenues flowing into public coffers in case crude oil prices drop on the international market, the benchmark customs duty can be increased when the crude oil export price is under US$13 per barrel. This scheme turns out to be highly inconsistent with the economic policy of basing prices on their own opportunity costs and highlights the eminently state-controlled character of pricing in Ecuador.

The evolution of domestic prices for oil products, except for LPG, in terms of U.S. dollars, is shown below.

Table 23 Oil product prices (US$ /barrel)

	DIESEL OIL		FUEL OIL	GASOLINES		TURBO	
YEAR	IMPORT PRICE	DOMESTIC PRICE	DOMESTIC PRICE	IMPORT PRICE	DOMESTIC PRICE	IMPORT PRICE	DOMESTIC PRICE
1990	25.34	16.96	13.68	23.00	18.05	48.27	18.05
1991		17.02	12.57	25.14	17.81	49.23	18.46
1992	25.41	24.38	11.65	23.61	24.74	37.04	26.92
1993		32.05	15.04		32.05	35.40	35.12
1994	22.10	33.46	14.95		48.68	36.45	31.60
1995	22.67	47.34	16.37	24.85	47.56	54.57	31.12
1996	29.13	34.62	18.17		48.09	57.81	33.04
1997	25.45	31.83	15.32	26.55	45.61	48.64	33.31

Source: OLADE, SIEE

The price of diesel has remained at about 30% lower than gasoline, in order to prevent the costs of heavy-duty transport of freight and passengers from rising; in addition, as a result of the higher calorific power, the difference in price in terms of final energy favours diesel much more. There are different prices for premium and extra gasoline as a result of cost considerations, depending on the quality of the product, and their prices are higher than opportunity cost, that is, the price of the imported product.

As for diesel, it is expected that the price hike that took place in the nineties will be an incentive for consumers to use this fuel more rationally. Nevertheless, factors such as the obsolescence of transportation units, especially in the cities, make it difficult to achieve this objective.

LPG is the product that has undergone the least price adjustment and this, along with the marketing expansion policy, has led to a very high growth in consumption of LPG. LPG use has increased even further as a result of the attractiveness of the illegal trade toward neighbouring countries, which springs from the difference between prevailing prices. In 1997, the price in Colombia for household gas was US$19.6 per barrel, in Peru the price for that same year was US$79.6 per barrel, whereas in Ecuador was US$7.12 per barrel, as it is shown in Table 24. In addition, the expansion of consumption is being fostered by the substitution of electricity for water heating in households and hotel establishments. Price readjustments for this fuel have become politically controversial and have been used as an election campaign ploy, so that decision making regarding this issue has become difficult inasmuch as LPG has benefited from a long-standing tradition of subsidies and its use is widespread, even in the rural sector.

Table 24 LPG prices (US$/barrel)

YEAR	PRICE OF IMPORTS	HOUSEHOLDS	COMMERCIAL
1982	37.15	33.96	33.96
1990	25.19	5.69	34.17
1991	24.71	5.45	27.13
1992	23.02	7.78	38.40
1993	22.20	8.84	52.56
1994	21.63	7.71	45.85
1995	22.16	6.53	38.85
1996	26.48	5.25	31.21
1997	23.43	7.12	

Source: OLADE, SIEE

During the nineties, LPG prices in terms of U.S. dollars were not able to recover their price levels of the preceding decade. In addition, the insufficiency of national facilities to meet domestic demand for LPG, 50% of which is being covered by national production, means that substantial amounts of foreign currency are being drained to ensure LPG imports. As indicated in the table above, the cost of imports has no relation whatsoever to the sale price on the domestic market. The price of LPG, which is equivalent to US$7.12 per barrel, is far from the international price paid by PETROECUADOR for LPG imports. This domestic price does not even cover costs for storage, bottling, wholesale and retail transport, and distributor profits and thus it is generating a clear deficit for PETROECUADOR. For industrial and commercial use, the LPG price is much higher than its economic cost (US$31.2 per barrel compared to US$26.5 per barrel in 1996), but this is a theoretical price because of the alternative of using household gas bottles.

The policy of suppressing kerex as such has led to the elimination of a product that could have been used as a substitute for household use by low-income groups instead of firewood when the price of LPG rises.

The products that are currently benefiting from a subsidy are LPG and diesel aimed at the electric power subsector, whose price is 590 sucres per gallon, equivalent to 22% of the market price.

The LPG subsidy can be considered from two points of view: a financial subsidy and an economic subsidy. The former would be determined on the basis of the difference between its domestic production, transport, and marketing cost and its consumer price, to which would be added the differential between this consumer price and the price of the imported LPG, plus the respective marketing and transport costs.

The LPG import volumes in 1996 and 1997 (2,211,600 barrels and 2,873,400 barrels, respectively) entailed expenditures of US$49,097,300 and US$62,151,00, in that order, which once sold on the domestic market meant financial subsidies for the imported LPG of US$29,701,800 and US$39,882,800, respectively, just for the imported fuel. To obtain the total financial subsidy being provided for LPG, one would have to add the part corresponding to the nonrecovery of costs for the sale of domestically produced LPG, including all transport, marketing, and distribution expenditures.

The economic subsidy, on the other hand, is based on the opportunity cost principle, which for goods that are not produced or are only partially produced in the country means the import price. For the years 1996 and 1997, the economic subsidy calculated this way is estimated to be US$69,881,700 and US$81,681,300, respectively, to which one would have to add the domestic transport, marketing, and distribution costs.

From this it can be concluded that the opportunity cost of this subsidy is extremely high, since resources are being diverted from the provision of basic services, such as health, education, housing, and sanitation.

This subsidy is eminently regressive as it benefits the higher-income groups, whose per capita consumption is much higher. For the higher-income families, annual consumption can amount to 1800 kg, whereas at the other end of the social scale, a low-income family may consume hardly 10 kg per year; it therefore becomes evident that the former are highly benefiting from the subsidy. In addition, the 17% of Ecuadorian families that are living in critical poverty do not consume any gas but rather firewood, without benefiting from the subsidy at all.

Mitigation Options

1 Energy end uses

1.1 Energy forecasting in the residential and services sectors

1.1.1 Reference scenario

The baseline case or reference scenario for these sectors is based on the following assumptions:

- The first hypothesis takes into account the energy pricing policy. With the new regulations recently applied to Ecuador's energy sector, it is clear that the prices of all sources will tend to reach levels reflecting their true costs, and this implies substantial hikes in current electric power rates and especially in the price of each kilo of LPG for household use. For electricity, it is has been determined that, up to the years 1999-2000, the rates should be equivalent to an average of 10 U.S. cents per kWh, according to the marginal cost structure defined in the New Tariff System for the Electric Power Sector of Ecuador (MEM-INECEL, 1996). Also in the case of LPG, although it is a fuel that is used massively and any LPG price adjustment will have major social repercussions, it is believed that, over the short term (to the year 2005), its price will come close to its opportunity cost (international price).
- With price hikes, there will be a contraction of demand, which according to estimates will be in keeping with price elasticities: -0.1 for electricity (MEM-INECEL, 1996), -0.05 for LPG in the urban sector; and -0.1 in the rural sector (ESMAP, 1994). It should be noted that the price elasticity values of LPG are significantly low, especially in the urban sector, because this fuel is virtually impossible to substitute. Variation in the consumption of this energy product due to the impact of tariff adjustments will take place only up to the year that the price levels off, at which time it is assumed that it will remain at its real levels, and therefore the price-elasticity effect would remain null.
- It is estimated that the intensities corresponding to the different uses of electricity in these sectors might decline in the baseline scenario by about 10% to 20%, depending on the specific energy use and the current trends regarding the introduction of new technologies for energy consumption.
- For the other energy sources used in these two sectors (biomass and oil products, except for LPG), the energy intensity values in each one of the uses throughout the period of analysis remain unchanged. The changes in energy efficiency in these cases are therefore considered to be the result of the weak trends observed in the substitution of energy sources, the replacement of equipment, and the penetration of new technologies. In other words, no important structural changes stemming from the introduction of specific measures for energy conservation or other types of action have been considered.

For the residential sector, hypotheses regarding energy substitution were introduced on the basis of processes observed over the last few years. The following parameters (penetration rates) have been used to simulate the evolution of equipment ownership in the sector[68].

Table 25 Rates of penetration of energy sources

Source / Sector	Urban area %	Rural area %
LPG	2.9	
Electricity	0.7	0.5
Biomass	-1.3	-0.4

Source: Own elaboration, based on INEC statistics

Taking these figures into consideration, the basic assumptions that have been taken into account in the baseline case forecast regarding energy source penetration / substitution are the following:

- Short / term substitution of gasoline and kerosene used for heating purposes for LPG.
- Steady substitution of firewood used for cooking and heating water for LPG, in keeping with the declining use of biomass fuels in urban and rural areas.
- 100% of middle-income and high-income urban households will be using LPG for cooking by the year 2010, whereas saturation for the low-income groups will be achieved by the end of the period being reviewed herein.
- As for water heating, the percentage of households using LPG, electricity-powered accumulation tanks, and solar energy heating systems remains constant, with the number of household using electric showers increasing, in keeping with the penetration rate of this electricity in each area. In other words, the baseline case does not envisage any type of measure that might accelerate the penetration of solar energy for heating water.
- Likewise, it is assumed that the kerosene currently being used for lighting in households without electricity will be entirely replaced by LPG lamps.
- As for the use of incandescent lamps, the assumption is that electric power coverage rates will amount to 100% for middle- and upper-income strata by the year 2010, whereas 100% for low-income strata in urban areas and 62% for rural sectors by the year 2030. In addition, the proportion of households using conventional fluorescent lamps will remain virtually unchanged, and it is not expected that more efficient lamps will achieve any greater penetration.
- Regarding the other uses of electricity, it is assumed that the number of households with electricity will grow in keeping with the rate of penetration of this energy source, but there are some uses, such as refrigeration in the middle- and high-income strata of the urban areas, which would become saturated much before the horizon year of the forecast.

---

68 The ideal in these case is the use of logistic curves to evaluate the penetration of technologies, which are built on the basis of the data obtained from manufacturers, concession holders, specialists, and users. Unfortunately, at present not all the information of this kind that could be used in the country exists.

1.1.2 Equipment used and technological options to conserve energy in the residential and services sectors

At this time it is worthwhile to mention some aspects of equipment ownership in Ecuador, although the most noteworthy is that in general energy use involves the use of traditional firewood stoves, incandescent lamps, refrigerators, and other appliances that are inefficient, in keeping with the low earnings prevailing in the country.

Cooking and preparing food

The use of highly efficient firewood stoves is virtually non-existent. Some of the campaigns undertaken to introduce this type of equipment, mainly by international organisations, have not yielded the results that were hoped for; therefore the most commonly used stoves are several types of traditional stoves, for the most part rudimentary in their construction and inefficient in terms of energy consumption.

Owing to the extensive use of LPG stoves, the use of electricity for cooking food is highly uncommon, unless one refers to the use of ovens and other types of complementary appliances (toasters, coffee makers, etc.). Likewise, LPG has substituted other fuels usually used in cooking, so that the use of other oil products is today quite infrequent. In the country, various models of gas stoves are used, usually involving a top range with two to four burners (of different sizes) and a lower part for the oven. One important aspect worth noting is that, in the country, there are no standards governing the construction, performance, and safety characteristics of these appliances, much less any kind of efficiency norms for them.

The efficiency of stoves is generally low, because their characteristics, in terms of design and construction, permit a huge amount of heat to be wasted in fuel burning. Because of this, improvements in the efficiency of food cooking is rather associated to other aspects such as the energy source used (electricity, solid, liquid or gas fuel), the type, shape, and material of the pots used, and the cooking practices (such as the use of covers on the pots, pressure cookers, etc.).

The most important breakthroughs in terms of stove efficiency have been in the use of electric appliances, where the direct contact between the heat delivery coil or plate (or resistance) and the bottom of the pot or pan eliminates a large part of the heat losses in the process. In addition, technological innovations have been introduced to reduce energy consumption, such as thermostatic timers, and now specialised appliances such as toasters, fryers, grills, electric pots, sandwich makers, etc. which generally have an internal resistance that reduces the losses stemming from transmission and enhances appliance efficiency, are widely used.

A high-efficiency infrared burner for stoves is being developed by Thermoelectron Corporation in Waltham, Massachusetts, United States, with an efficiency of 65 to 70%, which is higher than the efficiency of 40 to 50% of conventional gas-fired stoves and also involves lower CO and NOx emission levels (Goldemberg, 1988).

Regarding firewood, the use of various types of efficient stoves that were developed some time ago, is an option that can bring major savings in the demand for firewood. The efficiency of these stoves is between 14 and 18% (or even more, depending on the model), compared to widely used traditional models, whose overall thermal efficiency is not more than 10%, at a cost of between US$6 and US$10 (1992 prices). In the case of liquid fuels, improved stove models can be found for about US$40, whereas the solar energy alternative (solar stoves) have a cost of US$25 (IPCC, 1996 b).

Water heating

The electric shower is the most widely used water heating system in Ecuadorian households, and that is why consumption for these appliances is quite high (from 365 to 1,095 kWh per year). Households also resort, although to only a small extent, to central water heating systems (electricity-powered accumulation tanks, generally from 110 to 180 litres at 1.5 to 2 kW), especially in the middle- and high-income groups of the Ecuadorian highlands, which provide better hot water service albeit at a much higher cost. In the rural areas of the sierra, however, owing to the lower level of electric power service coverage, it is necessary to use biomass fuels to obtain the energy needed to heat water.

Electricity consumption savings in water heating can be achieved by improving the efficiency or reducing the amount of hot water used.

The principal option to enhance efficiency is the substitution of electrical resistances for heat pumps, which operate by extracting heat from the surrounding air and use it to heat the water of a water storage tank. These appliances are two to two-and-half times more efficient than the heaters that use electrical resistances, but their cost is high, from US$700 to US$1,800 depending on size (IPCC, 1996 b), although there is a small pump manufactured in Brazil that is being marketed at about US$220 (Geller, 1990).

The introduction of improvements in the insulation system of accumulation heaters is another lower-cost alternative, aimed at increasing water-heating efficiency.

One of the alternatives to reduce the amount of hot water is to add a variable power control to the showers, enabling the user to select the suitable power level for a given flow of water, instead of the current showers that have only three options: off, 50-75% of power, and 100% of power.

Regarding the substitution of electricity and / or fuels, solar systems for heating water have been available for a long time now, and they have evolved over time in terms of design and features. At present, the two most common types of solar collectors are: flat or with an integrated storage system. In this case, the cost range is highly variable, but it can be said that each squared meter of collection costs about US$300, to which should be added the cost of the storage tank if its installation is necessary.

Lighting

There is a marked prevalence for the use of conventional incandescent lamps, and it could be said that all the country's electrified households use this type of appliance for lighting, although on the market, at present, there are more efficient lamps on sale. The majority of households using fluorescent lamps belong to the upper-income group, which resorts to this type of lamp to light certain areas of the household, such as the kitchen, bathrooms, etc., more specifically on the coast, especially in rural areas, where these types of lamps are used in order to avoid attracting insects and to reduce the release of heat.

Electricity consumption in lighting can be reduced by the use of both higher-efficiency incandescent lamps and normal or compact fluorescent lamps.

The former consume about 10% less electricity than the conventional incandescent lamps, with a small reduction in lighting levels, and cost about 35% to 40% more than the conventional lamps. Normal fluorescent lamps (typically, long 19-watt tubes) produce close to three times more light per unit of power (including losses in the reactor), compared to incandescent lamps and cost about US$5.

Compact fluorescent lamps (9-20 watts) are at present widely available, at prices that are between US$9 and US$25, depending on the type of reactor they have. They can be used to substitute incandescent lamps by the use of adapter, which is the reactor itself, which has the same screw-on base as incandescent lamps. This type of lamp supplies the same flow of light as an incandescent lamp but with 85% less electricity consumption and a useful life that is 7 to 10 times longer (Abilux, 1992).

Refrigeration

The majority of refrigerators used in households have one single door, are manufactured in the country, have a capacity of 10 to 11 cubic feet (283 to 311 litres), and consume about 780 to 990 kWh per year. There are virtually no refrigerators with efficiency rating being sold in the country.

Experience shows that substantial progress in reducing the electricity consumption of refrigerators is constantly being achieved. The efficiency of these appliances has increased with the use of motors and compressors with higher yields, the modification of the design of the refrigeration system, reduction of the capacity of the electrical resistance of the warming, and/or improvements in insulation.

It is estimated that greater progress can be introduced, for example, through the use of insulation with polyurethane foam, instead of fiberglass that is generally used in models manufactured in Ecuador or the use of more efficient compressor-motors. A current refrigerator consume on average more than 2.0 kWh per litre of volume per year, but now models that consume less than 0.6 kWh per year per litre are being produced at a cost that is 10-20% higher than the ones most commonly available now (IPCC, 1996 b).

Studies conducted in the United States and Brazil indicate that about 30 to 50% of the reduction in the consumption of electricity could be achieved with an increase of only about 15-30% in the cost of manufacturing, which would imply savings of 150 to 400 kWh per year at a cost of US$45 to US$75 for the consumer (Geller, 1991).

Air conditioning and heating

Air conditioning is an unavoidable necessity in the coastal region of the country, in view of its high temperatures and humidity throughout the year. Nevertheless, owing to the high cost of air conditioning equipment, which is imported in its entirety, different types of ventilators are used more frequently and are even more noteworthy in rural areas. In the coldest zones of the highlands, heaters are used albeit not very frequently, and in many case biomass fuel is consumed in fireplaces.

There is a wide variety in the efficiency of air conditioners available on the world's markets, and this efficiency is indicated by their respective energy efficiency ratio (EER).

Depending on the type of air conditioner, the EER range is between 8.2 and 9.0 for the most commonly marketed systems, but there are advanced systems that have an EER that is higher than 12, and it is expected that this ratio will increase with the development of equipment with rotating compressors and with improvements in the motors and heat exchange system. It is estimated that the incremental cost of manufacturing more efficient air conditioners will not be more than 5% of the current sale price, and therefore reductions of 20% to 40% in electricity consumption could be achieved (IPCC, 1996 b).

Other uses

Water pumping is an electrical use that is very rarely required, whereas ownership of different types of household appliances (such as, ironing equipment, sound equipment, televisions, vacuum cleaners, etc.) is apparent, to a greater or lesser extent, in most electrified households. It is evident that the ownership of household appliances increases with the household income level.

1.1.3 Mitigation scenario

Residential sector

The proposal of the mitigation scenario for the residential sector is based on the following fundamental premises:

- The same economic and demographic contexts as those adopted for the baseline case, including the price adjustments made for electricity and liquefied petroleum gas, are kept.
- In order to be more realistic regarding the applicability of the different mitigation measures proposed in the mitigation scenario, it is assumed that the performance of different variables changes as of the year 2000, which means that until this year the growth of energy consumption will be similar in both alternatives.

For the specific case of energy use in the sector, the following assumptions have been adopted.

<u>Cooking</u>

- The same percentage of households using firewood in the urban and rural areas is maintained but the total, albeit gradual, substitution of traditional stoves for efficient stoves, which entails a reduction in energy intensity depending on the energy efficiency ratio of each stove (10 to 18%, respectively), is included. This is possible to achieve by means of demonstration and efficient use programs of this resource.
- It is assumed that the LPG penetration process in the household sector will continue in the future, substituting gasoline, kerosene, firewood and even electricity, and as a result a decline in energy intensity of this use will take place, owing to the use of a more efficient energy source. In addition, it has been considered that the introduction of better technologies in gas equipment and a more extensive use of auxiliary appliances for cooking with electricity, such as microwave ovens, could increase the energy conversion efficiency by about 10 to 40%, respectively (Geller, 1992).
- Although solar cooking technology is not widely accepted in the country, it is proposed that actions be implemented to permit making complementary use of this type of appliance, so as to ensure that at least 1% of households have these systems by the end of the forecasting period.

<u>Water heating</u>

- This is one of the uses that has the highest potential for the penetration of solar energy; because of this, the goals for the horizon year are to ensure that, by means of different types of promotion and incentive programs, at least 25% of urban households and 12.5% of rural households have solar water heating systems, substituting firewood, electricity, and LPG, which are the energy sources currently being used for this purpose.
- The more intensive use of solar energy would help to eliminate the use of firewood and LPG for this purpose, with only electricity being kept for water heating. Nevertheless, it is expected that the penetration of other technologies

such as heat pumps and variable power control of showers, in addition to improved design and construction and enhanced insulation of conventional tanks, will help to bring major energy savings in this area. Thus, the forecasting that was conducted assumes the introduction of heat pumps in the urban sector (1.7-3% of households by the year 2030, depending on the social sector), as well as the reduction of about 20% in the energy intensity of the showers and accumulation tanks.

Refrigeration

- Although the same rates of penetration as the ones used in the baseline case are kept for refrigeration appliances, it is assumed that, over the long term, all the appliances currently used in the residential sector will be entirely substituted. These appliances will be replaced by efficient refrigerators, whose energy intensity is expected to be 70% less than current ones.

Lighting

- It is assumed that the trend toward the disappearance of kerosene for residential use will prevail and kerosene will be replaced by LPG lamps in households that do not have electricity in lower-income urban and rural areas. Nevertheless, it is expected that there will be a decline in energy intensity on the order of 20% in this use.
- Regarding electric lighting, basically the application of mechanisms that facilitate the gradual substitution of conventional incandescent lamps is being proposed so that the goal of having the country's electrified households use efficient incandescent lamps for 50% of its needs, conventional fluorescent lamps for 25%, and compact fluorescent lamps for 25% is attained by the end of the forecasting period. No changes in lighting levels have been assumed, and thus the number of lamp-hours per day has remained the same for all social groups.

Air conditioning, heating, and other uses

- Regarding the use of firewood for district heating, it is assumed that those households now using this energy source will stop using it over the long term and eventually opt for the use of electric heaters.
- As for the electrical equipment for air conditioning (ventilators, air conditioners, etc.) and other uses, it has been taken into account that, now on the market, it is possible to find systems with efficiency levels that are higher than conventional systems, which will permit reducing energy intensity on the order of 20% for this use.

Services sector

- As in the residential sector, it is estimated that the use of rational-use-of-energy practices for cooking food, which can be achieved by means of energy conservation drives and the penetration of higher-efficiency equipment, could lead to a decline in the specific consumption of sources used for this purpose (basically LPG and electricity) on the order of 20% at the end of the period being reviewed.
- The uses such as water heating, air conditioning, and food preservation are assumed to achieve savings in the demand of oil products and electricity, which would be placed around 20% of current consumption.

- As part of the mitigation scenario, it is believed that important savings can be obtained in the use of electricity for lighting purposes by just substituting traditional lamps for more efficient lamps. Thus, for example, it has been taken into account that, in the subsector corresponding to street lighting, the lamps generally used will be replaced by lamps that provide higher lighting levels and improve energy consumption. The assumption in this case considers that, by the year 2010, there will be a 32% substitution of lower-efficiency luminaries (mercury, mixed, and other lamps) for sodium vapour lamps and that by the horizon year, the replacement of this type of luminaries will on the order of 70%.
- Savings in energy consumption in the other uses considered in this sector are also based on a reduction in the energy intensity of oil products (1% yearly average) and electricity, which could be achieved by applying diverse energy-saving measures.

1.2 Industry

Baseline and mitigation scenarios involve reductions of energy intensities for all of industrial uses, because of higher efficiency of energy consumption of industrial equipment as a result of technological improvements and the application of demand side management. Both, the introduction of energy efficient devices and energy savings programs will be possible through the foreseen increases of energy prices. Final result will be a better productivity of energy. The hypothesis considered for baseline and mitigation scenarios are described as follows:

- Thermal uses offer most of the potential for energy savings. It is possible to introduce improvements in steam generation related to heat production and transportation, whose application could achieve reductions of oil derivative consumption between 12% and 21% in relation to the baseline scenario. The variation of this potential depends on the industrial activity and the energy source. Regarding fuel consumption for motive power, potential of reducing energy intensity ranges from 5% to 18%, depending on industrial activity also.
- The baseline scenario considers reductions of electricity intensities as a result of tariff adjustments that will occur under the new economic and institutional organisation of electric sector, mainly due to the participation of private investment in generation and distribution. Once the reductions of energy intensities take place, as a response to tariffs increase, it is estimated that those indicators will not be modified during the remainder period of projection.
- Regarding oil product consumption in the mitigation scenario, it is estimated that a reduction of energy intensity in industry could reach an average of 0.75% per year, as a result of the application of technological changes at internationally. This trend will allow savings of oil products consumption for industrial use of about 40% for the whole analysis period. Same trend is forecasted for the evolution of electricity intensity in the industrial sector (0.75% per year).
- An important issue that is incorporated in the mitigation scenario has to do with substitution of energy sources. There will be a penetration of natural gas, for thermal industrial uses, replacing heavy oil derivatives, which allow considerable reductions of green house gases from industrial uses.

1.3 Transport

The transport sector is the main emitter of GHG, in the Ecuadorian energy system (MEM-97). However, and oppositely to what happens in both developed and developing countries (OECD-94), the participation of transport in the final consumption of modern forms of energy, has decreased in the country in 20 years (1975 to 1995) from 55% to 49%, according to the national energy balances (INE-97, MEM-96). The rate of growth of energy consumption in the transport sector is 3.17% / year, in 15 years (1990-1995), 25% larger than GDP and 47% larger than population (BCE-97, ILDIS –87). Average rates of growth of consumption for both, road (3.1% / yr.) and air (3% / yr.) transport are similar.

The consumption of gasoline grew (1.27% / yr.) much less than those corresponding to other forms of energy, in the transport sector. This is due to efficiency improvement of the fleet and to introduction of diesel vehicles of large capacity, for public transportation and heavy cargo.

These trends are the combined result of the following factors. Continuous damping of population growth, relative slow economic growth, elimination of subsidies to transport fuels, technical improvement of the fleet, by reduction of trade barriers, including tariffs.

Regarding reductions of emissions in the transport sector, Jϕrgensen –93 identifies the following three ways.

- Changes in each mode, due to technical improvements or increased load factors.
- Intermodal changes to lower emitting ones.
- Demand reduction.

Regarding to the last one, the demand for mobility as number of trips per capita, practically has not changed with time, in developed countries (Petersen –93). The travelled lengths have increased however, as well as the modal transfer to private cars. Both such trends result from the style of urban development and the style of life of the population. For example, in Germany around 60% of urban car trips have entertainment and leisure shopping purposes.

Regarding to load factors and intermodal changes, aimed to reduce emissions, their success depends on careful co-ordination and planning. Otherwise, reverse effects might take place. For these reasons, both Jϕrgensen –93 as well as Lawrence – Berkeley –95, consider that technological improvement is the only unambiguous way to achieve positive environmental changes.

In the case of Ecuador, as well as those of other countries, undergoing modernisation processes of their governments, in practice are reducing their intervention and planning roles in their economies. By other side, the globalisation process promotes competition among car manufacturers which stimulates innovation and technical improvement of their products.

With the depicted background and with the purpose of scenario design, technological improvement of the vehicle fleet is assumed the main agent of change.

1.3.1 Road transport

Criteria for scenario design

With the given premises, the common demand of mobility was established through correlations with population and GDP. Inter modal assignment, was also common for both, reference and mitigation scenarios.

Specifically, the demands for passenger (PD) and cargo mobility (CD) were established in the following way:

$$PD = C_1 * P * (Y / P)^{\alpha}$$

$$CD = C_2 * Y$$

where

P, population,
Y, national domestic product,
α, elasticity
C_1 and C_2, constants

Regarding, to the elasticity, the following growing figures through time were assumed.

PERIODS	α
1995 – 2000	0.49
2000 – 2005	0.75
2005 – 2010	0.87
2010 – 2030	0.97

To determine the energy demand in each mode, the improvement of vehicle efficiency of new cars, was the driving force. To quantify such potential a technological prospective exercise was carried out, as part of the present project (Quevedo – 98-a). With such a basis and given that the main decision-makers in the transport sector are private actors, the scenarios were designed in the following way.

<u>Reference scenario</u>

Given the technological potential for improvement (of new vehicles), the degree of assimilation of such potential depends on the economic benefit it represents to the owner. Such a benefit is the difference between, the amount saved due to reduced fuel consumption, and the corresponding incremental investment, in more efficient vehicles. The level of improvement corresponds to the maximum level of benefit to the transporter. To quantify such conditions an optimisation exercise was carried out (Quevedo – 98 –b) and the results applied ahead.

Thus, technological improvements are incorporated to the fleet through new modern vehicles, up to a model which corresponds to the optimum. Afterwards, no further improvement is economic and the technology will be stagnant up to the end of the time horizon.

This does not mean that the vehicles will run indefinitely. They will be renewed, but without increase in their investment costs. Thus efficiencies will improve slowly, by spontaneous innovation. Except for private passenger cars such an improvement is not considered explicitly in the scenario.

Mitigation scenario

This scenario considers an additional efficiency improvement, beyond the optimal for the decision-maker, considered in the reference scenario. Such an improvement is implemented through a fuel tax. The tax, while increasing the price for the user, makes economic an incremental investment in more efficient technology.

The new optimal conditions were computed for a sequence of taxes, for various modes. An analysis of the sensitivity of fuel reduction to tax levels provided a base to select the parameters of the scenario.

Computational procedure and developed formulae

For each transport mode an annual travel distance (L) is assumed. With such input, the demand is converted into a fleet size (N).

Assuming the rates (r and s) of new car acquisitions and old card discards, consistent with the overall growth of the fleet, under mild assumptions (Quevedo -98 b), the life cycle of the vehicles can be computed with the following formula:

$$T = \frac{1}{r-s}\frac{\ln r}{s}$$

On that basis, and starting with the composition of the fleet in the base year (1995), their evolution is simulated, giving the composition in any chosen year. The energy consumption for any such year (t) is thus given by:

$$E(t) = \sum_{i=t-T}^{t} m_i E_i L_i$$

$$N(t) = \sum_{i=t-T}^{t} m_i$$

Here E(t) and N(t) are the annual energy consumption and number of vehicles for that mode in the year t, m_i is the number of vehicles of model i, and E_i is the corresponding energy intensity.

This latter parameter changes with the model (Quevedo – 98 -a), and is expressed more easily, in terms of its reciprocal, the fuel economy (FE). Fuel economy improves linearly with time (following formulas), up to a model that constitutes the optimum, for the private decision-maker as discussed before. Afterwards, the characteristics of new cars remain stagnant.

The fuel economy formulae for new cars (international supply) is expressed as follows:

$$\frac{FE(t)}{FE(1998)} = 1 + a(t-1998)$$

Vehicle	**Fuel**	**a**
Passenger		
Light car	Gasoline	0.036
Public (bus)	Diesel	0.0167
Cargo		
Light	Gasoline	0.030
Heavy (truck)	Diesel	0.021

Besides, and referring also to the technological prospective (Quevedo – 98 -a), technological improvements require incremental investment cost (C), systematised in the following way, for gasoline and diesel cars, in terms of the relative reduction in energy intensity (x) defined by:

$$x = \frac{E_0 - E_i}{E_0}$$

where E_o is the energy intensity for the base year (1995), and E_i the intensity for model i. Thus, for gasoline vehicles:

$$C = 6000 - \frac{x}{1-x}$$

and for diesel vehicles :

$$C = 41250x^{3.3555}$$

Applying the mentioned optimisation criterion for the choice of the private investor (details in Quevedo –98-b), the following formulae were obtained for the optima:

Gasoline vehicles: $$X = 1 - \left(\frac{6000f}{E_0 L P_r} \right)^{0.5}$$

and

Diesel vehicles: $$X = \frac{(E_0 L P_r)^{0.424538}}{1384143.75f}$$

where, besides the predefined parameters, f is the annuity factor and P_r the price to the user (in US$) of the TOE of the corresponding fuel.

The procedure is illustrated in the flow diagram on page 84.

Application of the Optima and Energy Intensities for the reference scenario

The methodological elements just sketched, were applied to determine optimal values for the following modes:

0, private (gasoline) passenger cars;

1, public (diesel) passenger vehicles;

2, cargo (diesel) heavy vehicles;

3, cargo (gasoline) light vehicles.

The results indicate the following features.

- No technical improvement becomes economical for private gasoline cars (mode 0). However, considering non-economic factors it is assumed a light reduction with time in the energy intensity of new cars. Specifically, the relative fuel economy of new cars, entering the fleet after 1998, improve linearly with time, at a rate of 0.01 per year. This figure is smaller than the prevailing trend in the US market, according to the study Energy Innovation-97.

- Energy intensities of new cars were computed on these basis, previous to evaluate average fleet intensities fed into the LEAP model, for accounting the main variables for this mode.
- The calculations, corresponding to the other 3 modes are summarised in the following table. They display optimal values for X, and consequently for energy intensities and corresponding models.

All variables and parameters have already been defined, and thus, the table is self-explanatory.

Table 26 Application to the reference scenario

MODES **VARIABLES**		**BUS (1)** (diesel)	**TRUCK (2)** (diesel)	**LIGHT CARGO (3)** (gasoline)
P_r	$/TOE	207	207	261
L	Mm/yr.	38	40	35
E_o	KOE/km	0.183	0.220	0.162
r	$(yr.)^{-1}$	0.065	0.066	0.079
S	$(yr)^{-1}$	0.027	0.022	0.034
f	$(yr)^{-1}$	0.113	0.113	0.12
T	yr.	23	25	19
X optima		0.134	0.151	0.3025
E_i optima	KOE/km	0.158	0.187	0.113
Optimal Models	yr.	2008	2007	2012.5

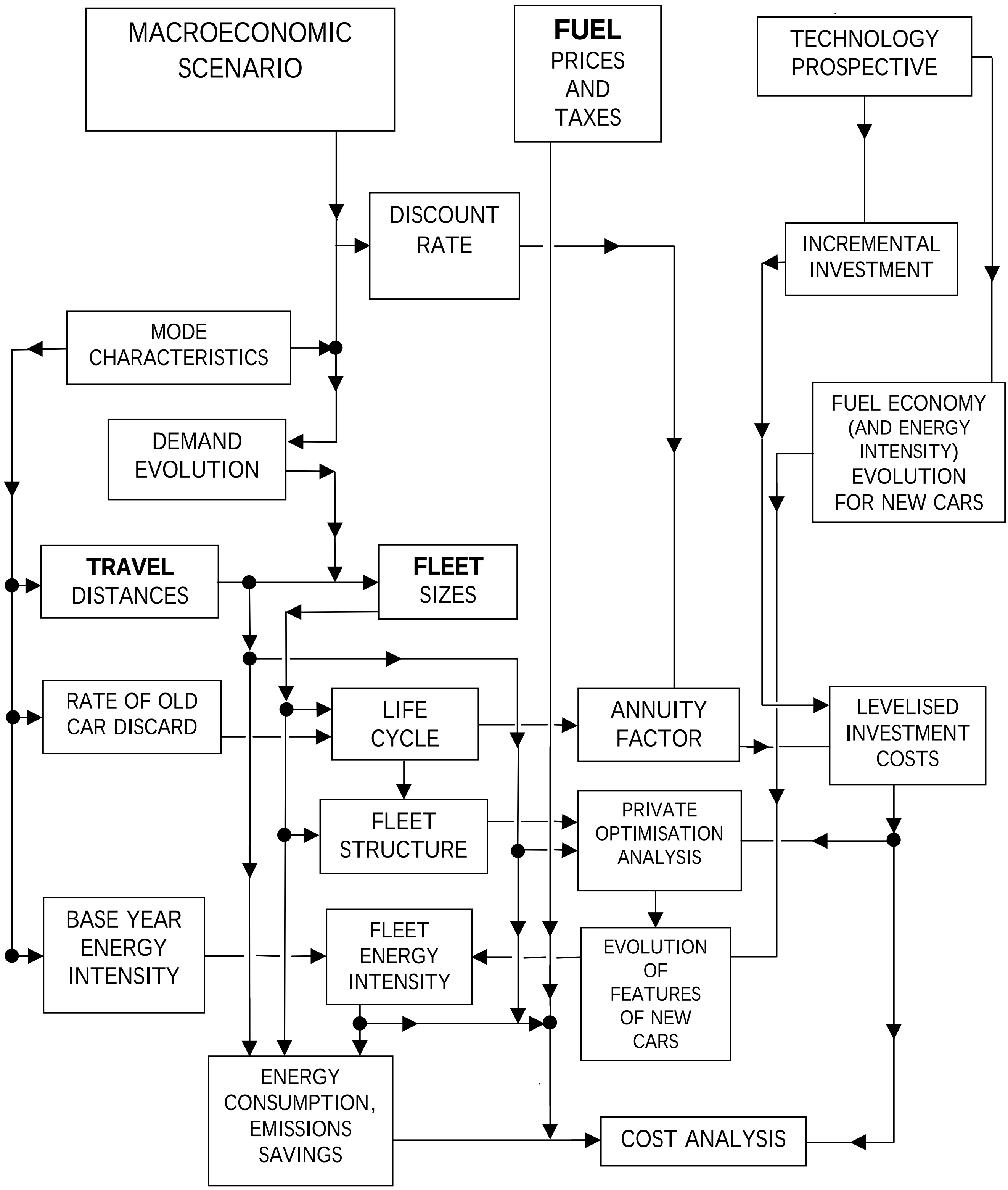
The results of the reference scenario show significant reduction of emissions, respect to those occurring in case the energy intensities of the base year would apply throughout the period. Such savings are more important for light cargo gasoline vehicles, and smaller for diesel vehicles (buses and trucks). This is due to the high incremental investment costs of the innovations for diesels. This fact limits emission reductions in the last subperiod (2010 –2030).

A sensitivity analysis, regarding rates of inclusion of new cars (r), and elimination of old ones (s), indicated weak influence in the results for diesels and certain influence for the light gasoline cargo vehicles.

With the values shown in the table above and adopted for the scenario, leading to the recorded life cycles of the vehicles, and optimal models, the optimal intensities saturate the fleet for diesels in 2030. Not quite for light cargo gasoline vehicles.

The results of the present analysis indicate that the most influential variable, affecting emission reductions, is the incremental cost of efficiency improvements.

Flow diagram: Application of the procedure to a transport mode



Mitigation scenario

A further reduction in energy consumption and emissions is aimed in this scenario, through a fuel tax.

The formulas of X, as function of P_r, let to evaluate the elasticity of the reduction of energy intensity respect to price, in the following form:

$$-\frac{dE_i/E_i}{dP_r/P_r} = 0.5 \qquad \text{(gasoline)}$$

$$-\frac{dE_i/E_i}{dP_r/P_r} = 0.424538\left(\frac{E_0}{E_i}\right) \qquad \text{(diesel)}$$

Applying them for conditions around the optimae yield the following values.

Table 27 Relative reduction of energy intensities ($\Delta E_i / E_i$)

MODE	ELASTICITY	TAXES		
		7%	10%	20%
Bus (diesel)	0.0672	0.005	0.007	0.013
Truck (diesel)	0.0749	0.005	0.007	0.015
Light Cargo (gasoline)	0.5	0.035	0.050	0.100

The preceding figures indicate a very weak influence of taxes, to enhance mitigation of energy intensities, in diesel vehicles. Such enhancement is less than 1.5%, for taxes as high as 20%. Thus, not such tax is considered for diesel vehicles, in the mitigation scenario.

Realising the moderate (elasticity 0.5) influence of taxes for mitigating energy intensities, of light cargo gasoline vehicles, a tax of 20% is adopted for such cars in the mitigation scenario. That policy would produce the following effects:

- Direct reduction of GHG gases, due to reduction of energy intensity for that mode.
- Indirect reduction, by stimulating replacement of gasoline (taxed) by diesel (untaxed) vehicles, which have better efficiencies. This is not quantitatively accounted in the present analysis.
- Negative local environmental impact, due to increase of particulates, resulting from greater use of diesels.
- Given that most productive transport and public passenger mobility are served by large diesel vehicles, no significant economic or social impacts are expected from taxing gasoline.
- Limited negative economic impact on small enterprises, whose main means of transport consist of light gasoline vehicles, due to increase of cost brought by the gasoline tax.
- Certain negative social impact on the middle class, who uses small gasoline cars.

Calculations for the mitigation scenario

The variables and parameters for the mitigation scenario are summarised below:

Table 28 Application to the mitigation scenario

MODES / **VARIABLES**		**BUS (1)** (diesel)	**TRUCK (2)** (diesel)	**LIGHT CARGO (3)** (gasoline)
P_r	\$/TOE	207	207	313.2
L	Mm/yr.	38	40	35
E_o	KOE/km	0.183	0.220	0.162
r	$(yr)^{-1}$	0.065	0.066	0.079
S	$(yr)^{-1}$	0.027	0.022	0.034
f	$(yr)^{-1}$	0.113	0.113	0.12
T	yr.	23	25	19
X optima		0.134	0.151	0.363
E_i optima	KOE/km	0.158	0.187	0.103
Optimal Models	yr.	2008	2007	2017

The only changes respect to the reference scenario (Table 26) are in the last column (light cargo vehicles) and refer to fuel price (due to 20% tax), X, E_i and optimal models.

Analysing the configuration of the fleet of light cargo gasoline vehicles in 2030, the following two other results are obtained:

1. Energy savings above those of the reference scenario = 172735 TOE/yr.
2. Net cost for society = 826 US\$ per TOE saved.

Implementation of the gasoline tax in the mitigation scenario

The purposes of the gasoline tax, which will set the user price at 313.2 US\$/TOE in 2017, are the following:

- To make economically attractive, to the private investor, the acquisition of cars with 2017 year technology. According to the calculations, this requires the mentioned tax and corresponding user price in that year.
- To extend vehicle innovation beyond 2013 models, which was the optimum without tax, up to 2017. This requires a gradual tax, from 0 % to 20% in that period. The exact amount of tax in each year could be determined with the developed formulae.
- The tax must be neutral, channelling the collected resources to improve the conditions of roads, streets, maintenance and signalling. That way, the taxpayer will receive a benefit and further reductions of energy consumption and emissions will be achieved.

A particular mitigation option: the urban trolley bus

An alternative applied recently in Quito, capital of Ecuador, to improve the quality of public transportation is the installation of a trolley bus system in a dedicated lane, along the main axis (north – south) of the city.

The experience so far has been successful, both from service and environmental points of view. The units are regularly powered electrically, representing a great reduction in energy consumption, and emissions, respect to diesel units. The situation is summarised and analysed in the table below.

Considered as a mitigation option, the figures show however that it is expensive.

Table 29 Characteristics of trolley and diesel (large) buses

Vehicle →		**Trolley bus**	**Diesel bus** (present tech.)
Number of Places (Pl)		174 (only 51 seated)	65
Length Travelled (Mm/yr.)		65	38
Capacity (10^6 Pl – Km/yr.)		11.31	2.47
Capacity normalised		4.58	1
Average Speed (Km/hr)		17	10
Fuel Economy (Km/gal)			8.125 (urban)
ENERGY Intensity	(kWh/Km)	2.183	
	(KOE/Km)	0.188	0.406
ENERGY Consumption	(MWh/yr.)	142	
	(TOE/yr.)	12.2	15.4
NORMALISED ENERGY Consumption		2.664	15.4
Initial COST (10^6 US$)		1.209	0.12
NORMALISED Initial Cost (10^3 $)		26.4	120
Life time (yr.)		20	26
Levelised NORMALISED Investment		31 (f= 0.1175)	13.1 (f= 0.1092)
Investment for TOE saved (US$/TOE)		1405	

1.3.2 Passenger air transport

The demand is assumed to be proportional to the GDP. The main data inputs for the analysis, were the following.

1. National energy balance series (INE-93, MEM-98).
2. Technological prospective (Quevedo – 98 –a).
3. Specification of characteristic parameters of the air fleet and their activity, through processing of formal and informal data, gathered from the National Directorate for Civil Aeronautics and from main domestic airlines.

Reference scenario

The following two changes on prevailing trends, were introduced in the scenario:

1. An increment of 6.67% in the occupation of the planes.
2. An increment of 32% in the use of the fleet, between1995 and 2000.

Regarding the composition of the fleet, a progressive substitution by last technology planes is scheduled. The mix involves a balance of large (310 seats) and small (40 seats) planes so as to satisfy the demand.

Such paced renewal of the fleet aimed to reduce both, energy consumption and emissions, becomes less expensive than keeping a fleet with the same technology of the base year.

The results of the exercise show that with a demand growth of 4.5 times, between 1995 and 2030, the added costs of investment and fuel, grow only 4 times and the energy consumption, less than 2.5 times.

Mitigation scenario

The design criterion of this scenario is similar to that of the reference one. The difference among them consists of a more aggressive modernisation of the fleet, in the mitigation case. Only 31% of the planes flying in 1995 will still be in the air in 2000 and practically, none of them will be utilised in 2010, in the mitigation scenario. Such accelerated replacement of planes, which still have useful life, is accounted among the incremental costs, corresponding to the mitigation.

1.3.3 Comparison of results of the scenarios

Main differences between scenarios occur in intermediate years. In the long range, due to the ending of the useful life of the planes, the differences among the corresponding fleets tend to disappear.

For such reason the differential energy consumption is only 13% in 2030, reaching a maximum of 28% in 2010. At the beginning of the period, 2000 and 2005, represents 17% and 18%, respectively.

Such differential evolution of the fleet gives way to relatively high incremental costs (investment and fuel) of 157 $/TOE saved, during the initial years, which decreases with time to 38 $/TOE saved, in 2010, becoming negative in 2030.

Table 30 Road transport sector reference scenario
Average energy intensities of the fleet (KOE/km)

Year **Mode**	**1995**	**2000**	**2005**	**2010**	**2030**
Light passenger cars (gasoline)	0.1000	0.09989	0.09845	0.09551	0.08160
Bus (diesel)	0.1830	0.1827	0.1784	0.1705	0.1580
Light cargo vehicles (gasoline)	0.1620	0.1613	0.1537	0.1408	0.1130
Heavy cargo trucks (diesel)	0.2200	0.2195	0.2122	0.2030	0.1870

Table 31 Road transport sector mitigation scenario
Average energy intensities of the fleet (KOE/km)

Year **Mode**	**1995**	**2000**	**2005**	**2010**	**2030**
Light cargo vehicles (gasoline)	0.1620	0.1613	0.1537	0.1408	0.103935

Note: Intensities of all other modes are similar to those of the reference scenario

Table 32 Characteristics of typical aeroplanes in the fleet

Characteristic	Plane B	Plane D	Plane A
Number of seats	110	40	310
Airborne (hr/yr.)	1500	3000	3600
Speed(Km/hr) (1)	644	470	674
Travelled length (10^6 Km/yr.)	0.966	1.410	2.4264
Capacity (10^6 seats – Km/yr.)	106.26	56.4	752.18
Normalised Capacity	1	0.53	7.079
Fuel Economy (seat – mile/gal) (2)	35.8	50.0	72.5
Fuel Economy (mile/gal)	0.3255	1.25	0.2339
Energy Intensity (KOE/Km)	6.018	1.567	8.374
Energy Intensity - short Flights (KOE/Km)	8.26	1.65	11.50
Energy Intensity - short Flights (KOE/Seat-Km	0.075	0.04125	0.037
Energy Consumption (10^3 TOE/yr.)	7.979	2.327	27.904
Initial Investment (10^6 US$)	6	11	40
Infrastructure Factor	1.3	1.5	2.0
Levelised Investment, 20-25 yr. (10^6 US$/yr.)	0.916	1.818	8.813

Notes: (1) From year 2000. (2) Data from Greene-92

Table 33 Passenger air transport, reference scenario

Year / Variables	1995(1)	2000	2005	2010	2030
Passenger- Km (10^6)	1788	2170	2705	3371	8128
Used Fleet (units)					
B - planes	29.56	16.86	15.54	15.24	14.22
D - planes	0	3.	4	6	20
A - planes	0	1	2	3	10
Energy consumed (10^3 TOE/yr.)	170	169.41	189.11	219.27	439.04
Capital Cost (10^6 US$ /yr.)	27.08	34.85(2)	39.13	51.31	137.52
Fuel Cost (10^6 US$ /yr.)	32.58	30.83	40.07	46.49	102.30
Both Costs (10^6 US$ /yr.)	59.66	65.68	79.20	97.80	239.82

Notes: (1) Load Factor is 0.75 in 1995, and increases to 0.8 from 2000 on.
Air borne is 1138 h/yr. for B – plane in 1995, and increases the table value from 2000 on.
(2) Includes 5.14 of cost available non-used B - planes.

Table 34 Passenger air transport, mitigation scenario

Year Variables	2000	2005	2010	2030
Used Fleet (units) B - planes D - planes A - planes	 9.25 4 2	 7.40 6 3	 0.03 8 5	 0.0 20 12
Energy consumed (10^3 TOE/yr.)	138.92	156.72	158.38	381.87
Capital Cost[(1)] (10^6 US$ /yr.) Fuel Cost (10^6 US$ /yr.) Both Cost (10^6 US$ /yr.)	 45.48 25.28 70.76	 51.07 33.22 84.29	 65.47 33.63 99.10	 142.17 88.95 231.12
Energy Saved (10^3 TOE/yr.) Cost of Energy Saved (US$ / Toe)	 30.49 157	 32.41 157	 60.89 38	 57.17 - 152

(1) Includes cost of non-used B- planes

2 Energy supply

2.1 Expansion of electric power generation and oil processing capacity

The last edition of the Master Electrification Plan prepared by INECEL was taken as a reference for the formulation of power generation capacity expansion scenarios for the baseline and mitigation cases. It also includes the stations that have been operating up to the year 1998 or that could start up over the short term and that are not considered in the above-mentioned Plan. It should be emphasised that the Plan takes into consideration, although on a small scale, the development of natural gas coming from the Gulf of Guayaquil, which could take place over the medium term.

For the reference case, the growth of electric power generation facilities relies on the operation of private-sector thermoelectric plants that could be using diesel for simple and combine cycle gas-fired turbines, fuel oil (bunker) for steam-driven station, and residual oil in large internal combustion engines. In the first case, the power generation capacity using simple cycle turbines would increase from the current 333 MW (1998) to 990 MW by the year 2030, and combined cycle plants are projected to be installed until reaching 250 MW by the year 2018. It is forecast that power generation facilities with steam-driven turbines could eventually have a capacity of 600 MW by the horizon year, whereas the installation of plants using residual oil, which would begin in the year 2002 with 270 MW and have at present been virtually contracted, would amount to a maximum o 970 MW by the year 2020.

The electric power generation facilities could be complemented by the start-up of large and medium-sized hydropower stations, according to inventories made by INECEL, which sequentially could increases installed capacity by 973 MW up to year 2030, along with the inclusion of 180 MW from a simple plant using natural gas (2006), and 100 MW from a combined cycle station also using natural gas (2010). Generation increases have also been forecast through the use of small hydropower stations that basically operate as stand-alone plants not connected to the National Interconnected System.

It is evident that the electric power supply scenario for the mitigation case shows lower electricity demand levels, and because of this there are considerably less facilities needed in terms of installed capacity, which assumes the possibility of deferring or avoiding investments for the expansion of power generation facilities. In these cases, as part of the mitigation options, an expansion schema based on the greater use of renewables such as hydraulic energy (mainly on a medium scale), wind energy, and geothermal energy, is being assumed. Indeed, in this scenario it is considered possible to obtain more than 1500 additional MW from hydropower stations by the year 2030, 32 MW in wind –powered stations by the year 2004, and 210 MW from geothermal plants (up to year 2024), which would considerable restrict the need to install conventional thermoelectric stations based on oil products (diesel, fuel oil or residual oil). Likewise, the possibility on increasing the efficiency of the thermoelectric generation facilities by operating combined cycle stations using diesel (170 MW in the year 2002) and natural gas (150 MW in the year 2008 and 240 MW in the year 2019) has been considered.

An important aspect involves the need to use the residual gas of liquefied petroleum gas plants, where there is a huge potential to recover the volumes of natural gas that are at present not used for energy purposes, by installing thermoelectric stations.

In the two scenarios, there is also a differentiation in the capacity to use this resource; this reviewed in the corresponding section. It should be emphasised that for the two cases (baseline and mitigation), the option of increasing the effective capacity of the country's major hydropower station (Paute, 1075 MW) was considered, and this would be achieved by building, upriver from the plant, the Mazar hydropower station (180 MW, year 2004).

An important aspect to take into account as part of the power generation requirements is the electric power losses. The assumptions for the electric power supply scenario of the mitigation case uses the recommendations made by the study on power loss reduction prepared by the World Bank's ESMAP Program, which is attached to the 1993 version of the Master Electrification Plan. In this study, a series of technical and administrative measures aimed at reducing technical losses by 2.4% and nontechnical losses by 5.0% are specified. The increase in electricity cogeneration is another alternative taken into consideration in order to complement energy supplies, even when no distinction has been made in the two scenarios, since it is estimated that it is a situation that will take place in the future in keeping with observed trends.

Regarding the enlargement of oil refining capacity, the same scheme for expanding the infrastructure for producing oil products has been maintained, considering that there are no long-term plans in this area. An increase in the oil refining capacity of about 60% has been specified up to the year 2015, by means of investments that would enable increasing the current processing capacity of 158,000 barrels per day to 250,000 barrels per day. As of the year 2015, it is assumed that the refining capacity will remain unchanged, considering that, regardless of the scenario being considered, the future demand for oil and gas would have to be met either by means of complementary enlargements or by means of imports to cover probable deficits, which means that greenhouse gas emissions will always be generated due to the use of fuels in the different consumption sectors, regardless of the origin of supply.

As for natural gas, the baseline that has been assumed is the certain possibility of recovering available volumes of gas and liquids in various oil fields in the eastern part of the country, which can be processed in modular plants to extract LPG, on the basis of which LPG production capacity would increase markedly. A detailed analysis concerning this is following presented.

2.2 Associated gas

2.2.1 Situation

The production of oil involves the simultaneous extraction of associated (natural) gas. Ecuador has been producing oil in the North and Central portions of its Amazonian region, since 1972, as was explained else where in this report. Most of the gas has been flared and the remaining part under went different uses, most of them related to the own oil activity. Among such uses, part of it is burned as fuel in different devices, supplying energy for oil production and transport activities, as well as to deliver power. Another part is reinjected to the oil reservoirs, to mitigate the natural decay of pressure. Finally, a last part (around 28%) constitutes the raw material for gas processing plants (Shushufindi and Secoya) that produce LPG, natural gasoline and residual gas. The first product is sold in the domestic market. The price was traditionally subsidised, due to social and political arguments. LPG is used mainly for cooking. The demand grew rapidly so that presently, the local production supplies only 40% of the domestic consumption.

The balance is covered through imports. A more rational management of these resources is assumed in both, reference and mitigation scenarios. That leads to substantial increase of the amounts of recovered and industrialised gas.

Such a policy will bring the following advantages.

- Reduction of atmospheric emissions by avoided flaring.
- Increased domestic supply of LPG, with corresponding reduction of imports.

Besides, the residual gas coming out of the industrial gas plants will be burned in modern efficient combustion turbines, to generate electricity. Such generating capacity will substitute many diesel-generating units that presently supply the neighbouring power demand.

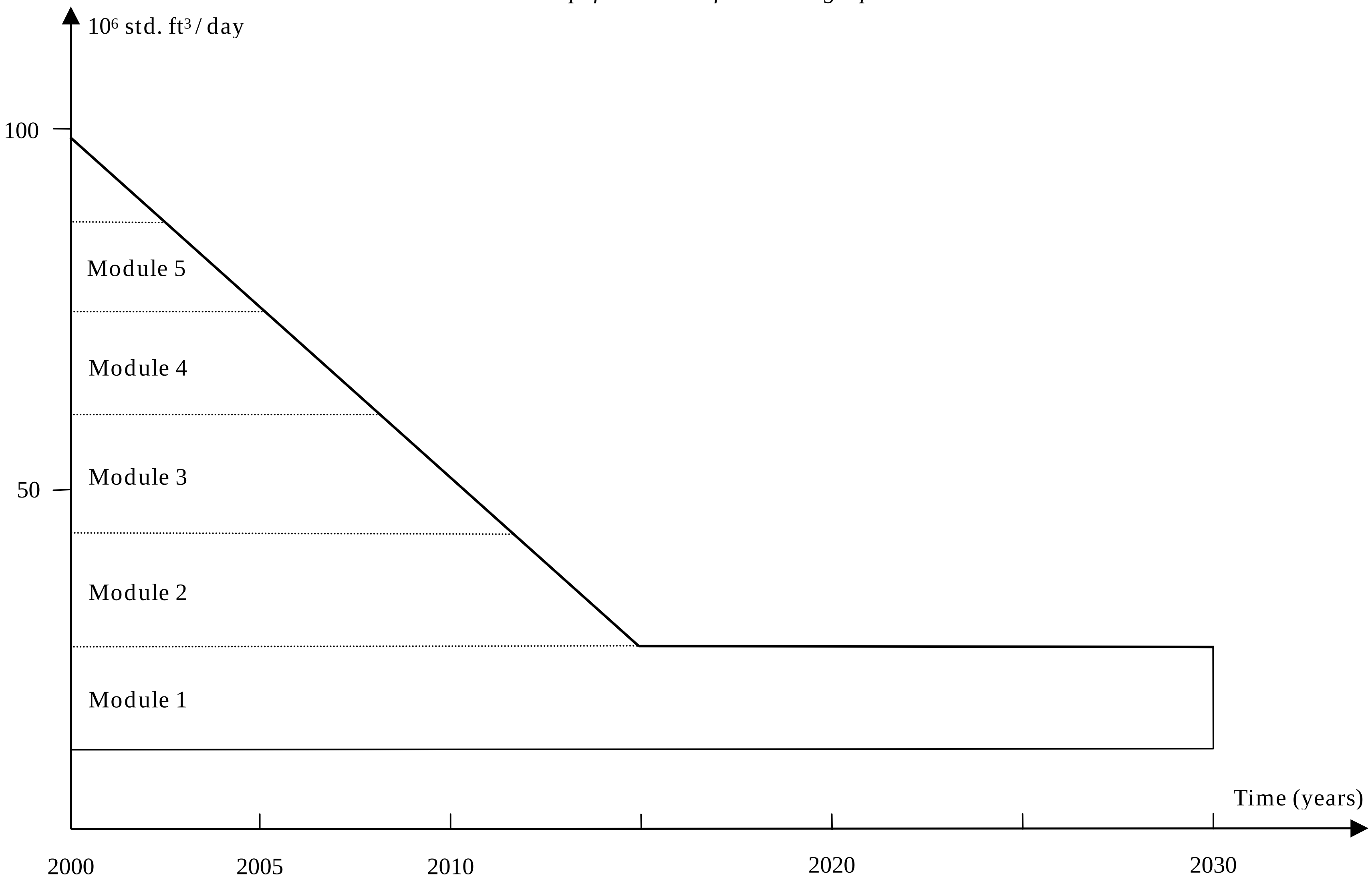
Such fuel substitution will also reduce emissions due to two reasons. First, the lower specific emission of residual gas respect to diesel. Second, the higher efficiency of the energy conversion equipment (combined cycle gas turbines) for gas, respect to that of the presently used for, diesel (small internal combustion engines).

2.2.2 The natural resource

According to the perspectives established in the oil analysis section of this report, future production of associated gas is expected to decay.

To simplify the analysis, a rectified decay curve is assumed (see next page) starting with the present values and flattening out in the last part of the time horizon. Thus, the potential amounts of emissions, due to gas flaring as well as the potential utilisation of associated gas, are more important at the beginning of the time interval.

Simplified scheme of associated gas production



2.2.3 *Scenario methodology and assumptions*

Production curves of associated gas are the same in both, the reference and the mitigation scenarios. They differ in the amounts of gas recovered and industrialised. The most of this, the less the gas flared and the less the emissions.

The criterion to determine the amount of recovery and industrialisation of gas, in the reference scenario, is economic. Specifically, it corresponds to an amount of available gas, such that the marginal cost of development in the first stage (process flow) equals the commercial value of the products (LPG, and natural gasoline).

The LPG, based on the Guidelines (Risϕ - 98), is valued at US$ 252 / Ton, for the beginning of the time interval.

The natural gasoline is valued at an equivalent rate, for similar energy contents. A relatively low value (US$ 20 / TEP, approximately US$ 720 / 10^6 std. ft^3) is assigned to the associated gas, given the present waste of the resource.

The actual calculation of the recovered associated gas consists of a stepwise procedure. Each step considers an additional discreet amount of gas to be captured and industrialised. The selected discrete amount was a 15 million std. ft^3 / day module.

Development stars with the richest fields, closest to the available infrastructure. So that costs increase, as more modules are incorporated, until they meet the anticipated criterion.

From a sample of field and project data, plus certain engineering analysis and regression calculations, the following cost formula was developed:

$$CR = 0.666 \, [(Q + 15)^{2.8} - Q^{2.8}]$$

For gas recovery investing cost C in 10^3 US$, Q in 10^6 std. ft^3 / day, with single direction gas lines, from the field separators to the processing plant. A specific and constant cost (without economies of scale) of 1.81 million US$, of investment in processing plants, by million of std. ft^3 / day was assumed.

Advanced combustion power plants, that burn the residual gas, coming out of the processing plants, are installed next to them. They constitute the second stage of the energy chain (diagram).

The installed capacity of the power unit represents 50 MW per each module of 15 * 10^6 std. ft^3 / day of associated gas recovered. Such a capacity assumes a load factor of 86%.

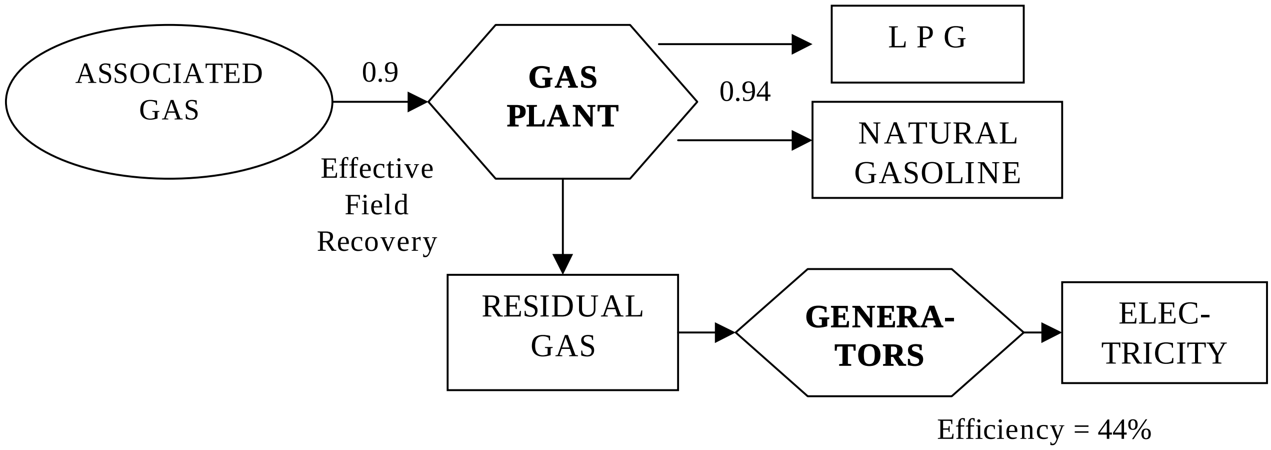
Efficiency is 44% and investment 595 US$ / kW (EPR I - 93). The electricity generated is transmitted back and distributed, in the gas producing fields. The corresponding costs are adapted from GTZ –95.

The cost of the resource, associated gas, accounted for in the 2 stages of the process is assigned proportionally to the energy content of the commercial products of the first stage (LPG and natural gasoline) 59%, and to the energy input to the second stage (power) 41%.

The attached tables contain intermediate and final results. For the reference scenario, the development of 60 million std. ft^3 / day of associated gas are economic and thus are considered for such scenario. However, due to the decaying nature of the production curve, they are coming out of service one by one, as time elapses.

In the mitigation scenario, one additional module (15 million std. ft^3 / day more) is developed. One issue that significantly contributes to the development costs is the very short life of the available resource (3 yr.).

Energy flow and transformation factors for associated gas



Typical energy values (TOE/10^6 std. ft^3 of associated gas)

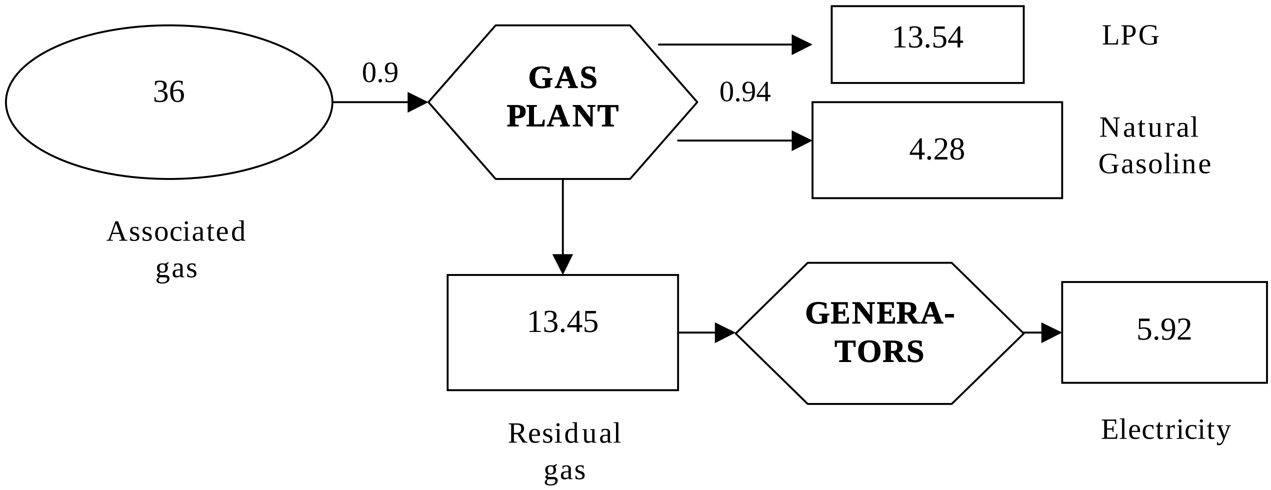


Table 35 Supply of associated gas from new projects, reference scenario

YEAR VARIABLES	2000	2005	2010	2030
Energy Recovery (10^3 TOE/yr.)	756	756	567	189
Cost of Associated Gas (US$/TOE)	52.75	52.75	42.00	31.69
Products (10^3 TOE/yr.)				
LPG	278.8	278.8	209.1	69.7
Natural Gasoline	88.8	88.8	66.6	22.2
Electricity	124.7	124.7	93.6	31.2
Total	492.3	492.3	369.3	123.1
Costs (US$/TOE)				
Hydrocarbons	106.6	106.6	85.7	64.9
Electricity	330.0	330.0	274.0	205.0
Electricity				
Generation (GWh/yr.)	1444.8	1444.8	1083.6	361.2
Cost (US$/Mw/h)	28.4	28.4	23.5	17.7

Table 36 Supply of associated gas from incremental projects, mitigation scenario

YEAR VARIABLES	2000	2005	2010	2030
Incremental Energy Recovery (10^3 TOE/yr.)	189	189	0	0
Cost of Associated Gas (US$/TOE)	145.20	145.20		
Products (10^3 TOE/yr.)				
LPG	69.70	69.70		
Natural Gasoline	22.20	22.20		
Electricity	31.20	31.20		
Total	123.10	123.10		
Costs(1)(US$/TOE)				
Hydrocarbons	296.00	296.00		
Electricity	767.00	767.00		
Electricity				
Generation (GWh/yr.)	362.80	362.80		
Cost (US$/Mw/h)	66.00	66.00		

Note: (1) The cost are incremental respect to those of the reference

*Table 37 Associated gas modular recovery (module size = 15 * 10^6 std. ft^3/day)*

Module No.	1	2	3	4	5	6
Recovery level of Associated Gas From/To (10^6 sdt ft^3/day)	0/15	15/30	30/45	45/60	60/75	75/90
Capital Investment (10^6 US$)	28.46	34.96	46.41	62.27	82.26	106.15
Life cycle, T (years)	30	14	11	7	3	0.5
Annuity factor (10%, T)	0.106	0.136	0.154	0.205	0.402	2
Annuity (10^6 US$/yr.)	3.02	4.74	7.15	12.79	33.08	66.15
Annual costs of operation: Maintenance, Energy, and Natural Resource	2.97				4.34	21.21
Direct cost (10^6 US$/yr.)	5.99	7.72	10.12	15.77	37.41	87.41
Cost of recovery and processing of Associated gas (US$/$10^6$ std ft^3)	1141	1470	1928	3003	7126	16450
Cost of LPG and Natural Gasoline Obtained (US$/TOE)	64.9	83.3	108.8	169.3	402.3	929.8

Note: Above costs exclude those of electricity generation. The later are presented in the next table

Table 38 Energy supply: electricity generation with modular plants

Module No.	1	2	3	4	5	6
Recovery level of Associated Gas From/To (10^6 sdt ft^3/day)	0/15	15/30	30/45	45/60	60/75	75/90
Electrical Investment: Generation + Transmission (10^6 US$)	30.5	31.55	34.15	37.80	42.35	47.85
Annuity (10^6 US$/yr.)	3.19	4.29	5.26	7.75	17.03	95.00
Annuity factor (10%, T)	0.106	0.136	0.154	0.205	0.402	2
Electricity generated (GWh/year)	361.2					
Specific Investment (US$/MW–h)	8.82	11.88	14.56	21.45	47.13	263.00
Specific Operation, Maintenance and Resource Costs (US$/MW-h)	8.83(1)	11.90(2)	14.58	21.48	47.20	263.40
Cost of Electric Energy (US$/Mw–h	17.65	23.78	29.14	42.93	94.33	526.40

Note: (1) Based on EPRI – 93 data.

3 Analysis of the forestry sector

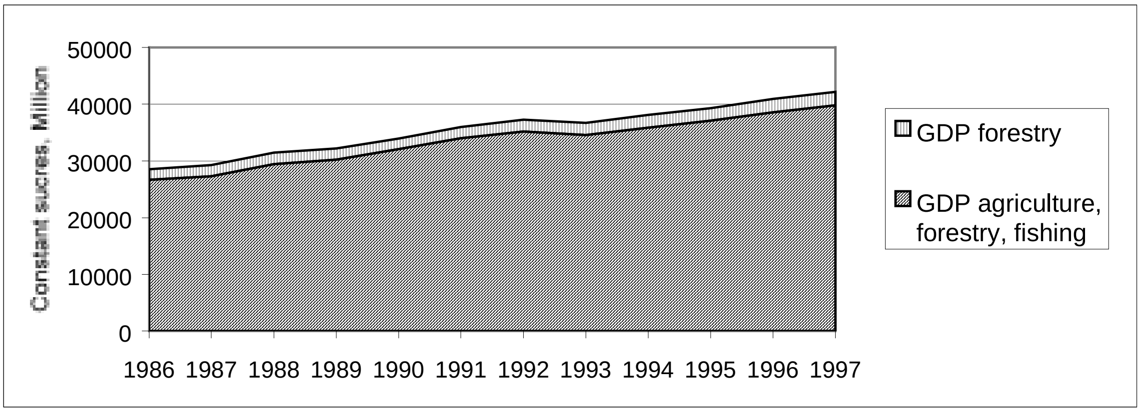
This analysis is being carried out in view of the impact of deforestation on global warming and the rapid rate of deforestation in Ecuador, which requires the application of urgent measures of mitigation.

3.1 Macroeconomic aspects

The forestry subsector accounts for a negligible share of total GDP over the last decade, namely, scarcely over 1%. If the wood industry is added to this, the share does not even amount to 2%, and therefore in macroeconomic terms it can be concluded that this sector is insignificant.

Within the agriculture, forestry, hunting, and fishing sector, the share of forestry subsector is quite low, about 6%, with slight variations throughout the decade[69]. These figures correspond to constant values[70]; this particular fact is mentioned because when the same share is calculated using each year's values, the forestry subsector appears to be much more important, amounting to 10.7% in 1994, and it is estimated that it will remain at 8.7% in 1998. This discrepancy stems from the variations in relative prices[71], reflecting the increasingly higher prices of forest products, compared with those for farm and livestock products. These higher prices may be due to situations of scarcity, greater difficulty in gaining access to the resources, the prohibition of cutting certain species which in turn leads to trading these species at higher prices on the domestic market, and competition from demand coming from abroad, for example. This situation could provide greater incentives for the exploitation of forest products[72] because they offer better prospects of profitability as a result of the higher prices.

Figure 11 GDP of forestry, agriculture and fishing



The momentum of the forestry subsector is not greater than that of the rest of the economy or the agricultural and livestock sector. Nor does it show a steady growth rate, but rather considerable fluctuations over time, as a result of the chaotic exploitation of this resource and specific market situations.

Regarding the wood industrialisation sub-branch, its importance inside the manufacturing sector has remained stable, at about 5%[73] throughout the decade. If comparisons are made at current prices, the results obtained are the inverse of those obtained in the case of the forestry subsector, with fluctuations of this share amounting to only 2%[74].

---

69 Central Bank of Ecuador, *National Accounts*, No. 17, and *Economic Forecasts*, 1997 and 1998.

70 Baseline year 1975 according to National Accounts.

71 The deflator indices of the forestry subsector are higher than those of the agricultural, livestock, and forestry sector as a whole.

72 And later these areas are developed for other uses, such as grazing and farming, in order to continue tapping other forest areas.

73 At constant prices of 1975, Central Bank of Ecuador, op. cit.

74 The price of cut and pressed wood, as well as other manufactured products, display lower price indices than the average price of industrialised products.

It should be noted that the figures involving production are not reliable enough, since only sales to lumber mills are recorded; this means that the figures are actually underestimated, as they do not include clandestine production and marketing.

On the other hand, although the forest production segment aimed at foreign markets is as yet incipient (a peak of 1% was reached in 1995[75]), gross wood exports have increased considerably during the decade, from US$236,000 in 1986 to US$31.3 million in 1995. As of 1988, the value of exports has grown, reflecting the increase of volume; likewise, between 1991 and 1994, the rise in value of these exports was boosted by the increase of prices on the international market. At present, forest exports (Table 39) are displaying levels that are comparable to those of industrialised wood products, which cannot be viewed as satisfactory since, on the one hand, these sales to foreign markets involve a lower value added than industrialised products[76] and because, the international demand for these goods is growing.

Table 39 Wood exports

	1986	**1990**	**1995**	**Annual growth**	
				1986-1990	1990-1995
LUMBER					
10^3 kg	1,253.0	11,934.4	82,355.9	75.7%	47.2%
10^3 US$, FOB	236.0	11,583.40	31,284.60	164.7%	22.0%
Average Price (US$/kg)	0.19	0.97	0.38	50.7%	17.1%
PROCESSED WOOD					
10^3 kg	19,005.0	27,654.7	64,340.4	9.8%	18.4%
10^3 US$, FOB	15,160.0	10,067.7	34,320.9	-9.7%	27.8%
Average Price (US$/kg)	0.80	0.36	0.53	-17.8%	7.9%
Total Lumber and Processed (10^3US$)	15,396.0	21,651.1	65,605.5	8.9%	4.9%
Participation Lumber/Total	1.5%	53.5%	47.7%		

3.2 Land use

Ecuador's extension is about 26 million square kilometres, which do not include populated areas[77]. For the present analysis, the information dates back to the years 1985 and 1992 and is broken down into two main land use areas: Forest Areas and Other Uses.

Between the two above-mentioned years, there is a change in the distribution of forest use, with a shift from 53%, which is the share of surface area covered by forests in 1985, to 48% in 1992. In absolute terms, this means a net loss of forest cover of almost 1.3 million hectares over the seven years that had elapsed, which were transferred to "other uses". On the basis of this information, there was an annual average deforestation of 178,000 hectares. It can therefore be asserted, without fear of committing a major mistake, that the trend in land use variation identified between 1985 and 1992 will persist, since no major measures that might revert this trend have been applied.

The exploitation of natural forests is not offset by plantations since, during this seven-year period, this surface area increased by hardly 12,000 hectares, equivalent to an annual

---

75 Central Bank of Ecuador, National Accounts, No. 17. Figures have been converted into constant sucres of 1975.

76 Cut and pressed wood.

77 1985 and CLIRSEN 1992.

average of about 1,700 hectares. In various studies of INEFAN, it is estimated that, between 1992 and 1995, about 11,000 hectares were reforested per year[78]. Therefore if this trend continues, both in terms of the pace of exploitation of natural woods and in terms of reforestation, then in less than 50 years the forest cover of the entire territory of Ecuador, including protected and protection areas, will have disappeared, with disastrous consequences. Considering that the forest available for production amounts to slightly over 4 million hectares, at the current deforestation rate, this forest will be depleted in less than 20 years.

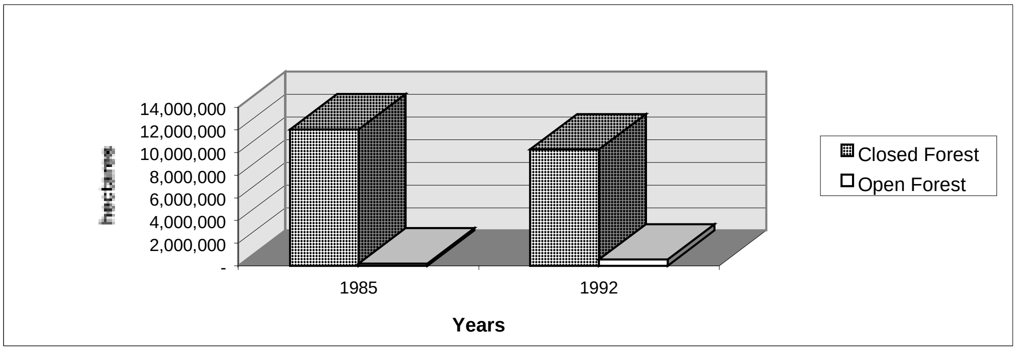
Table 40 Variation in land use in Ecuador

	Area (Hectares)		**Structure**				
USE	**1985**	**1992**	**1985**	**1992**	**Variation**	**Annual growth**	**Variation** (m^3/yr)
Closed Forest	12,030,285	10,272,898	45.8%	39.1%	-1,757,387	-2.23%	-251,055
Open Forest	196,000	558,370	0.7%	2.1%	62,370	16.13%	51,767
Total	**12,226,285**	**10,831,268**	**46.5%**	**41.2%**	**-1,395,017**	**-1.72%**	**-199,288**
Bamboo/palms	450,000	581,075	1.7%	2.2%	131,075	3.72%	18,725
Forest Plantations	60,000	78,000	0.2%	0.3%	18,000	3.82%	2,571
TOTAL FOREST	**12,736,285**	**11,490,343**	**48.5%**	**43.7%**	**1,245,942**	**0**	**-177,992**
Bushes Land	1,253,284	1,215,056	4.8%	4.6%	-38,228	-0.44%	-5,461
Other uses (water, urban, etc)	12,276,131	13,566,301	46.7%	51.6%	1,290,170	1.44%	184,310
TOTAL OTHER USES	**13,529,415**	**14,781,357**	**51.5%**	**56.3%**	**1,251,942**	**0**	**178,849**
TOTAL	**26,265,700**	**26,271,700**	**100%**	**100%**	**6,000**	**0**	**857**

Source: Institute of Forestry and Natural Areas of Ecuador (1992: Satellite Information)

The distribution of forest has also undergone changes, the "closed" wood, or wet forest, accounted for 46% of the country's total surface area and it now accounts for only 39%. A very small proportion of this loss has now become open forest, whose share as grown from 0.7% to 2.1% of total surface area, facilitating production conditions and motivating greater deforestation of primary woods.

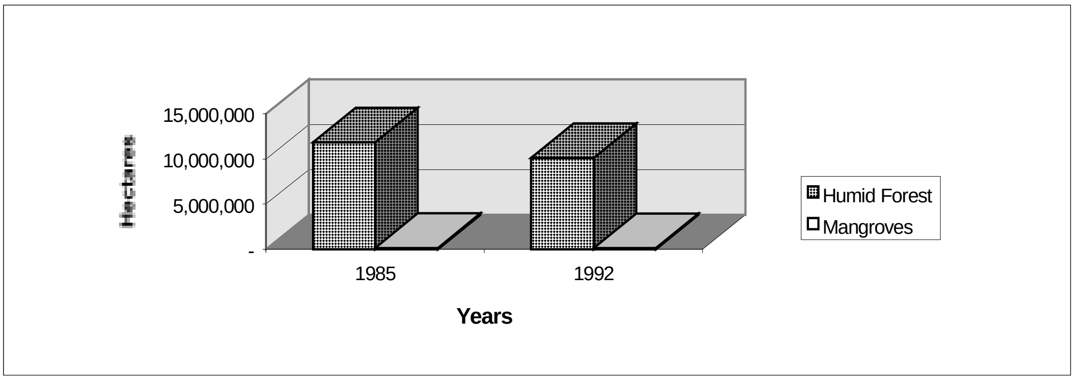
Figure 12 Variation of forest



[78] During the period 1992-1995, 47,000 hectares were planted; therefore, without including any possible or eventual production, the total planted area would amount to 125,000 hectares, which are scattered throughout the country and only a few of which are being managed using sustainable practices. INEFAN, PAFE, page 10.

Regarding mangroves, their share of total forest surface is negligible but because of their important for the equilibrium of the ecosystem, it should be emphasised that their disappearance involves an average of more than 1,800 hectares per year, which generally are generally transferred to shrimp production[79].

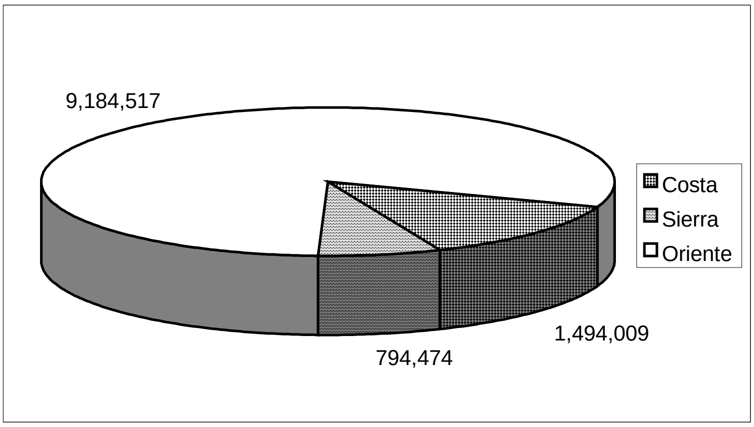
Figure 13 Closed forest



As for the distribution of woods by region, in the sierra there are few forest resources and in the northern coastal region, the province of Esmeraldas, forests are being steadily logged for industrial purposes, whereas in the eastern region of the country, the Amazon region, it is estimated that deforestation amounts to more than 60,000 hectares per year.

On the other hand, around 53% of the whole forested land can not be exploited because it is considered as national parks, protected areas, biosphere reserves and other similar categories.

Figure 14 Forest reserves (hectares)



3.2.1 Land use for agriculture and livestock

This section is aimed at showing the evolution of land use for agricultural and livestock purposes, since the performance of this variable is closely linked to what is happening to forest areas. The figures that were used are drawn from two sources of the Ministry of

[79] The area involved in this activity recorded an annual average increase of 4,000 hectares.

Agriculture and Livestock (MAG) and should be viewed as referential estimates, since they come from different surveys.

Table 41 shows land use over a 16-year period; the most noteworthy characteristic is that land surface for farming and livestock has increased by more than 100%.

Table 41 Land use

USE	Hectares			Structure			Annual Growth Rate	
	1972-73	**1984-85**	**1988-89**	**1972-73**	**1984-85**	**1988-89**	**1972-84**	**1984-88**
Agriculture Sierra	503	249	325	13.1%	4.1%	4.2%	-5.7%	6.9%
Agriculture Costa	1,060	1,304	1,258	27.6%	21.7%	16.3%	1.7%	-0.9%
Agricult. Oriente	30	60	135	0.8%	1.0%	1.7%	5.9%	22.5%
Total Agriculture	**1,593**	**1,613**	**1,718**	**41.5%**	**26.8%**	**22.2%**	**0.1%**	**1.6%**
Pasture Sierra	1,024	1,917	2,349	26.7%	31.8%	30.4%	5.4%	5.2%
Pasture Costa	833	2,005	2,792	21.7%	33.3%	36.1%	7.6%	8.6%
Pasture Oriente	384	484	880	10.0%	8.0%	11.4%	1.9%	16.1%
Total Pasture	**2,241**	**4,406**	**6,021**	**58.5%**	**73.2%**	**77.8%**	**5.8%**	**8.1%**
Sierra and Costa, Total	**3,420**	**5,475**	**6,724**					
Oriente Total	**414**	**544**	**1,015**					
TOTAL AGRIC. AND PASTURE	**3,834**	**6,019**	**7,739**	**100.0%**	**100.0%**	**100.0%**	**3.8%**	**6.5%**

Source: Southgate Douglas and Whitaker Morris. Development and Environment Policy Crisis in Ecuador. 1994.

On the other hand, the share of farming in total land use for agriculture and livestock has declined from 41% to 22%. During this period agriculture in the sierra declined by 62%, whereas in the coastal region farming, in terms of land use, increased by 20% and in the Amazon region of Ecuador it has increased by 350%[80]. Meanwhile, land surface for grazing has grown by 168%, with a substantial rise in grazing land in the coastal region. Economic reasons, higher earnings, and lower risk exposure are at the root of this important rise in grazing land, which means that ultimately there are no efforts to reforest those forest areas that have been cut and cleared for grazing. According to site-specific studies conducted by INEFAN, the breakdown of land use after deforestation is as follows: 35% of the land is used for farming, another 35% is used for grazing, and the remaining 30% becomes stubble fields[81].

3.2.2 Farm and livestock use of land

As for potential land use, the National Regionalisation Program of MAG has conducted surveys focusing on current land use, which have concluded that more than 90% of the land fit for farming and cattle raising is already occupied. On the basis of this, it can also be deduced that a share of the land that is currently being used for these purposes corresponds to areas that are not fit for farming and cattle and should be set aside for protection. The use of the latter type of land for agricultural and livestock purposes offers no long-term prospects of sustainability owing to its thin plant layer.

80 As a result of the land settlement policy and the incorporation of oil production into the economy.

81 Development of Forest Resources Apt for the Wood Industry of the Buffer Zone of the National Sumaco-Napo-Galeras Park.

It is estimated that the agricultural frontier of both the sierra and the coastal region has reached its limit, whereas in the Amazon region only about 17% of the land is apt for farming and grazing; the latter percentage has already been more than used up as a result of land grants to ensure colonisation of the Amazon region, as well as other settlements[82]. In the sierra and coastal region, it has been estimated that less than 30% of the areas that should be occupied by forest are actually covered by forests. One factor heightening the need for farmland is the type of farming that is generally implemented in the country, that is, extensive farming, where increases in production are mainly due to the enlargement of farming areas rather than substantial improvements in productivity[83].

3.3 Production and consumption potential

In order to assess the maximum potential of wood production, it should be observed that 65% of existing natural wood areas should not be logged for any purpose[84], since this would undermine the equilibrium of ecosystems. This means that there is only slightly more than 4 million hectares that can be used for production purposes, and if they are tapped using a sustainable approach they would be able to produce no more than 3.9 million cubic meters per year[85]. Comparing this figure with the 8.5 million cubic meters extracted in 1992 from native forests helps to highlight and explain the rapid rate of deforestation of the country's territory.

As for the distribution of consumption between industrial and energy use of biomass, there is contradictory information. According to INEFAN, in 1992, 9.7 million cubic meters were consumed, and of this 3.7 million cubic meters were for industrial use and 6.0 million cubic meters were consumed for energy purposes. This information is considered to be quite exaggerated because firewood consumption usually depends on gathering and use of forest production wastes rather than logging itself.

Of the 3.7 million cubic meters consumed by industry, 75% is extracted from native woods and the remaining 25% from forest plantations. One severe problem is the inefficient system of production and industrialisation[86], which generates a high proportion of waste, part of which is used for firewood production, but the majority of which, "for economic or transport reasons," is wasted at the site of the logging and in processing centres. On the other hand, industrial production is highly selective in order to meet the demand for well-known and widely used species, which fosters the cutting and clearing of extensive areas in the search for required resources, as well as the logging and waste of other species that could well have been used otherwise.

---

82 Southgate, D., and Whitaker, M., Development and the Environment: Policy Crisis in Ecuador, page 25.

83 In Ecuador, the use of fertilisers per hectare is quite low. In 19.., it amounted to 338 kilos per hectare, in contrast to 985 in the United States, 1094 in Spain, and 4800 in Switzerland. World Bank.

84 Of the 11.4 million hectares, 4.2 million correspond to Protected Natural Areas, 3.2 to protection forests (whose production capacity is limited, due to their location in the foothills and because they belong to ecologically vulnerable areas such as mangroves). INEFAN-PAFE, *Sustainable Development Strategy for the Forest Industry,* December 1995, page 8.

85 It is estimated that 85% of this surface is, at present, accessible and that the natural growth of the forest is 1.13 cubic meters per hectare per year. INEFAN-PAFE, op. cit., page 8.

86 According to INEFAN, only about 17% of the timber that is logged is actually used.

3.4 Consumption forecasts

The Sustainable Development Strategy of the Forest Industry of INEFAN[87] is based on a demand for wood in the amount of 2.8 million cubic meters for 1993, obtained from native woods and whose demand is being forecast for two ten-year stages, one extending up to the year 2003 and the other up to the year 2013, with annual growth rates of 2.8% for the first period and 1.1% for the second. In 1993, supply was estimated to be 5.3 million cubic meters, which must be sustained at 5.2 million to meet demand by applying sustainable management practices. According to INEFAN estimates, in order to meet the demand required for the three years referred to above (1993, 2003, and 2013), a sustainably managed land surface of 140,900 hectares, 185,400 hectares, and 206,500 hectares per year, respectively, will be needed, and in practice this is not being achieved.

Table 42 Consumption forecasts

Year	Demand 10^3 m	Supply 10^3 m	Balance 10^3 m
1993	2,819	5300	2,482
2003	3,709	5200	1,491
2013	4,131	5200	1,069

Source: INEFAN, Strategy for Sustainable Development of Forestry Sector.

3.5 Mitigation

Projects of reforestation, afforestation, agroforestry (intercropping for producing agricultural and forest products) should be undertaken urgently in order to mitigate the endangering effects of the accelerated deforestation process mentioned above. Participation of native communities and wood processing industries themselves, is a condition to reach the success of the projects.

It is estimated that 80.000 hectares could be dedicated to this use, distributed through the natural regions of the country, according to the share defined in Table 43. Initial investment costs and maintenance costs of each kind of forestry project were based on the experience of the Institute of Forestation and Wild Areas. Different costs are justified by the different density of forest areas.

The life of the project is 32 years, between 1998-2030, and the net present value of the total cost reaches US$ 363.9 million. This cost does not include opportunity cost of land diverted from other uses, because there is too much uncertainty about that. Taking into account the different density of each project, the estimated amount of CO_2 for the whole period of the project is around 592.4 million tons, and the Net Present Value of each ton of CO_2 is US$ 1.78, taking into account the diversity of biomass densities of each forest use, as it is shown in Table 43[88].

---

87 Working Paper No. 16, PAFE-INEFAN, December 1995.

88 Carbon sequestration was based on mean annual increment of growing vegetation. An average of 180tC/ha was used to calculate biomass carbon density and soil carbon density. Document on Forestry Sector. Training Workshop on the Economics of Greenhouse Limitation. August 1996. Risø.

Table 43 Cost of Forestry Program

REGION	Struc-ture	Cost (US$/Ha)	Ha per year	Trees per Ha	Initial Investment (US$)	Maintenance Costs (US$/Ha)	Maintenance Costs (US$)	Protection Costs (US$)	Years of Mainte-nance	Net Present Value Costs (US$)
Coast Producer 1	8%	399.9	6,400	1110	2,559,347	100	640,000	64,000	5	51,058,345
Coast Producer 2	12%	239.3	9,600	400	2,297,477	100	960,000	96,000	5	61,887,140
Coast Agroforestry	10%	116.2	8,000	150	929,334	50	400,000	40,000	5	25,526,336
Coast Natural Reproduction	7%	130.9	5,600	100	732,907	100	560,000	56,000	5	30,850,463
Sierra Producer	20%	279.9	16,000	1110	4,478,924	100	1,600,000	160,000	2	78,851,422
Sierra Wind Protection	10%	36.2	8,000	100	289,488	10	80,000	8,000	2	4,566,947
Orient Producer	10%	239.3	8,000	400	1,914,564	100	800,000	80,000	5	51,585,159
Orient Agroforestry	15%	116.2	12,000	150	1,394,001	50	600,000	60,000	5	38,289,504
Orient Natural Reproduction	8%	130.9	6,400	100	837,608	50	320,000	32,000	5	21,317,890
TOTAL	100%		80,000							363,933,206

Source of Costs: INEFAN.

Analysis of the Scenarios

1 Modelling approach

The analysis of energy scenarios and their associated emissions and CO_2 reduction costs has been undertaken using the Long-Range Energy Alternatives Planning System (LEAP) model. The LEAP model is a computer-based accounting and simulation tool developed by the Stockholm Environment Institute - Boston Center. The model enables users to analyse final energy demand, energy conversion processes, resource requirements, and environmental impacts within an integrated framework. Driven by the results of the LEAP demand module, the transformation programme of the model simulates energy flows and calculates the primary energy resources necessary to satisfy the demand. Emissions from energy conversion and final energy uses are calculated at all stages using technology specific emission factors.

The demand module of the model provides a disaggregated end use approach to the analysis of energy consumption. Based on the availability of data, energy demand is assembled in a hierarchical structure made up of four levels: sectors, subsectors, end-use and devices. The calculation of the final energy demand for each end-use is carried out on the basis of technical, economic and social indicators. The use of scenario approach allows to account for the development of all factors which depend on policy options both in the energy field and elsewhere.

The transformation programme is used to simulate the energy supply and energy conversion processes used to meet the set of energy demands calculated in the demand programme. Thus, the system is driven by the results of the demand programme. As each module operates, successive modules satisfy one set of final energy requirements but create another set of primary energy requirements. The final outcome is primary resource requirements for the system.

The Environmental Data Base on environmental loads allows for calculating the emissions associated with the demand and transformation scenarios.

2 Scenarios

The long-term development strategies and policies assumed in the scenarios are heavily dependent on the short-term decisions, and many of the uncertainties about such scenarios are due to the long-term consequences of short-term decision or behaviours. Despite those uncertainties an as it was underlined in the chapters on international framework and socio-economic analysis, a more stable regional and international environment, the gradual implementation of adjustment policies together with an expected significant growth in private flows over the coming decade make up a more favourable context for a sustained and relatively accelerated economic growth in the future.

Within the frame of a common macroeconomic scenario and on the basis of mitigation options discussed in Chapter IV two energy scenarios have been constructed for the CO_2 reduction cost analysis. Both reference and mitigation scenarios represent quite different and internally consistent patterns of energy development. The baseline scenario serves as reference point for the whole analysis and represents a development path for the energy system compatible with the existing portfolio of projects and programmes. The baseline scenario includes assumptions on expected efficiency improvements leading to lower primary energy requirements per delivered energy service. Of course those efficiency improvements in the energy system depend on the success of the assumed development path, given national political and regulatory conditions. However, a certain level of autonomous energy efficiency improvements has been incorporated in the assumptions of the reference case.

The amount of CO_2 reductions estimated in the future is defined as a relative quantity: the difference between baseline scenario and the mitigation scenario. Therefore, the potential for energy savings and associated CO_2 reductions are clearly dependent on the nature of both the baseline and mitigation scenarios, and thus on the assumptions and choices of technologies associated with each of these. The CO_2 reduction options which characterise the mitigation scenario represent a set of measures and policies plausible of being implemented from both the economic and technological point of view. Most of the options imply an economic and environmental double dividend and some of them are worth undertaking whether or not there are climate-related reasons for doing so.

3 Final energy demand

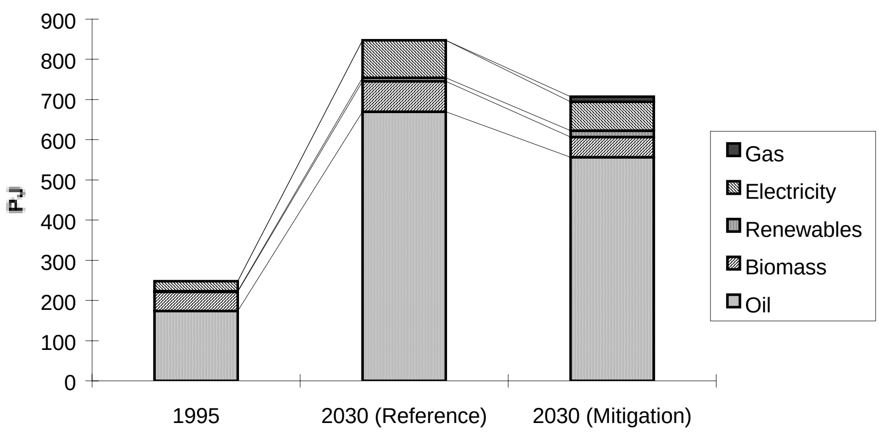
Main assumptions and technical options characterising final demand scenarios have been described in detail in the previous chapter. However, the following summary remarks are worth noting in order to understand the scope of the final energy demand forecasts:

1. Interfuel substitutions are not expected to play a meaningful role in energy demand scenarios. As an oil producer country, energy consumption in Ecuador will continue relying on oil products, and minor changes in the structure of energy demand among the two scenarios are mainly due to different growth rates of fuels as result of efficiency improvements considered in the mitigation scenario.
2. Taking into account the uncertainties on the amount of natural gas reserves, only a marginal penetration of gas in final uses in the industry has been assumed in the mitigation scenario. Since the infrastructure needed for the exploitation of natural gas is still to be built, the spectrum of future options for using this fuel is focused on thermal power generation.
3. Both scenarios assume reductions in the specific energy needs and energy intensities as result of the incorporation of autonomous energy efficiency improvements in energy use technologies. Specific measures concerning reductions in energy needs due to changes in nature of level of the required energy services have not be taken into account.
4. Higher levels of reductions in specific energy needs and energy intensities assumed in the mitigation scenario are the result of assumptions concerning efficiency improvements in existing technologies, mainly in the industrial sector, and faster penetration of new technologies (new lighting systems, improved electric appliances, more efficient vehicles). The flexibility or inertia of consumption patterns underlying the energy consumption in different economic sectors as well as the behavioural characteristics that determine energy consumption levels have been taken into account by assuming differentiated penetration rates of new technologies.

5. No major penetration of non-conventional technologies is expected in both scenarios. The contribution of solar thermal systems for water heating uses remains marginal, although faster penetration rates have been assumed in the mitigation scenario.
6. The transition from traditional fuels (biomass) to conventional fuels is expected to continue in both scenarios. The speed and characteristics of this process vary between the reference and mitigation scenarios. Additionally, mitigation scenario assumes a dissemination of more efficient woodstoves to cover 100% of households using fuelwood for cooking by the end year of the scenario horizon.

The final energy demand in the reference and mitigation scenarios is shown below.

Figure 15 Final energy demand by fuels



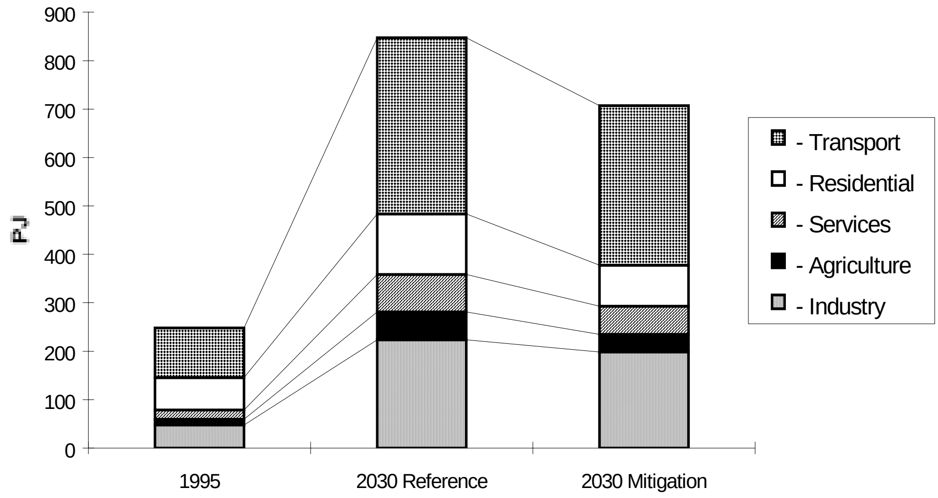
Final energy demand is forecasted to growth by 3.6% and 3.0% yearly from 1995 to 2030 in the reference and mitigation scenario respectively. In terms of energy consumption per capita these growth rates represent an increase by a factor of 2 and 1.6 compared with the consumption levels of the base year. Table 44 shows a summary of the main trends in the final energy demand under the two scenarios.

Table 44 Final energy demand in the reference and mitigation scenarios

	Base year 1995	**Baseline scenario 2030**	**Mitigation scenario 2030**
Energy Demand (PJ)	248.2	847.5	707.2
Shares (%):			
- electricity	10.1	11.0	10.2
- oil products + gas	70.0	79.0	80.5
- renewable energies	19.9	10.0	9.3
Annual Growth rate (%)		3.6	3.0
Energy per capita (GJ/capita)	24	47	39
Energy per GDP (GJ/10^3US$)	13.8	10.1	8.4
Energy/GDP elasticity		0.8	0.7

Regarding the fuel mix no remarkable differences can be noticed under the reference and mitigation scenarios. As mentioned above, this is mainly because of the modest assumptions about interfuel substitutions in both scenarios. However, compared to the base year the scenarios display a tendency for the biomass to decrease from near 20% of total energy consumption in 1995 to around 10% in 2030.

Figure 16 Final energy demand by sectors



Two opposite tendencies can be observed from figures presented in Table 44. On one hand, energy demand increases as result of the increase in energy demand per capita, and on the other hand, this increase is partially offset by a significant decrease in energy/GDP intensity. However, both population and output growth will significantly outpace the efficiency reduction potentials, implying absolute increases in final energy demand.

The potential for energy reductions on the demand side of the energy system amounts to approximately 140 PJ in the year 2030, amount which represents 17% of the final energy demand under the reference scenario. Energy savings play a different role in sectoral energy demand, ranging from as much as 28.4% in the residential sector to 13.2% in services. Energy savings in transport and industry account for 25% and 18% respectively, of total energy reductions in the mitigation scenario. Figure 16 shows final energy demand by sectors in reference and mitigation scenarios.

The contribution of the industrial sector to GDP is expected to remain constant (around 15%) along the period analysed and no major changes are assumed among industrial subsectors. Energy demand reductions in the mitigation scenario are driven by a combination of efficiency improvements in thermal uses, specific uses of electricity and motors. Four types of mitigation options have been considered:

1. Efficiency improvements in boilers. Avoided fuel demand of about $1.67 * 10^6$ BOE represents 12% of total industrial demand for steam generation in the reference scenario.

2. Improvements in specific uses of electricity. A combination of more efficient process together with the introduction of efficient motors leads to an important decrease of electricity demand in industrial uses of about 2.24 TWh in the year 2030.

3. Efficiency improvements in thermal uses. This includes assumptions on efficiency improvements in furnaces and dryers which results in about 10% of

fuel demand reduction respect to energy demand for thermal uses in the reference scenario.

The relatively modest growth of energy consumption in the transport sector of about 3.7% reflects the fact that the reference scenario already assumes important technological improvements in the fleet of vehicles. Therefore, fuel demand in the year 2030 in the base case shows significant energy savings compared to the level of energy demand which would have occurred under the specific energy consumption prevailing in the base year. The mitigation scenario assumes additional efficiency improvements mainly driven by the adoption of a fuel tax. The idea behind this mitigation option is that increasing the price of the fuels makes sense an incremental investment in more expensive but more efficient cars. The potential of energy saving results in about 6.1 * 10^6 BOE by the year 2030, amount which represents a decrease of 10% respect to the energy demand in the reference scenario.

Modal split changes, i.e., shifts in the relatively shares between different transportation modes, hold important implications for CO_2 emissions, in both the positive and negative directions due to the different energy intensity of various transportation modes for both passenger and freight. However, the substitutability between different transport modes is limited by relative economics and accessibility to infrastructures, among others. The assessment of modal split changes requires a great amount of data an information related not only to technical and economic parameters but also to behavioural changes on the spatial and temporal economic activities. This type of analysis is beyond the scope of the present study. Here, only one marginal option has been considered: the extension of the trolley bus system in Quito.

Final energy demand forecasts in the reference and mitigation scenarios indicate that the relative energy saving potential of the households is larger than that of either industry or transportation. The overall estimate, across all income classes is calculated in about 40 PJ by the year 2030, which represents 32% of household energy consumption under the reference scenario. The options for reducing energy and carbon intensity in the household sector can be classified as follows:

1. Efficiency improvements of energy appliances. Compared to the best available technologies existing in the market, specific consumption of the stock of refrigerators, freezers and room air conditioners show efficiencies significantly below the average efficient vintages. The average 1995 stock of refrigerators consumed between 750 and 1000 kWh/year and the best available models in Europe and the USA consumes below 200 kWh/year. Under the reference scenario the average consumption assumed by the year 2030 is about 450 kWh/year while in the mitigation scenario the average consumption is 150 kWh/year, which represents the best available technology in 1995. Similar hypothesis have been assumed for air conditioners and other end-use energy appliances.

2. Efficient lighting systems. The introduction of more efficient lighting systems results in electricity savings estimated at about 1000 GWh in the mitigation scenario, amount that represents near the 45% of the corresponding demand under the reference scenario.

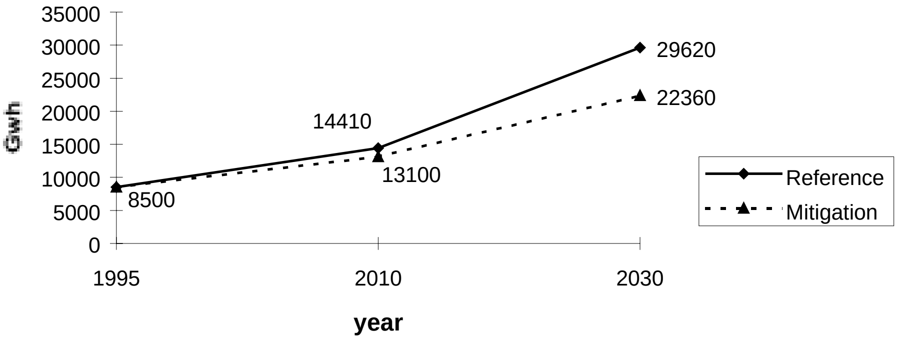
3. Efficiency improvements in electricity end-uses in rural areas. This mainly refers to lighting and in a lesser extend to energy appliances.

4. Solar water heating systems.

The CO_2 abatement options considered in the service sector refer to efficiency improvements of end-use conversion technologies, including lighting systems.

Figure 17 shows the trends of electricity demand in both scenarios. Total electricity savings resulting from the adoption of mitigation options has been estimated in 7.26 TWh by the year 2030. These savings represent about 25% of total electricity demand in the reference scenario. In terms of per capita electricity consumption per year, consumption in year 2030 exceeds that in 1995 by a factor of two, while in the mitigation scenario per capita consumption is only 50% higher. Per capita consumption by the year 2030 is 1654 kWh and 1250 kWh respectively.

Figure 17 Electricity demand



4 Energy supply scenarios

The supply-side mitigation options are focused on the potential for CO_2 reductions in electricity generation. Different alternatives for electricity supply have considered in both scenarios, being the main difference a major emphasis on hydropower generation in the mitigation scenario. Main assumptions underlying the scenarios can be summarised as follows:

1. In the reference scenario is assumed an addition of 900 MWh of hydropower capacity to the year 2030. This relatively modest increase is because the remaining hydro potential to be tapped becomes costly, with the appropriate sites for building dams becoming less attractive compared to cheap fossil fuel-based thermal generation. The mitigation scenario assumes a more aggressive penetration of hydro electricity, representing an increment of about 2000 MWh respect to 1995.
2. Both scenarios differ in assumptions on improvements in steam and combustion turbine efficiencies. While the reference scenario includes additional capacity of 300 MW of combined cycle turbines, this technology amounts 480 MW in the mitigation scenario.
3. The prospects of wind energy utilisation for power generation have not been properly assessed in Ecuador. However, with wind velocities of more than 5 meters/second in several zones of the country, the potential that could be harnessed by wind turbines to generate electricity appears promissory. In the mitigation scenario it has been assumed that wind energy will contribute about 1% to power generation capacity in the year 2030. This contribution represents 32 MW.

4. A modest contribution of geothermal electricity has been assumed in the mitigation scenario. Capacity for extracting electricity from hydrothermal resources accounts for 200 MW by the year 2030.

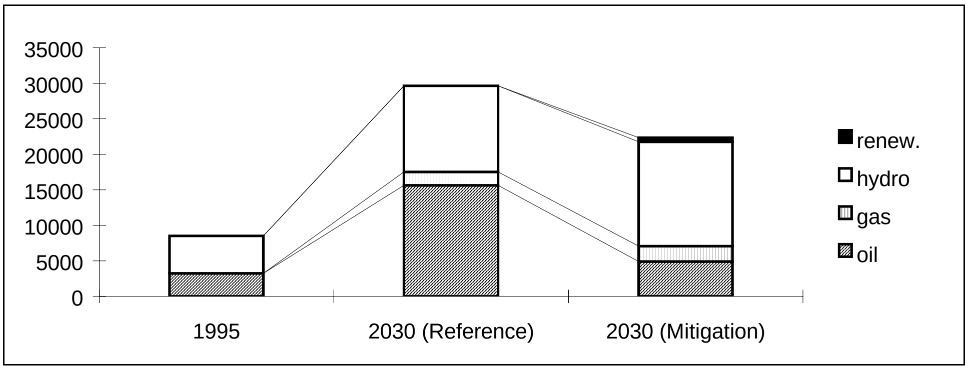
Table 45 presents the breakdown of electricity generation into main categories of energy sources. Both scenarios show opposite tendencies in the structure of energy inputs for power generation. Hydropower shows an overwhelming dominance in the reference scenario. Hydropower loses ground in respect to its present participation and its decline is compensated by sharp increase of generation from oil products. The mitigation scenario is characterised by a more balanced structure of fuel mix inputs. Thermal generation from oil drops from 73% in the reference case to 40% by the year 2030. Special mention is deserved by the contribution of natural gas and other renewable sources (geothermal and wind), whose share increases to 17% in the structure of power generation inputs.

Table 45 Power generation: inputs by fuels (%)

Energy input	1995	2030 reference	2030 mitigation
Diesel + fuel oil	65.2	72.6	40.5
Hydropower	34.8	20.4	42.2
Natural gas		7.0	12.6
Geothermal + wind turbines			4.7

Electricity generation by types of power plants exhibit the same tendencies as observed in fuel mix inputs as it can be observed in Figure 18. It is worth noting the overall efficiency of power generation, measured as the ratio between power outputs and energy inputs. Compared to the base year where overall efficiency is about 54%, the dominance of thermal generation in the reference scenario results in a decrease of the efficiency to 47% by the year 2030, while in the mitigation scenario the overall efficiency of 61% reflects the high share of renewable energy sources in the structure of power generation.

Figure 18 Electricity generation (GWh)



Primary energy supply in both scenarios exhibit on one hand changes in the final demand as result of the adoption of more efficient energy end use technologies and on the other hand the fuel mix changes in the power generation. The reference scenario is intended to represent the likely development of the energy system if no explicit effort is made to reduce GHG emissions. Reference scenario thus reflects energy resource allocations and technological development already identified in existing sectoral plans and programmes.

The mitigation scenario shows that reductions in final energy demand relative to the reference case can be achieved through the application of a wide variety of technologies and measures. Those reduction options together with technological changes in electricity generation lead to changes in the structure of energy supply, and what is most important in terms of GHG limitation, to a significant reduction en total primary requirements. By the year 2030 total reductions amount 214 PJ, which means about 21% of the primary energy demand in the reference case. In terms of demand per capita and under an annual growth rate held at 2.6% on average (3.3% in the reference scenario), primary energy per capita increases from 31 GJ/capita en the base year to 45 GJ/capita by the year 2030 (57 GJ/capita in the reference scenario).

Table 46 Tendencies in primary energy supply

	Base year 1995	**Baseline scenario 2030**	**Mitigation scenario 2030**
Total primary energy (PJ)	328	1028	814
- oil	225	861	636
- natural gas	32	34	49
- biomass	49	77	78
- primary electricity	22	55	51
Annual growth rate (%)		3.3	3.6
Energy per capita (GJ/capita)	31	57	45
Energy per GDP (GJ/10^3\$)	18.2	12.2	9.7
Energy/GDP elasticity		0.7	0.6

It is important to note that the primary energy required per unit of final energy output shows a declining tendency in both scenarios. In general the improvements in demand - and supply-side achieved in the scenarios show a declining tendency of the ratio primary energy/final energy. From a value of 1.32 in the base year, this radio drops to 1.21 and 1.15 by the year 2030 in reference and mitigation scenario respectively.

5 Carbon emission scenarios

Two important indicators in the comparison of CO_2 emissions under both the reference and mitigation scenarios are the primary energy/GDP intensity and the CO_2 intensity of primary energy consumption.

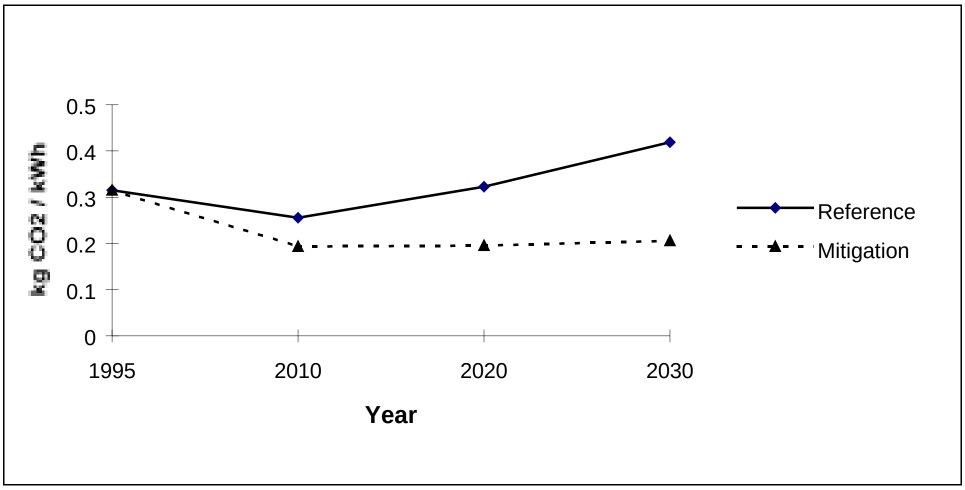
The projected value of primary energy/GDP intensity is a measure of how much energy the country will require, in relative terms, to satisfy the expected economic growth and development. Besides representing the extent to which energy is used in the economy, the indicator also implicitly incorporates expected changes in the conversion efficiencies of energy technologies. As shown in Table 46, tendencies of this indicator indicate that energy demand is expected to grow more slowly than GDP. Values by the year 2030 decrease from 18.7 GJ/10^3 US\$ in the base year to 12.2 GJ/10^3 US\$ and 9.7 GJ/10^3 US\$ in the reference and mitigation scenarios respectively. This means that a partial decoupling of energy consumption growth from economic development is expected in the future.

The CO_2 intensity of primary energy consumption reflects the dependency of the energy system on fossil fuels. The value of this indicator shows an increasing tendency in both scenarios. From 45.2 ton CO_2/TJ in the base year, carbon intensity of primary energy grows to 57.8 and 54.5 ton CO_2/TJ in the reference and mitigation scenarios respectively. In other words, while CO_2 emissions grows at an average rate of 4% and 3.2%, primary energy grows at 3.3% and 2.6% in the reference and mitigation scenarios respectively.

The above remarked tendencies in GDP and CO_2 emission growth rates can be explained by two mainly factors:

1. In both scenarios the share of biomass in energy supply drops from 15% in 1995 to 8% and 10% in the end year of the reference and mitigation scenario respectively. The use of biomass is replaced by the use of fossil fuels (mainly LPG), implying a net increase in CO_2 emissions;
2. In the mitigation scenario, additional emissions from biomass substitutions are partially compensated by lower specific emissions from power generation. This fact is illustrated in Figure 19, where it can be observed that emissions per kWh generated increase gradually after year 2010 in the reference scenario, while they remain practically constant in the mitigation scenario.

Figure 19 Electricity generation: CO_2 specific emissions



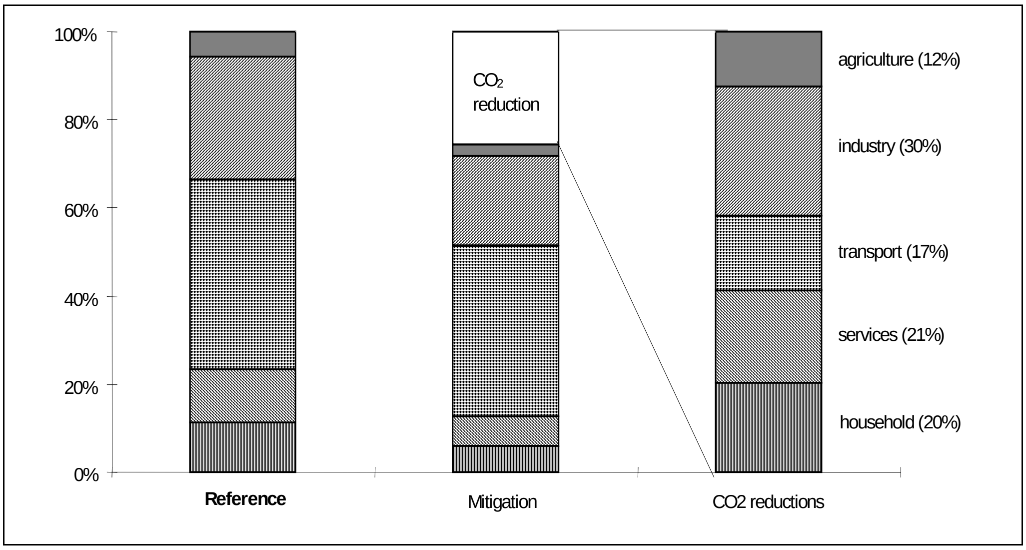
Total CO_2 reductions achieved in the mitigation scenario by the end year of the period amount to 15 million tons CO_2. A distinction is useful to make here: the reductions stemming from the final consumption of fossil fuels and reductions in thermal power generation induced by a lower demand of electricity. Table 47 shows the CO_2 emissions corresponding to these categories of energy consumption under the reference and mitigation scenarios. Direct fuel consumption account for 48% of total CO_2 reductions while power generation emissions induced by electricity savings account for 52%.

Shares of sectoral contributions to CO_2 reductions are depicted in Figure 20. Industry sector makes up the bulk of total reductions followed by the household sector. It is worth noting that spite the overwhelming contributions of the transport sector to the total emissions in both scenarios, its contribution to CO_2 reductions only accounts for 17%. As it was explained above, the relatively modest role of the transport sector in CO_2 limitations is explained by two factors. First, important achievements on efficiency improvements have been already assumed in the reference case; and second, other categories of reduction options such as modal split shifts, which can significantly affect the volume of emissions, have not been considered in the mitigation scenario. The analysis of those options requires very detailed and data demanding analysis and the use of specific models.

Table 47 CO_2 Emissions by main socio-economic sectors

10^6 ton CO_2	Reference scenario			Mitigation scenario		
	fossil fuels	electricity*	total	fossil fuels	electricity*	total
Household (urban)	2.56	3.23	5.79	2.01	0.98	2.99
Household (rural)	0.63	0.16	0.79	0.50	0.04	0.55
Services	2.80	2.44	5.24	1.97	1.05	3.02
Public services	0.69	1.15	1.84	0.49	0.44	0.93
Transport	25.41	0.02	25.43	22.90	0.01	22.91
Industry	11.02	5.31	16.33	9.88	2.05	11.93
Agriculture	3.32	0.09	3.41	1.49	0.07	1.56
Total	**46.42**	**12.40**	**58.82**	**39.23**	**4.65**	**43.88**

Figure 20 Sectoral contribution to CO_2 reductions



Respect to scenario behaviour in terms of emissions per capita, both scenarios forecast an increase in the value of this indicator respect to 1995 levels (1.4 ton CO_2). CO_2 emissions per capita increase by a factor of 2.4 at the end of the reference scenario, while mitigation scenario also display a tendency for the emissions per capita to increase but in a minor scale (2.5 ton CO_2/capita in 2030 year).

6 Changes in CO_2 emissions

In both of the scenarios analysed it appears unavoidable that with further development CO_2 emissions will continue to increase for some time to come. The instrumental determinants of future energy-related CO_2 emissions could be represented as multiplicative factors in the following hypothetical equation (Kaya identity) that determines national emission levels:

$$CO_2 = (CO_2/Energy) * (Energy/GDP) * (GDP/Population) * Population$$

The Kaya identity establishes a relationship between population growth, per capita GDP, national output energy intensity, and carbon emissions per energy on one side of the equation, and total CO_2 emissions on the other.

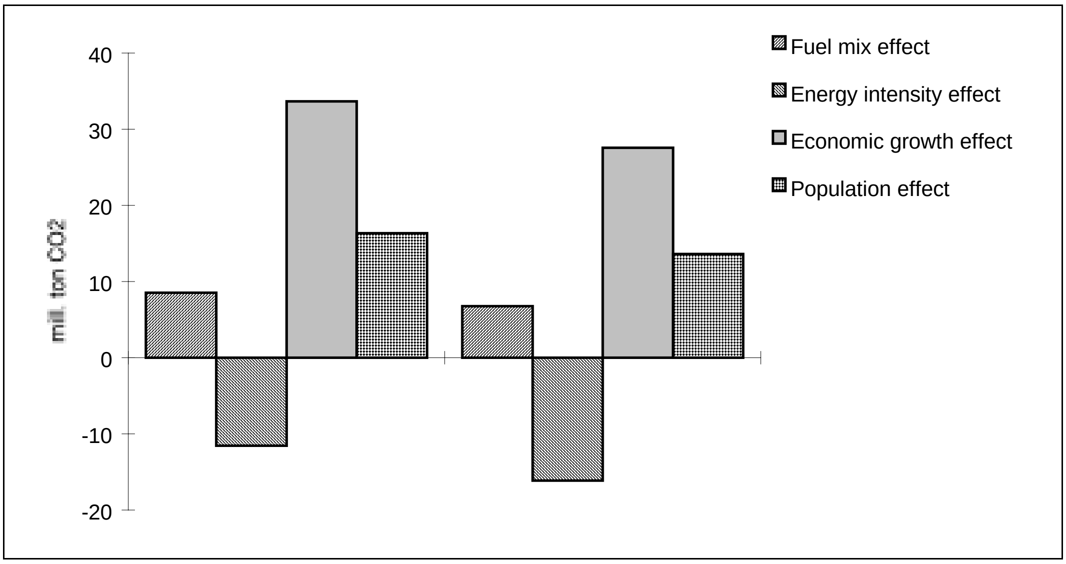
By applying the Divisia indices to the above identity changes in the amount of CO_2 with respect to base year can be explained as the aggregation of individual changes induced by the following factors:

1. Fuel mix effects which account for changes in CO_2 emissions due to changes in the structure of primary energy supply.
2. Energy intensity effect which takes into account changes in sectoral activity levels, efficiency improvements and final demand fuel mix.
3. Economic growth effects which account for changes in CO_2 emissions as result of economic growth expressed as change in GDP per capita.
4. Population effect which accounts for increase of CO_2 emissions due to population growth.

Figure 21 shows the impact of these effects in both the reference and mitigation scenarios.

In both scenarios energy intensity effect contributes to counteract emissions growth resulting from fuel mix, economic growth and population effects. The hypothesis assumed about the incorporation of autonomous energy efficiencies in the reference scenario, together with the energy saving options introduced in the mitigation scenario, results in a decreasing in energy intensity putting downward pressure on the growth of total CO_2 emissions.

Figure 21 Changes in CO_2 emissions in reference and mitigation scenarios, 1995-2030



Relatively high economic growth in both scenarios is reflected in an overwhelming dominance of the economic growth effect as the main factor of the increase of CO_2

emissions. In a lesser extent, population growth is the other driving force contributing to increasing CO_2 emissions in both scenarios.

As it should be expected, changes in the structure of power generation is reflected in the fuel mix effect. In the reference scenario emissions from electricity generation contribute 21% to the total emissions, while in the mitigation scenario the power generation contributes by about 11%.

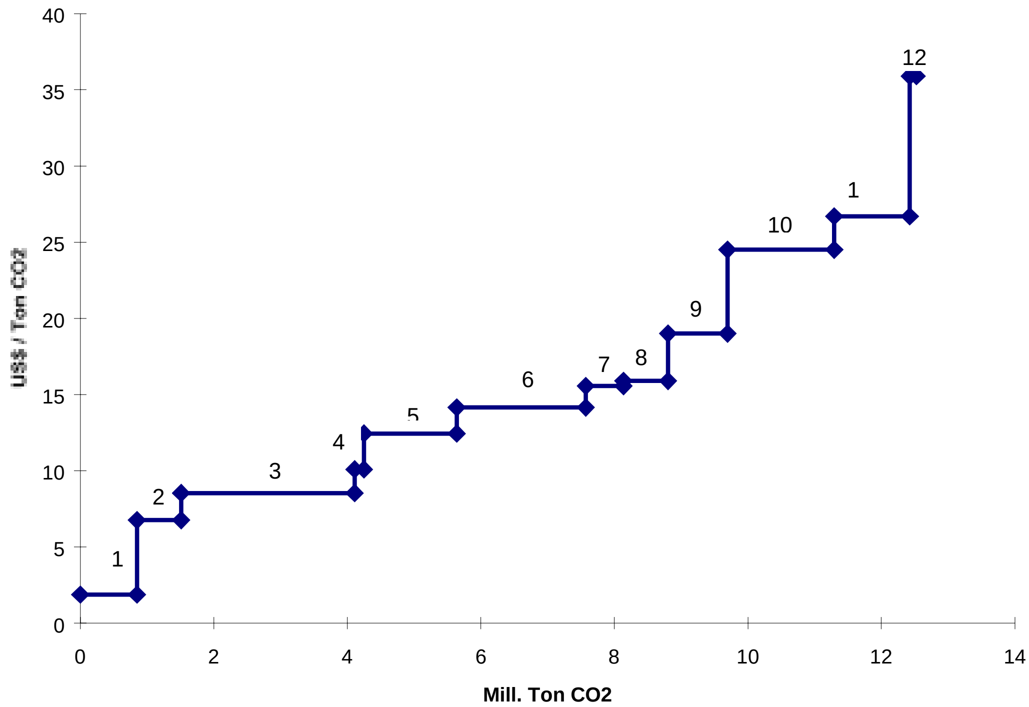
7 CO_2 reduction costs

Assessing the long-term costs of CO2 reduction options is an extremely difficult task confronted to a set of complex and interwoven conceptual, methodological and practical problems. This section does not intend to enter into theoretical and conceptual discussions on the issues related to the cost assessment, but only to explain some of the practical difficulties encountered in undertaking the cost analysis. This is important since the remarks presented bellow helps to clarify the preliminary and approximative character of the CO_2 reduction costs.

- The cost of mitigation options at the final demand level are estimated on the basis of either the costs of changing activity levels or taking into account the costs of equipment. The first approach is used for assessing the costs of options which involve increasing and decreasing the activity levels of various energy devices, to capture changes in energy equipment and / or fuel switching effects. Taking into account the wide range of technologies and production processes, average costs of improving energy intensities at sector, subsector or branch levels can provide only a very rough approximation of the real figures.
- The CO_2 reduction costs of replacing end-use devices by more efficient units are calculated on the basis of the differential prices of the equipment under the implicit assumption that the present price differences will prevail in the long term. This is a quite hazardous assumption. Moreover, it is unlikely that current inefficient equipment will be available in the market in the long-term.
- The model used to analyse the reference and mitigation scenarios does not allow to assess how electricity related mitigation options affect the structure of power generation. However, for the Ecuadorian electricity sector, where hydropower generation plays an important role, it is crucial to take into account if the mitigation options affect the base, medium or peak loads of electricity generation.
- The cost-effectiveness of mitigation options is highly sensitive to discount rates. This dependency is due to the differences in the time pattern of costs and the effects associated with different options. A discount rate of 10% has been used in the present analysis, but small changes in the discount rate can reverse the ranking of some mitigation options. This remark is also valid for the assumptions concerning the lifetime of the technologies.
- The results of the mitigation costing analysis are totally dependent on the definition and construction of the reference case. The baseline scenario constitutes the basis for the evaluation of incremental costs resulting from the adoption of CO_2 reduction options. Heavy uncertainties characterise the formulation of long-term scenarios and therefore, both the costs and ranking of mitigation options will depend on those uncertainties.

The long-term mitigation costs for the most representative options are presented in Figure 22. Two remarks are necessary: first, in the costs of the demand-side options the 'benefits' of delaying investments in energy supply (as result of a lower demand) are not taking into account; and second, the potential reduction showed in the cost curve refers to the potential of each options taken separately. Therefore, the total CO_2 reduction potential may be overestimated since some of the options overlap or they strongly affect each other.

Figure 22 Marginal cost curve of CO_2 reduction, year 2030



Option	CO2 reduction mill. ton CO2	Cost $/ton CO2
1. Household - lighting	1.09	1.5
2. Power generation - wind + geother.	0.26	6.8
3. Power generation - hydro electricity	1.33	8.5
4. Rural households - electricity	2.32	8.7
5. Services - electricity	0.75	12.4
6. Industry - motors	2.93	14.2
7. Power generation - natural gas	0.57	15.6
8. Public lighting	0.46	15.9
9. Household -refrigerators	0.18	18.1
10. Household - electric appliances	2.25	19.0
11. Industry - boilers	0.55	19.4
12. Transport- airplanes	0.62	26.8
13. Transport- gasoline vehicles	0.55	263

Despite the approximate character of the results presented above, they provide a first insight of both the potential for and the costs of limiting the CO_2 emissions. Even considering the uncertainties associated with the analysis, two conclusions can be drawn from the study. First, there exist alternative energy demand and energy supply strategies which in the long-term could lead to a less intensive development paths. Second, the costs associated to those strategies undoubtedly represent a burden to the economy but in some cases, the costs could be lower than they appear at first approximation when a number of positive side-effects are incorporated in the evaluation.

8 Energy price impacts

Additional to the CO_2 cost assessment for the mitigation scenario by using a bottom-up model, a further investigation can be carried out on relevant policy instruments for the implementation of the overall mitigation strategy. The policy measures most often suggested in the literature are energy-price changes through, for example, taxes. Depending on the price levels and substitution elasticity these changes may lead to emission reductions by providing consumers and producers with incentives to conserve energy or adopting more efficient technologies.

Assessing the impacts of energy prices on the volume of CO_2 emissions not only requires information of the different prices and elasticity in the economy but also knowledge of the interdependencies of prices and especially of the sensitivity of the price system. Modelling the complexity of the price system (if such model does exist) is beyond the scope of the present study. What has been carried out here is to undertake a very rough assessment of the potential impacts on economic branches due to an exogenous increase in energy prices.

An input-output price model has been used in this analysis. Starting from the well know, one part of the price system can be revealed, i.e. the price system for intermediate goods. The question the model tries to answer is: assuming any value as an exogenous price increase in the average output price of one sector, what are the price repercussions in all other sectors?

The input-output price model starts from an exogenous price variation of energy inputs (oil products and electricity) and enables estimates of new sectoral equilibrium output prices. The direct effect of price increase entails further price effects in different sectors which in its turn affect the prices of inputs products to the whole economy. Therefore, the exogenous price impulse leads to a chain of direct and indirect price impacts. The order of magnitude of the price effects depends on the interdependencies among intermediate sectors of the input-output matrix. The interdependent structure of the input-output matrix is revealed by the inverted Leontieff matrix, which is the basis for the price model.

On the basis of the 1995 input-output table, the impacts of an increase of oil products were estimated. Table 48 shows the main results which include the impacts on both the consumer price index and the export price index.

The economic branch most deeply affected by the increase in fuel prices is the chemical products sector, closely followed by the power generation sector. These results make sense: the high oil products intensity of the chemical sector (as energy inputs and feedstocks) and the fact that thermal power generation accounts for more than 20% of total electricity output make those branches highly sensitive to changes of oil products prices. As for the transport sector, a 50% rise in average price of oil products would affect the sector by about 20%.

The increase of electricity tariffs exerts a much lesser impact than the increase of fuels. Thus, a 50% tariff increase would, at the most, have a 20% impact on the electric power sector itself, whereas this percentage would be only 12% and 10% for costs of the chemical industry and equipment manufacturers, respectively. For the remaining sectors, impacts amount to less than 8%.

The input-output price model is based on the assumption of constant technical coefficients. Undoubtedly, this assumption is a very restrictive hypothesis. However, for the short-term it may be regarded as sufficiently realistic, although constant input coefficients in combination with price changes imply a series of further premises.

The model can only assess cost-oriented price impacts, i.e. price changes exclusively caused by cost changes. This implies constant profit margins. This is another important restrictive hypothesis since entrepreneurs often attempt to raise their profit margins in the wake of cost increases. Thus, the model underestimates price repercussions in the economy to a certain degree.

Table 48 Impacts of energy prices changes on economic sectors (%)

	Oil products		**Electricity**	
Economic sectors	**50 %**	**100 %**	**50 %**	**100 %**
Agriculture, forestry,	9.1	18.2	2.1	4.2
fishing	8.5	17.0	3.1	6.1
Crude oil and natural gas	11.8	23.7	2.5	4.9
Oil refining	17.8	35.6	5.7	11.4
Mining products	7.2	14.4	2.1	4.3
Food and beverage	16.4	32.9	5.4	10.8
industries	47.9	95.8	12.1	24.2
Textiles	21.7	43.4	8.6	17.3
Chemical products	28.1	56.3	10.2	20.4
Basic mineral industries	10.1	20.3	3.2	6.3
Machinery and equipment	41.4	82.8	20.0	40.0
Other industries	14.8	29.6	5.0	10.1
Electricity	19.9	39.9	2.8	5.5
Construction	9.4	18.7	3.2	6.5
Transport				
Commerce and services	13.4	26.7	4.0	7.9
	15.0	29.9	4.2	8.4
Price consumer index	10.9	21.9	3.1	6.2
Price producer index				
Price export index				

Lastly, the model allows for estimating impacts due only to price variations of intermediate goods but not for price changes of investment goods. For the short-term this is not a very restrictive hypothesis since impacts caused by price changes on investments goods may be neglected as output prices will react within a time lag. Despite the above mentioned conceptual constraints the model provide useful insights into the way policy instruments based on energy tax could affect the whole economy.

Reporting Forms

1 Reference scenario data

Total energy requirements (PJ)	**Base year**	**2010**	**2030**
Reference scenario total	328	503	1028
• Oil products	225	365	861
• Natural gas	32	40	34
• Coal products			
• Hydropower	22	38	55
• Nuclear			
• Fuelwood	49	60	77
• Other renewables			

Total final energy by sector (PJ)	**Base year**	**2010**	**2030**
Reference scenario total	248.20	405.0	847.54
• Industry	47.35	85.03	224.0
• Agriculture	12.61	21.70	57.57
• Service	18.51	33.90	76.37
• Residential	66.71	91.07	125.27
• Transport	102.98	173.3	364.33

Electricity supply (GWh)	**Base year**	**2010**	**2030**
Reference scenario total	8500	14410	29620
• Oil products	3250	4280	15610
• Natural gas		1110	1910
• Coal			
• Hydro	5250	9020	12100
Other renewables			

2 Mitigation scenario data

Total energy requirements (PJ)	**Base year**	**2010**	**2030**
Mitigation scenario total	328	461	814
• Oil products	225	314	636
• Natural gas	32	53	49
• Coal products			
• Hydropower	22	41	51
• Nuclear			
• Fuelwood	49	53	78
• Other renewables			

Total final energy by sector (PJ)	**Base year**	**2010**	**2030**
Mitigation scenario total	248.20	373.83	707.16
• Industry	47.35	81.26	198.81
• Agriculture	12.61	18.79	35.93
• Service	18.51	30.31	57.91
• Residential	66.71	82.1	85.34
• Transport	102.98	161.37	329.17

Electricity supply (GWh)	**Base year**	**2010**	**2030**
Mitigation scenario total	8500	13100	22360
• Oil products	3250	2710	4930
• Natural gas		1020	2140
• Coal			14670
• Hydro	5250	9280	
Other renewables		90	620

References

Abilux. Uso Racional de Energía em Edificações, PROCEL, Sao Paulo, 1992

Adda, J. La mondialisation de l'èconomie: 1. Genesè, 2 Problèmes, Ed. La Decouverte, Parìs, 1996.

Banco Central del Ecuador (BCE). Boletin de Cuentas Nacionales, Quito, 1990.

BCE. Información Estadística Mensual No. 1750 Quito, Dic. 31, 1997.

Cash-International. Un ùnico y dividido mundo, No. 77. Edimedios-Sycom, Cali, Agosto 1997, pp- 14 - 22.

Energy Innovations. 1997: A Prosperous Path to a Clean Environment. Alliance to Save Energy, American Council for an Energy-Efficient Economy, Natural Resources Defense Council, Tellus Institute, and Union of Concerned Scientists.

ESMAP. Electric Sector Management Assistance Programme, Word Bank.

FEDEMA. Estudio sobre Políticas Energéticas del Ecuador. Quito, 1995.

FEDEMA. Precios de la Energía, Pobreza y Mitigación Social.. Quito, 1994.

Geller, Howard. Efficient Electricity Use: A Development Strategy for Brazil. American Council for an Energy Efficient Economy, Washington, 1991.

Goldemberg, J; et al. Energia para o Desenvolvimiento, Sao Paulo, Brasil, 1998.

Goldemberg, J; Johansson, T.; Reddy, A. and Williams R. Energy for a Sustainable World, World Resources Institute, Washington, D.C., 1987.

Greene, D.L. Commercial Air Transport Energy use and Emissions: Is technology enough?. In *1995 Conference on Sustainable Transportation-Energy Strategies*, Jul 31 – Aug 3, 1995 (Oak Ridge National Laboratory), Pacific Grove (Calif.) 1995.

Greene, D.L. Energy efficient improvement potential of commercial aircraf. *In Annual Review of Energy and the Environment*, Vol. 17, 1992. Editor J.M. Hollander, Annual Reviews Inc., Palo Alto (Calif.) 1992.

Heilbroner, R. Visiones del futuro, De. Paidos, Barcelona, 1995.

Hufbauer, G. World economic integration and the revolution in information technology, Technology in society, 18, 2, 1996, pp. 165 - 173.

ILDIS. Estadísticas del Ecuador , Quito 1987.

Instituto Nacional de Energía (INE). Auditorías Energéticas Industriales. Quito, 1986.

INE. Balances Energéticos 1974-1986 Ecuador, Quito 1987.

INE. Balances Energéticos 1988-1992 Ecuador, Quito 1993.

INE. Diagnóstico de la Situación de Uso Racional de la Energía en el Ecuador. Quito, 1991.

INE. Encuestas Energéticas al Sector Residencial. Quito, 1990.

INE. Encuestas Energéticas al Transporte, Servicios e Industria. Quito, 1988.

INE. Resultados de las Encuestas Industriales. Quito, 1986.

INE. Serie de Balances Energéticos del Ecuador : 1969-1993. Quito, 1995.

Jørgensen C: H.; Krawack, S.; Sørensen, M & H. Therkelsen. Transport Planning & Policy: The Danish Experience, UNEP – Industry & Environment, Vol 16, No. 1-2, Jan. June 1993, pp 11-14.

KAJI, In the World Bank Development Economics Conference, Washington, D.C., 1996

Khana & Palepu. In *Cash-International, No. 73*, Edimedios-Sycom, Cali, April 1997.

Krauthammer, C. America Rules: Thank God. Time magazine, August 4, 1997, p. 18.

International Monetary Fund, Word Report 1997.

Lawrence Berkeley Lab. Guidance for Mitigation Assessments, Version 2.0, Energy Analysis Program LBL – 36 367, Berkeley, 1995.

Ministerio de Energía y Minas (MEM). Balances Energéticos 1988-1997 Ecuador, Quito 1998.

MEM. Balance Energético Nacional. Quito, 1996.

MEM. Ecuador Climate Change Country Study. Módulo 4 : Inventario Nacional de Emisiones Gaseosas que Producen el Efecto Invernadero, Quito 1996.

MEM, INECEL. Plan Maestro de Electrificación 1996-2000. Quito, 1996.

MEM, INECEL. Sistema Eléctrico Nacional : Estadísticas Anuales Quito, 1995.

MEM, Petroecuador. Estadísticas Hidrocarburíferas. Quito, 1972.

Negroponte, N. Ser digital, Editorial Atlàntida, Buenos Aires, 1995.

OECD/IEA. Climate Change Policy Initiatives. 1994 Update, Vol. 1 OECD Countries, OECD/IEA; Paris 1994.

Petersen, R. & E.V: Weiessacker. Mobility in the Greenhouse, UNEP – Industry & Environment, Vol. 16, No.1 – 2, Jan – Jun 1993, pp 7-10.

Quevedo, C. Technical Potential for Mitigation of Emissions in the Transport sector in Ecuador, Preliminary Report to UNEP- Risø, Quito, 1998 (a)

Quevedo C. Analisis de Mitigación de Gases de Efecto Invernadero en la Utilización de Energía en Ecuador – Sector Transporte, in *Memorias del Seminario Latioamericano y del Caribe sobre Gases de Efecto Invernadero*, (Hotel Oro Verde, Quito, 21 y 22 de Mayo de 1998). Edited by OLADE.

Reedy, A., Goldemberg, J. Energy for the Developing World. Scientific American. 1990.

Ruggiero, R. La globalizaciòn es un proceso irreversible. Tiempos del Mundo, July 31, 1997.

Santos, E., Desarrollo Humano y Sustentable, PUCE, Abrapalabra Editores, Quito, 1997.

SEI. Confronting Climate Change. Boston, USA, 1992.

SEI. LEAP: Use Guide for Version 95. Boston Center, Tellus Institute, Boston, USA, 1995.

Singer, M. & A. Wildavsky. Real world order: zones of peace/zones of turmoil, Chatham Publishers, Chathman, N.J., 1993.

The Economist. A survey of the world economy, September 28 - October 4, 1996.

Thurow, L. La guerra del Siglo XXI, Vergara Editores, Buenos Aires, 1992.

Thurow, L. Editorial. In *The Boston Globe*, Oct. 8, 1997.

UCCEE. The Economics of Greenhouse Gas Limitation Guidelines. Risø National Laboratory Denmark, 1997.

USCSP. Emisiones de Gases de Efecto Invernadero en América Latina y Opciones de Atenuación, Caracas, 1995.

Von hippel, D; Granda, B. Application of the LEAP / EDB Energy / Environment Planning System. SEI, Boston, 1993.

World Bank. Energy-Environment and Economic Development. Washington, USA, 1993.