Monitoring energy efficiency in Latin America

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Project document

Monitoring energy efficiency in Latin America

Economic Commission for Latin America and the Caribbean (ECLAC)

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Index

Summary 7

Introduction 11
A. Objectives and content 11
B. Data sources 12
C. Main results 13

I. Energy consumption and intensity trends 15
A. Trends in energy consumption 15
1. Primary energy consumption 15
2. Final consumption 18
B. Trends in primary and final energy intensities 21

II. Energy efficiency trends in the energy sector 27

III. Energy efficiency trends for households 33
A. Overall trends 34
B. Energy consumption by end use 38
1. Cooking 39
2. Water heating 41
3. Electrical appliances, lighting and cooling 41

IV. Energy efficiency trends in transport 47
A. Trends in consumption 47
B. Road transport 49
1. Overview 49
2. Cars and trucks 51
C. Air transport 53
D. Decomposition of the consumption variation in transport 54
E. Measuring energy efficiency progress in transport: case study with ODEX 55

V. Energy efficiency trends in industry 57
A. Energy consumption patterns 57
B. Impact of structural changes in manufacturing 60
C. Specific consumption of cement and steel 61
D. Decomposition of the energy consumption by industry 62

VI. Energy efficiency trends in services 63
VII. Energy efficiency in agriculture 67
Annex: Organization of the BIEE Programme on energy efficiency indicators 72

Figures

Figure 1 Primary energy consumption and GDP in Latin America (2012) 16
Figure 2 Trends in primary consumption and GDP by sub-region 16
Figure 3 Primary energy consumption and GDP trends by country (2000-2012) 17
Figure 4 Primary energy consumption by main sector (2012) 17
Figure 5 Breakdown of final energy consumption by sector (2012) 18
Figure 6 Breakdown of final consumption by energy source (2012) 19
Figure 7 Share of electricity in final energy consumption 19
Figure 8 Electricity consumption per capita (electrified) 20
Figure 9 Final energy consumption and GDP per capita (2012) 20
Figure 10 Primary energy intensity: exchange rate versus purchasing power parity (2012) 22
Figure 11 Primary energy intensity trends (2000-2012) 22
Figure 12 Trends in primary and final energy intensity (2000-2012) 23
Figure 13 Share of renewables in power generation, efficiency of thermal power and electricity penetration 24
Figure 14 Trends in final energy intensity: total and electricity (2000-2012) 24
Figure 15 Impact of structural changes in GDP on final intensity (2000-2012) 25
Figure 16 Change in GDP structure (2000-2012) 26
Figure 17 Avoided energy consumption from declining intensity in Latin America 26
Figure 18 Overall efficiency of the energy sector 28
Figure 19 Efficiency of power generation 28
Figure 20 Efficiency of thermal power plants 29
Figure 21 Share of renewable sources in electricity generation (2000-2012) 29
Figure 22 Decomposition of variation in power sector consumption 30
Figure 23 Share of households in final energy consumption 33
Figure 24 Final energy consumption of households by energy source (2000-2012) 34
Figure 25 Trend in average household size 34
Figure 26 Trends in the number of households: total and electrified (2000-2012) 35
Figure 27 Energy consumption, household income and number of households (2000-2012) 35
Figure 28 Average energy consumption per household 36
Figure 29 Average electricity consumption per household 36
Figure 30 Effect of household electrification on unit electricity consumption 37
Figure 31 Energy consumption per household and income (2012) 37
Figure 32 Electricity consumption per household and prices (2012) 38
Figure 33 Energy consumption per dwelling by end use (2000-2012) 38
Figure 34 Electricity consumption by end use 39
Figure 35 Unit consumption per household for cooking 39
Figure 36 Consumption for cooking per dwelling and substitution 40
Figure 37 Decomposition of the variation in consumption for cooking: case of Brazil 40
Figure 38 Equipment rate of households in solar water-heaters: comparison with EU countries 41
Figure 39 Specific electricity consumption for electrical appliances, lighting and cooling 42
Figure 40 Equipment rate of households with air-conditioners 42
Figure 41 Equipment rate of households in refrigerators, washing machines and TV 43

Figure 42 Drivers of the variation in the consumption of refrigerators in Brazil (2005-2012) ... 44
Figure 43 Drivers of the variation of the consumption of large appliances in Brazil (2000-2012) ... 45
Figure 44 Share of transport in final energy consumption ... 47
Figure 45 Trends in transport consumption, GDP and transport intensity ... 48
Figure 46 Energy consumption by mode of transport (2000 and 2012) ... 48
Figure 47 Vehicle pool (2000, 2012) ... 49
Figure 48 Number of cars per inhabitant ... 49
Figure 49 Trends in unit consumption of road transport (2000-2012) ... 50
Figure 50 Consumption per car equivalent and motor fuel prices (2012) ... 51
Figure 51 Road energy consumption by type of vehicle ... 51
Figure 52 Trends in consumption for road transport by type of vehicle (2000 and 2012) ... 52
Figure 53 Share of air transport in energy consumption of transport ... 53
Figure 54 Energy consumption of air transport per passenger ... 53
Figure 55 Decomposition of the transport consumption: case of Mexico (2005-2012) ... 54
Figure 56 Energy efficiency trends in transport in Mexico based on ODEX ... 55
Figure 57 Share of industry in the final energy consumption ... 57
Figure 58 Energy consumption of industry by energy source (2000 and 2012) ... 58
Figure 59 Energy intensity trends in industry ... 58
Figure 60 Energy intensive branches in industry (2000-2012) ... 59
Figure 61 Trends in manufacturing industries (2000-2012) ... 59
Figure 62 Energy intensities by branch (2000-2012) ... 60
Figure 63 Structural effect in manufacturing industry (2000-2012) ... 61
Figure 64 Trends in specific consumption of cement industry (2000, 2012) ... 61
Figure 65 Trends in specific consumption of steel industry (2000, 2012) ... 62
Figure 66 Decomposition of the variation in industrial energy consumption in Brazil (2000-2011) ... 62
Figure 67 Share of services in final energy consumption ... 63
Figure 68 Energy consumption of services by branch ... 64
Figure 69 Energy consumption, electricity consumption and added value in services (2000-2012) ... 64
Figure 70 Energy intensity of services ... 65
Figure 71 Trends in energy intensity of services (2000-2012) ... 65
Figure 72 Electricity consumption per employee ... 66
Figure 73 Electricity consumption by branch and per employee (2012) ... 66
Figure 74 Share of agriculture, fishing and forestry in final energy consumption ... 67
Figure 75 Share of added value of agriculture, fishing and forestry in GDP ... 68
Figure 76 Consumption of agriculture, fishing and forestry by fuel (2010) ... 68
Figure 77 Energy intensity of agriculture ... 69
Figure 78 Energy consumption of agriculture per hectare ... 69

Diagrams

Diagram 1 Energy efficiency labels for new cars in Chile ... 52
Diagram 2 BIEE - Energy Efficiency Indicators Database ... 73

Summary

It is clear that for Latin American and Caribbean countries, economic development with greater levels of energy efficiency would constitute an important step along the path to sustainability. Taking a medium term perspective, the main factors that mobilize the promotion of energy efficiency include security in energy supplies, enhanced cost-efficiency and the high potential to save energy, concerns over the mitigation of environmental impacts from Greenhouse Gas Emissions (GGE), which obviously includes the phenomenon of climate change and, it must also be noted, in developing countries like ours the limitations that might be produced by an investment perspective oriented toward the expansion of energy supplies. In fact, the tremendous potential of savings and improved efficiency at all productive stages and in the use of energy is well known, but achieving that potential continues to pose a challenge that demands the creation of informed policies that prioritize and focus always-restricted budgets toward the creation of programmes with higher potential to safe energy and other resources.

After analyzing the strengths and weaknesses of the energy efficiency programmes that the region's countries have been implementing, the Natural Resources and Infrastructure Division's (DRNI) Natural Resources Unit (NRU) has reached the conclusion that one of the main obstacles has been the lack of information and indicators to facilitate a quantitative, full and integrated analysis of the evolution of said policies with the objective of making policy interventions based on solid information. The quality of the statistics and the performance indicators to quantify results of national energy efficiency programmes in Latin American and Caribbean countries has been deficient. As a way to overcome this shortcoming, the ECLAC has created the Regional Program BIEE (Energy Efficiency Indicators Database for Latin America and the Caribbean). Following the technical-political process and the operating logic of the most successful energy efficiency and analysis Programme in the world, the ODYSSEE Programme (http://www.odyssee-mure.eu/), developed by the European Commission and managed by the French Agency ADEME (Agence de l'Environnement et de la Maîtrise de l'Energie) and with the aim of producing a series of specific and methodologically consistent indicators that allow the evolution of national energy efficiency programmes to be measured, analyzed in real time and —consequently— for appropriate policy decisions to be made. The ECLAC has undertaken the task of training and coordinating actions in the region's countries to develop a common tool that facilitates this task.

The experience that the division has been capitalizing on the subject was consolidated as of 2011, with the start of the BIEE Programme thanks to a contribution from the German Cooperation Agency GIZ and the technical support provided by the French Energy and Environment Agency

(ADEME), all in the framework of the IPEEC (International Partnership for Energy Efficiency Cooperation). While initially the initiative was aimed at supporting Mercorsur countries and associated nations, thanks to the achievements made to so far, 19 Latin American countries are now participating in it: Argentina, Bolivia, Brazil, Chile, Colombia, Costa Rica, Cuba, Dominican Republic, Ecuador, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama, Paraguay, Peru, Uruguay and Venezuela. Representatives of the Central American Integration System (SICA) and the Latin American Energy Organization (OLADE) also participate. Several non-Hispanic Caribbean countries will be joining the Programme soon. The ECLAC will be in charge of the Programme's operative coordination, in the context of the global SE4ALL initiative, while the technical aspect is run jointly by ADEME and ENERDATA's specialized international consultants, who were the technical staff in charge of undertaking the aforementioned ODYSSEE Programme.

To date 15 technical training workshops have been held, along with a technical tour of Europe to share experiences with institutions specializing in the issue and 2 regional technical meetings, co-organizing an international event. Thus, since 2012 a special session has been held to show the progress and achievements made at the Regional Political Dialogues on Energy Efficiency that the Division has organized over recent years with the participation by high-level energy officials.

The Programme's main objective has been to create a database of indicators that measure the performance of energy efficiency policies in participating countries. This first Regional Report containing recent trends in energy efficiency is the fruit of these coordinated efforts. The BIEE Programme activities were undertaken in stages. First, the type of sectoral indicators that could be obtained and how they could be used is shown. After this the information Template in Excel format is presented and a process to collect basic information is promoted (statistics on activity and production, in addition to energy consumption indicators), which must be done by the national team in close communication with the project's respective focus point in each country. Following the schedule of activities, once the stage for collecting basic information has concluded, the energy efficiency indicators are identified (intensities and efficiency ratios) for the 7 sectors considered: Macro/Energy Balance, Households, Industrial, Services, Agricultural, Transportation and Energy. Lastly, officials are trained in the interpretation and use of said indicators and advanced indicators. In general these are energy ratios or intensities related to the energy consumption in analysis units with regard to their levels of activity, measured, as the case may be, in economic (value units), physical (production units or physical consumption) or socio-demographic terms. The database's construction involved the use and treatment of information on an aggregate level, the source of which was national accounts and energy balances, in addition to the collection of information on a sectoral level, which underscores the trans-sectoral nature that the analysis and interpretation of indicators that must be undertaken. All of the Programme's activities seek to be reflected in the National Energy Efficiency Monitoring Reports that each country must make, closing the programme's cycle of activities for this stage. Likewise, the main indicators are part of the Data Mapper: a tool for visualizing the main indicators calculated (a provisional version can be viewed at http://www.biee-ECLAC.enerdata.eu/)

Considering that this is an important first step toward measuring the energy efficiency of countries in the region and keeping in mind the limitations encountered throughout the process of creating the database, especially with regard to the availability of basic sectoral information, both on levels of activity as well as energy consumption by source, this first regional energy efficiency monitoring report is the product of the intense work done by the national teams in the framework of the BIEE Regional Programme.

Despite the countries' greater or lesser availability of basic information, the proposed methodology for developing the energy efficiency indicators database has been applicable and easily adaptable to each of the participating countries. As new countries joined the programme, and considering the complexity of the training process and the coexistence of countries that had made greater or lesser degrees of progress in the process, this has been organized successfully and the exchange of experience and information has stood out as something very valuable, as the majority of participants have come across similar obstacles in the process of creating the database. Thus, and as was considered on several occasions during the debates in workshops, coordination with the suppliers of basic data, produced by different sectoral units in the countries, is important to facilitating access to more information, continuing the task of harmonizing and updating the database created with certain frequency and, if possible, increasing the amount of information that the database contains to deepen the capacity to monitor details and analyze evolution in energy efficiency.

To take advantage of the technical capacities that the BIEE Programme has promoted and to institutionalize the regular updating of the database and publication of regional reports like this one, we hope that this document is widely disseminated throughout the region and that its results can be analyzed in regional as well as international conferences. Lastly, we would like to congratulate and thank all of the officials and focus points in the 19 countries participating in the Programme for the work done to develop the energy efficiency indicators databases that facilitated the drafting of this report.

Introduction

A. Objectives and content

The objective of this report is to describe and compare energy efficiency trends in Latin American countries. The report is based on data and indicators prepared by the BIEE Programme ("*Base de Indicadores de Eficiencia Energética*") on energy efficiency indicators, developed by the Division of Natural Resources and Infrastructure of ECLAC (ECLAC in Spanish), in close cooperation with ADEME, the French government agency on Energy Efficiency and Environment.

The BIEE Programme aims to develop a common methodology for the evaluation of national and regional energy efficiency trends, globally and by sector. This project relied on the experience of the ODYSSEE MURE project for European countries: coordinated by ADEME, it aims to evaluate energy efficiency progress through a large variety of indicators (ODYSSEE) and to describe energy efficiency policy and measures in EU countries (MURE).[1]

The BIEE Programme participants include 19 countries in different phases, starting with 6 South American countries (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay). It was then extended to 8 Central American countries (Costa Rica, Dominican Republic, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama) and then to the remaining countries (Cuba, Ecuador, Colombia, Peru and Venezuela). The BIEE participants are the following organizations, mainly from Energy Ministries:[2]

- Secretaría de Energía, Ministerio de Planificación Federal, Inversión Pública y Servicios, República Argentina;

1 http://www.odyssee-indicators.org/.

2 The report presents data and indicators for the 13 countries for which the data that have been completed and validated at the time of writing the report (fourth quarter 2015): Argentina, Bolivia, Brazil, Chile, Costa Rica, Dominican Republic, Ecuador, El Salvador, Mexico, Nicaragua, Panama, Paraguay and Uruguay.

- Empresa de Pesquisa Energética (EPE), Estado Federativo de Brazil;
- Viceministerio de Desarrollo Energético, Ministerio de Hidrocarburos y Energía, Estado Plurinacional de Bolivia;
- Ministerio de Energía, República de Chile;
- Unidad de Planeamiento Minero - Energética, República de Colombia
- Dirección Sectorial de Energía, Ministerio de Ambiente y Energía, República de Costa Rica
- Oficina Nacional para el Control al Uso Racional de la Energía (ONURE), República de Cuba;
- Comisión Nacional de Energía, Dominican Republic;
- Ministerio Nacional de Sectores Estratégicos and Instituto Nacional de Eficiencia Energética y Energías Renovables (INER), República del Ecuador;
- Consejo Nacional de Energía (CNE), República de El Salvador;
- Ministerio de Energía y Minas, República de Guatemala;
- Secretaria de Energía, República de Honduras;
- Comisión Nacional para el Uso Eficiente de la Energía (CONUEE), Estados Unidos Mexicanos;
- Ministerio de Energía y Minas, República de Nicaragua;
- Secretaría Nacional de Energía, República de Panamá;
- Viceministerio de Minas y Energía, Ministerio de Obras Públicas y Comunicaciones, República del Paraguay;
- Dirección General de Eficiencia Energética, Ministerio de Energía y Minas, República del Perú;
- Dirección Nacional de Energía (DNE), Ministerio de Industria, Energía y Minería (MIEM), República Oriental del Uruguay
- Viceministra para Nuevas Fuentes y Uso Racional de la Energía Eléctrica, Ministerio del Poder Popular para la Energía Eléctrica, República Bolivariana de Venezuela

The main energy efficiency indicators are presented in an interactive database with maps and graphs on the BIEE web site at http://www.biee-ECLAC.enerdata.eu/.

B. Data sources

Collection of the data required for calculating indicators began with the creation of an Excel template. This template was adapted to the situation of Latin American countries and was discussed and amended with the participants. The data template is organized in 7 main sheets, each corresponding to a sector: macro (for general macro-economic and energy balance data), energy, industry, households, services, transport and agriculture. Annex 1 describes the data template and the process of data collection in greater detail.

The work of data collection was performed by the Ministries participating to the project, sometimes with the assistance of local consultants. Each participant was responsible for collecting data from national institutions (Ministries, Statistical Institutes), power and gas utilities, oil companies, industry associations, banks etc. They have been guided throughout the project to fill in the data template by the technical coordination of the project, made of ECLAC and ADEME, either through on-site visits, specific regional workshops or through emails; in particular, the role of the technical coordination has been to help them adapt existing national data sources to the template categories.

A methodological guideline was prepared at the beginning of the project to explain the definition and usual source of the data used in the data template and to explain the energy efficiency indicators.[3]

The project has demonstrated that there is a lot of data available in the different countries, but that the information is diffuse and scattered among different actors. Thus, the project has contributed to identifying the existing data sources and to centralizing them in the data template.

C. Main results

The main outputs and deliverables of the BIEE Programme on energy efficiency indicators are as follows:

- Training materials to enhance the experience of Ministries in the construction of indicators and in the interpretation and analysis of energy efficiency trends (capacity building);[4]
- A framework for data collection and updating (the "data template");[5]
- Completed and validated data sets by country for 13 countries covering the period 2000 to 2012;[6]
- A regional database on energy efficiency indicators with data for 13 Latin American countries containing around 80 different energy efficiency indicators by country, with the data used to calculate them;
- A regional report describing energy efficiency trends in Latin America (this document).
- National reports by country describing in energy efficiency trends by country in greater detail, available on the BIEE web site http://www.cepal.org/drni/biee/.[7]

The data collection process should be institutionalized to sustain the project and the calculation of energy efficiency indicators, so as to simplify the updating of the data base. Such steps have already been implemented in most of these countries.

The project made it possible to highlight several points that may be reinforced in the future:

- The project has already allowed the quality and quantity of data available to be improved: good examples are Paraguay or Bolivia where very little data was available at the beginning of the project, as well as El Salvador or Nicaragua.
- Data gaps persist in some countries, especially in transport, which can be solved with an additional effort.

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3 http://www.cepal.org/drni/biee/_include/img/material/Guide%20data%20template%20ECLAC.pdf.

4 All available on the project web site: http://www.cepal.org/drni/biee/.

5 See general description at http://www.cepal.org/drni/biee/include/img/material/1TemplatedonnéesECLAC.pdf.

6 As the project has been organized in different phases, with the 6 South American countries starting first (Argentina, Bolivia, Brazil, Chile, Paraguay and Uruguay), data for these six countries are not all updated to 2012, the most recent year shown in this report as specified in the footnotes.

7 As of end of 2015, 5 reports were available: Argentina, Brazil, Chile, Nicaragua and Uruguay. Others are expected in 2016.

- The work done so far focused on a statistical approach to measuring energy savings: efforts should be made to link these measures to a bottom-up evaluation of programmes, so as to have an extended evaluation of the observed indicators and to relate them with the energy savings from the programmes implemented by the countries.
- It is still difficult to show any change in the indicators as the energy efficiency programmes have been implemented recently in most countries and their impact cannot yet be seen on the energy efficiency indicators’ trends.

I. Energy consumption and intensity trends

A. Trends in energy consumption

1. Primary energy consumption

Total energy consumption, also called primary energy consumption,[8] includes final energy consumption and the consumption and losses of the energy sector (also called transformation sector), as well as consumption for non-energy uses. The final energy consumption includes the consumption in industry (excluding energy industries), transportation, residential, services and agriculture.

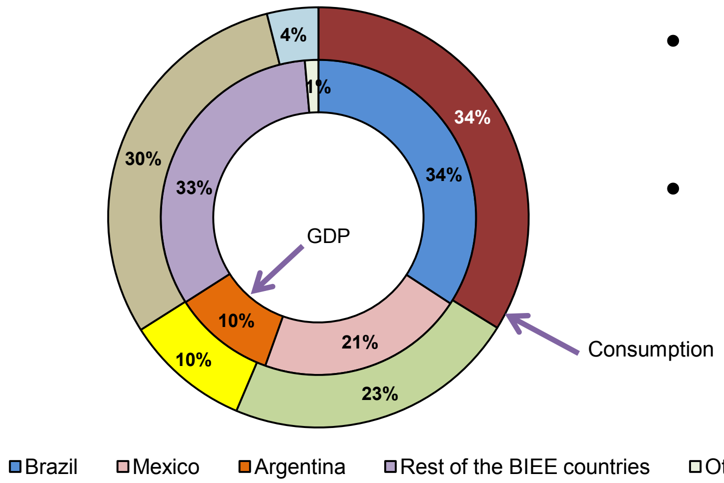
The total energy consumption of Latin America[9] reached 835 Mtoe in 2012, with Brazil and Mexico representing 57% of the total; followed by Argentina with 10% (figure 1). This consumption has been progressing by 2.8% per year, on average, between 2000 and 2012; this is much slower than economic growth, which averaged 3.6% per year. In other words, there was a net decoupling between primary energy consumption and GDP in Latin American countries.

The Caribbean countries have the highest decoupling (consumption only grew at a rate of 0.6%/year since 2006 while GDP has increased by 2.9%/year). In Central America and Mexico consumption and GDP increased at the same rate (figure 2).

Primary energy consumption is generally growing more slowly than GDP in the majority of countries participating in the BIEE Programme. The decoupling between energy consumption and GDP growth was especially significant in El Salvador, Nicaragua and Dominican Republic (with a consumption increase of less than 1%/year despite significant economic growth), and, to a lesser extent, in Mexico and Argentina with consumption growing at half the rate as GDP (figure 3).

[8] Called TPES, Total Primary Energy Supply, by IEA or “Oferta Total” by OLADE.
[9] Latin America includes South America, Central America and Caribbean countries.

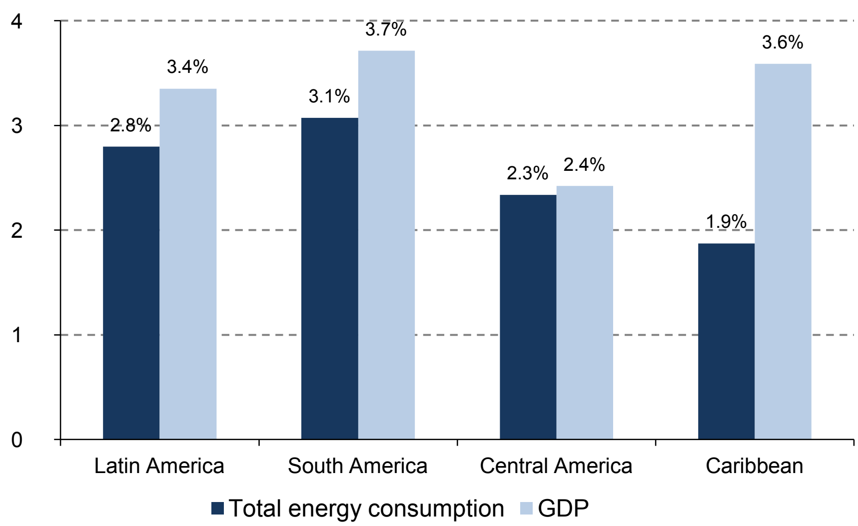
Figure 1
Primary energy consumption and GDP in Latin America (2012)
(Percentages)



- The countries participating in the BIEE Programme account for 96% of the consumption of Latin American countries (around 800 Mtoe in 2012) and around 99% of the GDP of the region.
- Brazil, Mexico and Argentina represent around 2/3 of the region's energy consumption (respectively 34%, 23% and 10% in 2012).

Source: Enerdata based on IEA and OLADE data for energy consumption and World Bank and IMF for the GDP, measured in purchasing power parities.

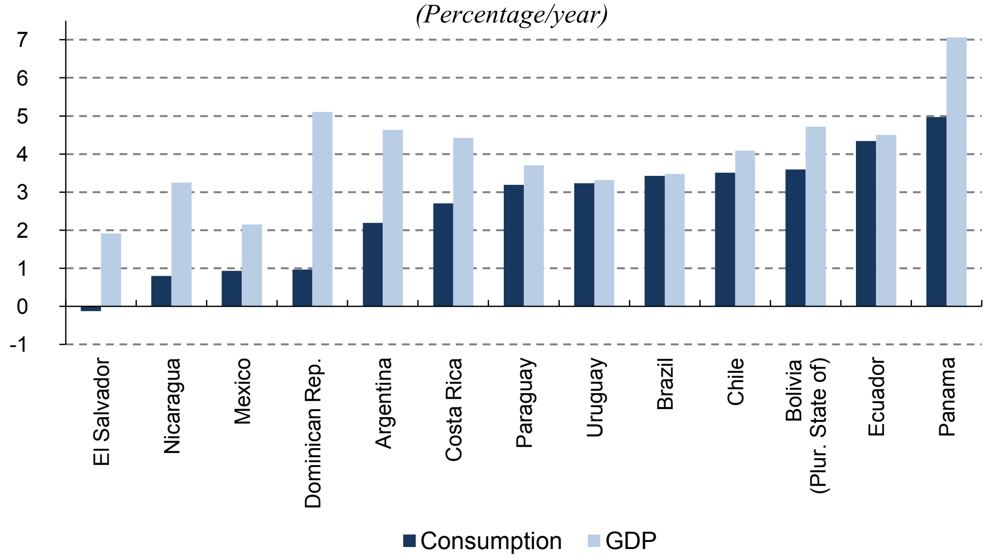
Figure 2
Trends in primary consumption and GDP by sub-region[a]
(Percentages)



Source: Enerdata based on IEA and OLADE data for energy consumption and World Bank and IMF for the GDP, measured in purchasing power parities.

[a] South America: Argentina, Bolivia, Brazil, Chile, Colombia, Ecuador, Guyana, Paraguay, Peru, Suriname, Uruguay, Venezuela; Central America: Belize, Costa Rica, El Salvador, Guatemala, Honduras, Mexico, Nicaragua, Panama; Caribbean: Netherlands Antilles and Aruba, Bahamas, Barbados, Bermuda, Cuba, Dominica, Grenada, Haiti, Jamaica, Dominican Republic, Saint Lucia, Saint Vincent and the Grenadines, Trinidad and Tobago.

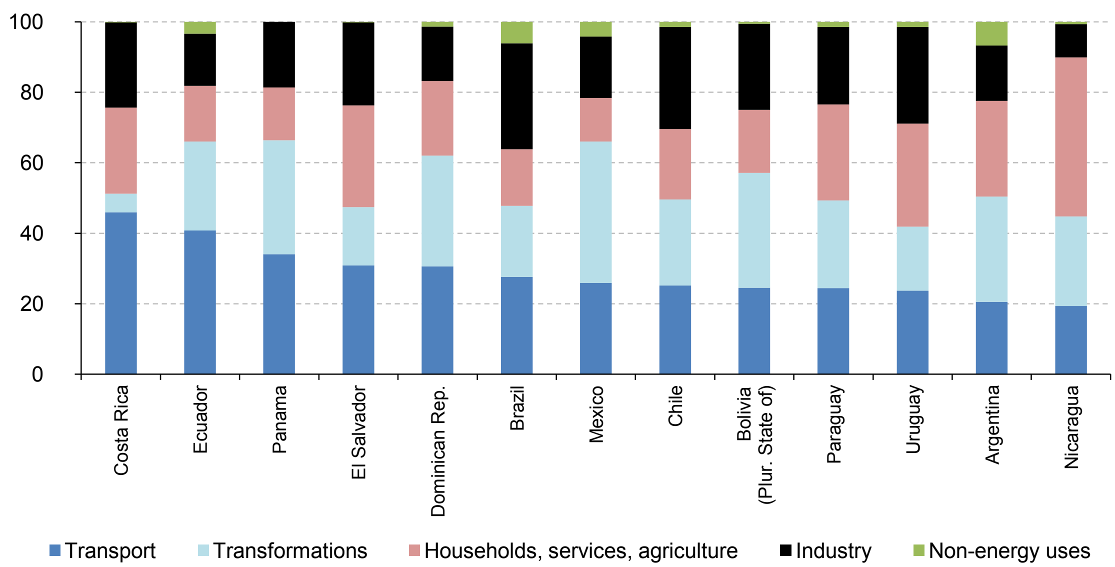
Figure 3
Primary energy consumption and GDP trends by country (2000-2012)
(Percentage/year)



Source: BIEE Programme, ECLAC.

Transformations (i.e. energy industries such as the power or hydrocarbons sectors) absorb a high share of total energy consumption in Mexico (40%), as well as in Bolivia, Dominican Republic and Panama (over 30%). The share of the transport sector is over 40% in Costa Rica and Ecuador. In Brazil and Chile, industry has the highest share (around 30%). Households, services and agriculture have the highest share of primary energy consumption in Nicaragua with 45%, followed by Uruguay and El Salvador (around 30%) (figure 4).

Figure 4
Primary energy consumption by main sector (2012)[a]
(Percentages)

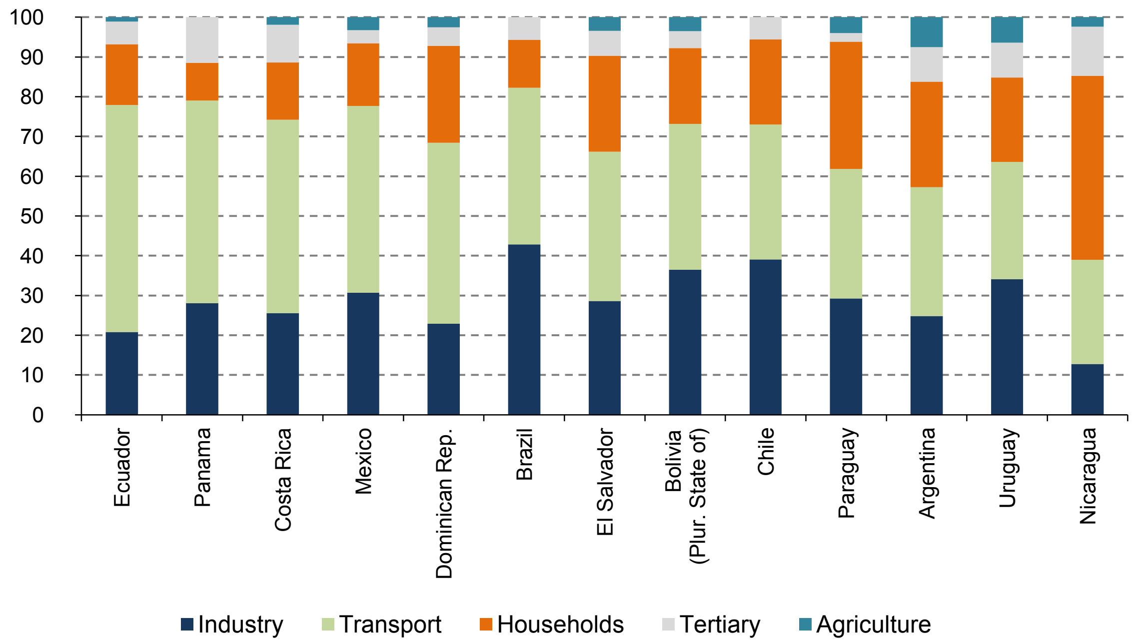


Source: BIEE Programme, ECLAC.
[a] Argentina: 2010. Bolivia, Brazil, Chile, Paraguay, Dominican Republic, Uruguay: 2011.

2. Final consumption

The final energy consumption of the countries participating in the BIEE Programme was around 450 Mtoe in 2012, with a growth of 2.6% per year since 2000. Transport accounts for the highest share in Ecuador (61%), Panama, Costa Rica, Mexico and the Dominican Republic (45-50%). Industry has an important contribution in Brazil and Chile (43 and 39%, respectively of the final consumption). Households absorb the largest share of this final consumption in Nicaragua and Paraguay (46 and 32% respectively) (figure 5).

Figure 5
Breakdown of final energy consumption by sector (2012)[a]
(Percentages)

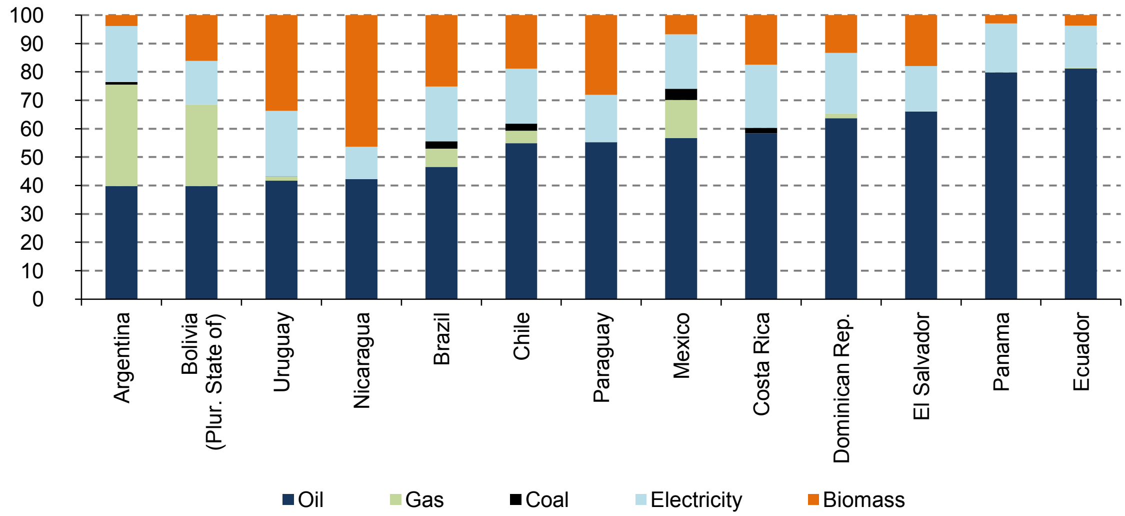


Source: BIEE Programme, ECLAC.
[a] Argentina: 2010. Bolivia, Brazil, Chile, Paraguay, Dominican Republic, Uruguay: 2011.

Oil is the main energy source of final energy consumed in the countries participating in the BIEE Programme: between 40 and 80%; with the highest share observed in Ecuador and Panama and the lowest in Argentina and Bolivia (figure 6). Gas is important in Argentina and Bolivia with a share of 36% and 29%, respectively, followed by Mexico (13%). The average penetration of electricity in the countries participating in the BIEE Programme is 19%, in a range between 11% (Nicaragua) and 23% (Uruguay, Costa Rica). Biomass is significant in Nicaragua, where it supplies almost half of the final consumption, as well as in Uruguay (34%), Paraguay (28%) and Brazil (25%). Coal is generally marginal and mainly used in steel industry (around 3% in Mexico, Brazil and Chile).

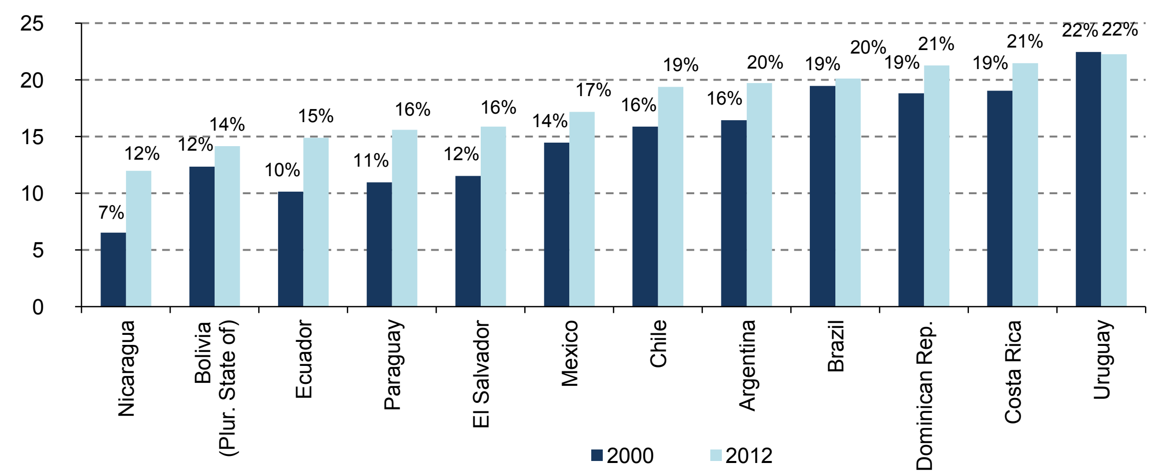
Electricity is at the heart of economic and social development of all these countries. Its share in final energy consumption grew in all the countries participating in the BIEE Programme, except Brazil and Uruguay (figure 7): the sharpest increases have been observed in Nicaragua, Ecuador and Paraguay (+5 points). This upward trend is linked to demographic change, industrialization, development of ICTs (Information and Communication Technologies) and air conditioning in services, as well as to the increasing ownership of households appliances (refrigerators, TV and air conditioning) and, in the case of Nicaragua, to the electrification of rural areas.[10]

Figure 6
Breakdown of final consumption by energy source (2012)
(Percentages)



Source: BIEE Programme, ECLAC.

Figure 7
Share of electricity in final energy consumption[a]
(Percentages)

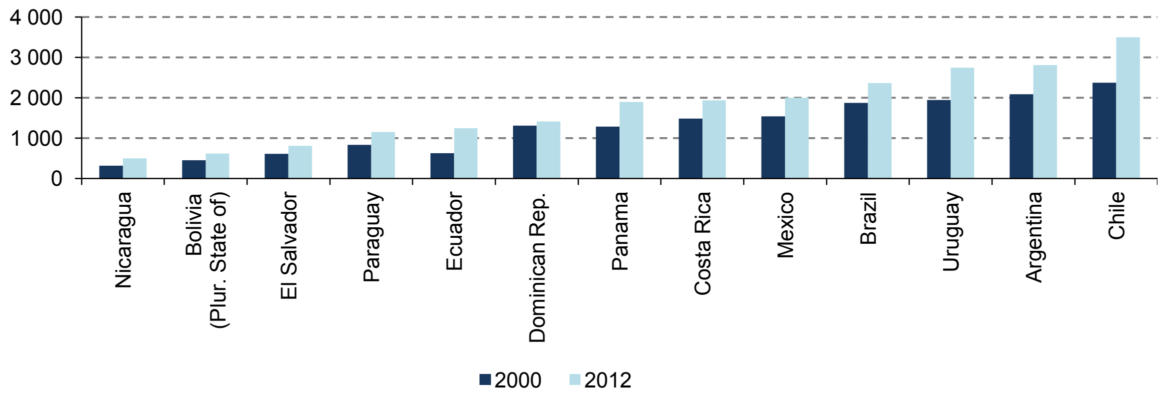


Source: BIEE Programme, ECLAC.
[a] Argentina: 2010. Bolivia, Brazil, Chile, Paraguay, Dominican Republic, Uruguay: 2011.

[10] In Nicaragua, the electrification rate grew from 49% in 2000 to 73% in 2012.

Nicaragua had the lowest electricity consumption per capita with 500 kWh[11] in 2012, followed by Bolivia (630 kWh) and El Salvador (810 kWh).[12] The largest consumer per capita is Chile with around 3,500 kWh. The electricity consumption per capita increased rapidly in half of the countries (over 3%/year), especially in Ecuador, Nicaragua and Bolivia (over 4% per year) (figure 8).

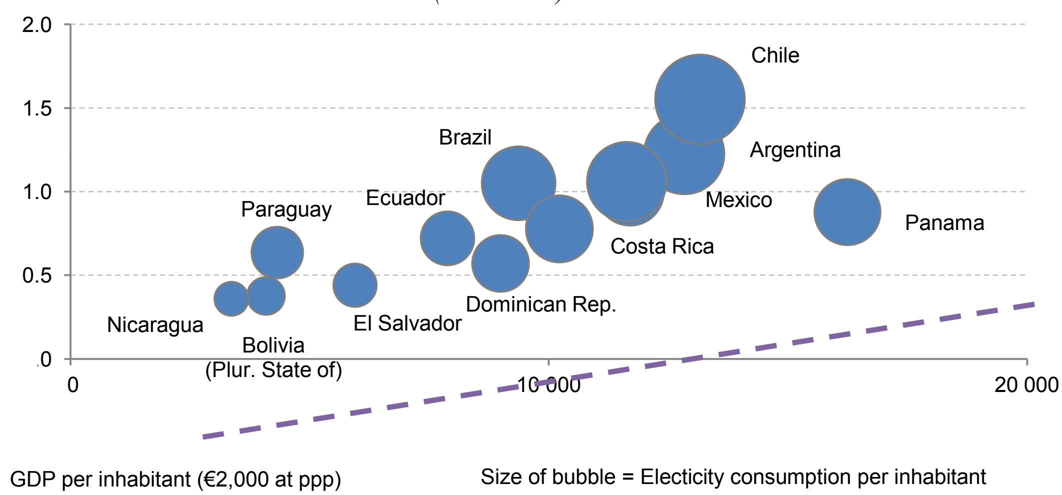
Figure 8
Electricity consumption per capita (electrified)[a]
(Kwh/inhab.)



Source: BIEE Programme, ECLAC.
[a] Argentina: 2010; Brazil, Chile, Paraguay, Dominican Republic, Uruguay: 2011. Bolivia: 2004-2012.

There exists generally a strong correlation between the final energy consumption per capita and per capita income: the higher the GDP per capita, the higher the energy consumption and electricity consumption per capita. Only Panama bucks the general trend due to the activity of the canal, which creates high added value without increasing energy consumption (figure 9).

Figure 9
Final energy consumption and GDP per capita (2012)
(Toe/inhab.)



Source: BIEE ECLAC; GDP at purchasing power parities.

[11] Total electricity consumption divided by the electrified population.
[12] Calculated based on the electrified population to make the comparison more meaningful.

B. Trends in primary and final energy intensities

The most common indicator used to evaluate the overall energy performance of countries is the primary energy intensity, i.e. the total amount of energy required to produce one unit of GDP. However, the energy intensity appears more as an indicator of "energy productivity" than a real indicator of energy efficiency, from a technical point of view or in relation to energy efficiency policies.

Energy intensity is nonetheless the only indicator that allows comparing the overall energy efficiency performance between countries, even if the observed differences also include other factors not linked to energy efficiency, such as: (i) economic structures, namely the contribution of the different sectors to GDP, (ii) the power generation mix (thermal, nuclear and renewable), (iii) the importance of other transformations (as in case of Argentina, Bolivia, Ecuador or Mexico with the hydrocarbon sector), (iv) the climate, and (v) lifestyles and economic development in general. In this report different indicators will be presented and corrected from some of these various effects to get a clearer picture of energy efficiency trends and levels in the different countries.

Within the framework of the European project ODYSSEE MURE, energy efficiency gains are measured by an energy efficiency index calculated for each consumer sector (ODEX).[13] However, this index requires a large amount of data and could not be calculated for most of the countries.

When comparing energy intensities, GDP need to be converted from national currencies to a common currency, for instance $ or €.[14] Conversions are usually made on the basis of market exchange rates, causing:

- The relative energy intensity between countries (the “ranking”) is affected by fluctuations in market exchange rates which can vary quite a lot even if the relative energy productivity did not change.
- This conversion does not reflect the fact that consumer prices are on average quite different among countries; for instance between Bolivia and Chile and even more if compared to OECD countries (for instance, the average cost of living in 2012 according to World Bank/IMF as measured with purchasing power parities is 3.5 times lower in Bolivia than in France; 2.5 times for Argentina and 1.7 times for Brazil): this means that an income of $1,000 in Bolivia is equivalent to $3,500 in France.

For these reasons, comparison of economic indicators among countries is more relevant if it is based on purchasing power parities rather than on exchange rates. In the case of energy intensities, let us take an example with the intensity of an industrial branch to illustrate why purchasing power parities are more appropriate.

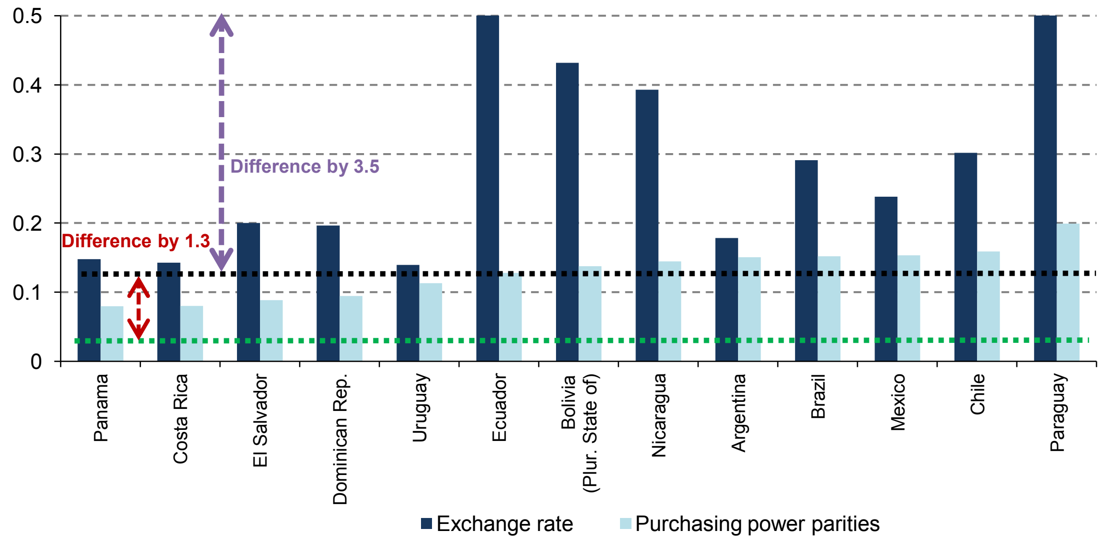
Let us consider two factories producing cars: one in France and one in Argentina, with the same technical performance, i.e. the same energy input per car produced (in toe or GJ per car). The added value of each car is mainly comprised of salaries (capital costs and profits also included), whose relative level across countries is mainly influenced by the average difference in the cost of living (2.5 times lower for Argentina according to World Bank). This means that with the same technical performance, the energy used per unit of added value (“energy intensity”) for the car industry will be 2.5 times higher in Argentina than in France with exchange rates but the same at purchasing power parities.

Primary intensities at exchange rates vary in a range of 3.5 between the lowest levels (Uruguay, Panama and Costa Rica) and the highest value (Ecuador) (figure 10). The gap between countries is narrower at purchasing power parities (ppp) (difference of 1.3 between the lowest value, Panama, and the highest, Paraguay). Using purchasing power parities reduces the intensity differences

13 More information about ODEX: http://www.odyssee-indicators.org/registred/definition_odex.pdf.
14 In the BIEE template both conversions are proposed.

by increasing the value of GDP of the less developed countries with a lower cost of living (case of Bolivia, Ecuador, Paraguay and Nicaragua): the intensity at ppp is more than 60% lower than at exchange rate in these four countries.

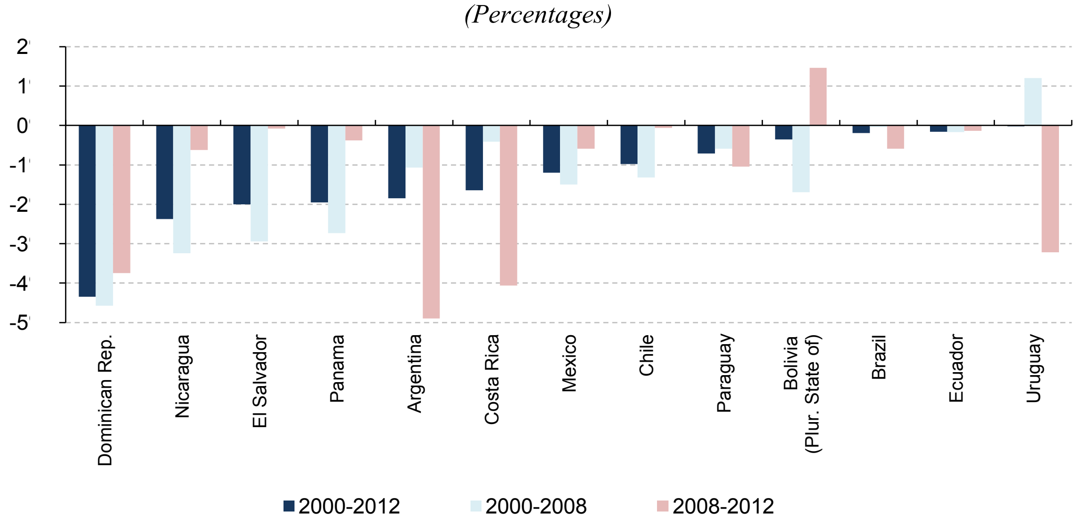
Figure 10
Primary energy intensity: exchange rate versus purchasing power parity (2012)
(Kep/$2000)



Source: BIEE Programme, ECLAC

Over the period 2000-2012, the primary energy intensity of all countries has decreased; the biggest decrease was observed in The Dominican Republic (above 4%/year) and the lowest in Uruguay (no significant change) (figure 11). Since 2008, the economic and financial crisis has slowed the intensity decline in half of the countries; it even led to an increase in Bolivia. However, since 2008 the reduction has been faster in Argentina, Costa Rica, Brazil and Uruguay.

Figure 11
Primary energy intensity trends (2000-2012)[a]
(Percentages)



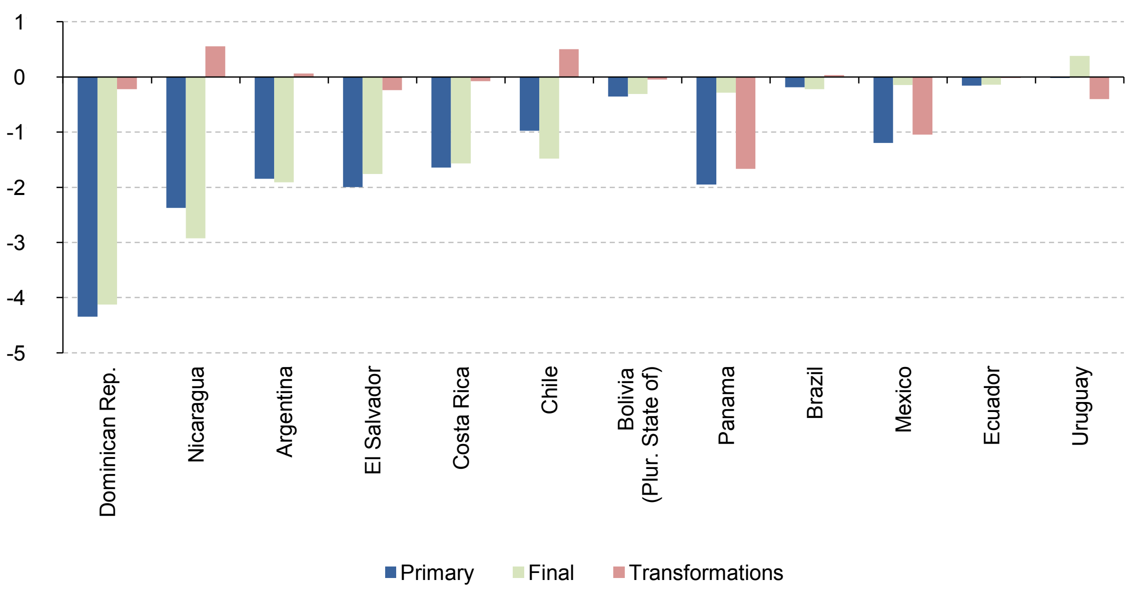
Source: BIEE Programme, ECLAC.
[a] Although climate may have a significant impact on energy consumption in the household and tertiary sectors, the intensity is not corrected for climate variation here due to a lack of reliable data on heating and cooling degree days.

Final intensity is decreasing in most countries, with a rather rapid reduction in the Dominican Republic (by 4%/year), Nicaragua and Paraguay (over 2%/year).

In Chile and Nicaragua, final intensity decreased more rapidly than primary intensity (figure 12).[15] In other words, energy productivity improved faster for final consumers. In Chile, this trend is due to a higher consumption by the energy sector (representing the difference between the primary and final consumption): such a trend is mainly explained by higher losses in power generation, linked to a lower share of hydro in the power mix, and to the rapid growth of electricity consumption, which, all things being equal, raise the losses of the power sector.

The reverse was the case for Panama, Mexico and, to a lesser extent Uruguay. Especially, in Uruguay, the energy sector has contributed to the reduction of the primary intensity as the power generation improved its efficiency with the penetration of gas combined cycles and renewables (figure 13). In Ecuador, Brazil, Bolivia, Costa Rica and Argentina there was no significant difference in the primary and final energy intensity trends.

Figure 12
Trends in primary and final energy intensity (2000-2012)
(Percentages)

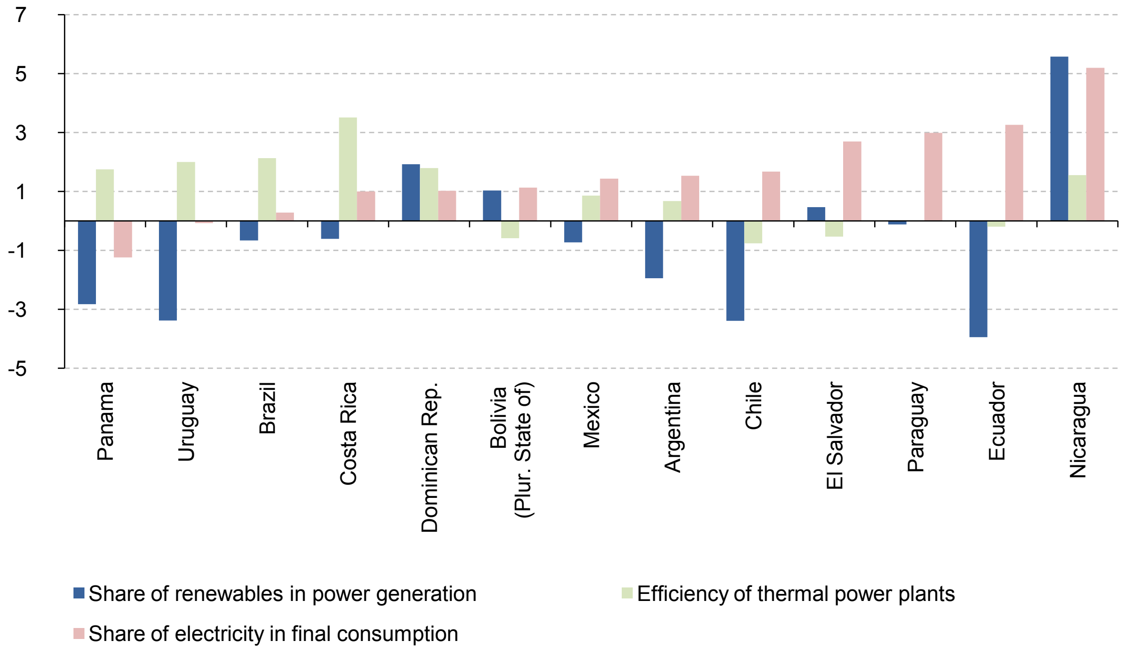


Source: BIEE Programme, ECLAC.

Electricity intensity has been increasing in 8 countries (figure 14). This growth is linked to the rapid rise in electricity demand across sectors, especially for households, due to the increasing number of electrical appliances and, in the case of Nicaragua, Ecuador, Paraguay and Bolivia, the electrification of rural areas.

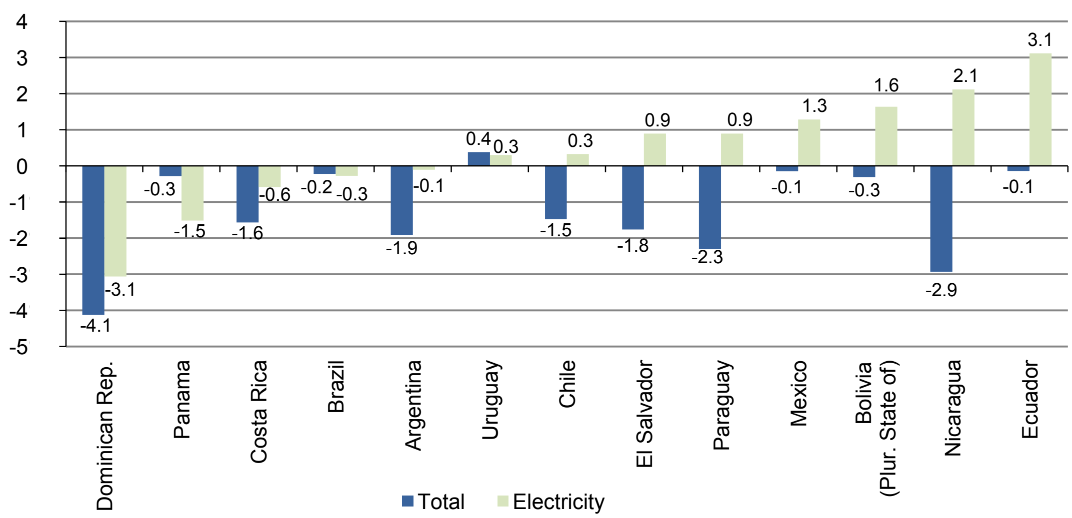
[15] See further analysis on the energy sector.

Figure 13
Share of renewables in power generation, efficiency of thermal power and electricity penetration
(Percentages)



Source: BIEE Programme, ECLAC.

Figure 14
Trends in final energy intensity: total and electricity (2000-2012)
(Percentage/year)

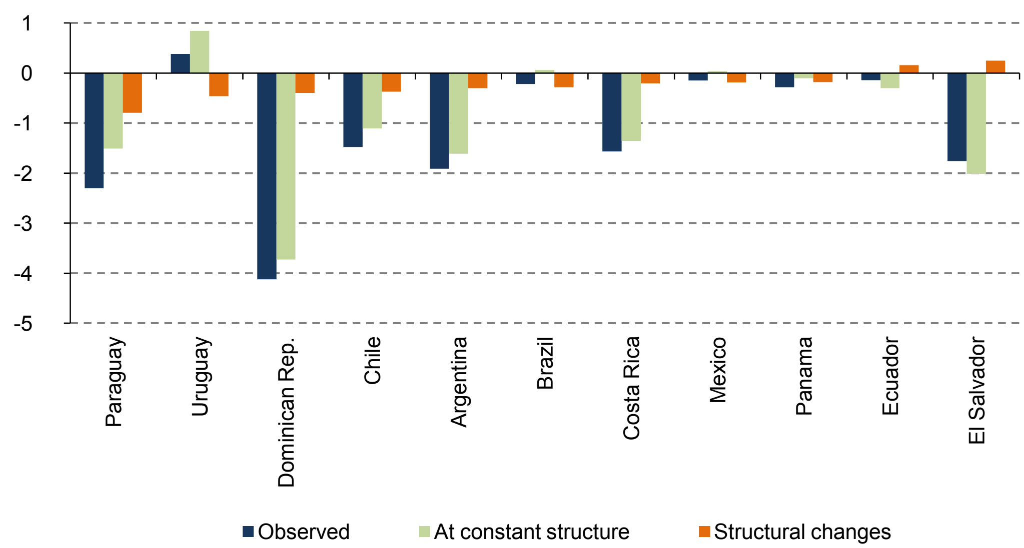


Source: BIEE Programme, ECLAC.

As all sectors do not have the same energy intensity, part of the variation in final energy intensity may be due to structural changes in the GDP, i.e. in the contribution of the three main economic sectors in the GDP (agriculture, industry and services). To assess the progress of energy efficiency in the different countries, it is more relevant to exclude these structural changes. This is obtained by calculating final energy intensity at constant GDP structure, assuming a constant share of agriculture, industry and services in GDP. The difference between the variations of the intensity at constant structure and the observed intensity shows the influence of these structural changes.

In Argentina, Costa Rica, and Chile final energy intensity has been decreasing faster than the intensity at constant structure: this means that part of the decrease was explained by structural changes, mainly the increase in the share of services, less energy intensive sectors (figure15). The share of services in the GDP has increased by 5 points in Costa Rica and Chile and by 4 points in Mexico between 2000 and 2012 (figure 16).

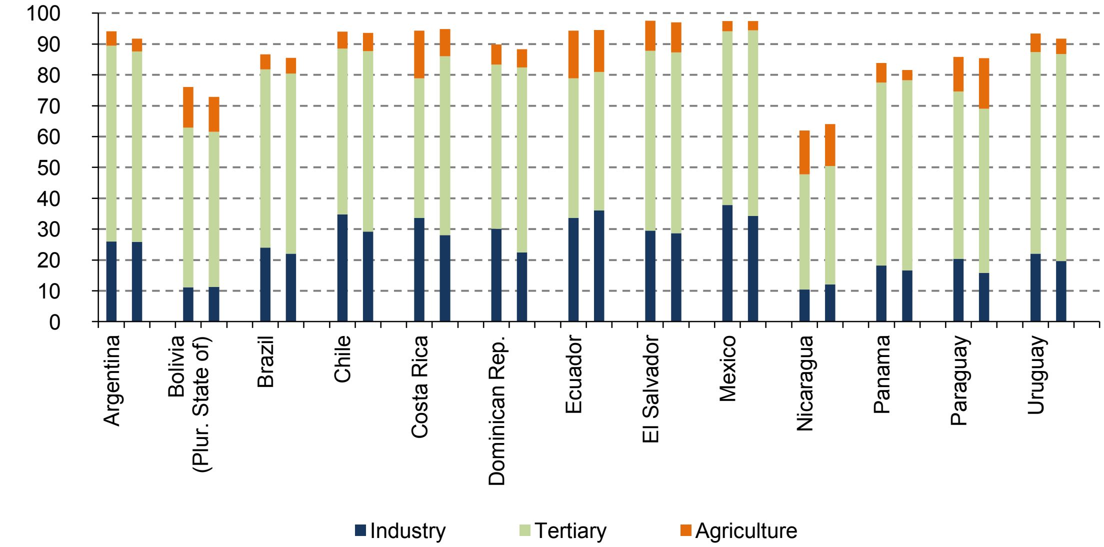
Figure 15
Impact of structural changes in GDP on final intensity (2000-2012)
(Percentage/year)



Source: BIEE Programme, ECLAC.

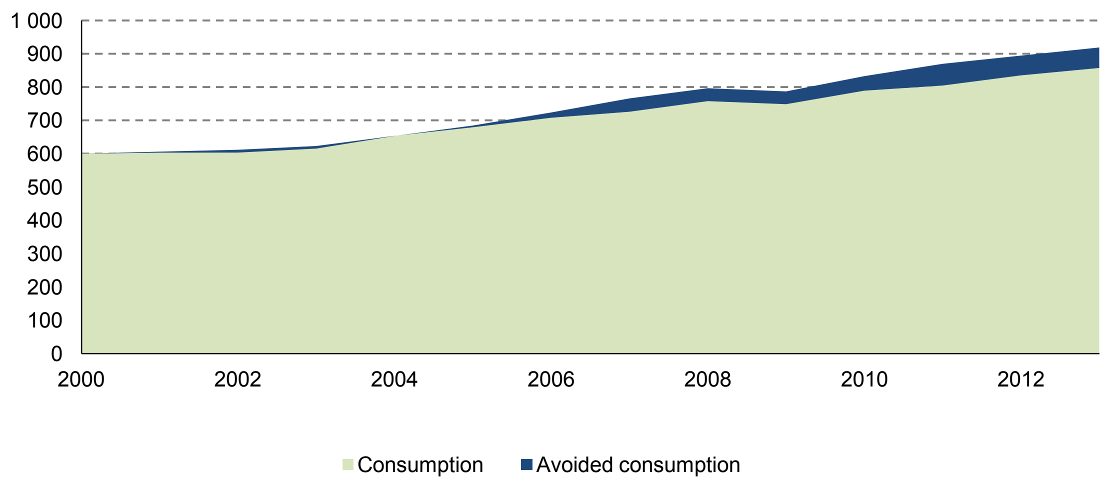
The decrease in primary energy intensity implies that less energy was consumed in 2013. The energy consumption avoided can be calculated as the difference between a theoretical consumption, calculated at constant energy intensity of a base year (2000) and the observed consumption. The primary energy consumption avoided totalled 62 Mtoe for Latin America as a whole in 2013, which represents 7% of the primary energy consumption for that year. In other words, without the intensity reduction, the primary energy consumption would have been 7% higher than what was observed in 2013 (figure 19). This avoided consumption is mainly visible since 2004 and is somehow less important than in other world regions.

Figure 16
Change in GDP structure (2000-2012)
(Percentages)



Source: BIEE Programme, ECLAC.

Figure 17
Avoided energy consumption from declining intensity in Latin America
(Mtep)



Source: Enerdata.

II. Energy efficiency trends in the energy sector

The energy sector's consumption corresponds to the energy consumption and losses in energy transformations. It includes the net consumption for power generation,[16] consumption and losses in oil and gas production, in refining, in LPG, LNG or biofuel plants, as well as the T&D power losses.

In countries that are not major fuel producers and which have a high share of thermal power, the energy sector's consumption mainly corresponds to losses in thermal power plants: this is the case of El Salvador, Costa Rica, Nicaragua or Panama, where power generation represents around 90% of the sector's consumption. In Chile and Uruguay this share is around 75%.

In oil and gas producing countries, such as Argentina, Bolivia, Ecuador or Mexico, the consumption of the power sector represents around 50-60% of the energy sector's total consumption.

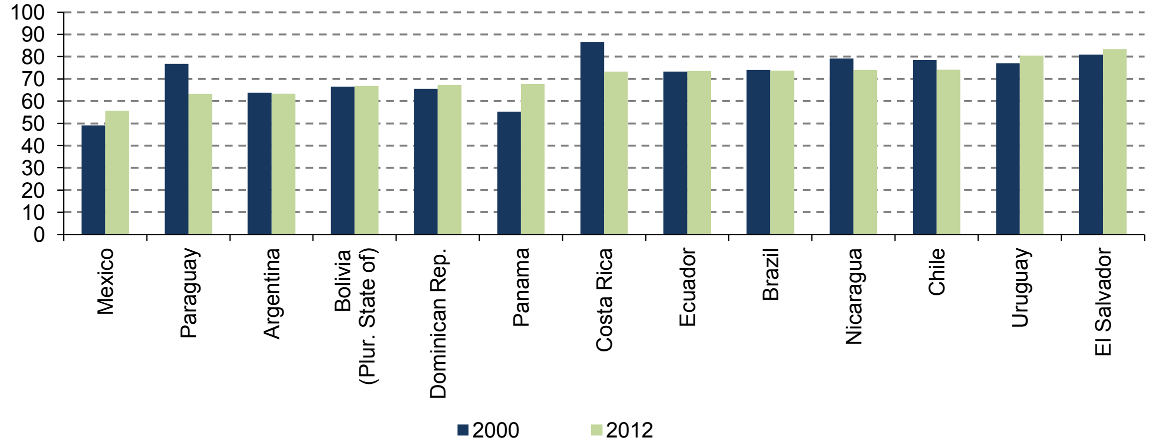
In countries with a high share of power production from renewables, power generation represents a limited share of the energy sector's consumption (almost 0% in Paraguay, around 30% in Brazil).

The overall performance of the energy sector is calculated by calculating the ratio between the final energy consumption and the primary energy consumption: the higher the ratio, the higher the share of primary energy reaching final consumers and, therefore, the more efficient is the sector.

The efficiency of the energy sector varies from 55% in Mexico to 81% in El Salvador. The high efficiency in El Salvador and Uruguay is due to the high share of renewables in power generation. Overall efficiency is only 55% in Mexico because of the importance of the oil and gas sector and of non-renewable power generation. Efficiency has been increasing between 2000 and 2012 in Mexico, Panama, Uruguay and El Salvador due to energy efficiency improvement in power production (figure 18).

[16] The net consumption of power generation is equal to the inputs for power generation minus the quantity of electricity produced. For hydro, wind and solar PV, the inputs are by definition equal to the output, as the production of electricity from these renewable sources is considered to have an efficiency of 100%: this means that the net consumption is equal to zero.

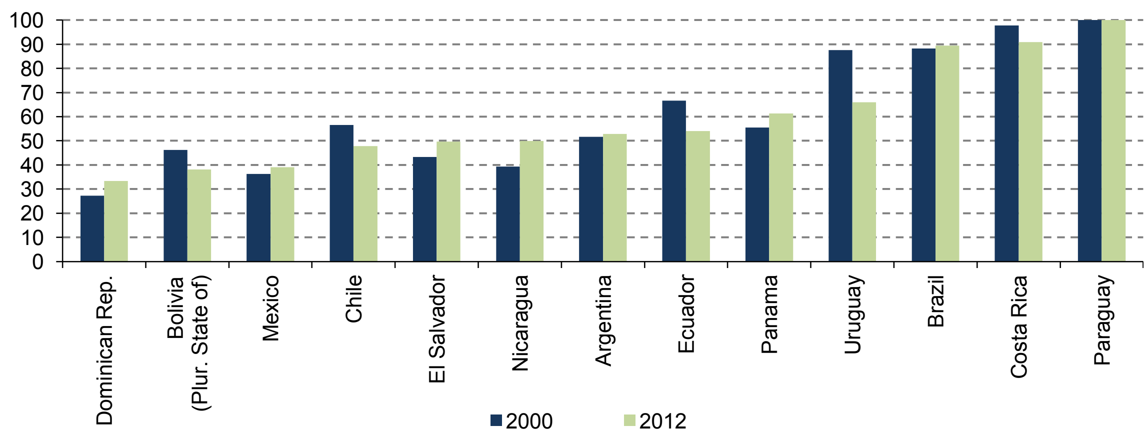
Figure 18
Overall efficiency of the energy sector
(Percentages)



Source: BIEE Programme, ECLAC.

The efficiency of power generation is influenced by the electricity mix (share of renewables and nuclear energy) and the efficiency of thermal production. Costa Rica and Brazil are the two countries with the highest performance (about 90%). The countries with the highest increase are Nicaragua, Dominican Republic, Panama and El Salvador (+11 points for Nicaragua and 6 points each for the others) (figure 21). This good result is explained by the sharp increase in the share of renewables in power generation[17] (+ 18 points in Nicaragua) and the rapid diffusion of gas combined cycles. The average power efficiency decreased in several countries especially in Uruguay (-20 points), Ecuador (-13), Chile (-9), because of a reduction in the share of renewables (-29 points in Uruguay, -18 points in Ecuador and -16 points in Chile).

Figure 19
Efficiency of power generation
(Percentages)

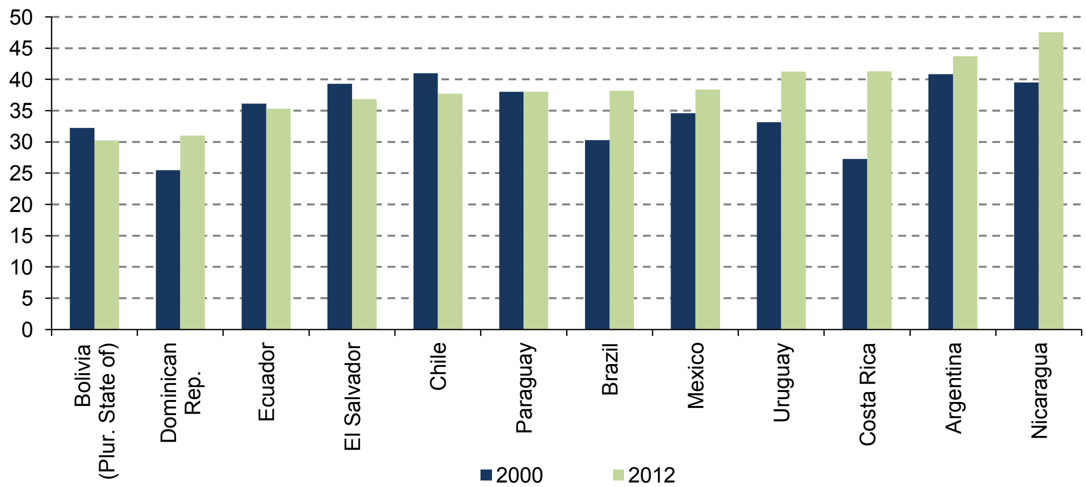


Source: BIEE Programme, ECLAC.

[17] The penetration of renewables in the power mix improves the average efficiency of power generation as they have an efficiency rate of 100%.

Argentina and Nicaragua are the countries with the most efficient thermal generation (48% and 44% respectively), due the high share of gas-fueled combined cycle generation in the power mix (figure 20). Bolivia and The Dominican Republic have the lowest thermal efficiency at about 30%. The efficiency of thermal power plants improved the most in Costa Rica, Uruguay and Brazil, also due to the high penetration of gas combined cycles.

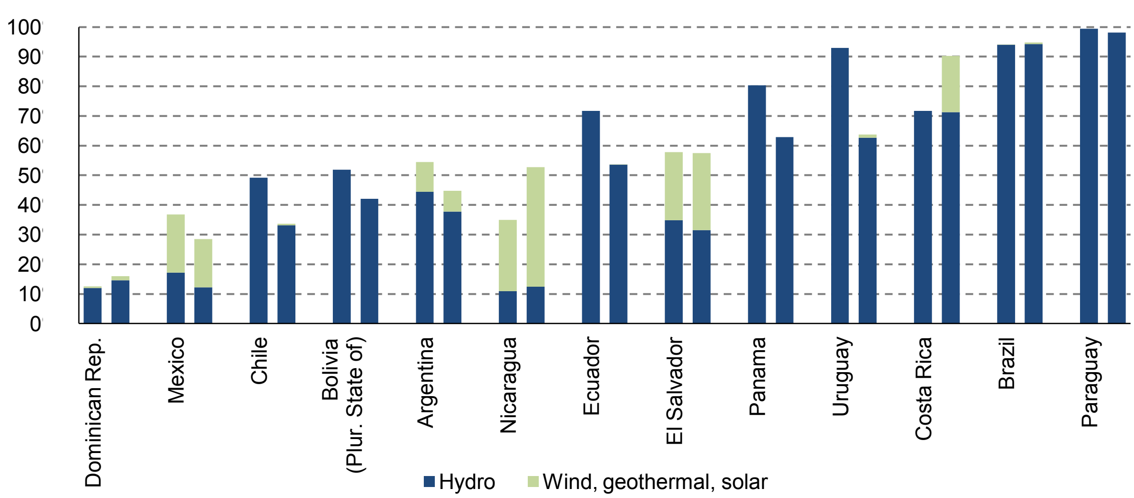
Figure 20
Efficiency of thermal power plants
(Percentages)



Source: BIEE Programme, ECLAC.

The share of hydropower in power generation has decreased in most countries since 2000; it remained rather stable in Brazil, Paraguay, Costa Rica and Nicaragua. Four countries had a high share of geothermal energy and to a lesser extent wind in 2012: Nicaragua came first with 40%, followed by El Salvador (26%), Costa Rica (19%) and Mexico (16%) (figure 21).

Figure 21
Share of renewable sources in electricity generation (2000-2012)
(Percentages)



Source: BIEE Programme, ECLAC.

Three main factors explain the variation of the net consumption for power generation[18] over a period:

- The increased consumption of electricity, which all things being equal, contributes to increase the losses in power generation.[19]
- Changes in the power mix between different sources with very different efficiencies ("power mix effect") , mainly between three main sources.
  - Wind, hydro, PVs (100% efficiency).
  - Thermal (between 30 and 50% depending on fuel mix and technology).
  - Geothermal and nuclear (respectively 11% and 33%).
- Variation in the efficiency of thermal power generation ("efficiency effect").

Figure 22 illustrates this decomposition in the case of Costa Rica and Brazil. The power mix and efficiency effect are calculated as the difference between the actual consumption of the power sector in 2010 and a theoretical consumption:

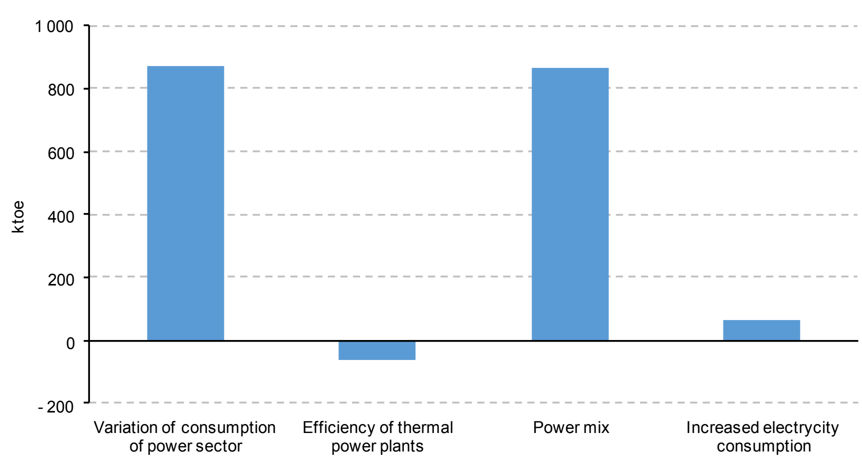
- At 2000 power mix and 2010 power efficiency for the power mix effect.
- At 2000 efficiency and 2010 power mix for the efficiency effect.

In Costa Rica, the increasing share of thermal power generation between 2005 and 2011 —from 3 to 9%— on its own contributed to increasing the power sector's consumption, and thus primary energy consumption, by around 800 ktoe. The increase in the efficiency of thermal power generation, from 31 to 37%, resulted in marginal savings (40 ktoe) due to the low share of thermal power.

In Mexico, increasing electricity consumption (3%/year) largely contributed to increasing the power sector's consumption (by 5 Mtoe), and thus the primary consumption.

Figure 22
Decomposition of variation in power sector consumption
(Ktoe / Mtoe)

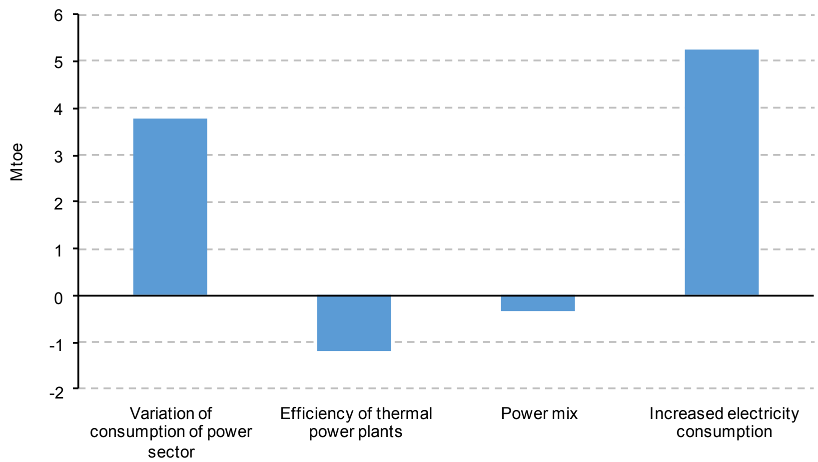
A. Case of Costa Rica, (2005-2011)



[18] Net consumption for power generation= sum of input and outputs for electricity generation.

[19] An increase in the electricity consumption of 1 Mtoe will translate into a much larger consumption in the power sector, the magnitude of which will depend on the average efficiency of power generation (e.g. + 2.5 Mtoe with an efficiency of 40%).

B. Case of Mexico (2005-2012)



Source: BIEE Programme, ECLAC.

III. Energy efficiency trends for households

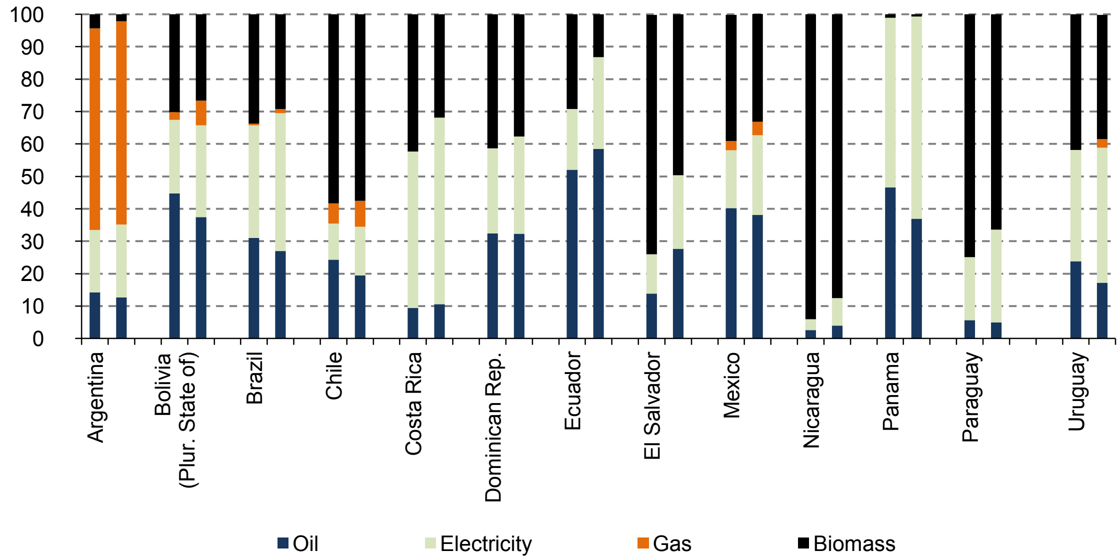
Households consume on average 21% of final energy consumed in the countries participating in the BIEE Programme (25% in 2000). However, significant differences exist among countries, with a share as low as 9% in Panama and 11% in Brazil, and as high as 46% for Nicaragua.

In most countries, the share of households in final energy consumption decreased between 2000 and 2012, except in Argentina (figure 23). This is explained by the lower use of biomass, especially in El Salvador, where the share of biomass in household consumption has decreased from 74% to 50% between 2000 and 2012 (-24 points) (figure 24); in some other countries the share of biomass has also declined significantly: Paraguay (-13 points), Costa Rica (-10) and Nicaragua (-7). Despite this trend, biomass remains the main energy source consumed by households in most of these countries, followed by electricity. Oil ha a significant share in Ecuador, Panama, Dominican Republic and Brazil.

Figure 23
Share of households in final energy consumption
(Percentages)

Source: BIEE Programme, ECLAC.

Figure 24
Final energy consumption of households by energy source (2000-2012)
(Percentages)

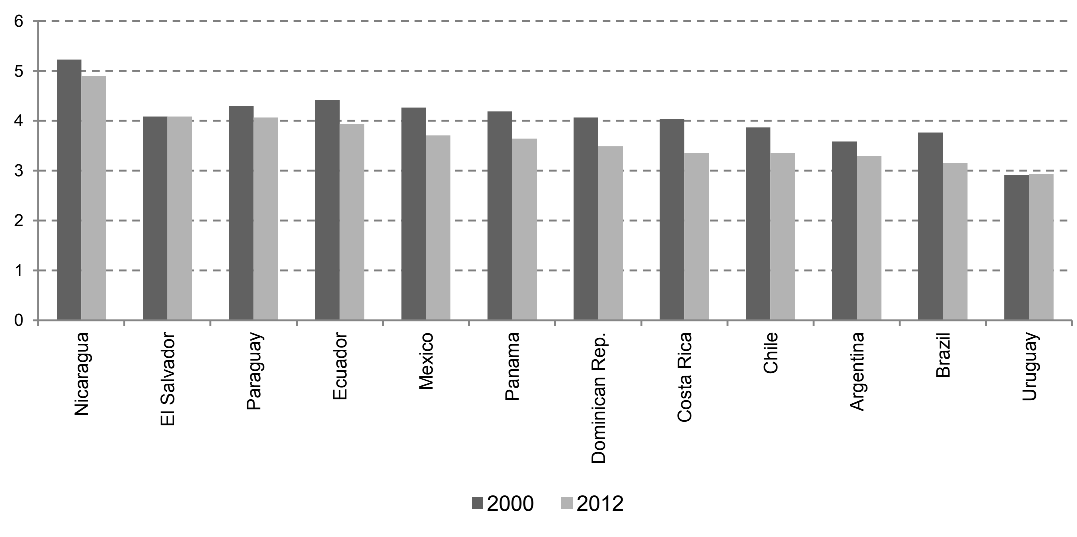


Source: BIEE Programme, ECLAC.

A. Overall trends

Growth in the number of households, one of the main drivers of the sector's energy consumption growth, was over 2%/year in most of the countries participating in the BIEE Programme from 2000 to 2012. This was the result of the combined effect of population growth and significant decline in the number of people per household (figure 26).

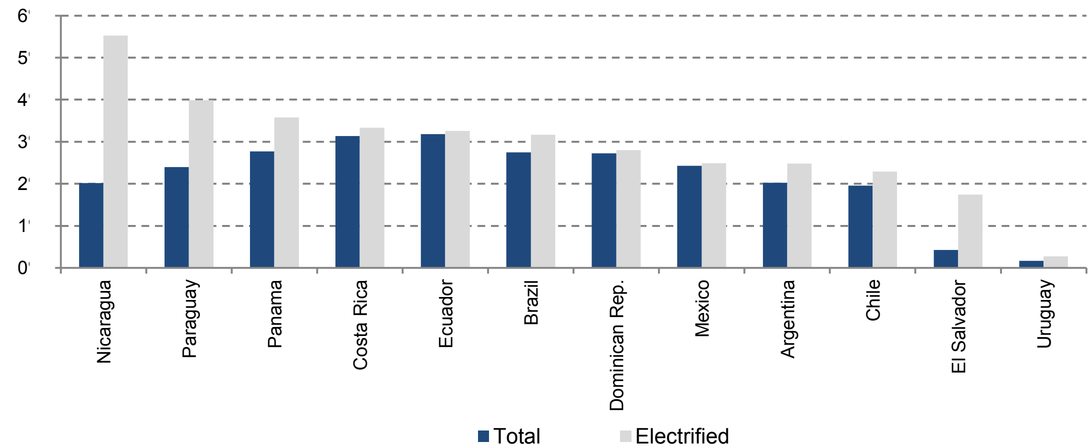
Figure 25
Trend in average household size



Source: BIEE ECLAC.

Another driver of growth in electricity consumption growth is the progress of rural electrification. This effect is particularly important in Nicaragua, where the share of electrified households increased by 25 points, from 49% in 2000 to 74% in 2012, resulting in 3.5%/year growth in the number of electrified households of between 2000 and 2012 (figure 26). The number of electrified households is a more relevant indicator to characterize the trends in household electricity consumption.

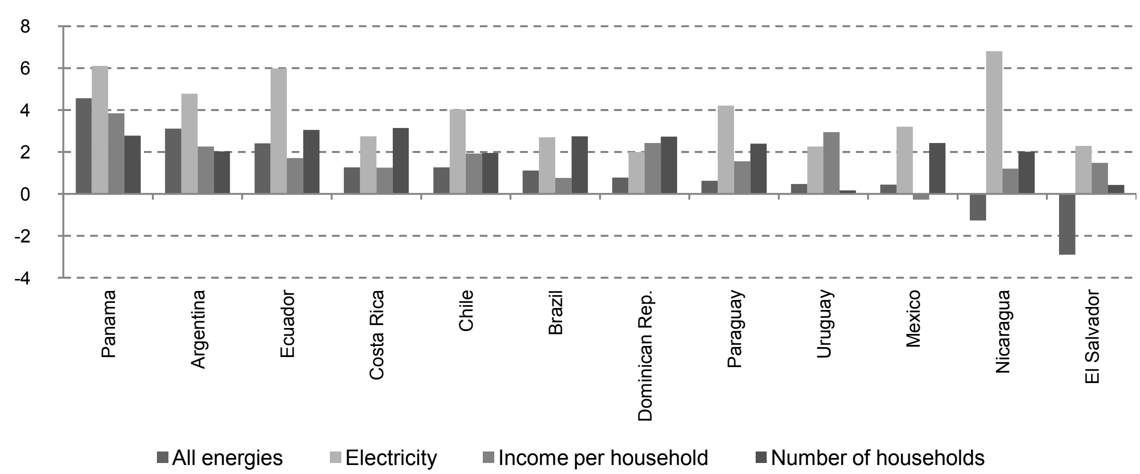
Figure 26
Trends in the number of households: total and electrified (2000-2012)
(Percentages)



Source: BIEE Programme, ECLAC.

In all countries household electricity consumption grew faster than total consumption (figure 27). This growth is directly linked to rising household income and therefore rising levels of equipment ownership, to the increase in electrification rate and to the substitution of fuels with electricity.

Figure 27
Energy consumption, household income and number of households (2000-2012)
(Percentages)

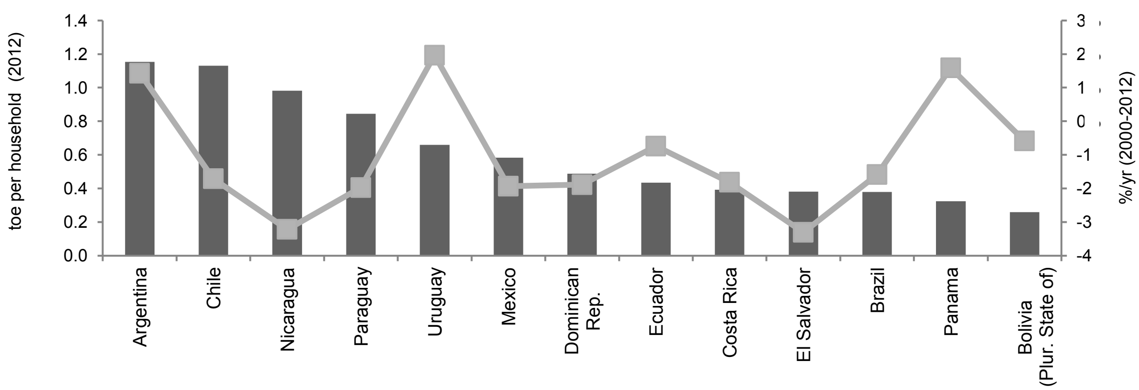


Source: BIEE Programme, ECLAC.

Average energy consumption per household ("specific consumption" varies quite significantly among the countries participating in the BIEE Programme, from 0.26 toe/household in Bolivia to around 1.15 toe in Argentina and Chile (figure 28). The high value in these two countries is due their greater heating needs, which either do not exist or are less important in the other countries; the high value in Nicaragua is linked to the massive use of biomass for cooking.

Between 2000 and 2012, this specific consumption increased in Uruguay, Panama and Argentina (by about 1.5%/year), while it has been decreasing in all the other countries mainly due to the substitution of biomass with LPG or electricity.

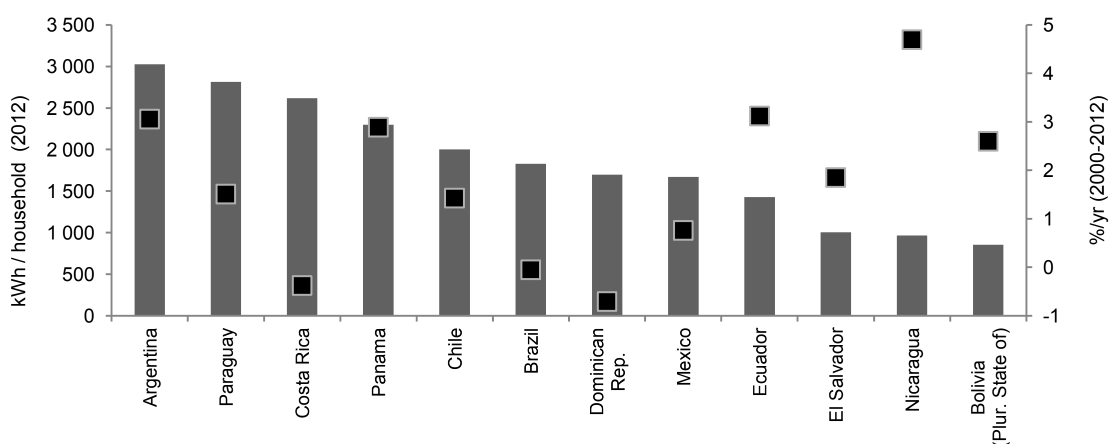
Figure 28
Average energy consumption per household



Source: BIEE Programme, ECLAC.

Average electricity consumption per household varies significantly among the countries participating in the BIEE Programme, from 850 kWh per household in Bolivia, to 1,670 kWh in Mexico and 3,000 kWh in Argentina (figure 29). It increased significantly in Nicaragua and Uruguay (over 4%/year) and to a lesser extent in the other countries (1-3%/year) because of growth in equipment ownership (refrigerators, TV, air conditioning, water heater) everywhere and also because of rural electrification in Nicaragua, Bolivia, Paraguay and El Salvador; growth was slower in Dominican Republic, Costa Rica and Brazil.

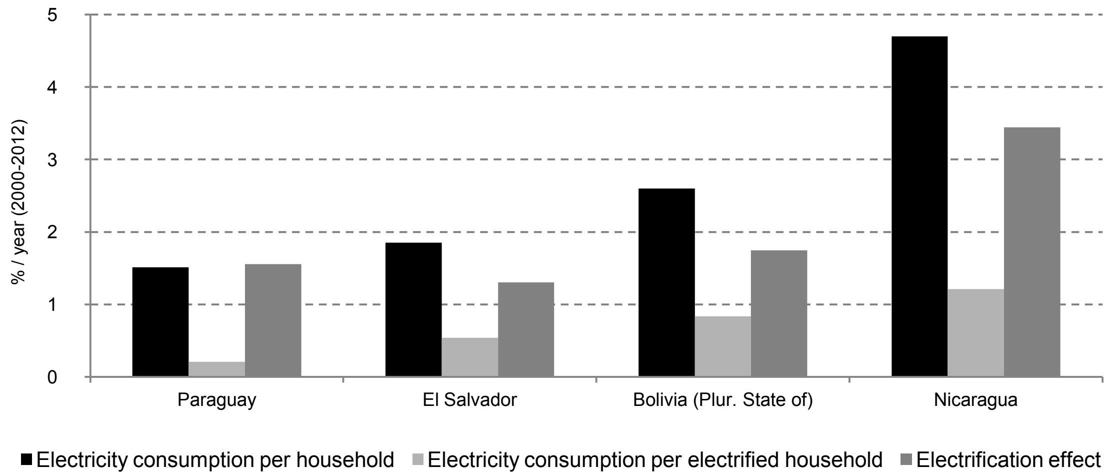
Figure 29
Average electricity consumption per household



Source: BIEE Programme, ECLAC.

In the four countries with strong growth in the electrification rate, average electricity consumption per electrified household increased less rapidly than consumption per household: the difference shows the effect of household electrification (figure 30). In Nicaragua, the sharp increase in the electrification rate, from 49 to 74% between 2000 and 2012, explains two thirds of the growth in electricity consumption per household from 2000 to 2012 and contributed to increasing the electricity consumption per household by over 3%/year. Electrification explains less than 30% of growth in electricity consumption in the other three countries.

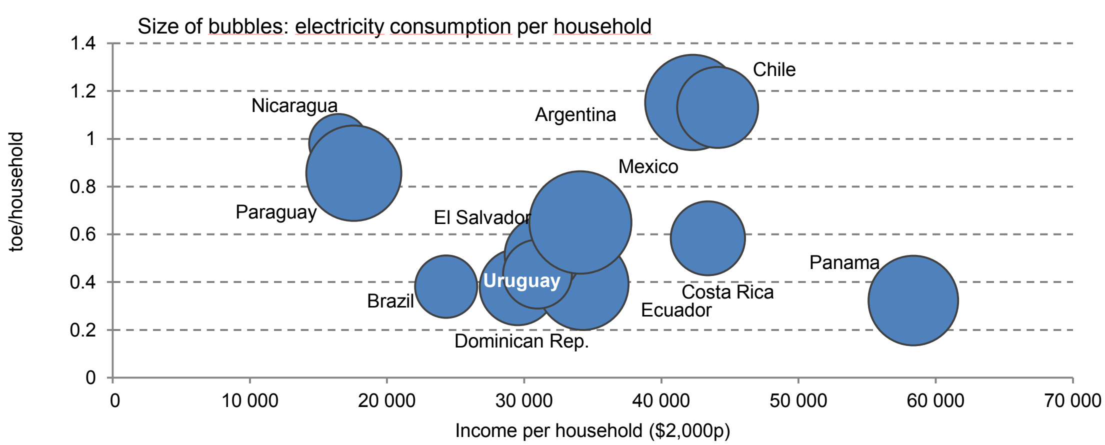
Figure 30
Effect of household electrification on unit electricity consumption



Source: BIEE ECLAC

Panama has the highest income per household and one of the highest electricity consumption rates, but its total consumption per household is low. Argentina, Costa Rica, Chile and Mexico have high electricity consumption per household. At the same level of income, there is a significant dispersion in the consumption per household, either for total consumption or for electricity alone. (figure 31).

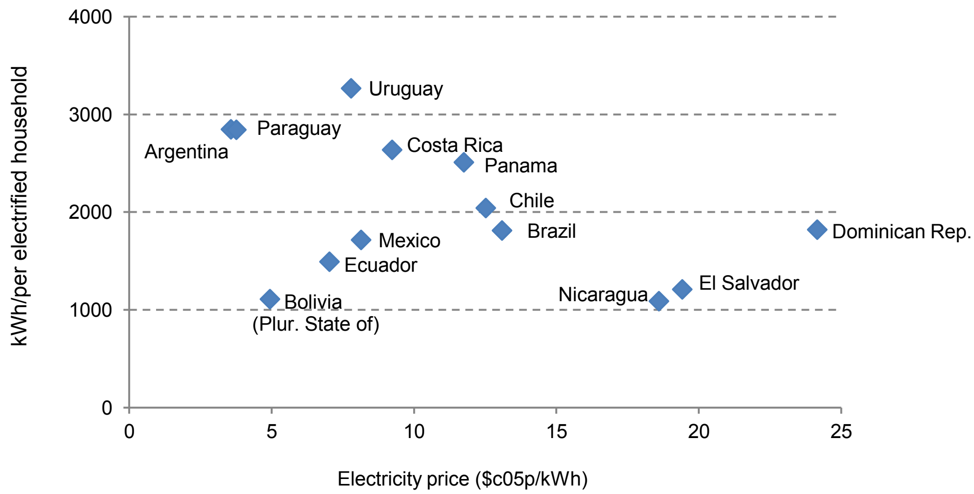
Figure 31
Energy consumption per household and income (2012)[a]



Source: BIEE Programme, ECLAC.
[a] The size of bubble measures the electricity consumption level.

Discrepancies in electricity consumption per household can be explained by differences in incomes, climate as well as in prices and policies. For instance, the Dominican Republic, El Salvador and Nicaragua, which are characterised by low income and high electricity prices (at purchasing power parities), are the countries with the lowest electricity consumption per household. However, at a similar price level, there is a wide disparity among countries in electricity consumption per household (e.g. Ecuador or Mexico and Uruguay)[20] (figure 32).

Figure 32
Electricity consumption per household and prices (2012)[a]

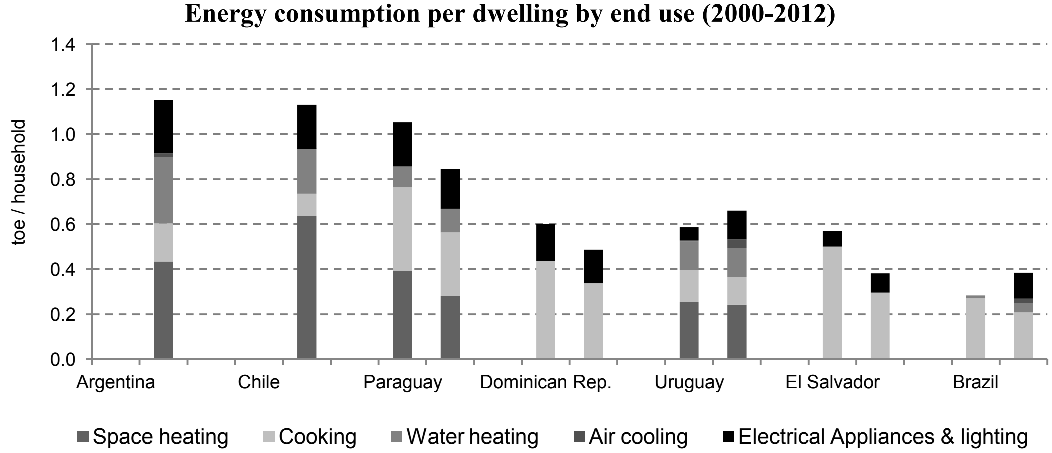


Source: BIEE Programme, ECLAC.
[a] kWh per electrified household, heating excluded.

B. Energy consumption by end use

Aside from countries with space heating needs (Chile, Argentina and to a lesser extent Uruguay and Paraguay), cooking is the dominant end use with more than 50% of household consumption (figure 33).

Figure 33
Energy consumption per dwelling by end use (2000-2012)

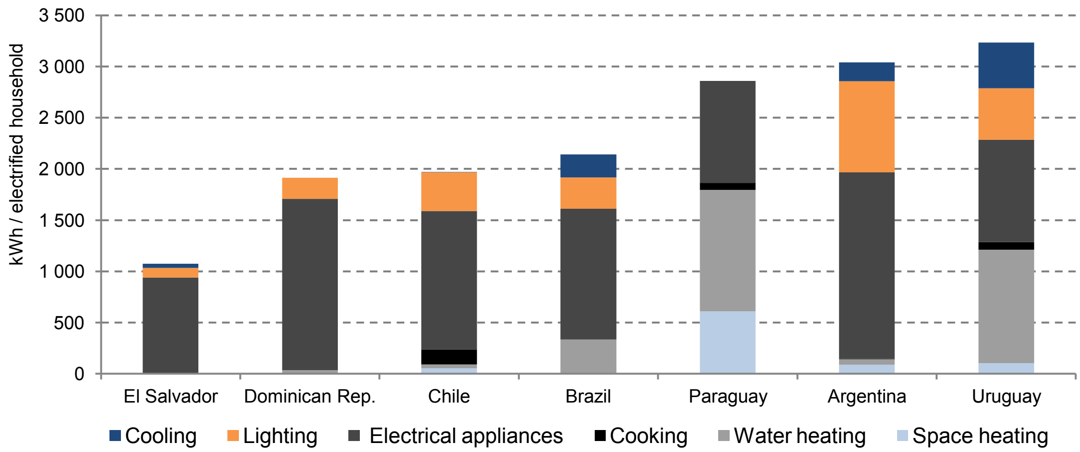


Source: BIEE Programme, ECLAC.

[20] Electricity price expressed at purchasing power parities.

Most of the electricity used by households is for appliances, such as refrigerators or TV. Water heating has also a significant share in Uruguay and Paraguay (over 30%) (figure 34). The share of cooling is the highest, among countries with data, in Uruguay and Brazil (14 and 11% respectively).

Figure 34
Electricity consumption by end use[a]

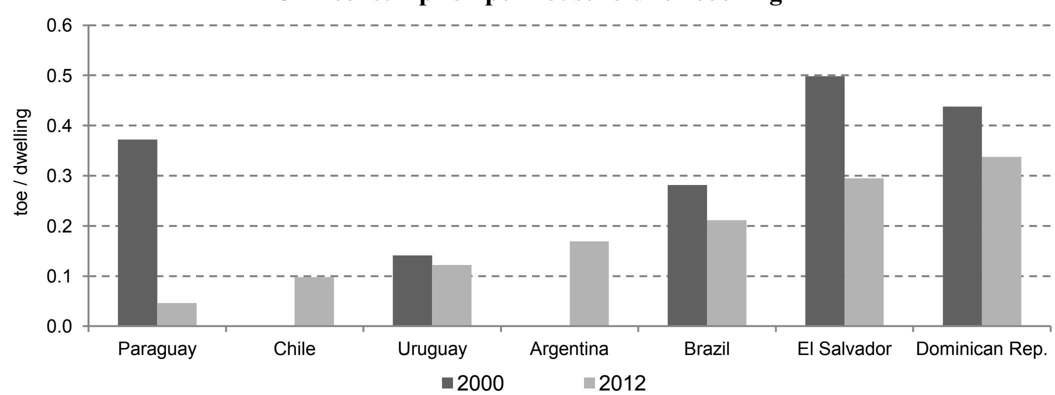


Source: BIEE Programme, ECLAC.
[a] Argentina and Chile: 2010; Uruguay and Paraguay: 2011-

1. Cooking

Unit consumption for cooking per household decreased in all countries, (figure 35). This is explained by the substitution of biomass with much more efficient modern fuels (LPG, gas and electricity).

Figure 35
Unit consumption per household for cooking

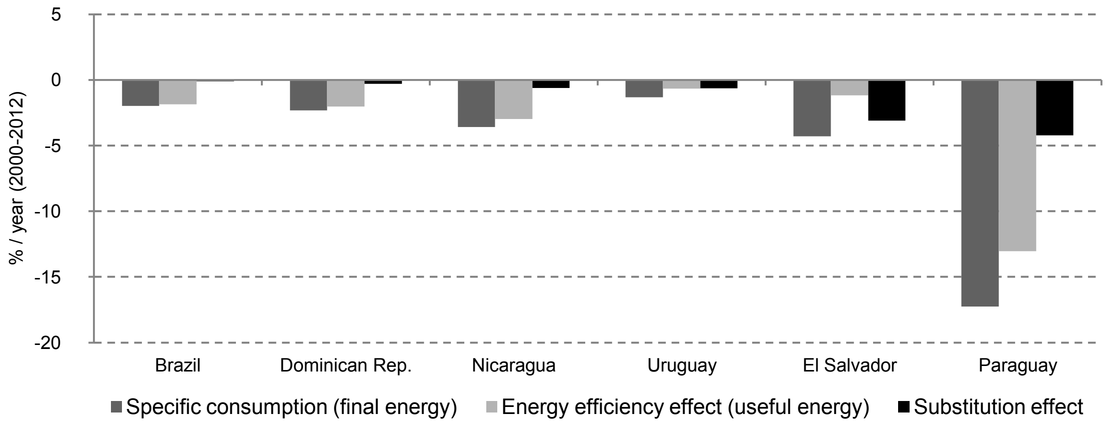


Source: BIEE Programme, ECLAC.

The effect of substituting biomass with modern fuels was the greatest in El Salvador and Paraguay: substitution of biomass with LPG in Salvador and electricity in Paraguay contributed to reducing specific consumption by over 3%/year (figure 36).[21]

[21] The substitution effect for cooking was calculated as the difference between the annual change in specific energy consumption per dwelling in final energy and useful energy. The energy efficiency effect is measured by the variation of specific consumption in useful energy. The value in useful energy is calculated by multiplying the final consumption of each fuel by its average energy efficiency (i.e. 45% for LPG and gas, 80% for electricity, 10% for charcoal and 5 % for wood).

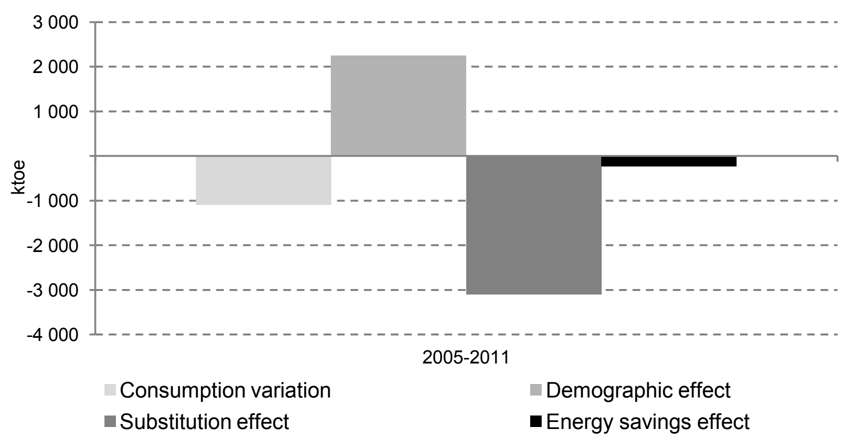
Figure 36
Consumption for cooking per dwelling and substitution



Source: BIEE, ECLAC.

In countries with a rapid transition from biomass to modern fuels, this substitution had an effect on the variation in final energy consumption by contributing to moderating its growth. The impact on consumption can be estimated by decomposing the variation in energy consumption for cooking using the above calculation, as illustrated in the case of Brazil (figure 37): substitution of biomass with LPG contributed to decrease energy consumption for cooking by a factor of 3.1 between 2005 and 2011.[22] In contrast, growth in the number of households contributed to increasing this consumption by 2.2 Mtoe. As a result, energy consumption for cooking decreased by 1.1 Mtoe over the period (e.g. 3.7%/year).

Figure 37
Decomposition of the variation in consumption for cooking: case of Brazil



Source: BIEE, ECLAC.

[22] The unit consumption effect has been divided into two components: one representing the substitution effect and one representing the energy savings effect. The energy savings effect is calculated from the unit consumption effect in useful energy. The substitution effect is calculated as the total unit consumption effect minus the energy savings effect.

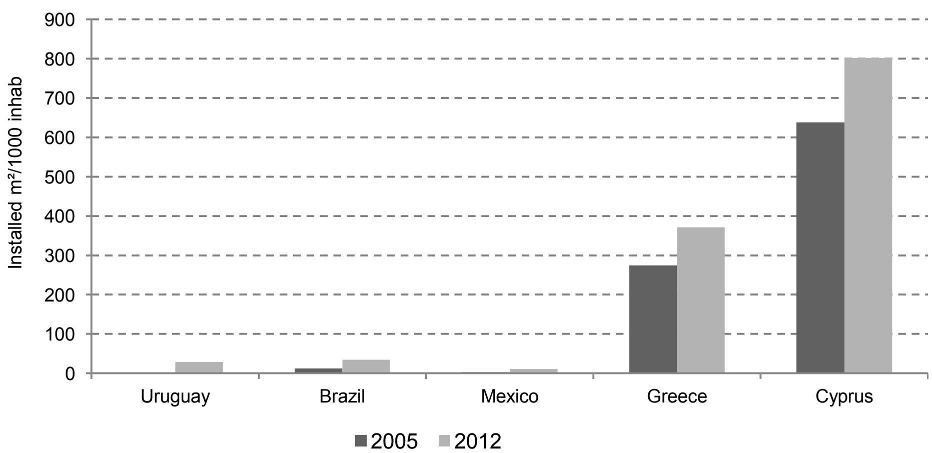
2. Water heating

The increase in unit consumption of hot water on the part of households is directly related to the needs of comfort. One way to reduce this consumption or slow its growth is to promote the installation of solar water heaters, which save conventional energy sources at the level of final consumers, to the extent that they replace electricity, LPG, natural gas or petroleum products, but also at the primary level if the electricity is generated from thermal power plants.

Brazil and Uruguay are the countries participating in the BIEE Programme with the highest penetration and the strongest growth in solar water heaters (from 1.3% to 3.5% of households in Brazil and from almost 0% to 1.2% in Uruguay between 2005 and 2012). The penetration of solar water heaters resulted in around 800 GWh of energy saving since 2005 in the case of Brazil.

The installed area of solar water-heaters is low in the countries participating in the BIEE Programme, especially when compared to some of the countries with the highest penetration, such as Cyprus or Greece: 30 and 35 m2/1,000 inhabitants in Uruguay and Brazil respectively, compared to 400 in Greece and 800 in Cyprus. This is explained by a lower use of water heating and less ambitious policies, but not really by a lower solar irradiation[23] (figure 38).

Figure 38
Equipment rate of households in solar water-heaters: comparison with EU countries



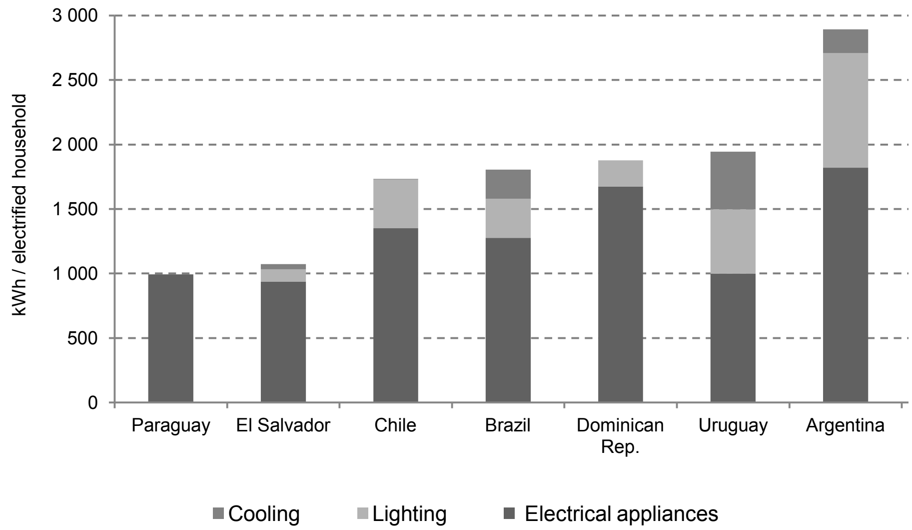
Source: BIEE, ECLAC.

3. Electrical appliances, lighting and cooling

Electrical appliances represent the bulk of electricity consumption for captive uses (i.e. excluding thermal uses like cooking or water heating, for which alternative fuels can be used (figure 39).

[23] Average solar irradiation is around 1,900 and 1,600 kWh/m2/year in Cyprus and Greece, respectively. It is around 1,800 in Chile and Brazil, 1,700 in Mexico and 1,550 kWh/m2/year in Uruguay.

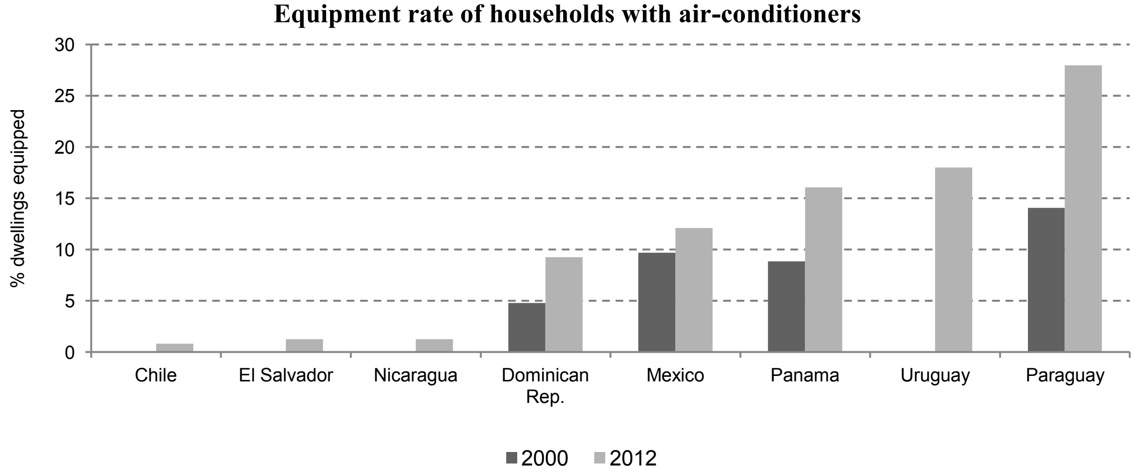
Figure 39
Specific electricity consumption for electrical appliances, lighting and cooling[a]



Source: BIEE, ECLAC.
[a] Electrical appliances include cooling for The Dominican republic and lighting and cooling for Paraguay.

The share of households with air conditioning has increased by 14 points in Paraguay and 7 points in Panama (figure 40), which probably drove the electricity consumption. However data are generally not available to capture the impact on electricity consumption. The data shown in figure 39 are mainly available for one year.

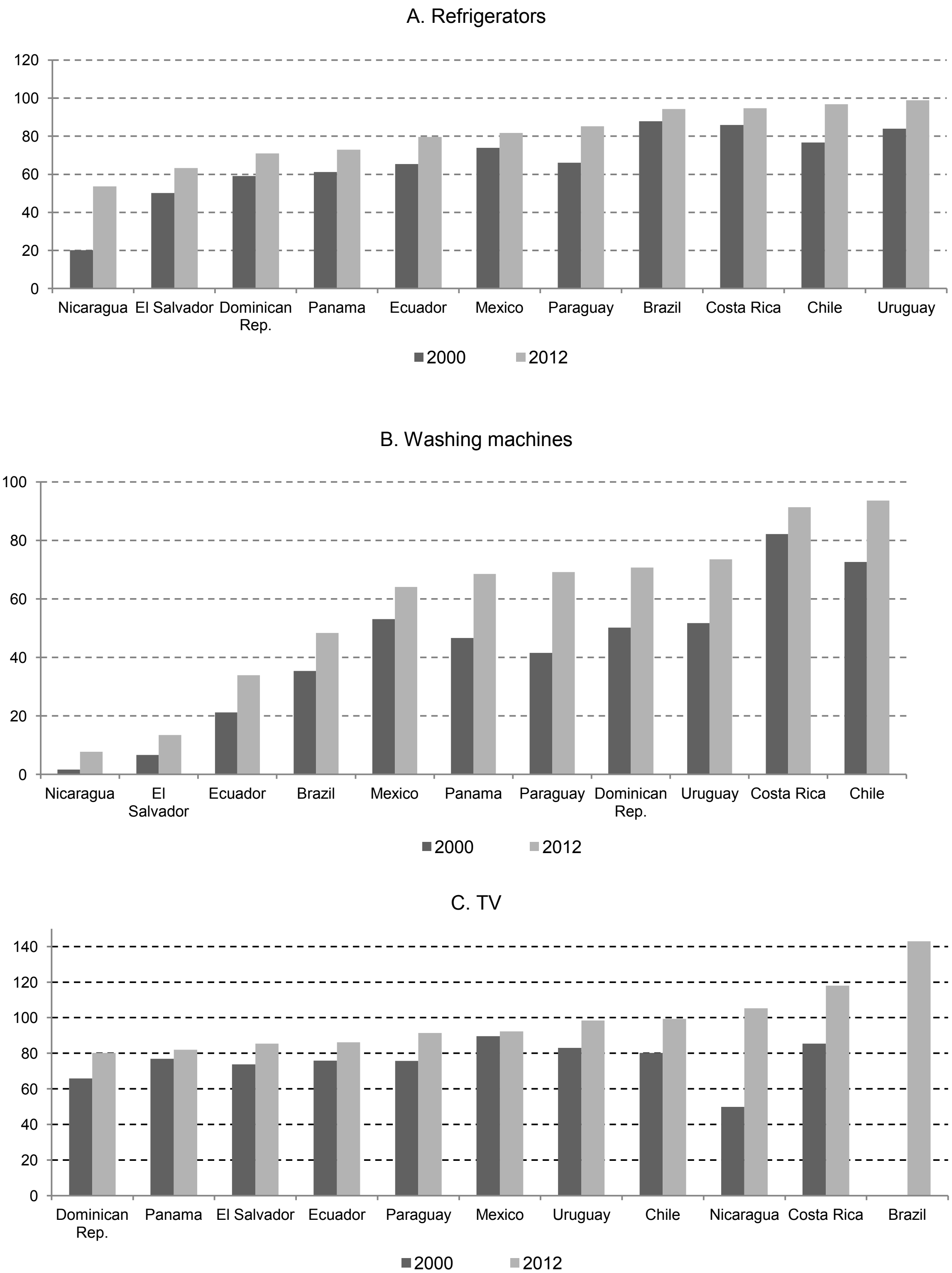
Figure 40
Equipment rate of households with air-conditioners



Source: BIEE, ECLAC.

The increase in specific electricity consumption for household appliances is the result of two opposed drivers: on the one hand, more equipment per household, as shown for large appliances (washing machines, refrigerators, TV) (figure 41); on the other hand, new appliances are generally more efficient, especially in countries with specific policies, such as Brazil, Uruguay or Chile (mainly on energy efficiency labelling).

Figure 41
Equipment rate of households in refrigerators, washing machines and TV
(Percentages)

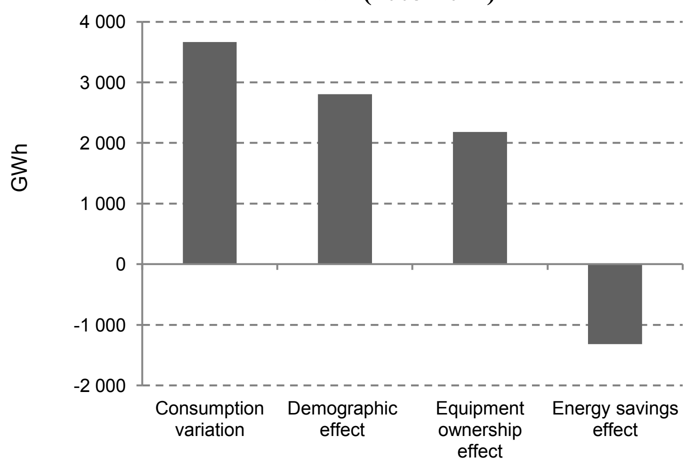


Source: BIEE, ECLAC.

Figure 42 illustrates the drivers behind the variation in electricity consumption for refrigerators in the case of Brazil between 2005 and 2012:

- The larger number of households contributed to increasing consumption by 2,805 GWh ("demographic effect").
- Growth in equipment ownership contributed to a further 2,180 GWh increase.
- However, the consumption of refrigerators only increased by 3,665 GWh, and not by 5,985 GWh, as energy savings contributed to reducing consumption by 1320 GWh.

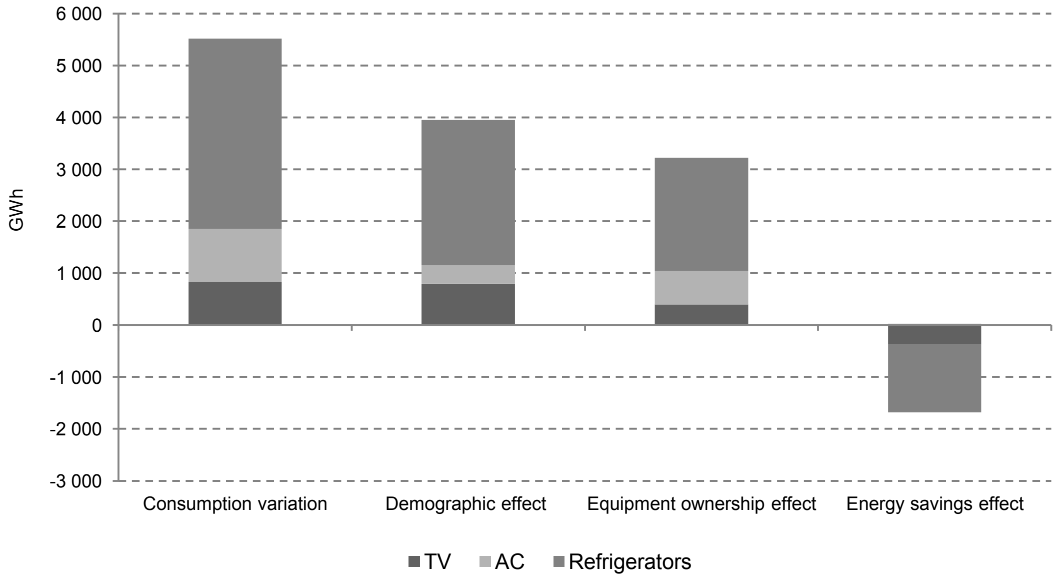
Figure 42
Drivers of the variation in the consumption of refrigerators in Brazil (2005-2012)[a]



Source: BIEE, ECLAC.
[a] The various effects are calculated as follows: demographic =ΔHH*TEQ0*SEC0; equipment ownership: HH0*ΔTEQ*SEC0 and energy savings: HHt*TEQt*ΔSEC with Δ: variation over the period, E consumption of the appliance, HH: number of households, TEQ: equipment ownership (% of households with appliance) and SEC: specific consumption of appliance (kWh/year).

As all effects are expressed in volumes, decomposition of the variation in electricity consumption for different appliances can be done by aggregating the results for each type of appliance as shown in figure 43 for TV, AC and refrigerators. Energy savings contributed to reducing electricity consumption by 1.7 TWh.

Figure 43
Drivers of the variation of the consumption of large appliances in Brazil (2000-2012)



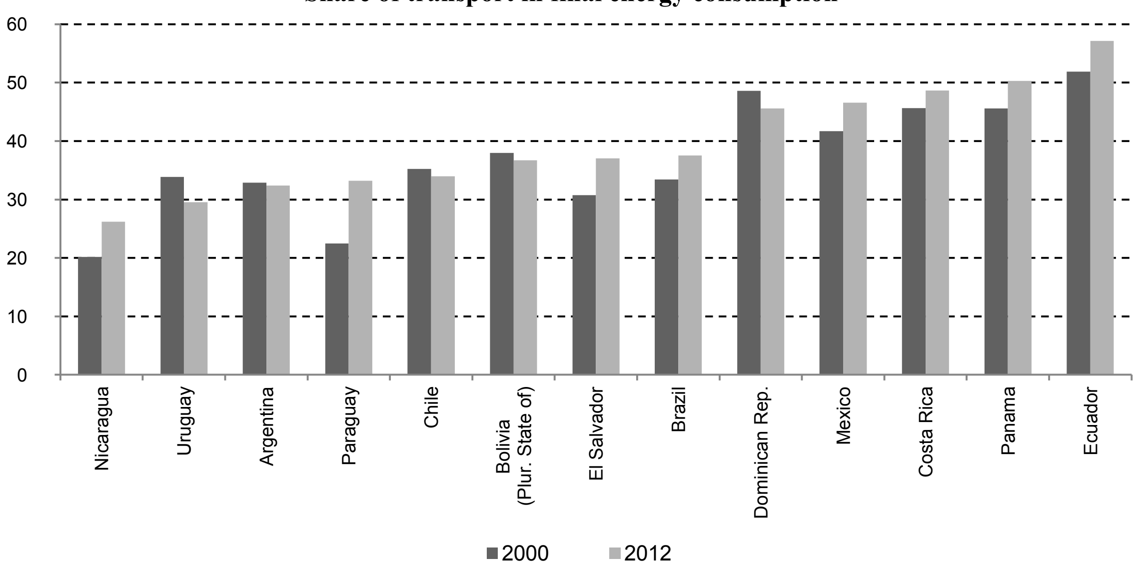
Source: BIEE, ECLAC.

IV. Energy efficiency trends in transport

A. Trends in consumption

The share of transport sector in final energy consumption ranges from 27% (Nicaragua) to over 55% (Ecuador). It has increased in more than half of the countries participating in the BIEE Programme since 2000 (figure 44).

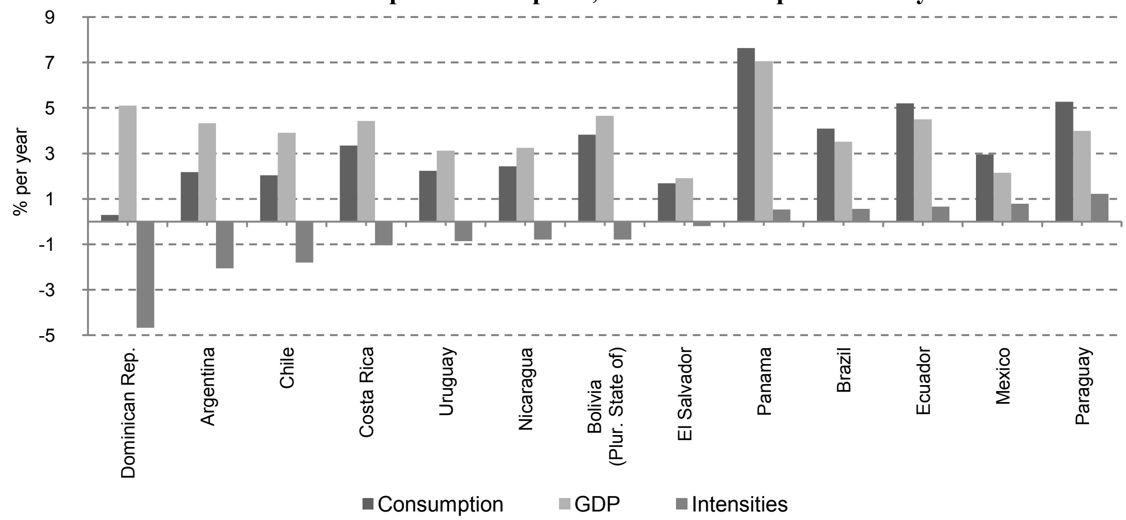
Figure 44
Share of transport in final energy consumption



Source: BIEE, ECLAC.

In two third of the countries transport consumption grew less rapidly than GDP from 2000 to 2012, as shown by the decreasing trend in the intensity of transport (i.e. the energy consumption per unit of GDP) (figure 45).[24] This trend was over 1%/year in Dominican Republic, Argentina and Chile. There was a reverse trend in Paraguay, Mexico, Ecuador, Brazil and Panama due to several factors: an increase in the number of road vehicles, in particular cars, at a rate faster than economic growth, as well as the low availability of public transport and the monopoly of roads for goods.

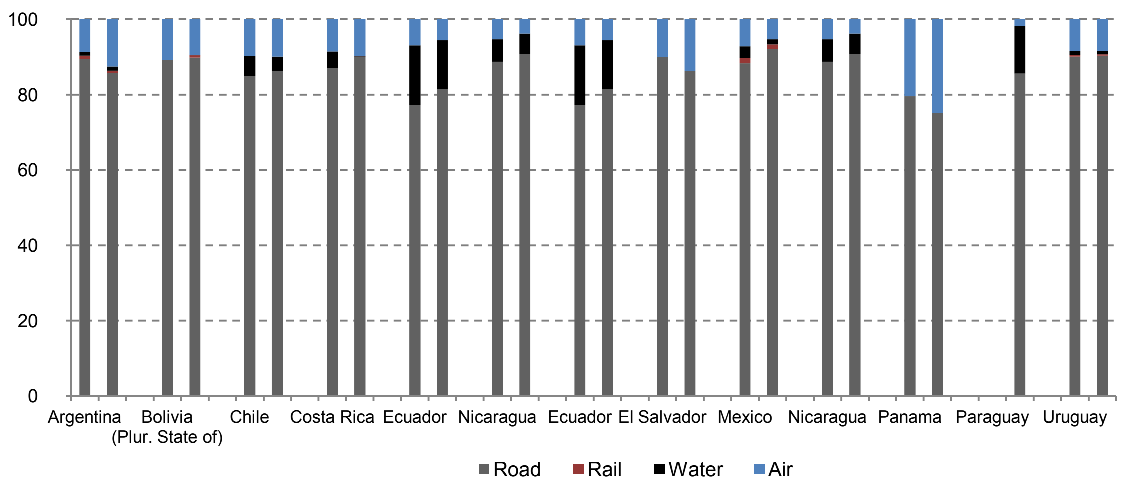
Figure 45
Trends in transport consumption, GDP and transport intensity



Source: BIEE, ECLAC.

Road transport is the main mode of transport: it accounted for over 80% of consumption in all countries in 2012, except Panama; where air transport consumption is significant due to its condition as aregional hub. The share of road transport remained relatively stable since 2000 in most countries (figure 46).

Figure 46
Energy consumption by mode of transport (2000 and 2012)
(Percentages)



Source: BIEE, ECLAC.

24 The energy intensity of transport is defined in relation to GDP as all sectors contribute to passenger and freight traffic, and thus to the energy consumption in transport. Using the added value of transport would be misleading as it only accounts for the activities of transport companies and exclude cars, most light duty vehicles and industrial trucks.

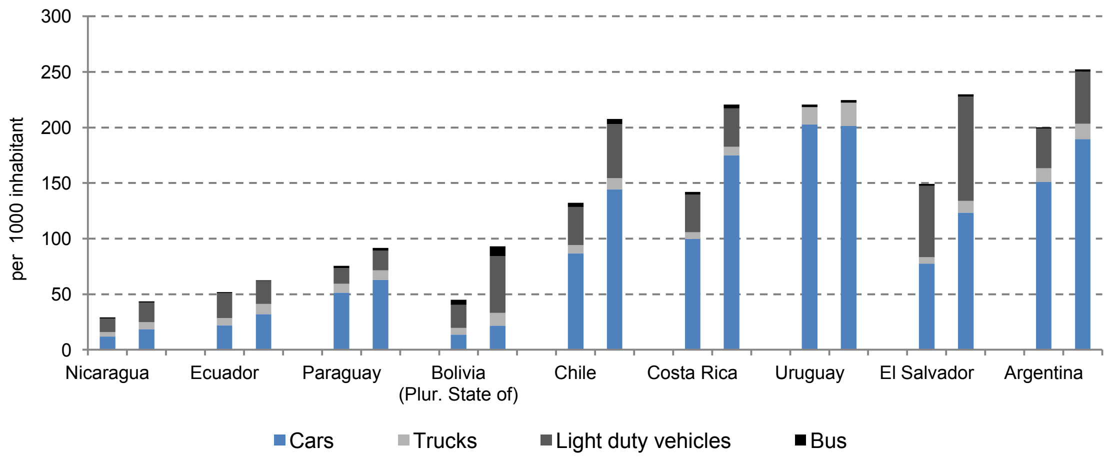
B. Road transport

1. Overview

The energy consumption of road transport has been increasing in all countries since 2000. It grew very rapidly in 5 countries: by 11%/year in Paraguay, 5%/year in Panama and Bolivia and over 4%/year in Argentina and Costa Rica.

The number of vehicles has increased by 3.5%/year on average between 2000 and 2012, by 5.8%/year in Costa Rica and it has remained stable in Uruguay. The vehicle pool is mainly made up of cars (figure 47).

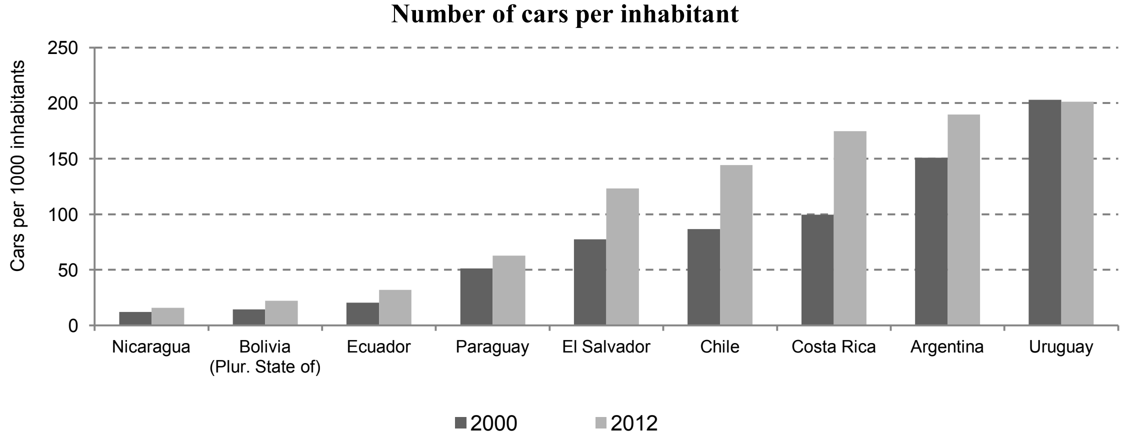
Figure 47
Vehicle pool (2000, 2012)



Source: BIEE, ECLAC.

There are significant discrepancies in the level of car ownership among countries: 16 cars per 1,000 inhabitants in Nicaragua, 123 in El Salvador and over 150 in Costa Rica, Argentina and Uruguay (figure 48). The growth in car ownership has been very rapid in Costa Rica (5%/year) as well as in Chile, El Salvador, Argentina, Ecuador and Bolivia (around 4%/year).

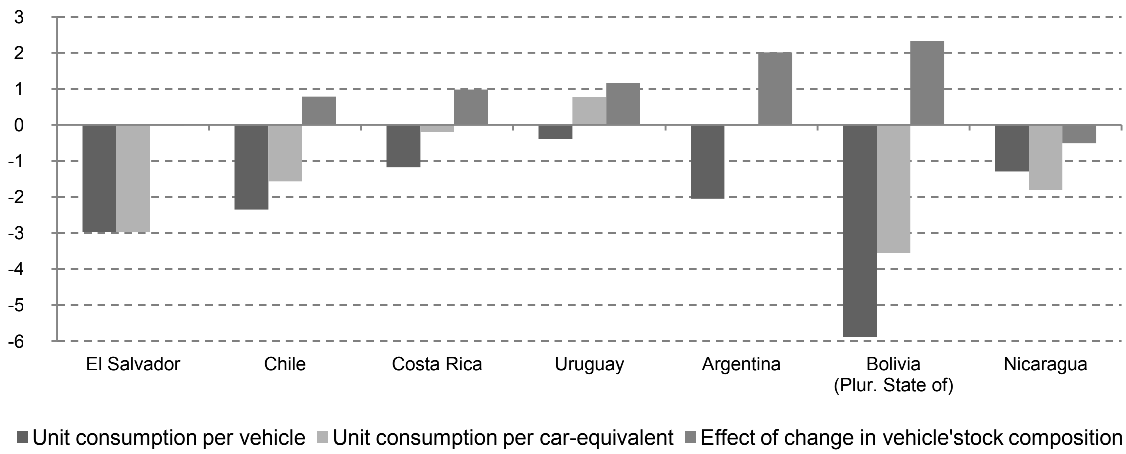
Figure 48
Number of cars per inhabitant



Source: BIEE, ECLAC.

Overall energy efficiency of road transport can be evaluated by calculating an average energy consumption per car equivalent, calculated as the ratio between the total consumption of road transport and the total fleet of road vehicles, expressed in car equivalent.[25] The difference between the energy consumption of road transport per vehicle and per car equivalent corresponds to the effect of changes in the composition of the vehicle pool. Energy efficiency improvements can be better evaluated with the variation of the unit consumption per car equivalent, as it is gleaned from changes in the vehicle fleet. El Salvador, Chile and Bolivia had the highest energy efficiency improvements (figure 49).

Figure 49
Trends in unit consumption of road transport (2000-2012)
(Percentage/year)



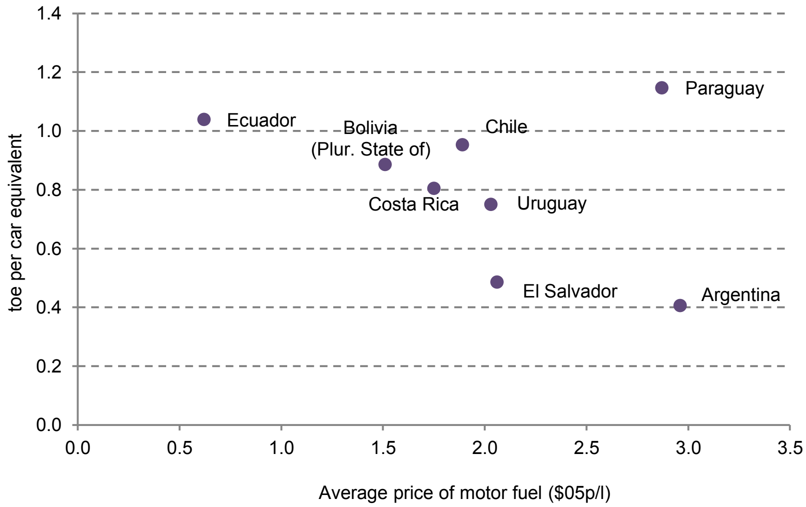
Source: BIEE, ECLAC.

There are some discrepancies in the energy consumption of road transport per car equivalent among countries with very similar fuel price: for instance, between Bolivia, Costa Rica, Chile, Uruguay and El Salvador (figure 50): the differences may be due to real differences in the energy efficiency of vehicles or their size, as well as to statistical problems in the vehicle pool actually in use (usually overestimated, which underestimates the specific consumption) or to overestimation of the consumption of road transport.[26]

[25] For each type of vehicle the pool is measured in terms of car equivalent on the basis of their specific annual consumption compared to a car. If, for example, a bus consumes on average 15 toe/year and a car 1 toe/year, a bus will be equivalent to 15 cars. Due to a lack of national surveys, the following default values were based on data from ODYSSEE: 0.15 car equivalent for two-wheels, 1.4 for gasoline light vehicles, 2.6 for diesel light vehicles, 15 for a bus and a truck.

[26] The vehicle pool is often overestimated as the retired vehicles are not always removed from the national registries.

Figure 50
Consumption per car equivalent and motor fuel prices (2012)

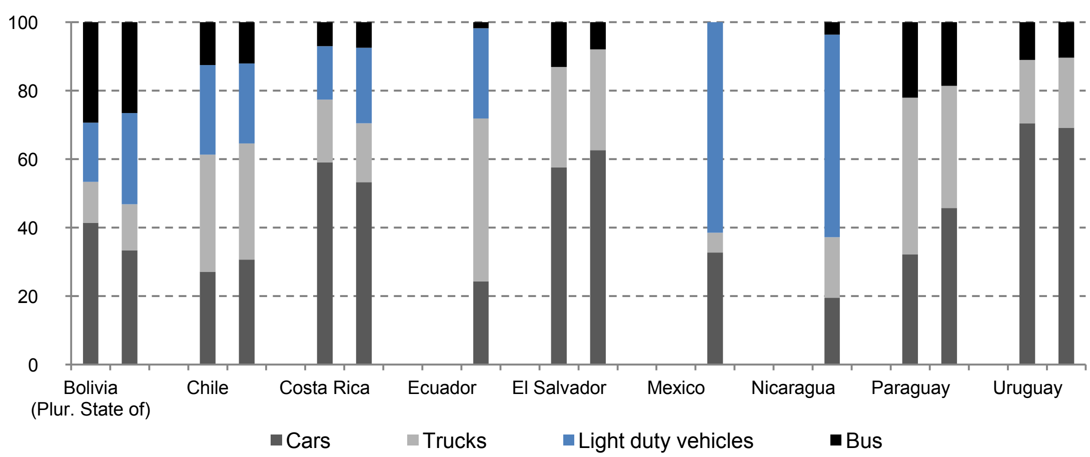


Source: BIEE, ECLAC.

2. Cars and trucks

Cars represent on average half of the consumption of road transport in the nine countries participating in the BIEE Programme with data on the breakdown of this consumption by type of vehicle. There are significant discrepancies among countries in the share of cars in the energy consumption of road transport: from a minimum of 20% in Ecuador or Nicaragua to a value of 69% in Uruguay (figure 51). In Nicaragua and Mexico, transport by light duty vehicles has an important share (over 55%).

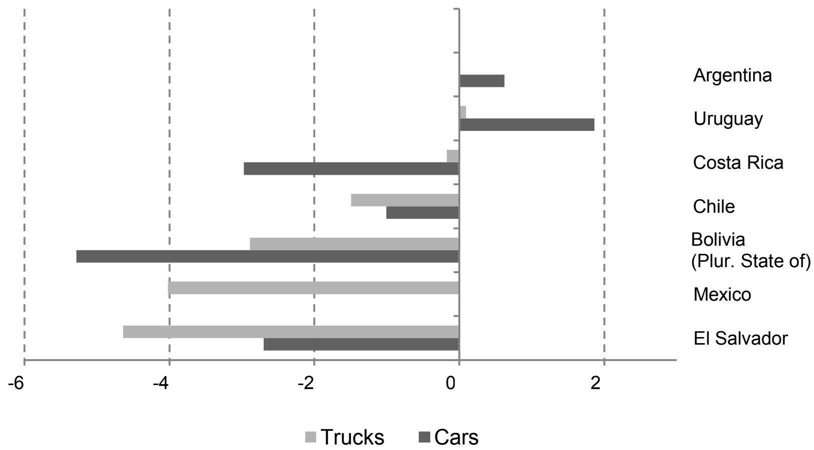
Figure 51
Road energy consumption by type of vehicle



Source: BIEE, ECLAC; trucks for Uruguay includes light duty vehicles.

The annual energy consumption of cars and trucks (in toe/vehicle/year) gives us a first overview of the energy efficiency of a vehicle. The energy consumption per vehicle has decreased in all countries, except in Argentina and Uruguay. This trend may be due to technical progress with the introduction of efficient new vehicles to the market but also to the use of smaller vehicles or decreases in the annual distance travelled (figure 52).

Figure 52
Trends in consumption for road transport by type of vehicle (2000 and 2012)
(toe per vehicle, in percentages)



Source: BIEE, ECLAC.

For cars, the most relevant indicator for measuring progress with energy efficiency, especially related to technical progress, is the specific fuel consumption in litres per 100 km. However, there are very few data available to monitor this trend, either for new cars or for the stock average: only Chile is requesting such data for new cars from car companies (as at EU level).

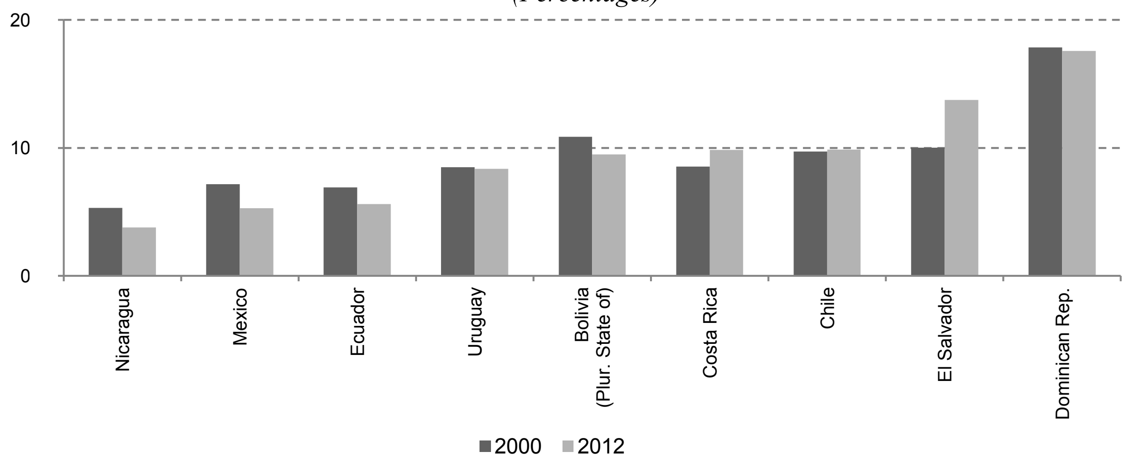
The implementation of policies to promote more efficient new cars is still at an early stage in the countries participating in the BIEE Programme. Chile (see diagram 1) and Brazil have implemented labelling of the fuel performance of new cars and Mexico has adopted Minimum Energy Performance Standards for new cars.

Diagram 1
Energy efficiency labels for new cars in Chile

C. Air transport

The share of air transport ranges from 5% of transport consumption in Nicaragua to over 15% in Dominican Republic, because of the importance of tourism. Between 2000 and 2012, there was a decline in the share of air transport in the total consumption of the sector in all countries except Costa Rica, Chile and El Salvador (figure 54): this is mostly explained by the dynamism of road transport. In most countries, the number of passengers has been growing rapidly: by over 6%/ year.

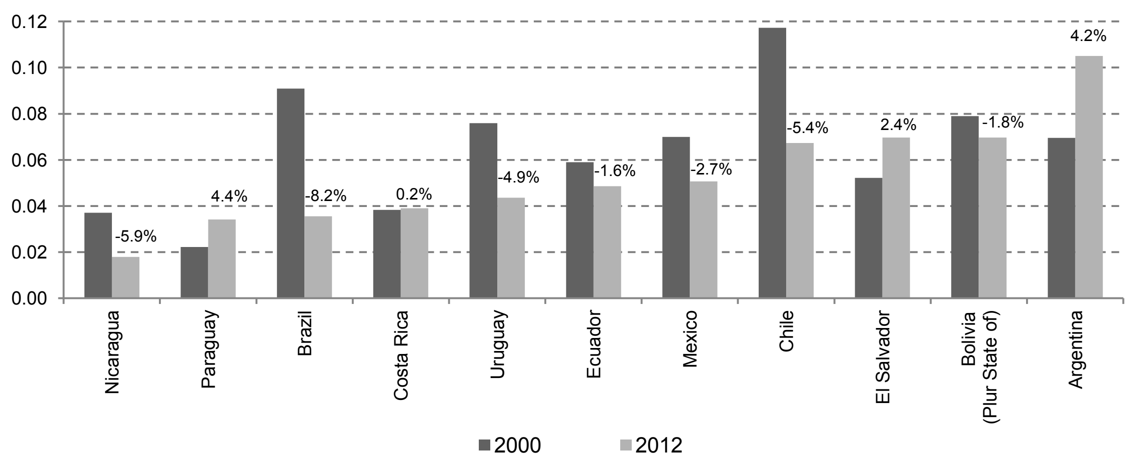
Figure 53
Share of air transport in energy consumption of transport
(Percentages)



Source: BIEE, ECLAC.

The unit consumption of air transport per passenger (defined as the ratio between the energy consumption and the number of passengers carried) tends to decline in most countries, mainly due technical progress with new aircrafts (figure 54).

Figure 54
Energy consumption of air transport per passenger
(Toe/passenger and percentages)



Source: BIEE, ECLAC.

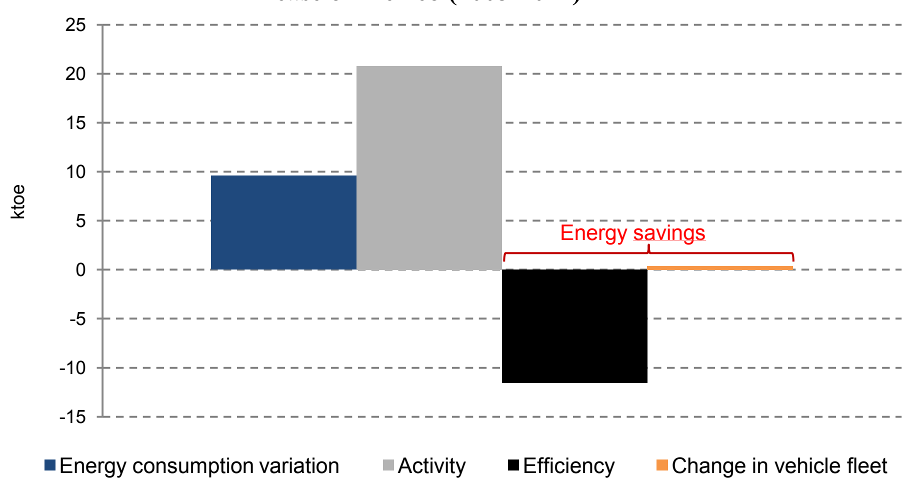
D. Decomposition of the consumption variation in transport

The variation in the consumption of transport can be explained, on the one hand, by an increase in the traffic and number of vehicles ("activity effect")[27] and, on the other hand, by the change in the unit consumption per vehicle or unit of traffic ("unit consumption effect").[28] The first factor is the consequence of economic growth, while the second one will reflect the increased efficiency of transport modes, as well as the effect of other factors, such as changes in the size of vehicles (e.g. larger or smaller cars), or in the distance travelled etc. Figure 56 illustrates in the case of Mexico the effect of these different factors on the consumption of road and air transport. Between 2005 and 2012, the consumption increase (+ 9.4 Mtoe) was the result of two main drivers:

- A growth in the number of vehicles and air passenger traffic, which all things being equal, would have increased consumption by 21 Mtoe ;
- Energy savings (11 Mtoe), due to lower unit consumption of road vehicles (measured in toe per car equivalent) and planes (toe per passenger), that limited the consumption increase.

Change in the composition of the road vehicle fleet only had a marginal impact.

Figure 55
Decomposition of the transport consumption: case of Mexico (2005-2012)



Source: BIEE, ECLAC.

If data are available on the consumption of cars, a similar decomposition of the consumption of cars can be done for cars to show the role of different drivers, such as the growth in population and in car ownership, the reduction in the specific fuel consumption (energy savings) and the change in the distance travelled by cars.

[27] The activity effect is calculated as the variation of the consumption E due to a variation of the number of vehicles Qi for road and number of passengers for air, compared to the base year 0: (Qit-Qio)*(Eio/Qio).

[28] The "unit consumption effect" is calculated, as the variation of the consumption Ei due to a variation of the specific energy consumption Ei/Qi compared to the base year : Qit*(Eit/Qit-Eio/Qio).

E. Measuring energy efficiency progress in transport: case study with ODEX

Energy efficiency progress was measured previously with indicators of specific consumption for road and air transport. A reduction in the indicator is generally assimilated to energy efficiency progress. To get the overall energy efficiency trend at the level of the whole transport sector, an indicator called ODEX can be used that combined the trends observed for each mode. ODEX is calculated as follows:

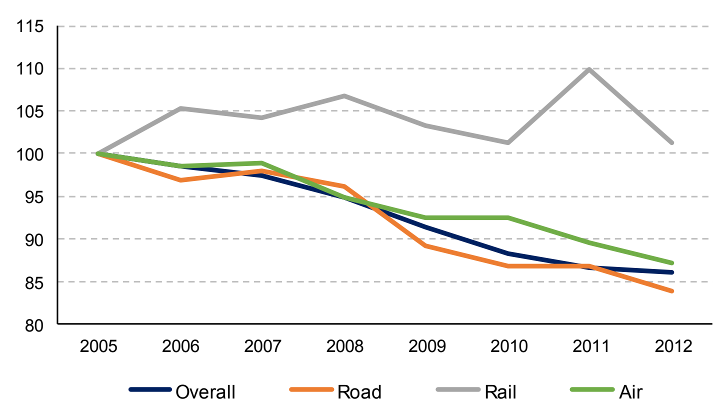
- By expressing trends in specific energy consumption by transport mode (e.g. cars, planes), measured in different units, as an index of variation.
- By calculating a weighted average index for the sector (ODEX) on the basis of the share of each mode in the transport sector's energy consumption.

For the countries participating in the BIEE Programme, taking into account the data available, the ODEX is based on the following specific consumption measured in:[29]

- Toe per car-equivalent for road transport as a whole, as no specific consumption by road vehicle (cars, trucks, bus, etc.) is available or fairly robust in the countries participating in the BIEE Programme.
- Goe (gram oil equivalent) per tkm for rail[30] and navigation[31] for freight.
- Goe/passenger-km for passenger rail.
- Toe/passenger for air transport.

The application of ODEX in Mexico's transport sector shows an ODEX value equal to 86 in 2012 compared to 2005, which represents a 14% energy efficiency improvement between 2005 and 2012, which is mainly due to road transport (figure 56).

Figure 56
Energy efficiency trends in transport in Mexico based on ODEX



Source: BIEE Programme, ECLAC.

29 For European countries where more detailed data are available, ODEX calculation in transport is based on the following indicators of specific consumption: litres/100 km for cars, goe per tkm for trucks & light vehicles, toe per passenger for air, goe/tkm for rail and water of goods, goe/pkm for rail transport of passenger, toe/vehicle for motorcycles and buses.

30 Data on rail are only available for Argentina, Mexico and Bolivia.

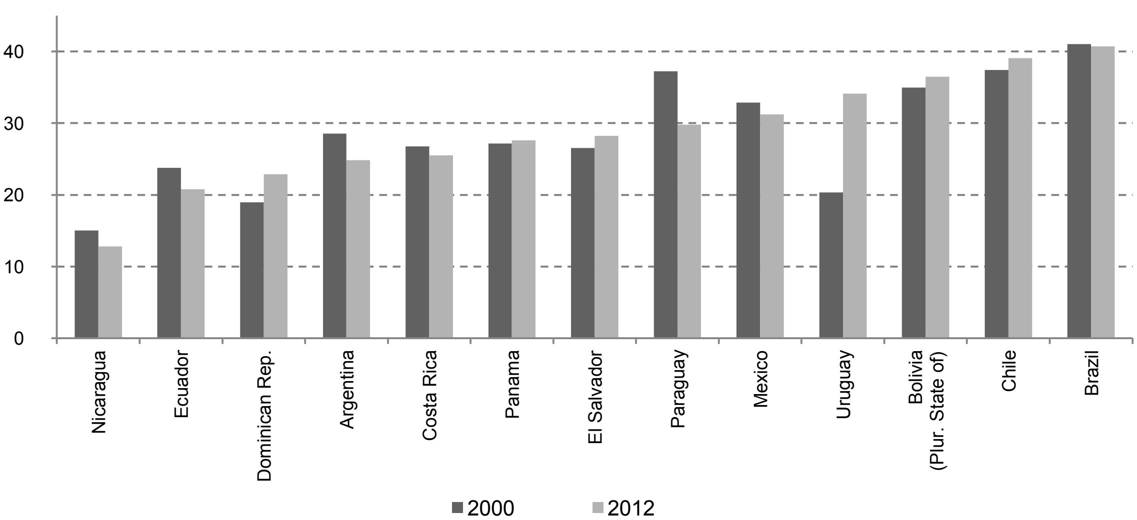
31 Data on navigation are only available for Bolivia, Columbia, Mexico and Nicaragua.

V. Energy efficiency trends in industry

A. Energy consumption patterns

In half of the countries, the share of industry in the final energy consumption is declining. The contribution of industry is the lowest in Nicaragua (12%), where this sector is traditionally less developed; it is on the opposite high in Brazil and Chile (around 40%). It increased significantly in Uruguay (+13 points) because of the commissioning of a large paper mill in 2008 that increased the energy consumption of the sector by 70% (figure 57).

Figure 57
Share of industry in the final energy consumption

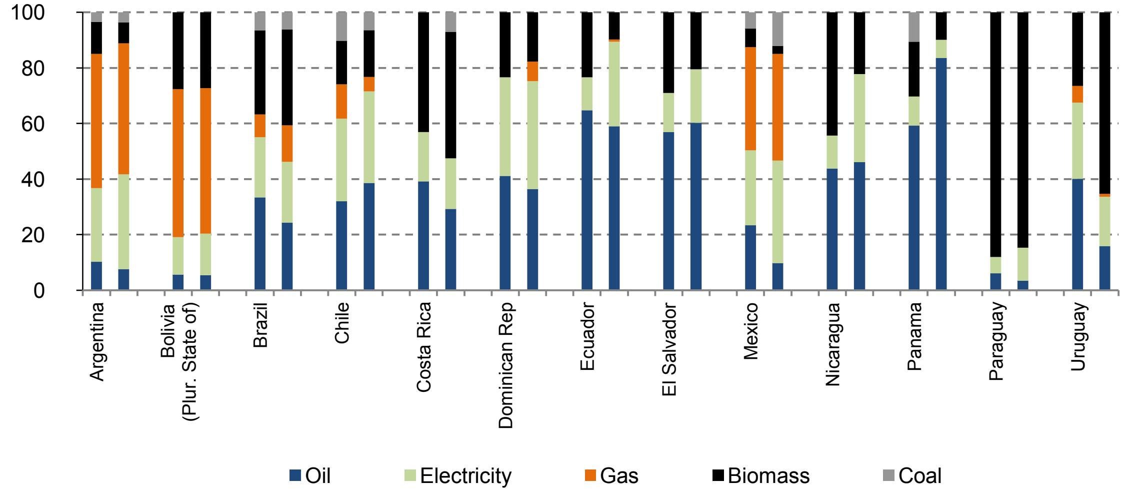


Source: BIEE, ECLAC.

Oil dominates the energy consumption of industry in Panama, El Salvador and Ecuador (around 60%). It also has a high share in Nicaragua, Chile and Dominican Republic (over 40%). In Uruguay, Paraguay and Costa Rica biomass is the main energy source used in industry (above 45%).

Gas is important in Bolivia, Argentina, and Mexico (40-50%). Electricity has a high market share in Mexico and the Dominican Republic; in Mexico electricity has almost the same share as gas (37%) (figure 58).

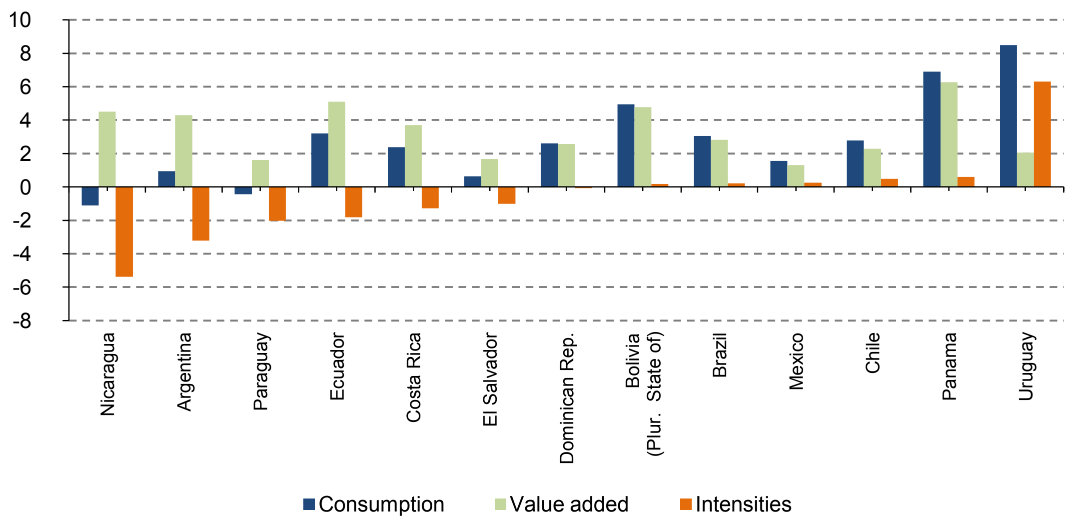
Figure 58
Energy consumption of industry by energy source (2000 and 2012)
(Percentages)



Source: BIEE, ECLAC.

The energy intensity of industry, calculated as the ratio between the energy consumption and the added value, decreased rapidly in Nicaragua and Argentina (around 5 and 3%/year respectively). In 4 other countries the energy intensity has been also decreasing, but less rapidly (below 2%/year) (figure 59). In Uruguay, the intensity has been decreasing until 2007 but jumped by 50% in 2008 with the commissioning of a new large pulp and paper factory coupled with a chemical complex.

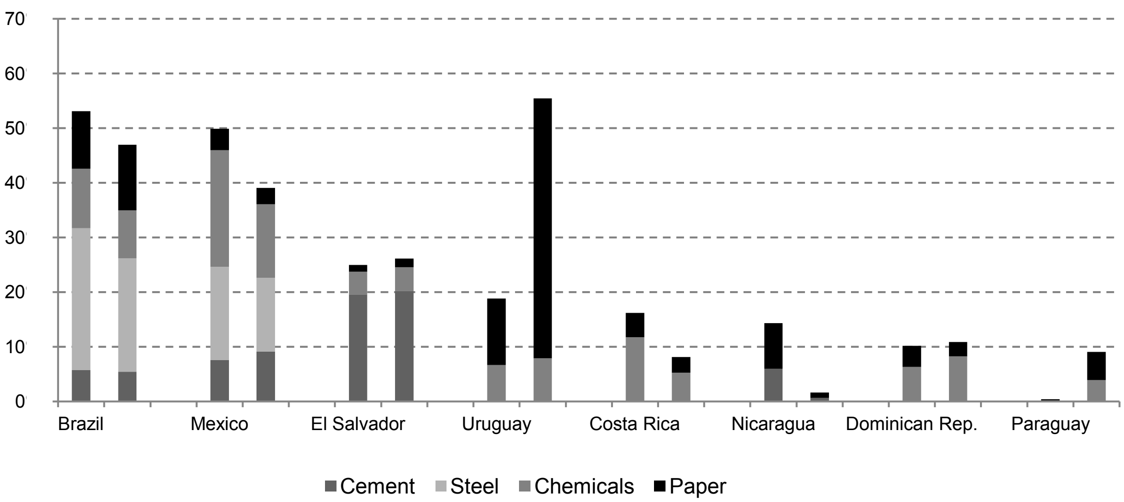
Figure 59
Energy intensity trends in industry
(%/year, 2000-2012)



Source: BIEE, ECLAC.

The share of energy intensive branches in industry consumption is the highest in Brazil, Mexico and Uruguay (figure 60). In Uruguay the paper industry now represents almost half of the consumption.

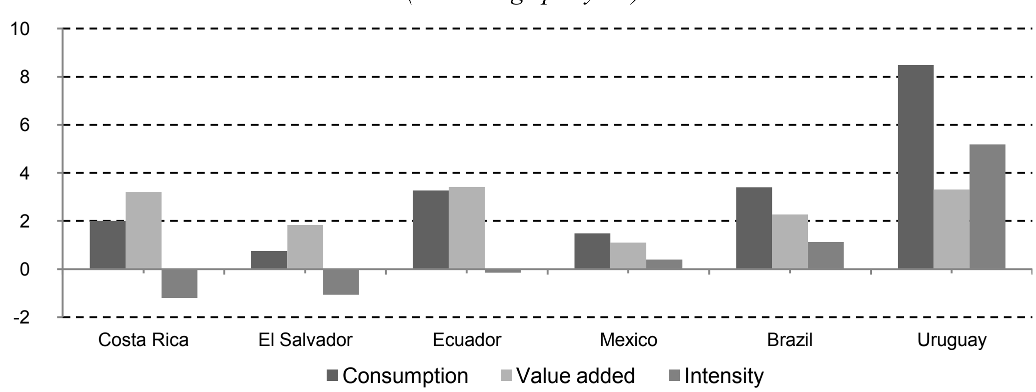
Figure 60
Energy intensive branches in industry (2000-2012)



Source: BIEE, ECLAC.

Manufacturing industry[32] represents the bulk of the consumption of industry, except in countries with a large mining sector (e.g. Chile). The energy intensity of manufacturing has been decreasing in Costa Rica and El Salvador, and increasing in Mexico, Brazil and, especially in Uruguay, as explained above (figure 61). The high intensity increase in Uruguay is mainly due to increased share of paper industry and increase in intensity of chemical industry. The variations observed for the total industry are smoother than for manufacturing because of the construction sector, which has a significant weight in the industrial added value but a low energy consumption.

Figure 61
Trends in manufacturing industries (2000-2012)
(Percentage per year)



Source: BIEE, ECLAC.

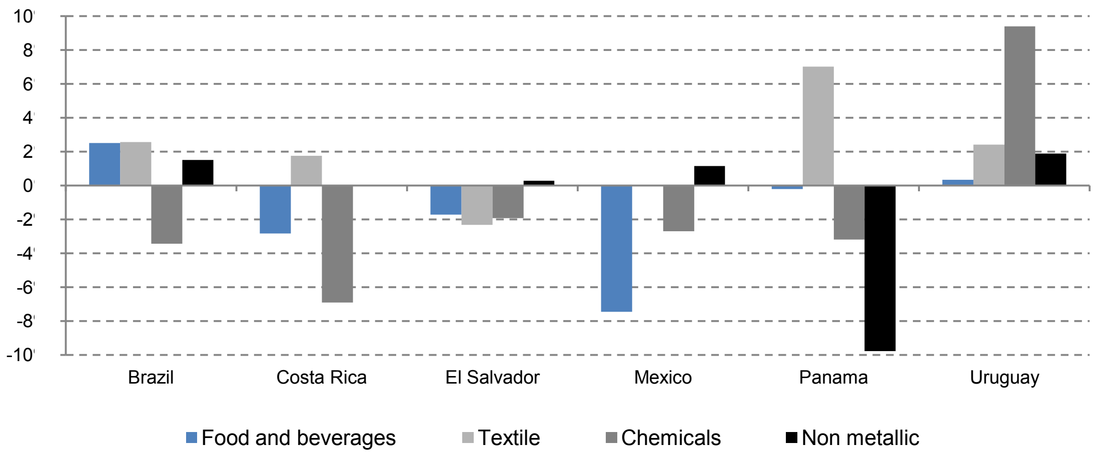
[32] Manufacturing represents the main part of the energy consumption and valued added of industry. The other main sub-sectors are mining and construction.

B. Impact of structural changes in manufacturing

Trends in the energy intensity of manufacturing industry are influenced by changes in sectoral intensities (i.e. intensities of the various branches, such as chemicals, minerals non-metallic, food processing, textiles, etc. ..), but also by changes in the structure of added value by branch ("structural changes"), i.e. changes in the contribution of each branch in the added value of manufacturing. In countries with an increasing share of energy intensive branches in the added value, the energy intensity increases, all things being equal. On the opposite, a greater specialization towards less intensive branches, such as textiles or electrical equipment, reduces the energy intensity.

Over the period 2000-2012, in most countries the sectoral intensities have decreased in most of the branches; on the other hand, in Brazil and Uruguay the sectoral intensities have increased in most branches (figure 62).

Figure 62
Energy intensities by branch (2000-2012)
(Percentage/year)



Source: BIEE, ECLAC.

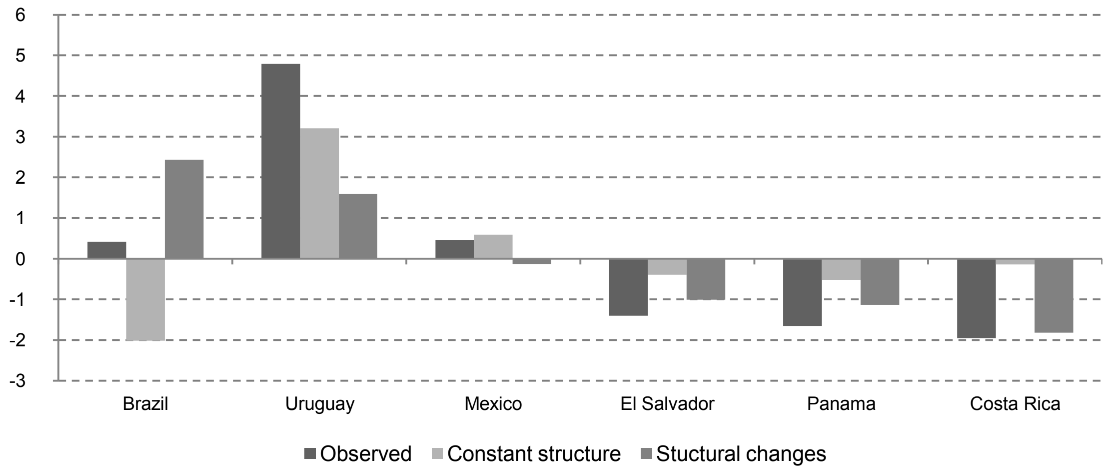
The variations in these sectoral intensities reflect the impact of technical progress, of energy efficiency policies and measures implemented, as well as changes in the types of products produced (some kind of structural changes within each branch).[33]

To separate the impact of these two factors, an intensity of manufacturing has been calculated at constant structure; it represents a theoretical intensity that would have been observed if the structure of the added value between the different branches had remained constant. The variation of the intensity at constant structure better reflects energy efficiency progress. The different trends in the two intensities (actual and at constant) structure measure the effect of structural changes.

In Brazil and Uruguay structural changes led to an energy intensity increase, because of a growing contribution of energy intensive branches. Structural changes towards less energy intensive branches contributed greatly to the decrease of the overall intensity in Costa Rica, El Salvador and Panama (from 2/3 to 90% of the total variation) (figure 63).

33 For instance an increasing share of deep frozen products in food industry will increase the energy intensity, all things being equal.

Figure 63
Structural effect in manufacturing industry (2000-2012)
(Percentage per year)

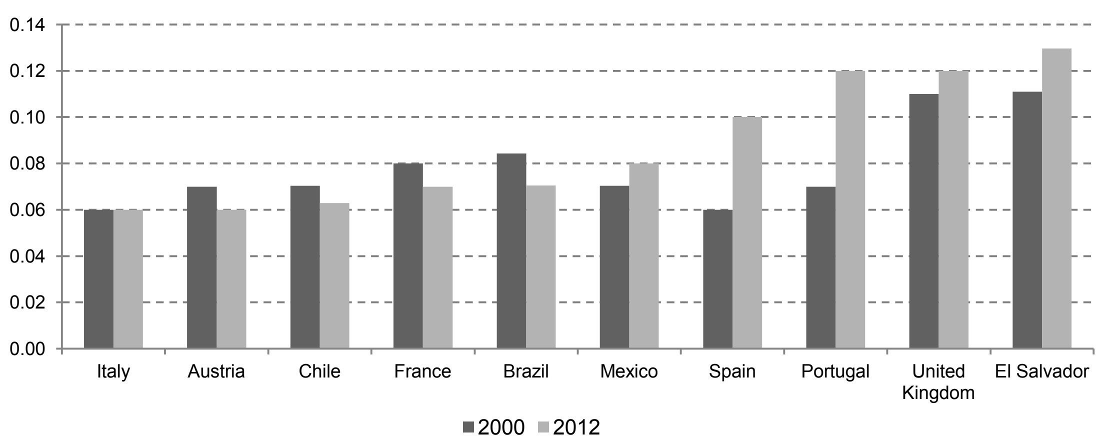


Source: BIEE Programme, ECLAC.

C. Specific consumption of cement and steel

Trends in the specific consumption per tonne of cement are shown in Figure 64 for a sample of EU and the countries participating in the BIEE Programme are very different among the countries: El Salvador has one of the highest specific consumption among the countries participating in the BIEE Programme. Chile is among the best performing countries. In EU countries, the increase in the specific consumption is due to the industrial recession and the inefficient operation of cement factories.

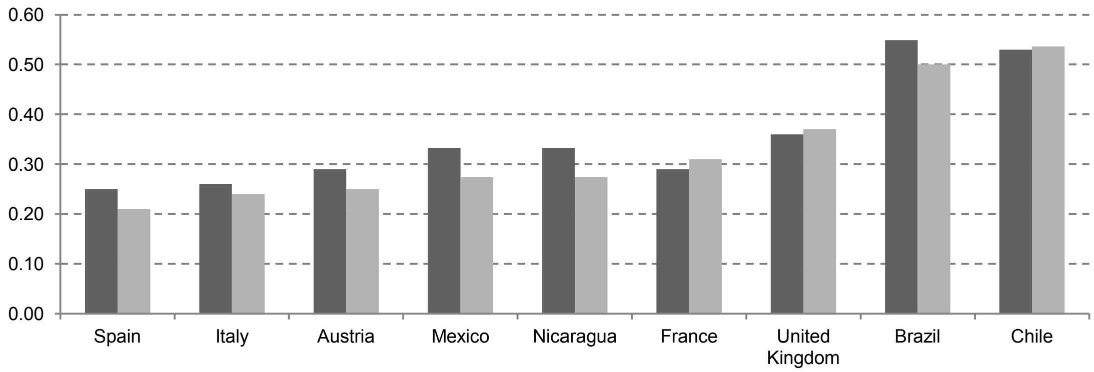
Figure 64
Trends in specific consumption of cement industry (2000, 2012)
(toe per tonne)



Source: BIEE, ECLAC.

Brazil and Chile have high specific consumption in the steel industry comparing to some European countries (figure 65). This specific consumption decreased since 2000 in Chile and Brazil, reflecting energy efficiency improvements.

Figure 65
Trends in specific consumption of steel industry (2000, 2012)
(toe per tonne)



Source BIEE, ECLAC

D. Decomposition of the energy consumption by industry

The industrial energy consumption is changing under the influence of various factors:

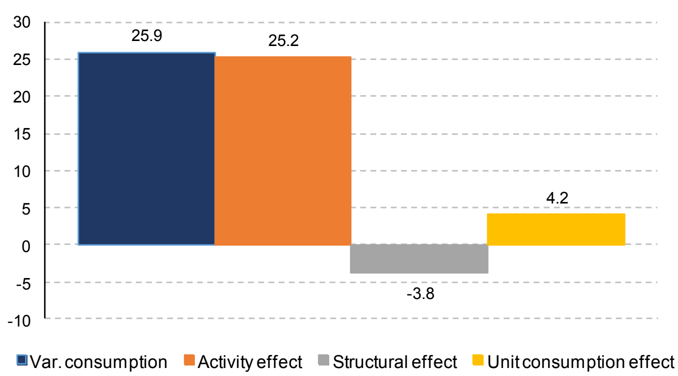
- Change in industrial activity, measured by physical production (e.g. for steel or cement) or Industrial Production Index (IPI) ("activity effect");
- Structural changes, i.e. the fact that individual branches with different energy intensities are not growing at the same rate ("structural effect"), as explained in section 6.3 above);
- Unit consumption effect (i.e. change in the ratio of energy consumption per IPI or physical production at branch level). A negative effect represents energy savings.

In Brazil for instance, industrial energy consumption increased by around 25 Mtoe between 2000 and 2011.

This growth was mainly due to increased activity by branch (25 Mtoe); the effect of changes in the unit consumption in the different branches contributed to increase energy consumption (by 4 Mtoe) and probably reflected structural changes within each branch figure 66).

In contrast, structural effects towards less energy intensive branches have contributed to decrease industrial energy consumption (by 4 Mtoe).

Figure 66
Decomposition of the variation in industrial energy consumption in Brazil (2000-2011)



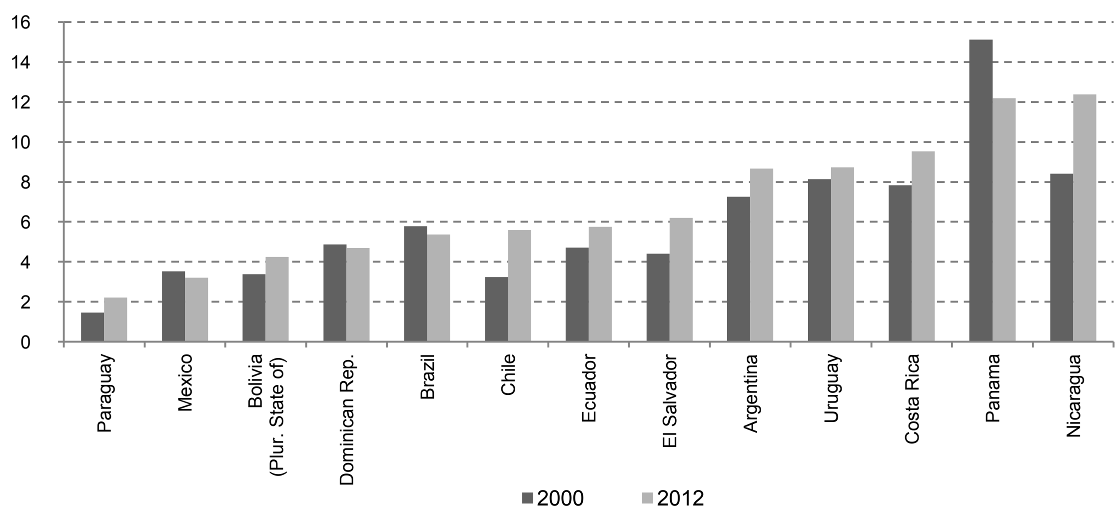
Source: BIEE, ECLAC.

VI. Energy efficiency trends in services

The services sector, also called the tertiary sector, consists in different activities, including wholesale and retail trade, tourism (hotels, restaurants), education, health, administration (i.e. public sector), offices (financial institutions and other private services). Public lighting is also included in the consumption of this sector.

The services sector's energy consumption has been rising quickly, especially electricity. Therefore, the share of services in final energy consumption grew in most countries between 2000 and 2012. The highest share (12%) and increase (by 4 points) is observed in Nicaragua (figure 67).

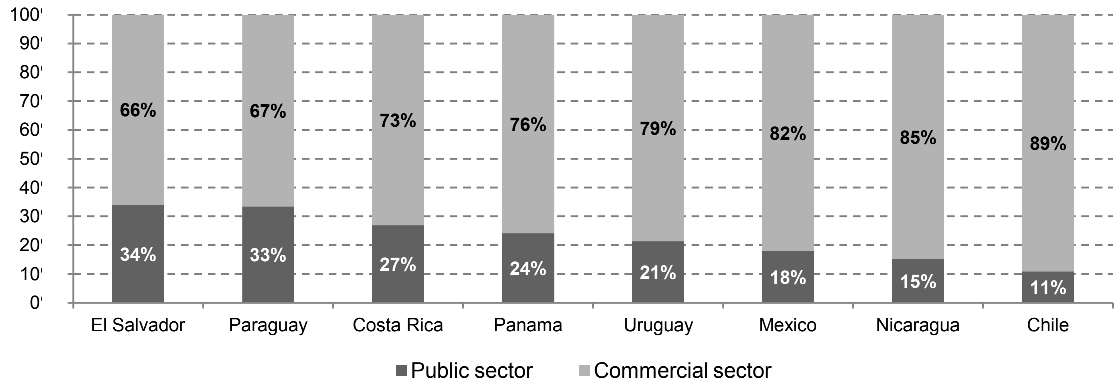
Figure 67
Share of services in final energy consumption



Source: BIEE, ECLAC.

The commercial sector (private services) represents more than 2/3 of the consumption of the sector in all countries, and even over 80% in Chile, Nicaragua and Mexico (figure 68).

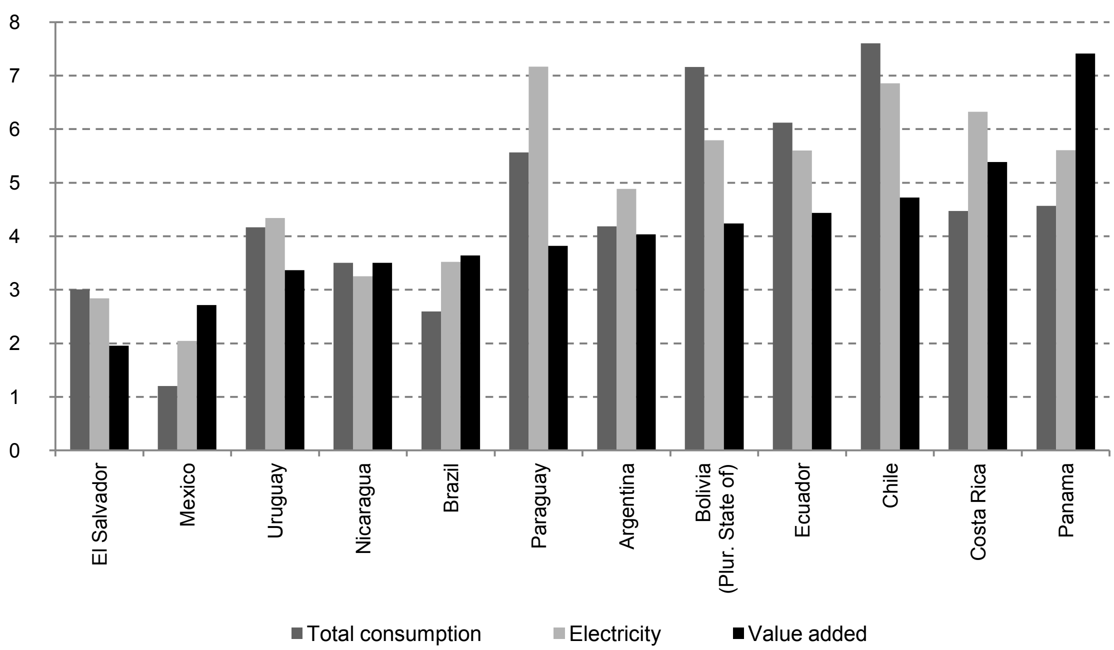
Figure 68
Energy consumption of services by branch



Source: BIEE, ECLAC.

In Bolivia and Chile, the energy consumption of services grew very rapidly (over 7%/year since 2000), almost twice the rate of added value. In Panama added value increased faster than consumption because of the activity of the Panama Canal. Mexico has the lowest intensity trend. Tourism and trade are generally the two sectors driving consumption, mainly because of air conditioning and other specific uses of electricity (figure 69).

Figure 69
Energy consumption, electricity consumption and added value in services (2000-2012)
(Percentage/year)

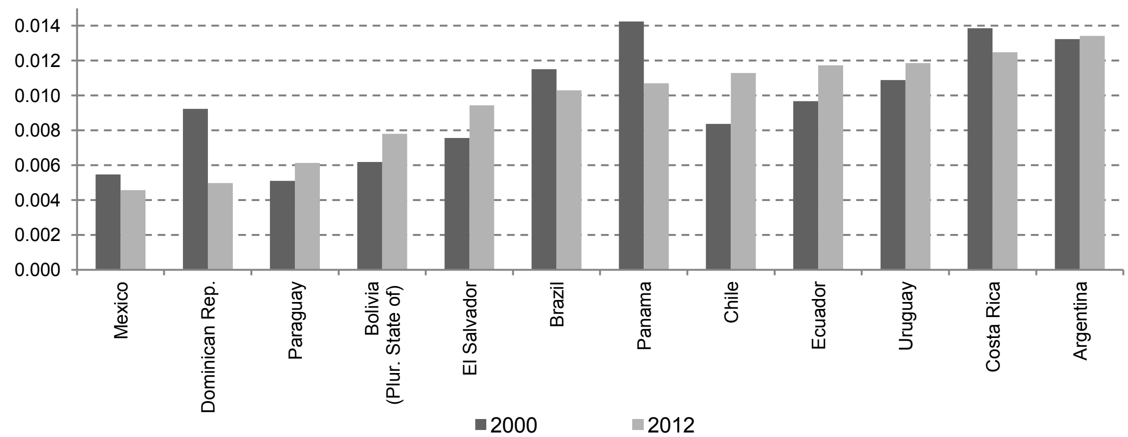


Source: BIEE, ECLAC.

In all countries, electricity is the main energy source consumed: the share of electricity is generally above 50% of the consumption and even exceeds 90% in Brazil and Paraguay. Trends in the electricity consumption can be explained in all countries by the diffusion of new office equipment and communication tools (internet, new types of telecommunications) as well as by the increasing use of air conditioning.

The energy intensity of service, i.e. the ratio energy consumption over added value, varies greatly from one country to the other; there exists a factor 3 of difference between Mexico, which has the lowest intensity, and Argentina, which has the highest intensity, in particular because of greater heating needs (figure 70).

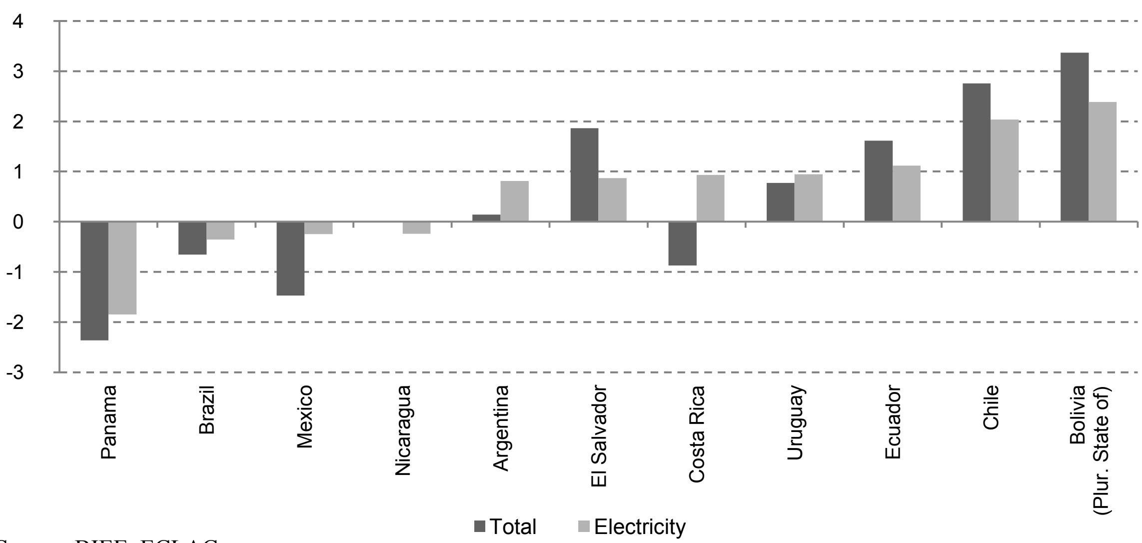
Figure 70
Energy intensity of services
(koe/$2000 ppp)



Source: BIEE, ECLAC.

Changes in intensities are very different according to countries: strong increase in Bolivia and Chile (more than 2%/year), slower growth in Ecuador, Uruguay, Costa Rica, El Salvador and Argentina. In these countries electricity intensity tends to increase less rapidly than the total intensity. There are decreasing trends in Panama, Brazil, Mexico and Nicaragua (figure 71).

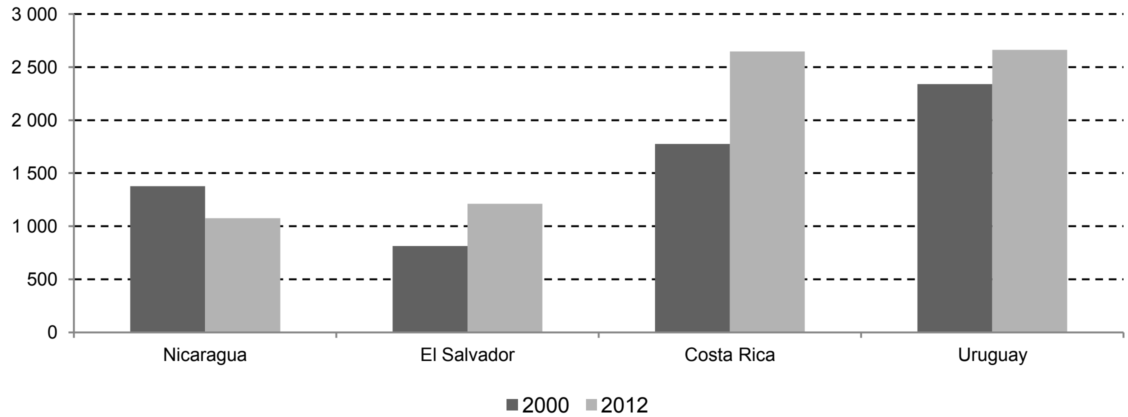
Figure 71
Trends in energy intensity of services (2000-2012)
(Percentage/year)



Source: BIEE, ECLAC.

The electricity consumption per employee in the services sector increased in El Salvador, Costa Rica and Uruguay, but decreased in Nicaragua. This consumption is driven by improved comfort and the rapid development of information technology and communication (ICTs), particularly related to internet (figure 72).

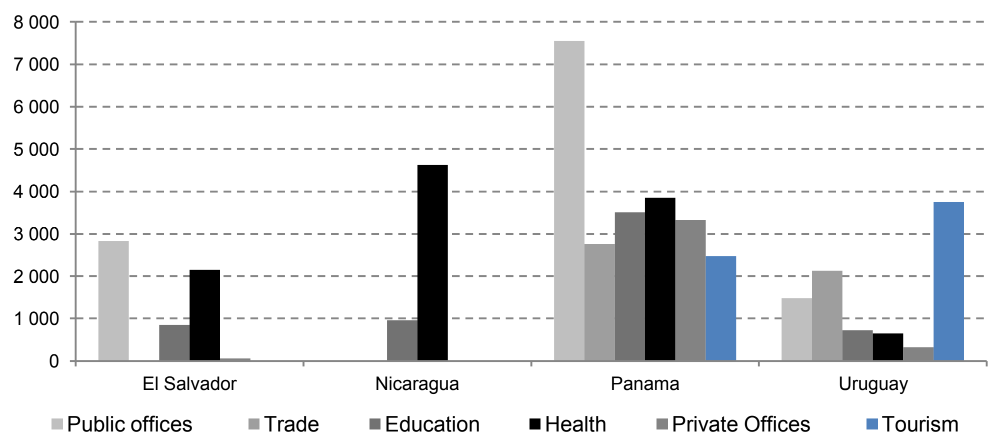
Figure 72
Electricity consumption per employee
(kWh/employee)



Source: BIEE, ECLAC.

Within the various branches, there exist important discrepancies among countries in unit consumption by employee (figure 73).

Figure 73
Electricity consumption by branch and per employee (2012)
(kWh/employee)

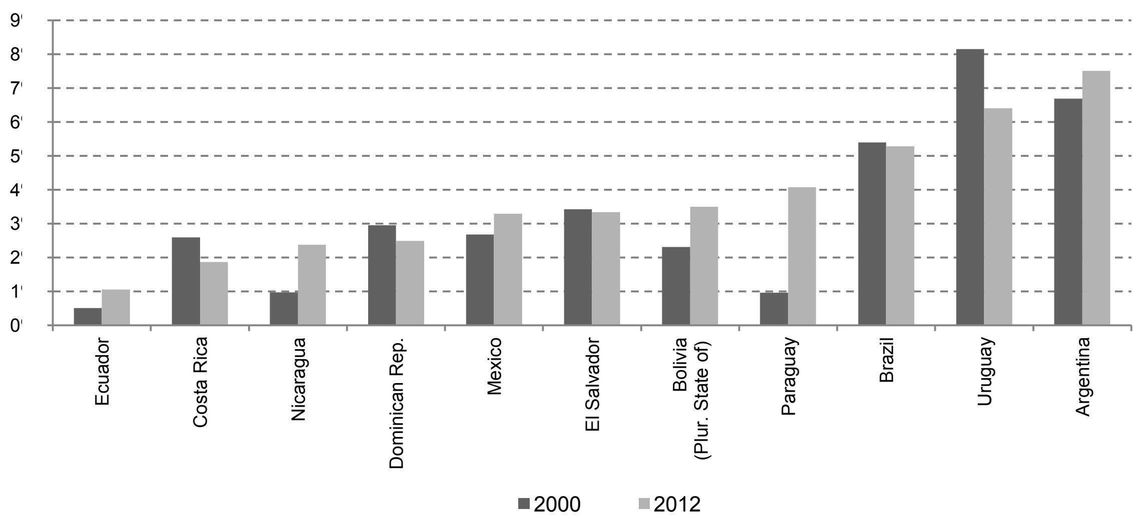


Source: BIEE, ECLAC.

VII. Energy efficiency in agriculture

In Argentina, Uruguay and Brazil the consumption of agriculture, fisheries and forests represents 5 to 8% of the final energy consumption (8 and 6% respectively) (figure 74). In all the other countries this share is below 5%.

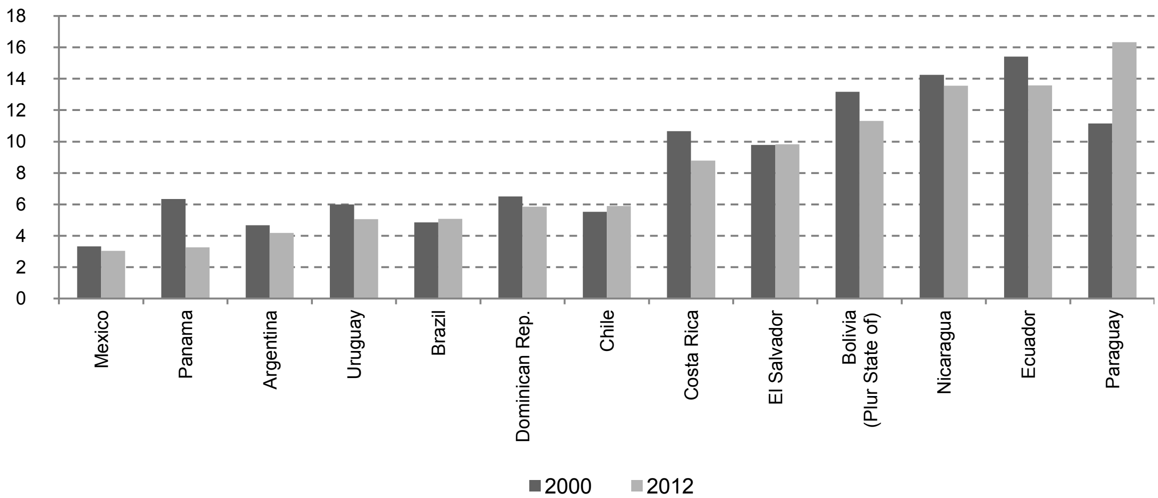
Figure 74
Share of agriculture, fishing and forestry in final energy consumption



Source: BIEE, ECLAC.

The added value of the sector is quite significant for the economy in Bolivia, Nicaragua, Ecuador and Paraguay where it represents more than 10% of GDP, even if this share tends generally to decrease (except Paraguay) (figure 76).

Figure 75
Share of added value of agriculture, fishing and forestry in GDP

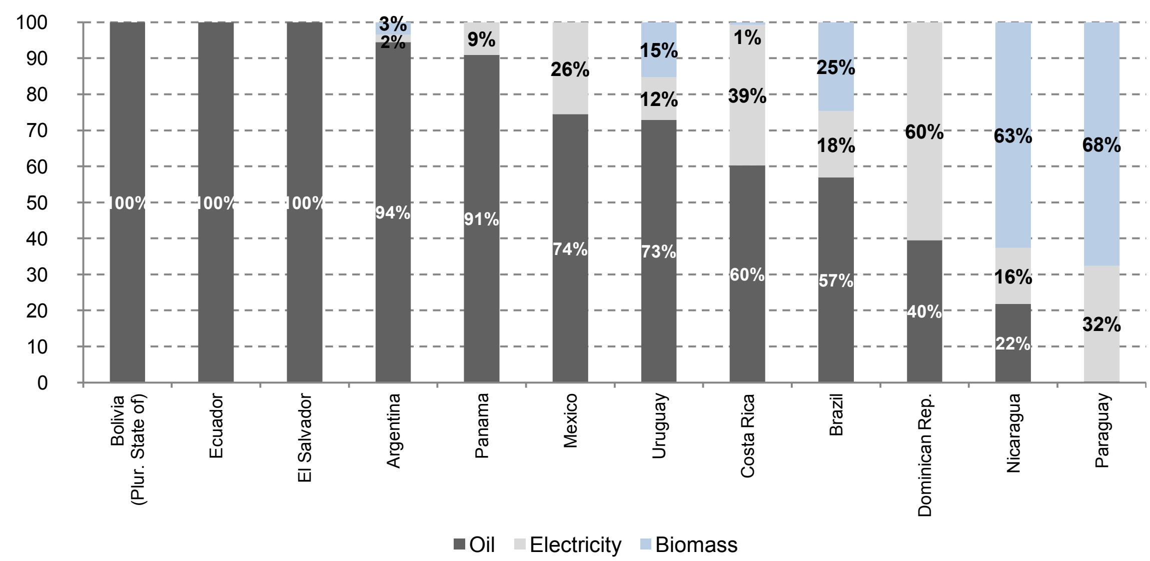


Source: BIEE, ECLAC.

Oil is the main energy source consumed in the agriculture sector, mainly as fuel for tractors, fishing boats and pumps (diesel and LPG). In Bolivia, Ecuador and El Salvador it is the only source used in agriculture. Biomass is the main fuel in Nicaragua and Paraguay, with over 60%. The Dominican Republic predominantly uses electricity; the share of electricity is also important in Mexico, Paraguay and Costa Rica. Electricity is used mainly for livestock farms and irrigation pumps (figure 76).

Agriculture alone (i.e. without fishing and forestry), which includes farms, livestock and irrigation, represents the most significant proportion of the sector's energy consumption.

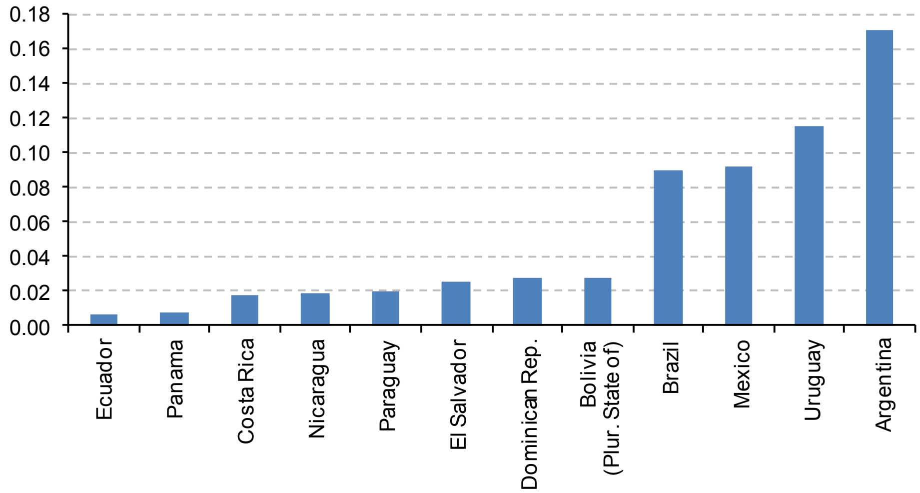
Figure 76
Consumption of agriculture, fishing and forestry by fuel (2010)



Source: BIEE, ECLAC.

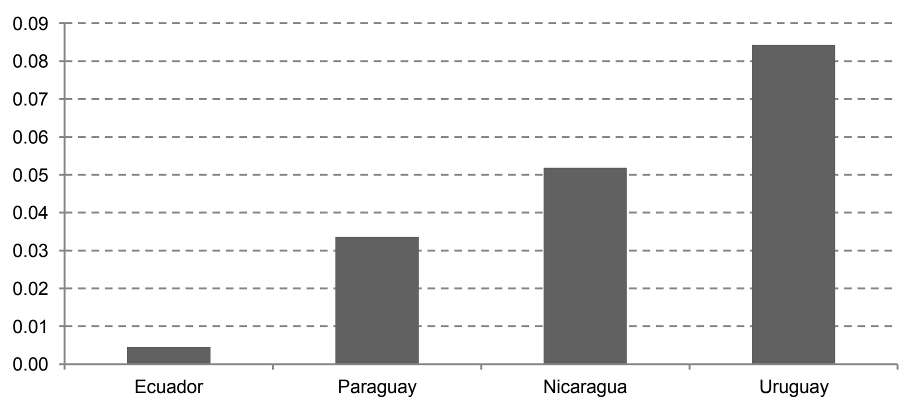
The energy intensities of agriculture are relatively similar among the countries participating in the BIEE Programme. Agriculture is very intensive in Argentina, Uruguay, Mexico and Brazil (figure 78). Consumption per hectare is the highest in Uruguay (figure 77).

Figure 77
Energy intensity of agriculture
(Kept/$2000 ppc)



Source: BIEE, ECLAC.

Figure 78
Energy consumption of agriculture per hectare
(toe/ha)



Source BIEE, ECLAC.

Annex

Organization of the BIEE Programme on energy efficiency indicators

The BIEE Programme on energy efficiency indicators was organised into three main activities:

- Training of experts from national energy Ministries;
- Data collection;
- Dissemination of data and indicators in a regional database on energy efficiency indicators by sector, with national databases and reports on energy efficiency trends by country.

Training

The first step was to train the different experts in charge of the project. Training materials adapted to the Latin American context were produced by the technical coordinator (Enerdata) and enriched as the project progressed with its first results.

Several training sessions have been organized, with a presentation of the main energy efficiency indicators by sector. The training was designed for experts with little knowledge of energy efficiency indicators, or to enhance the knowledge of other experts. The presentations were organized by sector presenting key performance indicators that could be relevant to the Latin American region, with an emphasis on definitions and concepts, and illustration through several case studies.

The training sessions also enabled the teams to strengthen their capacity to analyse and interpret t indicator trends. In particular, countries' representatives were asked to prepare several presentations based on the results for their countries with the assistance of the technical coordination for reviewing.

Finally, assistance was provided by the technical coordination for the preparation of the national reports by providing a very detailed template.

Data collection

The collection of data required for the calculation of indicators began with the creation of an Excel template. This template was adapted from the ODYSSEE data template that all EU member countries complete to update the ODYSSEE data base. The main adaptations were to add the energy sector, to simplify data on space heating, to add industrial activities that are specific to some Latin American countries (e.g. mining) and finally to go into further detail on the agriculture sector. The data template is organised in 7 main sheets, each of which corresponds to a sector: macro (for general macro-economic and energy balance data), energy, industry, households, services, transport and agriculture.

Each data sheet has the same structure:

- Column 1: identification code of the data series;
- Column 2: title in english;
- Column 3: title in spanish;
- Column 3: country code (in 3 letters; e.g. arg for Argentina);
- Colum 4: unit;
- Columns 5 to n: annual values (one column per year);
- Colum n+1: source (short source to characterize each data series)
- Colum n+2: note (used to detail the source).

All the indicators are directly calculated in the Excel template to allow users to understand their calculations. Predefined graphs are available at the end of each sheet to check trends and detect possible data disruptions.

Energy Ministries have been guided throughout the project the way that this file is to be completed and have had the support of the project's technical coordination (ECLAC and ADEME), either through on-site visits or through emails to help them adapt existing data sources to the template categories.

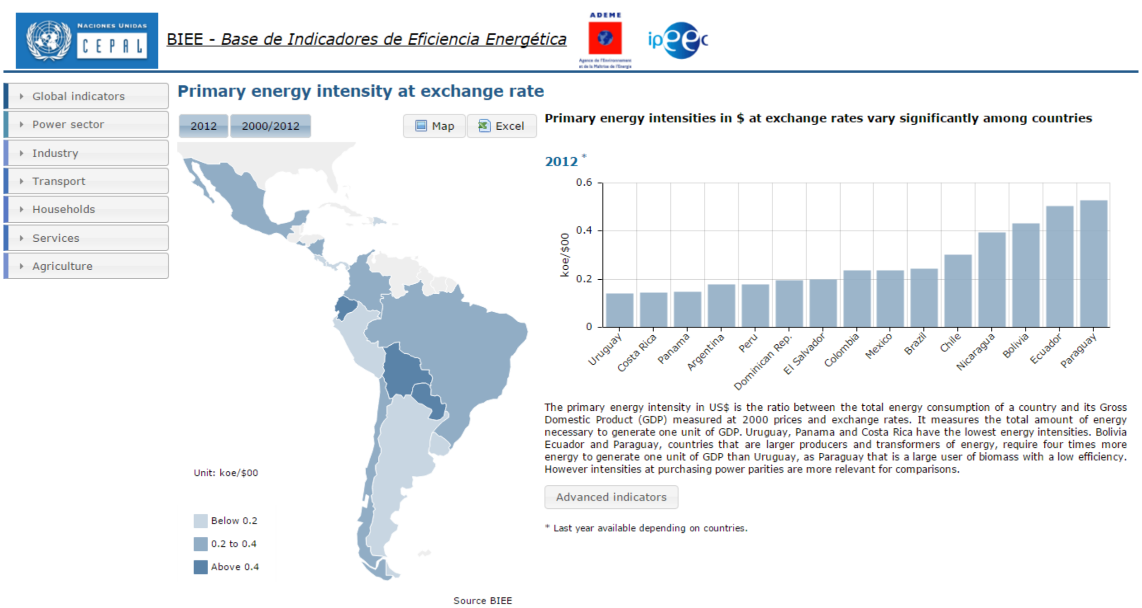
A methodological guideline was prepared at the beginning of the project to explain the definition and usual source of the data used in the data template and to explain the definition of the energy efficiency indicators.

Dissemination

An interactive database has been developed to present the main indicators through maps ("DataMapper") and is available on the project website http://www.cepal.org/drni/biee/.

Datamapper on main energy efficiency indicators for Latin American countries.

Diagram 2
BIEE - Energy Efficiency Indicators Database



Source: www.biee-cepal.enerdata.eu.

ECLAC

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