SUSTAINABLE
**ENERGY FOR ALL**

# Rapid Assessment Gap Analysis

# Ecuador

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## Rapid Assessment and Gap Analysis

Sustainable Enery for All

IDB

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SE4ALL

# RAPID ASSESSMENT AND GAP ANALYSIS OF THE ENERGY SECTOR

(RG-T1881) ECUADOR

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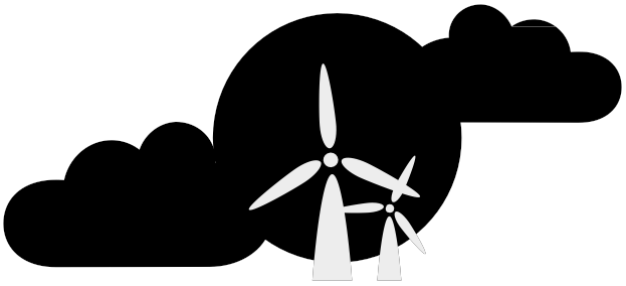
# EXECUTIVE SUMMARY



# 1. ECONOMY, SOCIETY, AND ENERGY

Ecuador is an oil exporting country, which has an influence on the national economy and also dominates the energy mix. Oil is the main export of the country, and the highly positive commercial oil balance compensates for the deficit created by the non-oil commercial balance. The oil sector represents around 12-15% of the generation of added value. Oil exports represented an average of between 50% and 60% of total goods, and oil revenues play a primary role in public finance. During the recent years of high international prices they accounted for between 30% and 40% of non-financial public sector revenues and between 15% and 20% of the GDP. Furthermore, oil derivatives currently supply around 77% of total energy consumption in the country.

Regarding the situation of high oil dependence in the economy and the energy mix, oil resources are already in a phase of decline. Even if production based on the addition of new reserves expands, the horizon for crossing the line between net exporter of energy and net importer could be between 25-30 years away. This is a reasonable amount of time, though not excessive, to carry out economic and structural transformations.

Furthermore, although advances in recent years produced substantial improvements in employment and decreased poverty, underemployment is still at 44% and the incidence of poverty is around 30%, with the greatest impact in rural areas.

The Human Development Index (HDI) also shows significant improvements like the equity of income distribution, which will improve in the future as part of a process of economic transformation involving equality and environmental sustainability. The country is at a turning point and is headed

for change in its productive energy mix with social equity based on a sustainable energy mix.

The three main objectives of SE4ALL (access to energy, energy efficiency, renewable energy) tend to shift to an environmentally, socially, and economically sustainable mix, i.e. to improve the energy mix while providing support to improve the living conditions of the poor, which coincides with the main objectives in Ecuador. Achieving these goals will have a great impact on the social and economic situation.

# 2. THE SITUATION OF THE COUNTRY IN RELATION TO THE SE4ALL OBJECTIVES

Overall, the country is in an advanced position with respect to the three SE4ALL objectives. In terms of energy access, both in relation to energy for thermal uses and electricity, the country has high penetration rates for modern energy for thermal uses and high electricity service coverage. Also, there is wide development of renewable energy for electricity generation based on existing hydroelectric projects and others under construction, as well as loopholes in existing regulations for private generation with non-conventional renewable energy and hydroelectric plants. There are also programs and projects to advance energy efficiency and use renewable resources on the demand side in productive sectors with the goal of driving advancement in these areas in which there is currently less development.

What remains to be done to achieve the goals of universal access to electricity in quantity and quality and thermal energy for efficient cooking, given the high current rates, is a greater effort to expand coverage in the most difficult to implement areas, as well as more intensively promoting energy efficiency in the productive sectors.

With respect to the source of energy used for cooking, the data from the 2010 population and household census indicates that there are still a significant number of households that use firewood or coal as their primary cooking fuel, mainly in rural areas. This is an important number, even if in terms of the total, it is low. The existence of a significant number of households that still use firewood inefficiently is relevant in light of the SE4ALL objectives that aim at universal access to modern energy regardless of whether the amounts consumed have little impact with respect to

national totals.

In relation to access to electricity, current coverage is high, although there is still a way to go to reach the goal of universal supply. While it is true that coverage levels increased significantly in both urban and rural areas, it is necessary to reach the entire population, which is an additional effort given that the country is close to the goal and the remaining portion of the population is the most difficult to reach.

## *a. Access to energy*

### i. Access to modern thermal energy for cooking

Firewood or coal are regularly used by 0.7% of urban households, 17.7% and 6.8% in relation to the total. This represents around ***260,000 households, 18,000 urban and 242,000 rural.*** The distribution by province shows a greater concentration of households that use firewood in some provinces on the coast and less in the Amazonian provinces.

The predominant source of energy for cooking is LPG, which is used in 96.7% of urban households and 80.7% of rural households, resulting in 91% for the total population. The residential sector consumes 92% of LPG marketed in the country, and it is strongly subsidized. The gas subsidy presents a risk to sustainability both for the potential substitution of firewood and for the current supply to the majority of the population of the country. For this reason, MEER is in the process of approving a massive plan to substitute LPG cookstoves for electric cookstoves.

### ii. Access to electricity

There is electricity coverage in 96.2% of urban homes (96.1% network and 0.1% solar panel), 88.2% of rural homes (88.0% network and 0.2% solar panel), resulting in 93.4% (93.2% distribution network and 0.2% solar panel) for the total households in the country. Households without any type of electricity service represent 2.2% of the total in urban areas, 10.5% of rural households, and the 5.2% remaining for the total country. In absolute terms, this means that around 196,000 households don't have electricity in the country – 54,000 in urban areas and 142,000 in rural areas.

In relation to environmental sustainability, the generation of electricity is quite sustainable; current hydroelectric generation is nearly half of the total and will increase to 90% when the big projects currently under construction begin operation.

With respect to the quality of service, it is important to reach universal access both physically and in terms of quality. The majority of electricity distribution companies don't meet the minimum requirements for the quality of service and products established in the current guidelines. Only three companies of a total of 20 meet the requirements. According to CONELEC, in reality there are problems with the quality of electricity supply due to limitations in the allocation of financial resources for the implementation of projects to expand and improve distribution networks. This is an issue that affects not only new users that are going to connect to the network but also all consumers and their activities. It is a problem that is already being faced, and although some difficulties exist, tangible results are expected in the short term. With this objective, the provision of resources will increase in order to reach the levels of quality or service and products established in the regulations. At the same time, necessary supervision will be carried out to verify that said regulations are being applied and met. If necessary, corresponding penalties will be applied.

On the other hand, it is necessary to consider that, in certain cases of isolated systems with ***"off-grid"*** solutions like, for example, solar photovoltaic panels, the parameters of quality of service can't be the same as those applied to interconnected networks.

In relation to the objectives of economic sustainability linked to SE4ALL, the subsidies constitute a significant barrier to promoting energy efficiency and the use of renewable energy in the productive and services sectors and in residential consumption. Although they could eventually indirectly affect the objectives of energy access and electricity generation with non-conventional renewable energy, this is not a real risk given the existence of sufficient guarantees for the sustainability of the investment programs related to energy access and the contracts for private generation with renewable energy.

The tariff deficit in the electricity sector will be offset by the introduction of low cost hydroelectric. The average prices of electricity are not currently

sufficient to cover the actual cost of supply, and there is a revenue shortfall that is covered by the National Government as established in Constitutional Mandate No. 15. When the hydroelectric projects that are under construction begin operation, the average cost of generation will fall substantially, and there will be a there will be a temporary tariff surplus, balancing revenues and costs up to 2020-2021. There is a special tariff (Dignity Tariff) for consumption below 110 KWh/month in the Sierra and 130 in the rest of the country.

## *b. Energy efficiency*

### *Insufficient information about energy consumption*

Scarce knowledge about the consumption of final users in the residential, productive, and service sectors divided by branch of economic activity makes it difficult to understand the real energy efficiency situation in the country and to establish precise goals for each type of economic activity and productive process. The MEER, among its projects, carries out the field studies necessary to cover this lack of information, although it doesn't include the transport sector. Based on this new information generated on the demand side, it would be possible to establish programs and specific projects.

***Global indicators.*** Although general indicators don't allow us to make a definitive conclusion about energy efficiency, they show certain indicators of behavior. For example, analyzing energy consumption per capita in terms of the GDP per-capita can be seen in Ecuador as a case of growth, while a tendency for decreasing energy intensity in the GDP would appear to indicate an important improvement in the global efficiency of the socio-economic system. However, energy consumption grows more proportionally than the Gross Fixed Capital Formation (GFCF). GFCF is a measurement of base of capital and the incorporation of technology. The increase in the GFCF should be made based on more efficient assets (equipment). Behavior in the case of Ecuador suggests exactly the opposite – as the GFCF grows, energy consumption grows proportionally. This means that there are important indicators of inefficiency in the productive system.

***Transport.*** Energy consumption grows more than proportionally to the GDP, although in this case its energy intensity is clearly upward, confirmed in good measure by its inefficiency. However, on the other hand, it is well known that

studies show that transport is highly inefficient and polluting.

***Industry.*** Energy intensity first shows an increase in the total consumption of industry that is clearly growing in relation to the growth of the Gross Added Value (GAV) of the sector without any sign of disconnection between energy consumption and added value generation.

***Residential sector.*** Analyzing the behavior of residential consumption by inhabitant in terms of the economics of family spending can provide evidence of inefficiency. Residential consumption clearly grows with family spending. Only in the past five years has this stabilized, possibly because of technological improvements in the use of domestic appliances that were introduced in the market a bit late. Average behavior in Latin America in the last two decades, for example, shows a disengagement between the levels of spending and energy consumption – as the income of the population grows, energy consumption barely grows (as has been shown in recent decades).

## *c. Renewable energy*

### i. General situation

The current renewable energy situation in Ecuador can be summarized as follows:

| TYPE OF RENEWABLE ENERGY | | APPLICATION | | STAGE OF DEVELOPMENT |
|---|---|---|---|---|
| Conventional | Hydroelectric | Electricity generation | On-grid | Generation 90% hydro starting in 2016 |
| | Biofuels | Final consumption | Transport | Incipient, ethanol in Guayaquil, biodiesel in process |
| | Firewood | Final consumption | Home use of open fire cooking | Still used by 260.000 households (replacement) |
| | Geothermal | Electricity generation | On-grid | Resource exploration detained for 20 years, recently reinitiated |
| | Hydro less than 50 MW | Electricity generation | On-grid | There are some hydro plants connected to the grid selling excess (Ex. Sibimbe) and others in construction. There is a regulation of prices. There is the need to drive the development of projects. |
| | Wind | Electricity generation | On-grid | 2.4 MW installed and three plants included in the plan |
| | | | Off-grid | Nothing |

| | | | | |
|---|---|---|---|---|
| No conventional | Photovoltaic generation | Electricity generation | On-grid (distributed generation) | Galapagos |
| | | | Off-grid (domestic use and productive rural) | Important in disperse rural electrification |
| | Solar thermoelectric | Electricity generation on-grid | On-grid | Nothing |
| | Biomass | Biogas | Electricity generation on-grid and off-grid | Nothing |
| | | | Heat for final use | Nothing |
| | | Agricultural and forestry residues | Heat for final use | Some cases are known (Ex. Contrachapados ENDESA), lack of information about other possible cases |
| | | | Co-generation on-grid and off-grid | There are some cases (Ej. Ecoelectric, San Carlos, others), lack of information about other possible cases |
| | | Firewood "non-conventional" | Domestic use cooking with efficient stoves | Nada |

Replacing "conventional" firewood with modern energies like LPG and eventually electricity and the introduction of more efficient stoves should be a priority.

Similarly, photovoltaic panels for clients connected to the network should be disseminated more because unit costs fall substantially over time. There are electricity companies in the USA and Europe that buy excess from users that is equivalent to distributed generation.

The development of wind resources should also be intensified based on the wind map created in the Action Plan for Sustainable Energy (PAES) carried out by MEER within the framework of aTechnical Cooperation with the IDB.

## ii. Renewable energy on-grid and off-grid

Private generation is regulated by the 2011 Regulations of CONELEC 002, 003, and 004.

Regulation 002/2011 refers to the exceptional nature of private participation in the electricity sector, which is in agreement with the reform of the Law governing the Electricity Sector introduced in the Organic Production Code. It determines the principles and parameters that apply to cases of exception for private participation in electricity generation. It should be noted that the Code also provides tax incentives for renewable energy equipment and energy efficiency.

Regulation 003/2011 permits direct negotiation of contracts with one or various distributors based on pre-set terms and rates established by referential calculated prices in which the methodology is created by the Regulation and then the companies that buy energy are billed. Generators can opt for to qualify for special treatment whether or not they meet the requirements of Regulation 004/2011.

Regulation 004/2011 is specifically for private generation via ERNC and hydroelectric plants of up to 50 MW. It establishes that energy prices will be paid to generators, and proportionately distributes the bill to all distributors in the system according to the monthly payment made to CENACE in contracts of energy purchase of 15 years with the possibility of extension after paying current market prices.

All electricity produced by plants that use renewable resources will be dispatched into the system up to the limit of 6% of installed capacity and

operation of the National Interconnected System generators. Hydroelectric plants that produce less than 50 MW, biomass, and geothermal are not included.

According to current regulations, the CENACE is in charge of establishing the amounts of energy to be billed monthly by private generators subject to handling (greater than 1 MW) in the framework of Regulation 004/11 based on the preferential established prices. The costs of private generation with ERNC are assumed by the whole electricity system and in consequence are distributed proportionately by CENACE among all the distributors. Each private generator is shown the amount of the monthly bill. In the case of the generators less than 1MW not subject to handling and those found in the framework of Regulation 003/11, they should directly bill the involved distributors.

The mechanism for paying companies is via trusts managed by financial institutions. All existing distribution companies have trusts that are generally managed by specialized bank entities, for example, the Bank of Guayaquil, Bank of Pichincha, private banks, and the Bank of the Pacific, which is currently controlled by the state.

All the proceeds from each of the electricity distribution companies are automatically deposited into each of the respective trusts. Private generation via ERNC is a high priority in the preference of the payments of trusts. It is second only to international connections. This way private generation has an independent payment mechanism with a priority for payment that ensures the collection of revenues even in a possible financial crisis which could come about due to the risk of sustainability of the State contribution. It could occur under any circumstances.

The response to opening electricity generation to the private sector was positive. By November 29, 2012 (Regulation 004/11 was issued in April 2011) CONELEC published that 116 applications had been turned in. The space available of 6% of installed capacity (284.5 MW) was awarded entirely, 200 MW to the ERNC with the title already signed. The remaining 84.5 MW are not yet signed but have already been authorized by the Board of CONELEC.

### iii. Use of renewable energy sources for thermal applications (cooking/heating)

Given the economic impact of the LPG subsidy and the availability of low cost electricity, it is projected that gas cookstoves will be replaced by electric ones. This subject was analyzed by the Quito Electricity Company for its concession area,[1] and the MEER is proposing replacement at a national level.

The MEER formulated a plan, which is in the process of being approved, to replace gas cookstoves with efficient electric induction cookstoves. This plan will allow, within the national energy policy framework, a high replacement (not complete because that would be impractical) of LPG with electricity. It would have a significant impact on public finances given the reduction in the LPG subsidy and the drastic change in the consumption mix in the residential sector and in GHG emissions in the sector.

The plan is designed to substitute LPG for electricity in cooking food in the residential sector by replacing LPG cookstoves with electric induction cookstoves with LPG.[2]

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**1** Determination of final use of energy in the residential sector. ENERINTER International Energy Assessment, conducted by the Quito Electricity Company. March 2012.
**2** MEER. National Plan for Efficient Cooking, Executive Summary. 2013

The fundamental components of the Plan are:

- To adapt the electricity system to cover the demand generated by cookstoves,
- To define new prices both for electricity and for LPG,
- To create the supply of induction cookstoves on the national market at accessible and competitive prices
- To generate the conditions for Ecuadorian families to adopt the technology

The subject of introducing firewood efficient cookstoves and of substituting LPG for electricity is not the objective of any specific program at the level of the responsible entities.

### iv. The use of renewable energy for productive activities

In the productive sectors increased electricity consumption in thermal uses substitutes fossil fuels in applications wherever possible, and it indirectly leads to the greater use of conventional renewable energies given that the majority of electricity generation is hydroelectric.

In this case, photovoltaic panels for industrial clients connected to the network could also be promoted. There are also small hydroelectric or winds plants for auto-consumption that could be taken advantage of by the productive sectors.

The subject is directly linked to energy efficiency. There are projects underway that research the profiles of human consumption for different productive activities and then establish economic sectors and activities that are priorities for designing specific projects.

In the case of productive sectors, energy efficiency and renewable energy should be managed jointly. In the case of productive uses of energy associated with the domestic rural or marginal urban sector, these form part of the programs to increase electricity service coverage.

## 3. LINES OF ACTION, INDICATORS, AND TARGETS

At this preliminary stage of the analysis, the lines of action can be

summarized as follows:

## *a. Access to energy*

### i. Access to energy for domestic and productive uses

The expansion of electricity coverage is already underway through the Fund for Rural and Urban Marginal Energy (FERUM) that coordinates the CONELEC. The projects are implemented by distribution companies based on existing inter-institutional agreements and in coordination with other government agencies and regional and local entities. The FERUM serves rural and urban marginal sectors with the characteristics of a social program with a technical foundation. It is a high priority and supports the incorporation of new basic services with the objective of improving the quality of life of those sectors of the population.

In general, the rural population works in the agricultural, livestock, wood, fishing, tourism, and other sectors. The urban marginal population works in the service, sales, handiwork, and informal activities sectors, which means that access to energy covers not only household use but also communal and productive uses.

Between 1998 (the year FERUM began) and 2007, $316 million in projects were implemented, while during between 2008-2012 it was $356 million. In 2012, the program was assigned $120 million USD annually.

It is important to highlight that FERUM was originally created with funds that came from a contribution to consumers that was 10% of commercial and industrial tariffs. It was eliminated by Constitutional Mandate 15, which converted FERUM into a specific mechanism to finance rural and marginal urban projects with the support of the national treasury so that they would enter into the prioritization of projects on a national level in the process of selection. This is why the pre-selection carried out by CONELEC should be approved by MEER and then by SENPLADES.

FERUM currently has an IDB loan to co-finance electrification projects. According to CONELEC data, in 2013 FERUM will reach 96% of electricity coverage of households in marginal urban areas. In 2014, it is estimated that

32,549 households in the rural sector and 59,948 households in marginal urban areas will need electrification. Between 2014-2021 it is estimated that US$ 191 millions will be needed to serve all households in the rural and marginal urban sectors.[3]

The goal of 100% coverage is anticipated by 2021 even though the SE4ALL goal provides until 2030. The indicator for monitoring this objective is the coverage index that is published regularly by CONELEC on a national level, a provincial level, and by distribution companies.

While CONELEC set the goal to reach 100% electricity coverage by 2021, the current plan being implemented refers to household electricity access via the extension of networks. There is still not a specific plan to reach potential consumers or isolated locations or an estimate of the precise number of households that are in such conditions. However, it is estimated that it is a small portion and also the most difficult portion in which to implement rural energy programs. This is a gap that could be covered with the support of the SE4ALL initiative given that the IDB is already considering the issue.

## ii. Access to modern thermal energy for cooking

There are currently not any programs of this type. It is proposed that the objective be taken care of, at least partially, within the framework of the Fund for Rural and Marginal Urban Electrification, which will be described in the next section about distribution companies.

**3** CONELEC. Master Plan for Electrification 2012-2021.

The distribution of households without electricity and of homes that use firewood/coal as the main source of energy for cooking is uneven. Crossing the data by province from the 2010 Census, it can be observed that in some provinces, following the hypothesis that there is one household per home, the cases of cooking with firewood and a lack of electricity service are higher while in others the opposite is true. The cases of firewood use are higher than those of cases without access to electricity. This means that there are homes with electricity that use firewood and others that don't have it (137,564 in the whole country).

The proposal posits the following:

- Extending electricity service coverage with financing by FERUM with the goal of total access to electricity by 2021.
- In provinces where the number of homes without electricity is greater than the number of homes that cook with firewood, electrification would arrive in the form of extended networks, mini-networks with renewables, or other solutions. The homes would be identified and contacted.
- In provinces where the number of homes without electricity is less than the number of homes that cook with firewood, part of these would be served when electricity service arrived.
- Electricity distribution companies are the only entities that have direct access to users.

- While it is not strictly the responsibility of distributors to deal with energy consumption for cooking, it would be convenient to explore the feasibility of designing an efficient wood cookstove program and distributing them via the electricity companies as electricity service is provided to households. This would allow improved use of firewood by 53% of homes that cook with wood, which is the portion that still doesn't have electricity service. Another possibility is to structure an operational scheme separately via MEER.
- The remaining 47% of homes that cook with firewood that already have electricity service would work with FERUM to see about the potential of providing efficient wood cookstoves, and eventually they could use LPG. This could be done in consultation with Petrocomercial and in conjunction with other electricity companies since they already have those households registered in their databases

If this proposal is followed, goals would have to be established to define the specific operation and estimate the equipment requirements, where it would

be located, the cost, and other details. It would be convenient to conduct a pilot project to confirm that people will accept these technologies and to measure the performance of the teams.

## *b. Energy efficiency and renewable energy for productive uses*

It is premature to propose specific goals and actions. In the case of energy efficiency and the use of renewable energy in productive sectors, the first step is to know the consumption profile of the different branches of economic activity that work in the field on a national level and in contact with the productive sectors. This will help identify the priority areas and establish goals to quantify investment. It is a study that the MEER has already planned.

It is important to highlight that part of any energy efficiency program is also the use of renewable energy by consumers. This can be via self-generation of electricity with small hydro or wind plants for self-consumption and the sale of the excess to the network or the use of waste produced in the production process. In addition to making the process more efficient and reducing operative costs, it improves environmental performance and reduces the added costs of fines. There are currently several companies in the country that do this. The total number isn't known, but in general it is estimated that there is significant potential in several production sectors.

The MEER is designing and/or carrying out some specific relevant projects like the substitution of inefficient refrigerators, providing solar thermal energy systems for hot water, an immediate action project for efficient energy use in the public sector, public lighting on a national level, replacing public lighting with more efficient lighting in the Galapagos, energy efficiency for industry in Ecuador, and a massive communication campaign to promote energy savings.

The most important action that MEER will conduct is a study about the final use of energy, which in itself is part of the first goal to be reached before December 2014. It falls within the objective of energy efficiency in the SE4ALL initiative. The more specific goals would be established to reach the efficiency objectives in the different productive and services sectors such as residential consumption (in this case, LPG would be replaced by electricity). In order to carry out this important study, MEER had the support of the

Sustainable Energy Action Plan for Ecuador (PAES), via a non-refundable technical cooperation agreement from the IDB. It described the methodology and the information platform for the indicated study, a wind map, and other relevant results.

## *c. Renewable energy: electricity generation on-grid and off-grid*

This is already underway and has shown that investors are interested, which is very important for structuring financing for these projects with developers.

A relevant point is that the limit of 6% of installed power is a dynamic goal that allows the expansion of installed generation capacity with the ERNC as the electricity system grows. The indicator of verification in this case is complying with the timeline agreed upon in the purchase-sale energy contracts.

# 4. NATIONAL FRAMEWORK FOR MONITORING THE SE4ALL PROGRAM

The focal point for establishing and monitoring the SE4ALL program on a national level should be the Ministry of Electricity and Renewable Energy (MEER) given that it is the entity responsible for the development of renewable energy and energy efficiency in the country via the Undersecretary of Renewable Energy and Energy Efficiency (SEREE).

Besides approving rural and marginal urban energy projects presented by distribution companies and prioritized by the CONELEC, it also passes through MEER before final approval is granted in SENPLADES. The MEER could coordinate actions with CONELEC and other entities in the energy sector and organizations linked to production (both in the State and in the private sector). The latter should be incorporated into the process given that consumers should specify actions and investments to improve energy efficiency and use renewable energy for final uses.

# 5. SUMMARY: IMORTANT GAPS, BARRIERS, AND ADDITIONAL REQUIREMENTS

Based on the advances of the country in relation to the SE4ALL objectives, the areas that require more attention and the additional support of technical cooperation and financing are thermal energy for cooking, efficiency, and the use of renewable energy in the productive sectors, and electricity access for isolated homes and locations.

Additionally, we imagine an area for action for financing private generation projects with non-conventional renewable energy and hydroelectric plants of less than 50 MW based on open niches in current regulations.

Electricity and fuel subsidies are an important barrier to promoting and implementing energy efficiency programs and using renewable energy in the productive, service, and residential consumption sectors.

On the other hand, while subsidies and the complete absorption of investments on the part of the State could constitute a risk for the financial stability of programs in the long term given the huge weight of the subsidies on the

national economy, this risk is controlled depending on the allocation of resources for rural and marginal urban energy programs. They also have the support of international entities and existing guarantees of the payment of purchase-sale energy contracts to private projects with renewable energy.

There might be other institutional obstacles given the difficulty of coordinating efforts among diverse state and private institutions to reach final energy users.

# SECTION 1:
# INTRODUCTION

# 1.1 VISION OF THE COUNTRY

## 6. BASIC MACROECONOMIC DATA AND SOCIAL INDICATORS

### *a. Macroeconomic indicators*

Ecuador has a population of 14 million according to the last housing and population census. Average income measured by the Gross Domestic Product (GDP) per-capita is from 1,760 dollars to 2,000, which is a little more than 4,000 dollars per-capita in current currency. This shows sustained growth with important fluctuations over the last decade (Table 1).

**Table 1** Indicators per-capita

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 (sd) | 2006 (p) | 2007 (p) | 2008 (p) | 2009 (p) | 2010 (p) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Population (thousands of inhabitants)** | 12,121 1 | 12,299 9 | 12,480 0 | 12,661 1 | 12,843 3 | 13,027 7 | 13,215 | 13,408 | 13,605 | 13,805 | 14,005 | 14,205 |
| **DOLLA** | | | | | | | | | | | | |
| **Gross domestic product** | 1,394 | 1,324 | 1,704 | 1,952 | 2,212 | 2,506 | 2,795 | 3,110 | 3,345 | 3,927 | 3,715 | 4,082 |
| **Final consumption of homes** | 914 | 842 | 1,192 | 1,363 | 1,544 | 1,683 | 1,854 | 1,999 | 2,129 | 2,397 | 2,481 | 2,765 |
| **Gross fixed capital formation** | 233 | 265 | 364 | 458 | 476 | 541 | 619 | 694 | 745 | 943 | 900 | 1,027 |
| **Exports** | 444 | 480 | 453 | 482 | 568 | 687 | 864 | 1,053 | 1,173 | 1,487 | 1,097 | 1,345 |
| **Imports** | 348 | 407 | 540 | 629 | 622 | 733 | 895 | 1,025 | 1,152 | 1,484 | 1,188 | 1,576 |
| **DOLLARS OF** | | | | | | | | | | | | |
| **Gross domestic product** | 1,290 | 1,324 | 1,367 | 1,393 | 1,419 | 1,522 | 1,587 | 1,638 | 1,647 | 1,741 | 1,722 | 1,759 |
| **Final consumption of homes** | 819 | 842 | 886 | 930 | 964 | 994 | 1,050 | 1,091 | 1,115 | 1,175 | 1,150 | 1,221 |
| **Gross fixed capital formation** | 240 | 265 | 323 | 379 | 373 | 386 | 421 | 431 | 435 | 498 | 470 | 511 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Exports** | 490 | 480 | 469 | 459 | 498 | 565 | 605 | 649 | 654 | 666 | 618 | 623 |
| **Imports** | 359 | 407 | 509 | 593 | 557 | 611 | 687 | 739 | 786 | 851 | 742 | 851 |
| **RATE OF VARIATION OF** | | | | | | | | | | | | |
| **Gross domestic product** | -6.69 | 2.65 | 3.23 | 1.95 | 1.81 | 7.28 | 4.24 | 3.24 | 0.56 | 5.69 | -1.07 | 2.12 |
| **Final consumption for homes** | -8.38 | 2.77 | 5.21 | 5.00 | 3.59 | 3.09 | 5.72 | 3.89 | 2.16 | 5.37 | -2.12 | 6.16 |
| **Gross fixed capital formation** | -28.70 | 10.44 | 21.69 | 17.22 | -1.58 | 3.44 | 9.29 | 2.30 | 0.99 | 14.42 | -5.63 | 8.69 |
| **Exports** | 5.44 | -2.07 | -2.24 | -2.21 | 8.53 | 13.45 | 7.07 | 7.28 | 0.86 | 1.79 | -7.24 | 0.84 |
| **Imports** | -30.72 | 13.49 | 24.96 | 16.57 | -6.16 | 9.82 | 12.44 | 7.55 | 6.36 | 8.29 | -12.83 | 14.65 |

**Source:** Central Bank of Ecuador (sd) Semi-definitive data (p) Provisional data

The sustained growth of the GDP and especially imports (10.8% annually during the 1999-2010 period on the side of global offerings of goods and services) sustains the growth of family consumption. During 1999-2010 there was 5.7% annual accumulated growth, which is above the product growth rate (4.8%). There was nearly 10% growth in the gross formation of capital while exports grew at an average rate of 4.1%, less than the GDP (Table 2).

**Table 2** Supply and use of goods and services (millions of dollars, 2000)

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 (sd) | 2006 (sd) | 2007 (p) | 2008 (p*) | 2009 (p*) | 2010 (p*) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gross domestic product (PIB)** | 15,633 | 16,283 | 17,057 | 17,642 | 18,219 | 19,827 | 20,966 | 21,962 | 22,410 | 24,032 | 24,119 | 24,983 |
| **Import of goods and services** | 4,349 | 5,008 | 6,350 | 7,509 | 7,148 | 7,963 | 9,082 | 9,910 | 10,695 | 11,752 | 10,392 | 12,085 |
| **Total final offer** | 19,982 | 21,291 | 23,407 | 25,151 | 25,367 | 27,790 | 30,048 | 31,872 | 33,105 | 35,785 | 34,512 | 37,068 |
| **Total final consumption** | 11,425 | 11,921 | 12,612 | 13,400 | 14,022 | 14,647 | 15,643 | 16,458 | 17,105 | 18,378 | 18,351 | 19,618 |
| **General government** | 1,493 | 1,564 | 1,554 | 1,621 | 1,644 | 1,703 | 1,762 | 1,827 | 1,938 | 2,162 | 2,249 | 2,280 |
| **Resident homes** | 9,932 | 10,357 | 11,058 | 11,779 | 12,378 | 12,944 | 13,881 | 14,631 | 15,167 | 16,216 | 16,102 | 17,337 |
| **Gross fixed capital formation** | 2,913 | 3,265 | 4,031 | 4,794 | 4,786 | 5,022 | 5,568 | 5,780 | 5,922 | 6,876 | 6,583 | 7,257 |
| **Changes in inventories** | -297 | 203 | 909 | 1,148 | 164 | 761 | 844 | 935 | 1,174 | 1,335 | 924 | 1,343 |
| **Exports of goods and services** | 5,940 | 5,902 | 5,855 | 5,809 | 6,395 | 7,359 | 7,993 | 8,700 | 8,904 | 9,197 | 8,655 | 8,851 |
| **Total final use** | 19,982 | 21,291 | 23,407 | 25,151 | 25,367 | 27,790 | 30,048 | 31,872 | 33,105 | 35,785 | 34,512 | 37,068 |

**Source:** Central Bank of Ecuador (sd) Semi-definitive data (p) Provisional data

Note: The Central bank is revising the historic series of national accounts and publishing revised data as it is available

With regard to the sectoral structure of the GDP, the most relevant sectors in

terms of value added generation are the exploitation of mines and quarries, the manufacturing industry, trade, and services, and, to a lesser degree, construction and agriculture (Figure 1 and Table 3).

**Figure 1** Structure of the GDP by sector in 2010

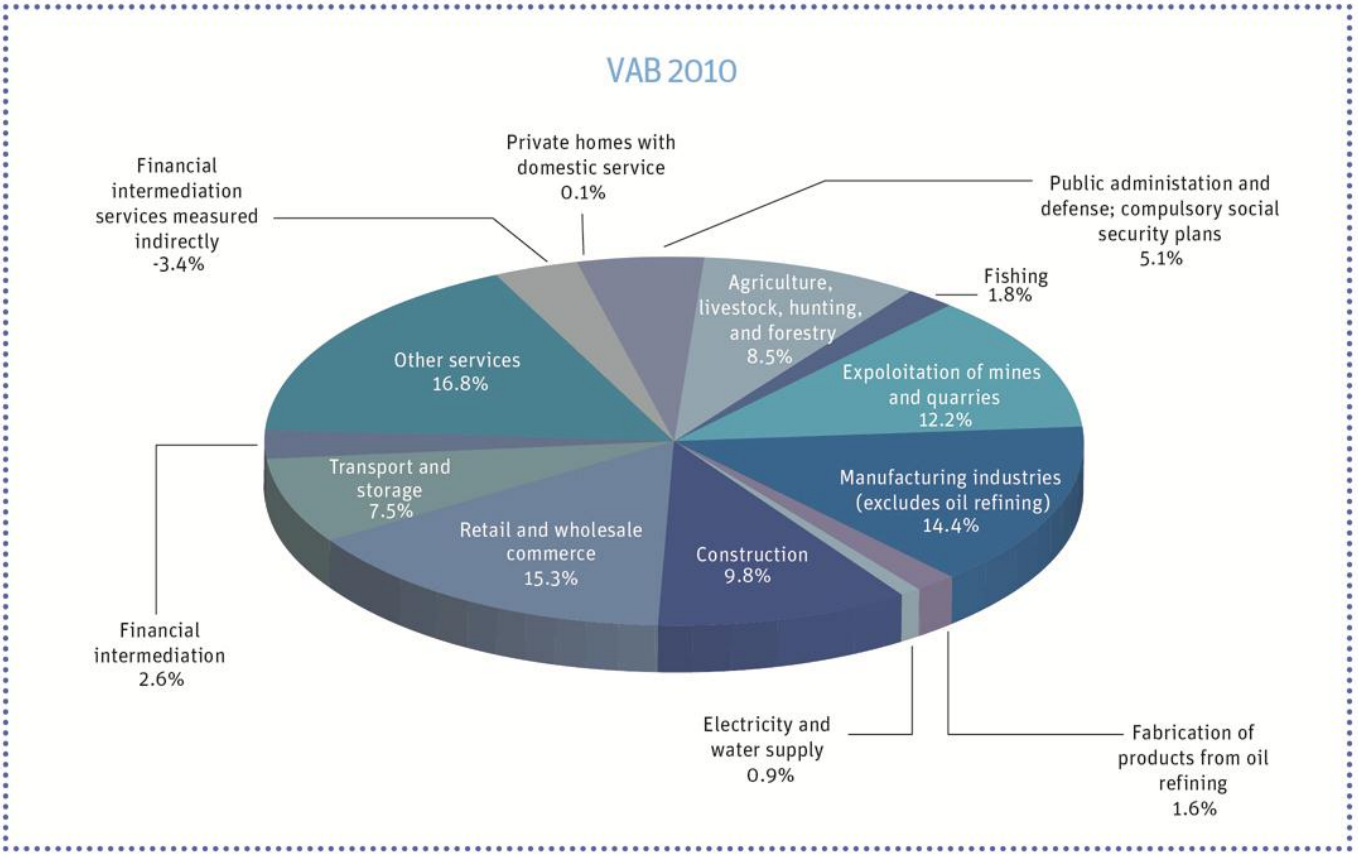



**Table 3** Gross added value by sector (millions of dollars, 2000)

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 (sd) | 2006 (sd) | 2007 (p) | 2008 (p*) | 2009 (p*) | 2010 (p*) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Agriculture, livestock, hunting, forestry** | 1,405 | 1,466 | 1,524 | 1,620 | 1,690 | 1,726 | 1,814 | 1,877 | 1,959 | 2,062 | 2,076 | 2,062 |
| **Fishing** | 289 | 215 | 231 | 229 | 262 | 263 | 331 | 377 | 386 | 412 | 434 | 442 |
| **Exploitation of mines and quarries** | 2,202 | 2,141 | 2,212 | 2,110 | 2,305 | 3,169 | 3,224 | 3,339 | 3,062 | 3,062 | 2,961 | 2,968 |
| **Manufacturing industries (excluding petroleum refining)** | 2,329 | 2,170 | 2,276 | 2,333 | 2,440 | 2,519 | 2,752 | 2,946 | 3,091 | 3,341 | 3,290 | 3,511 |
| **Manufacture of petroleum refining products** | 383 | 748 | 564 | 497 | 409 | 475 | 448 | 446 | 431 | 465 | 479 | 385 |
| **Supply of electricity and water** | 165 | 169 | 170 | 184 | 186 | 170 | 172 | 173 | 200 | 240 | 211 | 214 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Construction** | 952 | 1,127 | 1,349 | 1,619 | 1,608 | 1,673 | 1,796 | 1,864 | 1,866 | 2,124 | 2,238 | 2,387 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Wholesale and retail sales** | 2,422 | 2,515 | 2,679 | 2,731 | 2,816 | 2,934 | 3,104 | 3,261 | 3,365 | 3,587 | 3,503 | 3,725 |
| **Transport and storage** | 1,321 | 1,413 | 1,420 | 1,421 | 1,447 | 1,477 | 1,511 | 1,590 | 1,639 | 1,729 | 1,792 | 1,837 |
| **Brokerage financier** | 295 | 301 | 281 | 289 | 291 | 310 | 366 | 442 | 477 | 531 | 540 | 633 |
| **Other services (2)** | 2,336 | 2,421 | 2,521 | 2,627 | 2,737 | 2,900 | 3,172 | 3,355 | 3,555 | 3,809 | 3,874 | 4,083 |
| **Financial intermediation services measured indirectly** | -380 | -385 | -322 | -440 | -422 | -411 | -447 | -555 | -620 | -697 | -719 | -833 |
| **Public administration and defense; plans for compulsory social** | 764 | 835 | 844 | 864 | 889 | 916 | 933 | 960 | 1,016 | 1,165 | 1,228 | 1,234 |
| **Private homes with domestic service** | 28 | 28 | 29 | 30 | 31 | 32 | 31 | 32 | 32 | 30 | 30 | 32 |
| **Gross value added** | 14,511 | 15,164 | 15,777 | 16,114 | 16,690 | 18,155 | 19,208 | 20,107 | 20,460 | 21,858 | 21,938 | 22,680 |
| **Other elements of the GDP** | 1,122 | 1,119 | 1,280 | 1,527 | 1,530 | 1,672 | 1,758 | 1,855 | 1,949 | 2,174 | 2,182 | 2,303 |
| **GDP** | 15,633 | 16,283 | 17,057 | 17,642 | 18,219 | 19,827 | 20,966 | 21,962 | 22,410 | 24,032 | 24,119 | 24,983 |

**Source:** Central Bank of Ecuador; (sd) semi-definitive data, (p) provisional data.

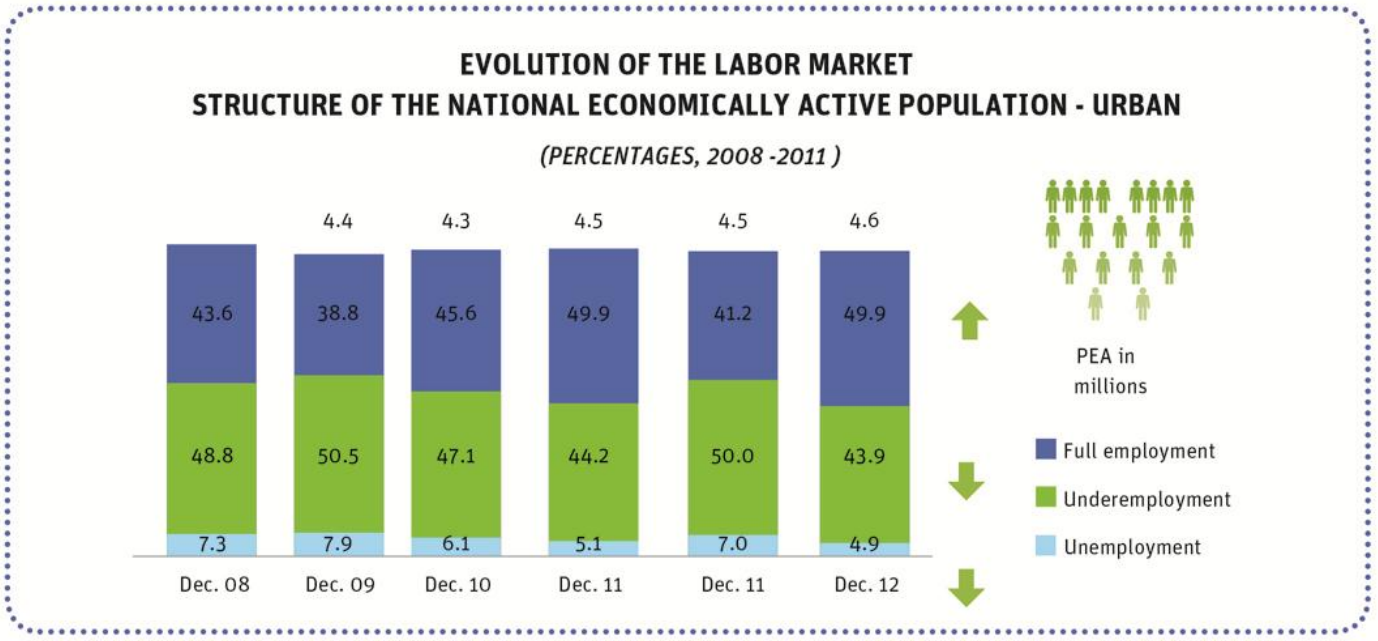
The historic evolution of the 1999-2010 period clearly highlights the dynamism of the two sectors: construction with an annual growth of 9.6% for the 1999-2010 period and financial intermediation with 7.9% annual growth. The first of these sectors contributes 10% of National Gross Value Added, while the second has modest participation but a very high dynamic of growth. Productive sectors like industry, agriculture, fishing, mines, and quarries, as well as trade, had moderate growth rates ranging between 3.9% and 4.4% annually.

## *b. Social indicators*

### i. Employment, unemployment, underemployment, and poverty

In March 2012, the economically active population was 4.6 million with a rate of open unemployment at approximately 5% and underemployment at 46%. These indices showed a significant downward trend in the last four years. However, there is still considerable work to do, especially with respect to the subject of underemployment. (Figure 1)

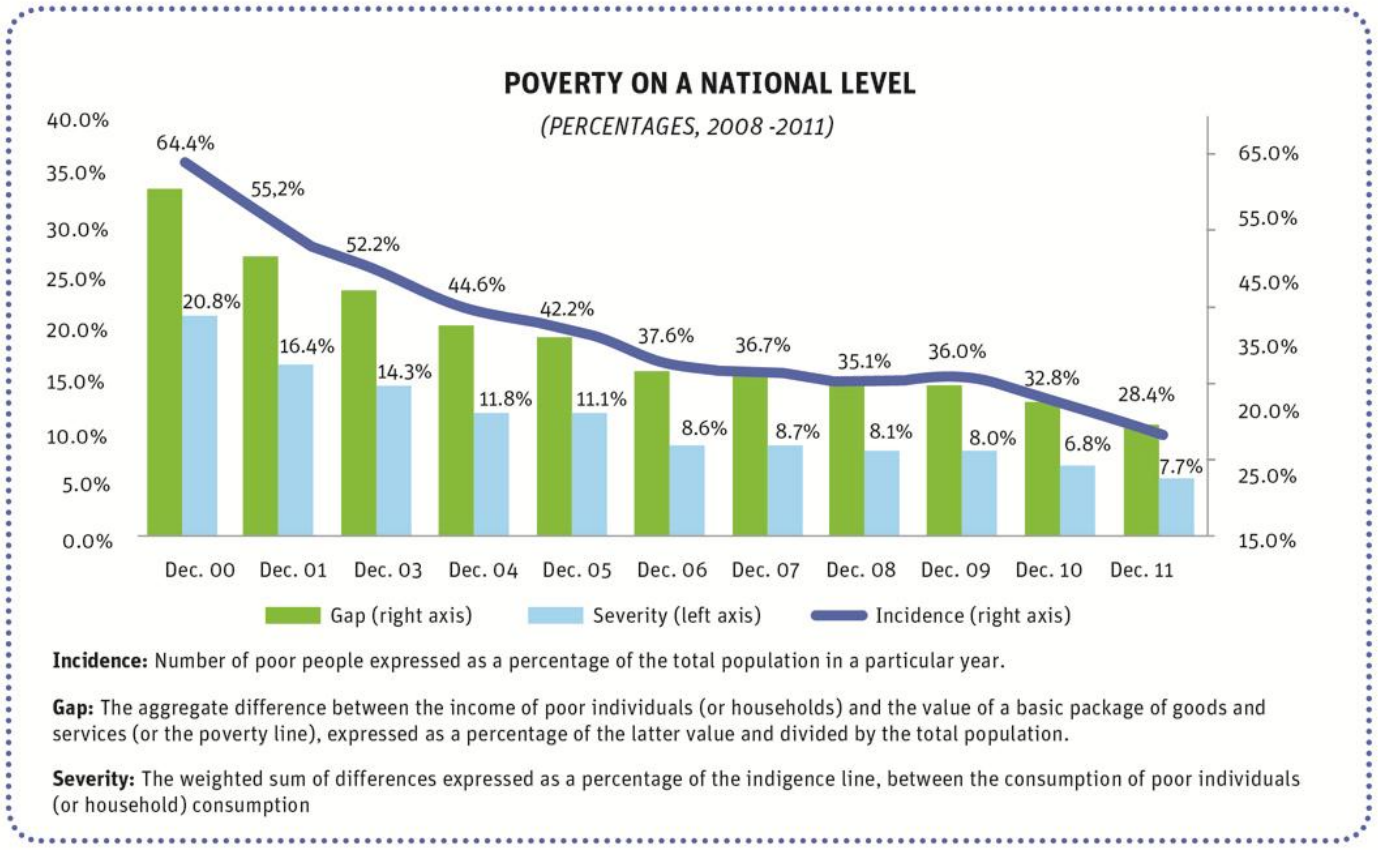
**Figure 1** PEA and trends in employment, unemployment, and underemployment




**Source:** BCE, Macroeconomic Statistics, Structural Presentation 2012

The rate of poverty shows a noticeable trend of decreasing in the decade of the 2000s. In December 2011 it decreased by 28% nationally. (Figure 2).

**Figure 2** Poverty rate on a national level.




**Incidence:** Number of poor people expressed as a percentage of the total population in a particular year.

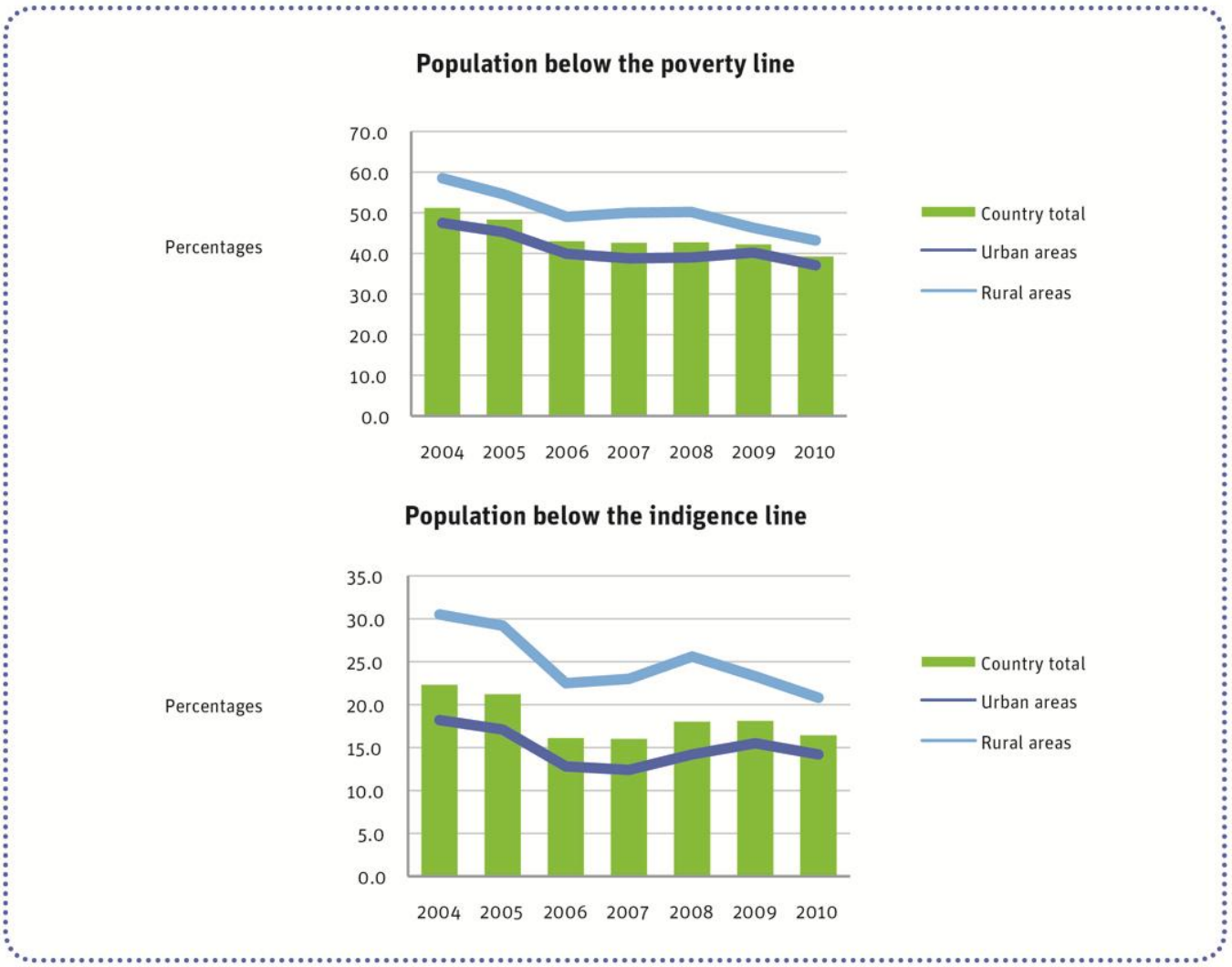
**Gap:** The aggregate difference between the income of poor individuals (or households) and the value of a basic package of goods and services (or the poverty line), expressed as a percentage of the latter value and divided by the total population.

**Severity:** The weighted sum of differences expressed as a percentage of the indigence line, between the consumption of poor individuals (or household) consumption

**Source:** BCE, Macroeconomic Statistics, Structural Presentation 2012

At the level of the urban and rural population, CEPAL data shows similar trends for both the rate of poverty (extreme poverty) and extreme poverty although there are some differences in data (Figure 3).

**Figure 3** Decrease in the rate of poverty and extreme poverty in Ecuador

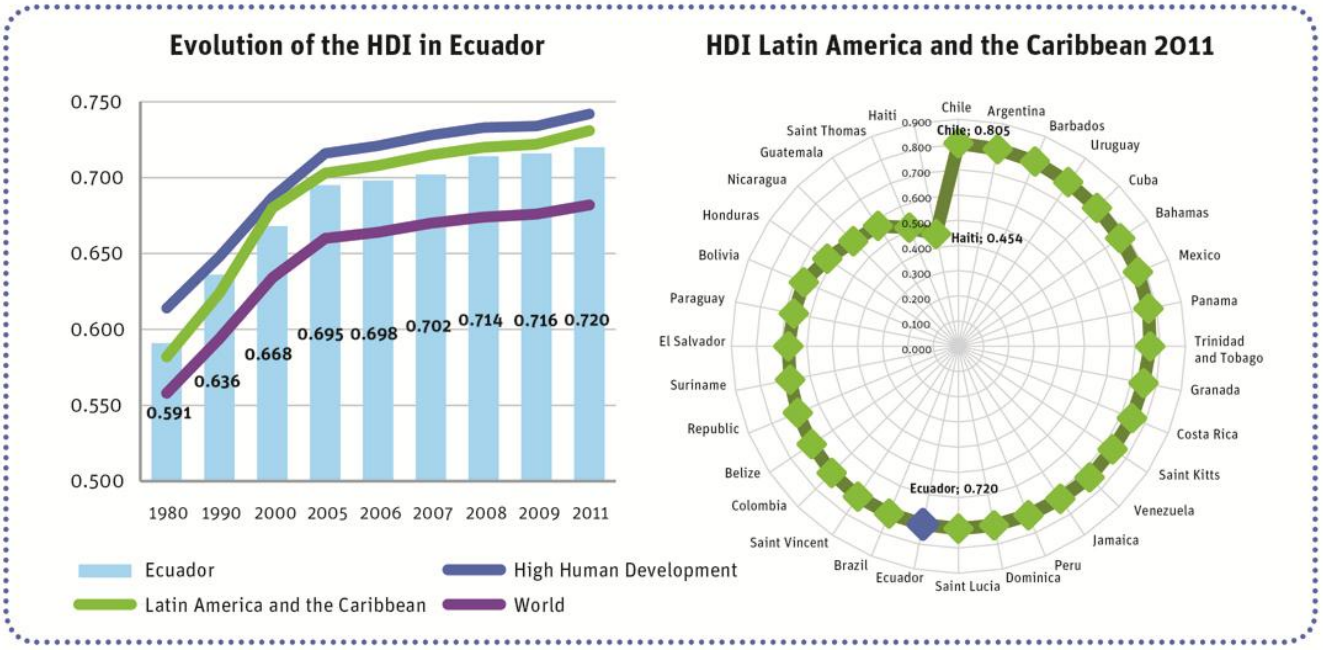



**Source:** Own elaboration based on CEPAL data, Social Panorama of Latin America and the Caribbean, 2011. Publication of the United Nations. ISBN: 978-92-1-221087-2. ISSN print: 1020-5152

## ii. Human Development Index (HDI)

Ecuador's HDI shows a growing trend that has intensified in recent years. It was above the world average and near the average for Latin America and the Caribbean. The 2011 statistics indicated a level of 0.702 for Ecuador in relation to a maximum of 0.805, which is the case in Chile, and a minimum of 0.454, which is the case in Haiti (Figure 4).

**Figure 4** Growth of the Human Development Index in Ecuador and regional comparison

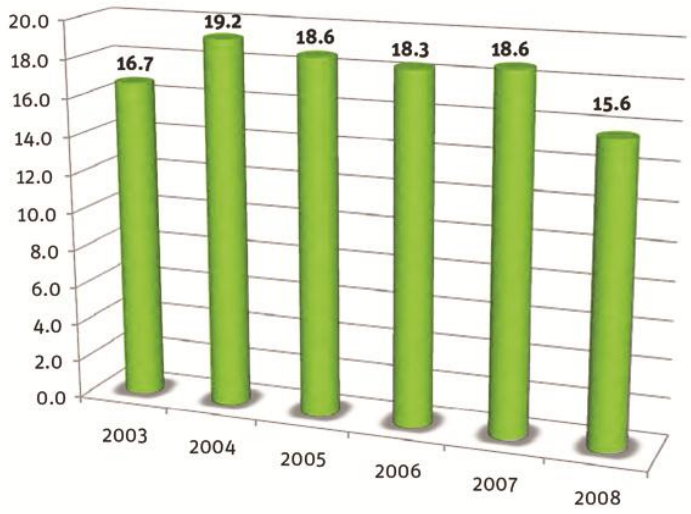



**Source:** Own elaboration based on UNDP data, Indexes and data on Human Development http://hdr.undp.org/es/estadisticas/

## iii. Income distribution

The equality of income distribution, measured via the relationship of income among the richest quintile and the poorest fifth of the population according to CEPAL data (Figure 5) shows and improvement in the last year that data was available (2008).

**Figure 5** Ecuador: evolution of the distribution of income between the richest quintile and the poorest

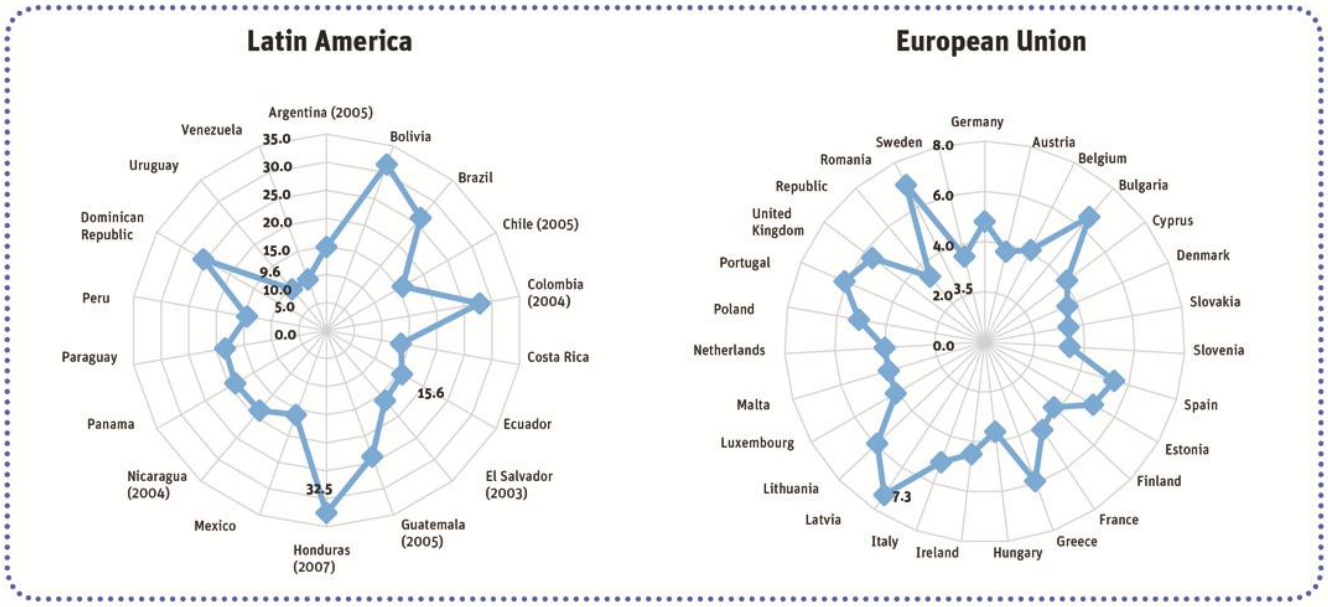



**Source:** Source: Own elaboration based on CEPAL-CEPALSTAT data, statistics and indicators of social cohesion, poverty, and income. Difference in income between the richest quintil and the poorest (Latin America and the European Union)

Considering Ecuador in the regional context of Latin America and the Caribbean, the relationship in terms of income between the richest quintil and the poorest is 15.6 in Ecuador, which is within a range with a minimum of 9.6 in Uruguay and a maximum of 32.5 in Honduras (Figure 6).

It is important to note the differences that exist between countries in the region and countries in the European Union in which the distribution of income is more equitable (within a range of 3.5 in Sweden and 7.3 Latvia).

**Figure 6** Relationship of income between the richest quintil and the poorest, 2008 (Latin American and the European Union)




**Source**: Own elaboration based on CEPAL-CEPALSTAT data, statistics and indicators of social cohesion, poverty, and income. Difference in income between the richest quintil and the poorest (Latin America and the European Union)

**Source:** Own elaboration based on CEPAL-CEPALSTAT data, statistics, and indicators of social cohesion, poverty, and income. Relationship between the richest quintile and the poorest (Latin America and the European Union)

# 1.2 ENERGY SITUATION

Ecuador is an oil exporting country, which has a big impact on the national economy and dominates the energy mix. Its quantitative representation in the 2010 cut is represented in the National Energy Balance (Table 4).

Although dependence on oil exports has decreased by a certain measure, the country is at a turning point because the national economy remains highly dependent on these exports and consequently also the power supply from oil. Therefore, there needs to be a substantial change in the energy mix, a change which has already started on the supply side of energy.

The country also has significant renewable energy potential, especially in the area of hydroelectricity, which has an important role in electricity generation even though its development has been delayed in the past two decades. However, recently a plan to construct large-scale hydroelectric projects was implemented which will begin operation between 2016 and 2018.

**Table 4** National Energy Balance 2010. Thousands BEP (Part 1)

| | Oil | Natural Gas | Hydropower | Fire wood | Sugarcane products | Primary Total | Electricity | Liquefied Gas |
|---|---|---|---|---|---|---|---|---|
| **PRODUCTION** | 182,8 | 8,394 | 5,351 | 3,368 | 2,151 | 202,105 | 12,088 | 1,435 |
| **IMPORTS** | - | - | - | - | - | - | 541 | 6,295 |
| **EXPORTS** | 128,4 | - | - | - | - | 128,435 | 6 | - |
| **CHANGE IN** | (88 | - | - | - | - | (888) | - | (36) |
| **UNUSED** | - | 3,679 | - | - | - | 3,679 | - | - |
| **TOTAL SUPPLY** | 53,5 | 4,715 | 5,351 | 3,368 | 2,151 | 69,104 | 12,623 | 7,694 |
| **REFINERY** | (51,35 | - | - | - | - | (51,359) | - | 891 |
| **ELECTRIC PLANTS** | - | (1,979) | (5,068) | - | - | (7,047) | 10,072 | - |
| **AUTOPRODUCERS** | (1,42 | (1,414) | (283) | - | (912) | (4,034) | 2,016 | (124) |
| **GAS PLAN** | - | (1,321) | - | - | - | (1,321) | - | 543 |
| **COAL BUNKER** | - | - | - | - | - | - | - | - |
| **COKE/OVEN** | - | - | - | - | - | - | - | - |
| **DISTILLERY** | - | - | - | - | - | - | - | - |
| **OTHER PLANTS** | - | - | - | - | - | - | - | - |
| **TOTAL** | (52,78 | (4,715) | (5,351) | - | (912) | (63,762) | - | (124) |
| **OWN CONSUMPTION** | 736 | - | - | - | - | 434 | 186 | 100 |
| **LOSSES** | - | - | - | - | - | 273 | 2,038 | - |
| **ADJUSTMENT** | - | - | - | - | - | 29 | - | 0 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **TRANSPORT** | - | - | - | - | - | - | 7 | 85 |
| **INDUSTRY** | - | - | - | 278 | 1,238 | 1,516 | 4,413 | 425 |
| **RESIDENTIAL** | - | - | - | 3,090 | - | 3,090 | 3,169 | 6,877 |
| **COMMERCIAL PUB.** | - | - | - | - | - | - | 2,810 | - |
| **AGRO, FISHING,** | - | - | - | - | - | - | - | 83 |
| **CONSTRUCTION,** | - | - | - | - | - | - | - | - |
| **ENERGY** | - | - | - | 3,368 | 1,238 | 4,606 | 10,398 | 7,470 |
| **NON-ENERGY** | - | - | - | - | - | | - | - |
| **FINAL CONSUMPTION** | - | - | - | 3,368 | 1,238 | 4,606 | 10,398 | 7,470 |

(Parte 2)

| | Gasoline/ Naphtha | Kerosene and Turbo | Diesel | Fuel Oil | Reduced Crude | Gases | Non Energy | Total Secondary | TOTAL |
|---|---|---|---|---|---|---|---|---|---|
| **PRODUCTION** | 8,771 | 2,584 | 11,178 | 19,202 | 3,460 | 28 | 4,672 | 63,418 | 202,105 |
| **IMPORTS** | 10,849 | 85 | 19,960 | 3,231 | - | - | - | 40,961 | 40,961 |
| **EXPORTS** | 492 | - | - | 10,193 | - | - | - | 10,691 | 139,126 |
| **CHANGE IN INVENTORY** | 185 | (165) | 560 | 1,488 | - | - | - | 2,032 | 1,144 |
| **UNUSED** | - | - | - | - | - | - | - | - | 3,679 |
| **TOTAL SUPPLY** | 19,313 | 2,504 | 31,698 | 13,727 | 3,460 | 28 | 4,672 | 95,720 | 101,406 |
| **REFINERY** | 8,411 | 2,584 | 11,178 | 19,202 | 3,460 | - | 4,672 | 50,399 | (960) |
| **ELECTRIC PLANTS** | (360) | - | (5,736) | (6,480) | - | - | - | 10,072 | (9,552) |
| **AUTOPRODUCERS** | - | - | (1,779) | (434) | - | - | - | 2,016 | (4,232) |
| **GAS PLANT** | 359 | - | - | - | - | 28 | - | 543 | (777) |
| **COAL BUNKER** | - | - | - | - | - | - | - | | |
| **COKE/OVEN** | - | - | - | - | - | - | - | | |
| **DISTILLERY** | - | - | - | - | - | - | - | | |
| **OTHER PLANTS** | - | - | - | - | - | - | - | | |
| **TOTAL TRANSFORMATION** | (360) | - | (7,516) | (6,914) | - | - | - | (14,914) | (15,521) |
| **OWN CONSUMPTION** | - | - | 96 | 1,463 | 3,460 | 28 | - | 5,334 | 5,769 |
| **LOSSES** | - | - | - | - | - | - | - | 2,038 | 2,312 |
| **ADJUSTMENTS** | - | - | - | (1,141) | - | - | - | (1,141) | (1,112) |
| **TRANSPORT** | 18,188 | 2,504 | 17,455 | 3,876 | - | - | - | 42,115 | 42,115 |
| **INDUSTRY** | 110 | - | 5,653 | 2,614 | - | - | - | 13,215 | 14,731 |
| **RESIDENTIAL** | - | - | - | - | - | - | - | 10,046 | 13,136 |
| **COMMERCIAL PUB.** | 25 | - | 125 | - | - | - | - | 2,960 | 2,960 |
| **AGRO, FISHING,** | 607 | - | - | - | - | - | - | 691 | 691 |
| **CONSTRUCTION,** | 22 | - | 852 | - | - | - | - | 874 | 874 |
| **ENERGY CONSUMPTION** | 18,953 | 2,504 | 24,086 | 6,491 | - | - | - | 69,901 | 74,507 |
| **NON-ENERGY** | - | - | - | - | - | - | 4,672 | 4,672 | 4,672 |
| **FINAL** | 18,953 | 2,504 | 24,086 | 6,491 | - | - | 4,672 | 74,574 | 79,180 |

**Source:** National Energy Balances MICSE.

# 7. ENERGY RESOURCES AND ENERGY SUPPLY

## *a. Renewable resources*

### i. Hydroelectric potential

Ecuador has significant potential for hydroelectric resources. There are 11 water systems (of the 31 existing) with a theoretical potential of about 74,000 MW. The installed technical and economic capacity is estimated at 21,500 MW, 90% in the

Amazon basin and 10% in the Pacific watershed (Table 5).

**Table 5** Hydroelectric Potential in Ecuador

| Watershed | Potential Technically Available (MW) | Potential Economically Available (MW) |
|---|---|---|
| **PACIFIC** | | |
| Mira | 488,50 | - |
| Esmeraldas | 1.878,50 | 1.194,00 |
| Guayas | 310,70 | - |
| Cañar | 112,20 | - |
| Jubones | 687,70 | 590,00 |
| Puyango | 298,70 | 229,00 |
| Catamayo | 459,60 | |
| SUBTOTAL 1 | 4.235,90 | 2.013,00 |
| | | |
| Napo-Coca | 6.355,00 | 4.640,00 |
| Napo-Napo | 5.929,50 | 3.839,00 |
| Pastaza | 1.434,00 | 1.121,00 |
| Santiago-Namangoza | 5.810,60 | 4.006,00 |
| Santiago-Zamora | 5.857,60 | 5.401,00 |
| Mayo | 859,00 | 500,00 |
| SUBTOTAL 2 | 26.245,70 | 19.507,00 |
| | | |

**Source:** CONELEC, Master Electrification Plan 2012-2021.

Note that the currently installed hydroelectric capacity in public service in 2012 was 2,160 MW, which translates into approximately 10% of the potential identified as technically and economically exploitable. When the large-scale projects that are under construction come into operation around 2016, said capacity will increase around 5,000 MW, which is 23% of the potential. The expectation is that by 2030 it will increase to levels around 10,000 MW, a bit less than half the potential of the 21,520 MW shown in the previous table.

This calculation was designed for a scenario of increased efficiency in consumption combined with greater use of electricity to replace other sources and continued hydroelectric development to cover between 85% and 90% of generation.

## ii. Wind energy

Within the framework of the PAES project (Sustainable Energy Action Plan), Component II includes a wind map based on satellite data. Two measurement towers were installed in two provinces in the country (Imbabura and Loja), and were developed in parallel to a wind atlas and the measurement campaign that began in 2011.

The Wind Atlas of Ecuador is in the process of being published. It presents the annual wind conditions for the entire Ecuadorian territory with a resolution of 200m x 200m.

Based on information from the wind map, the MEER estimated the potential for electricity generation from wind parks installed in areas with significant wind resources. The following scenarios were developed: Gross Total Potential and Short-Term Achievable Potential. The first takes into account sites under 3500 m.s.n.m with velocities above 7m/s. The second, in addition to these restrictions, takes into account sites that are at a distance of less than or equal to 10km from electricity lines and highways.

The Total Available Gross Potential is estimated at 1,670 MW and the Short-Term Achievable Potential is around 900 MW, with plant factors in the range of 25-35%.

Moreover, the prospect of viable wind potential for electricity generation propelled by the National Government is currently 165 MW (Table 6).

**Table 6** Wind projects in development

| | Effective potential [MW] |
|---|---|
| Villonaco (Execution) | 15 |
| Salinas Etapa I (Studies) | 15 |
| Salinas Etapa II (Studies) | 25 |
| Membrillo – Chinchas (Studies) | 110 |

**Source:** CONELEC, Master Electrification Plan 2012-2021.

## iii. Solar energy

In relation to solar energy, in 2008 CONELEC published the Solar Atlas of Ecuador that included a quantification of the solar potential available and its potential for electricity generation.

Via programs such as Euro-Solar and the FERUM fund, taking advantage of solar for electricity generation in rural areas far from distribution lines was promoted. Through a regional agreement signed in 2006 between the European Union and eight countries in Latin America, Ecuador among them, the program "Euro-Solar" was born. This program has goals to improve life conditions related to health, education, and telecommunications for 91 rural communities in the country via access to a source of renewable electricity. The 91 communities are located in the provinces of Guayas, Morona Santiago, Pastaza, Orellana, Napo, Sucumbíos, and Esmeraldas.[4]

Regulation 004/11 establishes special prices for electricity generated with non-conventional renewable energy (ERNC). On this basis, some developers became interested in projects. Three solar photovoltaic projects, each with a potential near 1 MW, are being constructed in the areas of Malchinguí, Paragachi, and Escobar. In addition, five solar photovoltaic and thermoelectric generation projects have applied to begin construction (Milenio Solar I and II, Solarconnection, Shyri I and Condorsolar), for a total potential of 150 MW.[5]

## iv. Geothermal

Ecuador is located on the Pacific ring of fire, and there is geothermal potential that can be taken advantage of. This development was abandoned a long time ago, but it has been recently taken up again. Although we need to move forward with related studies, the potential is estimated at between 400 MW and 500 MW.

**4** CONELEC. Master Electrification Plan 2012-2021.
**5** CONELEC. Master Electrification Plan 2012-2021.

## v. Biomass

There are some plants that produce energy and steam in a co-generation scheme and sell the excess to the interconnected network. These plants are linked to the sugar industry, although in one plant they use both bagasse and other agricultural residues. The most important ones are Ecoelectric (36,5 MW, use bagasse and other

agricultural residues), San Carlos (35 MW) and Ecudos (29,8 MW).

## vi. Biofuels

The country has the potential to develop a biofuels market to use in jet engines for transport mixed with fossil fuels. The use of biofuels has important environmental advantages given that their impact on the environment during their life cycle is reduced compared to oil products. In addition, many jobs could be generated in the agro-industrial, sugarcane, and palm oil chain: they could reach an estimated 12,000 (between direct and indirect employment), especially in the agricultural phase.

Ethanol is already available in the city of Guayaquil as a mix – E5, 5% bioethanol and 95% gas between base and high octane. Also, between 2016 and 2017 this mix could reach the average goal of 5% (E5, the current Ecocountry), and by 2020 could reach 10% (E10) in the whole country. This would require planting an additional 40,000 to 50,000 hectares of sugarcane.

In 2011, an executive decree was passed that changed the formula for bioethanol prices. It also created a strong incentive to promote investment in newly planted areas and in distillation. All of this came about because the formula was established based on the equivalent FOB price in New York for raw sugar (Contract 11).

The case of biodiesel is different than that of bioethanol given that the Ecuadoran palm oil agroindustry has a surplus of raw palm oil that is being exported (240,000 tons). The industry itself expects that these numbers will grow in the future, especially based on an increase in productivity (and, to a lesser degree, on the increase in planting, which is currently very low in comparison to other producing areas in the world).

Surplus palm oil to produce biodiesel, a mix of B15 with a total penetration in the diesel market for transport, could be commercialized by the end of the 2012-2030 period. In addition, production could increase based on other biomass and technology.

Recently, an executive decree was passed that established goals for obligatory mixes for the oil industry, starting with a plan for B3 and B5 mixes. In addition, the implementation of a plan for the partial substitution of diesel for biodiesel in mixes

for all types of fixed consumption (electricity generation, industry) and mobiles (terrestrial and marine engines) in the Galapagos Islands is being considered. All of this is part of the "Zero Fossil Fuels in the Galapagos" initiative.

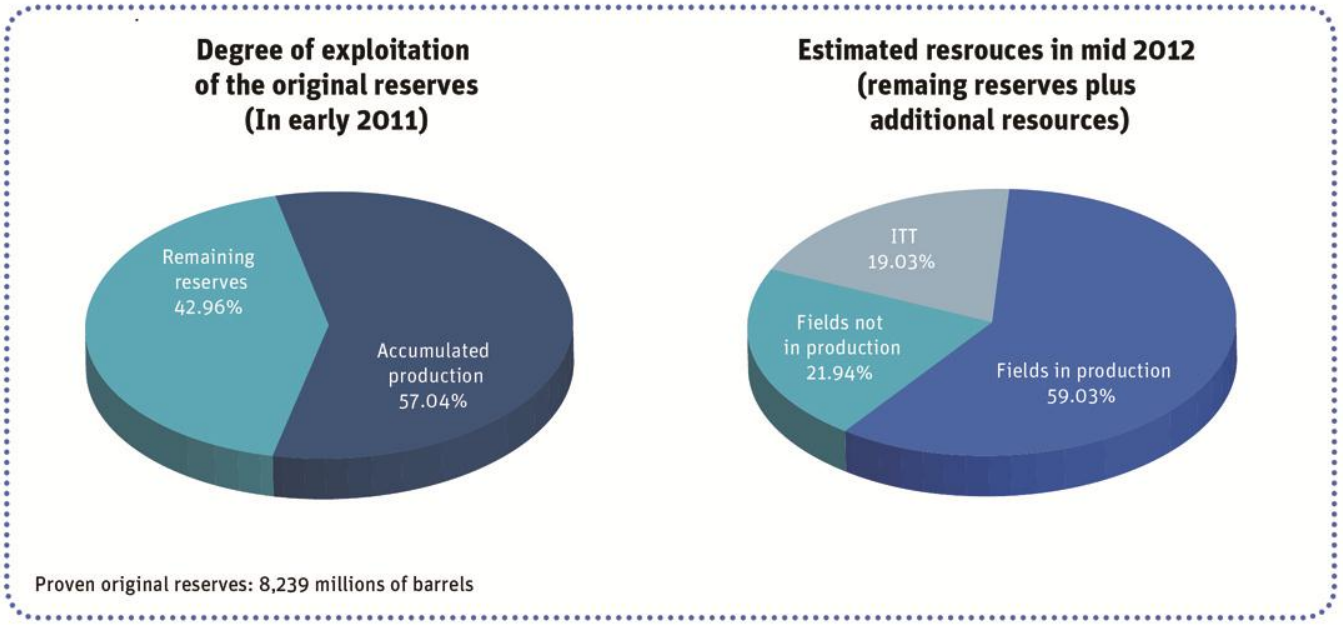
## *b. Non-renewable resources*

### i. Oil

Ecuador is an oil producing and exporting country, although given the size of its reserves and production, its participation in the global market is small. Nonetheless, oil is the main source of resources for export, and it plays an important role in the national economy and in public finances.

Oil exploitation began in the country in 1972. Currently, taking into account the accumulated production of some 4,700 million barrels, the proven remaining reserves reach 3,500 million barrels. This means that 57% of the existing reserves have been exploited, while 43% remain to be exploited (Figure 7 and Table 7). Taking into account the remaining reserves plus additional resources,[6] the total 13,000 million barrels could be exploited now. Of those, 59% are in fields that are already in production, 22% are in fields that aren't currently in production, and 19% are in the ITT fields (Ishipingo, Tiputini and Tambococha).

**Figure 7** Remaining reserves and additional oil resources




**Source:** Own elaboration based on MRNNR/MICSE data

**Source:** Own elaboration based on MRNNR/MICSE data.

**Table 7** Remaining reserves and additional oil resources (Millions of barrels)

| | Remaining proven reserves (1) | Additional resources (2) | Total |
|---|---|---|---|
| Fields in production | 2,123.3 | 5,605.8 | 7,729.1 |
| Fields not in production | 455.1 | 2,416.9 | 2,872.0 |
| Subtotal of fields in production and not in production | 2,578.4 | 8,022.7 | 10,601.1 |
| ITT | 960.7 | 1,530.6 | 2,491.3 |
| Total | 3,539.1 | 9,553.3 | 13,092.4 |

(1) A t the beginning of 2011.
(2) Probable, possible, and prospective reserves, data revised in mid 2012.
**Source:** Own elaboration based on MRNNR/MICSE data.

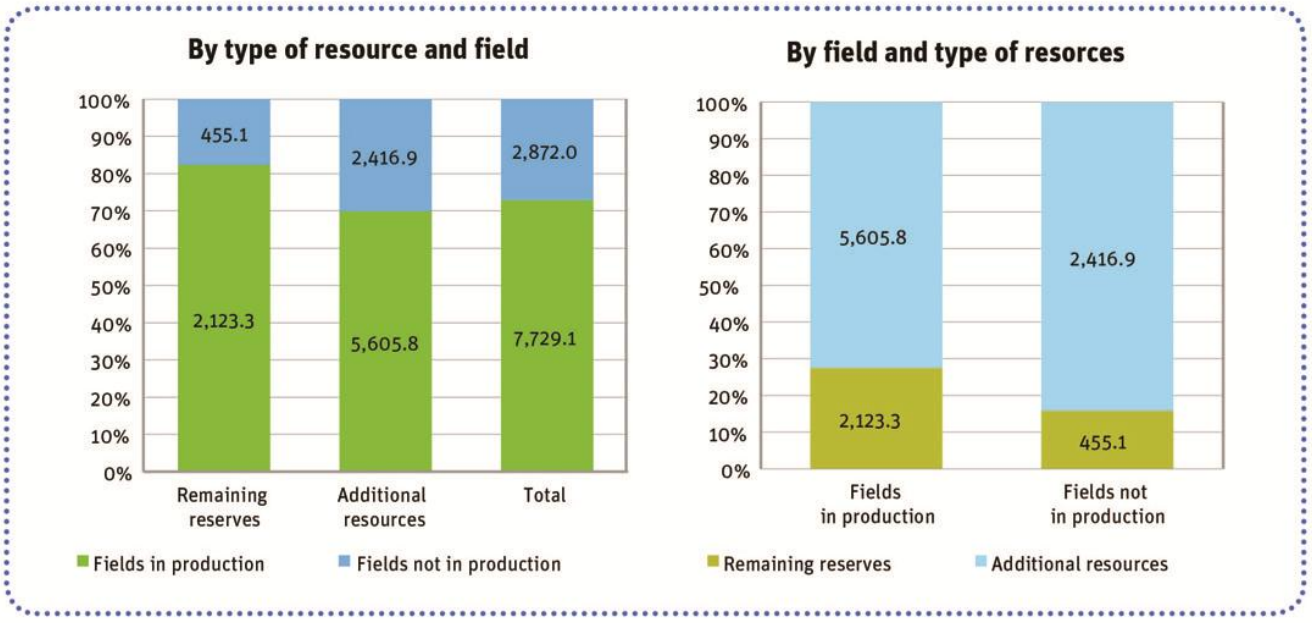
**6** Probable, possible, and prospective reserves, including improved or assisted recuperation, EOR (Enhanced Oil Recovery).

The national government decided not to exploit the ITT fields given that most of the reserves are found in a protected area. Therefore, a fund was established to promote contributions from the international community to provide compensation for the loss of income from exports.

Thus, considering only the remaining reserves and additional resources in the production fields and those that are not currently in production (excluding the ITT), petroleum resources yet to be developed and exploited would be 10,600 million barrels, 72% of which are found in fields currently in production. This is also where 80% of the remaining reserves and 70% of additional resources are found.

Resources in fields in production represent nearly 30% of remaining reserves and the rest belongs to additional resources. Remaining reserves represent only 15% of the resources of fields not in production.

**Figure 8** Distribution of oil resources to be exploited by mid 2012 (without ITT).




**Source:** Own elaboration based on MRNNR/MICSE data

**Source:** own elaboration based on MRNNR/MICSE data.

Petroleum reserves in the country are in decline, which means that additional reserves, either by enhanced recovery or the addition of new reserves, are extending the life of production. Without additional resources from fields not in production and the production fields Petroecuador, Petroamazonas and Río Napo, the country would have to import crude to fulfill the needs of refineries, especially between 2016 and 2017, which is when the Pacific Refinery will begin operation. Although the surplus of refined products reverses the current situation, around 2020 the country will become a net importer of energy, even in a scenario that demands energy efficiency and continues the hydropower development that has already begun.

With additional oil resources, the oil has a brighter future and refineries could be supplied with national crude until the end of 2030. In approximately 2035, the country could become a net importer. The exploitation of ITT can change the situation and substantially prolong the horizon for depleting those resources. The decision not to exploit those resources will have a strong impact on the future of the national economy, something that the international community should consider when setting resource contributions to compensate for the effect.

## ii. Natural gas

Although Ecuador is not a gas producing country, it has reserves of free gas in the Gulf of Guayaquil (Campo Amistad), and there are prospects of confirming recent discoveries. In any case, if you wanted to increase the penetration of natural gas in the energy mix, even with the addition of new reserves, the country might have to increase the supply via imports of Liquefied Natural Gas (LNG) or via gas pipelines from Venezuela and Colombia.

On the other hand, combined with oil production in eastern Ecuador, gas that is currently vented is mostly produced.

The production of free natural gas in Campo Amistad began in August 2002. At the end of 2010, the remaining reserves were 145,000 million feet squared (MMCF). Accumulated production at this date was approximately 80,000 MMCF, which

means that 35% of 225,000 MMCF of original proven reserves had already been exploited.

At the beginning of 2012, the identification of 1.7 TCF (trillions of cubic feet) in the Campo Amistad was announced. These were in the resource category, which means that if exploratory activity was allowed and they could become proven reserves, the horizon for expanding the production and use of natural gas would open up.

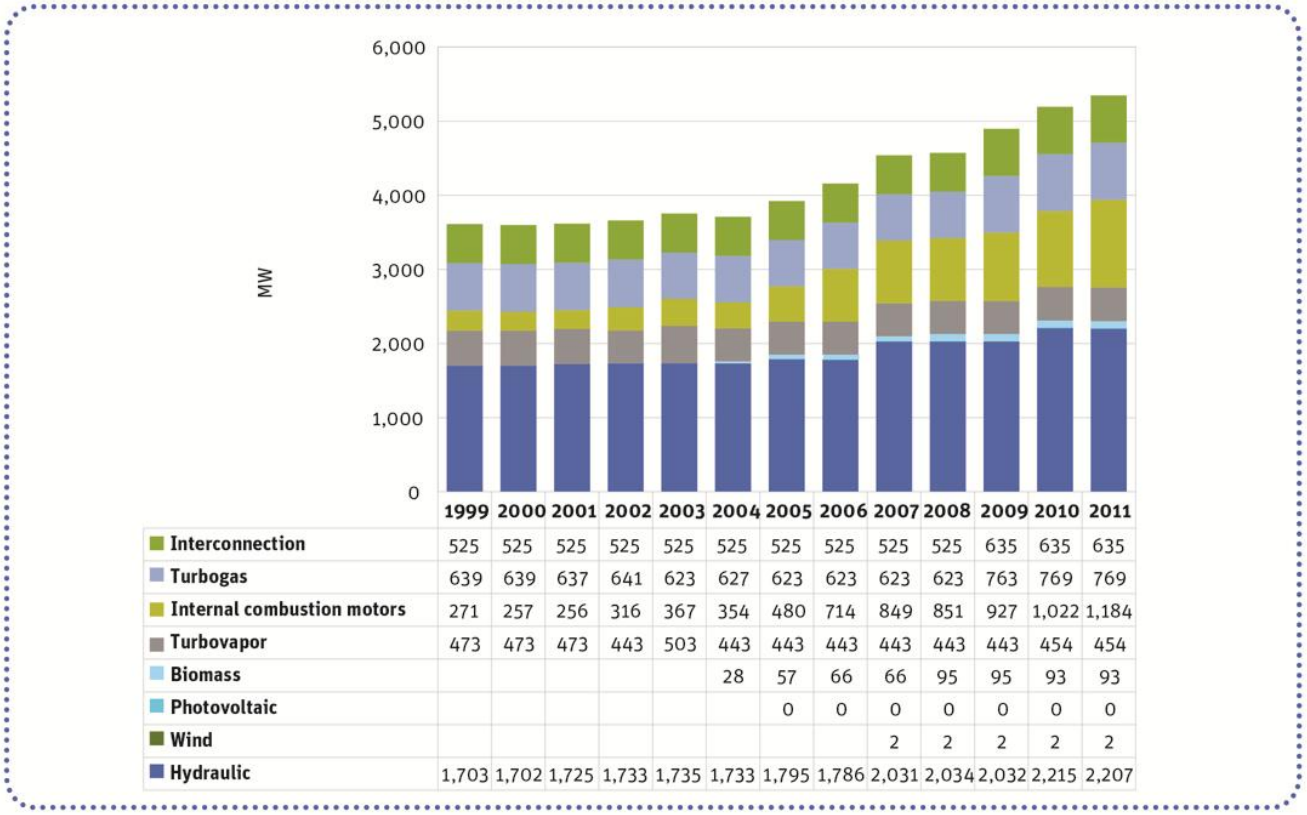
## *c. Energy supply*

### i. Electricity sector

#### a. Installed capacity and generation

Installed power in public electricity service plants grew from 3,070 MW in 1999 to 4,150 in 2010. However, during that period there was a lag in hydropower development and an increase in the installation of thermal plants, which came to represent 50% of the generation towards the end of the period (Figure 9).

**Figure 9** Effective installed capacity by type of plant




| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Interconnection | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 525 | 635 | 635 | 635 |
| Turbogas | 639 | 639 | 637 | 641 | 623 | 627 | 623 | 623 | 623 | 623 | 763 | 769 | 769 |
| Internal combustion motors | 271 | 257 | 256 | 316 | 367 | 354 | 480 | 714 | 849 | 851 | 927 | 1,022 | 1,184 |
| Turbovapor | 473 | 473 | 473 | 443 | 503 | 443 | 443 | 443 | 443 | 443 | 443 | 454 | 454 |
| Biomass | | | | | | 28 | 57 | 66 | 66 | 95 | 95 | 93 | 93 |
| Photovoltaic | | | | | | | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Wind | | | | | | | | | 2 | 2 | 2 | 2 | 2 |
| Hydraulic | 1,703 | 1,702 | 1,725 | 1,733 | 1,735 | 1,733 | 1,795 | 1,786 | 2,031 | 2,034 | 2,032 | 2,215 | 2,207 |

Own elaboration based on CONELEC data.

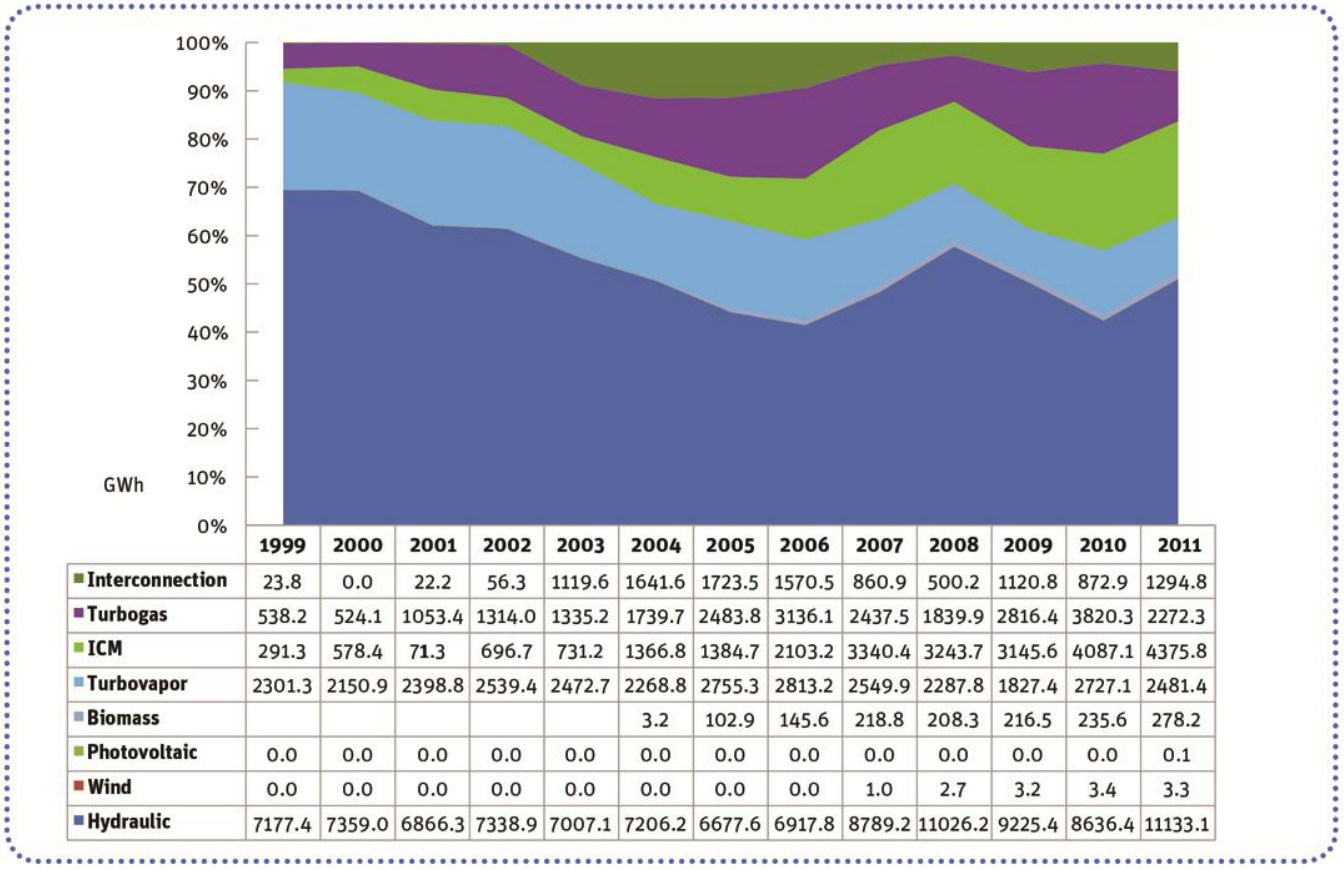
Above all, this increase is notable in installed capacity in gas turbines and diesel cycle internal combustion motors (ICM), especially those of average speed. Thus, more rapidly installed equipment was used given the vulnerability of the system, which suffers the risks of shortages and blackouts frequently.

This situation will be reversed in a few years when the hydroelectric projects under construction begin operation.

Changes in the composition of the generation park and operative characteristics and availability of different types of plants created a structure of electricity generation that experienced the marked decrease of hydraulic participation, which lowered from 70% to 50% between 1999 and 2010.

In turn, there was a growth of thermal generation, especially generation with ICM and high imports from Colombia, which came to represent more than 12% of the generation total in 2004 (Figure 10).

**Figure 10** Electricity generation for type of plant



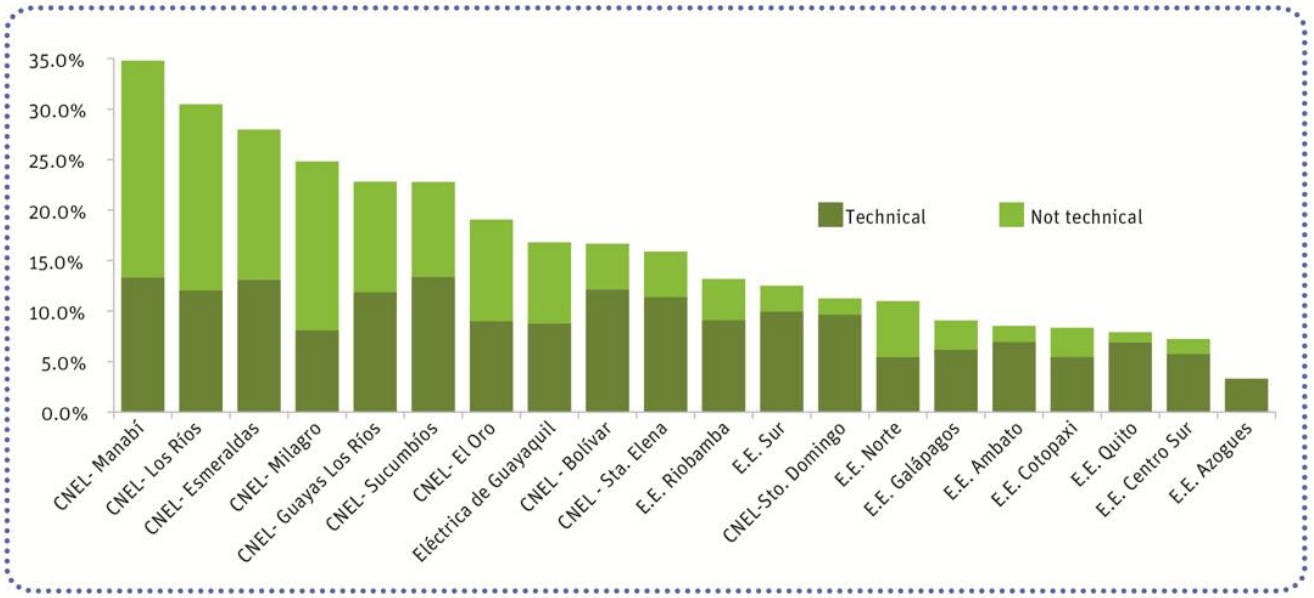

| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Interconnection | 23.8 | 0.0 | 22.2 | 56.3 | 1119.6 | 1641.6 | 1723.5 | 1570.5 | 860.9 | 500.2 | 1120.8 | 872.9 | 1294.8 |
| Turbogas | 538.2 | 524.1 | 1053.4 | 1314.0 | 1335.2 | 1739.7 | 2483.8 | 3136.1 | 2437.5 | 1839.9 | 2816.4 | 3820.3 | 2272.3 |
| ICM | 291.3 | 578.4 | 71.3 | 696.7 | 731.2 | 1366.8 | 1384.7 | 2103.2 | 3340.4 | 3243.7 | 3145.6 | 4087.1 | 4375.8 |
| Turbovapor | 2301.3 | 2150.9 | 2398.8 | 2539.4 | 2472.7 | 2268.8 | 2755.3 | 2813.2 | 2549.9 | 2287.8 | 1827.4 | 2727.1 | 2481.4 |
| Biomass | | | | | | 3.2 | 102.9 | 145.6 | 218.8 | 208.3 | 216.5 | 235.6 | 278.2 |
| Photovoltaic | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.1 |
| Wind | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 0.0 | 1.0 | 2.7 | 3.2 | 3.4 | 3.3 |
| Hydraulic | 7177.4 | 7359.0 | 6866.3 | 7338.9 | 7007.1 | 7206.2 | 6677.6 | 6917.8 | 8789.2 | 11026.2 | 9225.4 | 8636.4 | 11133.1 |

**Fuente:** Own elaboration based on CONELEC data

With respect to the distribution of electricity, there are 20 distributors in the country. Ten were grouped together a few years ago in the National Electricity Corporation (CNEL) with the objective of improving the performance of these companies in terms of losses, billing, collection, and quality of service. The total number of final clients of distribution companies has grown steadily with annual rates between 4% and 6%. This percentage was also consistent with population growth and the expansion of coverage. Currently, the number of subscribers to electricity service is 4.3 million according to the figures from July.

An important aspect to consider is distribution losses (Figure 11), given that to a great extent it indicates the management capacity of the companies that are in charge of expanding service coverage. Similarly, this is how CONELEC channels funds from the Rural and Marginal Urban Electrification Fund (FERUM). Total losses from the entire national distribution network have been reduced steadily from a maximum of 23% in 2004 to 14.7% in 2011. However, it could still be said that in several distribution companies losses continue to be high, especially, according to 2010 statistics,[7] those that aren't "technical."

**Figure 11** Distribution losses by company 2010



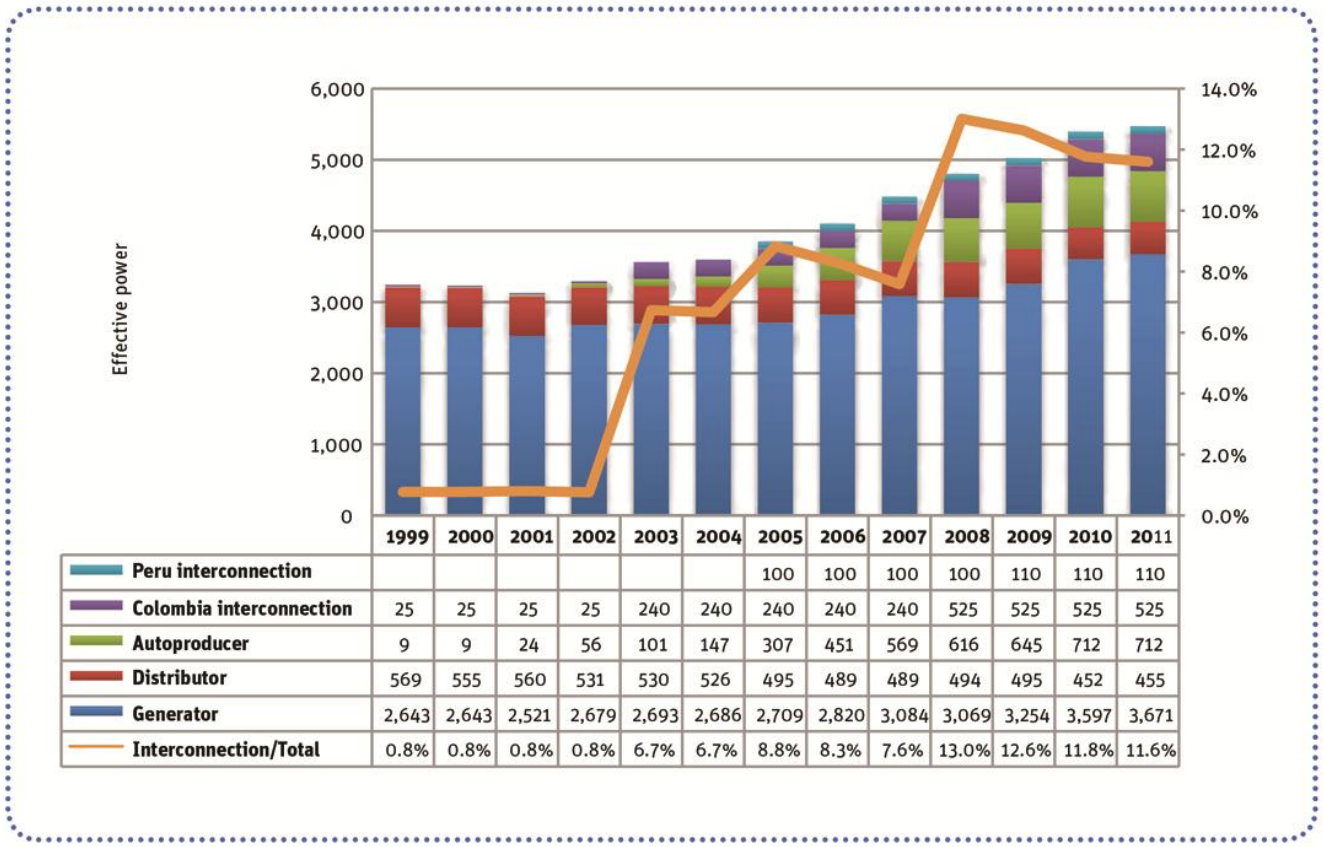

**Source:** Own elaboration based on CONELEC data

**7** The losses show similar levels in the majority of companies according to available statistics on total losses (technical and non-technical) 2011.

b. International interconnection, import, and export

At present, the defective capacity of international interconnection links reaches a total of 635 MW, which represents nearly 12% of the total effective capacity of the Ecuadorian electricity system (Figure 12).

**Figure 12** Effective installed capacity by type of business and interconnection




| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peru interconnection | | | | | | | 100 | 100 | 100 | 100 | 110 | 110 | 110 |
| Colombia interconnection | 25 | 25 | 25 | 25 | 240 | 240 | 240 | 240 | 240 | 525 | 525 | 525 | 525 |
| Autoproducer | 9 | 9 | 24 | 56 | 101 | 147 | 307 | 451 | 569 | 616 | 645 | 712 | 712 |
| Distributor | 569 | 555 | 560 | 531 | 530 | 526 | 495 | 489 | 489 | 494 | 495 | 452 | 455 |
| Generator | 2,643 | 2,643 | 2,521 | 2,679 | 2,693 | 2,686 | 2,709 | 2,820 | 3,084 | 3,069 | 3,254 | 3,597 | 3,671 |
| Interconnection/Total | 0.8% | 0.8% | 0.8% | 0.8% | 6.7% | 6.7% | 8.8% | 8.3% | 7.6% | 13.0% | 12.6% | 11.8% | 11.6% |

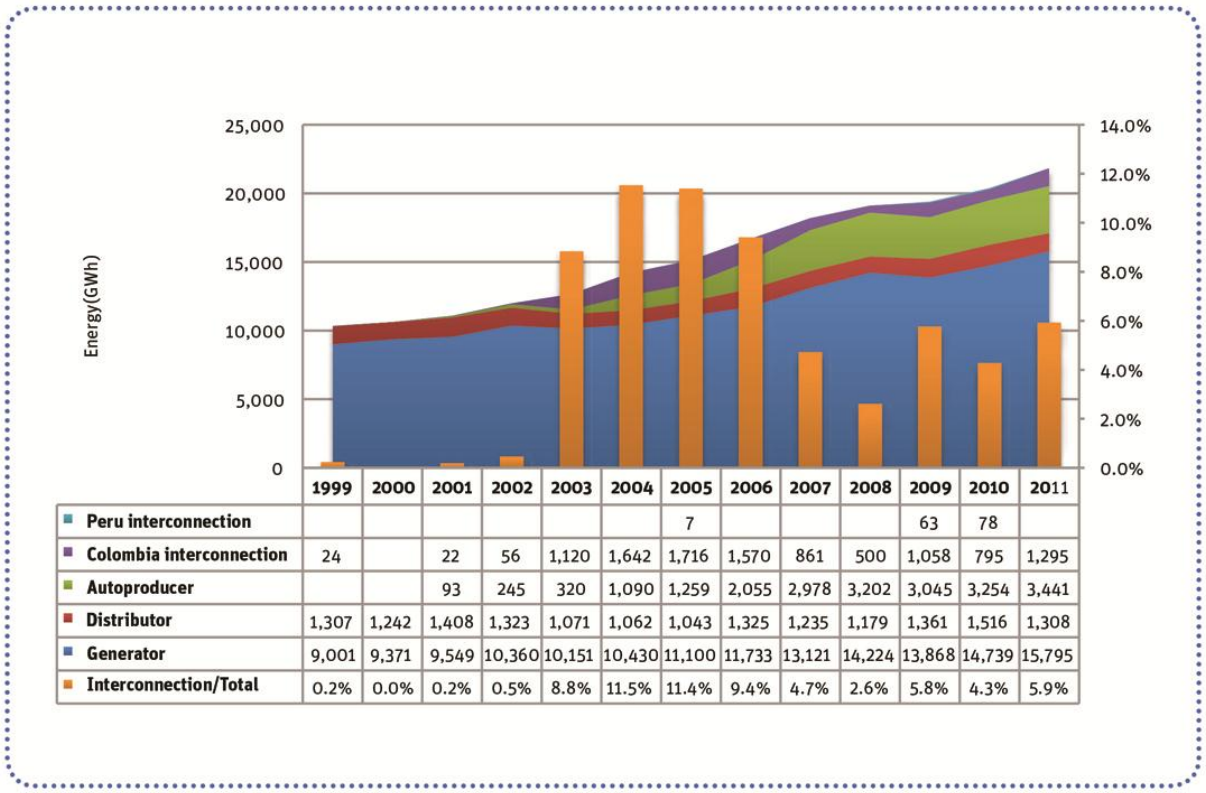
**Source:** Own elaboration based on CONELEC data

The historic evolution of International Energy Transactions (IET) shows that the exchanges have basically been between Colombia and Ecuador. In the case of Peru, there was virtually now flow after the 230 KV Machala-Zorritos began operation in 2005. Ecuador only had minimal imports from Peru in that year, while in 2009 and 2010 it registered a flow of 0.21 GWh and 6.3 GWh respectively from Ecuador to Peru. Ecuador's imports from Colombia began on a greater scale in 2003 with the opening of the first 230 KV interconnection line with 240 MW of effective power. With this it acquired a major stake between 2003 and 2006 in the supply of electricity demand on the Ecuadorian market that came to represent between 8% and 12% of gross system generation. These figures are mainly due to hydrological

decreases, requirements in periods of drought, and a lack of operational thermal backup with frequent limitations to supply in Ecuador.

In 2007 said imports reduced drastically because the hydroelectric San Francisco began operation. Similarly, other installations reduced the need for imports for the Ecuadorian system. However, during the 2009-2011 period imports grew again to significant levels: between 4% and 6% of gross generation (Figure 13).

**Figure 13** Gross generation by type of company and interconnection




| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Peru interconnection | | | | | | | 7 | | | | 63 | 78 | |
| Colombia interconnection | 24 | | 22 | 56 | 1,120 | 1,642 | 1,716 | 1,570 | 861 | 500 | 1,058 | 795 | 1,295 |
| Autoproducer | | | 93 | 245 | 320 | 1,090 | 1,259 | 2,055 | 2,978 | 3,202 | 3,045 | 3,254 | 3,441 |
| Distributor | 1,307 | 1,242 | 1,408 | 1,323 | 1,071 | 1,062 | 1,043 | 1,325 | 1,235 | 1,179 | 1,361 | 1,516 | 1,308 |
| Generator | 9,001 | 9,371 | 9,549 | 10,360 | 10,151 | 10,430 | 11,100 | 11,733 | 13,121 | 14,224 | 13,868 | 14,739 | 15,795 |
| Interconnection/Total | 0.2% | 0.0% | 0.2% | 0.5% | 8.8% | 11.5% | 11.4% | 9.4% | 4.7% | 2.6% | 5.8% | 4.3% | 5.9% |

**Source:** Own elaboration based on CONELEC data

The value of transactions, mainly imports from Ecuador to Colombia, reached a maximum value of 1,716 million dollars in 2005, while in 2011 it was almost 1,300 million (Table 8).

**Table 8** Value and average prices of electricity exchanges with Colombia

| | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|
| GWh | 1,119.61 | 1,641.61 | 1,716.01 | 1,570.47 | 860.87 | 500.16 | 1,058.20 | 794.51 | 1,294.59 |
| Millions US$ | 68.38 | 134.11 | 148.55 | 122.53 | 17.82 | 33.99 | 102.38 | 74.13 | 87.83 |
| Cents US$/KWh | 6.11 | 8.17 | 8.66 | 7.80 | 2.07 | 6.80 | 9.67 | 9.33 | 6.78 |
| | | | | | | | | | |
| GWh | 67.20 | 34.97 | 16.03 | 1.07 | 38.39 | 37.53 | 20.76 | 9.74 | 8.22 |
| Millions US$ | 0.87 | 0.18 | 0.14 | 0.03 | 0.29 | 0.63 | 1.08 | 0.68 | 0.19 |
| Cents US$/KWh | 1.29 | 0.51 | 0.87 | 2.80 | 0.76 | 1.68 | 5.20 | 6.98 | 2.31 |

**Source:** Own elaboration based on CONELEC data.

It should be noted that the Andean electricity market is the only case in Latin America in which there are supranational regulations, which are issued by the Andean Community of Nations (CAN). However, the market is still in the beginning stages given that there are unresolved issues that are being discussed. With respect to this situation, the CAN, in CAN Decision 757 from August 2011, extended the period that had been established in Decision 720 by two years. Ecuador is working on the issue via MEER, CONELEC, and other entities given that starting in 2016/2017 the country could become a net exporter of electricity. This fact will reverse the current situation, and the surplus, whose magnitude will depend on the nature of the structural changes produced in final demand by substituting fossil fuels (mainly domestic LPG and industrial diesel) for electricity.

## i. Oil and natural gas

### a. Oil production

As has been mentioned previously, Ecuador is a oil exporter and producer and it participates minimally in the world market with respect to the volume of its reserves and production. This is why hydrocarbons (oil and its derivatives, and, in lesser measure, gas) have high participation in the energy structure of the national economy.

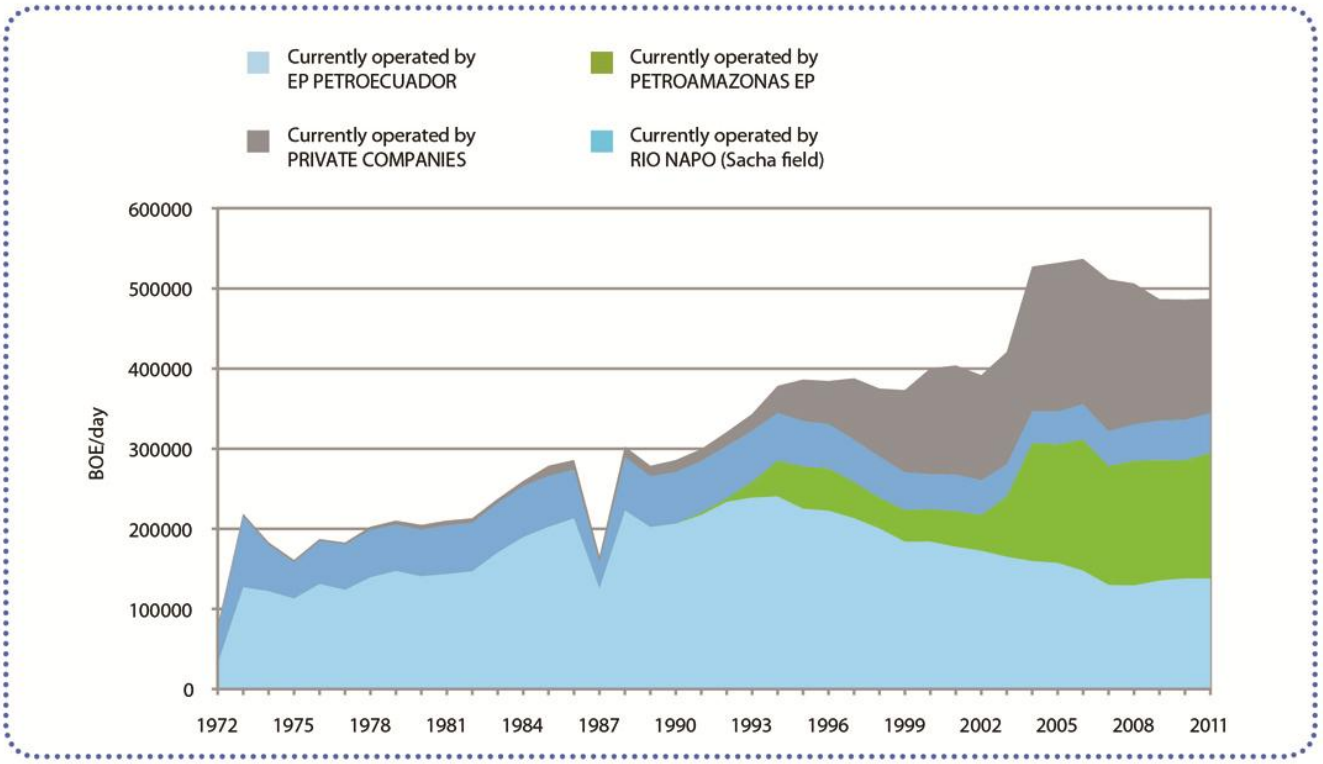
The country became an exporter of oil when commercial oil exploitation began in 1972. For two decades, there was sustained growth that stabilized between 1994 and 2004. In 2004, there was a strong recovery and then growth fell starting in 2006. It was not until 2012[8] (average daily production, Figure 14) that growth

recovered again.

b. Natural gas production

The production of free natural gas in Campo Amistad began in August 2002 and grew to reach levels between 10,000 and 12,000 millions of feet squared (Table 9)

**Figure 14** Production of crude oil by field




Source: Own elaboration based on MICSE-MNNR data

This production is used mainly for electricity generation in the Machala Thermogas plant. In 2011, the plant's power increased from 130 MW to 210 MW with the installation of four additional turbines. With the increase in natural gas production, the use of gas from the Gulf allowed an increase in electricity generation and the savings of imported diesel in the production of these four turbines.

**8** Estimated values 2012.

**Table 9** Natural gas production

| | Millions of feet squared |
|---|---|
| 2002(*) | 3,063 |
| 2003 | 8,810 |

| | |
|---|---|
| 2004 | 8,523 |
| 2005 | 9,301 |
| 2006 | 10,005 |
| 2007 | 10,513 |
| 2008 | 8,872 |
| 2009 | 10,550 |
| 2010 | 11,776 |
| 2011 | 8,630 |

**Source:**
MRNNR
(*) Production began on August 6, 2002.

The surplus of natural gas, 200 metric tons daily, which is equivalent to 10 million cubic feet a day, goes to a liquefaction plant. Liquefied natural gas (LPG) is transported in special trucks to storage and regasification plants in Cuenca where natural gas is transformed from its original gaseous state in order to feed the city's industry. This process is intended to partially replace diesel with natural gas and LPG.

With respect to associated natural gas, by 2015 natural gas flaring in eastern Ecuador is expected to be significantly reduced. The project "Optimization of Electricity Generation" (OGE) seeks to reduce pollution from greenhouse gases that are produced with the burning of associated gas in the oil fields. At the same time, it seeks to substitute diesel consumption for untapped gas to generate electricity to use in the operation of oil fields.

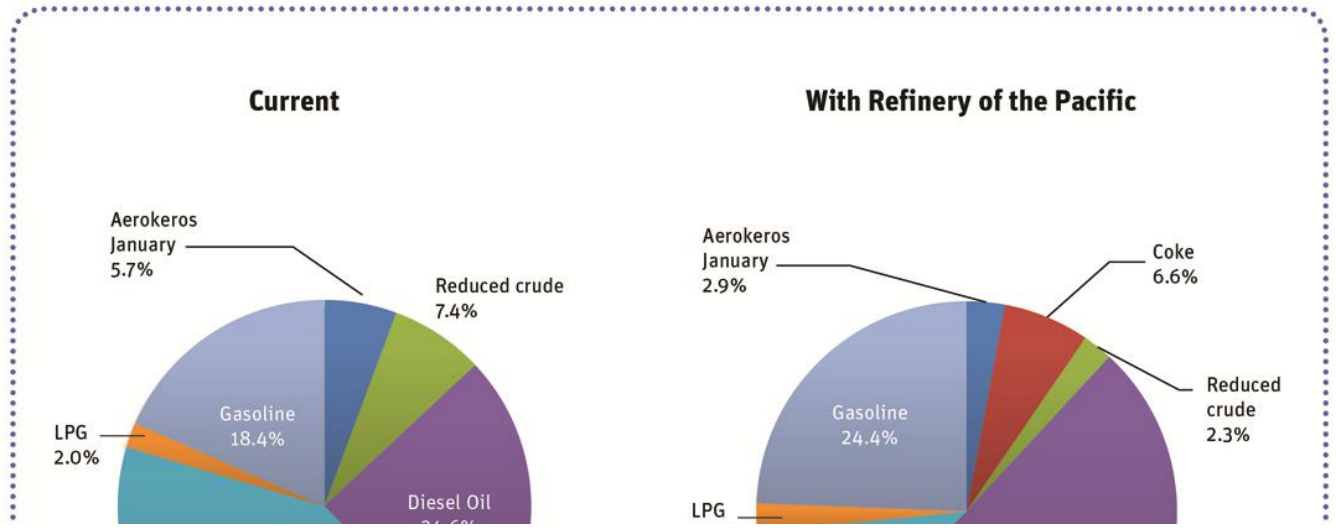
### c. Oil refining

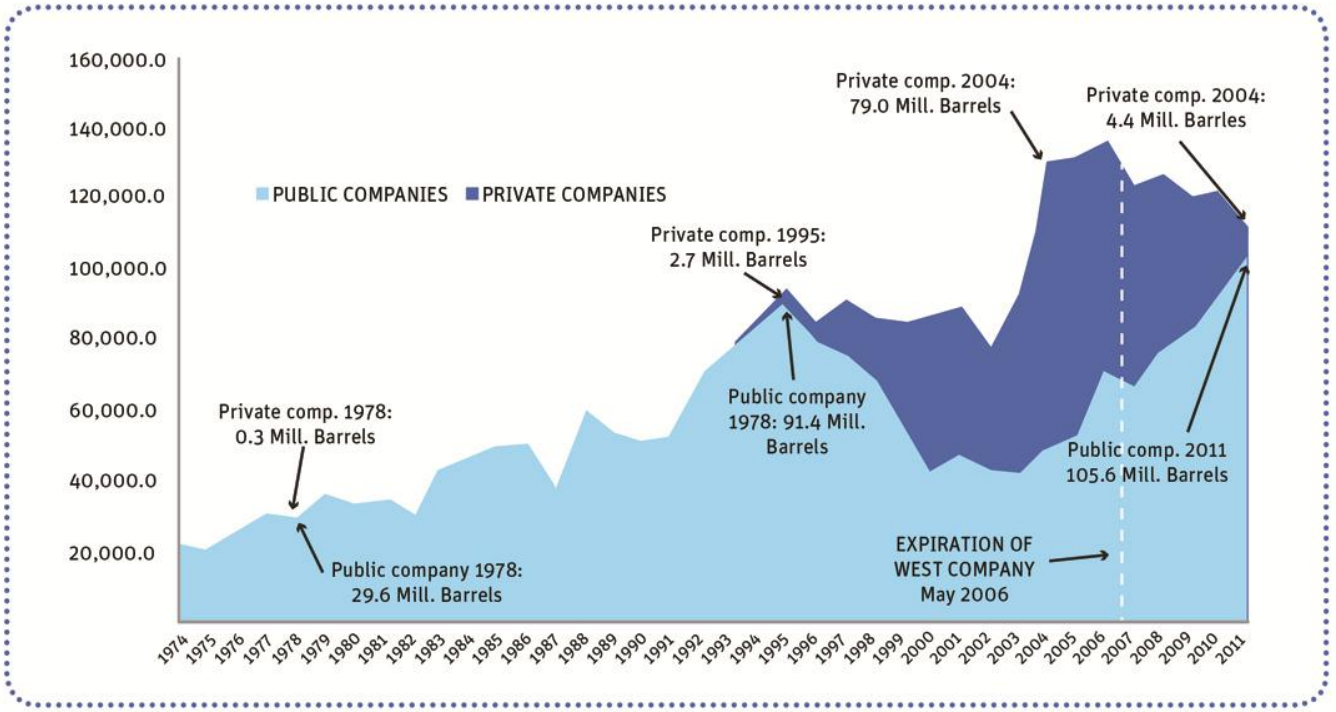
Currently the capacity and structure of existing refineries is not adequate for the levels and structure of the market. Therefore there are imbalances between national production and the demand for oil derivatives. On the one hand, the imbalance leads to elevated import of costly derivatives like Liquefied Petroleum Gas (LPG, a mix of propane and butane), gasoline, and diesel. On the other hand, it leads to exports of surplus fuel oil which has a lower value on the market.

Currently a deep conversion refinery with a capacity of 300,000 barrels per day is in construction. It would drastically change the structure of refining. The Refinery of the Pacific (RDP), whose investment reaches 12,000 million dollars, will not produce fuel oil (only residual coke), but it will have high yield production of diesel and gasoline. Thus the structure of combined refining in current refineries would change

substantially by 2017 when the RDP begins operation (Figure 15).

**Figure 15** The structure of oil derivative production in refineries




**Source:** BCE, Macroeconomic Statistics, Structural Presentation 2012

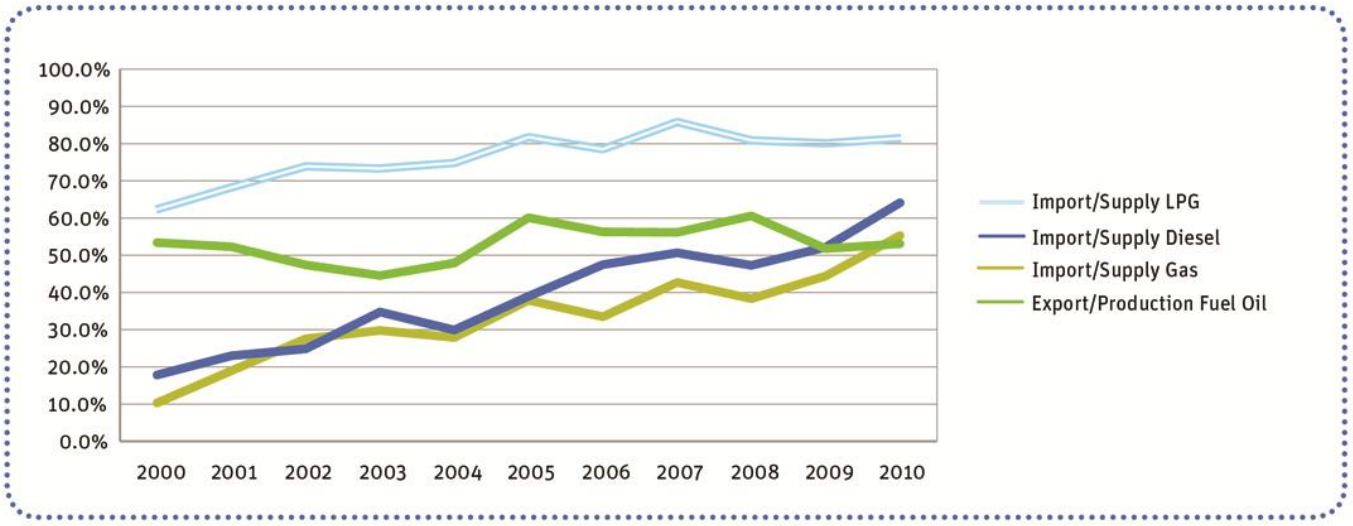
d. Exports and imports

Since its inception, the volume of crude exports grew continuously in function to the growth of oil production. However, in recent years it showed a considerable decline (Figure 16).

**Figure 16** Crude exports

Both production and exports will potentially continue to be stable or decline in the short term, but later will recover due to the increase in production in the fields and due to the addition of fields that aren't in production currently. This way, the timeframe for exhausting the resource will be prolonged, as the chapter about oil resources will explain.

Furthermore, imbalances caused by the refining structure led to the current situation of high value imported market products like LPG (more than 80% is imported), gas (more than 50% is imported), and diesel (more than 60% is imported). On the other hand, more than half the production in fuel refineries is exported as a low value product on the international market (Figure 17).




**Source:** Own elaboration based on National Energy Balances

# 8. ENERYG DEMAND

## *a. Final energy demand*

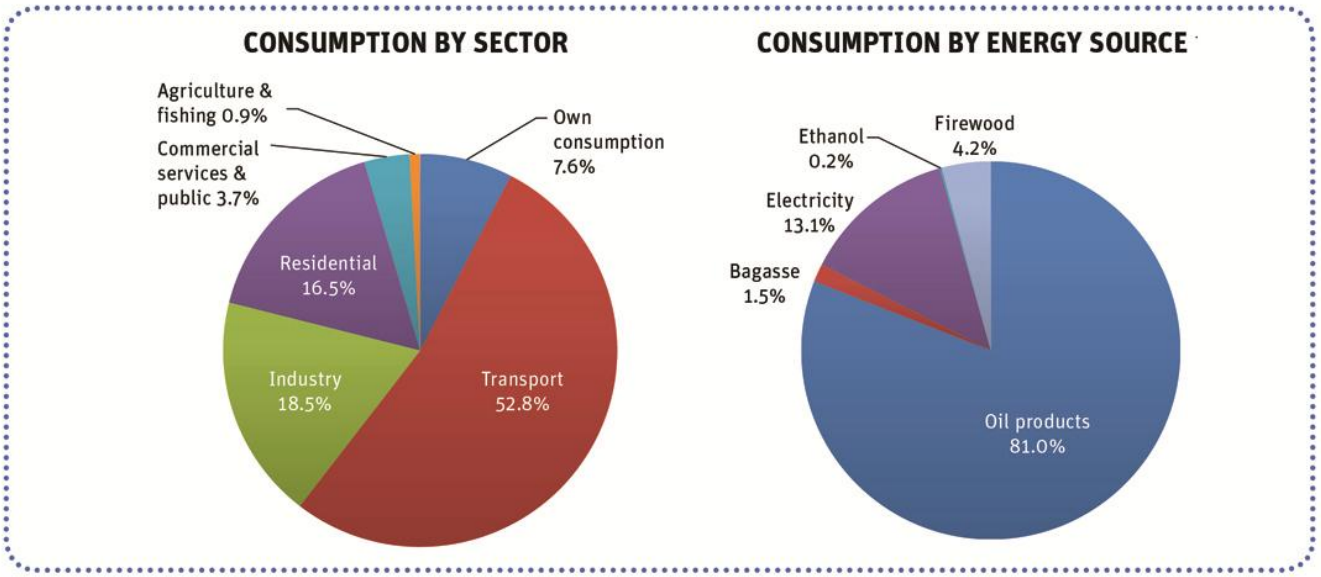
Final energy consumption was 75.5 million barrels of oil equivalent (BOE). Transport represented more than half of final energy[9] consumption in the country. It is the consumption sector with the greatest influence and also possibly the one that is most inefficient.

**Figure 17** Import and export of oil derivatives

Industry and the residential sector, in this order, are the sectors with the greatest

consumption aside from transport (although in much lower proportions than the first two), while the commercial and service sectors don't reach 4% of energy consumption (Figure 18).

**Figure 18** Consumption by sector and energy source, 2010




**Source:** Own elaboration based on the National Energy Balance

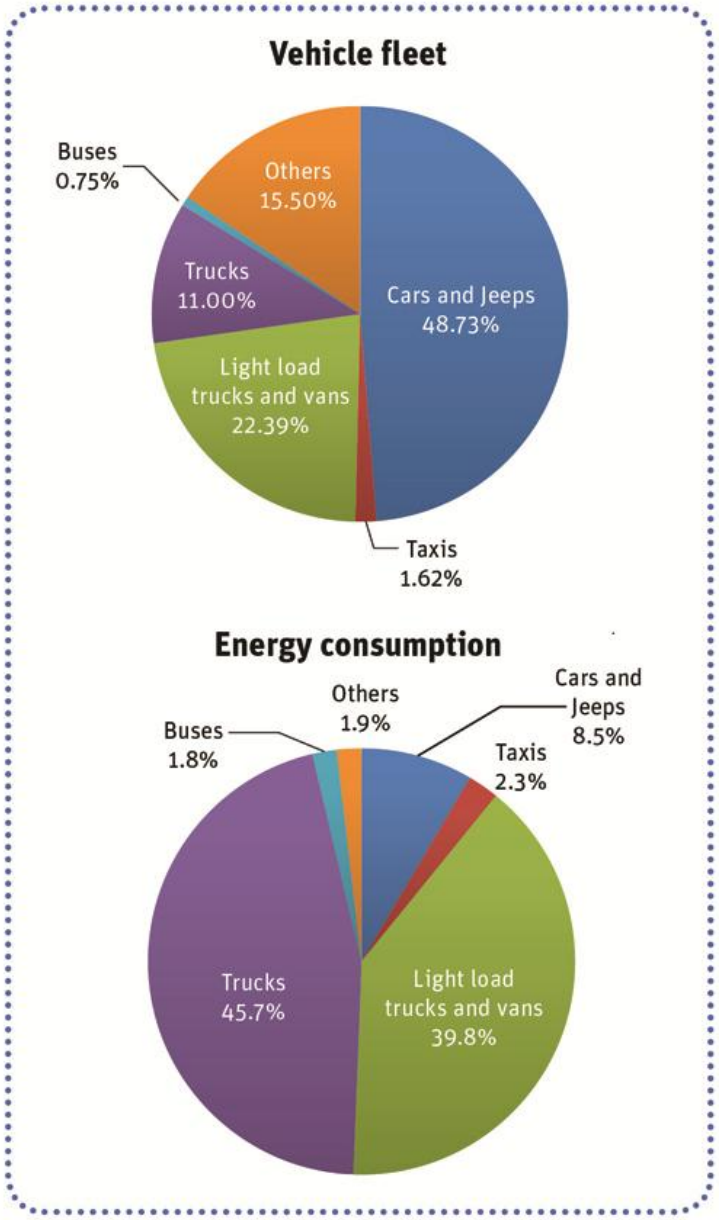
**9** Not including non-energy consumption.

Oil derivatives cover more than 80% of electricity consumption, while electricity covers 13%. With respect to firewood, it should be noted that the data are estimates from long ago which should be corroborated by specific measurements in the field. Based on the strong penetration of LPG for domestic cooking, one might think that firewood consumption is overestimated. However, data from the "2010 Population and Housing Census" indicates that there are still a significant number of homes, mostly rural, that use firewood and coal as the main source of energy for cooking.

## *b. Sectoral demand*

### i. Transport sector

Figure 19 Auto Fleet




**Source:** Own elaboration based on the National Energy Balance

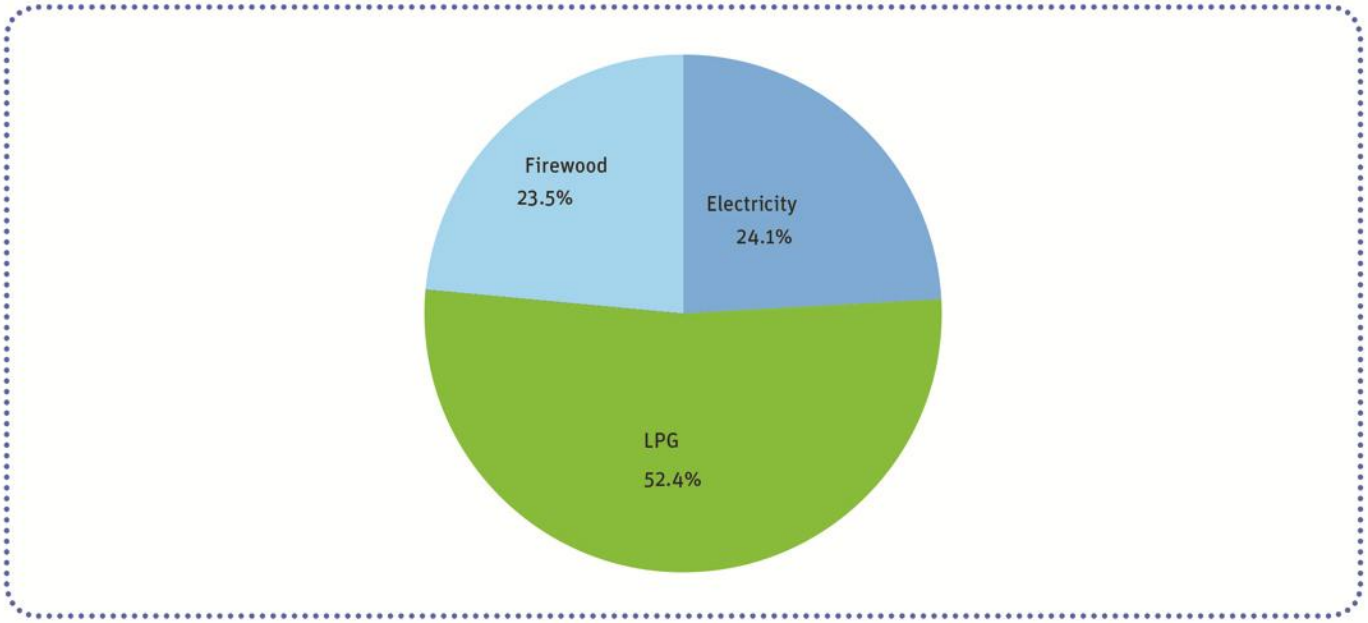
The transport sector is the largest energy consumer and currently uses only oil derivatives. Consumption of electricity by the trolleybus in Quito is very reduced. 84% of total consumption corresponds to the auto fleet, and the remaining 16% to sea, air, and rail transport. Nearly half of the auto fleet in circulation, according to 2010 data, is made up of cars and jeeps, in general passenger vehicles, while light load vehicles (semi-trailer trucks and cargo vans) make up 20% of the fleet and trucks 11%. Energy consumption, given longer trips and larger motor sizes, is concentrated 46% in semi-trailer trucks and almost 40% in light load vehicles (Figure 19).

Energy consumption for highway transport is fundamentally made up of diesel and gas, almost in equal parts. Cars and jeeps use gas 98% and diesel trucks 88%. A number of the vehicles still have gas motors, and vans and light duty trucks consume approximately 85% gas and 15% diesel.

## ii. Residential sector

According to 2010 data, residential sector consumption is covered 52% by LPG and the rest by electricity and firewood (Figure 20).

**Figure 20** Residential energy consumption structure by source 2010




**Source:** Own elaboration based on National Energy Balances

LPG is mainly used for cooking food and, to a lesser extent, for heating water, mainly in mountain areas where the climate is cold. As will be explained, the product is strongly subsidized which causes the majority of the population to use it given that it is for all consumers. As was seen previously, more than 80% is imported. The annual estimated cost of the subsidy is around 600 million dollars. In the specific case of Ecuador, this causes an additional universal access to modern energy problem because the modern energy source is not sustainable in financial terms. This is one of the elements included in the concept of sustainability defined within the SE4ALL focus.

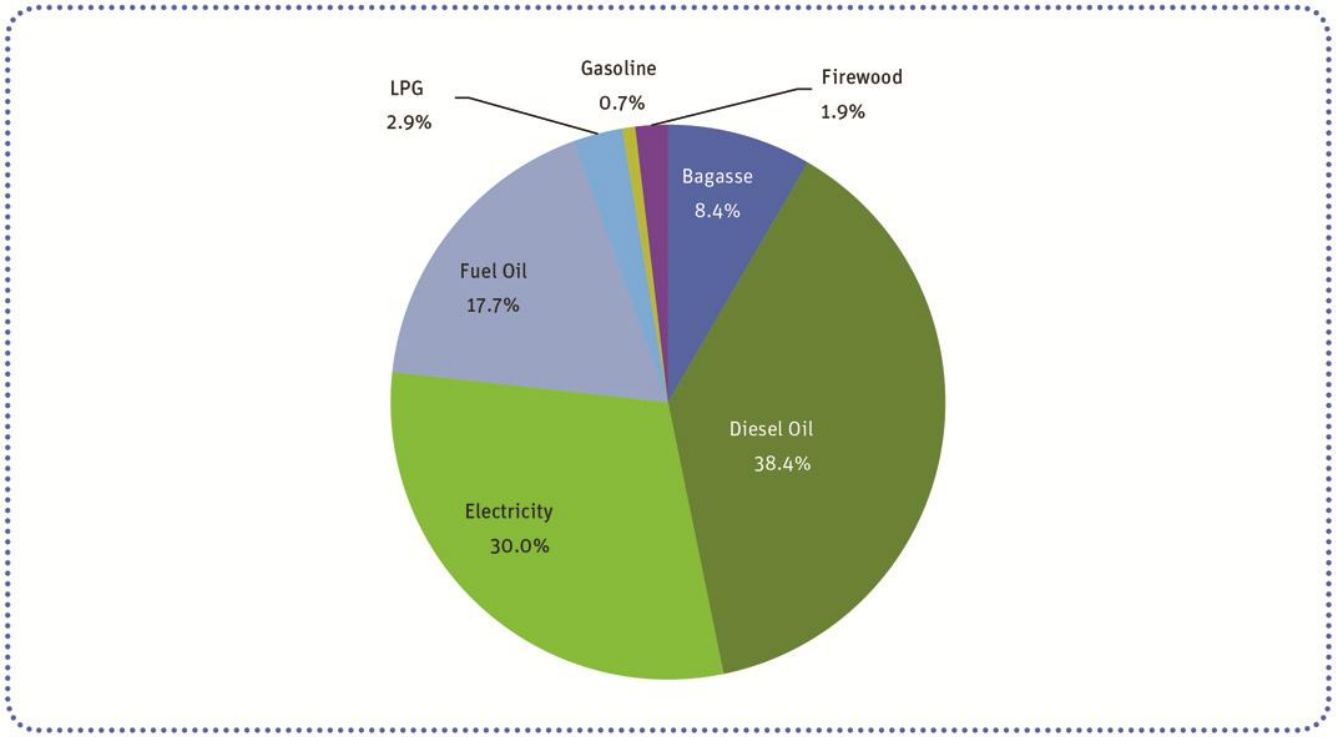
## iii. Industrial sector

The industrial sector mainly consumes, in order of importance, diesel, electricity, and fuel oil that together represent 86% of energy consumption in the sector (Figure 21).

The industrial sector accounted for in the energy balance corresponds to formal industry. In general, productive consumption linked to consumption for productive uses in small businesses and industries aren't represented, especially if they are associated with sectors with less income, specifically in rural areas.

On the other hand, industrial consumption figures are included for the entire sector, based on electricity billing rate for that segment and sales of fuel distribution companies thereof.

**Figure 21** Structure of industrial consumption by energy source



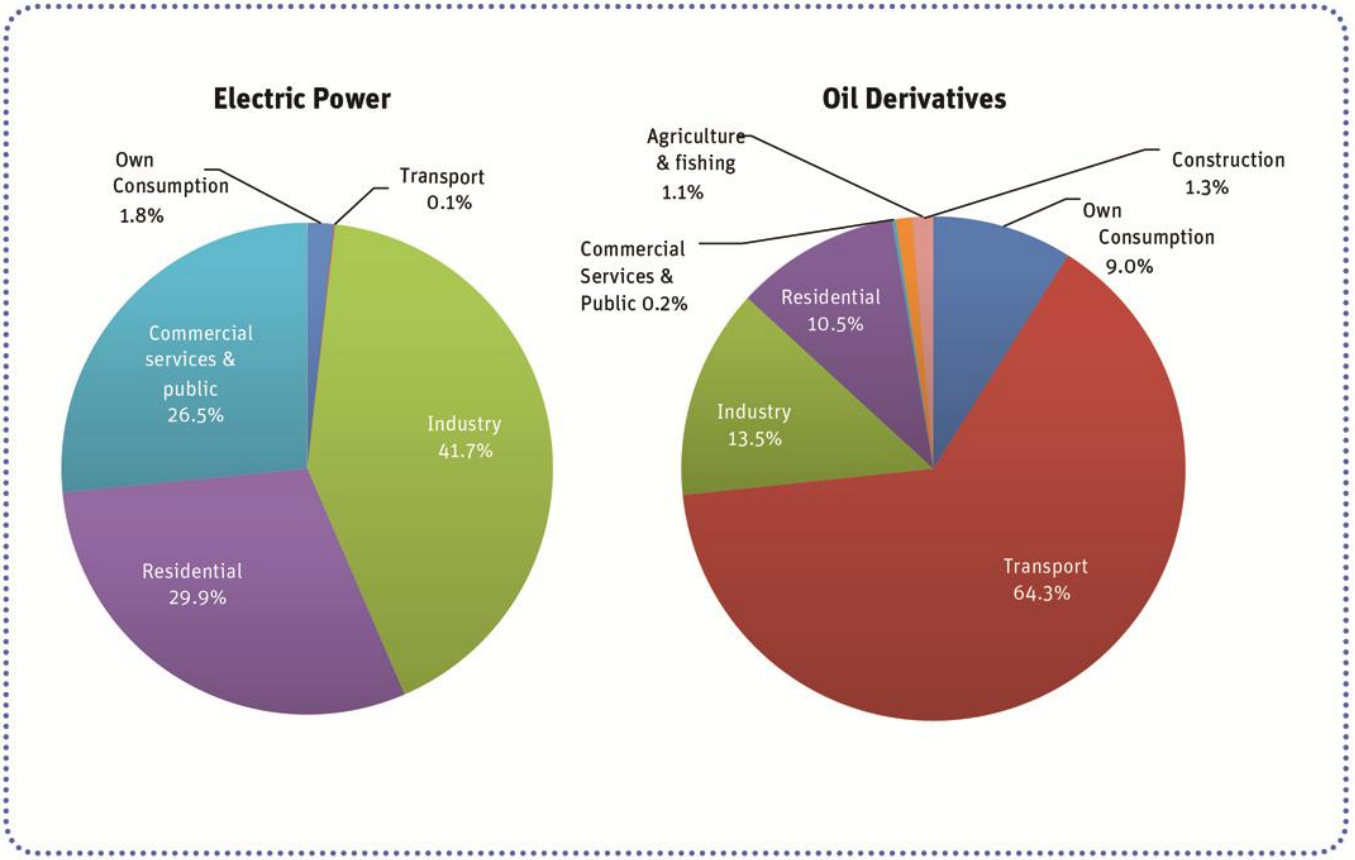

**Source:** Own elaboration based on National Energy Balances

## iv. Sectoral demand for the main energy sources

The main consumer of electricity is industry, with more than 40%. It is followed by the residential sector and the commerce and services sectors (Figure 22). Given that transport is the largest consumer of energy and that it uses only oil derivatives, the consumption of these last sectors goes two thirds to transport and, in much

smaller measure, to the industrial and residential sectors.

**Figura 22** Consumption by sector in 2010



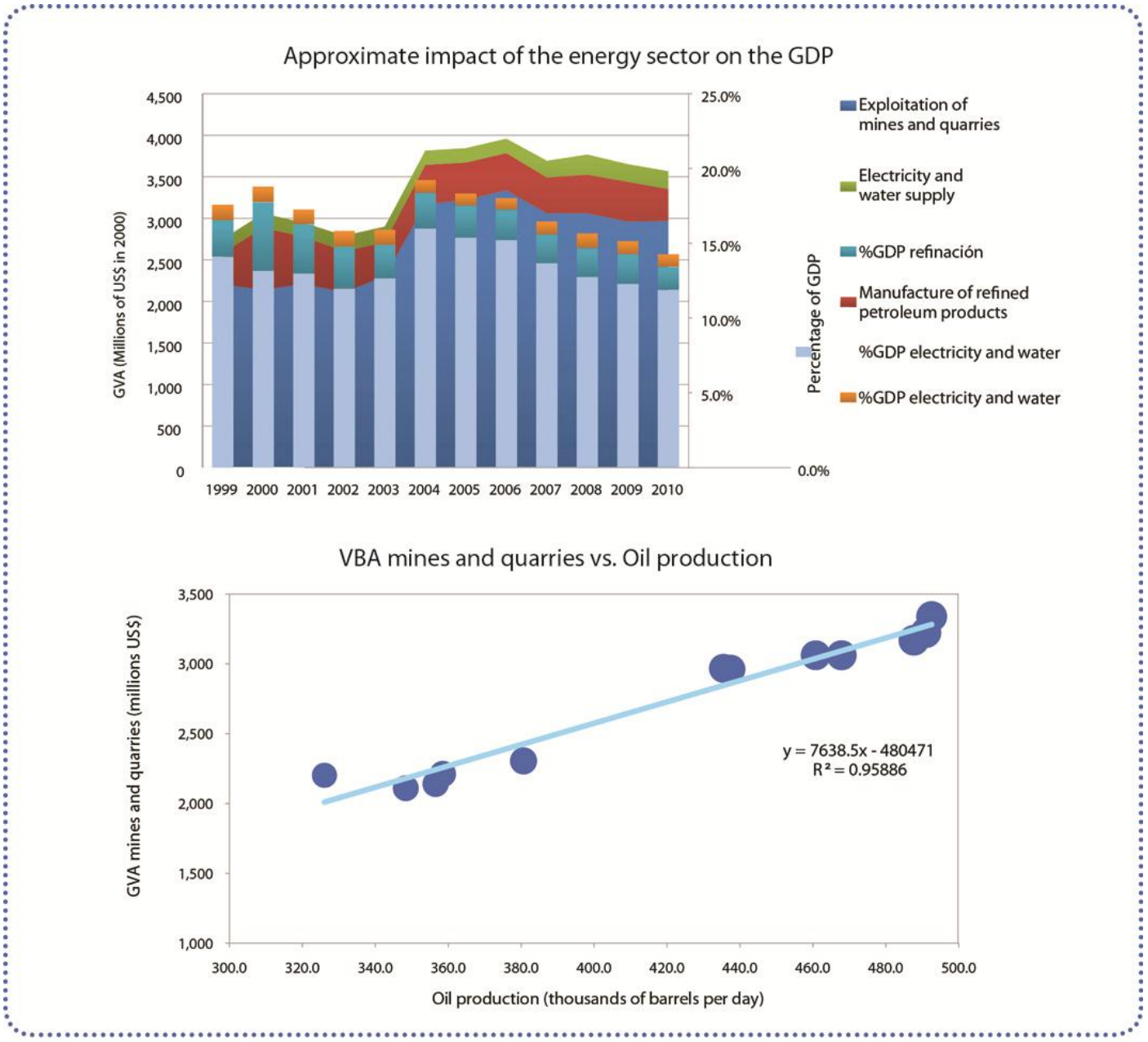

**Source:** Own elaboration based on the National Energy Balance

# 9. ENERGY AND ECONOMIC DEVELOPMENT

## *a. Participation of the energy sector in the GDP*

In the energy sector, the oil economy has been the motor for the national economy for more than four decades (Figure 23).

**Figure 23** Participation of the energy sector in the GDP and oil production as the leading variable




Source: Own elaboration based on BCE and MRNNR data

Although specific information wasn't obtained,[10] except for the oil and electricity sectors, if you take into account the exploitation of the mining and quarries sectors (which is basically oil exploitation), oil refining, electricity, and water, you can get an approximate idea of the strength of the energy sector in generating added value.

**10** At the level of information referring to the GDP, data from national accounts published by the Central Bank of Ecuador did not differentiate between oil and non-oil ranks as is the case of exports and public finances. However, it is probable that afterwards this separation of GDP could be found given that the growth of the "oil economy" and the "non-oil" economy is followed.

The mining and quarries exploitation sector has the greatest influence over the GDP. As you can clearly see in Figure 20, its driving force is oil production.

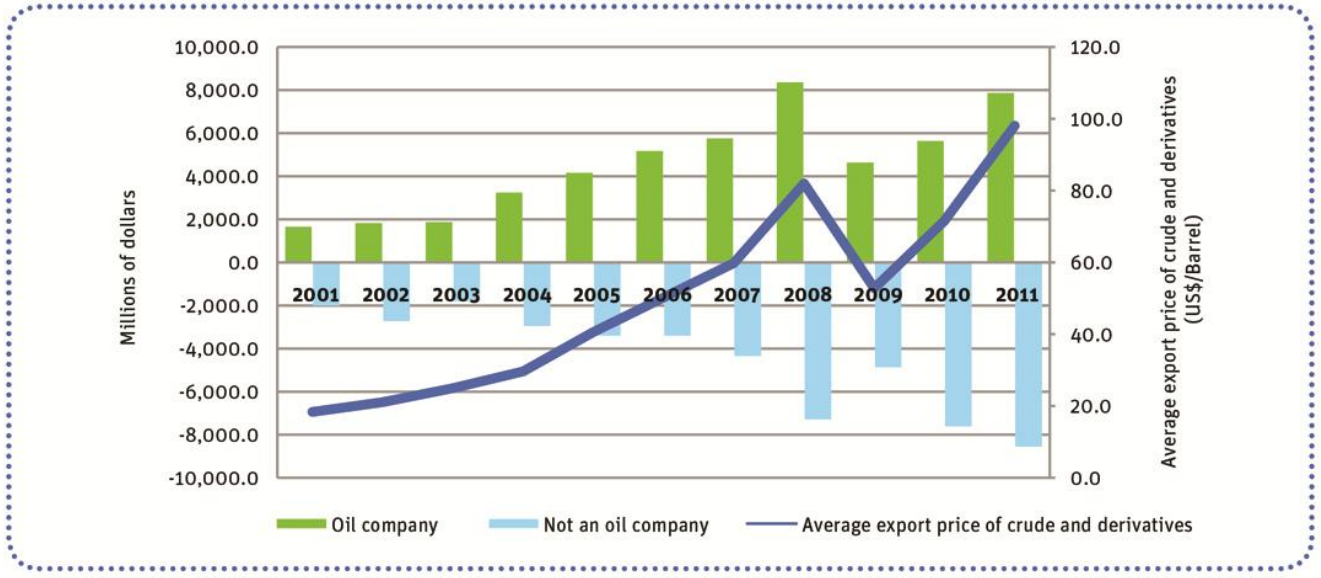
The abrupt increase in Gross Value Added (GVA) in the mining and quarries sector in 2004 coincided exactly with a strong increase in oil production (see Figure 14).

## *b. Impact of oil on the balance of payments*

Oil is the leading export in Ecuador. However, as we previously mentioned, the commercial oil balance and the import of oil are so positive in some years that in other years they have compensated for the deficit in the non-oil commercial balance.

The behavior of exports and the national trade balance is represented in Figure 24. Naturally, the oil export price variable is crucial, plus the volume of exports.

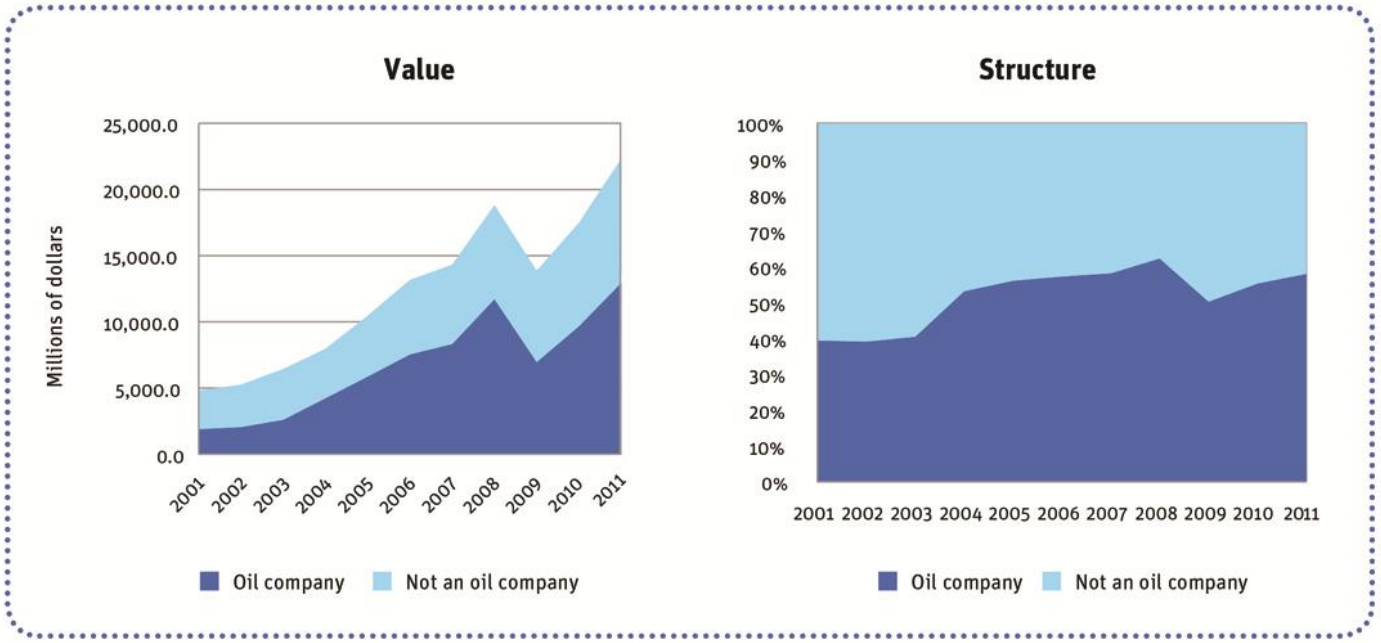
**Figure 24** Commercial oil and non-oil balance




**Source:** Own elaboration based on BCE data

For their part, in the past few years, oil exports represented an average of between 50% and 60% of total goods exported. These were determined according to the changes in production and oil prices (Figure 25).

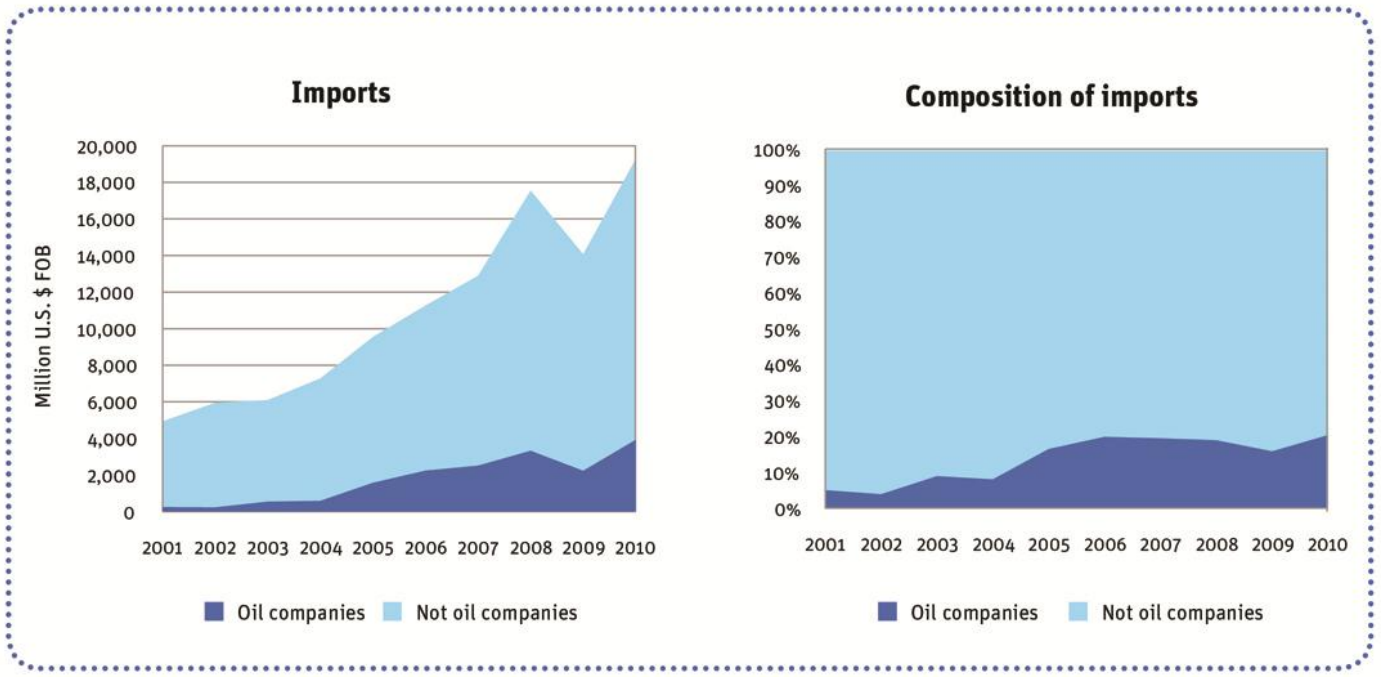
**Figure 25** Effect of oil and derivatives on the export of goods




**Source:** Own elaboration based on BCE data

Regarding imports, the influence of oil derivatives is less important, especially starting in 2005. During that year, their weight represented around 20% of the export of goods, a figure that was a function of the distortion between the refining structure and the domestic market (Figure 26).

**Figure 26** Effect of oil derivatives on the import of goods

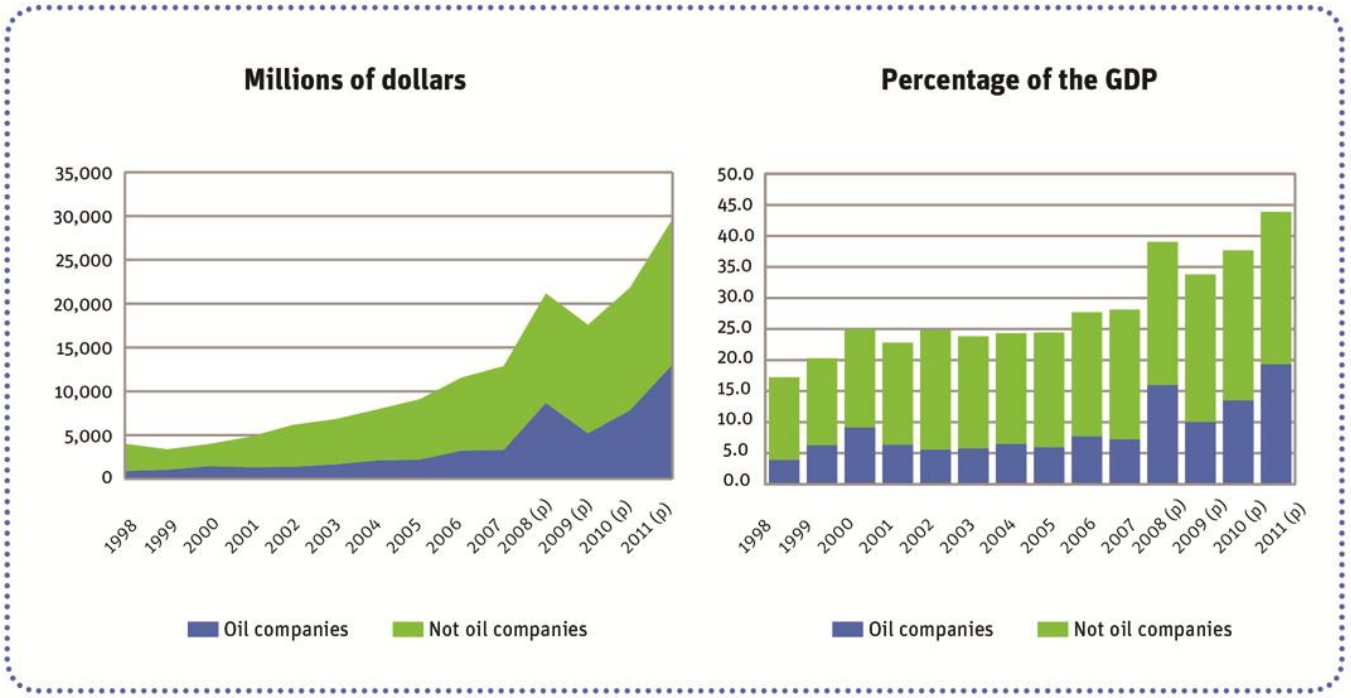



**Source:** Own elaboration based on BCE data

## *The Effect of Oil on Public Finances*

The net income for the oil and derivatives trade balance also had an important influence on public finances, which in recent years of high international prices made up between 30% and 40% of public sector non-financial income, and between 15% and 20% in relation to the GDP (Figure 27).

**Figure 27** Total income for the public non-financial sector (base yield)




(p) Provisional data

**Source:** Ministry of Economy and Finances and Public Sector Organizations

# 10. ENERGY STRATEGY

In Ecuador there is no organization in charge of comprehensive energy planning. The Ministry of Coordination for Energy Sectors, which coordinates the electricity and hydrocarbons sectors, in addition to other strategic sectors like communications and water, recently made a prospective and long-term planning analysis. This project started by reviewing and updating information and creating a comprehensive strategic plan. The plan was based on energy demand, supply, and energy resources. It included some economic, environmental, and institutional issues. The strategies discussed still haven't been formalized, because no decision has been made regarding the institutional framework for implementing the comprehensive energy planning system.

On the other hand, in the electricity sector there is systematic planning. Every year CONELEC publishes a projection for the next ten years. In the case of hydrocarbons, although there are mid-term goals and objectives, development plans are not systematically published.

However, analyzing the current energy matrix and the availability of energy resources in the country, they can visualize relevant strategic plans, several of which are reflected in the decisions made or considered by the national government via diverse organizations.

On the side of supply, which has been studied the most and where large investments have been made, the main strategies are the following:

- Electricity generation: reduction of cost, clean energy, drastic reduction of GHG, total elimination of blackouts:
  - To substantially increase the participation of hydroelectric energy in generation: there is a plan for new hydroelectric construction projects to take advantage of the existing potential. Similarly, large-scale works are moving in this direction and will begin operation between 2015 and 2016, with the majority of other mid-term projects.
  - The most significant projects are Coca Codo Sinclair (1.500 MW), Paute-Sopladora (487 MW), Toachi-Pilatón (253 MW), and Minas-San Fran- cisco (276 MW): the incorporation of new projects signals a substantial increase in hydroelectric capacity in the coming years and will lead to an energy mix

that will be approximately 90% hydroelectric and 10% thermal.

- To drive non-conventional renewable energy generation in addition to advancing studies about wind and geothermal potential (there is already a solar atlas). The "Master Electrification Plan" already includes a 50 MW geothermal plant and two 15 MW wind projects scheduled for 2017.
- The hydroelectric generation strategy will continue over the long term. Also, soon studies about new projects that begin providing service in 2020-21 should be undertaken. The same will happen with non-conventional renewable energy, although it is limited depending on the magnitude of demand and the installation of hydroelectric plants.
- To promote completing the regulatory framework and systematic operation of the regional Andean market on a larger scale. Starting in 2016 the situation in Ecuador will change drastically because it will move from importing all its electricity from Colombia to become a net exporter. The size of the surpluses will depend on the implementation of efficiency and replacement strategies on the demand side even though, in any case, there will be surpluses and the installed capacity for exportation could increase.

- Oil: is a resource in decline whose timeframe should be extended to maintain a level of income that allows for the profound transformation of an economy based on a sustainable energy mix:
  - The identification of new prospects to ensure a sustained supply for oil refining and export is a priority. In this sense, plans are directed at improving recovery in mature production fields and the development and exploitation of fields that are not in production (excluding ITT). These actions would increase production so that the timeframe for depletion is extended.
  - The project of the Refinery of the Pacific is aimed at changing the refining structure to substitute high market value light and intermediate derivative imports and not export heavy derivatives at a low price.
- Biocombustibles: to develop a market for ethanol and biodiesel on a national level to use fuel mixes:
  - The ethanol project has already begun in Guayaquil with ethanol from sugarcane produce in existing sugar industry distilleries
  - It is expected that soon biodiesel production from palm oil will begin on a national scale.

- Natural gas: increase the penetration of gas in the energy mix to the extent that

the reserves permit and then consider importing via pipeline or LNG:

- Free natural gas in the Gulf of Guayaquil, which feeds the Central de Machala and the industry in Cuenca is a non-renewable resource. Thus it can be used up if new prospects aren't discovered. As a result, the construction of an unloading port and a natural gas regasification plant should be considered according to the penetration of natural gas in different sectors.
- A high percentage of natural gas associated with oil production in the east is being vented which is why the OGE project expects to use it for electricity generation.

On the demand side, which is the part of the energy matrix where there is still more to do, the main strategies should be oriented at adjusting the consumption structure to the availability of resources (substitution among energy sources) and to achieve more efficient energy use via new technologies and good operational practices. The main strategies can be summarized as following:

- Transport: is the largest and growing consumer of energy. There are big opportunities to improve efficiency and to partially use renewable energy, both directly and indirectly, by using electricity generated mainly by renewable energy:
  - To promote greater use of public passenger transport to encourage decongestion. This policy should be accompanied by regulations related to cargo and passengers on the road, as well as to monitoring emissions.

- Development of an urban road network according to the growth of the vehicle fleet in circulation to avoid collapses during rush hour to induce increased fuel consumption and higher emissions.
- To study and, in some cases, develop rail alternatives to partially replace truck transport.
- To substitute liquid fuels by increasing the penetration of hybrid vehicles and introducing electric vehicles on the market, as well as increasing biofuels.
- To support a national production industry, marketing, and the import of vehicles with more efficient motors and new technologies like hybrid and electric cars. It is important to consider the specific characteristics of the country and the increase in development in the national metalworking industry.
- To substitute LPG in taxis for compressed natural gas (CNG) on the coast and in other types of vehicles. All this depends on the availability of gas in the future.

- Industry: is an important consumption sector with the potential to improve its efficiency, something that not only reduces the system energy requirements but also makes them more competitive and provides greater earnings on the markets. Improved energy-environmental actions are:
  - Improve technologies to produce heat.
  - Use renewable energy, either external or generated by productive processes (for example, agricultural residues) to produce direct heat or electricity
  - To promote energy and heat cogeneration (vapor) or cold to make more efficient use of renewable energy o fossil fuels.
  - Design and implementation of energy efficiency and renewable energy via direct interaction with the productive sectors.
  - Substitution of diesel and fuel oil for electricity and natural gas (in the measure that national or imported gas is available).

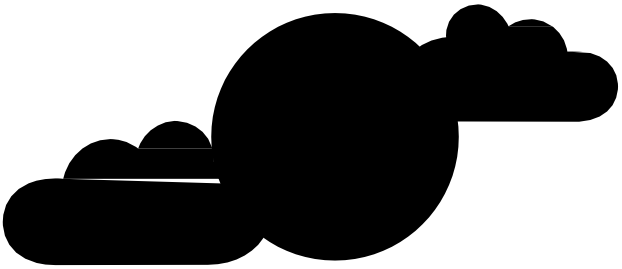
- Residential sector:
  - Education and information about energy savings mechanisms.
  - Promotion to market labeled energy efficient appliances.
  - Substitution of conventional water heating for solar heating.
  - Gradual substitution of LPG cookstoves for high performance electric cookstoves as the availability of electricity is extended.
  - To extend electricity service coverage to reach the goal of universal

supply weather it is via the extension of distribution networks, the installation of mini-networks supplied by renewable energy (mini hydro, wind, and solar), or by individual supply (photovoltaic panels).

- To substitute firewood with LPG and electricity or, if this is not possible, to make it more efficient.

# SECTION 2:

## CURRENT SITUATION IN RELATION TO THE OBJECTIVES OF SE4ALL



# 2.1 ACCESS TO ENERGY IN RELATION TO THE OBJECTIVES OF SE4ALL

## 11. GENERAL OVERVIEW

In general, the country is in an advanced position in relation to the three SE4ALL objectives.

With respect to energy access, there are high penetration rates of modern energy for thermal use and high electricity service coverage. There is also extensive development of renewable energy for generating electricity based on existing hydroelectric projects and others under construction. Current regulations also allow the support of private generation with non-conventional renewable energy and hydroelectric plants. In addition, there are programs and projects to advance energy efficiency and the use of renewable resources on the side of demand in the productive sectors with the goal of advancing these issues, especially those that are currently less developed.

Given the current high rates, what remains to be achieved in terms of universal access to electricity in quantity and quality and for thermal energy in terms of efficiency for cooking, is a greater effort to increase coverage in areas where it is most difficult to implement. Similarly, energy efficiency should be promoted more in the productive sectors.

The last housing and population census undertaken in 2010 provides updated information about the energy sources used in cooking and rural and urban access to electricity.

With respect to the energy source used for cooking, census data indicates that there is still a significant quantity of homes that use firewood or coal as the main source of cooking fuel, especially in rural areas, where this fact represents an

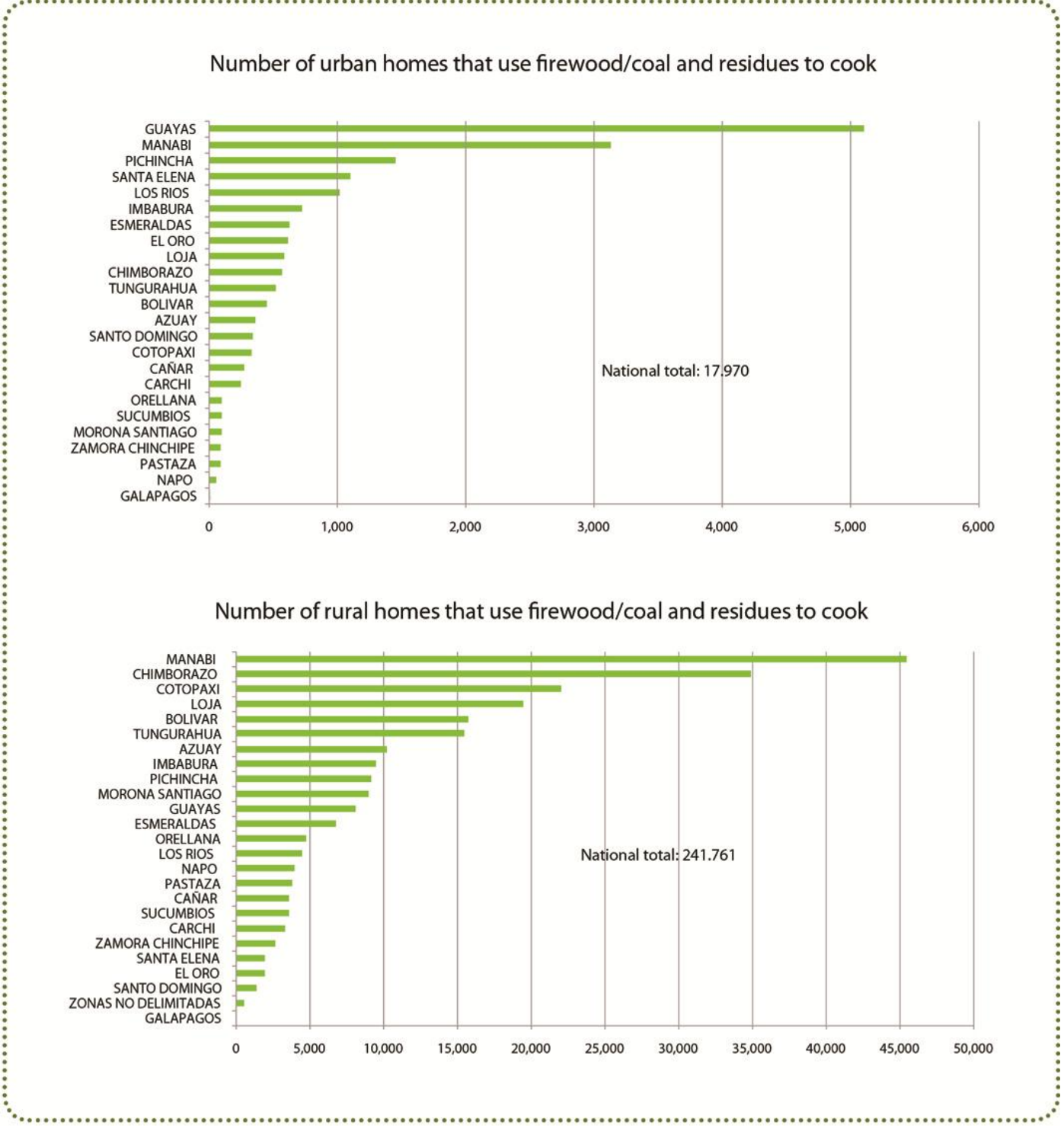
important number even though its overall weight in terms of the total is low. The existence of a significant number of homes that still use firewood inefficiently is relevant in relation to the SE4ALL objectives which involve universal access to modern energy regardless of whether the quantities consumed may have little impact with respect to national totals. Regarding access to electricity, the current coverage is high, but there is still a way to go to reach the goal of universal supply. Although coverage levels increased significantly in both urban and rural areas, it is necessary to reach the whole population, which implies a big additional effort given that the closer you get to the goal, the more difficult it is to reach the remaining population.

# 12. MODERN ENERGY FOR THERMAL APPLICATIONS (COOKING, HEATING WATER)

Thermal energy in homes is mainly for cooking food. However, in some cities in the mountains with colder climates, segments of the population use hot water to shower. The magnitude of their consumption is much less than that for cooking according to some studies carried out by the Quito Electricity Company.[11] Firewood or coal are regularly used by 0.7% of urban homes, 17.7% and 6.8% respectively in relation to the total. This represents nearly 260,000 homes, of which 18,000 are urban and 242,000 rural. The distribution by province shows a greater concentration of homes that use firewood in some provinces on the coast while use is lower in the Amazonian provinces (Figure 28).

**11** The 2010 census didn't gather information about the use of hot water for showers, but it did record whether bathing facilities were shared or individual.

**Figura 28** Number of homes that use firewood/coal as the main cooking fuel




Source: Own elaboration based on INEC data and the 2010 Population and Housing Census

While LPG is consumed 32% in rural areas and 68% in urban areas, the use of firewood/coal is 91% in rural areas and 9% in urban ones (Table 10 and 11).

Also, the main source of energy for cooking is LPG, which is used in 96.7% of urban homes and in 80.7% of rural homes, which means that 91% of the total population uses it (Table 12).

**Table 10** Number of homes according to the main energy source for cooking

| | Gas (tank or cylinder) | Central gas | Electricity | Firewood, coal (*) | Veg. and/or animal residues | Other (Ex. gas, kerosene or diesel etc) | Not cooking | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **Rural** | 1.107.214 | | 1.867 | 241.292 | 469 | 185 | 20.159 | 1.371.186 |
| **Urban** | 2.347.562 | 11.961 | 14.356 | 17.924 | 46 | 260 | 47.253 | 2.439.362 |
| **TOTAL** | 3.454.776 | 11.961 | 16.223 | 259.216 | 515 | 445 | 67.412 | 3.810.548 |

**Source:** INEC, National Housing and Population Census 2010 (*) The census doesn´t separate firewood and coal.

**Table 11** Rural and urban distribution of the use of energy sources for cooking

| | Gas (tank or cylinder) | Central Gas | Electricity | Firewood, coal | Veg. and/or animal residues | Other (Ex. gas, kerosene or diesel etc) | Not cooking | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **Rural** | 32,0% | 0,0% | 11,5% | 93,1% | 91,1% | 41,6% | 29,9% | 36,0% |
| **Urban** | 68,0% | 100,0% | 88,5% | 6,9% | 8,9% | 58,4% | 70,1% | 64,0% |
| **TOTAL** | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% | 100,0% |

**Source:** INEC, National Housing and Population Census 2010 (*) The census doesn´t separate firewood and coal.

**Table 12** Number of homes according to the main energy source for cooking (Percentages)

| | Gas (tank or cylinder) | Central Gas | Electricity | Firewood, coal | Veg. and/or animal residues | Other (Ex. gas, kerosene or diesel etc) | Not cooking | TOTAL |
|---|---|---|---|---|---|---|---|---|
| **Rural** | 80,7% | 0,0% | 0,1% | 17,6% | 0,0% | 0,0% | 1,5% | 100,0% |
| **Urban** | 96,2% | 0,5% | 0,6% | 0,7% | 0,0% | 0,0% | 1,9% | 100,0% |
| **TOTAL** | 90,7% | 0,3% | 0,4% | 6,8% | 0,0% | 0,0% | 1,8% | 100,0% |

**Source:** INEC, National Housing and Population Census 2010 (*) The census doesn´t separate firewood and coal.

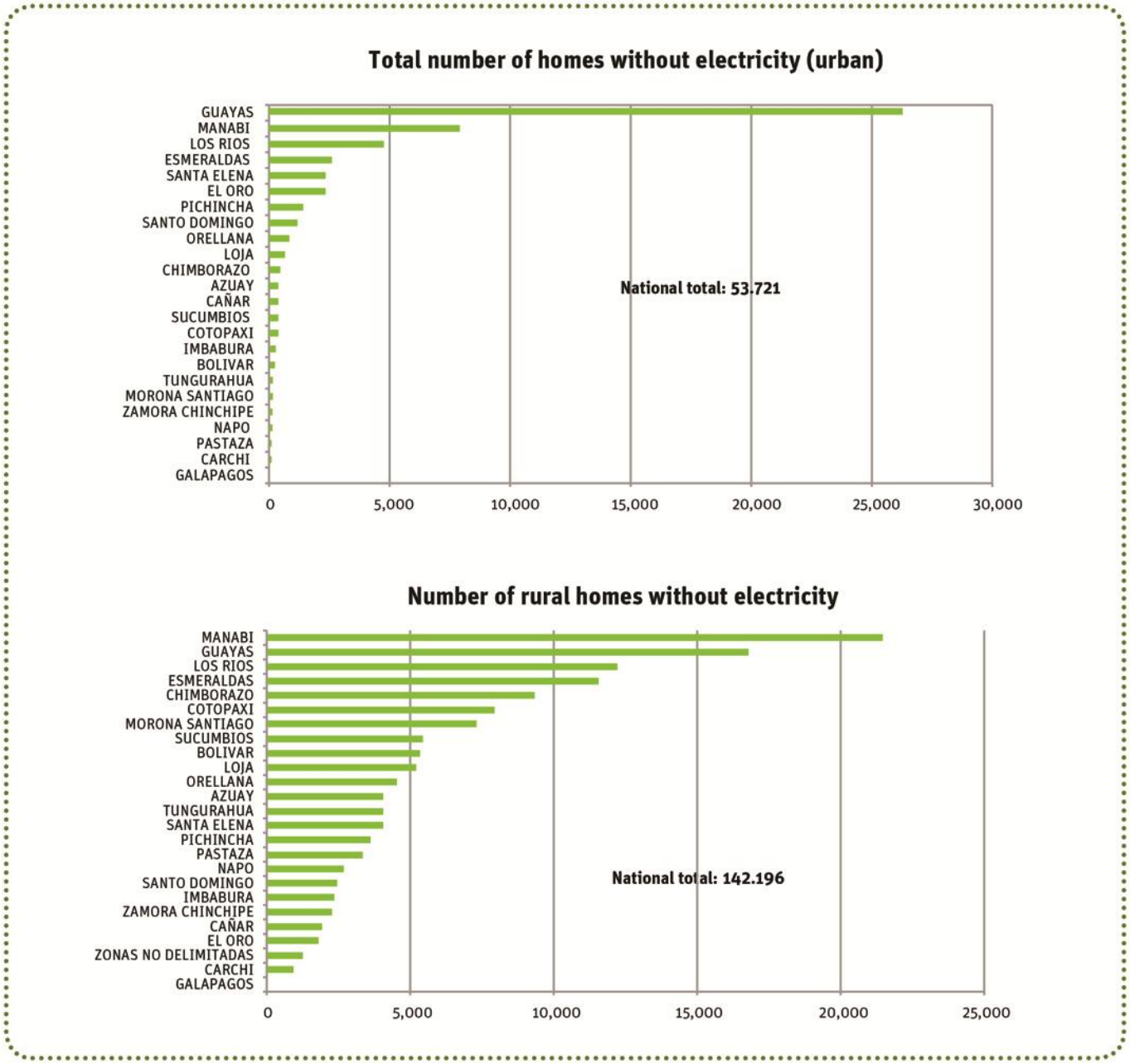
# 13. ACCESS TO ELECTRICITY

## *a. Physical access: electricity service coverage*

Electricity service coverage is 96.2% (96.1% network and 0.1% solar panels) in urban homes and 88.2% in rural homes (88.0% network and 0.2% panels), which results in 93.4% (93.2% distribution network and 0.2% solar panel) for homes in the whole country. Apart from the minimum contributions of autogeneration and others, households without any type of electricity service represent 2.2% of the

total in urban areas and 10.5% of rural homes, which is 5.2% for the whole country. This means, in absolute terms, that near 196,000 homes in the country don't have electricity, and 54,000 are in urban areas and 142,000 in rural areas (Figure 29)

**Figure 29** Number of homes without access to electricity

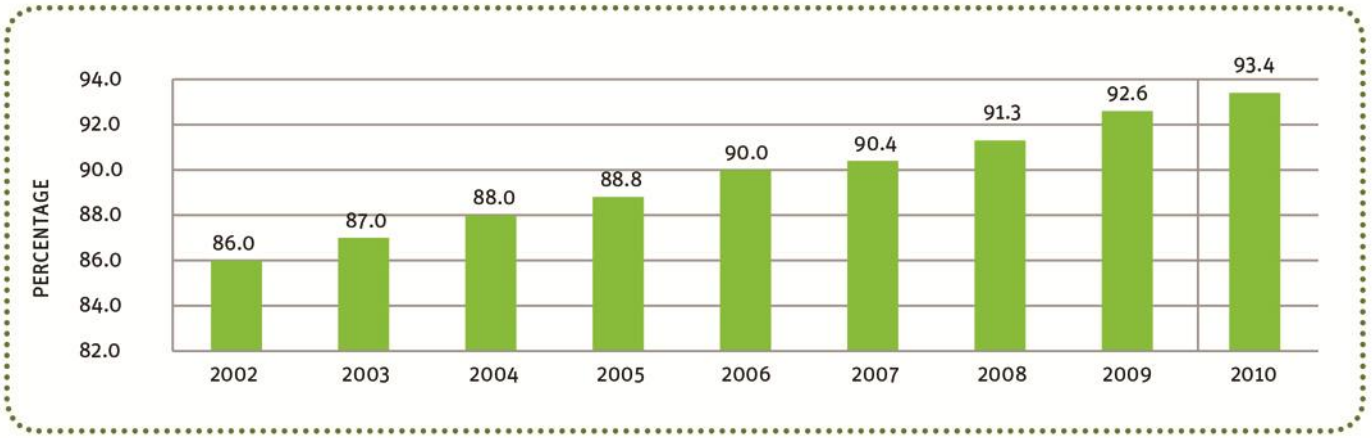



**Source:** Own elaboration based on INEC data, population and housing census 2010

The geographic distribution of houses without electricity shows how, in general, they are mainly distributed not only in provinces on the coast and in the mountains, but also in some Amazonian provinces. Electricity service grew continually in the past decade to arrive at 93.4% (average percentage in the 2010 population and

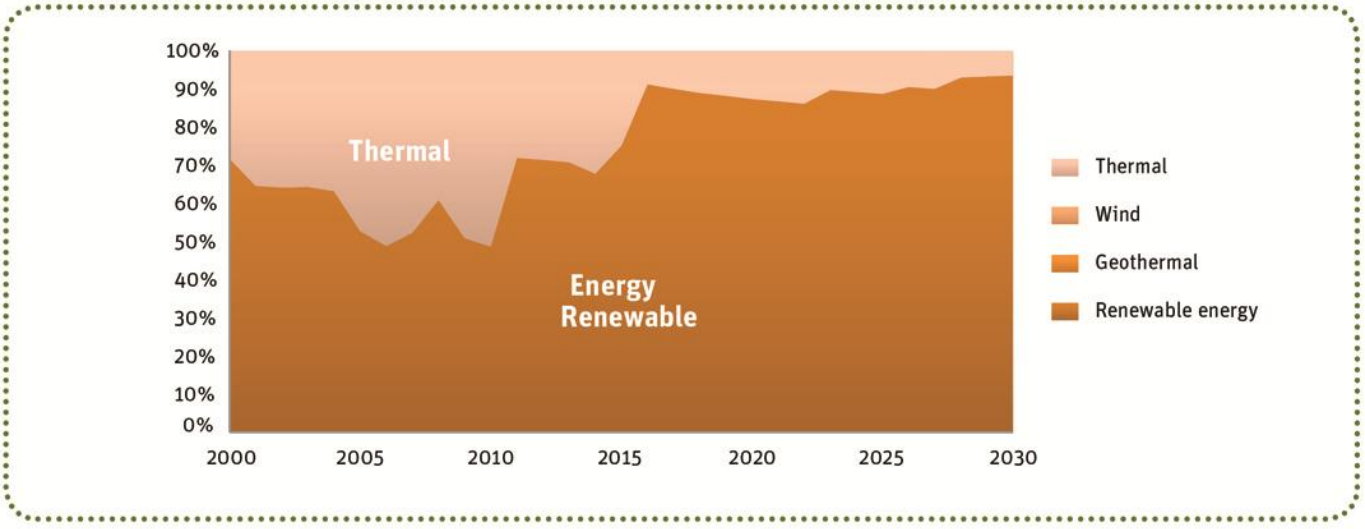
housing census, Figure 30)

**Figure 30** Historic evolution of electricity service coverage




**Source:** CONELEC

## *b. Participation of renewable energy in the electricity generation mix*




**Source:** Own elaboration based on CONELEC and MISCE data

The increase in electricity coverage to reach universal access, which is the objective of SE4ALL and of the national government, is environmentally sustainable given that 90% or more of electricity is generated by plants that use renewable energy, mainly hydroelectricity (Figure 31).

**Figure 31** Strongly hydroelectric electricity generation

## *c. Quality of service*

The quality of technical service is measured by the Momentary Average Interruption Frequency for KW installed (MAIFI) and the Customer Total Average Interruption Duration Index (CTAIDI). The majority of electricity distribution companies don't meet the minimum requirements for quality of service-product established in current regulations. This can be seen clearly in Figure 32, which exemplifies the case of Customer Total Average Interruption Index (CTAIDI). The same situation can be seen in the case of MAIFI[12] although with a variation in terms of the regulation that the company does not meet.

**Figure 32** Total interruption time 2010


**Source:** CONELEC, Master Electrification Plan 2012-2021

This is an issue that affects not only new users that are going to connect to the network but all consumers and their activities.

**12** According to CONELEC in PME 2012-2021, "The average interruption in 2010 is around 33 hours a year, while what is permitted by the regulator is 8 hours. These indexes presented reflect reports from the distributors, which don't always adjust to the reality given the difficulty of keeping track of indicators of technical quality. Thus, in some cases the real situation is worse than what is described in the graphics."

This problem is already being faced and is expected to have tangible results in the short-term although there are some difficulties.[13] With this objective, the contribution of resources to reach the levels of quality of service and product established in the regulations will increase. At the same time, the necessary supervision needed to verify compliance with the rules will be carried out. If necessary, corresponding penalties will be applied.

On the other hand, it is necessary to consider that in certain cases of isolated systems with off-grid solutions, like, for example, photovoltaic panels, the parameters for quality of service can't be the same as those that are applied to interconnected networks.

### *d. Prices and subsidies*

This is a sensitive issue that could be a barrier both for the long-term economic sustainability of the energy supply and for the economy in general given the size of subsidies in terms of public finance and the economy.

Specifically in relation to the SE4ALL objectives, subsidies constitute an important barrier for energy efficiency and the use of renewable energy in productive sectors. Although at some point this could indirectly affect the energy access objectives of SE4ALL and electricity generation with non-renewable sources, this is not a real risk. There are sufficient guarantees for the sustainability of investment programs related to energy access as well as for private generation contracts with renewable energy.

92% of LPG consumption on a national level occurs in the residential sector. Gas for domestic use is subsidized only for cooking, and it excludes the use of heating water. However, the real impossibility of exercising control over consumption inside homes means that in large measure it is used to heat water.

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**13** El PME 2012-2021 points out: "Due to the limitations in allocating financial resources for the implementation of distribution network expansion and improvement projects, currently there are problems with the quality of the electricity supply which affect the entire society. This is because distributors don't have information systems associated with their main clients. Therefore, when it is not possible to know the number or type of customers affected by an interruption. It is estimated that these problems have a major impact on the productive sector, which in turn directly influence the development of the country."

The LPG subsidy is not specific, and is applied to all commercial gas in the 11 distributors that operate in the country. Petroecuador runs wholesale distribution. Thus, areas of medium, high, and very high income (not only low income segments) can buy LPG at 1.60 US$ per 15 Kg cylinder. Even including some overhead for delivery to homes, the price will not rise above US$ 2 to 2.2 per cylinder. Note that the State contribution is made on a wholesale level.

It is estimated that the total magnitude of the LPG subsidy fluctuates around 600 million annual dollars. Thus, in the case of Ecuador, reaching the SE4ALL objectives, which coincides with the government's objectives (universal access to modern energy sources for cooking) that are environmentally, socially, and economically sustainable implies not only substituting or improving efficiency in the use of inefficient energy sources and pollutants but also replacing LPG with electricity. To do this, the MEER designed a LPG to electricity replacement plan, which will be explained later.

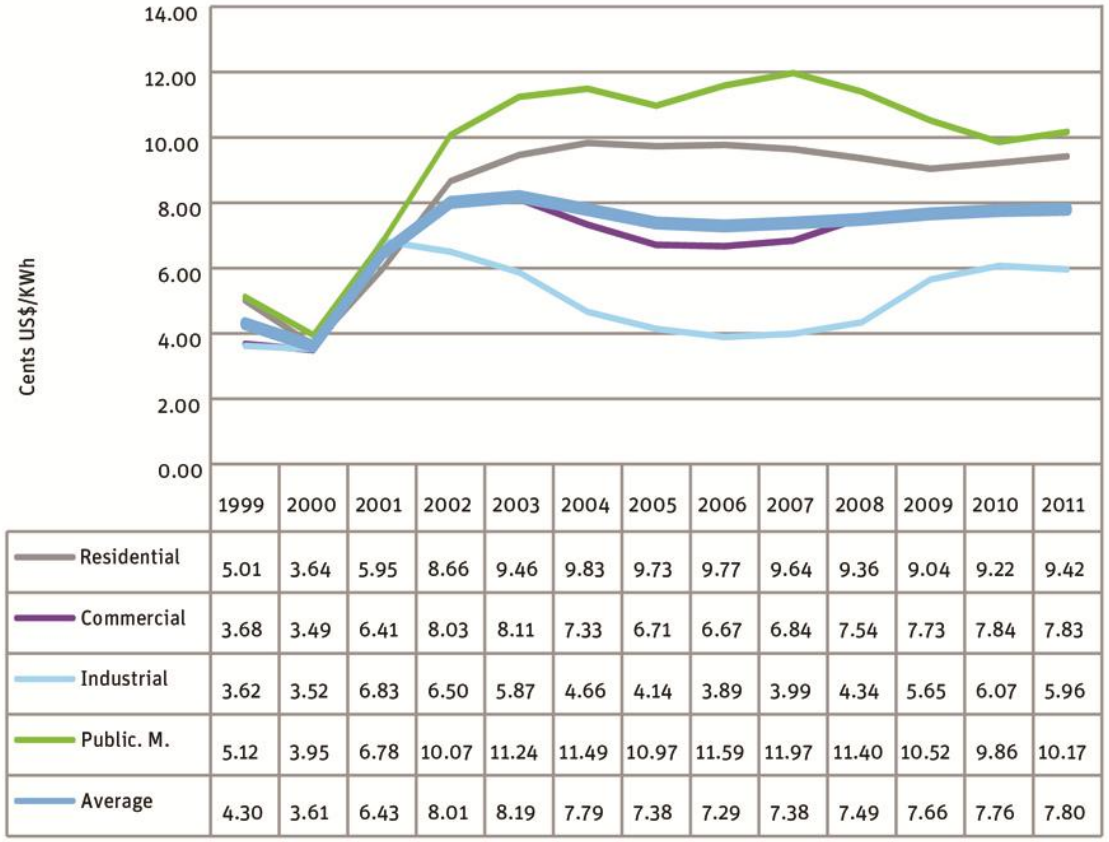
With respect to electricity rates, Constitutional Mandate No. 15 emitted in July 2008 establishes in Article 1 that: "The National Electricity Board – CONELEC – [...] will approve the new rate structures to establish one rate for electricity distribution companies that can be applied to each type of electricity consumption [...]. These parameters will eliminate the concept of marginal costs for calculating the generation component. Investment components for the expansion in cost of distribution and transmission will not be considered. The resources required to cover the investment in generation, transmission, and distribution will be covered by the State and will be a compulsory part of the General Budget. They will be transferred monthly to the Fund for Solidarity and will consider the capital contribution of said institution."

Article 2 states that: "The Ministry of Finance will cover monthly differences between the costs of generation, distribution, transmission, and fixed flat rates for the consumer determined by CONELEC. To this end, the Ministry of Finance shall make all relevant budget adjustments needed to comply with this mandate.

Average electricity prices have stayed relatively stable since 2003 (Figure 33). Note that there is a special rate for consumers under 100 KWh/month in the mountains, and 130 KWh/month in the rest of the country where the "Dignity rate" of 4 cents on the dollar per KWh is applied. Current rates are applied to the rest of consumption by category and consumption rank in different sectors: residential, commercial, and industrial.

Average prices don't cover the current cost of supply, which means that there is a rate deficit that the National Government covers each month via the Ministry of Finances as is established in Mandate 15.

**Figure 33** Average prices of electricity




| | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 | 2007 | 2008 | 2009 | 2010 | 2011 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Residential | 5.01 | 3.64 | 5.95 | 8.66 | 9.46 | 9.83 | 9.73 | 9.77 | 9.64 | 9.36 | 9.04 | 9.22 | 9.42 |
| Commercial | 3.68 | 3.49 | 6.41 | 8.03 | 8.11 | 7.33 | 6.71 | 6.67 | 6.84 | 7.54 | 7.73 | 7.84 | 7.83 |
| Industrial | 3.62 | 3.52 | 6.83 | 6.50 | 5.87 | 4.66 | 4.14 | 3.89 | 3.99 | 4.34 | 5.65 | 6.07 | 5.96 |
| Public. M. | 5.12 | 3.95 | 6.78 | 10.07 | 11.24 | 11.49 | 10.97 | 11.59 | 11.97 | 11.40 | 10.52 | 9.86 | 10.17 |
| Average | 4.30 | 3.61 | 6.43 | 8.01 | 8.19 | 7.79 | 7.38 | 7.29 | 7.38 | 7.49 | 7.66 | 7.76 | 7.80 |

**Source::** Own elaboration based on CONELEC data

When the hydroelectric projects in construction begin operation, the average cost of generation will fall substantially given that thermal generation will be limited (as was shown previously). Thus, according to calculations made by CONELEC and presented in the PME 2012-2021, the average cost of generation, transmission, and distribution will remain below the average price of energy.

This would generate a rate surplus that would come into balance by 2020-2021. In the coming years, while continuing disbursements for investments in process, the rate deficit will increase and by 2014 will reach a maximum level of 670 million US$.

# 14. MODERN ENERGY FOR PRODUCTIVE USES

With respect to productive uses in rural and marginal urban sectors (small workshops, crafts, food, etc.) there is no detailed information. As is true with companies, it is necessary to verify with CONELEC if there are consumption estimations. In general, rural populations work in the agricultural, livestock, forestry, fishing, tourism, and other sectors. The marginal urban population works in services, sales, crafts, and informal activities.

Thus, the issue of modern energy for productive uses is part of electricity access. As coverage increases, the population benefits not only in terms of having energy for use in the home, but also in terms of productive activities.

As has been indicated in the analysis of the energy situation, there is not complete information about consumption data by branch of industrial activity and there is even less data about final users. There are only a few analyses of it, although there is a MEER program to fill these information gaps related to the development of energy efficiency activities. These information gaps make it difficult to measure inefficiencies although some indicators show certain general measurements, as you will see below.

For reference, it may be noted that, based on a Mining and Manufacturing Survey conducted by the INEC (National Institute of Statistics and Census), and taking into account spending on electricity and fuel use in 2008, the estimate of energy consumption by ISIC division (classification Industrial Classification) indicates that the main consumption subsectors are: Food and Beverages (45%), Other Non Metallic Mineral Products (28%), Paper and Paper Products (7%) and Textiles (6%) 14.[14]

On the other hand, the productive and service sectors (including transport in general) have access to modern energy sources, and don't register significant difficulties in the supply chain.

In this case, there is also the issue of subsidies given that diesel is use is number one in transport and number two in industry and agroindustry. It is also strongly subsidized. The fixed internal price is between a forth and a third of what should be applied if the costs of import incurred by Petroecuador are taken into account. The gas subsidy is less, and the price is between 50% and 80% of the cost of import.

# 2.2 ENERGY EFFICIENCY IN RELATION TO THE SE4ALL OBJECTIVES

## 15. GENERAL OVERVIEW

The lack of systematic information about energy consumption from different sources for final use makes it difficult to understand the real energy efficiency situation in the country both in the residential sector and in the productive and services sector disaggregated by branch of economic activity. It is also not easy to establish precise goals for each type of economic activity.

As has been indicated, the MEER, among its projects, wants to conduct the field studies necessary to cover these gaps in information although it doesn't include the transport sector. The issue of information and the subsequent design and implementation of programs could be the object of some type of cooperation scheme in the SE4ALL initiative.

With the information available at the moment, only a few conclusions can be made. They are limited to the analysis of some indicators, which will be presented below.

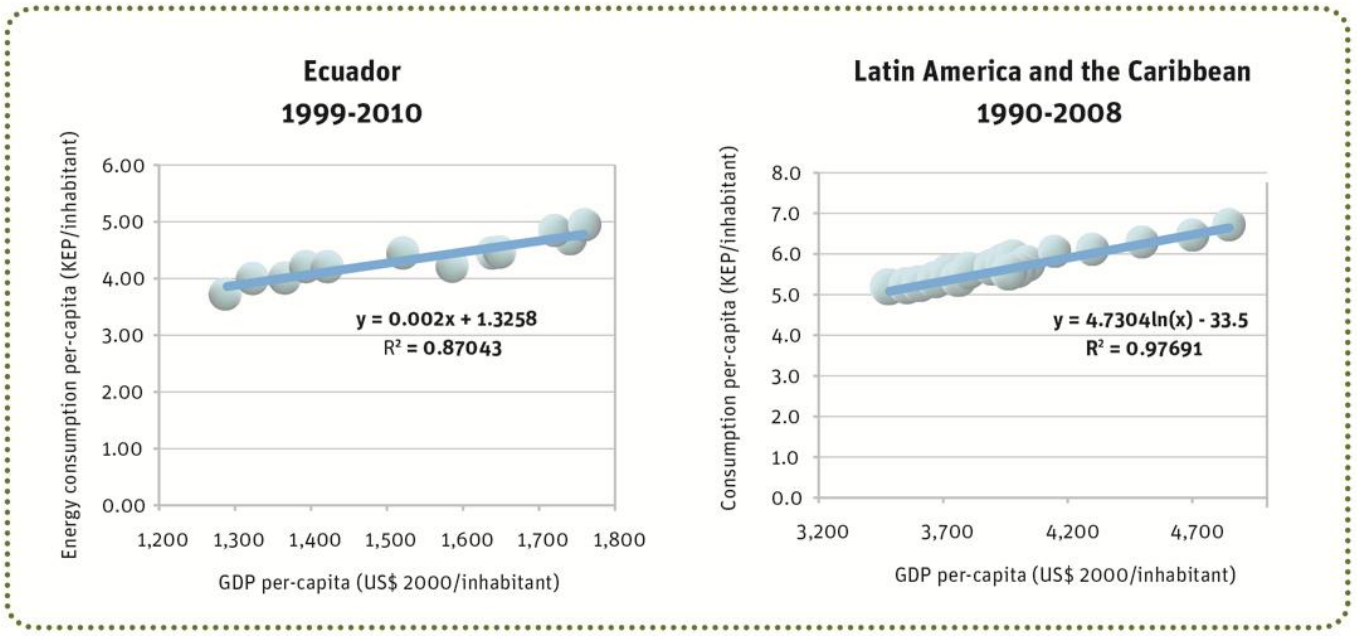
**14** Design of "Plan for Energy Savings in the Residential, Public, and Industrial Sectors of Ecuador." CREARA-ENERPRO Consortium. Ministry of Electricity and Renewable Energy (MEER). January 2012.

## 16. ENERGY INTENSITY: SOME INDICATORS

### *a. Global indicators*

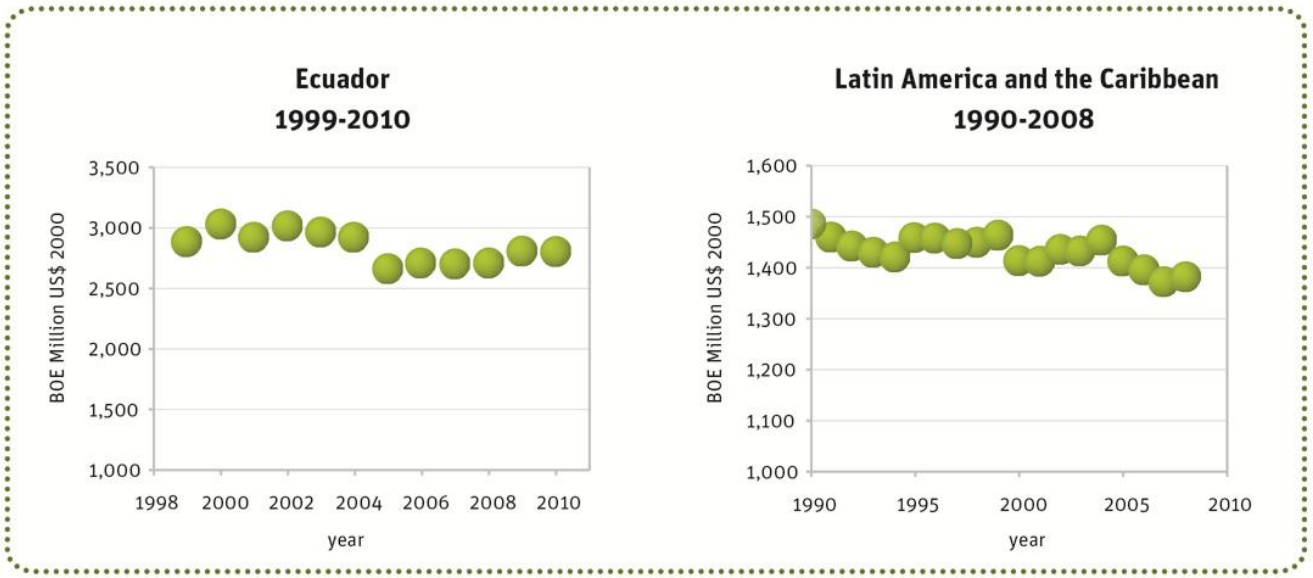
Figures 34 to 36 present some indicators related to the global link between energy consumption and the growth of added economic variables. The indicators, like the sectors presented in the following chapter, compare with those of Latin American and the Caribbean (LAC) for illustrative purposes only.

**Figure 34** Energy consumption per capita vs GDP per-capita



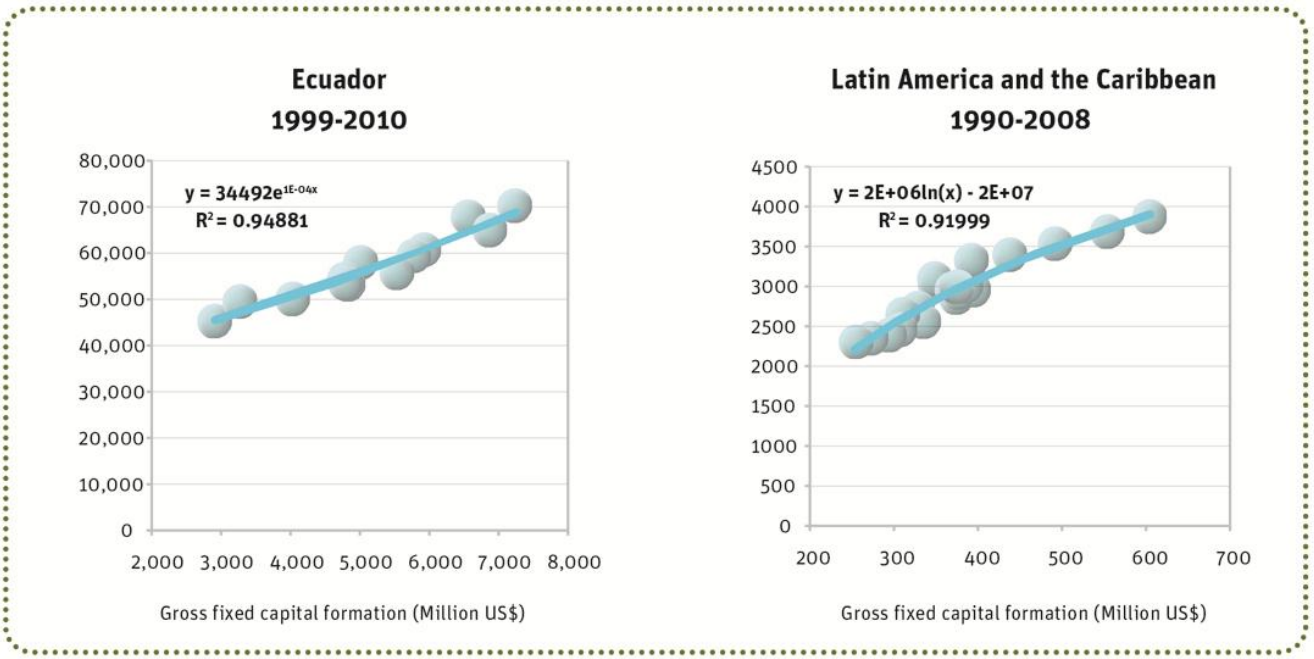

**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

**Figure 35** Energy intensity of the economy




**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

**Figure 36** Energy consumption vs. Gross fixed capital formation




**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

General indicators don't allow us to establish definitive conclusions about energy efficiency. We can only extract signs of behavior. If energy consumption per capita is observed in relation to the GDP per capita, Ecuador shows growth although with greater variability than the trend in LAC.

By observing the behavior of the energy intensity of the economy in terms of consumption levels and GDP totals, one can see a notable parallel between behavior in Ecuador and LAC. On the other hand, the downward trend seems to indicate an important improvement in the global efficiency of the economic system.

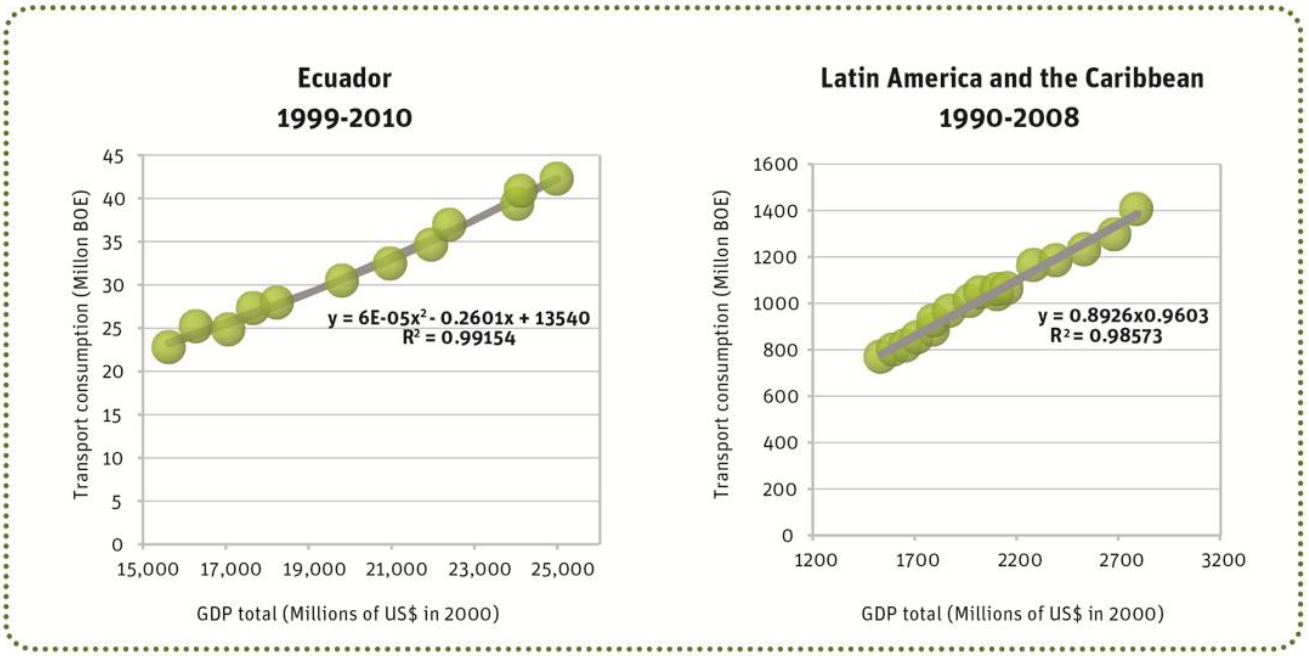
However, energy consumption grows more than proportionally with the growth of Gross Fixed Capital Formation (GFCF), and the adjustment meets a potential function, with an inverse logarithmic curve fit to LAC. The GFCF is a measure of the capital stock and the incorporation of technology; its increase should be done on the basis of more efficient assets (equipment). The behavior, in the case of Ecuador, suggests exactly the opposite, as the GFCF grows, energy consumption

increases more than proportionally.

## *b. Sectoral indicators*

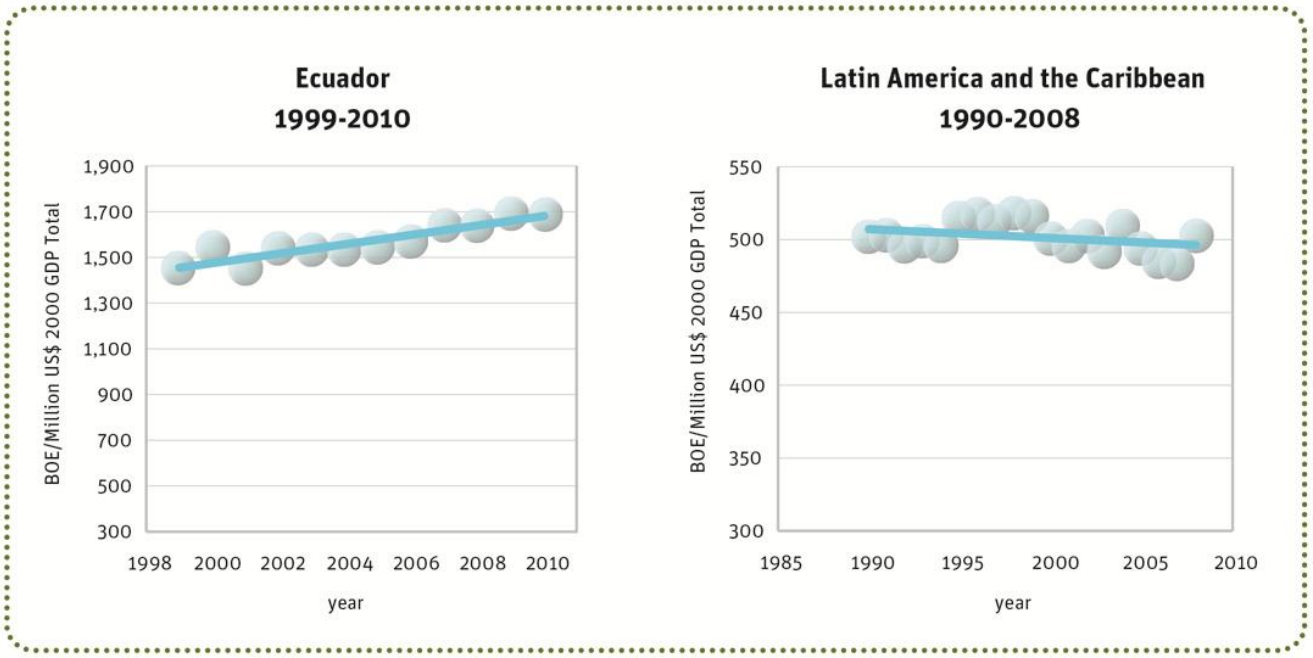
The behavior is similar to that described in the case of transport energy consumption, which grew more than proportionally in relation to the GDP (Figure 37). However, in this case, energy intensity is clearly growing (Figure 38), which largely confirms the indication of inefficiency. Studies show that transport is highly inefficient and contaminant.

**Figure 37** Energy consumption of transport vs total GDP




**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

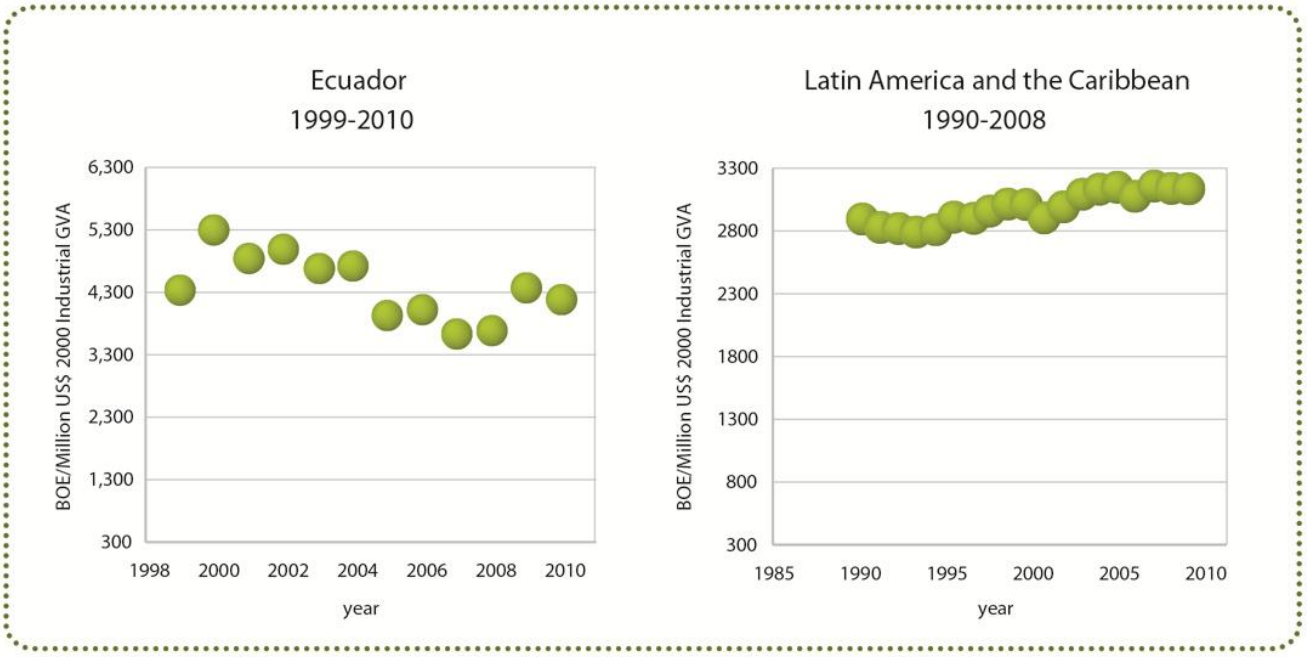
**Figure 38** Energy intensity of transport




**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

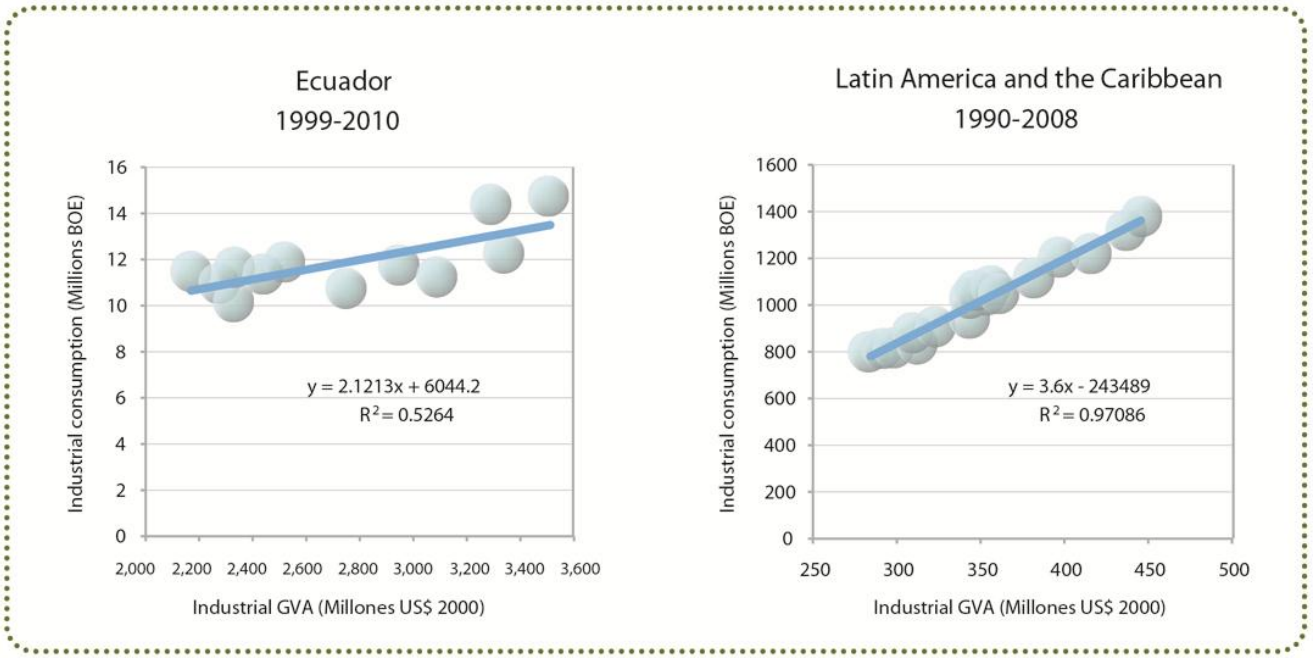
In the case of industry, energy intensity shows behavior that decreases and then increases. The total consumption of the sector is clearly growing in relation to the growth of the Gross Value Added (GVA) of the sector. There is no sign of disconnection between energy consumption and Gross Value Added (Figure 39 and 40). Energy intensity in industry in LAC is clearly growing. It doesn't necessarily reflect great efficiencies but rather reflects changes in the economic structure. In total intensive energy activities were developed in 26 countries.

**Figure 39** Energy intensity of industry




Source: Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

**Figure 40** Industrial energy consumption vs. industrial GVA

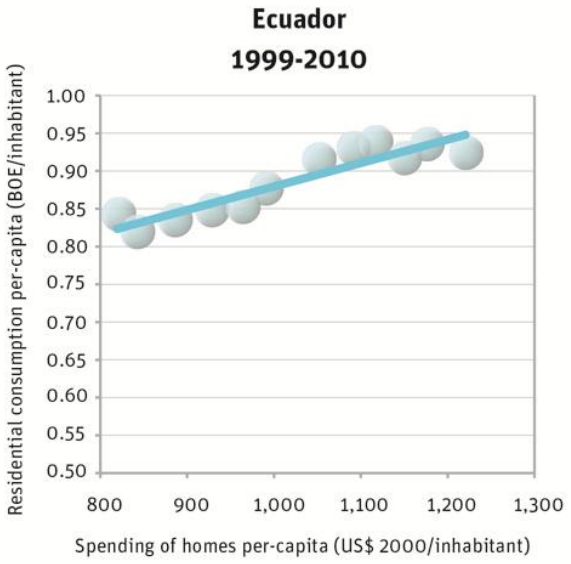


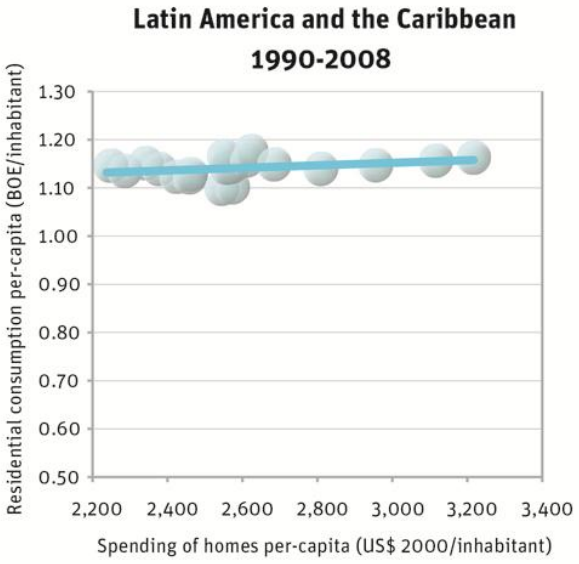

Source: Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

In the residential sector, a relatively clear indication of inefficiency can be seen when analyzing the behavior of residential consumption per capita according to an economic aggregate (household spending, also per capita, Figure 41). The average behavior of LAC indicates a disconnect between these levels and energy consumption; i.e., as incomes grow, so does household expenditure per person. However, energy virtually hasn't grown, and this indicates an improved "built in" for incorporating consumer devices that are becoming more efficient and are available on the market.

In the case of Ecuador, historical behavior is completely opposite. Residential consumption grows as household spending increases. It has only stabilized during the last five years, and this is possibly due to technological improvements in household appliances that were introduced on the market late.

**Figure 41** Per capita residential consumption vs. per capita spending by households




**Source:** Own elaboration based on data from the National Energy Balance, BCE, OLADE, CEPAL

Based on various factors such as these general indicators, studies, and some international experiences, right now it is not possible to establish potential energy savings in the residential, industrial, and transportation sectors. Only prudent and reasonable objectives should be proposed to improve efficiency in the long term (e.g., within a range between 15% and 30%, depending on the sectors and subsectors of residential, transport and industry). These objectives should be confirmed or amended when the necessary information is generated using data from consumers. It should not be based on the global sales of electricity, oil, and gas companies. Note that the study of end uses of energy that the MEER carried out has considered implementing this measure.

# 2.3 RENEWABLE ENERGY IN RELATION TO THE SE4ALL OBJECTIVES

## 17. GENERAL OVERVIEW

With regard to renewable energy, it is convenient to consider both conventional and unconventional energy. Similarly, with regard to the mode of use, it is necessary to consider ***on-grid and off-grid*** electricity generation and off-Grid as well as heat production and cogeneration for the consumption sectors.

In order to sort and clarify some concepts, Table 13 summarizes the types of renewable energy applications, their uses, and the current state of development.

**Table 13** Type of renewable energy, applications, and state of development in the country

| Type of renewable energy | | Application | | Degree of development |
|---|---|---|---|---|
| Conventional | Hydroelectric | Electricity generation | *On-grid* | 90% hydroelectric generation in 2016 |
| | Biofuels | Final consumption | Transport | Emerging, ethanol in Guayaquil, biodiesel in process |
| | Firewood | Final consumption | Domestic cooking use of open fires | Still used by 260.000 homes (substitution) |

| | | | | |
|---|---|---|---|---|
| Unconventional | Geothermal | Electricity generation | *On-grid* | Resource exploration detained for 20 years, recently returned |
| | Hydro less than 50 MW | Electricity generation | *On-grid* | There are some hydraulic plants connected to the network selling surpluses (Ex. Sibimbe) and others in construction. There is Price regulation and the need to develop and promote project develoment |
| | Wind | Electricity generation | *On-grid* | 2.4 MW installed and 3 plants included in the plan |
| | | | *Off-grid* | Nothing |
| | Photovoltaic panels | Electricity generation | *On-grid* (distributed generation) | Galapagos |
| | | | *Off-grid* (domestic use and rural productive) | Important in dispersed rural electrification |
| | Solar termoelectric | Electricity generation "on-grid" | *On-grid* | Nothing |
| | Biomass | Biogas | Electricity generation *on-grid* y *off-grid* | Nothing |
| | | | Heat for final use | Nothing |
| | | Agricultural and forest residues | Heat for final use | Some cases are known (Ex. Contrachapados ENDESA), lack of information for other potential |
| | | | Cogeneration *on-grid* and *off-grid* | There are some cases (Ex. Ecoelectric, San Carlos, others), lack of information for other |
| | | Firewood "unconventional' | Domestic use, cooking in efficient kitchens | Nothing |

**Source:** Own elaboration.

It is necessary to focus more on renewable energy and its applications. In particular, it should be a priority to substitute "conventional" firewood for modern energy like LPG and later with the introduction of efficient electric stoves.

Similarly, photovoltaic panels for customers connected to the network should be disseminated to a greater extent as unit cost falls substantially over time. Likewise, electricity companies in the U.S. and Europe buy surplus from users, which is equivalent to distributed generation.

The development of wind resources should also be intensified, beginning with the development of a wind map to determine the extent of the resource and the location of sites of interest and, thus, have a catalog of potential projects.

# 18. RENEWABLE ENERGY *ON-GRID* AND *OFF-GRID*

With regard to non-conventional renewable energy for electricity generation, recently a space for private investment to generate non-conventional renewable energy (NCRE) was opened. The purpose is to act on 6% of the installed capacity of the national system and also in small and medium hydropower plants up to 50 MW.

CONELEC Regulations 002, 003, and 004 of 2011 govern private generation. Regulation 002/2011 refers to the uniqueness of private participation in the electricity sector according to the amendment to the Electricity Sector Law, introduced in the Organic Production Code, which sets the principles and parameters that allow companies to apply for an exception to allow private participation in power generation.

Regulation 003/2011 allows for the direct negotiation of contracts with one or more distributors based on pre-established terms and rates based on a reference price, which is calculated based on the methodology set out in this regulation. It would be invoiced to companies that buy energy. Generators can opt for this alternative whether or not they meet the requirements to qualify for special treatment under the Regulation 004/2011.

Regulation 004/2011 specifically applies to private generation through the ERNC and hydro plants of up to 50 MW. It sets energy prices to be paid to generators and indicates billing be distributed to all distributors in the system according to the monthly settlement that CENACE made in 15-year energy purchase contracts with possibility of extension after paying current prices.

## *a. Regulation 002/2011 "Exceptionality of private participation in electricity generation"*

Regulation 002/2011 establishes the principles and parameters that allow companies to apply for exceptions for private participation in power generation. This is defined in the second paragraph of Article 2 of the Law on the Electricity Sector, as established in the Organic Code of Production Reform.[15] It should be noted that the Code also provides tax incentives for renewable energy equipment and energy efficiency.

In its scope, Regulation 002/11 identifies two exceptional cases: 1) That it is necessary and appropriate to meet public, collective, or general interest through private investment in power generation; and 2) that public companies cannot meet the demand for electricity.

It is necessary and appropriate to promote power generation through the use of ERNC to meet the public, collective interest, among others.

It also provides three options for private participation: 1) Projects for coverage of demand and generation reserves included in the "Electrification Master Plan" (PME); 2) Projects proposed by the private sector not included in the PME; and 3) self-generation Projects.

Regarding the first option, Regulation 002/2011 states that the PME shall include the projects to be carried out by the State, such as those that will be delegated to the private sector for construction and operation.

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**15** Reform Provision Four of the Code of Production, Trade, and Investment had to add an additional article 2 to the the Electric Sector Law paragraph: "The state may delegate the provision of electricity during the stages of generation, transmission, distribution, and a marketing joint venture in which it has majority shareholding. Exceptionally, it may grant delegations to private initiatives and in solidarity to provide public electricity service in any of the following circumstances: 1) when necessary and appropriate to meet public, collective, or general interest ; or 2) when the service demand can not be met by public companies."

In the second case, it establishes the possibility that a private initiative can propose the development of generation projects that are not in the PME to CONELEC, where the minimum conditions indicate what the project must cover, as well as the steps for qualification, negotiation, and execution of the "Enabling Title."[16]

## *b. Regulation 003/2011 "Determining the methodology for calculating the time and the reference prices of generation and autogeneration projects"*

Regulation 003/2011 defines the methodology for determining the terms and prices that apply to generation and self-generation projects developed by the private sector, including those using renewable energy.

The scope of this regulation refers to the establishment of: 1) The methodology for determining deadlines for the apply for "Authorization certificates"; 2) The methodology for determining the reserve price to be applied in the public selection process for awarding generation projects, which are recorded by the PME and that the State has delegated to the private sector; 3) The methodology for determining the benchmark applied in the negotiation process for awarding money-generating projects, which do not appear in the PME and that were proposed by the private sector; 4) The deadlines for application for "Authorization certificates" that the CONELEC gives autogenerators and generation projects that use renewable energy developed by the private sector;

**16** Regulation 002/11, Article 5: Projects proposed by the private sector. Private initiative can propose the development of generation projects to CONELEC that are not in the PME. The CONELEC will analyze the projects submitted, and then go through an acceptance and rejection process. To be considered for acceptance, the following is necessary: 1) that the studies presented are pre-feasibility level; 2) that the proposed project does not appear in the "Electrification Master Plan" - PME; 3) to optimize the use of natural resources for power generation (PME projects should not be affected); 4) the cost of power generation does not exceed the average cost stipulated in contracts covered for each type of technology; 5) that the calculation for guaranteed energy is technically supported.

If the project is to be accepted by the CONELEC, after verification that the detailed requirements are met, prices and terms will be determined based on the application of specific rules, and the feasibility study will determine which should then be presented by the interested party. The determined values are reserved and will be referenced and maximum values accepted for negotiation. Once the CONELEC and the proponent have come to an agreement on prices and terms to be considered in regulated contracts between the parties, the proponent will continue with the process to obtain authorizations for the use of natural resources, environmental permits, and all that is required for project implementation. The CONELEC, having reviewed and accepted the additional documentation required according to current regulations, will proceed to the "Enabling Title" correspondent, and will help the generating agent sign regulated contrac

4) The prices of surplus energy from autogenerators and power from generation projects using renewable sources in the electricity sector.

To determine the timing of generation projects using renewable energy that do not meet the technical specifications to enable them to qualify for the incentive regulation of this type of project (refer to Regulation 004/2011), or they are not eligible for adjustment even meeting the technical characteristics; it shall apply to the provisions of Regulation 002/2011, Annex II.

Regulation 003/11 allows CONELEC to determine prices for:

1) Each public process for selecting generation projects for the private sector, as contained in the PME; 2) Each negotiation of proposed generation projects and those for the private sector; 3) generation projects using renewable energy and making use of the incentive regulation for this type of project (004/2011); 4) The marketing of surplus energy autogeneration projects.

In general terms, the methodology for establishing prices and deadlines is based on the financial criteria of return on investment.

To calculate the referential prices for generation projects for private initiatives, information from the feasibility studies will be taken into consideration by the PME. Based on this, the financial flows that will determine the price that allows the investment to be recouped will be estimated. It will recognize the profitability and apply the term determined by CONELEC for the type of technology and the range of power that corresponds to the project. The prices that result from the calculation made by CONELEC will be used as the referential price in the public selection process.

To calculate the reference prices of proposed private initiative generation projects that don't appear in the PME, information from feasibility studies carried out by the proposer will be used. A specific methodology determined in Regulation 003/2011, Annex III will be applied to the information. The value that results from the calculation made by CONELEC will be used as the reference price in the process of negotiation.

The price for generation projects that use renewable energy and qualify for the Regulation for incentives for this type of projects will be determined by the Regulation ***(Regulation 004/2011)*.**

For generation projects that use renewable energy and don't meet the technical specifications, they can use the Regulation as an incentive for this type of project. The methodology applied in ANNEX III of Regulation 002/11 will be applied to those that have decided not to use the Regulation even though they meet the technical specifications.

## *c. CONELEC Regulation 004-11 "Treatment for energy produced with Unconventional Renewable Energy"*

CONELEC Regulation 004-11 establishes the requirements and price preferences of energy for unconventional renewable energy projects (Table 14). It also fixes the conditions for hydroelectric plants of less than 50 MW that are connected to the network or in isolated systems.

**Table 14** Prices of energy regulation CONELEC 004-11

| CENTRALES | Continental Territory | Insular Galapagos Territory |
|---|---|---|
| ERNC | | |
| WIND | 9.13 | 10.04 |
| PHOTOVOLTAIC | 40.03 | 44.03 |
| THERMOELECTRIC SOLAR | 31.02 | 34.12 |
| MARINE CURRENTS | 44.77 | 49.25 |
| BIOMASS AND BIOGAS< 5 MW | 11.05 | 12.16 |
| BIOMASS AND BIOGAS > 5 MW | 9.60 | 10.56 |
| GEOTHERMAL | 13.21 | 14.53 |
| HYDROELECTRIC LESS THAN 50 MW | | |
| HYDROELECTRIC PLANTS UP TO 10 MW | 7.17 | |
| HYDROELECTRIC PLANT GREATER THAN10 MW UP TO 30 MW | 6.88 | |
| HYDROELECTRIC PLANT GREATER THAN 30 MW UP TO 50 MW | 6.21 | |

**Source:** Regulation CONELEC 004/2011.

The prices for ERNC indicated in the previous table are fixed during the contractual period and are not adjusted for inflation. These were established by the CONELEC based on international parameters. In the future, methodologies will be applied based on rates of return on investment calculated by future cash flow. This is similar to what is already used by other private generation sources (as is established in Regulation 003/11).

The prices for hydroelectric less than 50 MW are determined with a mathematical model based on the flow of funds and the return on investment for plants with different levels of investment and operative characteristics (plant factor, for example).

Article 6.3 of Regulation 004/11 establishes: "El CENACE will dispatch, in an obligatory and preferential manner, all electricity that plants using unconventional renewable resources deliver to the system, ***up to the limit of 6% of the installed and operational capacity of the National Interconnected System generators*** according to what is established in the regulation that supplements regulation 15. To calculate the limit, all unconventional renewable plants benefitting from this regulation will be considered ***with the exception of hydroelectric plants of less than 50 MW, biomass, and geothermal, which will not have this limit.***

The limit of 6% of the installed generation capacity with ERNC is naturally dynamic. The maximum MW contracted will vary as the installed capacity grows. The percentage was established based on the impact on public finances, and it sought to maintain an increase in the contribution of the State within the acceptable limits, as was established in Constituent Mandate 15. Such a contribution would occur under the higher costs of ERNC generation.

The applicability of preferential prices indicated in the previous table is for a period of 15 years starting with the signing of the "Enabling Title," if it is signed before December 31, 2012. After the period of applicability ends, prices for the ERNC will be established by regulations existing at that time. For hydroelectric plants of less than 50 MW, an average of the price of regulated contracts for generation units in operation will be paid, which should correspond to the current technology at that date.

Article 9 of 2013 states that, "Those projects whose contracts are signed or who have increased capacity should be modified starting in 2013. CONELEC will carry out a revision of energy prices and of their period of validity; prices will be applicable only for previously marked cases during this year and for a period that will be defined by CONELEC during this time." The methodology to establish said prices will be created by CONELEC.

This regulation is important not only for promoting the ENRC but also for establishing the possibility for independent private generators to develop hydroelectric projects of up to 50 MW. This has been possible for a few years, and independent projects have been constructed that are now in operation. However, later that possibility was eliminated and projects were only authorized for autogeneration with the sale of surplus to the network.

In addition, article 13 of Regulation 004/11 established: "the obligation of public companies subject to the Organic Law of Public Companies to accept CONELEC Regulation No – 004/11, and they should implement programs for the "State of Good Territorial Living" in areas where generation projects are developed. Such programs should be in line with the policies and regulations set out by the central government. Such companies "will create an 'Account for the State of Good Territorial Living' that will allow them to cover the costs of social responsibility in favor of autonomous decentralized governments that are found within their areas of influence." The companies should make contributions according to the type of project: "they should set aside resources for the 'State of Good Territorial Living" via the creation of an account clearly identified within the system of accounts of the company. To this end, the account will receive funds from a fraction of the income of energy sales…"

## *d. Mechanisms for paying for ERNC projects*

According to current regulations, CENACE is in charge of establishing the amounts of energy to be charged annually for private generators subject to clearance (greater than 1 MW) in the framework of Regulation 004/11 and based on established preferential prices.

The entire electricity system assumes the costs of private generation with ERNC. Accordingly, these costs are apportioned by CENACE among all distributors. Thus, each private generator indicates the amount to be billed monthly to each.

In the case of generators of less than 1 MW not subject to dispatch and generators that aren't found within the framework of Regulation 003/11, the involved distributors should be billed directly.

The payment mechanism for companies is through trusts administered by banks. All existing distributors' trusts have generally been managed by specialized entities of the Bank, for example, the Guayaquil Bank, and Pichincha Bank, which are private banks, and the Bank of the Pacific, currently controlled by the state.

All proceeds from each of the electricity distribution companies automatically enter into the respective trusts. Private generation via the ERNC is a high priority in the payment of trusts, being second only to international interconnections. Thus, private generation has a separate payment mechanism and, at the same time, a payment priority that ensures the collection of turnover, even in an eventual financial crisis that may occur for any reason and in function of the risk-based sustainability of the State's contribution.

## *e. Response to private initiative*

Regulation CONELEC 004/11 was issued in April 2011. By November 29, 2012 the quota for the ERNC has been entirely assigned as can be seen in Table 15, which presents information from CONELEC and indicates a very positive response from the private sector.

**Table 15** Private participation in electricity generation projects with the ERNC

| Description | Indicator |
|---|---|

| | |
|---|---|
| Total installed operative capacity in the National Interconnected System (S.N.I) | 4,742.0 MW |
| Total capacity for the ERNC*: 6% of the total installed capacity in the (S.N.I) | 284.5 MW |
| Total capacity available for the ERNC* except biomass projects (sugar mills) | 284.52 MW |
| Power with ERNC* that accepts a preferential rate, with signed authorization certificate | 200 MW |
| "Authorization Certificates" for authorized registration by the CONELEC Board | 84.52 MW |
| Ratings certificates given to 11 companies | 215 MW |
| Capacity available with ERNC* | 0 MW |
| Number of applications submitted | 116 |

*ERNC: Unconventional renewable energy (not including hydroelectric).
**Source:**
CONELEC.

# 19. USE OF RENEWABLE ENERGY SOURCES FOR THERMAL APPLICATIONS (COOKING/HEAT)

Given the economic weight of the LPG subsidy and the availability of low cost surplus electricity, the substitution of gas stoves for electric ones is under analysis. Quito Electricity Company has already studied the issue in its concession area;[17] while MEER is proposing a replacement on a national level as will be described.

However, the responsible entities are not considering the issue of substitution of firewood and the introduction of firewood efficient kitchens.

In any case, it could be argued that, for this segment of the population detected in the 2010 census, a program should be designed to introduce efficient firewood stoves and to introduce the partial substitution of firewood with LPG stoves, depending on the access to households.

**17** Determination of final energy use in the residential sector. ENERINTER International Energy Consulting, conducted for the Quito Electricity Company. March 2012.

Within the FERUM program for rural and marginal urban electrification, it could be argued that not only is it an approach to increasing electricity coverage, but also for increasing cooking, as it would be working on reaching the segment that lacks electrification. On the other hand, there could also be firewood consumption for cooking in households that already have electricity, and that would not be detected by the previous approach. In any case, it is necessary to cross-reference the information from different databases to define a program for efficient wood or charcoal stoves or the potential replacement of firewood with LPG.

# 20. USE OF RENEWABLE ENERGY FOR PRODUCTIVE ACTIVITIES

In the productive sectors, the increase of electricity consumption for thermal uses that substitute fossil fuels in potential applications indirectly leads to a greater use of conventional renewable energy given that the majority of electricity generated in hydroelectric.

In this case, photovoltaic panels used by industrial clients connected to the network could be promoted. Similarly, there are small hydroelectric or wind plants for autoconsumption that could be taken advantage of by the productive sectors.

This issue is directly tied to energy efficiency because there are projects that research consumption profiles for different productive activities. Later, priority sectors and economic activities will be established for the design of specific projects.

The proposal in the case of the productive sectors is that the objectives of energy efficiency and renewable energy are managed together.

In the case of productive uses of energy related to the domestic rural and marginal urban sector, these form part of programs to increase electricity service coverage.

# 21.
# SUMMARY

With respect to energy access, the size of the problem is known and CONELEC has established goals so that by the end of 2013, it will achieve 96% coverage, and by 2021, 100% will be achieved, as will be seen in Section 3.

However, at the moment, only an increase in energy access via the extension of networks is being undertaken. There is still no plan to reach potential isolated consumers.

In the case of energy efficiency and the use of renewable energy in the productive sectors, the first step is to know the consumption profile of different branches of economic activity. To do this fieldwork on a national level, requires working in contact with the productive sectors to identify priority areas, establish goals, and quantify investments. The MEER scheduled the beginning of this work in 2013 and hopes to finish in 2014.

In relation to renewable energy for electricity generation, a space has already been opened for the ERNC. It is worth noting that it would be desirable to extend to more than 6% of installed capacity if the costs of the supply system permit.

# 2.4 SE4ALL GOALS

# 22. GOALS

Prior to the discussion with national entities, more precise goals should be established related to access to service and energy (including thermal for cooking food). However, this recommendation doesn't apply to the energy efficiency objective. Given the reasons stated throughout the study, more detailed information will be needed. MEER is about to study final use in the residential, industrial, commercial, and service sectors. These studies would provide the necessary information.

Related to the universal energy access objective, CONELEC has established goals to meet 100% electricity service coverage by 2021. Currently it is carrying out a

program for the electrification of homes via the extension of networks. It should be noted that there is still no plan for reaching potential isolated consumers nor is there a precise estimation of the number of homes that are in said condition. This continues to be a gap that could be covered with the support of the SE4ALL initiative. Also, it should be taken into account that the IDB is already considering the issue.

# SECTION 3:

## CHALLENGES AND OPPORTUNITIES TO REACH THE SER4ALL OBJECTIVES

# 3.1 POLITICS AND INSTITUTIONAL FRAMEWORK

The energy sector in Ecuador is not unified in one entity. There are two executant ministries (MEER and MRNNR), as well as the Coordinating Ministry (MICSE). The institutional issue of integrated management of policy and strategy for energy development is still not resolved.

## 23. ENERGY DEVELOPMENT

The National Secretary of Development Planning (which has a ministerial rank) is the entity that deals with national development plans. The last current one is the "National Plan for Good Living 2007-2012" and the 2013-2019 plan is, as yet, unknown.

SENPLADES establishes lines of economic and social development and defines, in coordination with relevant ministries, the general guidelines for sectoral strategies, including those of energy and social inclusion.

The Ministry of Social Inclusion works on issues related to reducing poverty and incorporating the population into productive activities.

## 24. THERMAL ENERGY FOR THE RESIDENTIAL SECTOR

As has already been indicated, there are no programs, objectives, or goals. The responsible entities in terms of formulating and executing specific plans are MEER and CONELEC, given that the latter is legally assigned to do electricity planning. As will be described, CONELEC works together with MEER and is in charge of selecting projects in the FERUM program.

# 25. ELECTRICITY SECTOR

MEER is the governing body that is in charge of developing the electricity sector. The regulatory entity is CONELEC, and together the two carry out planning in a sector whose basic strategies are to maximize generation with renewable energy, expansion, reinforce the National Transmission System, organize the distribution system, and universalize electricity service coverage.

The electricity sector is almost entirely in the hands of the state in terms of generation, transmission, and distribution. There is a state company for generation and transmission (CELEC) and 20 distributors, 10 of them grouped in CENEL.

# 26. MODERN ENERGY FOR THE PRODUCTIVE SECTORS

This should be managed in an integral way that respects energy efficiency, so the MEER should also manage the issue. In addition, the Ministry of Coordination of Production, Employment, and Competitiveness (MCPEC), which works with the productive sectors, also works with issues related to biofuels and energy efficiency. The ministry wants to improve the competitiveness of production and develop new productive activities with an inclusive social focus.

# 27. NATIONAL FRAMEWORK FOR MONITORING THE SE4ALL PROGRAM

The focal point for establishing and monitoring the SE4ALL program on a national level should be the Ministry for Electricity and Renewable Energy (MEER) given that it is the entity responsible for the development of renewable energy and energy efficiency in the country. It does this via the Undersecretary of Renewable Energy and Energy Efficiency (SEREE). In addition, the approval of rural and marginal urban energy projects presented by distribution companies are prioritized by CONELEC and pass through MEER before getting final approval from SENPLADES.

MEER could coordinate actions with CONELEC as well as with other energy sector entities and organizations related to production in the state and private sectors. At the same time, it is necessary to incorporate the latter into the process given that consumers

need to act and make investments to improve energy efficiency and use renewable energy for final use.

# 3.2 PROGRAMS AND FINANCING

## 28. THERMAL ENERGY: PROGRAMS AND FINANCING TO IMPROVE ENERGY ACCESS, ENERGY EFFICIENCY, AND THE USE OF RENEWABLE ENERGY FOR COOKING AND OTHER RESIDENTIAL USES

There are no programs of this type. In consequence, it is convenient to propose that this objective be met also, at least partially, within the framework of the Fund for Rural and Marginal Urban Electrification (FERUM) and via distribution companies. The following chapter will describe the fund in more detail.

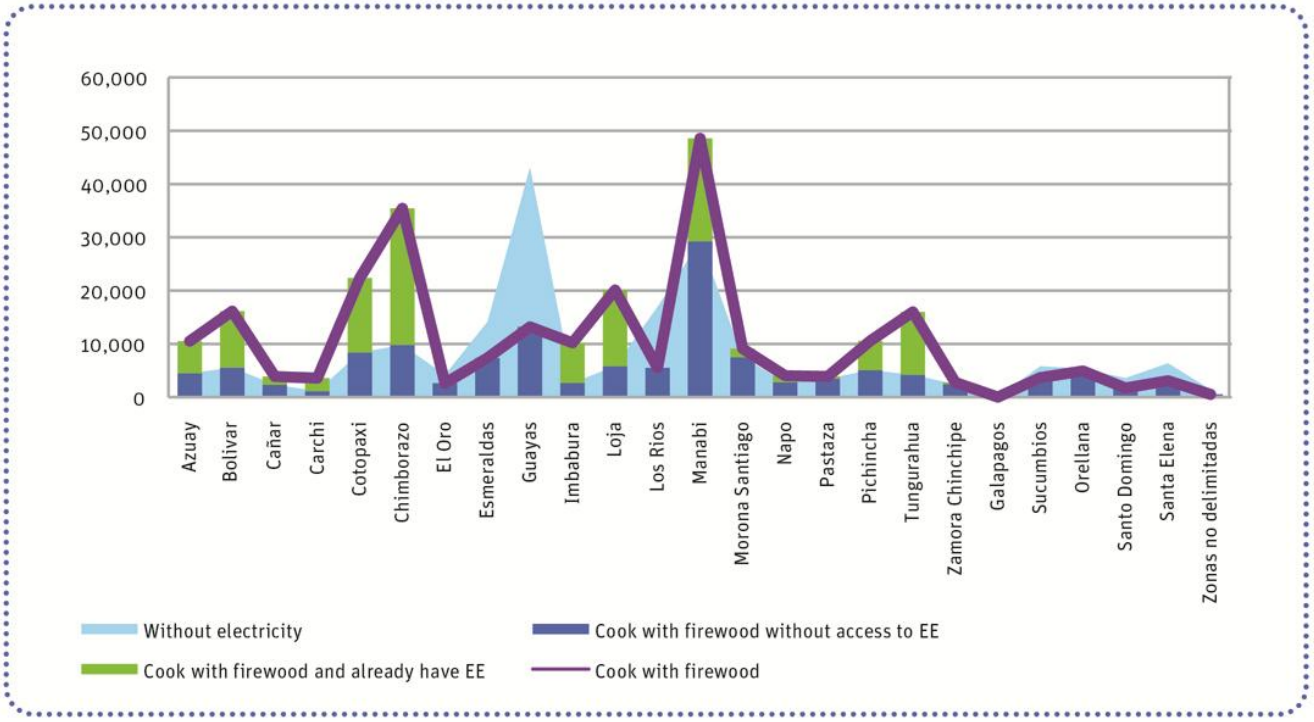
The distribution of homes without electricity and homes that use firewood/coal as the main energy source for cooking is uneven. If data is compared for provinces from the 2010 Census, it is possible to observe that in some provinces, under the hypothesis that there is one household per home, the cases of homes cooking with firewood that lack electricity service are greater. In other homes the opposite occurs - the total cases of firewood use in homes are greater that those without access to electricity. Thus there are households that have electricity and also use firewood. However, there are also others that use it and don't have electricity (Table 16 and Figure 42).

**Table 16** Cooking with firewood vs. no access to electricity

| Province | Without electricity | Cooking with firewood | Difference | Cooking with firewood without access to electricity | Cooking with firewood with access to electricity |
|---|---|---|---|---|---|
| | **1** | **2** | **3=2-1** | | |
| AZUAY | 4,480 | 10,518 | (6,038) | 4,480 | 6,038 |
| BOLIVAR | 5,555 | 16,135 | (10,580) | 5,555 | 10,580 |
| CAÑAR | 2,341 | 3,883 | (1,542) | 2,341 | 1,542 |
| CARCHI | 1,140 | 3,577 | (2,437) | 1,140 | 2,437 |
| COTOPAXI | 8,359 | 22,365 | (14,006) | 8,359 | 14,006 |
| CHIMBORAZO | 9,805 | 35,435 | (25,630) | 9,805 | 25,630 |
| EL ORO | 4,164 | 2,603 | 1,561 | 2,603 | |
| ESMERALDAS | 14,142 | 7,366 | 6,776 | 7,366 | |
| GUAYAS | 43,101 | 13,194 | 29,907 | 13,194 | |
| IMBABURA | 2,670 | 10,203 | (7,533) | 2,670 | 7,533 |
| LOJA | 5,825 | 20,106 | (14,281) | 5,825 | 14,281 |
| LOS RIOS | 16,957 | 5,501 | 11,456 | 5,501 | |
| MANABI | 29,274 | 48,570 | (19,296) | 29,274 | 19,296 |
| MORONA SANTIAGO | 7,500 | 9,107 | (1,607) | 7,500 | 1,607 |
| NAPO | 2,824 | 4,030 | (1,206) | 2,824 | 1,206 |
| PASTAZA | 3,474 | 3,881 | (407) | 3,474 | 407 |
| PICHINCHA | 5,086 | 10,561 | (5,475) | 5,086 | 5,475 |
| TUNGURAHUA | 4,218 | 15,999 | (11,781) | 4,218 | 11,781 |
| ZAMORA CHINCHIPE | 2,409 | 2,757 | (348) | 2,409 | 348 |
| GALAPAGOS | 36 | 18 | 18 | 18 | |
| SUCUMBIOS | 5,813 | 3,677 | 2,136 | 3,677 | |
| ORELLANA | 5,350 | 4,915 | 435 | 4,915 | |
| SANTO DOMINGO | 3,584 | 1,716 | 1,868 | 1,716 | |
| SANTA ELENA | 6,379 | 3,088 | 3,291 | 3,088 | |
| ZONAS NO DELIMITADAS | 1,431 | 526 | 905 | 526 | |
| TOTAL | 195,917 | 259,731 | -63,814 | 137,564 | 122,167 |

**Source:** Own elaboration based on INEC data, National Population and Housing Census, 2010.

**Figure 42** Households without electricity service and homes that use firewood




**Source:** Own elaboration based on INEC data, Population and Housing Census 2010

The proposal is based on the following:

- As will be explained in the following section, the expansion of electricity service will be carried out with financing from FERUM with the goal of universal electricity access by 2021.
- In provinces where the number of homes without electricity is greater than the number of homes that cook with firewood, electricity would be provided to the latter either via the expansion of networks or via mini-networks with renewables or other solutions. These homes would be identified and contacted.
- In provinces where the number of homes without electricity is less than the number of homes that cook with firewood, a portion of those can be taken care of when electricity service arrives.
- The electricity distribution companies are the only entities that don't have direct access to users.
- While it is not strictly the responsibility of distributors to deal with energy consumption for cooking, it would be convenient to explore the feasibility of, for example, designing an efficient firewood cookstove program and having them distributed via electricity companies as electricity service is provided to households. This

would promote the improved use of firewood in the 53% of homes that use it and it is also the percentage that still lacks electricity service. Another possibility is to structure an operational scheme via the MEER.

- For the remaining 47% of homes that cook with firewood that already have electricity service and who would thus be served by FERUM, the possibility should be analyzed of arriving with efficient firewood cookstoves. Later it would be possible to introduce LPG cookstoves. It is necessary to consult the strategy with Petrocomercial and with the electricity companies given that they have already registered these homes in their databases.

# 29. ELECTRICITY SECTOR: PROGRAMS AND FINANCING TO IMPROVE ACCESS, ENERGY EFFICIENCY, AND THE USE OF RENEWABLE ENERGY FOR ELECTRICITY SUPPLY

In Ecuador there is a Fund for Rural and Marginal Urban Electrification (FERUM). This serves rural and marginal urban sectors via a social program with a technical foundation that gives high priority to the incorporation of new basic services. Its objective is to improve the quality of life in those sectors of the population.[18]

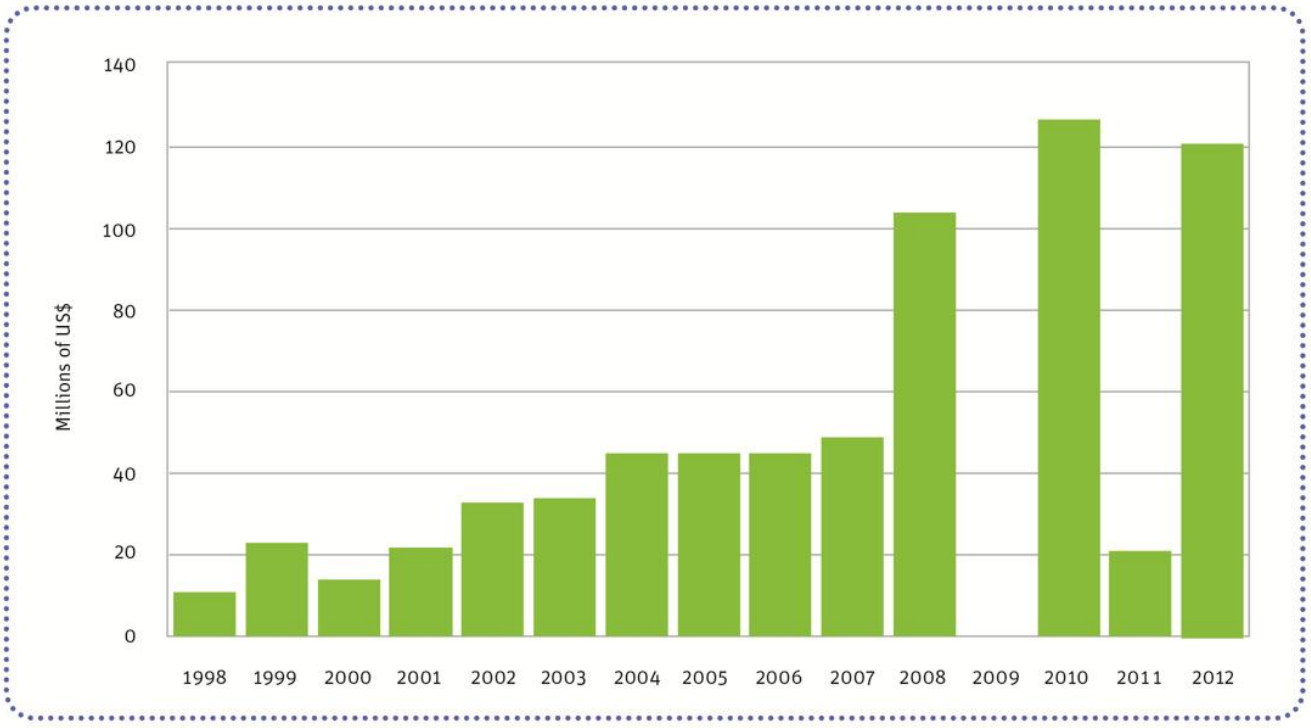
A strategy has been established for the incorporation of beneficiaries and other related actors who participate in activities. Among those are: representatives of autonomous decentralized governments, local organizations, communities, peasant, and women's and indigenous movements. They also include entities such as the MEER, the National Parochial Council (CONAJUPARE), the Association for Municipalities of Ecuador (AME), the Consortium for Amazonian and Galapagos Municipalities (COMAGA), the Consortium for Provincial Councils of Ecuador (CONCOPE), the Council for the Development of Nationalities and Peoples of Ecuador (CONENPE), the Institute for Regional Amazonian Eco-development (ECORAE), and the College of Electrical Engineers and Electricians of Ecuador (CIEE), among others.

**18** CONELEC. Master Electrification Plan 2012-2021.

Furthermore, the results of the program, like the norms that govern their presentation, rating, approval, and the execution of projects and good use of energy will be broadcast.

CONELEC promotes the development of comprehensive projects for improved communications, education, health, and others, mainly on the border, and in the Amazon, and costal regions. These sites almost always use alternative energy sources. Between 1998 and 2007 US$ 316 million in projects have been executed, while between 2008-2012 the figure was 356 million. In 2012 the allocation was US$ 120 million annually (Figure 43).

**Figure 43** Allocation of FERUM funds




**Source:** CONELEC

By 2013 the country is expected to reach 96% electricity coverage for homes located in rural areas and 98% for homes in marginal urban areas. During 2014 approximately 32,549 homes will still need electrification in rural areas and 59,948 in the marginal urban sector.

From 2014-2021, it is estimated that US$ 191 million is needed to serve all the homes in the rural and marginal urban sectors.[19]

It is important to emphasize what was already mentioned, that the current planned increased in physical access to energy is through grid extensions. However, there is still no plan to reach isolated communities or consumers. Nor is there even an estimate of the number of homes that are in those conditions.

Originally FERUM was created with funding from consumer support, which was 10% of commercial and industrial tariffs. Subsequently, Constituent Mandate 15 removed it and converted it into FERUM, a specific mechanism to fund rural and marginal urban electrification projects with contributions from the National Treasury. Thus, the fund enters into the prioritization of projects in the selection process at the national level. That is why the pre-selection made by CONELEC must be approved by the MEER and finally by SENPLADES.

FERUM currently has an IDB loan to co-finance electrification projects.

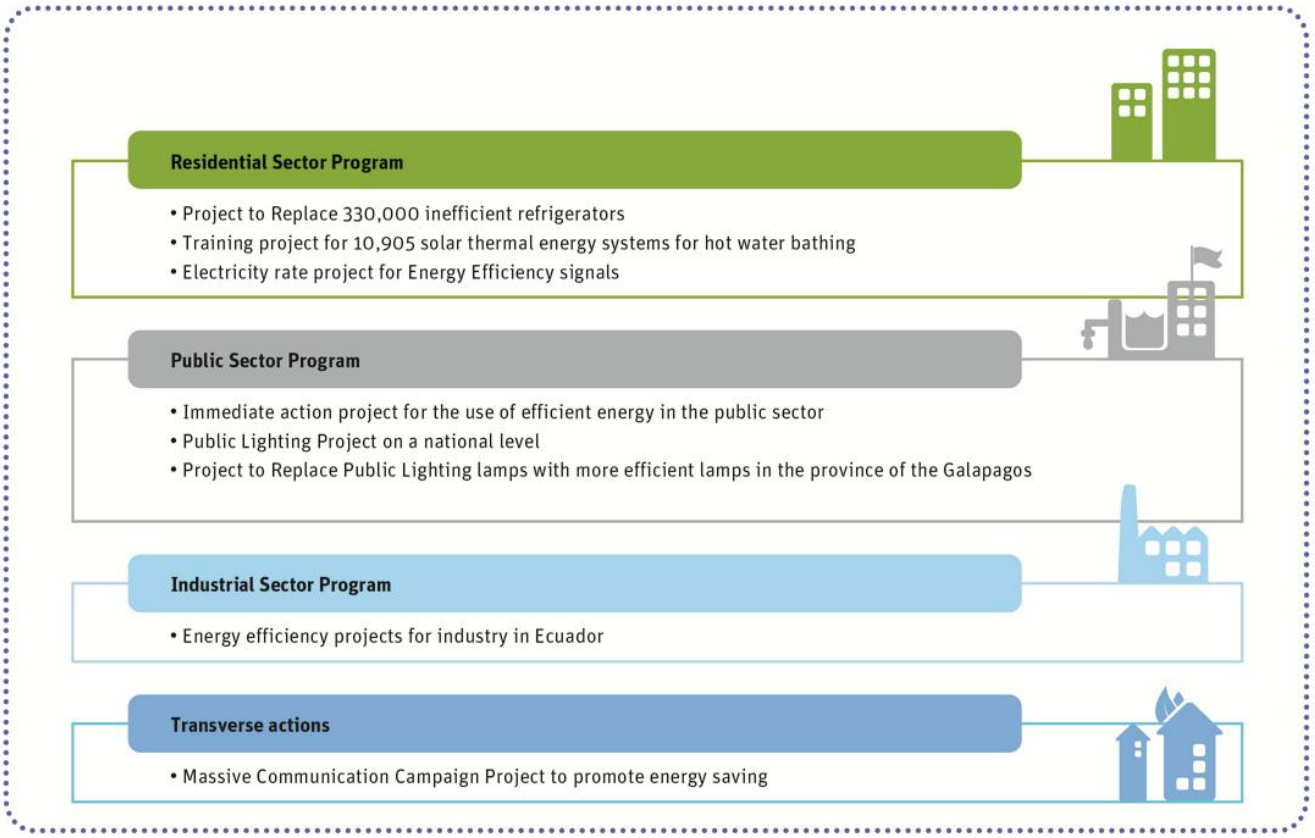
# 30. MODERN ENERGY FOR PRODUCTIVE USE: PROGRAMS AND FINANCING TO IMPROVE ACCESS, ENERGY EFFICIENCY, AND THE USE OF RENEWABLE ENERGY SOURCES IN PRODUCTIVE SECTORS

## *a. Energy Efficiency Programs*

In the Ministry of Electricity and Renewable Energy (MEER) there are some programs aimed at improving efficiency in the areas of short-term consumption. Figure 44 summarizes the programs planned for the next five years.

**19** CONELEC, Master Plan, Op.Cit.

**Figure 44** Programs and energy efficiency projects for 2012-2017




**Source:** MEER/CONELEC (May 2012 information)

Moreover, the MEER executed a project in a non-refundable cooperation from the IDB, the "Plan of Action for Sustainable Energy for Ecuador" (SEAP ATN/MC-11398-EC Convention). The PAES, which recently completed financing (although there are a few activities to be completed), had four components, one operational and three substantive:

Component I. Energy Efficiency Program: this component included two activities 1) a baseline study to formulate a plan for saving energy; and 2) A methodology and software platform to develop an array of end uses of energy in the residential, industrial, commercial, and services sectors. This last item is particularly important, as it will be applied in the study of end uses of energy the MEER undertook nationwide.

Component II. Wind measurement campaign: a wind map based on satellite data was developed and measurement towers were installed in two provinces (Imbabura and Loja). Also in parallel a wind atlas and a measurement campaign were developed starting in December 2011. Based on information from the wind map, the MEER estimated a potential Available Gross Total of around 1,670 MW and a Feasible Short-Term potential of about 900 MW, with capacity factors in the range of 20% to 35%, installable from wind farms in areas with the best wind resources. All that remains to be completed is a study on the integration of wind energy projects to the electricity networks.

Component III. Institutional strengthening: a study is being finalized to identify regulatory, legal, taxation, institutional, technological, economic, and financial barriers and to design tools for the development of renewable energy, energy efficiency, and bioenergy in Ecuador. In addition, specific training events in CDM, carbon markets, project management, and renewable energy were carried out.

As noted, applying the methodology designed in Component I of the SEAP, MEER has budgeted its own resources for a study of end uses of energy in the residential, industrial, commercial, service, and public sectors, whose implementation started in 2013 and will conclude in 2014. This study is crucial to understanding energy use, equipment, and efficiencies in the various sectors and subsectors, and to developing indicators and establishing specific programs with verifiable energy efficiency goals. In fact, the study itself is part of the first national goal within the SE4ALL objectives related to energy efficiency.

## *b. National Plan for Efficient Cooking*

The MEER formulated a "Replacement Plan for Gas Cookstoves with Efficient Electric Induction Cookstoves," which is in the process of being approved. This plan will, within the framework of a strong national energy replacement policy (not all, since it would be impractical) of LPG for electricity, have a major impact on public finances due to the reduced LPG subsidy and a drastic change in the consumption mix in the residential sector and GHG in the sector.

The plan seeks to substitute LPG for electricity use in cooking in the residential sector through the replacement of LPG stoves with electric induction cookstoves and mixed LPG.[20]

The cornerstones of the plan are:

• Adapt the electrical system to meet the demand generated by the cookstoves.
• Define new prices for electricity and LPG.
• Create an offer on induction cookstoves for the domestic market at accessible and competitive prices.
• Create the conditions for Ecuadorian families adopt this technology.

With the commissioning of new hydropower plants under construction, as well as a back up thermal park, the demand generated by induction cookstoves can be met (taking into consideration an additional peak demand of 480 MW in 2016 with a penetration of 1,000,000 cookstoves, and a demand of 1,400 MW for a penetration of up to 3,000,000 kitchens). This would translate into an increase of between 12 and 15% that the electricity system must meet.

However, it is necessary to provide reinforcement for the low voltage distribution network and the connections to consumers. This requires that necessary investments be made in distribution company plans.

From an economic and financial viewpoint, to make the plan viable it is important to make the required adjustments in price structure related to LPG/electricity and in the availability and relative prices for cooking appliances.

**20** MEER. National Plan for Efficient Cooking, Executive Summary, 2013.

The plan estimates that for the user to continue to pay the same monthly price for concept cooking, the electricity tariff should be 3 cents USD/kWh for the first 100 KWh. Also, the price of residential LPG would have to change as an additional tool for getting households to use electricity and also to reduce what the country spends on the LPG subsidy, which a is 80% imported. The changes should be identified, evaluated, and established in conjunction with the introduction of electric cookstoves.

The implementation strategy for the domestic manufacture of cookstoves nationwide and their installation in homes should be a gradual transition. Also, incentives should be considered to move users from LPG to electricity.

Contacts with appliance manufacturers allow us to estimate that the cost of an electric induction stove could be between US$150 and US$300, depending on the induction zones and market size. These values are very competitive with the prices of LPG stoves with similar features.

Based on the pilot by the MEER in the Carchi province, the key areas for the success of a cookstove plan in relation to consumers are: training, dissemination, advertising, technology, logistics, suppliers available, strategic partnerships with utilities and other stakeholders in the sector, and monitoring, control, and project maintenance.

## 3.3 PRIVATE PARTICIPATION AND REGULATORY FRAMEWORK TO PROMOTE INVESTMENT

In Ecuador strategic sectors are in state hands, although there is room for private investment in power generation and NCRE hydroelectric plants under 50 MW (as seen above). There are also gaps in relation to oil exploitation through contracts with Petroecuador. Similarly, note that most of the LPG distributors are private.

# 31. THERMAL ENERGY FOR THE RESIDENTIAL SECTOR:

In this case, if firewood for cooking LPG is replaced, the distributors should intervene. However, because gas distribution is widespread and the market to replace wood is scattered and small, it is very likely that Petroecuador (which also has one of the 11 existing distributors) will take this supply.

The introduction of efficient firewood cookstoves would be carried out by the State and coordinated by the MEER. However, the design, manufacture, and supply of cookstoves may be a private activity.

# 32. ELECTRICITY SECTOR

The state makes investments in the electricity sector. The last paragraph of Article 1 of Constitutional Mandate 15 states: "[...] The resources required to cover investments in generation, transmission, and distribution will be covered by the State as part of its General Fund and shall be transferred monthly to the Solidarity Fund, and will be considered capital contributions of that institution."

However, it has already been mentioned that there are niches for generating on-grid, off-grid, and below 50 MW hydroelectric plants, which are set out in Regulations 002, 003 and 004/11. There are no barriers, but there is a limit of 6% of the installed capacity of the system to NCRE; for hydroelectric plants the limit reaches 50 MW. The State can make concessions to other generation projects that are within the "Master Electrification Plan."

Private investment in transmission and distribution is not permitted.

Obviously, providers of goods and services are private, either for generation or rural electrification.

Major funding comes from the National Treasury leveraged by international development banks (IDB, CAF), international banks (China and others) and national development banks. As already mentioned, the FERUM currently has an IDB loan to co-finance electrification projects.

In the case of management of demand and energy efficiency, we can say that there are no obstacles to the provision of services or equipment to consumers. Naturally, the actors in this area are private.

## 33. MODERN ENERGY FOR PRODUCTIVE SECTORS

Companies on the demand side are private, like most of the banks, with some exceptions. The areas in which they operate are: agriculture, agribusiness, manufacturing, construction, and all other areas of production, as well as services (trade, import, export, tourism, etc.).

The idea is that the production of equipment for energy efficiency and renewable energy, as well as its provision, will be private. It is worth mentioning that this is one of the sectors included in the agenda prepared by the productive MCPEC.

# 3.4 GAPS AND OBSTACLES

## 34. THERMAL ENERGY FOR THE RESIDENTIAL SECTOR

In this case, there are other obstacles, because the institutional issue is complex. Although it seems that the issue of using wood for thermal energy in the residential sector itself is handled within the scope of FERUM, this item could operate properly with all regional and local institutions. At the same time, it could overcome some cultural barriers such as those already experienced in several countries with efficient wood stoves.

## 35. ELECTRICITY SECTOR

In this case, in principle there seems to be an additional obstacle to those indicated above. An important aspect to consider is the slowness with which changes are being made in the field of electricity distribution.

As noted in previous chapters, most distribution company indicators are still far from the required levels of efficiency.

## 36. MODERN ENERGY FOR PRODUCTIVE SECTORS

In this case, a specific additional obstacle is the lack of information and consumer awareness, which could be in the process of being resolved.

There is an important aspect to consider: there should be more communication and exchange between the public sector and the leading companies or trade associations representing the production sectors regarding issues of energy efficiency and use of renewable energy. It is essential to involve more productive sectors from the design stage of programs and projects. After all, it is the consumers who have to implement these programs in their production units.

## 37. SUMMARY: IMPORTANT GAPS, BARRIERS, AND ADDITIONAL REQUIREMENTS

In this case, a specific additional obstacle is the lack of information. Based on knowledge of the progress that the country has made in relation to the SE4All objectives, areas requiring further attention that may demand additional support or technical cooperation funding are: thermal energy for cooking, efficiency and use of renewable energy in the productive sectors, and access to electricity for isolated locations or dwellings.

Additionally, we envision potential for financing private generation projects with unconventional and renewable energy and hydroelectric plants below 50 MW hydroelectric via open niches in the regulations.

Subsidies for electricity and fuel are a major barrier to the promotion and implementation of energy efficiency programs and renewable energy use in the productive, service, and residential consumption sectors.

Furthermore, although the subsidies and the total absorption of investments by the state may constitute a risk to the financial sustainability of long-term programs (due to the pressure it exerts on the national economy), this risk is controlled depending on the allocation of resources to rural and marginal urban electrification programs. Furthermore, it features contributions from international institutions and guarantees with respect to the payment of contracts for sale of power to private renewable energy projects.

Lastly, it is noted that there may be other institutional barriers. This is due to difficulties in coordinating efforts between various government and private institutions to reach all end users of energy.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