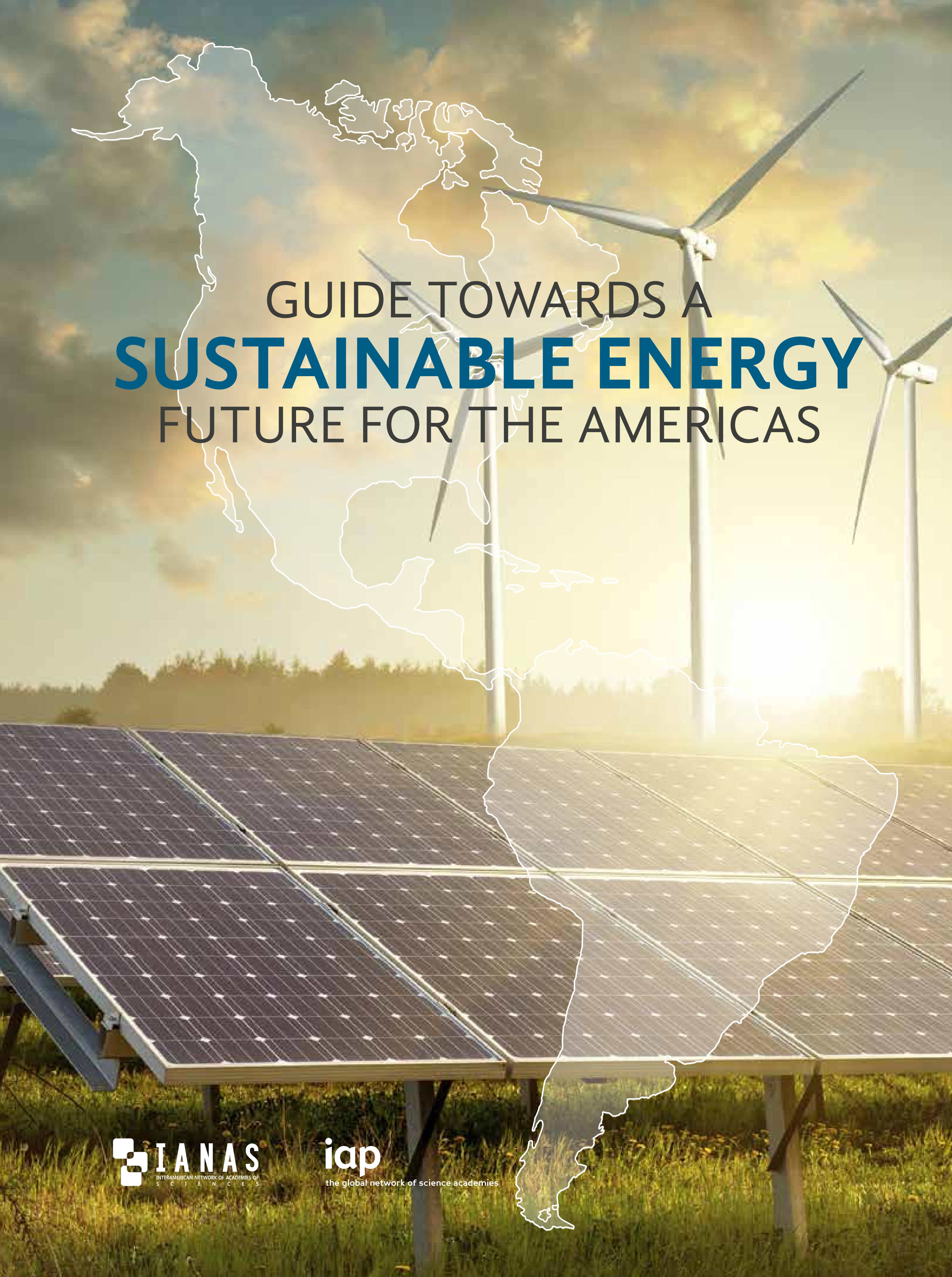
GUIDE TOWARDS A SUSTAINABLE ENERGY FUTURE FOR THE AMERICAS



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GUIDE TOWARDS A
SUSTAINABLE ENERGY
FUTURE FOR THE AMERICAS

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Chapters 1,2,3,4,5,6,7 and all Boxes included in the book
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Box: Energy for Heating
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Editorial Design
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ISBN: 987-607-8379-32-3
Printed in Mexico

Published by The Inter-American Network of Academies of Sciences. IANAS is a non profit international organization hosted by the Mexican Academy of Sciences since 2010. Calle Cipreses s/n, Km 23.5 de la Carretera Federal México-Cuernavaca, 14400 Tlalpan, Distrito Federal, Mexico.

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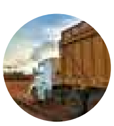


Preface

Energy is essential to human civilization. It is necessary for all aspects of modern life ranging from cooking, to powering machines, to transportation, to heating our dwellings and to providing a source of artificial light. Over the broad sweep of human history, we have moved from relying on wood based energy to the coal-powered industrial revolution to petroleum based energy to nuclear and to solar and biobased energy sources and each of these energy sources continues to be important in the world's contemporary energy economy.

As the human population approaches eight billions the challenges of sustainable energy are taking center stage. The United Nations Sustainable Development Goals (SGDs) include as SDG 7 "to ensure access to affordable, reliable, sustainable and modern energy for all". Concerns about climate change, driven by fossil fuel based CO2 emissions, are forcing a reevaluation of our dependence on different energy sources and are stimulating new research investments in low carbon and sustainable energy systems. We are witnessing an energy transformation that seems gradual, but when looked at retrospectively is impressive. Fuel efficiency and per capita energy consumption have improved substantially over the last half-century, but the pace of improvement must accelerate if we are to achieve a sustainable energy economy.

The purpose of this volume is to provide a science-based analysis of the current energy situation of the Americas and to look into the near term future of energy in the Hemisphere. The book considers key challenges such as bringing adequate energy to under served populations; renewable energy sources and the biofuel revolution and the role of gender in the energy economy. Each chapter includes country specific boxes that provide a picture of energy sources on a national and regional basis. The book also considers the challenges of building the institutional capabilities necessary to advance national energy economies.

The Hemisphere of the Americas is fortunate is having rich energy sources and in having a strong scientific enterprise dedicated to improving energy efficiency and access. While many challenges must be addressed as we move forward, the picture is one of substantial, yet still inadequate progress. It is vital to continue to invest in the scientific innovations that will support a sustainable energy future. Accordingly, we are pleased to present this contribution to the road map for achieving SDG 7 from the Science Academies of the Americas.

Michael Clegg
Co-Chair IANAS, USA

Juan Asenjo
Co-Chair IANAS, Chile

Introduction

John Millhone and Claudio Estrada
IANAS Energy Program Co-Chairs

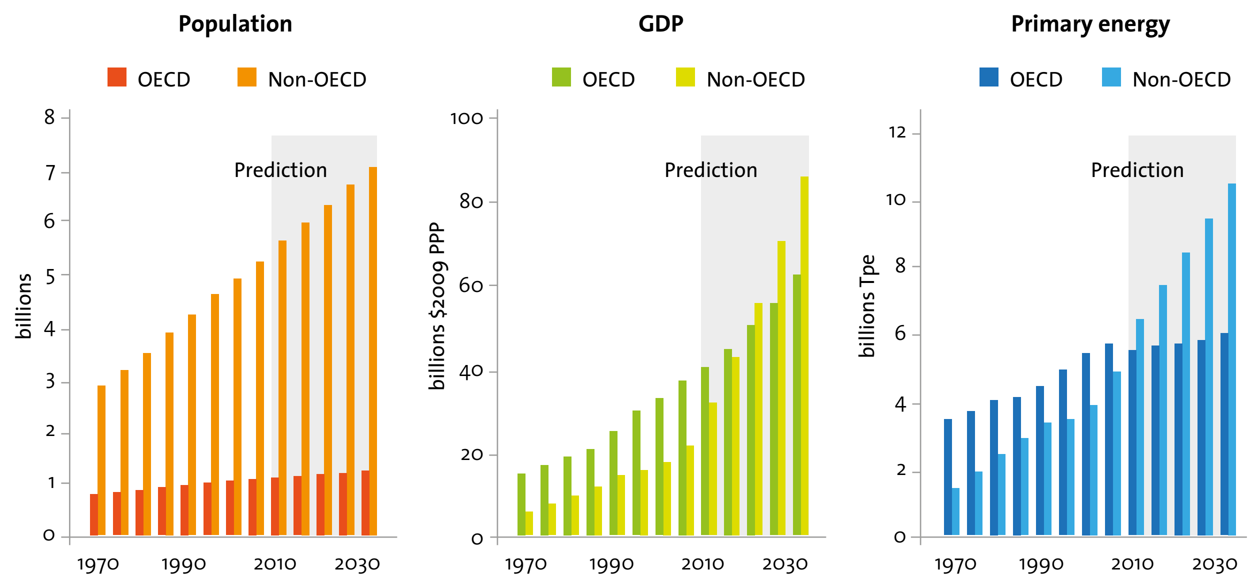
The Americas are an abundant source of energy; all forms of energy, fossil energy and renewable energy, traditional sources and newly discovered sources. We are continuing to discover new sources of energy and how these sources can be used more efficiently and with less pollution. These energy sources are distributed geographically across North, Central, South America and the Caribbean. They contribute to sustain the industries, buildings and transportation of the Americas. A sustainable energy future for the Americas will depend on how we select from this mix of energy resources, transform those sources into useable forms, transport the energy to end users, and improve the efficiency of the end uses. The results will determine the social, environmental and economic future for generations of Americans.

Science and technology have a critical role to play in achieving this sustainable future. Science discovers the energy resources, develops technologies that bring energy sources to end-users, invent energy efficient products, and guide the management of energy systems. Recognizing this role, the InterAcademy Council (IAC), representing the world's leading academies of science, published a report in 2007, *Lighting the way; Toward a sustainable energy future*.[1] For more information on the report, see Box A.

The report motivated the Inter-American Network of Academies of Sciences (IANAS), the network of the 21 science academies in the Western hemisphere, to initiate an Energy Program to chart the path to a sustainable future in the Americas. Thanks to the commitment of the 21 Energy of Focal Points, experts appointed by the Academies of Sciences, and the support of other people and organizations from different scientific organizations, this book summarizes the findings and recommendations of the Program.

1. The Americas played a leading role in the InterAcademy Council's report. The Study Panel that drafted the report was co-chaired by Steven Chu, then Director, Lawrence Berkeley National Laboratory, and later U.S. Secretary of Energy, and Jose Goldemberg, Professor, University of Sao Paulo, Sao Paulo, Brazil,

Figure 1. Population, Energy and Gross Domestic Product (BP, 2011)



The initial IANAS meeting was held in Rio de Janeiro in 2008, where the IANAS academies identified the higher priorities in the Americas in the IAC report. They identified five areas: Energy efficiency, Energy for unserved populations, Renewable energy, Bioenergy, and Capacity building.

The IANAS Energy Program pursued this mission through annual meetings and interim communications where academy representatives shared their insights on the role science can play in advancing these programs. The chapters in this book summarize their findings and recommendations. The authors are listed in Box B. The program would not have been possible without the support from the international InterAcademy Panel and the science academies that supported the program meetings in Argentina, Colombia, Bolivia and the United States.

In the crowded field of publications on energy issues, the book seeks to make a useful contribution in two ways:

First, by focusing attention on the role that science, the science academies, and the science, technologies and engineering communities can play in an energy future of the Americas that is effective, affordable and minimizes environmental impacts including climate change. This includes both the physical and social sciences.

Second, by addressing major energy issues from the perspective of the Western Hemisphere –the perspective of IANAS– and its unique mix of energy sources, uses population distribution, geography and the opportunities for multi-country and south-north collaboration.

The understanding of the perspective of the Americas begins by reviewing the rapid transformation of energy, which has shaped recent global history and the projections for the future role of energy as we project global changers in the coming decades.

World Energy Issues

The world has seen unprecedented population growth in the past one hundred years. It is estimated that in 1900, 1.650 billion people lived on earth and that by 1960 the number had grown to 3 billion, and then doubled in only 39 years, meaning that in 1999 the population had reached 6 billion. In 2013, the world population exceeded 7 billion and it is estimated that by 2030 there will be 8 billion people on the planet. This unprecedented population growth is closely related to the rise in global energy demand.

In a recent study on energy perspectives (BP, 2011) the correlation between population growth, economic growth in terms of GDP and worldwide consumption of primary energy is clearly shown. Figure 1 contains the three corresponding graphs: on the right, world population data; in the center, world GDP values for Organization for Cooperation and Economic Development (OCED) member and non-member countries; on the left, figures for primary energy production during the period from 1970 to 2030.

The first forty years correspond to historical values while the next twenty-year period, from 2010 to 2030, is discussed in terms of a projection based on an evaluation of the most likely world trends.

According to these graphs, the world population has increased by 1.6 billion in the past 20 years, suggesting an increase of 1.4 billion over the next 20 years. At the same time, real economic income in the world has increased by 87% during the past two decades and will probably register a 100% increase in the next two decades. Likewise, the integration of the world economy will continue for the next twenty years, bringing more rapid growth to low and middle-income countries.

Looking more closely at this aspect, emerging countries (including China, India, Brazil and Mexico), and less developed countries, require direct access to modern energy sources, understood as electricity and petroleum-based fuels, in order for their economies to grow.

The International Energy Agency, an authoritative source of strategic analysis, provides a look into the future in its World Energy Outlook, released in November 2014, and extended for the first time to 2040.

The WEO includes three future scenarios. The Scenario of New Policies sees a continuation of current policies and measures as well as a cautious adoption of policy proposals. The Scenario of Current Policies sees no new policies. The 450 Scenario presents what it would take to limit long-term increases in global temperature to 2° C.

In the New Policies Scenario, the global energy demand is set to grow by 37% in 2040, but the rate of growth slows markedly from 2% a year in the past two decades to reach 1% a year in 2025, a result of higher prices and economy shifts to services and lighting industries. Energy use would be essentially flat in North America, Europe, Japan and Korea. The rising consumption would be concentrated in the rest of Asia (60% of the global total), Africa, the Middle East and Latin America.

In 2040, the world's energy supply would then be divided into four almost-equal parts: oil, gas, coal and low-carbon sources.[2]

The WEO warns that the short-term view of ample oil sources should not disguise the challenges ahead. The worry is the small number of oil suppliers. The Americas play a role in this uncertainty: The recovery and financing issues facing production from Brazil's deepwater wells; the environmental and transport issues slowing the flow from Canada's oil sands; the policy and management problems limiting production from Venezuela's vast oil resources; and the anticipated leveling off of United States tight oil output in the early 2020s.

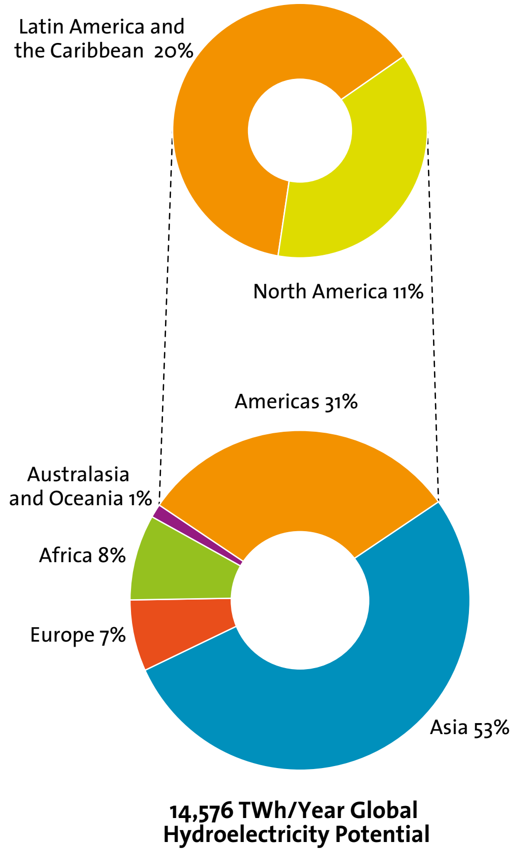
Natural gas use will grow at the fastest pace among the fossil fuels in the WEO's outlook, increasing its consumption by half. The United States is playing a leading role in two ways. The USA leadership in fracking, the hydraulic fracturing of shale to recover natural gas and oil, has boosted natural gas supplies. Aggressive new U.S. restrictions on air pollution are driving a conversion from coal to gas-fired power plants. Mexico, Brazil and Argentina also have major shale resources and could tap this new resource. But tapping this shale resource has its own uncertainties. Opponents argue fracking contaminates ground water, depletes fresh water and degrades air quality. And there is an affordability question. Although the number of liquefaction plants has nearly tripling, the future market for more expensive LNG isn't certain.

Coal is abundant globally, but its future use is impacted by pollution and high CO2 emissions. The WEO expects coal demand to increase 15% to 2040, with most of the gain in the next 10 years. Coal use in the United States, the dominant user in the Americas, is expected to plunge more than one-third, reduced by stringent air-quality regulations.

The WEO expects one-quarter share of global energy will be provided by low-carbon resources in 2040. This includes nuclear power and renewable energy technologies.

2. The description of the an energy system under stress draws heavily on the WEO, pp. 23-25.

Figure 2. World potential for generating hydroelectric energy (TWh/year) (IPCC, 2012)



The outlook for nuclear power is complex. Nuclear power can provide reliability and diversity to a country's electricity system. It avoids the release of CO2 emissions. But nearly 200 reactors–of the currently 434 operating reactors–are expected to retire by 2040.

Growth will depend on state backing, protective regulated prices, and support for private investment. And a shadow lingers from the accident at Fukushima Daiichi. Balancing these factors, the WEO expects nuclear power's share of global electricity generation to rise by only one percentage point to 12% in 2040.

The growing role of renewable energy technologies is a critical element in the WEO report. Renewable energy is projected to be the fastest growing source of energy from now to 2040. Advanced technologies, lower costs, and supporting government policies are driving this transformation. Electricity is the fastest growing final form of energy in the 2040 outlook. Renewable energy is expected to provide half the increase in electricity generation. The major renewable resources supporting this increase are wind power, 34%; hydropower, 30%, and solar, 18%.

The WEO's 450 Scenario, which describes the measures that would avoid the catastrophic impacts of climate change, places even greater reliance on increases in the contribution of renewable energy technologies.

The Potential of Renewable Energy in the Americas and the World

The increased global attention being given to renewable energy and its role in reducing greenhouse gas emissions give a special meaning to the timing of the IANAS book on a sustainable energy future for the Americas.

When the IANAS Energy Program was initiated five years ago, the link between sustainable energy and renewable energy was recognized in its priorities. Providing modern energy to unserved populations relies primarily on solar, wind, low-head hydropower and environmentally harvested firewood. Renewable energy was reflected in two of its priorities. The advancement of bioenergy was singled out as a separate priority because of the leadership of Brazil and the Americas in advancing the development of modern bioenergy. The energy efficiency priority was extended to efficiency of the use of renewable energy in buildings and equipment. Capacity building included the personnel training and physical infrastructure essential for an expanded reliance on renewable energy sources. Cooperation between the IANAS Energy and Women for Science programs is drawing attention to the gender, energy and water nexus that demands additional attention if we are to have a sustainable future

The importance of the existing and potential future role of renewable energy in the Americas is apparent from a comparison of the size and mix of the renewable resources in the Americas and the world. The following text and figures show the potential, used and unused sources of hydropower, geothermal, solar and wind energy in the Americas and the world.

Figure 2 shows the world hydroelectric potential for power generation according to the IPCC (2012), which accounts for 14,576 TWh per year (TWh/year).

The potential for the Americas totals 4,515 TWh/year, of which only 30% is used. North America has a potential of 1,659 TWh/year, while LA & C have a potential of 2,856 TWh/year, of which only 38% and 26% are being used respectively (Figure 3). This implies that large reserves of as-yet-unused hydroelectric energy exist in the region.

Likewise, Figure 4 shows the world potential for the generation of geothermal power, totaling 11,200 TWh/year, according to the International Geothermal Association (IGA), of which the Americas represent 37% (4,130 TWh/year) and of which only 1% of the regional potential is used. Figure 9 shows that the geothermal potential in North America is 12% (1,330 TWh/year) while in LA&C it is 25% or 2,800 TWh/year.

Figure 5 shows the distribution of solar energy on Earth, given the average daily amount of sunshine per year, measured in kilowatt-hours per m2 (kWh/m2) per year. Along the 40oN and 35oS parallels, the "Sunbelt" houses 70% of the global population and receives the majority of the world's sunlight.

Figure 3. Used and unused potential for generation of hydroelectric energy (TWh/year) in North America and LA &C. (IPCC, 2012)

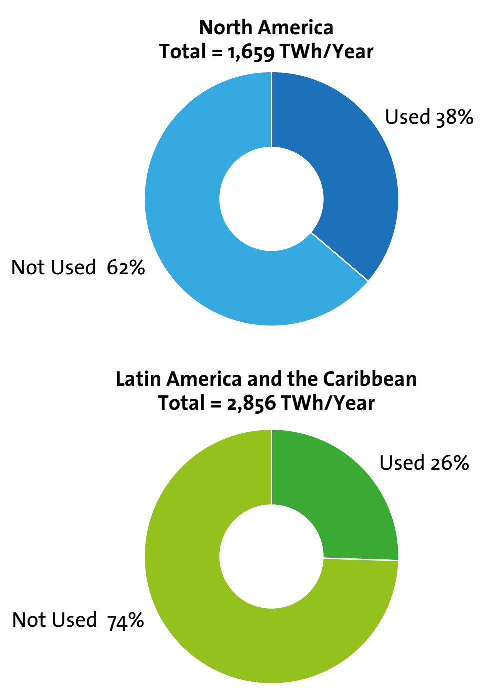
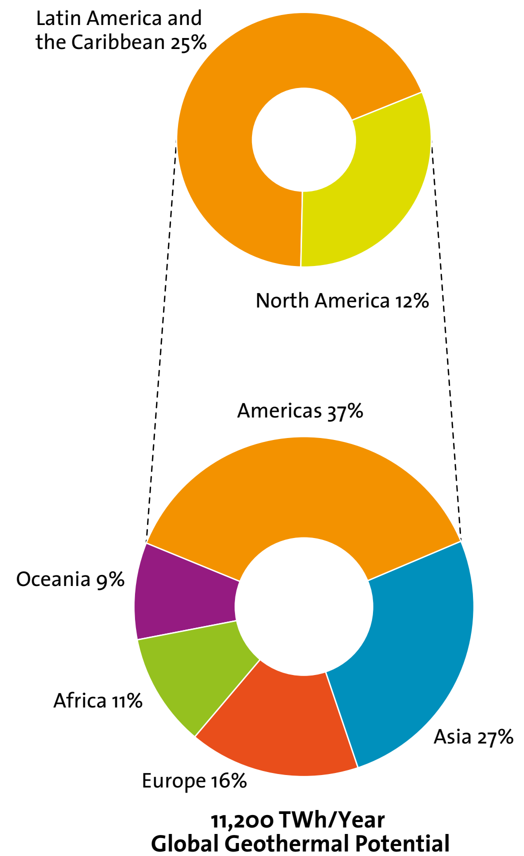


Figure 4. World Potential for the Generation of Geothermal Electricity by Region (IGA, 2012)



The world solar power potential for power generation by region is shown in Figure 6

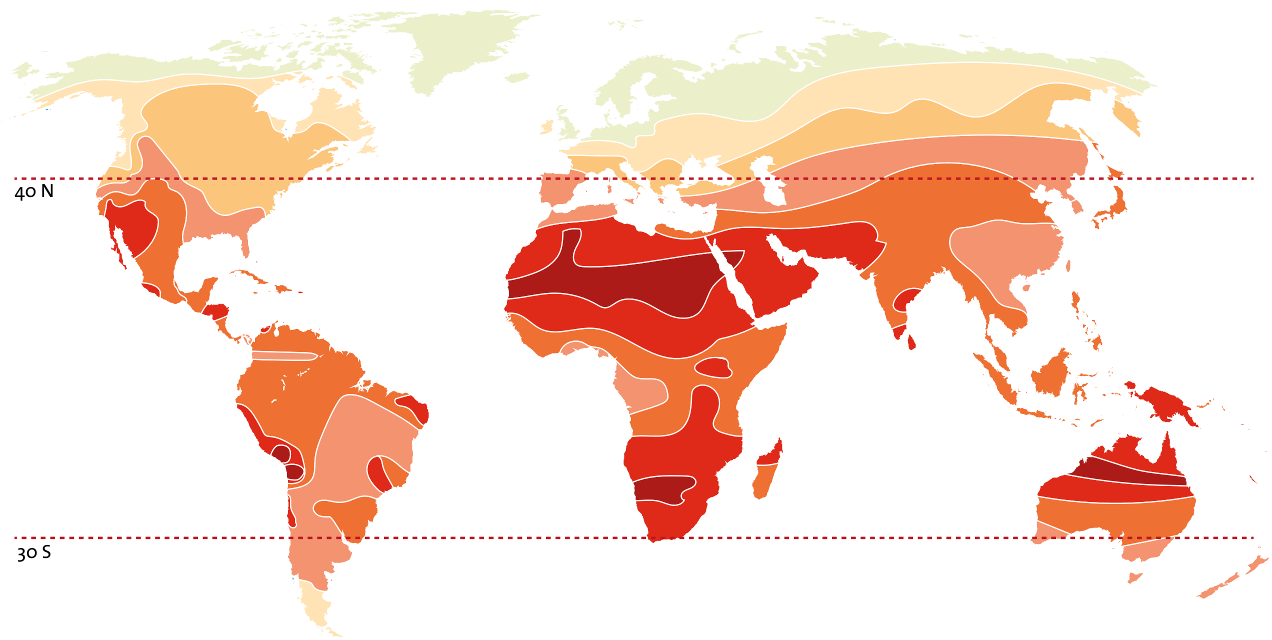
(NREL, 2009). Here the Americas represent almost 30% of the potential, with North America accounting for 13% and LA &C for 17%.

Figure 7 illustrates the global potential for power generation by wind power. It shows that 31% of the world potential corresponds to the Americas, 22% of which is from North America and the remaining 9% from LA &C. Only 0.1% of North America's vast potential is currently used, as opposed to only 0.02% in LA &C (GWEK, 2014)

Integrating Renewable Energy into the Americas Sustainable Energy Future

While the book recognizes the prominent role of renewable energy in the hemisphere's energy future, the book also describes how these sources are integrated with other energy sources and uses in the Americas as we address the challenges of the future.

Figure 5. Global Solar Energy Distribution, kWh / m² / year (OK Solar, 2013)



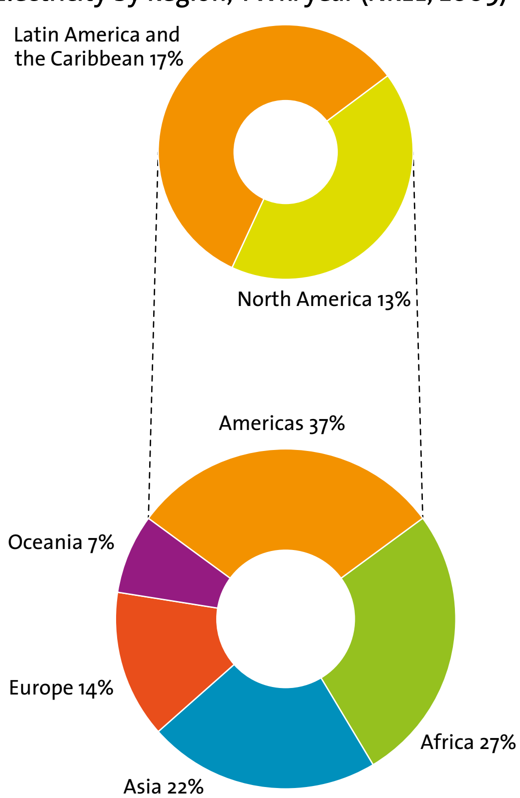
The challenges are great. The WEO and other long-term projections of the world's energy future increasing recognize that our current worldwide energy patterns are not sustainable. They cite three reasons.

- First, the population growth and rising living standards are increasing energy demands.
- Second, there is a finite supply of the primary energy sources (hydrocarbons) used by humans to meet their needs.
- Third, the catastrophic effect of the intensive use of carbon fuels on the environment of our planet.

In addition to the need to change the mix of energy sources, the WEO also highlights other energy issues with major impacts globally and in the Americas, including low energy efficiency, energy subsidies and Climate Change.

The WEO foresees continuing improvements in energy efficiency, critical to slowing global energy use and reducing environmental pollutants.[3] It cites the transport sector as the accelerator of the

Figure 6. Global Potential for Solar-Generated Electricity by Region, TWh/year (NREL, 2009)



3. WEO, p. 26.

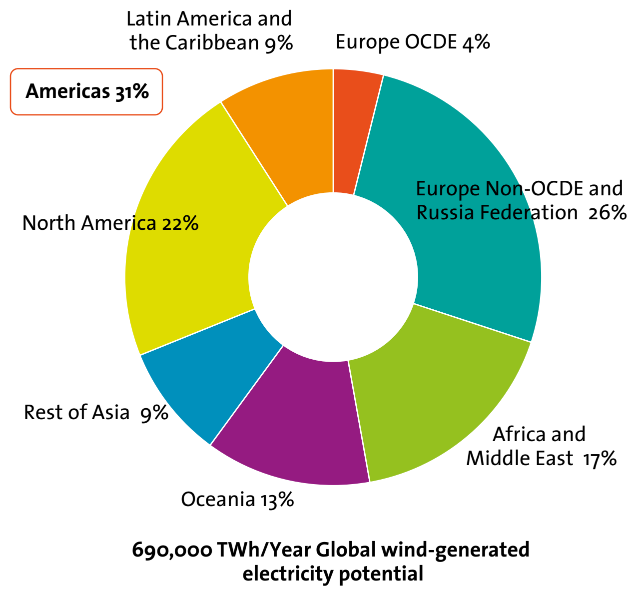
savings with three quarters of all cars now subject to efficiency standards. Oil transport demand is projected to increase only one-quarter while the number of cars and trucks doubles. Efficiency can also reduce the energy-cost impact of high import dependent regions. Regional price disparities are expected to narrow but remain with North America remaining a low-cost region. In the Americas, this involves a changing mix of fuels, global leadership in biofuels, multiple infrastructure challenges, and price disparities

The WEO devotes a chapter to fossil energy subsidies, pointing out that they totaled $550 billion in 2013, four times more than renewable energy subsidies. The 40 countries that subsidize fossil energy account for more than half the global consumption. The rate of subsidization (the rate of the subsidy to the international reference price) averages 23%. The rate varies among the countries, but Venezuela is the highest at 93%. The WEO and a recent study by the International Monetary Fund[4] document the negative impacts of subsidies. They discourage investments in energy sector, crowd out public spending that would boost growth, misallocate capital and energy-intensive activities and increases energy consumption, environmental pollution and carbon emissions. As we know in the Americas, these damaging impacts extend to neighboring countries, preventing them from adopting programs and policies consistent with modern energy realities. The WEO and IMF reports are constructive in they don't simply condemn these subsidies; they also provide workable guidelines for ending subsidies. They require time and commitment, but are essential for sustainable energy futures in the impacted countries.

The book goes to press before the United Nations Climate Change Conference in Paris in December, but the debate leading up to the conference is underscoring the importance of sustainable energy programs in the Americas. The conference objective is a legally binding universal agreement that avoids catastrophic climate change impacts on all the nations of the world. The climate stabilizing WEO 540 Scenario is getting a second look.

4. International Monetary Fund, *Energy Study Reform: Lessons and Implications.* January 28, 2013

Figure 7. Global potential for wind-generated electricity (IPCC, 2012)



The stabilizing scenario would rely heavily on a greater future role for renewable energy. Globally, the increase in renewables share of total electricity generation would rise from 33% in the New Policies Scenario to 51% in the 450 Scenario; for biofuels, an increase from 6% in the New Policies Scenario to 20%.in the 450 Scenario.[5]

The build-up to the Climate Change Conference is attracting numerous policy statements on what should be done in Paris. Wide attention is being given to a New Climate Economy report which argues that lowering greenhouse gas emissions can be achieved without the adverse economic impacts that many fear. The report was drafted by a commission chaired by former President of Mexico Felipe Calderón and composed of 28 chief executives, political figures and economists.[6] The inclusive make-up of the commission helps explains the attention it is receiving.

5. WEO, p. 242.

6. New Climate Economy, Global Commission on the Economy and the Climate, *Seizing the Global Opportunity: Partnerships for Better Growth and a Better Climate,* www.newclimateeconomyreport.net Additional information from the Financial Times, July 7, 2015, p. 7, and July 9, 2015, p. 6.

The New Climate Economy report has a special relevance for the IANAS energy book because many of its findings and recommendations at the global level are similar to the analyses and proposals that the book recommendations for the Americas.

The Climate report says future economic growth doesn't have to copy the high-carbon model of the past, pointing to the potential transformation of three key systems of the economy: cities, land-use and energy. The book also supports these transformations.

The transformation of the cities in the Americans has a potential that often goes unnoticed. The world's most urbanized regions are Northern Americas (82% living in urban areas in 2014) and Latin America and the Caribbean (80%).[7] The role that science can play in the transformation of urban regions is described in the chapters on Women Energy and Water and Renewable Energy. The Capacity Building chapter addresses the importance of focusing on priorities, including more compact and connected urban development.

The transformation of land use is essential, the report says, to feed a global population projected to exceed 8 billion in 2030. The book's chapter on bioenergy describes the progress and challenges of reducing deforestation in Brazil and the countries bordering Amazonia and the restoring of forests and sustainable agriculture. Progress has been made through legislation and compliance, improved recently verified by drone technologies.

The transformation of energy, the report says, because the world is on the cusp of a clean energy future based heavily on advances in renewable energy and energy efficiency. This resonates directly in the book. The Americas have the opportunity to be the global leaders in the clean energy future. The use of abundant solar and wind resources is rising rapidly, driven by higher efficiency and lower costs. The mix of hydropower energy, environmental and social issues are getting increased attention. The Americas bioenergy leadership is exploring the next generation of bioenergy technologies. The geothermal resources, immense and untapped, are waiting to be tapped. This mix of resources is generating electricity, that is used directly, and bringing modern energy to unserved populations. The Renewable Energy; Women, Energy and Water; and Unserved Population and Bioenergy chapters describe these opportunities in detail. The immense potential for energy efficiency from sources to final end uses is described in the Energy Efficiency chapter. The human and physical resources needed for these advances are described in the Capacity Building chapter. The media's attention to the New Global Economy report has focused on its 10-point Global Action Plans that would meet up to 96% of the emission cuts in the WEO 540 Scenario, without denting the global economy. The 10 points focus on the decisions at the world's Climate Conference in December in Paris, but also have relevance to the IANAS book recommendations. See Box C.

IANAS is fortunate to have the release of the New Climate Economy plan as we are preparing to publish a book that champions many similar programs in the Americas. While we can't match the plan's clarion call for government policy leadership, the book can provide information on the science, engineering and education that supports the advancement of those goals in the Americas.

Summary

The chapter introduces readers to a science-based book that seeks to advance sustainable energy in the Americas. The book traces its origin back to 2007 when InterAcademy Council, an organization composed of the world's leading academies of science and equivalent organizations, published a trailblazing report on sustainable energy, *Lighting the way; Toward a sustainable energy future*.

The report stimulated IANAS, the network of science academies in the Americas, to ask how the priorities and insights of the report could be could be advanced in the Americas. A priority-setting workshop in Buenos Aires identified unusual priorities. The dominant fossil fuels –oil, natural gas, coal– were not where the academies saw their greatest potential. Their priorities were energy for unserved populations; renewable energy, particularly bioenergy; energy efficiency and capacity building. An Energy Program was

7. United Nations, Department of Economic and Social Affairs, Population Division (2014). *World Urbanization Prospects. The 2014 Revision, Highlights* (ST/ESA/SER.A/352).

created to advance these priorities. The chapters of the book present the programs research and recommendations.

The chapter includes graphic comparisons of the Americas' potential share of the world's renewable energy resources. The Americas abundant mix of renewable resources influences all the chapters, not only the renewable energy and bioenergy chapters. The primary modern energy sources for unserved populations are solar, wind, micro-hydropower and sustainable forestry. Efficiency is driving down the cost of solar and wind power and the use of this power in lighting, appliances and equipment.

The academies' representatives showed some prescience when they selected the priorities of the IANAS Energy Program. The priorities they choose–energy for unserved populations, renewable energy, energy efficiency, capacity building–modest at that time, have become today's major policy topics. This is shown in two recent reports cited in this introduction, the IEA's World Energy Outlook 2014, and the New Climate Economy report released in the build-up to the climate change conference in Paris. Both rely heavily on strong renewable energy programs and energy efficiency measures to secure a sustainable future.

The challenge for those committed to shaping the energy future of the Americas is to understand these changes, their impact on the Americas and how those shaping these impacts can make and implement policies that advance the well-being of all Americans. The role of IANAS is to bring the potential of the energy sciences and technologies to this collaborative process that involves government, industry, education and social partners.

Major energy policies and challenges for the Americas

The introduction and chapters of the book explore the energy policies and challenges that must be met to secure a sustainable future of the Americas. They are:

- To develop a changing mix of fossil fuels, which is part of the global as well as the American markets, which balances economic, political, environmental and social priorities?
- To expand the development of Americas' abundant renewable resources, increasing their local, state and regional programs and serving as the model to the rest of the world.
- To provide modern energy resources to all Americans through policies that include advanced, low-cost technologies designed for the emerging market and the optimal combination of site-based renewable sources and electric grid extensions.
- To improve the efficiency and performance in all energy uses from initial sources to final end uses through research and development, the introduction of advanced products, and education and market transformation programs.
- To enhance the understanding of energy and environmental issues, with special attention to Climate Change programs, and advance the Americas support for an energy trajectory that limits the low-term increase in average global temperature to 2° C.
- To strengthen capacity building programs in the Americas so they have the science, technical, education and labor resources needed to design and deliver a sustainable energy program for the Americas.

We want to finish this introduction by expressing our sincere thanks and appreciation to each and every one of the authors (that being many we have listed in Box B) of the different chapters of the book and their respective Academies of Sciences, for their tremendous commitment to make this book came to light. In particular, we recognize the impressive work of coordination of Adriana de la Cruz, from secretariat of IANAS and Drs. Mike Clegg and Juan Asenjo, our two Co-Chairs of IANAS, who never stopped believing in the importance of this book for our scientific communities of the Americas.

Acknowledgments

We thank for support in retrieving and ordering information, execution of the graphs are due to Genice Grande Acosta, academic technique of the Energy Planning Group at the UNAM Institute for Renewable Energies. Also we thank Dr. Jorge Islas for his comments and suggestions during the elaboration of this introduction.

Bibliography

British Petroleum (BP), (2011), Energy Outlook 2030, 80 pp. Available at: http://goo.gl/Moj9xQ Consulted August 14th, 2013.

British Petroleum (BP) (2013), BP Statistical Review of World Energy June 2013. Available at: http://goo.gl/G4LXNc Consulted June 3rd, 2014.

German Advisory Council on Global Change, 2003.

International Energy Agency (IEA) (2013), Renewables Information. IEA, France.

Intergovernmental Panel on Climate Change (IPCC) (2012), Special Report on Renewable Energy Sources and Climate Change Mitigation, Full Report, New York, Cambridge University Press.

National Petroleum Council (NPC) (2007), after Craig, Cunningham and Saigo.

US DOE/EIA (2013), US Energy Information Administration. Annual Energy Outlook 2013 with projections to 2040, 244 pp. Available at: http://goo.gl/IkeIRa Consulted on August 14, 2013.

Box A
The Science Behind the Book

When a sustainable future gained increase attention in the new millennium, international science leaders recognized the importance role of science in achieving this future. The InterAcademy Council (IAC) Board created a Study Panel to draft a report on the role of science. The Americas played a leading role in the report. The panel was co-chaired by Steven Chu, then Director, Lawrence Berkeley National Laboratory, and later the U.S. Secretary of Energy, and Jose Goldemberg, Professor, University of Sao Paula, Sao Paulo, Brazil. The IAC Board is composed the presidents of 15 leading national academies of sciences of three international organization representing developing world, engineering, and medical scientists.

The study panel's 2007 report, Lighting the way; Toward a sustainable energy future, contains nine conclusions:

1. Meeting the basic energy needs of the poorest people on this planet is a moral and social imperative that can and must be pursued in concert with sustainable objectives.
2. Concerted efforts must be made to improve energy efficiency and reduce the carbon intensity of the world economy.
3. Technologies for capturing and sequestering carbon from fossil fuels, particularly coal, can play a major role in the cost-effective management of global carbon dioxide emission management of global carbon dioxide emissions.
4. Competition for oil and natural gas supplies has the potential to become a source of growing geopolitical tension and economic vulnerability for many nations in the decades ahead.
5. As a low-carbon resource, nuclear power can continue to make a significant contribution to the world's energy portfolio in the future, but only if major concerns related to capital cost, safety and weapons proliferation are addressed.
6. 6. Renewable energy in its many forms offers immense opportunities for technological progress and innovation.
7. Biofuels hold great promise for simultaneousl7 addressing climate change and energy-security concerns.
8. 8. The development of cost-effective energy storage technologies, new energy carriers, and improved transmission infrastructure could substantially reduce costs and expand the contribution from a variety of energy supply options.
9. The S&T community–together with the general public–has a critical role to play in advancing sustainable energy solutions and must be effectively engaged.

Box B
Authors y coordinators

The following is the list of authors, academies of science and countries in alphabetic order of last name and the coordinators of the book:

- Ricardo Baldassin Jr. Cruz | Brazilian Academy of Sciences |Brazil
- Tomás Bazán | Panamanian Academy of Exact, Physical and Natural Sciences | Panama Nicole Bernex | National Academy of Sciences of Peru | Peru
- Carlos Brito-Cruz | Brazilian Academy of Sciences | Brazil
- Andrea C. Bruce | Jamaican Chapter of Caribbean Academy of Sciences | Jamaica

- Anthony Clayton | Jamaican Chapter of Caribbean Academy of Sciences | Jamaica
- Luis Cortez | Brazilian Academy of Sciences | Brazil
- Mónica M. Gómez | National Academy of Sciences of Peru | Perú
- Rafael Espinoza | National Academy of Sciences of Peru | Perú
- Claudio A. Estrada Gasca | Mexican Academy of Sciences | Mexico
- Wilfredo César Flores Castro | National Academy of Sciences of Honduras | Honduras
- Frances Henry | The Academies of Arts, Humanities and Sciences of Canada | Canada
- Manfred Horn | National Academy of Sciences of Peru | Perú
- Jorge M. Islas Samperio | Mexican Academy of Sciences | Mexico
- Mario Jiménez | Nicaraguan Academy of Sciences | Nicaragua
- Miguel Kiwi | National Academy of Sciences of Chile | Chile
- Miguel Laborde | National Academy of Exact, Physical and Natural Sciences of Argentina
- John Millhone | US National Academy of Sciences | United States of America
- Luiz. A. H. Nogueira Cruz | Brazilian Academy of Sciences |Brazil
- José Rincón | Colombian Academy of Exact, Physical and Natural Sciences | Colombia
- Gustavo Sequiera | Nicaraguan Academy of Sciences | Nicaragua
- Patricia L. Serrano-Taboada | National Academy of Sciences of Bolivia | Bolivia
- Katherine Vammen | Nicaraguan Academy of Sciences | Nicaragua
- Walter Wehrmeyer | Jamaican Chapter of Caribbean Academy of Sciences | Jamaica

Other contributors for the book process:

- Arturo-Fernandez Madrigal | Centro de Investigación en Energía | Mexico
- Mario Alberto Juan Mariscotti | ANCEFN
- Daniel-Lopez Aldama | Cuba energia
- Sergio Pastrana | Cuban Academy of Sciences | Cuba
- Melio-Saenz Echeverria | Centre Latin American de Calcul Sciengifique et d'informatique industrielle | Ecuador |
- Ivan-Azurdia Bravo | Academia de Ciencias de Guatemala
- Manuel Benigno-Gil Morlis Facetti | Sociedad Cientifica del Paragua | Paraguay
- Jose Manuel-Aller Castro | Universidad Simon Bolivar | Venezuela
- Luis Berriz | Cubasolar | Cuba
- Roberto Williams | National Academy of Exact, Physical and Natural Sciences of Argentina

Coordinators:

John Millhone, Energy Program Co-Chair
Claudio A. Estrada, Energy Program Co-Chair
Adriana de la Cruz, IANAS Executive Director

IANAS Co-Chairs:

Mike Clegg | USA
Juan Asenjo | Chile

Box C
10 Point Global Action Plan

1. Accelerate low-carbon transformation by integrating climate into core economic decision-making processes.
2. Enter into a strong, lasting and equitable international climate agreement.
3. Phase out subsidies for fossil fuels and agricultural inputs, and incentives for urban sprawl.
4. Introduce strong, predictable carbon prices.
5. Substantially reduce capital costs for low-carbon infrastructure investments.
6. Scale up innovation in key low-carbon and climate resilient technologies.
7. Make connected and compact cities the preferred form of urban development.
8. Stop deforestation of natural forests by 2030.
9. Restore at least 500 million hectares of lost or degraded forests and agricultural lands by 2030.
10. Accelerate the shift away from polluting coal-fired power generation.

Chapter 1

Energy Efficiency in the Americas

From turning off the lightbulb to exploiting opportunities to improve conversion efficiencies

John Millhone | United States

Summary

The countries in the Americas have a unique and far-reaching opportunity to improve their energy efficiency due to rapid advances in in energy-saving technologies, the countries' rich mix of energy resources, the benefits of collaborative action, and the insights of their science communities.

The pathways to achieving these efficiencies depend on clear, accurate and comprehensive data on how energy is produced, transported, used and disposed of in the Americas This pathway can be measured in two ways: monetary and environmental. Historic sources have tracked energy when it is given a monetary value. Increased attention is being given to environmental impacts that begin when energy is drawn from natural sources and extended to when its products are returned to the environment.

The chapter focuses on the energy efficiency opportunities along this chain from the capture of energy from fossil and renewable sources, the conversion and transport of energy to end-use sectors and the end use of energy.

The early opportunities for savings are in the capture of fossil fuels, transport to refineries and power plants, their efficiency, pipelines and transmission lines and, most importantly, the chosen mix of energy sources. Other chapters that also address these front end efficiencies are: Renewable Energy; Bioenergy; Energy for Unserved Populations; Women, Water and Energy; and Capacity Building.

The end-use sectors provide large, diverse and cost-effective opportunities for improved energy efficiency. This is critical because the end-use savings also produce savings back up the energy chain, particularly by lower demand on electricity

generation and transmission. The chapter divides energy end use into four sectors: industry, transport, buildings and agriculture (including forestry and fishing)

The industry sector focuses on energy-intensive industries but also covers high value-added and low energy industry. The best available industrial technologies can reduce energy use and carbon emissions by one quarter to one third. The transport sector is the largest energy user in the Americas. The sector is critical and complex because of the Americas history, economics, climate, geography and diverse population density. Little change in transport energy use is projected in the United States and Canada by 2040, but a nearly 50% increase is projected for Central and South America. New transportation infrastructure that respects environmental values is critical. The building sector—residential, commercial and public buildings—is advancing energy efficiency through a robust program of research, development, demonstration and deployment. The advances are ensured by building codes and appliance, equipment and lighting labels and standards. The fourth sector includes agriculture, forestry and fishing. Their combined energy use in the Americas is small, only 1.2%, but their importance in related environmental and land use areas is huge, including agricultural output, changes in land use and deforestation.

The energy efficiency recommendations include support for sustainable energy policies and programs; recognize the potential savings along the energy chain; exchange RD&D among countries; build relationships among governments, industry, financial sources and NGOs; inform the public about the advances in science; and participate actively in multi-country policies and actions.

Introduction

Improving energy efficiency can be described as simply as turning off a lightbulb. But when you look beyond the light switch you find a wire that brings electricity to your site through a transmission line from a generating plant, powered from a primary energy source, which was transferred to the power plant by rail or pipeline from a mine or a well. Everywhere along this energy chain there are opportunities to increase efficiency, lower costs, reduce pollution and moderate the impact of climate change.

The countries of the Americas are in a unique position to improve energy efficiencies along this energy chain because of their mix of energy resources, their leadership in developing advanced technologies, and the collaborative spirit among the countries and their scientific communities. The pursuit of economic competitiveness, environmental improvements and energy security all argue for increased energy efficiency.

"Maximum energy savings can be achieved by comprehensively exploiting opportunities to improve conversion efficiencies and reduce end-use intensity throughout the energy supply chain," as stated in *Lighting the way; Toward a sustainable energy future*,[1] the InterAcademy Council report that inspired the IANAS Energy Program.

1. InterAcademy Council, 2007. p.23. Accessible at www.interacademycouncil.net

Energy passes through three stages from its sources to its final end uses and each stage offers opportunities for improved efficiency, environmental benefits, and lower costs. This chapter identifies opportunities or improved efficiency along this energy chain.

Energy efficiency stages

The first stage is the production of energy from a primary energy source. This includes the mining of coal and uranium, the extraction of oil and natural gas from underground wells and hydropower, solar, wind, geothermal and other renewable sources. It also includes the transport of produced energy among countries that determines the available energy in each country, its Total Primary Energy Source (TPES). Each country is then responsible for the efficient use of its TPES.

The second stage is the transfer of a country's primary energy resources, its TPES, to its energy end-use sectors: industry, transport, buildings and agriculture. The largest energy use in this link is the generation of electricity and its transmission and distribution to the end use sectors. This stage also includes the refining of petroleum and processing of natural gas and delivering them to end use customers.

The third stage is the use of energy in the four end-use sectors. The industry sector focuses on energy processes, but also includes less-intensive uses. The building sector covers all residential, commercial and public buildings. The transport sector covers all forms of vehicular, rail, air and pipeline transport. The agriculture sector also includes forestry and fishing. There are opportunities for energy savings in each of these stages.

Energy efficiency reports often cover only the opportunities for energy savings in the end-use sectors. This fails to recognize that end-use savings mean less energy will be used to produce, convert, and transport energy to the end uses and also avoids their associated costs, environmental impacts and greenhouse gas (GHG) emissions. The energy chain perspective also highlights the benefit of site-based sources, e.g. solar and wind, which require no energy in the first two stages.

The International Energy Agency (IEA) is a valuable source of energy data that covers all the countries of the world. The data tracks energy volumes and prices from when the energy enters into commercial markets. Table 1 shows the data for the Americas from the IEA website. The Total Primary Energy Sources (TPES) is the primary energy available in a country after its exports and imports.

The IEA groups data separately for Organization for Economic Cooperation and Development (OECD) and non-OECD countries. Canada, the USA, Mexico and Chile are in the OECD. The top tables below combine the data for all the Americas, followed by tables on the OECD and non-OECD countries. The data shows the balances in terms of thousand tonnes of oil equivalent (ktoe) in 2011. The percentages show the energy required to move primary energy to final consumption and the shares used by the end-use sectors. The IEA tables don't include traditional bioenergy sources, such as firewood used by indigenous communities. Bioenergy also includes other biofuels, agricultural products, peat and manure. Bioenergy plays a significant role, accounting for 77% of renewable energy, most of which comes from wood (87% of bioenergy). More than 2 billion people in the world depend upon firewood and charcoal to meet their daily energy needs. (REN21,2012).

Total Primary Energy Source

The Americas are fortunate in having abundant and diverse energy resources as a hemisphere and within North, Central and South America. The challenge in this book is to identify these energy resources so their development can be optimized giving attention to global supply issues, such as the petroleum supplies, and to an increased reliance on renewable energy.

Energy resources are distributed unevenly among countries. The first link in the energy chain is to find and characterize these energy resources, produce this energy and transport it to the countries where it will be used.

Science and engineering play an important role in finding and characterizing energy resources, recovering them efficiently and transporting them to the countries where they will be used, their TPES. The science academies can advance this contribution through collaborative action among neighboring countries and increasing public awareness of the global and the here-and-now in-country impacts of Climate Change.

TPES to End Uses

The second link in the energy chain connects the primary energy in a country, its TPES, to its end-use sectors—industry, transport, buildings and agriculture. There are cost-effective opportunities for improved efficiency across all of these connections.

The dominant potential savings in this link is the modernization of the power generation and power grids in many multi-country regions of the Americas. Because of the shared-interests of neighboring countries, the science academies of these countries are in an influential position to help achieve these reforms and realize their energy, economic and environmental benefits.

Electric grid improvements could achieve large energy savings and reductions in greenhouse gas emissions through improved efficiency, grid access to lower-cost power plants, the integration of hy-

Table 1. Americas Energy Balance Table

Indicators	Balance in ktoe	Percentages
Americas Energy Balance		
Production	3,228,863	
TPES	3,251,992	100
Total final consumption*	2,299,614	29.3
Industry	540,045	16.1
Transport	851,634	26.2
Buildings	652,170	20.1
Agriculture	55,518	1.2
Non-energy use	200,527	6.2
OECD Americas		
Production	2,431,890	
TPES	2,662,783	100
Total final consumption*	1,848,933	30.6
Industry	382,342	14.4
Transport	707,511	26.6
Buildings	557,142	20.9
Agriculture	36,376	1.4
Non-energy use	165,562	6.2
Non-OECD Americas		
Production	796,973	
TPES	589,209	100
Total final consumption*	450,681	23.5
Industry	157,703	26.8
Transport	144,123	24.5
Buildings	95,028	16.1
Agriculture	19,143	3.2
Non-energy use	34,695	5.9

* The percentage is the difference between the TPES and the Total final consumption.

dropower and other renewable sources and net metering, demand-side management and smart grids. The modern grids also would advance other IANAS priorities, including expanded use of renewable energy, access to energy for unserved and underserved populations, and the capacity needed for sustainable energy.

These priorities are making electric grid reforms a priority in the countries of the Americas. In addition, multi-country reforms are getting more attention and offer opportunities for the collaboration among neighboring countries. These growing global power grid projects include:

- **SIEPAC**. The Central American Electric Interconnection System network (SIEPAC for its Spanish acronym) was completed in 2013.and has the potential to increase the capacity of energy and improve the power transfer among six Central American from Guatemala to Panama. An existing link between Mexico and Guatemala is being expanded and proposals would link SIEPAC with the Colombian grid.
- **Caribbean Islands.** The interconnection of electricity and fuels supply systems among some of the Caribbean islands has been considered for several years. A study by Nexant for the World Bank is a recent example. It focused on two possibilities involving nine countries. One would connect six small countries in the Lesser Antilles, St. Lucia, St. Vincent and the Grenadines, Grenada, Antigua and Barbuda, St. Kitts and Nevis, and Dominica. The other would connect Haiti and the Dominican Republic, both on the island Hispaniola, and Jamaica.
- **Southern Cone.** The energy policies in the Southern Cone countries are complicated by politics, shale gas, and oil exploration, but the shared benefits of electric grid cooperation—which have received on-again, off-again attention—shouldn't be dismissed.
- **Connecting the Americas 2022.** Launched at the Sixth Summit of the Americas in April 2012 in Cartagena., the hemispheric initiative would provide universal access to electricity in 2022 by measures including enhanced electrical interconnections. Colombia's former Minister of Mines and Energy Mauricio Cardenas and U.S. Secretary of State Hilary Clinton announced the plan at the summit meeting.

End-Use Energy Efficiency

The third link is in the end-use sectors—industry, transport, buildings and agriculture. The energy savings in these end uses sectors also lowers costs and reduces the energy required to produce energy and deliver it to the end uses.

The significant and cost-effective energy saving potential of the industry, transport, buildings and agriculture end-use sectors are described below.

Industry Sector

The industry sector accounts for about one-third of the global energy demand. The U.S. Energy Information Administration has provided a helpful division of the manufacturing sector into three major groups: High-energy consumers, high value added consumers and low-energy consumers. See Table 2.[2]

In the manufacturing industries, while improvements have been made in recent years, the International Energy Agency estimates that energy use and CO_2 emissions could be reduced a further quarter or third if the best available technology were applied worldwide and through national and local programs.[3] The IEA report presents a new approach to industry energy savings through "system/life cycle improvements" that achieve benefits across different subsectors. These system improvements include motor systems, combined heat and power, steam systems, process integration, industrial innovation, increased recycling and energy recovery.[4]

The Energy and Climate Partnership of the Americas (ECPA) supports an industrial systems initiative, the Closed Looped Cycle Production in the Americas.[5] The initiative applies a "cradle-to-grave" industrial concept where materials at the end of their initial useful life are recycled into new applications. The goal is to increase the productivity,

2. https://www.eia.gov/consumption

3. IEA. Tracking Industrial Energy Efficiency and CO_2 Emissions.

4. Ibid. IEA. "Tracking..." p. 22.

5. http://goo.gl/JNofgP

Table 2. Major Industry Groups

High Energy Consumers	Description
• Food and kindred products • Paper and allied products • Chemicals and allied products • Petroleum and coal products • Stone, clay and glass products • Primary metal industries	The high-energy consumers convert raw materials into finished goods primarily by chemical (not physical) means. Heat is essential to their production and steam provides much of the heat. Natural gas, byproducts and waste fuels are the largest sources of energy for this group. All, except food and kindred products, are the most energy-intensive industries
High Value-Added Consumers	**Description**
• Fabricated metal products • Industrial machinery and equipment • Electronic and other electrical equipment • Transportation equipment • Instruments and related products	This group produces high value-added transportation vehicles, industrial machinery, electrical equipment, instruments, and miscellaneous equipment. The primary end uses are motor-driven physical conversion of materials (cutting, forming, and assembling) and heat treating, drying and bonding. Natural gas is the principal energy source.
Low-Energy Consumers	**Description**
• Tobacco manufacturers • Textile Mill products • Apparel and other textile products • Lumber and wood products • Furniture and fixtures • Printing and publishing • Rubber and miscellaneous plastics • Leather and leather products	This group is the low-energy-consuming sector and represents a combination of end-use requirements. Motor drive is one of the key end uses.

competitiveness and sustainability of businesses, particularly small and medium-sized enterprises. Ecuador is leading the initiative. Other ECPA initiatives that include industrial energy efficiency are the Energy Efficiency Working Group, Energy Policy and Sector Analysis in the Caribbean and Clean Energy Exchange Program of the Americas.[6]

The mining sector of industry offers an example of the major opportunities for improved energy efficiency in the Americas as well as the environmental, social and health benefits. A recent Technical Note by the InterAmerican Development Bank (IDB) provides a guide on how to achieve these benefits, "Incentivizing Clean Energy Technology in the Mining Sector in Latin America and the Caribbean; The Role of Public Mining Institution.[7]

The report investigates clean technology and mining processes and the role of governments in promoting their use. The report draws on information gathering by missions to Bolivia, Guyana and Peru, but its findings and recommendations are valuable throughout the Americas.

The LAC is a world leader in the production of key minerals (copper, gold, silver, iron ore and nickel} which has attracted global investments, but also has had heavy environmental costs. The years of prospecting, exploration, exploitation, processing, and closure mining have had impacts on the physical and social environments. While the report focuses on mining in LAC countries, similar benefits and costs are experienced in the recovery of oil and natural gas and are an issue in the proposed "fracking"—the hydraulic fracturing of shale deposits to obtain oil and natural gas.

The report recommends a four stage approach:

1. A discussion of technology and practices in the mining industry, emphasizing the role of the public sector.
2. An outline of the features of the mining sectors in Bolivia, Guyana and Peru and the barriers to implementing cleaner technologies.
3. The changes necessary to eliminate these barriers, identifying key areas that require further attention.

6. Information on the ECPA initiatives is available on the program's website: www.ecpamericas.org.

7. Masson, Malaika, Martin Walter, Michael Priester, Inter-American Development Bank, Energy Division (ENE), Technical Note, No. IDB-TN-612. December 2013.

4. The recommendations applicable in the countries to introduce cleaner mining technology.[8]

The science academies and organizations in countries with mining resources have an understanding of these physical, engineering and social issues and can influence their governments and the general public on clean mining practices. The education and training of the human resources for sustainable mining is a capacity building issue.

The U.S. Industrial Assessment Center program is a model for a broader university, industry and science and engineering collaboration on energy efficiency. The IACs, currently located in 24 of the top U.S. engineering schools, provide small- and medium-sized manufacturers with site audits and recommendations for improving efficiency, reducing waste, and improving productivity through changes in processes and equipment. A typical IAC client receives recommendations that save more than $47,000 annually. The students' hands-on experience in the faculty-led audits broadens their employment opportunities on graduation. The U.S. program was initiated in 1976 and included international universities in its early years. The science academies could consider working with their university and government contacts to expand the IAC program to the Americas. The data base of the audits is a rich source of information on potential energy savings. Rutgers University manages the program for DOE. More information is available on the DOE and Rutgers websites. http://goo.gl/STLvZT and http://goo.gl/xII1tG

8. "Supplying Society and Natural Resources: The Future of Mining—From Agricola to Rachel Carson and Beyond", in the spring 2015 issue of the U.S. National Academy of Engineering's "The Bridge; Linking Engineering and Society." Other articles include: "Geothermal Energy: An Emerging Option for Heat and Power," "Shale Gas Development: Opportunities and Challenges," "Mining Groundwater for Sustained Yield" and "Carbon Dioxide Capture, Utilization, and Storage: An Important Part of a Response to Climate Change." A copy of the Bridge is available in PDF format at www.nae.edu/TheBridge .

Transport

The transport sector includes energy consumed to move people and goods by road, rail, water, air and pipeline. The transport sector is the largest end-user of energy in the Americas, accounting for 26.8% of total final consumption. See Table 1.

The transport sector plays a critical and complex role in the Americas, resulting from the diversity in its history, economies, climate, geography, and diverse population density. This diversity also creates opportunities for the science community to identify and connect the opportunities for progress on this unique landscape.

The focus of this chapter is on improving the energy efficiency and reducing the GHG emissions of the transport end-use sector of the Americas, but it also is linked to the pattern of energy supplies in the hemisphere and the other end-use sectors, industry, buildings and agriculture. Transport also has an important role in advancing the other IANAS priorities: energy for unserved populations, renewable energy, bioenergy, and capacity building.

America's OECD and non-OECD countries consumed about the same percentage of their energy in their transport sectors, according to the U.S. Energy Information Administration's 2013 International Energy Outlook.[9] (See Table 1). The Outlook's projections to 2040 show this is about to change. The IEO sees virtually no growth in consumption for transportation in America's OECD countries. The United States and Canada are expected to continue to tighten their stringent fuel economy standards causing a slight decrease. Mexico and Chile are expected to see a robust increase in transportation, although constrained by their own policies that encourage energy efficiency, resulting in no net change in the four countries' total over three decades.

The IEO projects a nearly 50 percent increase by 2040 for the non-OECD countries in Central and South America. The IEO forecasts this change based on a mix of drivers, a relatively strong regional GDP growth (3.3 percent a year), a population growth of 0.7 percent a year, demographics (28 percent of the population is under age 14), high urbanization (79

9. U.S. Energy Information Administration. International Energy Outlook, 2013. p. 142.

percent, the most urbanized region in the developing world), increased intra- and interregional trade, and a needed uptick in infrastructure investments.

The accuracy of the Outlook's projections is critically important to the Americas. It could also be important globally. The Outlook says the transportation sector accounts for the largest share (63 percent) of the total growth in world consumption of petroleum and other liquid fuels from 2010 to 2040.[10] The Americas are already the leader in the development and use of biofuels, as described in the Bioenergy Chapter. The integration of energy efficiency, bioenergy, and Climate Change priorities in an Americas' program could be a model for other countries and regions.

The major opportunities for increasing the energy efficiency and related benefits in the Americas is through a new approach to transport planning and policies and through investments in transportation infrastructure, which are described below.

Avoid-Shift-Improve (ASI)

The "Avoid-Shift-Improve" paradigm is a new, holistic approach to achieving sustainable improvements in the energy, environmental and public service features of transport systems. ASI is particularly useful in addressing the complex of issues in the densely urbanized areas.

The Inter-American Development Bank (IDB) has published a monograph championing the adoption of the ASI approaches.[11] While the monograph was directed to LAC countries, the approach is equally applicable to Canada and the United States.

The old paradigm responded to congestion by increasing capacity, inducing more traffic, which created more congestion.

The new ASI paradigm ties together three approaches:

1. Avoid unnecessary travel
2. Shift travel to more efficient modes, e.g. public transport, bicycles
3. Improve the efficiency of the remaining travel.

Box 1

ASI Approach to Sustainable, Low Carbon Transport.

Avoid motorized trips:

- Motor and fuel taxes
- Road user fees and tolls
- Cordon and congestion pricing
- Car-sharing programs
- Transit oriented development
- Car free zones
- Commuter trip reduction policies
- Avoid freight empty loads
- Better freight logistics
- Information and community technologies and working at home[15]

Shift to more efficient modes of transportation:

- Public transport improvements
- Parking management
- Transit oriented development
- Improvement in non-motorized transportation
- Freight rail
- Intensive use of bicycles

Improve efficiency of remaining traffic activity:

- Active traffic management
- Eco-driving
- Fleet management schemes
- Intelligent transportation systems
- Traffic signal synchronization
- Energy efficient vehicles
- Lower carbon fuels
- Aerodynamic vehicle design

The policies in ASI, drawn from the IDB monogram, are summarized in Box 1.

The IDB monogram, in addition to setting forth the ASI strategy, also describes how to measure and mitigate the energy savings and GHG emission reductions from transportation projects. The monogram expresses the IDB's commitment to support these programs and the related carbon finance and climate finance programs of the Clean Development Mechanism (CDM), Clean Technology Fund (CTF) and Global Environment Facility (GEF) programs.[12]

As the IDB monograph states, "In the long run, investment in institutional capacity to evaluate system performance, through the systematic collection of transport data and development of robust

10. Ibid. p. 141.

11. Inter-American Development Bank, "Mitigation Strategies and Accounting Methods for Greenhouse Gas Emissions from Transportation. July, 2013.

12. Ibid. p. 15.

13. This bullet has been added to those listed in the IDB's monogram.

models for ex-ante and ex-post-project evaluation – will benefit cities and countries throughout LAC by enabling the use of more finance mechanisms and supporting development of high performance, sustainable, and modern mobility systems. Such investment, however, is not a pre-requisite for advancing toward more sustainable transportation."[14]

The academies could play a significant role in developing the models that would support these sustainable mobility systems. As well as supporting the IDB goal of: "Winning political and fiscal support for sustainable mobility investment and policy programs... facilitated by better analysis of the distribution of diverse benefits and burdens of current and alternative future initiatives."[15]

Transportation Infrastructure

The infrastructure issues fall into two categories. There are new infrastructure investments, such as the completion of the Mesoamerican Pacific Corridor highway and the proposed Nicaragua canal connecting the Atlantic and Pacific oceans. And there are long overdue investments to renovating deteriorating existing infrastructure. Science and engineering have roles to play in both categories.

The Pacific Corridor highway

Is the largest regional transport project in the Mesoamerican corridor, planned to run more than 2,200 kilometers from Puebla, Mexico to Panama. The Inter-American Development Bank (IDB) is a champion and major source of funding for the highway.

IDB President Luis Alberto Moreno has urged support for the project, which is expected to carry 90 percent of the land freight along the Pacific Corridor. When completed, the travel distance between Mexico and Panama would be shortened by some 200 kilometers. A report by the IDB, the major funding source for the highway, estimates the highway would increase the average speed from 17 km/hour to 60km/hour and reduce travel time from 190 hours to 54 hours.[16]

The driver of a long TransMilenio articulated bus in downtown Bogota.

The goal of the project goes beyond transportation to includes related infrastructure improvements and reform of custom procedures and trade facilitation measures at six border crossings to achieve significant economic benefits. While economic benefits are the main driver for the project, it also would save energy and reduce GHG emissions.

Nicaragua Canal

The proposed Nicaragua Canal would be a 300-kilometer waterway joining the Pacific and Atlantic Oceans. The challenge here is not to build the project, but to secure an independent assessment of the economic, environmental and social benefits and negative impacts of the proposed canal before construction starts, scheduled for December.

The adverse environmental impacts are described in an article in Nature magazine written by Axel Meyer and Jorge A. Huete-Pérez, Former-President of the Nicaraguan Academy of Sciences.[17]

As for the benefits, the article cites the Nicaraguan government's claim that the US$40-billion project would boost the economic growth of the country—the second poorest nation in the Americas—from 4.5

14. Ibid. p. 115

15. Ibid. p. 119

16. IDB News Release. "IDB president urges leaders to invest in Mesoamerican corridor" Dec. 5, 2011.

17. Meyer, Axel and Jorge A. Huete-Pérez, "Nicaragua Canal could wreak environmental ruin." Nature magazine, 20 February 2014. p.287.

percent in 2013 to 14.6 percent in 2016. However, no economic or environmental feasibility studies have been made public. The Nicaraguan government has granted a concession to a Hong Kong company, operating as HKND Group, to build the canal, signing a lease for 50 years, renewable for another 50 years. Nicaragua has not solicited its own impact assessment, relying instead on an assessment by HKND, which is under no obligation to make public.

The authors write: "…the canal could create an environmental disaster…traversing Lake Nicaragua, the largest drinking water reservoir in the region… destroy around 400,000 hectares of rainforest and wetlands…imperil surrounding ecosystems…threatens multiple autonomous indigenous communities… and some of the most fragile, pristine and scientifically important marine, terrestrial and lacustrine ecosystems in Central America…"

The article's proposed action: "An international community of conservationists, scientists and sociologists needs to join the concerned citizens and researchers of Nicaragua in demanding two things: first, independent assessments of the repercussions of the mega-project; and second, that the Nicaraguan government halt the project should the assessments confirm fears that this canal will yield more losses than gains for the region's natural resources, indigenous communities and biodiversity."

Turning from new projects, the need to maintain and upgrade existing transport infrastructure is a common problem in many countries. It is a north-south challenge as represented by a recent tragedy.

In the USA, the Minneapolis Interstate-35W bridge crumbled into the Mississippi River in August 2007, killing 13 people and injuring 145. The tragedy gave jarring evidence of the deterioration of the U.S. infrastructure. One quarter of the nation's bridges are estimated to have structural problems. Bridges were built to last 50 years; the average age is 45 years.[18]

But despite that tragedy and the public awareness, little has been done. The federal Highway Trust Fund, created in the late 1950s to provide support for highway and transit infrastructure investments, has lost 25 percent of its value when measured as a share of GDP. States pay for about two-thirds of surface transportation funding and their budgets are stressed. Gasoline prices have plummeted, erasing the consumer pain of a higher infrastructure tax, but with no noticeable political response. Meanwhile, the down-side of increased vehicle efficiency and more hybrid and electric vehicles is lower gasoline purchases and gas tax revenue.

While this is primarily a political and economic problem, there is a role for science. The ASI paradigm, referenced above, can be a guide for prioritizing public spending to get the highest societal benefits out of transportation budgets. The transition from a gas tax to a vehicle miles traveled fee (VMT) would be a more equitable "user-fee" than the gas tax and would avoid the drop in tax revenue due to increased efficiency and hybrid and electrical cars. Getting acceptance of the change could use help from social scientists. One positive note: In the aftermath of the Minneapolis bridge collapse, researchers have developed automated monitoring systems to identify overstressed bridges and upgrade them first. Researchers are also working on "smart bridge" technologies—high-performance steel; self-healing materials; and wireless, real-time monitors.

Building Sector

The building sector is where people live, work and buy goods and services. The sector's energy consumption includes residential and commercial building subsectors and many connected opportunities for energy savings.

Globally, the sector is projected to be the fastest growing energy user between now and 2040 in the EIA's International Energy Outlook's Reference Case, increasing from 81 to nearly 131 quadrillion Btu from 2010 to 2040 with an average annual growth of 1.6 percent.[19]

The building sector currently is the second highest end-use consumer of energy in the Americas according to the IEA balance sheets. In 2011, the sector consumed 652,170 ktoe, 20.1 percent of the Americas

18. The information on strengthening the U.S. infrastructure draws on an article by Russell Nichols and Ryan Holewell, "Six Ideas for Fixing the Nation's Infrastructure Problems," in the Governing the States and Localities magazine. June 2011. http://www.governing.com/topics/transportation

19. EIA IEO, p. 111.

primary energy; 20.9 percent in the OECD Americas and 16.1 percent in the Non-OECD Americas.[20]

The energy is used for space heating and cooling, lighting, appliances, equipment and other energy-using equipment. In most OECD countries, building patterns are expected to change slowly, reflecting aging populations and mature economies. More rapid growth is expected in non-OECD countries reflecting their stronger economic growth and increased demand for housing and commercial buildings to meet rising consumer and service demands. The IEO projects that 80 percent of the growth in building energy uses between now and 2040 will be in non-OECD countries.

The United States and Canada reflect this OECD pattern. The U.S. residential energy use per capita is expected to decline 0.8 percent per year till 2040; for Canada, a 0.1 percent decline. But not Mexico and Chile, which are projected to have GDP growth rates of 3.7 percent till 2040, the highest within the OECD. Their residential energy consumption is projected to grow more than 2 percent a year through 2040, a level shared with Brazil and other non-OECD LAC countries. Commercial building consumption in the Americas is projected to follow a similar pattern. The dominant energy saver in Americas' building sector is expected to be mandatory energy efficiency standards for appliances and equipment. See below.

The provision of modern energy to unserved populations is a significant share of this increase in energy market statistics. Households relying on traditional wood and wastes for cooking and heating are expected to gain increased access to electricity and modern appliances, which will show up on the IEA market data. (For more information, see the Chapter on Energy for Unserved Populations.)

The building energy savings are achieved by the combination of advanced technologies, land use planning and energy standards and labels.

20. The numbers reflect the IEA definitions. The IEA doesn't allocate to end-use sectors the energy required to move primary energy to them. The dominant primary-to-end use is the transmission and distribution of electricity and the primary consumer of electricity is buildings. When the building sector's energy use includes the energy required to provide electricity to building, the sector consumes 30 to 40 percent of energy of most countries, 41 per cent in the United States.

Research, development, demonstration and deployment

The earliest contribution to building energy efficiency comes from the research laboratories that create advances in building envelopes, equipment, appliances and lighting. Building efficiency is benefitting today from the innovations from Americas laboratories and the science community has an important role to play in supporting these laboratories so they receive the support they need to produce tomorrow's advances. The active exchange of information among laboratories and strong public information programs will help gain this support.

Buildings and community planning

New buildings are not isolated structures, but are part of communities with unique land uses and clusters of low-rise and high-rise housing, commercial, public and manufacturing activities. In transport, the Avoid-Shift-Control strategies that reduce energy use and environmental pollution are applied at the community level.

A community perspective can also benefit from new renewable energy programs. Multi-building renewable energy systems have lower per-building costs than isolated projects. The distribution of electricity is changing rapidly with "smart grids," distributed generation, peak load management and the net metering of renewable projects. The science community has an important role to play in understanding how these features interact and sharing this understanding with decision makers and the general public.

Building standards and labels

The advances in research and community planning find their results in the buildings themselves. There are two related approaches that determine how buildings perform their mix of functions effectively and efficiently: mandatory energy standards and voluntary labels that recognize energy efficiency leaders.

The foundation of building energy standards rests heavily on the work of the American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE). In response to the 1973 OPEC oil embargo in 1973, ASHRAE issued its first standard in 1975, which initiated an ongoing process of upgraded standards which are reviewed and approved by the

U.S. DOE for adoption by the states. Most states do, some slowly and few not at all.

ASHRAE and the International Energy Conservation Code (IECC) are the primary code sources. They work closely together and lead the building code activities in the Americas.[21] ASHRAE and the U.S. DOE have been more aggressive in pursuing energy savings in recent years. In 2013, ASHRAE issued a major tightening of its Energy Standard for Buildings Except Low-Rise Residential Buildings (90.1). The announced goal is a 50 percent energy savings in buildings over the 2006 standard.

The World Bank is a strong supporter of Building Energy Efficiency Codes (BEECs) as expressed in its Working Paper No. 204, "Mainstreaming Building Energy Efficiency Codes in Developing Countries; Global Experiences and Lessons from Early Adopters." (2009)

Building Commissioning

Building commissioning is the process of verifying that all the systems of a building are working the way the owner, architect and engineer intended. The scope is inclusive: heating, ventilation, air conditioning, lighting, plumbing, electrical, building envelope, wastewater and control systems.

Initially, commissioning was seen as something done on a new building. This remains a priority, particularly for buildings with advanced systems, e.g. solar systems, energy storage, load management, smart glazings, etc. Experience shows it is also wise to have a certified commissioning professional on the building design team to help ensure that the systems will work together smoothly and to identify problems quickly if something goes wrong. Commissioning also helps recognize the responsibilities of building operators and their needed skills, training and performance. Since building functions change, subsystems fail, and advanced technologies come available, regular recommissioning makes sense.

Standards and labels for appliances, and equipment and lighting

The largest and fastest way to save traditional energy and reduce greenhouse gas emissions is through more efficient appliances, equipment and lighting. There are several reasons. New technologies are rapidly improving efficiency and performance, particularly in lighting. The lifetime of appliances is short, compared with buildings, so advanced products are introduced faster, including efficient and new renewable products. The savings in electricity and fuel are not only on site, but also savings back up the energy chain of primary energy sources—transmission lines, power plants, mines, pipelines, refineries, wells, etc. The advances are not only meeting the needs of traditional customers, but also bringing modern energy products to the world's unserved populations.

The United States took the lead in adopting appliance standards, initiating its journey in 1975 in response to the 1973 OPEC oil embargo. The challenging process has some lessons which remain relevant to modern policymakers. See Box 2.

Since 1987, the coverage of the U.S appliances and equipment has continued to grow to cover lighting, plumbing, electric motors, commercial water heaters and HVAC systems and many other products. Now approximately 50 categories of appliances, equipment and lighting are covered by the DOE program. The covered products are responsible for 90 percent of residential building energy consumption, 60 percent of commercial building energy consumption and approximately 29 percent of industrial energy consumption.[22]

The International Energy Outlook projects that: "Residential energy consumption in the United States grows minimally between 2010 and 2040, as state and federal energy efficiency standards for residential equipment restrain the growth in energy use."[23] The largest energy saving is in lighting through the phasing out of most incandescent

21. The IECC is developed under the auspices of International Code Council's and its government consensus process. The IECC code covers all residential and commercial buildings. The IECC has adopted, by reference ASHRAE 90.1. The U.S. DOE supports the adoption by states of the IECC code for residential buildings. Both update their codes about every three years.

22. Cymbalsky, John, Program Manager, DOE Appliance and Equipment Standards. Presentation at the DOE Building Technology Office Peer Review, Arlington, Virginia. April 22, 2014. And: http://energy.gov/eere/buildings/history-and-impacts

23. Op cit, IEO. p. 114.

lamps. Canada has made similar savings through its 1992 Energy Efficiency Act which covers more than 30 products.

Drawing on this experience, a program for advanced equipment, appliances and lighting in the Americas has the potential for huge energy savings and reductions in carbon emissions. A practical requirement is multi-country regional appliance performance test laboratories, essential facilities to ensure compliance. The market assessment should cover all income groups. Manufacturers tend to focus on the upscale market for larger products. The inclusion of advanced technologies in modest products for low-middle income buyers is important, particularly in growing urban neighborhoods. The covered products should be extended to those products bringing modern energy to currently unserved populations. Science academies with their understanding of these technical and social issues and their international contacts could play a key role in moving these plans forward.

Beyond Codes and Standards. While ENERGY STAR, LEED and RESNET[24] labels were drawing attention in the United States, they were getting little notice in the LAC countries until about ten years ago. That's changed, reports César Ulises Treviño, president of the Mexico Green Building Council, writing in "edc," LEED's magazine.[25]

He credits innovative financial mechanisms, workforce training and education, government awareness and capacity building for the change. Pioneering countries include Mexico, Brazil, Colombia, Argentina, Chile and Peru. In these earlier stages, he writes that what's needed are "success stories and reliable, hard facts."

Box 2. Appliance Standards: Lessons Learned

In response to the OPEC oil embargo, the USA passed the Energy Policy and Conservation Act (EPCA) in 1975 which established appliance test procedures, labeling and energy saving targets. By 1979, the results of relying exclusively on targets were disappointing and Congress passed an amendment directing DOE to establish mandatory appliance standards.

Lesson: Energy labels—Energy Star, mandatory stickers show energy performance and estimated annual costs, miles per galon labels on cars, etc.—influence the energy and environmentally sensitive and life-cycle cost buyers—but to have a major impact you need to have mandatory standards.

The 1979 amendment set the guideline for the standards as the strongest efficiency levels that were "technologically feasible" and "economically justifiable." Ronald Reagan was elected President in 1979. Guided by his antipathy for Big Government, DOE was directed to decide that no appliance standards could be found to be economically justifiable and DOE published a "no standard standard" in the Federal Register.

States responded by adopted their own appliance standards, each a little different from the others. Manufacturers were flummoxed at the prospect of tinkering with their products to meet this maze of different state standards. Manufacturers and environmentalists got together, drafted legislation that balanced their business and environmental priorities, took the draft bill to Congress, lobbied for it and Congress passed the National Appliance Energy Conservation Act in 1987 setting minimum efficiency standards for common household appliances.

Lesson: Manufacturers and environmental groups have common interests in effective and workable appliance and equipment standards and should be participants in the design and implementation of any program.

Lesson: The coverage of the program needs to be broad enough to include the existing and anticipated future market of the appliances. In 1987, this was states; a quarter century later, this means the international markets of the Americas.

Agriculture, including Forestry and Fishing

The share of energy used for agriculture, forestry and fishing in the Americas is small, only 1.2 percent, but the size of its energy, environmental and Climate Change issues is huge. Over 46 percent of the LAC countries Greenhouse Gas (GHG) emissions come from changes in land use, compared with the world average of 18 percent.[26]

24. The U.S. Environmental Protection Agency established the criteria for an ENERGY STAR certification. The U.S. Green Building Council established the LEED, or Leadership in Energy and Environmental Design, a green building program. The Residential Energy Services Network (RESNET) provides training and certification for a home energy rating system (HERS).

25. http://goo.gl/UzijtW Downloaded 5/7/2014.

26. IDB. Areas of Action – Mitigation. http://goo.gl/Qop5xP

Brazil, the home for 60 percent of the Amazon rain forest, is the vortex for this clash between forests and agriculture and the challenges spin into neighboring countries. The impacts affect indigenous people and the warming of the globe. Until last year, Brazil was lauded for aggressive enforcement of its 1965 Forest Code which dropped from a high of 10,588 square miles in 2004 to 1,797 square miles in 2011.

That changed last year. The deforestation rate increased 28 percent in 2013. The forest law was changed in 2012, a change initially hailed as balancing the passions of the environmentalists and the "ruralistas" who opposed restrictions on agriculture. The outcome now is not clear. Ruralistas are seeking a liberal interpretation of the agricultural rights. The government is pledging to aggressively enforce a requirement that farmers preserve up to 80 percent of the forest on their land.

This is primarily a political problem that's dramatized in Brazil, but similar agriculture-forestry issues are being acted out in neighboring Amazonia countries and throughout the Americas. Science and engineering can help move this issue forward. Some examples:

Monitoring and enforcing the forest preservation requirements on Brazil's farmers is critical to the success of the new law. Municipalities are preparing the rural environmental registry, a database that will map each property's farming and preservation acreage. Advanced satellite photography may ease the task. The Alta Floresta municipality in Mato Grosso state is turning to drone aircraft.[27]

A new study by UC Berkeley researchers and international collaborators supports sustainable cattle ranching practices in Brazil.[28] The study, published in the *Proceedings of the National Academy of Sciences*, says Brazil could cut its rate of deforestation by half through a more productive use of pastureland. The "semi-intensive" cattle ranching practices include rotating where animals graze, planning better grasses more frequently and amending the soil to unlock more nutrients.

The Amazonia deforestation issues extend beyond Brazil and so do the controversies. An example: the disastrous flooding the 2014 year of the Madeira River's watershed across Bolivia's Amazon rainforest and into Brazil. The flooding caused 60 deaths and 66,000 families were displaced.

Environmentalists and the Bolivian authorities blamed hydroelectric dams built over the border in Brazil.

"That isn't logical," according to Mark Dourojeanni, professor emeritus at the National Agrarian University in Lima, Peru, as quoted in the Inter Press Service.[29] Deforestation was the main driver, he said. The Madeira is the largest tributary to the Amazon, bringing rain and snow melt from the Andes down slopes to the Madeira and Amazon that were covered with forests 1,000 years ago. Now they're bare, because of fires set to clear the land for subsistence farming, according to Dourojeanni.

At the international level, deforestation in developing countries has gained increased attention under the UN Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. A framework mechanism for reducing the emissions from deforestation in developing countries (REDD) was put forward by Costa Rica and Papua New Guinea in 2005. The mechanism would provide incentives for forested developing countries to protect and better manage their forest resources with payments for verified emission reductions. REDD has continued to attract attention and support at different UN forums and conventions but action is still pending. The situation is well described by the title of a Policy Update by the Climate Change Policy & Practice resource: "REDDy to Put the Jigsaw Together?"[30]

Summary

Improvements in energy efficiency have multiple benefits. They reduce costs and improve competitiveness, lower adverse environmental impacts and

27. Financial Times, Apr. 22, 2014. p. 3.

28. www.pnas.org/cgi/doi/10.1073/pnas.1307163111

29. InterPress Service, "Deforestation in the Andes Triggers Amazon "Tsunami"", by Mario Osava. Apr. 16, 2014. Dourojeanni, an agronomist and forest engineer, was head of the IDB's environment division in the 1990s.

30. Climate Change Policy & Practice, By Eugenia Recio and Alice Bisiaux. "REDDy to Put the Jigsaw Together?" Apr. 8, 2013.

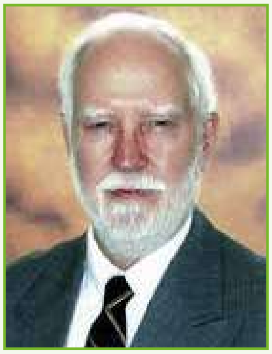
improve national security. The benefits of energy efficiency should be pursued from energy sources to their final end uses.

The countries in the Americas are in a favorable position to advance these improvements because of their mix of energy resources and uses, geography and climates and history of collaboration on major shared priorities. Major opportunities for increased energy efficiency are available from a rich mix of resources to the industrial, transportation, buildings and agriculture end uses. The science academies and organizations of the Americas can bring a knowledge and insight to a collaborative program that advances these opportunities.

Recommendations

- Support energy efficiency in the countries of the Americas as a core component of public energy policies and programs.
- Recognize the opportunities for increased energy efficiency from energy sources to final end uses.
- Optimize the introduction of advanced energy-saving technologies through the exchange of research, development, demonstration and deployment experience among countries.
- Build constructive relationships among governments at all levels, manufacturers, financial institutions, NGOs and others to foster informative, respectful cooperation.
- Inform the general public in an attention-getting, understandable way through popular media about how the advances in science can improve their energy futures.
- Participate actively in the processes that create multi-country electrical grids that optimize central power, distributed generation, renewable sources, net metering, smart grids, demand-side management, energy efficiency and reasonable kWh prices.
- In the industrial sector, support multi-country strategies for efficiency in energy-intensive industries and support small- and medium-sized industries through university-based industrial assessment centers.
- In the transportation sector, prioritize and support multi-country infrastructure investments that improve efficiency and minimize environmental impacts and in urban areas implement the ASI guidelines for improved service, energy savings and environmental benefits.
- In the building sector, support land use planning that optimizes the energy and environmental relationships among residential and commercial buildings, transportation and industry land uses; adopt and enforce efficient building codes; integrate renewable energy resources in building systems and adopt and enforce strong appliance, equipment and lighting standards.
- In the agriculture, forestry and fishing fields, there is growing recognition of the importance of strategic plans for future policies and programs. IANAS has a north-south and south-south scientific perspective that can add to the breadth and vision of these plans.

John Millhone



Represents the U.S. National Academy of Sciences and is the co-chair of the IANAS Energy Program. He began his career in journalism with a degree from the University of Missouri and jobs with the Associated Press, Detroit Free Press and Des Moines Register. After the 1973 OPEC oil embargo, Millhone was named director of the new Iowa energy office, then the Minnesota energy office and joining the U.S. Department of Energy in 1979. At DOE, he managed building research and regulatory programs, climate change, and U.S. and international technology transfer programs before retiring in 2003. While at DOE, he chaired the IEA End-Use Working Party. Since retiring from DOE, he has served as a consultant for the Federation of American Scientists, Lawrence Berkeley National Laboratory, and Carnegie Endowment for International Peace. He is a member of the Board of Directors of CLASP, the global network on appliance standards and labels.

Chapter 2

Two Guatemalan women, with great effort walking back to the village to bring the wood collected to cook dinner for the family. Chichicastenango, Guatemala.

Energy for Underserved Populations

Meeting the basic needs of the poorest people in Latin America and the Caribbean

Mónica M. Gómez, Rafael Espinoza and Manfred Horn | Peru

Summary

The first part of the chapter shows the need for the poorest people in Latin America and the Caribbean to have access to energy. To this end, through statistical data obtained from the World Bank and ECLAC, energy consumption is linked to GDP and poverty, depending on whether the area is rural or urban. The chapter highlights aspects such as the fact that over 90% of the population have electricity in their homes, and in most countries, rural areas constitute the "underserved population," with 17 million lacking access to electricity. The comparison of various countries shows how electricity consumption generally implies a proportional growth of the Gross Domestic Product (6.7 US$ / kWh), yet has an inverse relationship with poverty. It also demonstrates that poverty has declined by an average of 10% between 1999/2002 and 2011/13.

The following parts of the chapter provide a more detailed discussion of three basic energy needs in rural areas: cooking, lighting and, in the high Andean regions, indoor heating.

Approximately 150 million people in LAC burn wood or dung to cook their food, which is not only an energy issue, but also a complex problem with social, health and environmental components. In response to this problem, a wide range of programs have been developed to install what are known as improved cook stoves for over three decades. As an example, outstanding experiences of certain LAC countries have been described, where several million of these improved cook stoves have been installed or efforts made to implement other cooking technologies.

After cooking, energy for lighting is the next priority for the rural poor who have no electricity at home, and require lighters and candles for lighting. The expansion of electricity networks is extremely expensive in these cases, given the low population density and limited geographical access. For this population, the most feasible sustainable solution is currently a photovoltaic system. In particular, Photovoltaic Pico Systems, which basically include LED lamps and Lithium – ion batteries, costing $30-$135, can meet basic lighting needs.

The chapter ends with a description of the energy needs for heating homes in the high Andes that reach very low temperatures. Various technical proposals for addressing this problem are outlined, based on improvements in the thermal insulation of traditional houses and the use of the high intensity of solar energy in these areas (5-6 kWh/m² day).

The authors note that there are economically viable technologies that can meet the basic energy needs of the poorest people in LAC. However, implementing these in a massive, sustainable manner requires disseminating knowledge of standardized, certified technologies, establishing technical and commercial networks, and promoting microfinance schemes.

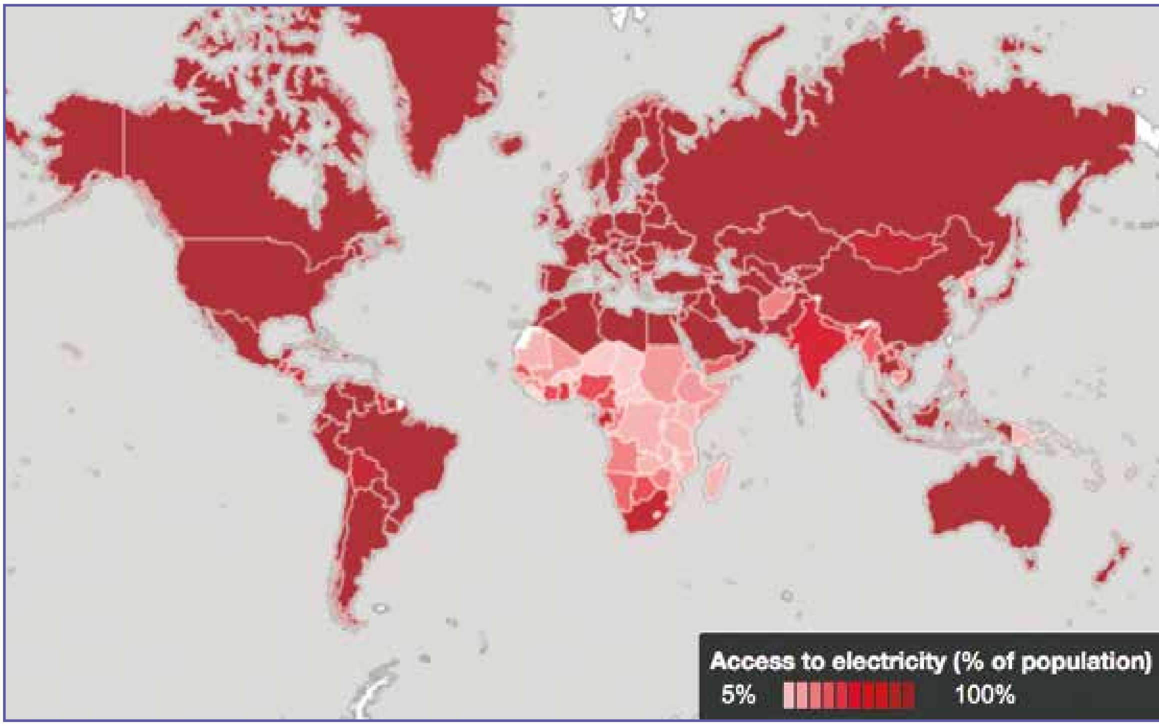
In 2007, the InterAcademy Council published the report "Lighting the way - towards a future with sustainable energy." This publication not only became the starting point for the IANAS Energy Program, but also one of the worldwide contributions that opened the debate on the importance of proper, efficient energy use. The conclusions presented at the time are still fully valid, particularly when they point out that: "Achieving the basic energy needs of the world's poorest people is a moral and social imperative that can and must be achieved in accordance with sustainable objectives" (1). This conclusion is consistent with one of the objectives of the Sustainable Energy for All (SE4All) Initiative: "Guarantee universal access to modern energy services," presented by UN General Secretary Ban Ki-Moon in September 2011. (2).

As a result of the recent agreements reached in Paris at COP21, held from November 30 to December 11, 2015, every effort will be made to prevent the global temperature rise from exceeding 1.5 degrees Celsius, since this increase would have a devastating effect on many vulnerable areas, especially those in developing countries that still have unique, fragile ecosystems, where droughts, floods and heat waves can occur. For example, the publication noted that between 1994 and 2013, five out of the ten most severely affected countries worldwide were located in America, namely Honduras and Haiti, followed by Nicaragua, Guatemala and Dominican Republic (3).

This chapter will show the need for energy access of the poorest inhabitants of LAC, regarded as "underserved populations." To this end, statistical data obtained from the World Bank (4) and ECLAC (5), will be used to link parameters such as energy consumption to GDP and poverty, and access to energy depending on whether the area is rural or urban. Although up to date information was unavailable for certain key countries in the region such as Argentina, Cuba and Venezuela (the country with the world's largest proven oil reserves), for the remaining countries, the rural area is understood to constitute the "underserved population" with 17 million people without access to electricity, as opposed to 5 million people in urban settings. Three aspects that determine the energization process in rural areas: cooking, lighting and heating, will also be explored as specific experiences.

Before exploring these issues, this chapter will identify the existing global energy gap between countries in sub-Saharan Africa and southern Asia, and the rest of the world. The former concentrate the majority of the 1.3 billion people who lack electricity in their homes (Figure 1) (4). Moreover, whereas in LAC, more than 90% of the population have access to electricity, meaning that 22 million people have no electricity, in Africa, the number of people without access to electricity increased by this same figure in 2014 (6).

Figure 1. Map of Worldwide Energy Access. Source: The World Bank, 2015.

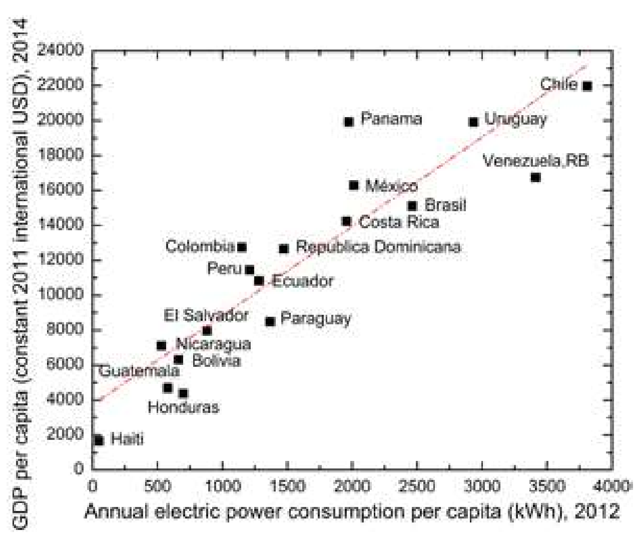


4.1 Energy and poverty: Overall Status

It is commonly said that for a population, the capacity (consumption) to access energy is directly related to its well-being, which in turn can be quantified by the gross domestic product per capita. This statement is shown in Figure 2, where both parameters are shown for certain countries in the region. This figure highlights three aspects:

- The proportional link between these two parameters, representing a GDP of $6.7 USD per kWh of electricity.
- The extreme cases of the curve: Chile and Haiti. Haiti has a GDP per capita of $1652 USD, thirteen times less than that of Chile, while electricity consumption per capita in 2012 was 50 kWh, seventy times less than that of Chile.
- The countries that "deviate" most from the proportional ratio: Venezuela and Panama. For the former, the ratio per capita (GDP/electricity consumption) is almost 5, whereas for the latter it is almost double.

Figure 2. Electricity consumption per capita for certain LAC countries, related to the gross domestic product. The dots are the data and the line corresponds to a proportionality adjustment between the two parameters. The World Bank and ECLAC



At the same time, it is interesting to observe how electricity consumption per capita (2012) is linked to national poverty (2014), a relationship shown in Figure 3.

Figure 3. Electricity consumption per capita for certain LAC countries, related to the gross domestic product. The points are the data and the line corresponds to their linear adjustment. Source: The World Bank and ECLAC

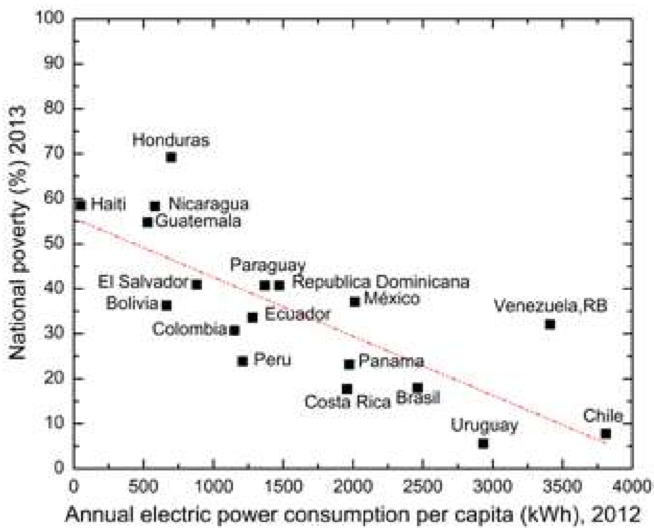


Figure 4. Population in poverty (%) in rural and urban areas, for the countries listed, for the period 2011-2013. Data source: ECLAC

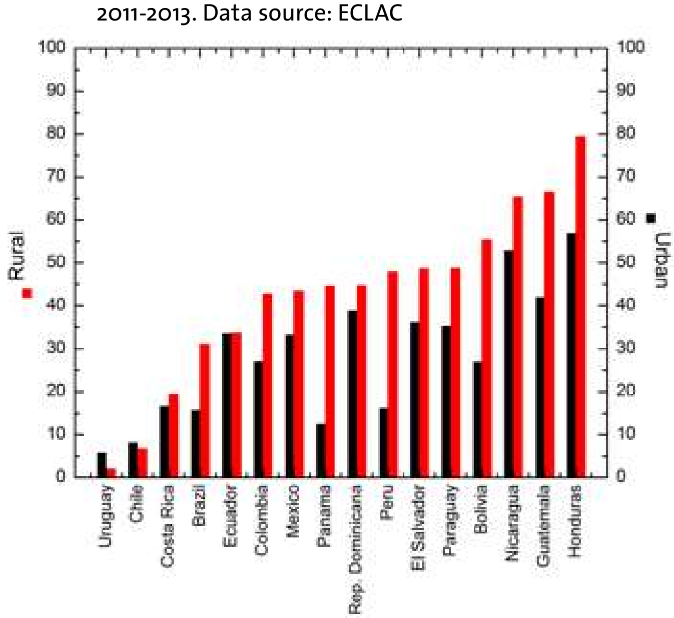


Figure 3 highlights the following aspects:

- The inverse relationship between poverty and energy consumption, in other words, higher energy consumption indicates less poverty among the population.
- The case of Chile, with a poverty rate of under 8% and per capita electricity consumption of more than 3800 kWh in 2012, and that of Honduras, where 69 out of every 100 inhabitants are poor and electricity consumption per inhabitant was 700 kWh that same year.

One of the aspects that characterize developing countries is the wealth gap between rural and urban areas. Figure 4 shows the latest information obtained for each of the countries (in all cases, data correspond to the period 2011-2013). The graph shows that:

- Of the sixteen countries represented, only two have a slightly higher poverty rate in urban than rural areas, namely Uruguay and Chile, where agriculture has a state of industrial development that makes it an intensive, nationally important economic activity, with a high degree of diversification. They are also the countries with the lowest poverty levels, 6% and 8% respectively, and the only ones with rates under 10%.
- Two other countries where poverty rates are similar for rural and urban settings are Costa Rica and Ecuador, with approximate values of 18% and 30% respectively. In these countries, agriculture is also an industrial activity.
- In the rest of the countries, there is a definite gap between rural and urban areas, which is more pronounced in countries such as Panama, Peru and Bolivia, where poverty is two to three times more intense in the countryside. The case of the last two countries will be specifically discussed later on to explore the issue of heating for rural population that does not have suitable housing for climates with temperatures below zero degrees Celsius.
- Three countries, representing 19% of all the countries shown, have an urban population with a poverty rate of over 40%, namely Nicaragua, Guatemala and Honduras, which in turn have rural poverty rates of 65%. No information is available on Haiti, which undoubtedly belongs to this group.

- Eleven countries, accounting for 69% of all the countries shown, have a rural population with a poverty index of over 40%.

Thus, discussing underserved populations in LAC as regards energy access can also be approached from the rural sphere, particularly since this is where 47 million poor people throughout the region live, 17 million of whom as yet lack access to electricity. The World Bank recently released figures on energy access for the corresponding rural populations up to 2012. Figure 5 provides a photograph of these data corresponding to urban settings.

In approximately half the countries (45% out of a total of 22), less than 90% of the rural population have access to electricity, which constitutes an energy gap between rural and urban areas. The case of Haiti is not representative of the region, since 72% of its urban population have access to electricity as opposed to 15% of its rural population.

The question then is how are access to electricity and poverty linked in rural areas? Moreover, how has the poverty index in rural areas altered over the past 10 years? Figure 6 answers these questions by presenting both sets of data, for which the rural poverty rate obtained for recent years (2011-2013) has been arranged in ascending order.

This figure highlights the following:

- Poverty has declined in all countries without exception. This is particularly notable in Ecuador, where it was reduced by 50%, and countries such as Brazil, Paraguay, Peru and Bolivia, where poverty fell by over 30%.
- On the other hand, in countries such as Guatemala and Honduras, which have national poverty rates above 60%, the decline in poverty was less than 5%.
- Uruguay has a rural poverty rate of 2% and over 95% energy access. It should also be noted that this country has made enormous efforts to ensure that 95% of its electricity is obtained from renewable sources (7).
- Performing a linear adjustment of the data for both groups of years shows that poverty has declined by an average of 10% within a period of approximately 10 years.

But how many people actually live in rural areas? Figure 7 shows the percentage of rural population, arranged in descending order for the countries presented, as well as the total number of inhabitants comprising it.

Of the total population for the region, equal to approximately 590 million, rural inhabitants account for 111 million, of which over 47 million

Figure 5. Percentage of population with access to electricity, for the countries listed, in 2012, in the following areas: rural and urban. Data source: The World Bank

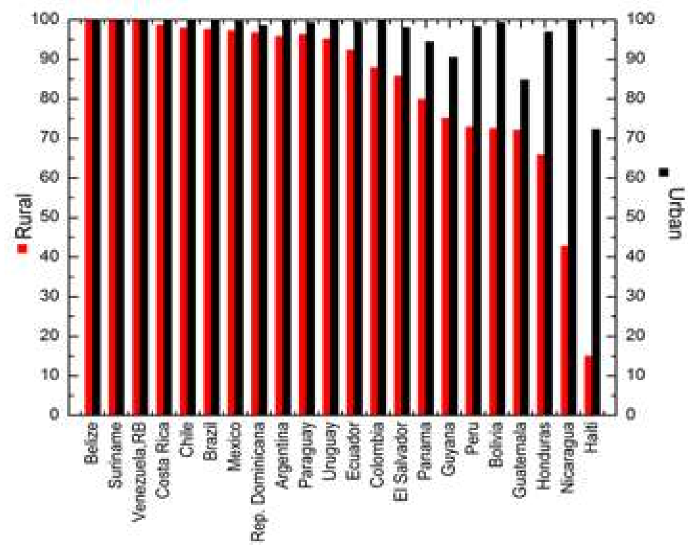


Figure 6. Energy access for the rural population in 2012, and rural poverty for the period 1999-2002 and 2011-2013. The points are the data and the line corresponds to a linear adjustment for the two groups of years. The World Bank and ECLAC.

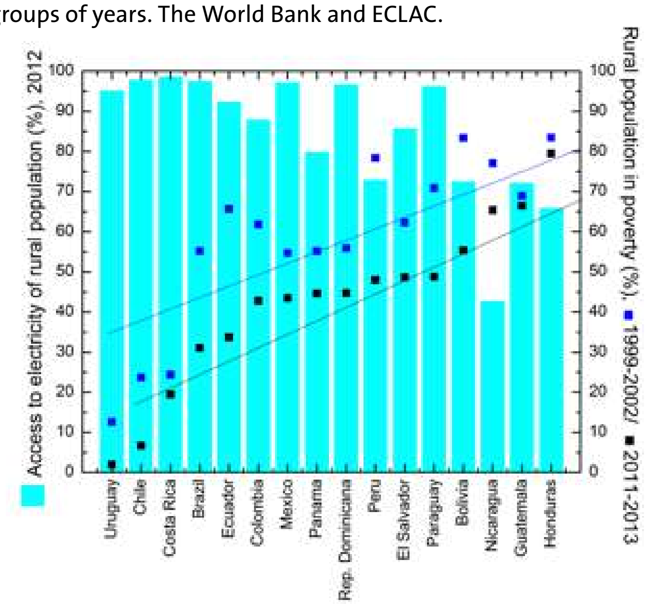


Figure 8. Indoor air pollution (IAP) due to cooking using solid fuels on open fires. (EnDev Photo)

live in poverty, compared with the more than 100 million poor people located in urban and peri-urban areas. However, the number of people without access to electricity in rural areas (17 million) is more than three times that of those in urban and peri-urban areas (5,000,000).

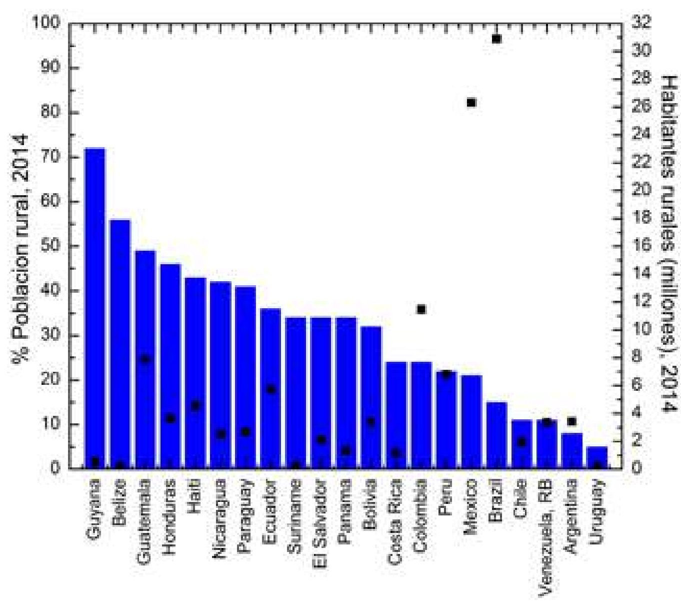
4.2 Energy for cooking

Household Air Pollution (HAP)

Worldwide, more than 3 billion people (nearly 40% of the total population) burn solid fuels to cook their food. This process is mostly done using firewood, which is burned on open fires inside their homes. This form of cooking is a process involving the inefficient combustion of organic matter that creates solid particles and greenhouse gases (GHGs) such as: carbon monoxide, nitrous oxides, sulfur oxides and organic compounds, all directly highly toxic for living beings and indirectly toxic by causing an enormous imbalance in the environment (Table 1). Moreover, about 25% of carbon emissions are produced by the burning of solid fuels to meet energy needs in the poorest households (8).

Moreover, globally in 2012, it was reported that approximately 4.3 million premature deaths were the result of Household Air Pollution (9), a figure that exceeds the number of deaths caused by malaria and AIDS (WHO, 2014d) Moreover, 50% of these premature deaths occurred in children under five due to pneumonia caused by the inhalation of particulate matter.

Figure 7. Ratio between the percentage of rural population and the number of inhabitants comprising it. Source for data: The World Bank

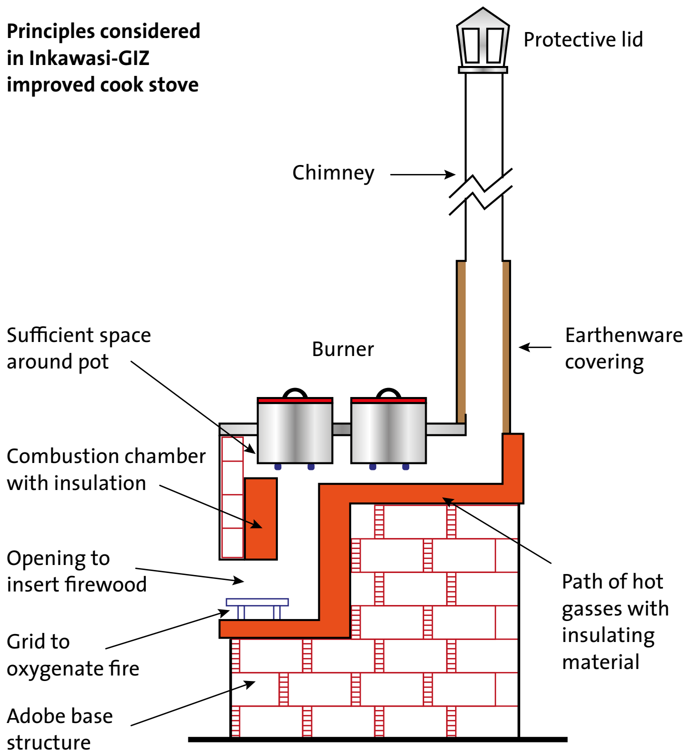


But the health and environmental aspects caused by HAP are not the only problems that characterize this means of cooking food. This process is also associated with social problems that affect the most vulnerable segments of underserved populations, women and children, since they are customarily responsible for collecting fuel. That is, the time spent on fetching firewood should be invested in studying, in the case of children, and in undertaking an economically productive activity, in the case of women.

Table 1. Effects on people and the environment of products resulting from inefficient solid fuel combustion

Innefficient biomass combustion products	Effects on living beings	Effects on the environment
Solid particles	toxic to the respiratory tract	Causes smog
Carbon monoxide (CO)	Causes lack of oxygen. Affects the cardiovascular and nervous system.	GHG
Nitrogen oxides (NOX)	Cause of disease and tumors. Produces lack of oxygen.	GHG
Sulfur oxides (SOX)	Irritant, affects mucous membranes and respiratory tract.	GHG, causes acid rain, affects vegetation growth

Figure 9. General diagram of improved Inkawasi cookstove (13)



The energy access gap between countries in sub-Saharan Africa and southern Asia, and the rest of the world (presented in the previous section) also exists in the case of cooking. LAC is home to approximately 150 million people, i.e. 5% of the entire world population that burns wood or dried manure to cook their food (10).

Improved stoves as a technological option

In response to this problem, for over three decades, a wide range of programs have been developed to install what are known as *improved cookstoves.* A broad range of them have been developed to facilitate their appropriation by the population. The structure of these cookers basically consists of the following: an insulated combustion chamber with an adobe base and an opening for the supply of wood, burners, a channel for the gases and a chimney to eliminate them. A general diagram of the improved Inkawasi cookstove model, shown in Figure 9.

Under optimal operating conditions, an improved cookstove has the following features:

- Smoke from combustion does not enter the house and instead, is released through a chimney.
- The risk of overturning pots and therefore of burns is minimized.
- It saves fuel.
- It concentrates heat.
- The food does not smell of smoke and cooking is more hygienic.
- The person cooking does so in a more comfortable position.

Moreover, the environmental impact is favorable because it reduces the release of greenhouse gases and curtails deforestation.

Experience has shown that welfare programs that provide improved cookstoves at no cost are not the best way to create a sustainable process in the most underserved populations. Social programs must strike a balance, protecting the poorest without creating a fiscal deficit. It has been shown that small loans are viable options, but that they can be promoted when the future user is convinced that purchasing the technology is beneficial to his or her development. Part of making the appropriation of improved cookstoves sustainable as a means of cooking food is to create a market that facilitates their commercialization, so that the use of this technology will not be affected when the intervention of a welfare program is suspended.

Since 2010, all the efforts to implement improved cookstoves have been coordinated worldwide by the Global Alliance for Clean Cookstoves (GACC), which is based on a specific objective: “Cooking must not kill.” GACC is an Alliance that uses a market-based approach to involve a diverse group of actors: government institutions, non-government organizations, companies and research centers in working towards a common goal. One of its stated objectives is to provide 100 million clean cookstoves by 2020, and achieve a priority intervention in 8 countries (Bangladesh, China, Ghana, Guatemala, India, Kenya, Nigeria and Uganda) (11).

At present, there are a wide range of improved cookstove models worldwide, which, as cooking alternatives, are viable, feasible and sustainable, yet in order to be assimilated by a given population, must necessarily meet their demands.

Enabling a program for adapting improved cookstoves to meet its initial goals can be regarded as a development process consisting of a strong link between the following aspects: adoption, sustainability, outcomes and impacts. Figure 10 shows this proposal.

Notable experiences in LAC

Specifically, LAC has examples of projects to install improved stoves that have achieved very good results in which public and private organizations have jointly participated. Some highlights from the First Latin American Seminar Workshop on Clean Cookstoves, held on June 16-17, 2014 in Lima, Peru are given below. (12)

- **Honduras**, where over 1.1 million families use open fire for cooking their food. To date, approximately 150,000 improved cookstoves have been installed throughout the country. There is still no national policy for the development and promotion of technology, nor is there a process of standardization and evaluation.
- **Bolivia**, where more than 730,000 families rely on biomass as fuel for preparing their food. The construction of improved cookstoves began in the 80's in rural communities where the Lorena model was built. In 2006, a great impetus was provided at the state level in cooperation with EnDev/GIZ. There are currently institutions involved in installing cookstoves in several regions, where the Malena is most widely used model. Since 2007, the Cookstove Testing Center, a neutral body that regulates and certifies the design of improved cookstoves for their implementation in community kitchens, has also been a regional GACC reference center. Since 2012, there has also been a national standard for regulating the design of improved cookstoves.
- **Peru**, where over 2.2 million families, accounting for 29% of the rural population, use firewood and dung for cooking their food.

The use of improved cookstoves began in the 80's with the implementation of small projects. In 2008, an upscaling strategy consisting of a national initiative was established. Laboratory certification was implemented and, through a supreme decree, a certifying body (SENCICO) was appointed to ensure the quality of the improved cookstove models. In 2009, a campaign entitled: "Half a million improved cook stoves

Figure 10. Figure 10. Process of development required to observe the expected impact on the population adopting the use of improved cookstoves

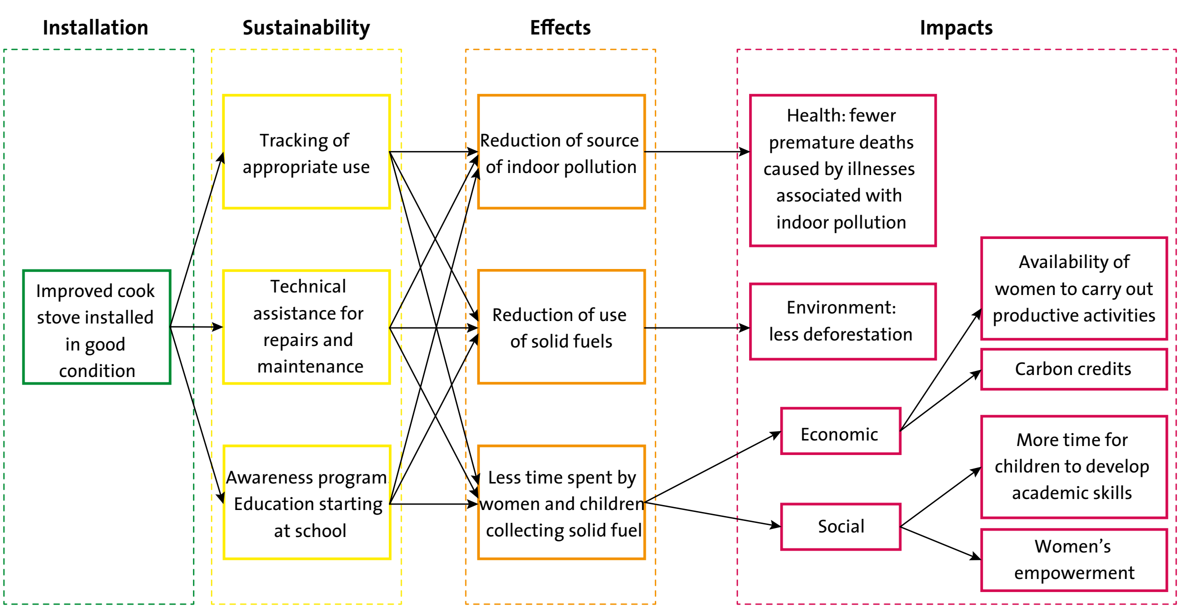


Figure 11. Using an improved cookstove makes it possible to improve the quality of life of its users (EnDev photo)

for a smokeless Peru," was launched with the participation of the state and various NGOs. To date (2015), the campaign has permitted the installation of over 287,000 improved cookstoves. Peru is currently seeking to integrate interventions to ensure a sustainable process of investment in technology.

Technological innovations

Although, as noted earlier, improved cookstoves have been widely disseminated, they still suffer from a number of drawbacks, hindering the process of appropriation of this technology and even casting doubt on their long-term sustainability. In response to this problem, there are a wide range of other technological solutions for cooking, including the following:

- Improved portable cookstoves
- Using biomass pellets for cookstoves with gasification.
- Turbo cookstoves.
- LPG Stoves (welfare action taken by the Ministry of Energy and Mines of Peru, which distributed 400,000 LPG cookstoves to the poorest sectors in 2015).
- Solar cookstoves.

4.3 Energy for lighting

Use of candles and fuel lamps

After cooking, energy for lighting continues to be the energy priority for poor people. For most of the world's population, producing light with electricity is now so common that many people and businesses in the Spanish-speaking world use the word luz (light) to mean electricity. Electric lamps, increasingly effective in converting electrical energy into light, are now the modern form of producing artificial lighting.

As mentioned in Section 4.1, 1.3 billion of the world's inhabitants still have no electricity at home and must therefore use candles or fuel lamps for light (Figure 12) with all their negative effects: inef-

Figure 12. Use of candles for lighting in rural areas (EnDeV photo)

ficiency, pollution, high cost, damage to health and fire hazards. It is essential for these people to have electricity so that they can use electric lamps.

To provide electricity in a house, it is usually desirable to connect the house to a power grid, which not only permits the use of electric lights, but all the equipment that uses electricity as a power source: televisions, radios, refrigerators, motors, etc. However, as electrification increases, so does the cost of connecting the remaining houses to the network, because they are increasingly scattered and further away from an existing network, which also reduces the sustainability of these connections. In Peru, for example, connecting houses to the grid cost an average of over $1800 USD in 2013. In these cases, it is cheaper and more sustainable, to generate electricity locally from renewable energies, especially solar photovoltaic panels.

Electricity for everyone

For the past 25 years, Solar Home Systems (SHS) have been regarded as a means of supplying a house that is far away from a grid with the electricity required for lighting and communication purposes in an economic, sustainable way. A SHS currently (2015) costs $400-2,000 USD, depending on the country and the size (from 50 to 150 Wp, providing 6-20 kWh/month, depending on the climate). Considering the relatively small percentage of homes without electricity in most Latin American countries, several countries have developed programs to provide SHS to most of those houses. Thus, for example, in Bolivia there are over 30,000 SHS, mostly installed through partially subsidized programs (14). Over 10,000 SHS have been set up in Peru and in 2014, the government issued an invitation for tenders for a program to install 500 000 SHS to remote homes without electricity over the following four years.

A SHS consists of a photovoltaic module, typically with a power of 50 to 150 Wp, a battery, typically 12 V of acid lead with an energy storage capacity of 1 kWh of energy, designed to withstand a higher number of charge and discharge cycles than car batteries, and an electronic device that prevents overloading of the battery and protects against deep discharges, which reduce the battery's service life.

"Did you know that..."

What kind of light do we need and how much?

The human eye is sensitive to electromagnetic radiation, called "light", if the wavelength is within the range of 400 nm (violet light) to 800 nm (red light), with a maximum sensitivity for green light. We call sunlight, which has radiation of all colors, natural or white light. Mixing blue, green and red light also gives us the sensation of white light (a technique used, for example, in televisions).

Whereas the power of electromagnetic radiation is measured in watts, the "luminous flux" detected by the human eye, is measured in lumens (lm). A candle has a luminous flux of 10-15 lm while a kerosene lamp (with a burner) has one of 8-60 lm.

The intensity of the light striking a surface, the "illuminance," is measured in lumen/m^2= lux (lx). A candle produces an illuminance of 1 lx at a distance of 1m. To replace fuel lamps in rural areas, a minimum illuminance of 20-30 lx is recommended for reading, together with lamps of 50 lumen or more per room, and 300 lm per household.

Why use LED lamps?

The efficiency of an electric lamp indicates the light intensity obtained, measured in lumens (lm) per Watt (W) of electrical power consumed. An incandescent lamp has an efficiency of 10 to 15 lm/W, a compact fluorescent lamp, CFL, of 40 to 75 lm/W and good LEDs, 100-150 lm/W, in other words, they consume 10 times less electricity than an incandescent lamp to produce the same light intensity. Moreover, a LED has a lifespan 10-50 times that of an incandescent lamp and is much more robust than the latter or a CFL.

SHS generally work at 12 V DC, although they may also include DC-AC converters (220v). Compact fluorescent lamps are generally used with these SHS. SHS are installed in a fixed form in homes by a technician, with cables connecting the SHS components.

Experience has shown that maintaining a SHS requires post-sales service, including the training of users and technicians, and local spare parts supply. Failure to consider this has led many SHS projects to flounder.

In recent years, there has been a substantial reduction in the cost of photovoltaic modules (factory cost: From $3 USD/Wp in 2005 to $0.6 USD/Wp in 2015). There has also been a very rapid development of new Li – ion batteries, with high charge density and useful lives of 3 or more years and, on the other hand, of LED "light emitting diodes" lamps (see table below), which has led to the rapid technological development of "plug and play" "photovoltaic peak systems," at a cost well below the cost of an SHS, with greater scope for the poor.

Photovoltaic Pico Systems (PVPS)

Small, modern pieces of equipment, known as Pico Voltaic, now offer a sustainable alternative to replace the use of candles or oil or kerosene lamps, with environmental but also economic, social and health advantages for its users, described in great detail in various publications: (14-17).

In order to address this situation, several international and government as well as NGO cooperation programs have emerged such as Lighting Africa (18), Lighting Asia, and more recently, the World Bank's Global Lighting (19) to support the market for these new lighting technologies for places that are remote from the power grid.

PVPS technology is rapidly developing. Modern PVPS typically used rechargeable Li ion (iron phosphorus) with a capacity of 2 -10 Wh and useful lives of 3 to 5 years, LED lamps with an efficiency of over 100 lm/W, and a photovoltaic panel of 3 to 10 Wp. The cost of these PVPS to the user is in the range of $30-135 USD.

Global Lighting has also developed technical specifications and evaluation procedures to ensure minimum quality, recently consolidated in the IEC 62257-9-5 (20) official standard and includes on its website a list of commercially available equipment that meets these minimal requirements.

PVPS in Peru

Social and economic evaluations of a proposed EnDev / GIZ project, which between 2012 and 2015 installed and tested over 1000 PVPS in rural regions of Peru, have yielded a number of conclusions regarding the use of PVPS as an immediate solution to the lack of basic energy services for lighting in isolated regions of Peru. (21)

One impact was the observation that PVPS almost entirely replaced the use of candles and Diesel oil lamps if the lamps were portable. People regarded better lighting and less pollution as the greatest advantages. People with PVPS saved an average of $3 to $4 per month through savings in candles and Diesel oil In the communities studied, which are below the poverty line, this represents 30% of the money used for energy. People are aware that PVPS lighting allows them to engage in evening activities that were not previously possible. As a result of the project, PVPS can be said to represent a technology that can solve basic lighting needs with a rapid impact on rural households living in regions far from a power grid. They also produce significant local impacts at a social, economic and environmental level.

On the other hand, given that PVPS technology is rapidly changing, the PVPS available on the market must be evaluated locally to select the most suitable systems, taking into account local needs and characteristics.

With a small budget, it is possible to improve the health, economic and general welfare of nearly three million Peruvians in the very short term, without the need for more powerful electrification in an undefined future.

Figure 13. PVPS diagram showing components

4.4 Energy for heating

Population exposed to cold climates in America

The American continent has a variety of climates. Hot weather extends throughout Central America, the Caribbean and much of South America. Temperate climates are found in intermediate latitudes. Cold climates are located at higher latitudes and predominate in much of North America and the southern tip of South America.

The Andes, a determining factor in the climates of America, is a mountain range in South America that runs almost parallel to the Pacific coast, from Cape Horn to the vicinity of Panama. It is one of the largest mountain ranges in the world with a length of 7,240 km, a width of 241 km and an average height of 3,660m. From the point where they narrow in southern Chile, the Andes extend in parallel chains through Argentina, Bolivia, Peru, Ecuador and Colombia. In Venezuela, they divide into three different chains. Throughout its length, the range rises up abruptly from the Pacific coast.

All the steps or mountain passes of the Andes located north of Patagonia are located at a high altitude (3,900-4,800 masl) and are narrow, stepped and dangerous. Its mountain formations and Inter-Andean valleys are inhabited by approximately thirteen million people at altitudes of between 3,000 and 5,000 meters, who are engaged in agricultural activities distributed throughout Bolivia, Colombia, Ecuador and Peru, as shown in Table 2 (22).

Table 2. Population engaged in agricultural activities exposed to frost, 2007-2009

Country	Exposed population (millions)
Bolivia	2.9
Colombia	1.8
Ecuador	2.5
Peru	5.7
Andean community	12.9

This amount of people, accounting for approximately 13% of the total population of the Andean countries, suffers severe cold weather from May until October period, with minimum temperatures of approximately 20 degrees Celsius below zero, far removed from the comfort zone defined by Givoni, as shown in Figure 14 (23).

The formation of the Cordillera de los Andes has determined the current geography of Latin America, creating three natural regions:

- The coast, whether flat or slightly undulating, in the western part of America.
- The Andean Sierra region, formed by the Andes, in the central part.
- And the largest region, The Amazonian Rainforest or Amazonia, in the eastern part.

The intense cold in the Andean region with temperatures ranging from -20°C to -1°C cold occurs from the central part of Peru and extends southward, reaching parts of Bolivia, Argentina and Chile, as shown in Figure 15.

Figure 14. Psychometric Chart for an altitude of 4500 masl

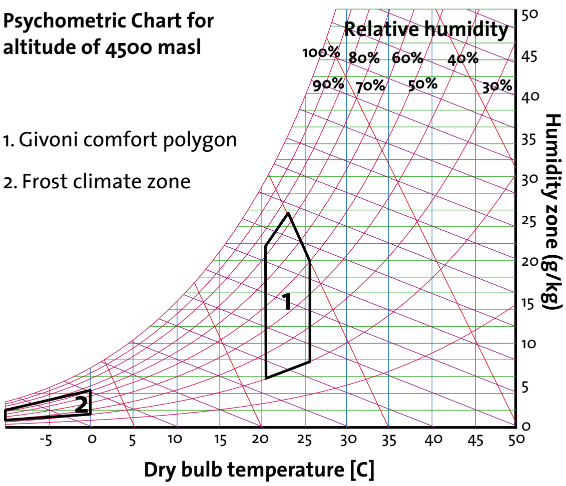


Figure 15. Map of frosts in America, showing a wide area of frost located in the highlands of Bolivia and Peru, with the greatest frequency in the Collao Plateau (22)

However the natural resource of solar energy in the Andean region of Peru and Bolivia reaches approximate values of: 7 to 8 kWh/(m^2day).

Figure 16 shows the map of frosts in Peru (24) while Figure 17 shows the solar resource available for Peru (25). It should be noted that the geographical areas subject to frost are also those with the greatest amount of sunshine.

According to the map of frosts in Figure 16, the geographical areas of Peru that are within the altitude range of 3,000-5 000 masl have between 120 and 270 days of frost a year, affecting 5.5 to 6 million people.

Figures 18 and 19 show a similar situation for Bolivia regarding the presence of frost (26) in geographic areas with considerable solar insolation (27). According to the frost map, the geographic areas of Bolivia within the altitude range of 3,000 to 5,000 masl have between 120 and 260 days of frost a year, affecting approximately 3.5 million people.

On the other hand, the precariousness of the dwellings in the rural areas referred to and the degree of poverty of its inhabitants increases their vulnerability to cold, leading, in extreme cases, to the death of children and old people; as well as their animals, which in many cases, are the only source of resources for their survival, as is the case of the alpacas that provide meat, wool, manure and goods transport.

Solar radiation maps for both Bolivia and Peru show that the geographic areas with frost receive an average of 5.5 to 6.5 kWh/(m2day) of solar power, relatively high levels given that the regions with the highest solar incidence receive up to 9 kWh/(m2day) of solar radiation.

But the most important aspect of this natural situation of Bolivia and Peru is that the amount of solar energy that hits every square meter of their surface daily is more than enough to raise the indoor temperature of the dwellings located in these areas to levels that generate feelings of thermal comfort among their inhabitants, particularly those homes within the rural areas of those countries, dwellings in remote Andean communities far away from populations that have more effective means of coping with the intense winter cold.

In addition to this large amount of natural sunlight, these regions have natural materials used since ancient times whereby the inhabitants used to protect themselves from the intense cold, adapting their natural qualities until they turned them into everyday items in their homes and clothing. The mixture of soil and clay to which straw and water are added becomes adobe, solid blocks in the shape of a parallelepiped measuring approximately 0.1x0.2x0.4 m, with which they built and indeed continue to build the walls of their homes, using Andean grass or ichu and tiles to build roofs. For their personal protection, they fashioned clothes from the wool of their cattle, sheep and auquenidos, which they complemented with a diet based mainly on potatoes, goose, corn, kiwicha, quinoa, meat and

Figure 16. Map of days of frost (Tmin <= 0°C) in Peru; average for the period 1964 - 2009 (24)

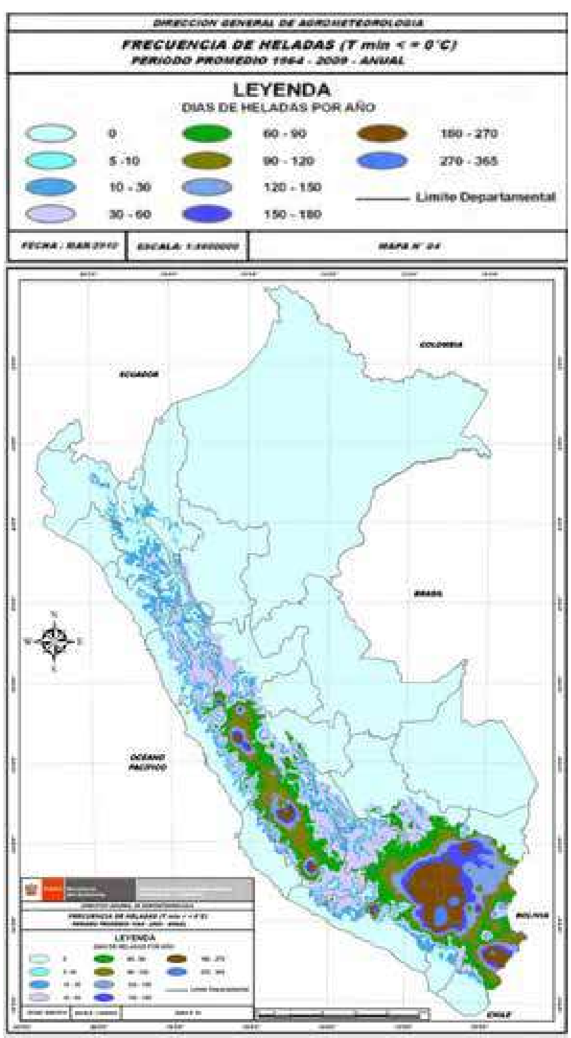


Figure 17. Map of average annual solar insolation in Peru (25)

cheese. These were good practices or customs that have unfortunately declined in the present due to a certain Andean-coastal transculturization driven by a misinterpretation of progress, which led to changes such as, for example, using corrugated metal roofs to replace ichu and tiles, clothes made from synthetic materials rather than animal wool and, most critically, the invasion of pre-prepared foods such as potato chips, chizitos (packaged corn snacks), cookies in general and candies.

Proposed Solution

A bioclimatic approach to this reality begins by recognizing that sunlight is available as an abundant clean, free energy source. At the same time, there are local materials to develop technologies with a low requirement of foreign materials that make it possible to capture the sun's heat, insert it into housing and prevent it at any time from returning to the external environment. In other words, it metaphorically lets the sun enter the dwelling during the day and does not let it out at night.

One would be talking about bioclimatic strategies and techniques, bioclimatic indicators and thermal comfort.

Thermal comfort should be understood as a situation resulting from the confluence of several factors on people who are in a particular environment. Each of these factors has its own characteristics, including the function of the environmental conditions surrounding the person while several others depend on the person himself, his physical fitness, health, clothing and mental state. This heterogeneity of conditions, both measurable and non-measurable, determines the personal sense of wellbeing or feeling at ease in an environment, and being able to comfortably perform the activities he must undertake in that environment (23).

A bioclimatic indicator is the technical means whereby one can determine the value or range of values of the so-called neutral temperature or comfortable temperature within a dwelling. The bioclimatic strategy that can be deduced from a bioclimatic indicator is the conceptual route to follow to achieve or approach a comfortable room temperature. The bioclimatic technique or component is the physical means developed or constructed to materialize the concept of the bioclimatic strategy.

It is important to note that in the dynamic created to achieve a comfortable temperature in a given indoor environment, it is crucial to secure the participation and involvement of the people who will inhabit this environment, particularly if, as is the case, the target groups are rural ecosystems populated by human beings who bring valuable knowledge from their ancestors, many of which would significantly contribute to this goal.

Figure 18. Map of frost days (TMIN <= 0°C) in Bolivia, annual average (26)

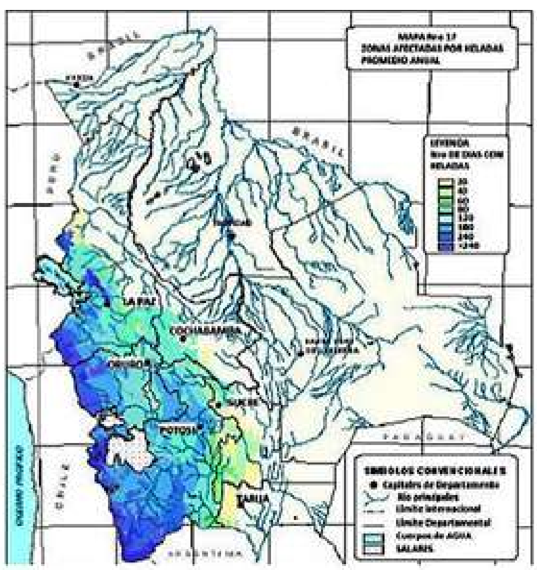
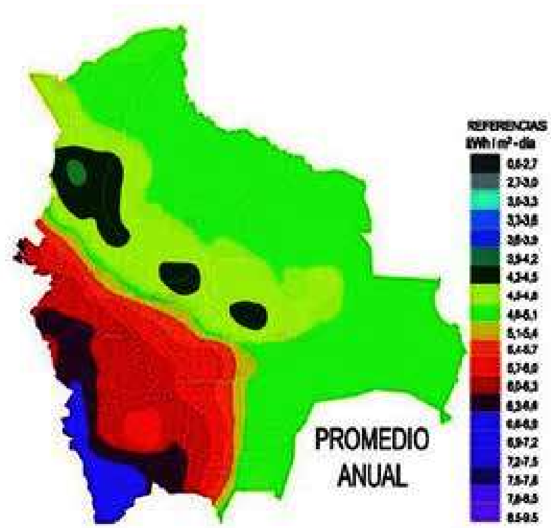


Figure 19. Map of solar insolation in Bolivia, annual average (27)



The Technology

First of all, one should consider the position of the target building relative to the sun's position at all times of the year, and know the effects of the apparent movement of the sun around the earth as well as the characteristics of movement itself in order to have accurate knowledge of the trajectory of the sun's rays in the direction of the part of the building assigned for its capture. At the same time, one should subsequently define the way to materialize this solar capture, in other words, identify the bioclimatic strategy and bioclimatic technique to be used. A list of bioclimatic techniques suitable for use in Andean rural buildings (28) is listed below.

- Thermal insulation of floors, ceilings and windows
- Elimination of thermal bridges
- Thermal windows in roofs (direct capture of solar radiation during the day)

- Adobe walls with high thermal mass and radiant devices (heat storage for night-time)
- Greenhouses attached to walls in critical thermal zones.

Figures 20 and 21 illustrate some of the bioclimatic techniques listed above

Experiences

Argentina has extensive experience in analytical and experimental studies on buildings related to Andean thermal comfort (29-34).

Between 2004 and 2008, the Latin American Network of Renewable Energy Use in Low-Income Buildings was developed under the auspices of the CYTED Program, as part of which three publications (35-37) were produced as the proceedings of regular meetings to present the research and developments of professionals from Latin American countries comprising this Network, whose contents are relevant to the subject of this publication.

The Case of Peru

In Peru, the first steps have been taken to build and evaluate 10-15 prototypes of high Andean rural households in the regions of Ayacucho, Huancavelica, Cusco and Puno at latitudes of over 3,500 masl.

Peru has made significant progress in the field of Andean thermal comfort, (38) producing suitable technology for the thermal improvement of the indoor environments of dwellings in isolated communities with high levels of social exclusion. This technology has been considered by the Ministry of Housing, Construction and Sanitation through its National Directorate of Construction, and incorporated into national plans to improve remote, scattered rural dwellings. IICA has also played a key role in the adaptation of 31 existing dwellings in the Río Cunas Basin in Junin, where greenhouses were attached to the walls.

2013 saw the approval of the Technical Standard for *Thermal and Lighting Comfort with Energy Efficiency*, which was incorporated into the National Building Regulations.

At the same time, the necessary academic support has been reinforced since 2012 through the creation of a Master's in *Renewable Energies and Energy Efficiency* in the Science Faculty of the National University of Engineering of Lima, one of whose lines of research is *Andean Thermal Comfort*. The graphic information below shows some of the results and progress of the Peruvian development commented on in this article.

Figure 20. Bioclimatic techniques used on roofs: (a) thermally insulated roof, (b) and (c) Ceiling windows, indoor and outdoor view respectively

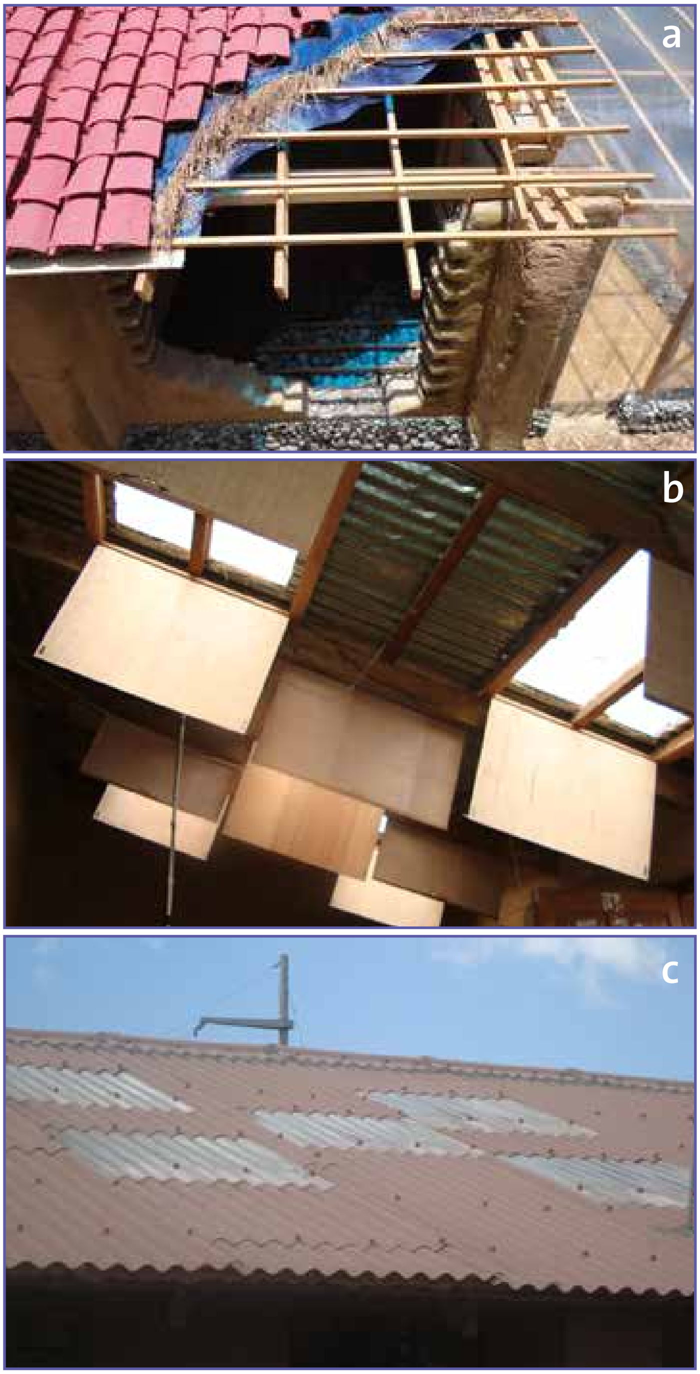


Figure 21. Bioclimatic techniques used on roofs and walls: (a) Hygrothermally insulated floor and (b) Infrared image of radiant wall

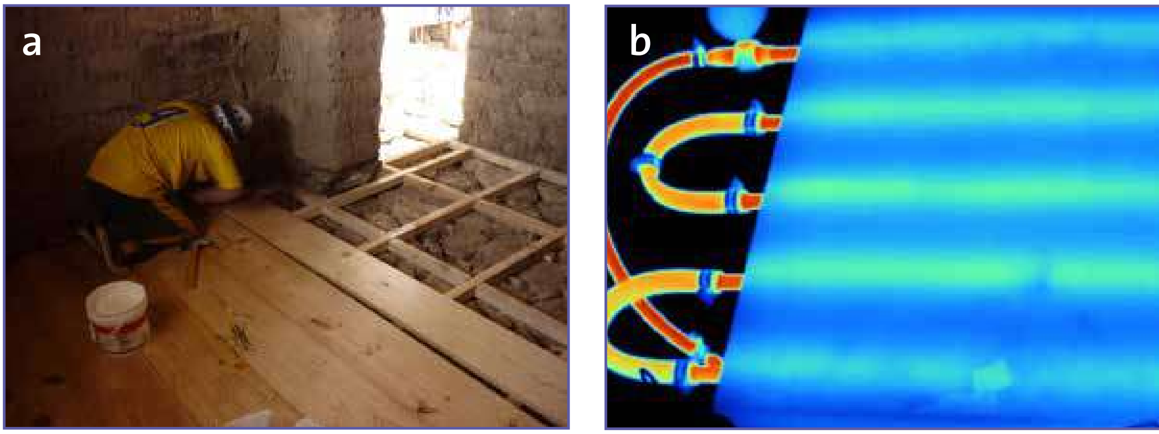
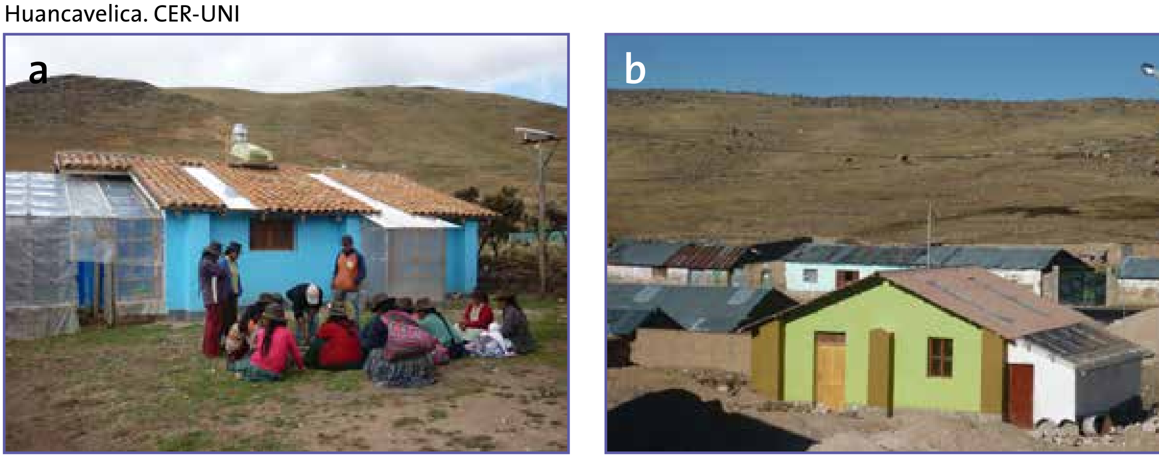


Figura 22. (a) Rural hostel in San Francisco de Raymina, Ayacucho and (b) rural housing model in Santa Rosa, Huancavelica. CER-UNI



Conclusions

In the LAC region, although the underserved population as regards energy access is less than 10% of the total, this still represents 22 million people, for whom it is crucial to address basic aspects of cooking, lighting and, in the Andean region, the heating of their homes.

A range of technologies are currently available, making it possible to meet these energy needs at lower costs than those borne by the affected population in the form of gathering firewood for cooking, buying candles for lighting and the loss of life caused by the low temperatures in the high Andean zones. However, implementing these technologies in a massive, sustainable way requires:

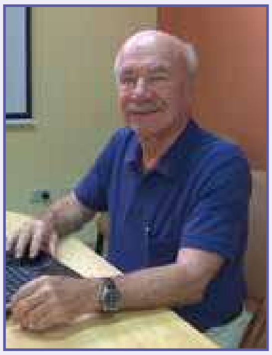
- Spreading awareness of these technologies through education and awareness programs that will allow future users to know about their advantages and participate in their subsequent appropriation.
- Establishing a technical and commercial network to supply parts and services to introduce and maintain these technologies.
- Promoting the implementation of institutions that regulate and certify technologies.
- Developing microfinancing schemes, considering that the implementation of these technologies represents an initial cost that cannot be assumed by the user.

Monica Marcela Gómez León

Born in Lima, Peru in 1970. PhD in science with special mention in physics in the cooperative system between the Universidad Nacional de Ingeniería (UNI), Lima-Peru and the University of Uppsala-Sweden (2001), MSc in Materials Science at UNI (1997), BSc in chemistry - UNI (1995). Winner of the L'Oreal-CONCYTEC-UNESCO, "For Women in Science" Award (2011), and joint recipient of the Grana y Montero Peruvian National Research Award, 5th Edition (2014). Specialist in the synthesis, development and application of multifunctional nanostructured materials for environmental and energy applications.

Rafael Leonardo Espinoza Paredes

Born in Arequipa, Peru, pursued a degree in mechanical engineering at the National University of Engineering in Lima, Peru between 1968 and 1973, and graduated with a BSc in mechanical and electrical engineering in 1979. He subsequently obtained an MSc at the same university in 2014, defending a research thesis on the field of the thermal comfort of rural buildings in the Andean area of Peru. He currently directs the Center for Renewable Energy and Rational Use of Energy, CER-UNI and is senior professor at the Mechanical Engineering Faculty in the energy sector, and in the Master's Degree Program in Renewable Energy and Energy Efficiency at the Science Faculty of the National University of Engineering.



Manfred Horn

Professor of Physics at the Science Faculty of the National Engineering University (UNI), Lima, Peru.Physicist (Dipl. Phys., U. Munich, 1964; Ph.D., UBC, Vancouver, 1971). Activities: Research in solid state physics and materials for solar energy conversion. Pilot projects and consultations in renewable energy, energy planning, energy efficiency and environment. Development and transfer of renewable energy technologies, particularly solar drying of agricultural products and photovoltaics for rural electrification. Quality control of solar and lighting equipment. Former Dean of Science Faculty and Former President of the Peruvian Physical Society and the Peruvian Solar Energy Association. Distinctions: Honorary doctor of the National University of Tacna, Peru and Honorary Professor of the National University of Cuzco, Peru. Member of the Peruvian Academy of Science (Member of the Board), Focal Point of the IANAS Energy Program. **mhorn@uni.edu.pe**

References

1. Chu, S. and J. Goldemberg (2007). Lighting the way: Toward a sustainable energy future, Inter-Academy Council.
2. Sustainable Energy for All (SE4All) (2014) Annual Report.
3. Kreft, S., Eckstein, D., Junghans, L., Kerestan, C., and Hagen, U. (2015) Global Climate Risk Index 2015: Who suffer most from extreme weather events? Weather-related loss events in 2013 and 1994 to 2013, Germanwatch.
4. World Bank, World Development Indicators, available from data worldbank.org/indicator. [December, 2015]
5. Comisión Económica para América Latina y El Caribe (CEPAL), Población en situación de indigencia y pobreza según área geográfica, available from estadisticas.cepal.org/cepalstat/. [December, 2015]
6. GVEP International, Annual Review 2015, Accelerating Access to Energy.
7. Ministerio de Energía y Minas, Balance Energético Nacional, available from www.miem.gub.uy/web/energia/-/balance-energetico-nacional-2014. [August, 2014]
8. Global Alliance for Clean Cookstoves, Five Years of Impact 2010-2015, avaliable from www.cleancookstove.org. [June, 2014]
9. World Health Organization, Indoor Air Pollution, available from www.who.int/indoorair/en/. [July, 2014]
10. World Health Organization: Data and Statistics, available from www.who.int/research/en/.[December, 2015]
11. Energising Development (EnDev), available from energypedia.info/wiki/Energising_Development_(EnDev). [December, 2015]
12. Global Alliance for Clean Cookstoves-Ministry for Foreign Affairs of Finland. Informe: I Seminario Taller Latinoamericano de Cocinas/Estufas Limpias, "Promoviendo la adopción y uso sostenible en gran escala", Lima, 16-17 Junio 2014, available from cocinasmejoradasperu.org.pe/documentacion/Intervenciones/Informe_01_copia.pdf. [Diciembre, 2015]
13. Cooperación Alemana al Desarrollo – Agencia de la GIZ en el Perú, Influencia del Estado de la rejilla y cámara de combustión en el desempeño de las cocinas mejoradas Inkawasi, available from www.cocinasmejoradasperu.org.pe/documentacion/VidaUtil/Ensayo_copia.pdf. [Diciembre, 2015]
14. Energética, Experiencias con Sistemas Fotovoltaicos de Tercera Generación en Argentina, Bolivia y Perú, en www.energética.org.bo (2015)
15. Reiche, K. et al. What difference can a PicoPV System make?, GTZ (2010)
16. IEA International Energy Agency 2013, Pico Solar PV Systems for Remote Homes, Report IEA-PVPS T9-12: (2012)
17. Keane, J., Pico – Solar Electric Systems, First edition, Routledge, New York (2014)
18. Lighting Africa, available from www.lightingafrica.org. [7 July, 2014]
19. Lighting Global, available from www.lightingglobal.org. [7 July, 2104].
20. IEC, International Electrotechnical Commission, IEC, Technical Specification 62257-9-5, Recommendations for small renewable energy and hybrid systems for rural electrification - Part 9-5: Integrated system - Selection of stand-alone lighting kits for rural electrification, available from www.iec.ch. [7 July, 2014]
21. EnDEv /GIZ: Informe "Evaluación en campo de funcionamiento, aceptación e impactos de sistemas pico fotovoltaicos en la región San Martín", publicado (en español) en www.energypedia.info (2014)
22. CAN 2009, Atlas de las Dinámicas del Territorio Andino: Población y Bienes Expuestos a Amenazas Naturales; Secretaría General, Comunidad Andina – Cali: Corporación OSSO, 2009.
23. Givoni, B., Man, A., Climate and Architecture, Sydney (1969).
24. SENAMHI, Atlas de heladas del Perú, Convenio de Cooperación Técnica Internacional SENAMHI-FAO, LIMA – PERÚ (2010).
25. SENAMHI, Atlas Solar Perú [2003].

26. SENAMHI Atlas Solar Bolivia, [2008].
27. Lucano, M. y Fuentes, I. Evaluación del Potencial de Radiación Solar Global en el Departamento de Cochabamba Utilizando Modelos de Sistemas de Información Geográfica e Imágenes Satelitales, La Paz (2010).
28. CER-UNI, Archivo Técnico, Universidad Nacional de Ingeniería de Lima- Perú. (2000-2013)
29. Flores, L., Flores Larsen, S., Filippín, C., Comportamiento Térmico de Invierno y Verano de Viviendas de Interes Social en la Provincia de Salta; Argentina (2007).
30. Gatani, M., et al., Definición de Indicadores de Análisis de Diseño Sustentable. El Caso de una Vivienda Serrana en Córdoba; Argentina (2008)
31. G. E. Gonzalo, et al., Diseño Bioclimático de Viviendas de Interés Social en San Pedro de Colalao, Argentina (2008).
32. Gallipoliti; N. Sogari; M. Gea; A. Busso, Evaluacion del Desempeño Higrotermico – Energetico de una Vivienda Social en loa Ciudad de Corrientes, Argentina (2012).
33. Garzón, B., Mendonca, C., Monitoreo y Simulación Térmica de dos Viviendas Sociales Unifamilliares Bajo Condiciones Reales de Uso en la Localidad de Colalao del Valle, Argentina (2007).
34. Cangemi, M. C., Ledesma, S.L., Nota, V.M. Diseño de Viviendas de Interés Social. su Adecuación a las Condiciones Climáticas de Tucumán; Argentina (2013).
35. INETI-PORTUGAL, Los Edificios Bioclimáticos en los Países de Ibero América, Portugal (2005).
36. INETI-PORTUGAL, Los Edificios en el Futuro, Estrategias Bioclimáticas y sustentabilidad, Programa CYTED; Editores Helder Gonçalves y Susana Camelo 2007.
37. INETI-PORTUGAL, Los Edifícios Bioclimáticos a Integração das Energias Ronováveis e os Sistemas Energéticos, Portugal (2008).
38. Espinza, R., Evaluación Experimental de la Performance de dos Componentes Bioclimáticas de Calentamiento Aplicadas en un Módulo de Vivienda de San Francisco de Raymina-Ayacucho con el Propósito de Validarlas como Técnicas De Estrategias Bioclimáticas para Viviendas Rurales Alto Andinas, Lima-Perú (2014).

Box

Firewood Use in Latin America and its Effects on the health

Gustavo Sequiera and Mario Jiménez | Nicaragua

1. Introduction

Biomass, including firewood, charcoal and crop residue, is a broad concept that refers to the use of all types of organic matter for producing energy for either personal or industrial use.

Using charcoal or firewood for cooking is not bad in itself. After all, they are both renewable, entirely natural fuels. However, their main problem lies in the way they are used in poor households, since their incorrect usage harms the health of users while failure to renew forests has a lasting impact on the environment (Pobreza energética: La biomasa como combustible, 2014).[1]

2. Socioeconomic factors in Latin America

In 2012, poverty levels across Latin America reached 28.2%, while the percentage of those living in extreme poverty reached 11.3%. (CEPAL, Panaroma Social de América Latina, 2013)

The Mexican government estimated that in 2013, 33% of the country's population lived in conditions of moderate poverty, while another 9% lived in conditions of extreme poverty. (1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012, 2013).

Within the Central American Isthmus, the poorest countries are Honduras and Nicaragua, where over half the population lives below the poverty line (55%) and almost a third lives in conditions of extreme poverty (32%). (What Have We Learned about Household Biomass Cooking in Central America?, 2013)

In the Southern Cone, the four countries with the highest poverty index, according to the 2013 CEPAL report were: Bolivia with 42.2%, Colombia with 34.2%, Ecuador with 35.3% and Paraguay with 49.6%.(CEPAL, Panaroma Social de América Latina, 2013).

3. Use of firewood as an energy source in Latin American households

The census sample for living conditions and firewood use from the XII Mexican General Population Census 2000 revealed that over half of rural households and occupants (59%) use firewood as cooking fuel (XII censo de población y vivienda , 2000).

In Central America, twenty million people cook with biomass on open fires or rudimentary stoves. Approximately 86% or seventeen million of the people who consume firewood in both urban and rural areas within the region are concentrated in three countries: Guatemala, Honduras and Nicaragua. Meanwhile, in Costa Rica, Panama and El Salvador, firewood users are primarily rural inhabitants (What Have We Learned about Household Biomass Cooking in Central America?, 2013).

The 2011 Continuous Household Survey (ECH) undertaken by the Nicaraguan National Institute of Information and Development reported that 42.7% of rural households and 15.6% of urban households exclusively use firewood to prepare food.(Encuesta Continua de Hogares , 2011)

1. Gustavo Sequeira Peña is PhD in medical sciences with honorable mention in immunology from Friedrich-Schiller University, Germany. Specialist training in immunology, and subspecialty in allergology from the General Medical Council of Thuringia, Germany.

Mario Jiménez García is PhD in Medicine and Surgery and MS in Epidemiology from the National Autonomous University of Nicaragua (UNAN). Former research Professor in Water and health at the Nicaraguan Research Center for Water Resources.

Xiaoping Wang's report, published by the World Bank, reported that in Honduras, 37% of the urban population sector and 96% of the rural population use firewood as fuel in their homes.

In 1998, 36.22% of households in Bolivia used firewood, a percentage that had fallen to 17.05% by 2011. The reduction in firewood use was offset by a 20% increase in the use of liquefied gas during the same period. (Encuesta de Mejoramiento de Condiciones de Vida (MECOVI 2000-2002), Encuesta Continua de hogares 2003-2004, Encuesta de Hogares. 2005-2011, 2011).

In contrast to the situation in Central America, the Permanent Household Survey in Argentina (EPH/INDEC) reported that 72.11% of households cook with piped gas, while only 0.13% use kerosene, firewood or charcoal to prepare their meals. (Encuesta Permanente de Hogares - EPH, 2013).

Peruvian woman using firewood for cooking inside your home

4. Indoor firewood use and its effect on human health

Wood smoke is a complex mix of volatile and particulate substances, including organic and inorganic elements. Over 200 chemical compounds have been identified in wood combustion; the primary ones being carbon monoxide, nitrogen dioxide and particulate matter, all of which are toxic for the respiratory system. There is growing evidence that exposure to indoor wood smoke causes respiratory disease, especially amongst women and children, who are the most vulnerable groups. Three respiratory diseases in particular have been strongly associated with long-term exposure to wood smoke: acute lower respiratory tract infections in children under the age of five, chronic obstructive pulmonary disease (COPD) and lung cancer. (Enfermedad Pulmonar Obstructiva Crónica - EPOC, 2013)

COPD, generally caused worldwide by tobacco use and air pollution, is now considered the fourth leading cause of death throughout the world, and is expected to become the third by 2020. (Enfermedad Pulmonar Obstructiva Cròníca - EPOC, 2013)

The Proyecto Latinoamericano de Investigación en Obstrucción Pulmonar (Latin American Pulmonary Obstruction Research Project-PLATINO) found that COPD figures for Chile, Uruguay, Venezuela and Brazil, were over 12% (Venezuela 12.1%, Brazil 15.8%, Uruguay 19.7%, Chile 15.9%) compared with the average in Europe of less than 10%.(Recomendaciones para el Diagnósticoy Tratamiento de la Enfermedad Pulmonar Obstructiva Crónica (EPOC), 2011)

Despite having reported a 7.8% prevalence of the disease, 88% of COPD patients in Mexico with wood smoke exposure were female. (1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012, 2013).

5. Alternative solutions

Proper, controlled use of biomass fuel, for example, the production of crop residue pellets, which provide energy generated by the agrifood industry, is an alternative that can provide sufficient energy to cover household needs such as food preparation or small industry. However, their use must be combined with efficient cookers (that do not permit the accumulation of indoor smoke).

Bibliography

1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012. (29 de julio de 2013). Animal Político. Consultado el 31 de julio de 2014, de http://www.animalpolitico.com/2013/07/hay-53-3-millones-de-pobres-en-mexico/

Chapter 3

Renewable Energy

Immense Opportunities for Renewable Energy in its Many Forms

Claudio A. Estrada Gasca | Mexico
Jorge M. Islas Samperio | Mexico
Wilfredo César Flores Castro | Honduras

Summary

In the last decade, the development of renewable energy (RE) has exceeded all forecasts. Both the installed capacity, as world production of all RE technologies increased significantly and steadily. Although this growth in the share of total consumption of RE has been moderate, due to increasing population and demand for the world's energy (especially economies in developing and emerging), the markets of RE and the developments of technology associated with these technologies have increased significantly, even compared to other rapidly developing technologies such as mobile telephony.[1]

Today, the use of RE technologies to provide electricity, heating and/or cooling, and transport fuels extends worldwide, and the trend is to increase steadily in the coming decades. A decade ago, renewable energy technologies predominantly occupied an environmental niche. RE today have shown that, in addition to its environmental benefits are also economic engines of job creation, which help diversify income sources, and stimulate new technological developments.[2]

In this chapter, in a first section, the deployment of different commercial technologies using renewable energy sources is presented. In a second section, some alternative routes of action are identified for RE in the Americas. Finally, in a third section, some public policies associated with the construction of the identified solutions are proposed. As every country has its peculiarities in all America, only general policies are proposed and examples of what some countries are doing to support the development of renewable energy are given.

1. REN21 The first decade: 2004–2014

2. Idem

1. Technologies for harnessing renewable energy

Technologies for harnessing renewable energies have had in the last decade a very important development. As early as 2010, the generation of alternative electrical power (AE) produced less than 32% of the world total, of which renewable energy (RE) accounted for 19.4% and nuclear energy (NE) 12.8%. This trend has continued until the present.Of all the AEs, renewable energy sources have grown the most in international markets in recent years. In 2011, approximately 50 countries had installed wind power technology and the use of solar power systems is growing throughout the world; likewise, interest in geothermal power is on the rise and there are generally high expectations surrounding the existence of these important resources worldwide. These power sources have been enhanced by the rising production of liquid biofuel in Brazil, the United States and Europe and the presence of solar-powered heaters in over 200 million homes. It is important to point out that the majority of RE technology has seen continual growth in both the manufacturing of equipment and sales and installation. Much of what is available is due to decreasing sale prices and technological advances, especially where the application of solar power is concerned.

World investments in RE saw a 17% increase between 2010 and 2011, reflecting a $257 million USD investment. This number does not include the amount estimated for solar thermal collection devices, calculated to have received a $10 billion USD investment that same year.

It should be noted that the world recently (2102) reduced its political and financial support for these technologies because of international tensions and crises that also caused support for new projects to decline (REN21, 2012).

Where EE are concerned, the International Energy Agency (2012) estimates that improvements in power production could potentially achieve a 31% decrease in emissions from the world energy system by 2050. This reduction would be achieved mostly through the control of and reduction in the current use of obsolete technologies and inefficient practices that prevail throughout the world. Norms and standards for industrial and residential energy consumption, in additional to modifications in transportation vehicles, among other elements, would have to change.

Where NE is concerned, 66 nuclear plants were being built in 14 countries at the beginning of 2012, it is estimated that they will eventually produce 63,849 MW. Nevertheless, March of 2011 saw the most important nuclear accident since Chernobyl in 1986: the radioactive leak at the Fukushima Daiichi center in Japan. This event has become a serious obstacle for nuclear power development throughout the world (NEI, 2013).

Lastly, it is essential to mention the issue of Carbon Capture and Storage (CCS) technology, designed to create clean, new generation of thermoelectric power stations with decreased carbon dioxide emissions. There are eight large CCS projects in the world that together store approximately 23 million tons of carbon dioxide. However, this technology is still being developed and validated for commercial use and continues to face a number of challenges, including the high costs of introducing it into fossil fuel-based thermoelectric power stations (Global CCS Institute, 2012).

The following section describes the state of science and technology for each AE, EE and CCS source considered in this book.

The main technologies based on harnessing solar power are outlined below.

Photovoltaic solar power

Of all the solar technologies, photovoltaic (PV) solar power has seen the greatest growth worldwide. The technology is based on the use of solar panels. The most common form of panels uses photovoltaic effects in which sunlight hits a two-layer semiconductive surface that produces a discrepancy between the electrical potential (voltage) between the two layers. This voltage is able to conduct a current through an external circuit to generate useful work.

As mentioned earlier, the solar panel industry is growing very quickly; with photovoltaic systems integrated into electrical networks seeing the most growth. Europeans in particular have recently

Figure 1. Solar dryer and solar intermittent refrigerator. México

installed more photovoltaic systems in their regions. This is primarily due to forward-thinking energy policies within the European Union that require major investments in incentives for this type of technology.

The popularization of photocell-based technology has a long history of technological and industrial development that has resulted in a long-lasting, safe, and reliable product.

Within this context, in 2011, growth in the world PV technology market was significant: additional operational capacity grew to 30 GW, equivalent to a 74% increase from 2010 resulting in nearly 70 GW total. Of course, the European Union dominated the world PV market, accounting for nearly three quarters of the global total of this type of power (REN, 2012).

The PV technology that has seen the greatest growth in recent years is silicon (Si) based. Nevertheless, this rapid growth, tied to the application of Si in electronics, has caused a shortage of material, leading to a flow of investment in thin film solar cells. This has created opportunities for the manufacture of copper-indium-gallium-selenide (CIGS) technology (Wadia, 2009).

These advances have made PV an important option for substituting the use of HCs and reducing greenhouse gas emissions. Furthermore, these advances have significantly decreased the cost of PV systems, one of the greatest obstacles to their application in developing countries.

Low-Temperature Solar Thermal Energy

Solar thermal energy refers to solar panel systems that use the sun's energy to produce heat. In these systems, solar power is captured through an absorbent surface that transfers heat to a thermal liquid (water, air, oil or others) to raise its temperature and meet various requirements for applied heat.

These systems are classified as low, medium or high temperature depending on how hot the absorbent surface can become. This section discusses low-temperature surfaces (LTSTE).

These surfaces are called LTSTE because the temperatures reached by the thermal fluid are lower than the boiling point of water. These low-temperature solar thermal collectors are used to heat water in homes, pools, certain industrial processes, and farming; they can also be used in the desalination of water, food drying, space heating and refrigeration. (See Figure 1).

Low-temperature solar thermal collectors are highly-developed, well-established, and increasingly popular worldwide. Incidentally, this is the most commonly used technology for heating water for domestic use.

In late 2010, the operating capacity of all the solar thermal collectors in the world was 195.8 thermal gigawatts (GWth) or 279.7 million square meters of heat. By the end of 2011, this number had grown by 25% to 245 GWth (Weiss W. and Mauthner F., 2012). Of this total, 88.3% corresponded to flat plate solar collectors (FPC) and vacuum tube collectors (VTC), 11% to non-glass covered solar collectors and a mere 0.7% to air-heating solar collectors with or without a glass cover. China is currently the leader in the production and installation of LTSTE systems (REN21, 2012).

Medium-Temperature Solar Thermal Energy

In accordance with the classification explained above, medium-temperature solar thermal systems are those which use vacuum tube or concentrated solar power to reach thermal fluid temperatures above 100°C but below 250°C.

Figure 2. Parabolic concentrated solar power modules for industrial heat process Instituto de Investigaciones Eléctricas, Mexico

In fact, development of so-called "solar-heating technology for industrial use" is relatively new, which allows solar power to be applied in both industrial and commercial sectors. This is essential since the industrial sector consumes the greatest amount of energy in the world. However, although there is great potential for development, the use of solar energy in this sector is still limited worldwide.

One factor that determines commercial and industrial power use is that these sectors generally require temperatures of below 250°C. There are many industrial processes that require energy temperatures of below 80°C, which can easily be reached with commercial solar thermal collectors or vacuum tubes already available on the market. Regarding uses that require temperatures of between 80°C and 250°C, both high efficiency solar collectors and concentrated solar power, with their diverse components, must be developed. So far there have been 90 solar thermal plants for industrial heat production reported globally. Together their capacity is close to 25 thermal megawatts (MWth) or 35,000 square meters. Nevertheless, their potential is much higher. Only in European Union countries (EU25) does the potential reach an estimated 100 to 125 GWth (IEA, 2007).

Energía Solar térmica de Alta Temperatura (ESAT)

Solar power systems that reach temperatures above 250°C are called high-temperature solar thermal energy or high concentration systems (HTSTE). HTSTE systems have valuable applications in both industrial processes and power generation.

HTSTE Technologies for power generation, also called concentrated solar power (CSP) technology, have seen significant growth in recent years. CSP plants produce electrical power by transforming solar power into high-temperature thermal energy. This thermal energy is transferred to the power block to generate electricity.

For optimal output, CPS plants can be built to generate electricity for small populations (10 kWe) or for applications connected to the grid (up to 100 MWe or more). Some of these systems include thermal storage systems for use on cloudy days or at night. Other plants can combine their use with systems operating on natural gas, resulting in hybrid plants offering high-value dispatchable power on demand. These attributes, together with the world record for solar energy conversion efficiency (30% efficiency), make these technologies an attractive option for areas within the sunbelt with high annual sunshine levels.

In 2014, there are four existing technologies being promoted on an international level. Each one varies in design and configuration. The amount of power generated by a CSP depends on the amount of direct solar radiation that reaches it. These technologies mainly use direct solar radiation. Figure 3 shows photographs of the four existing designs: Parabolic cylinder, Linear Fresnel, Sterling dish and Central receiver.

The most important example of CSPs is the solar thermal power complex located at Kramer Junction in California, which uses SEGS (Solar Energy Generating Systems). This complex comprises nine plants using parabolic cylinder technology, occupying an area of 2.5 million square meters of solar concentrators. The nine SEGS with varying capacities have an aggregated total of 354 MWe.

This solar thermal complex was built between 1986 and 1991. The experience in operating SEGS in California amounts to 100 equivalent years of commercial operation, demonstrating the highest solar efficiency and producing the least expensive, most widely available solar power on the planet. These systems were designed as hybrid plants using 75% solar and 25% gas power.

Finally, after a long, 15-year period when no CSPs were constructed, new plants are being built around

Figure 3. Concentrated solar power plants with four different existing designs: cylindrical-parabolic, b) Linear Fresnel, c) Sterling dish, d) Central receiver. California, US

the world at an accelerated rate. The increase is surprising and there are now over 10,000 MWe in operation or under construction or development.

CSP Gemasolar, located in San Lucar La Mayor, Seville, Spain is an example of these new plants. This 19.9 MWe plant with central receiver design is the first commercial plant in the world to use central tower receiver and molten salt storage technology. Its net power production is 110 Gigawatt-hours per year (GWh/year) generated by a 185 hectare solar field containing 2,650 heliostats. The plant's thermal storage system is a reservoir tank of molten salt that allows for autonomous generation of power for up to 15 hours without sunlight. This means that the plant operates 24 hours a day. Figure 4 shows the central tower in operation at the Gemasolar power plant (photo: Torresol Energy).

Another HTSTE technology being developed is linked to the production of solar fuel, particularly hydrogen or industrial products.

Despite the existence of well-recognized, internationally collaborative research groups that focus on HTSTE research, and conscientiously share their work with young researchers, the HTSTE research community is still fairly small. It is thought that the reason for this is a lack of public policy that regards it as strategic and supports and expands on previous efforts in the field .

It is important to note that one of the characteristics of solar power is its intermittency. This disadvantage, in terms of primary energy sources, has led to hybridized systems and/or power storage. In other words, solar systems are hybridized by connecting them to fossil systems to guarantee on-demand

Figure 4. The Gemasolar concentrated solar power plant. Central tower. Seville, Spain

power. Solar power storage strategies are designed to satisfy demand for power during periods without sunshine. Both of these strategies have been successful, enabling significant growth in a variety of markets.

Bioenergy technology

Bioenergy is a power source obtained from biomass, which may be firewood, charcoal, agricultural, livestock and municipal waste (likely to be directly burned or gasified to produce heat and power, or to be transformed into biogas through aerobic or anaerobic processes). This section will also discuss biofuel production plantations, terrestrial power crops and lastly, aquatic power crops (such as algae).

The sustainable production of biomass has many environmental benefits, including the control of soil erosion, regulation of the water cycle and protection of wildlife habitats. Power plantations can rehabilitate eroded lands by improving on the quality and fertility of the soil.

The installed capacity for the production of electrical power through bioenergy increased worldwide between 2010 and 2011 from 66GW to 72GW. Power is generated though 88% solid biomass and solid urban waste, processed through direct burning plants or co-combustion (with coal or natural gas) (REN21, 2012).

The world leader in power generation through solid biomass and urban waste is the United States. By the end of 2011, installed capacity in the U.S. was nearly 14 GW. This is proof that use of bioenergy is on the rise around the world, wood pellets, biodiesel and bioethanol being the primary, salable fuels. Markets within the European Union are experiencing the greatest expansion, as these fuels are used for heating (REN21, 2012).

Nevertheless, plantations and power crops across large areas have been severely criticized with regards to social and environmental problems and economic development in underprivileged regions because of their negative effect on biodiversity, ecosystems and local food production. There is evidence that the increased presence of power crops causes food price increases. In addition, some countries (such as Brazil) have favored corporations and large-scale agriculture over local farming (Hall, 2009).

Wind power technology

Wind is an energy source that can be harnessed to generate power or mechanical energy. The technology used to convert wind into electricity is called wind turbine (see Figure 5).

Wind power is the AE that has achieved the largest presence in the world market, producing just over 196 GW (WWE, 2011) by the end of 2010. In 2011, its capacity rose by 20%, reaching nearly 238 GW, making it the greatest addition to RE generative capacity in the world. China accounted for 44% of the world market, followed by the USA and Germany. (REN21, 2012).

The world wind power industry has become big business. This is largely due to its technology having matured into an efficient, reliable, inexpensive source of power. Investments in this sector have continuously increased in recent years. By the close of 2010, the wind power industry employed nearly 670,000 people worldwide. (REN21, 2012).

Geothermal technology

Geothermal energy is obtained from the heat in the Earth's crust. In the presence of water, this heat can create high levels of temperature and pressure, producing hot water or water vapor. This thermal fluid can be used to generate power (via vapor turbines working with or without binary cycles) or to acclimatize spaces (via heating pumps).

Figure 5. Wind turbines, Horizontal axis design and vertical axis design. Technologies widely used in America

The most conventional geothermal systems are hydrothermal convective systems, used commercially to generate hydroelectricity. This convective equipment includes a heat source, a fluid (liquid and/or vapor) and rock where geothermal fluid is stored at temperatures reaching approximately 500°C. These systems in turn are classified as vapor-dominant, high-enthalpy liquid-dominant, or low-enthalpy liquid-dominant deposits.

At present, there are at least 78 countries in the world using geothermal power. The majority of growth in use of this resource has been to produce heat, whereas growth in use of geothermal electrical power has been modest (REN21, 2012). Countries where production and installed capacity are significant include the United States, the Philippines, Indonesia, Mexico, Italy, Iceland, New Zealand and a few in Central America (El Salvador, Nicaragua and Costa Rica) and East Africa. (Bertani, 2007).

The use of geothermal power has advanced significantly due to the development of new technologies such as advanced geothermal systems, better known as hot dry rock systems. These systems are characterized by the availability of the heat source (hot rock) and the absence of fluids. Access to this resource requires the creation of artificial fractures through hydraulic fracturing techniques that inject water at ambient temperature into an injector well drilled for this purpose. This water is then heated though conduction when it comes into contact with the hot dry rock and, after reaching a suitable temperature and pressure, is extracted through a second production well for use on the surface.

This geothermal resource is available in the subsoil at a depth of between two and four kilometers, with temperatures of between 90 and 350 degrees Celsius; for this reason it is considered both an abundant and practically inexhaustible resource. Although the production process of advanced systems appears simple, there are certain technological barriers and challenges to transforming it into a commercially viable process. (Santoyo, E., Torres, I., 2010)

A modest technology with a simple working principle is the most highly developed one to date. Geothermal acclimatization has been commercialized for a while and is now on the rise. This equipment functions like standard air conditioning systems, except that the thermal source is no longer the atmosphere, but the earth. Pipes are submerged from 60 cm to up to a dozen meters to come in contact with the base of the building (they can even be submerged in bodies of water such as rivers or lakes that serve as thermal sources). The same tubes also run throughout the building to be cooled where they exchange heat with the thermal source. These installations may use low-enthalpy (without a heating pump) or high-enthalpy (with a heating pump). The former are more economical since they only require pipes to exchange heat between the earth and the space to be cooled. The latter require a heating pump to increase the exchange of heat between the two deposits.

On a global level, geothermal power supplied an estimated 205 TWh, a third in the form of electricity (11.2 GW) and the remaining two thirds in the form of heat for direct use. (REN21, 2012).

Hydroelectric technology

Hydraulic power uses potential and kinetic energy associated with the fall of water or the difference in heights along the course of a river to create electricity.

Hydroelectric technology is highly developed around the world, and therefore considered a mature, highly-efficient albeit costly, technology. Most hydraulic power used worldwide is produced through large-scale hydroelectric plants, and less frequently through small-scale plants.

The definition of a small-scale hydroelectric power station depends on the country. For example, Europe categorizes small-scale as producing no more than 10 MW, whereas in China and certain Latin American countries, the limit may be 25 MW. On the other hand, there are certain countries where the production of a mini-plant must not exceed 2 MW. (Paish, 2002).

Thanks to economies of scale, large hydroelectric power stations are generally competitive, especially with regards to meeting base load and peak load requirements, despite the relatively high investment required. At the same time, small-scale hydroelectric plants have provided power generation for isolated areas, and are also relatively competitive in relation to other conventional and renewable power sources when partially or wholly supplying businesses or localities. These energy sources are also more socially accepted because they have a less significant environmental impact. (Paish, 2002)

To date, hydroelectric power is the most important RE in the world. The market for hydroelectricity is still considered important despite the fact that large-scale plants often have an environmental impact. Within this context, the more socially acceptable small-scale plants are more promising , and are being rapidly developed in countries across Asia, Africa and Latin America. (REN21, 2012).

Technologies for harnessing ocean power

The ocean is a major RE source that has yet to be fully exploited. Its power comes from tides, waves, ocean currents and saline and thermal gradients.

In 2010, there were just over five ocean power plants, three of which use tidal power: the La Rance plant in France (see Figure 20), with a capacity of 240 MW, one in Canada producing 20 MW and another in China producing 5 MW. There are also two plants that use sea currents: one in Norway and another in Great Britain. (ADEME, 2010)

In 2011, world capacity for generating ocean power doubled when South Korea installed a plant producing 254 MW, another one in Spain used wave power to produce 0.3 MW and yet another one in France was built to harness sea currents. The total amount of power produced from ocean power plants across the world in 2011 was 527 MW. (REN21, 2010).

These advances have been encouraged because ocean power has a number of advantages: it does not produce greenhouse gasses and its technology, which requires many years of research, development and innovation (R+D+i), is on its way to maturation. Nevertheless, negative effects on local flora and fauna in addition high investment costs, explain why it has seen so little development to date.

In accordance with nationally and internationally funded programs dedicated to RE R+D+i, investment of 300 million dollars for ocean power development is expected. (AMC, 2010)

Energy use in buildings

Worldwide, residential and commercial sectors are the leading consumers of power, accounting for 40% of total consumption, with 27% from the residential and 9% from the commercial sector (IEA, 2008). Most of this consumption is used to operate buildings. This is because in the past twenty years, both commercial and residential buildings have become more prevalent, leading to a corresponding increase in power and water use and waste generation.

It is therefore now crucial to propose energy efficiency measures in the construction sector. Members of the European Union, Japan, Australia, New Zealand, Canada and the United States among other countries, have implemented building quality standards at all levels of government and private enterprise, aimed at significantly reducing power consumption in buildings. (AMC, 2010)

The United States, via the International Energy Agency, issued Energy Efficiency Certification in 2009, which acts as a key political tool for supporting government in reducing energy consumption in this sector (IEA, 2010). England has implemented an Energy Performance Certificate along these lines, compulsory for all rented apartments, while the EU has an efficient buildings project. (DCLG, 2008)

Energy efficiency

The primary energy sources that currently dominate the world market are hydrocarbons (HC), accounting for 81.2% of all the primary energy produced and consumed (31.8% being obtained from petroleum, 21.3% from gas and 28.1% from coal). This enormous dependency on HCs has played a major role in climate change and its consequences for mankind, since it is a well-known fact that the colossal production of greenhouse gasses is caused by intensive hydrocarbon exploitation. This is why a reduction of HC use is important, particularly if we consider world population growth and lifestyle demands on energy sources. Human needs will continue to be met by HCs for a number of years because replacing these fuels with alternative energies is a gradual, long-term process.

From this perspective, energy efficiency (EE) activities –referred to in this book as "energy saving"—focus on the optimization and reduction of the amount of HC energy used to meet society's demands. These actions are crucial to diminishing environmental impact and climate change and transitioning to the use of alternative and sustainable power.

EE can be achieved on both the supply (power production) and the demand side (consumption). Current policies emphasize EE in the supply side; it is a fact that the energy production and transformation sector is HC intensive and therefore represents a great potential for improved efficiency. Globally, there are more options for EE in some regions than others. This is the case with carboelectric plants in China, which consume 22% more mineral than their counterparts in the USA.

This phenomenon is repeated throughout many developing countries, in large part because they employ, and even acquire, obsolete technology, which they then use in inefficient ways. These facts together translate into room for improving EE by between 50% and 60%. An example of this is apparent in the lack of energy consumption standards for all the equipment used to produce and transform HCs, particularly motors and boilers, which waste power through lack of maintenance and the absence of reengineered thermal and gas-burning processes. In fact, the IEA estimates that improvements in EE could contribute to potentially reducing 47% of carbon dioxide emissions linked to the power sector by 2030.

Figure 6. 240 MW ocean power plant La Rance, France

With respect to EE on the demand side, this section will approach the issue at what is called the "pipe end" where another great opportunity for improvement exists. This option was the first to arise when the concept of EE emerged after the first oil crisis in the 1970s. The concept made great strides in Europe, especially in France, where the term "birthplace of the energy economy" was coined, and the first ex professo institution dealing with the issue was created. The lack of standards for industrial sector equipment, electrical appliances and air conditioning in the residential sector; the lack of both active and passive solar modules in buildings, and low levels of transportation vehicle substitution are all areas of opportunity where HC consumption levels could be reduced across the globe.

When petroleum prices declined, EE programs became lax again, until the second oil crisis hit, creating the same kind of breakthrough as the first. Nowadays, this issue is being addressed with a new focus on at least four criteria: the conversion of HCs, the decrease in negative environmental impact due to fossil fuel use, the battle against climate change and guaranteed electrical power especially in countries dependent on foreign HC sources.

Due to the above, the international agenda has rekindled the concept of EE under the name 4E in energy demand, in other words, Efficient Electrical End-use Equipment. This program is fundamental since this secondary fuel, electricity use, has seen one of the highest growth rates in the past few years, and one that is expected to continue.[3]

Where standards are concerned, there have been great advances across the world, since they are even suitable for use in countries with inefficient energy use. Below are a few items to which the standards apply: fluorescent and mercury vapor lights with their respective electrical ballasts; ceiling fans; exit signs, dry-type voltage transformers; dehumidifiers, commercial atomization nozzles and air conditioning and heating systems; commercial and domestic refrigerators and freezers; ice-makers; washing machines and dishwashers.

Likewise, businesses with industrial, electronics and electronic appliances equipment continue to improve their energy consumption standards, including mechanisms to counteract consumption of what are colloquially called "vampires" (devices "on standby": the well known "red-light" on televisions, telephones, computers, etcetera), estimated to consume 3% of total annual demand.

All these measures to reduce HC use, on both the supply and demand sides, also provide the best short-term cost/benefit ratio. The search for EE extends across all intensive energy sectors from the main one, the energy sector, to those with the highest consumption rates, such as transport and industry. These sectors have extensive knowledge and experience with improvements that have gone beyond simply eliminating waste and, in many cases, have even arrived at technological change (for example, in the petrochemical, cement, and steel industries) and in the transport sector, by improving the performance of automobiles.

3. It is important to note the benefits achieved in the state of California, USA immediately following the implementation of an EE program put in practice as a response to the energy crisis the country experienced in 2001. This program reduced demand by 5% during its first year and it is estimated that its continued use will save 5.9 GWs of power for a net total of approximately $12 billion USD over the next decade. The same amount will be saved in environmental terms as well.

In order to maintain this dynamic and avoid stagnation, the obstacles that EE measures have faced are being considered throughout the world. These include: inadequate or incomplete information on opportunities provided by EE; b) lack of a regulatory framework and development organizations; c) inappropriate incentives; d) absence of standards for equipment; e) unprofessional energy management; f) lack of programs aimed at modifying cultural values.

Regulatory and institutional weaknesses arise from the fact that a consensus must be reached among a variety of forces and actors, which is no easy task. In fact, the energy business conflicts with the concept of EE. Its mission is to earn money by maximizing energy sales. This complicates agreements favoring EE; therefore, only when the energy sector is within a cohesive public context can the interests of both converge: efficient electricity supply and consumption .

The above reasons have caused energy businesses and their regulators in general (and electricity firms in particular) to converge on the criterion that "EE is also a supply option." This notion is based on the fact that since its inception, EE has been good business, even for supply companies, because it minimizes losses within their systems (both technical and non-technical, particularly theft). Moreover, in the majority of cases where this type of program has been implemented, these corporations have received major economic benefits from their governments, to which it should be added that many of the companies offering EE services come from, or are associated with, the supply companies.

On the consumer side, the relationship between corporations and their users has also been leveraged when information on the issue is shared and the acquisition or replacement of devices allows users to reduce their energy bills through more efficient consumption.

It is important to mention that the world has already gone through these energy saving phases, despite there having been periods where steps backwards were taken, generally in relation to reduced HC prices, when the profitability of investments in EE declined or disappeared altogether. Consequently, one way to avoid reversing the advances already made is to ensure that recommendations about, information on and sensitivity toward EE are constantly shared with consumers. This will help consumers shift their habits, not only for economic reasons, but also in the interest of conserving non-renewable resources and, above all, the environment, since EE measures have a favorable impact on the adverse effects of energy use.

Hydrogen technology

As an energy vector, hydrogen is a relatively abundant fuel with few negative effects on the environment. In terms of power production, this gas is primarily used to generate electricity and run cars through energy conversion devices such as fuel cells.

Hydrogen may be produced through a variety of technologies that can roughly be grouped into two categories: by chemical reactions and by electrolysis. The former may be obtained from water thermolysis, carbon or biomass gasification or hydrocarbon reforming. On the other hand, the latter category is created by electricity from a renewable source (for example, photovoltaic, wind power, etcetera), nuclear or fossil (carbon-based, etcetera), to carry out hydrolysis on water molecules thereby obtaining hydrogen.

Most of the hydrogen produced worldwide is extracted through hydrocarbon reforming, primarily from natural gas. Although natural gas comes from a fossil source, its use in fuel cells produces fewer emissions per kWh generated as compared to the direct combustion of fuel. It is worth noting that the best known form of hydrogen production from RE sources is through water electrolysis.

Use of renewable hydrogen for power production is still at R+D stages around the world. In fact, even though there are some prototypes in existence, there is still no plant for commercial production. Likewise, its use as a fuel promises to be a solution to reducing greenhouse gas emissions and noise pollution. In 2013, there were already experimental automobiles that run on hydrogen rather than gas.

2. Identifying alternatives and solutions. Action paths

This section will discuss AE options in the Americas in the words of academics, researchers, institutions and other experts on the topic. Their proposals are drawn from the various meetings, forums, and congresses. Generally speaking, alternative options and action plans to increase AE usage as the world moves toward a sustainable power system, include the following:

- Use of subsidiaries to promote RE sources and EE programs.
- Including externalities to evaluate energy production options, especially with regards to socio-environmental and health hazard issues.
- Specialized training of human resources in the areas of AE.
- Gathering sufficient economic and material resources for the R+D+i process, to be directed towards innovation, patent creation, the development of specialized computer programs, pilot projects and escalation at an industrial level.
- Strategy development and financing mechanisms using national and international resources.
- Dissemination of information on the advantages and disadvantages of using AE.
- Creation of networks for AE research and development.
- Standardization, regulation, monitoring, verification, certification and development of legal instruments to achieve maximum AE performance.
- Prioritization of AE in government energy agendas (long-term political agendas)
- Assessment of the advantages of AE sources in terms of long-term energy prices and the reduction supply risks.
- Creation of more R+D institutions, with a substantial increase in job positions.

The alternatives or solutions have been established, as in the previous section, according to types of AE sources (AMC, 2010). The main ones are listed below:

Photovoltaic power

The action plans proposed for PV are:

- Evaluation of solar resources and drawing up of a solar map of the region.
- Compilation of regional inventory, performance databases and maintenance of PV systems.

- Undertaking of studies to establish the production chain of PV systems.
- R+D for new solar cells and other PV components at national laboratories.
- Design and construction of medium and high potential PV systems for a variety of applications.
- Development of standards, certifications and installment training programs, adaptation and adoption of PV systems in a variety of social sectors. (AMC, 2010)

Low-Temperature Solar Thermal Energy (LTSTE)

The specific action path for LTSTE revolves around one point: the development of a database of climatic conditions in each country from which to calculate solar cell systems. The following actions are also proposed:

- R+D+i in: a) advanced automation and control systems; b) low-temperature solar thermal collectors; c) new materials for the manufacture of low-temperature solar thermal collectors; d) solar heating equipment for specific application such as refrigeration, drying and desalination.
- Programs designed to share information on the functioning, maintenance and benefits of this technology, particularly for users.
- Technical training for those responsible for the sale and installation of this technology. In addition, it is necessary to create a certification program for people who install, maintain and repair these devices in order to guarantee the quality of LTSE equipment.

Medium and high enthalpy solar power

With regards to MTSTE and HTSTE, action paths revolve around basic and applied research, as well as technological development:

- Work on designs, materials and fabrication methods for CSP devices including linear focal systems (cylindrical or Fresnel) and parabolic dish systems (Stirling Dish and central tower) to reduce investment and maintenance costs.
- Improve materials, fabrication methods and devices for thermal storage, reflectors and absorbers.
- Identify, characterize and analyze industrial processes that may be adapted to reliable, efficient solar thermal collectors.
- Develop experimental and display plants for the different MTSTE and HTSTE technologies to validate existing technology, develop new methods and establish links between these technologies and the industrial sector while training specialized labor forces.
- Development of high concentration system receivers/reactors.

Bioenergy

- Bioenergy requires undertaking a more accurate evaluation of the existing resource potential in the country, reinforcement of R+D+i related to sustainability studies on biofuel, as well as the social and environmental considerations of said projects. (AMC, 2010)
- Likewise, R+D is crucial in processes that focus on maximizing production of biomass and Biofuel (ethanol, biodiesel, biogas, charcoal) in devices and materials. Examples include biomass pellets, biomass co-combustion, inexpensive waste digesters, pellet burners, biogas from vinasse, ethanol produced from agricultural waste, selection of national species and varieties for sustainable production of biofuel and ethanol, technology for sustainable management of forests and jungles, optimal logical systems for collecting and transporting biomass waste, bio-refineries and biofuel production systems using algae.
- Other paths of action envisaged for bioenergy include production models and other environmental services, taking into account the ecological treatment of forests and jungles, and models for energy, economy, plantation and crop evaluation.

Wind power

Action paths considered for wind power, the most abundant source of RE in each country, mainly seek the development of a solid, competitive wind power industry to be at the leading edge in this area worldwide.

The following specific actions are proposed:

- Design a technology assimilation program.
- Increase industrial projects for the development of small- and medium-scale capacity wind turbines to provide services for existing niche markets.

- Encourage and develop industrial capacity to create solid and competitive industry through which aero generators, subsystems and components can be manufactured; this leads to job creation and captures investors' interest in the national wind power industry.
- Create a reliable wind resource database.
- Develop models projecting the variability of the resource.
- R+D+i on power trains, small aero generators, blades and rotors with advanced design, self-diagnosing failures, foundations and towers in addition to improvements of equipmentexposed to extreme conditions.
- Communicate the environmental benefits of electricity from wind power sources.
- Undertake studies on the social and environmental impacts of wind power development in each country.

Geothermal

The following plans of action are proposed to make better use of geothermal power:

- Evaluate usable resources on a national scale, characterizing tectonic environments where usable geothermal resources may exist.
- Develop new methods of exploration and educate researchers specializing in these new methods.
- R+D+i in surface and well drilling and construction equipment.
- Encourage the application of geothermal energy in heat pumps.
- Educate and inform the population about the direct benefits of using geothermal energy.

The following points are proposed as regards R+D action plans for the reduction of environmental impact upon using geothermal energy:

- Exploit mineral extraction as an additional policy to residual fluids.
- Remove contaminants and develop remediation techniques in geothermal exploration and exploitation.
- Undertake a diagnosis of geothermal energy regulation in each country.

Small-scale hydraulic energy

The first plan of action for better use of small-scale hydraulic resources is repeated demand for each RE resource and a country-wide evaluation of hydraulic resources. The following actions are proposed:

- Establish specific programs for small-scale hydraulic plants ranging from the design and manufacture of equipment to the installation, operation and maintenance of these systems.
- Design R+D programs for flow control strategies, new materials and improvements in plant and turbine design and to decrease the concentration of aquatic fauna.
- Evaluate the small and large-scale potential of the region.

Ocean power

Action plans for ocean power, as with all RE sources, begin with an evaluation of the resource and the advances in knowledge about the various forms of ocean energy in order to define a development strategy tailored to this RE (AMC, 2010). The following are also required in terms of R+D+i:

- Strengthen existing research teams.
- Explore the various technologies for harnessing ocean power.
- Undertake environmental impact evaluations in areas where ocean power may be used.

Energy use in buildings

The following actions are proposed to strengthen and develop energy use issues in buildings at the regional level:

- Complement national standards for energy evaluation and building certification with enforced standards and mechanisms for their implementation and certification in both the construction and sales processes (applicable to residential, commercial, industrial and service-oriented edifices).
- Establish consensual strategies for designing buildings with low energy consumptions.
- Define parameters for air conditioning and artificial lighting systems for visual comfort.
- Develop and design new building materials that reduce use of non-renewable natural resources, consume less energy and have fewer

negative effects on the environment both during the production process and throughout their life-cycles.

- Elaborate and design voluntary and obligatory standards and certification processes that apply to construction materials whether new or recycled.
- The following actions paths are proposed for the R+D process:
  - Increase financing options for priority projects.
  - Develop example projects in various regions of every country.
  - Build technology transfer programs in conjunction with the construction industry.
  - Improve links between academia and the energy production and consumption sectors.
  - Develop new construction methods.
  - Reinforce research and application of bioclimatic design in construction.
  - Encourage the inclusion in university syllabuses of themes and issues related to energy efficient buildings.

In short, the main action path will be to 1) ensure that buildings have the technical capacity to provide and store enough energy from natural sources to meet their needs; 2) encourage the design and construction of buildings with less demand for power. These goals can be achieved by using bioclimatic design.

Energy efficiency in hydrocarbon use

The following paths of action to implement large-scale, high-impact EE programs are proposed:

- Undertake studies on end use of energy in all sectors.
- Educate EE specialists.
- Create standards in the methodologies used to be able to undertake reliable diagnoses of power usage.
- Develop EE standards for all equipment and devices in all sectors. These standards will also be applied to imported equipment.
- Create links between government, academia and industry regarding EE.
- Establish the application of EEs as obligatory in the public sector, in the three levels of government.
- Make EE a priority in the governmental strategies for EE to ensure optimal assignation of public funds.
- Encourage technological development to produce high efficiency equipment adapted to operating conditions within Mexico.
- Promote specific information and certified materials and equipment that further EE.
- Establish international standards as a reference for Mexico's domestic power and manufacturing industries with the aim of improving their competitiveness.

Hydrogen

With regards to power from hydrogen sources, the following action paths are proposed:

- Encourage science applied to developing components and materials for: electro-catalysts, electrolytes for fuel cells, catalysts for hydrogen production (based on renewable organic products) and metallic bipolar plates.
- R+D+i for thermal conversion of biomass, thermo-chemical cycles for solar concentrated energy, fuel cells, internal combustion and hydrogen motors, catalysts for reforming and micro-reforming, collectors and other hydrogen storage systems.
- Establishment of research networks.
- Ensure the specialization of professionals and the train a new work force within the area.

3. Public policy associated with building identifiable solutions

In order to promote public policy toward an energy transition where EE is a priority in all sectors of the country, by strengthening the use of AE sources (especially RE sources) and CCS to support the majority of power consumption, nine fundamental premises should be considered:

1. Improve energy efficiency in technology and processes throughout the entire energy chain: production, transport, transformation, supply and consumption.
2. Support research, development and innovation for technology of AE sources, especially related to RE, EE and CCS.

3. Educate and inform the population about EE and use of AE, especially RE.
4. Undertake behavior pattern studies for power consumption in all productive sectors with the primary goal of proposing changes to consumer habits.
5. Support research for the development of technology that uses AE, especially RE, both for power generation and heat production in all sectors.
6. Make technologies that use AE more efficient, affordable and subsidized so that the entire population can have access to them.
7. Propose that for the medium-term (by 2030) at least 30% of all end use energy should be derived from AE sources, especially RE.
8. Promote and develop a culture of awareness of the environmental consequences of energy use.
9. Encourage the training of specialized human resources in both AA and AE, particularly in the areas of RE and CCS.

Within this same context it is important to consolidate the planning and establishment of short-term energy strategies to achieve the following:

- Conventional energies that show real costs and any subsidies including environmental externalities.
- Greater financing for scientific development, technology and innovation for EE and AE, especially for RE and CCS.
- Propose investment programs for the use of REs for the government and financial institutions, highlighting the social and environmental benefits as well as the savings that can be achieved.
- Create regional academic hubs to propose specific projects for the government and the industrial sector.
- Create economic instruments that will promote EE technology as well as RE sources.
- Train human capital to specialize in EE and AE, particularly in the field of RE and CCS.
- Support links between academia, industries, society and the government, using the creation of a national initiative to coordinate between small and mid-sized businesses, state and municipal governments and social organization, universities and research centers as an action path.
- Identify renewable resources in each region and undertake actions evaluated by academics to encourage the government to undertake them.
- Share EE and AE technology, especially for RE and CSC.

Medium and long-term:

- Create national production industries that will participate in the RE chain, giving preference to and facilitating the national industry.
- Establish an incentives program for the use of RE and EE, by technology and sector.
- Political willingness to develop national technology and reduce dependence on the exterior.
- Create EE models within academia and transfer them to private industry and the government.
- Create national institutes for RE that strengthen and coordinate with IDT efforts in every country.

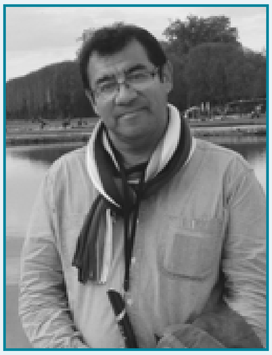
Undertaking these public policies is designed to strengthen research, technological development and innovation (R+D+i) for AE, especially where RE and EE are concerned, with the corresponding education of a work force to undertake these activities.

Acknowledgments

Thanks for support in retrieving and ordering information, execution of the graphs in section 1 & 2 of this chapter are due to Genice Grande Acosta, Technical Academic Associate C for the Energy Planning Office at the UNAM Institute for Renewable Energies.

Claudio A. Estrada Gasca

Prof. Estrada is physicist from UNAM and has a PhD degree in Mechanical Engineering from the New Mexico State University, USA. Prof. Estrada has worked for the UNAM Institute of Renewable Energy since June 1988 and his specific areas of interest are transport phenomena in solar systems, mainly in solar concentration systems. He has published over 170 research papers in conferences and the journals of the Science Citation Index and is associate editor of the International Journal of Solar Energy. He has supervised 40 theses (including 12 doctoral dissertations). He is one of the most active and important promoters of solar energy in Mexico; he has been a co-organizer and member of scientific committees at several national and international meetings. He has been president of the Mexican Association of Solar Energy (ANES) and a member of the Board of Directors of the International Solar Energy Society (ISES). He has won several awards, including the award from the Mexican Society of Physics for the Development of Physics in Mexico (2009). He was director of the Center for Energy Research of UNAM (Dec. 2004 – Dec. 2012), now the Renewable Energy Institute. Under his directoship, the Energy Research Center was transformed into the UNAM Institute of Renewable Energy in January 2013. Also, under his tenure as director of the CIE, the UNAM Engineering in Renewable Energy Bachelor's Degree Program was designed, managed and approved by the University Council in March 2011. He is currently a member of the National System of Researchers, Level III, and is responsible for the National Laboratory on Solar Concentrating Systems and Solar Chemistry of Mexico project and since April 2015, he has been the director of the UNAM Tucson-Center for Mexican Studies.



Jorge Marcial Islas Samperio

He obtained a bachelor's degree in physics and a master's degree in energy engineering at the National Autonomous University of Mexico (UNAM) and a PhD in Applied Economics at the Pierre Mendès France University in France. He is currently a full researcher and coordinator of the Energy Planning Group at the UNAM Institute of Renewable Energy (IER UNAM). He is also scientific manager of the Energy Area of the Ibero-American Science and Technology Program for Development (CYTED) and Social Director of the Coordination Office for the Evaluation of the National Climate Change Policy. He is a member of the National System of Researchers and the Academy of Engineering. He has been Head of the Department of Energy Systems and Academic Secretary as well as Coordinator of the Graduate Engineering Program (in Energy) at the IER UNAM. His lines of research include energy and technology prospects for renewable energies, energy and climate change mitigation and the economics of renewable energy, in which he has been the principal investigator in over 30 research projects and a consultant to several national and international institutions. He has published over 80 research papers in international, peer-reviewed journals and the proceedings of international and national congresses. He has published books and book chapters in the area of science and technological development and other renewable energy issues.

Wilfredo César Flores Castro

Wilfredo César Flores Castro, was born in Tegucigalpa, Honduras, received the Electrical Engineer degree from Autonomous National University of Honduras, the MBA degree from TEC of Monterrey, México, and the PhD degree from National University of San Juan, Argentina. Dr. Flores was the National Coordinator of the Honduras Energy Policy on 2007-2010. Also he has been Lecturer of Physics and Engineering in Autonomous National University of Honduras and Universidad Tecnológica Centroamericana, respectively. His topics of interest are Energy Policy, Regulatory Framework of Electricity Power Markets, Regional Energy Markets, Analysis of Electric Power Systems, Renewable Energy and the use of Type-2 Fuzzy Logic Systems for applications in diagnosis of High Voltage equipment. Dr. Flores is Senior Member IEEE and Member of National Academy of Sciences of Honduras. He is author of several documents related to Energy and Artificial Intelligence. At present Dr. Flores is Full Researcher and Lecturer in Universidad Tecnológica Centroamericana, UNITEC, in Tegucigalpa, Honduras.

References

ADEME (2010), Agence de l'Environnement et de la Maitrise de l'Energie, Feuille de route sur les énergies renouvelables marine, 32 páginas, ISBN: 978-2-35838-1550-0. Disponible en: http://www2.ademe.fr/servlet/getDoc?sort=-1&cid=96&m=3&id=74563&ref=14152&nocache=yes&p1=111. Consultado el 14 de agosto de 2013.

Agredano Díaz, Jaime (2008), Tecnología Fotovoltaica, Boletín IIE *Tendencias Tecnológicas*, Abril-Junio, 7 páginas. Disponible en: http://www.iie.org.mx/boletin022008/tenden02.pdf. Consultado el 14 de agosto de 2013.

AIEA (2012), International Atomic Energy Agency, Nuclear Technology Review 2012, Austria, 182 páginas. Disponible en: http://www.iaea.org/Publications/Reports/ntr2012.pdf. Consultado el 14 de agosto de 2013.

AMC (2010), Academia Mexicana de Ciencias, Energías alternas: propuesta de investigación y desarrollo tecnológico para México, 152 páginas. Disponible en: http://www.coniunctus.amc.edu.mx/libros/energias_alternas.pdf. Consultado el 14 de agosto de 2013.

AMEE (2012), Asociación Mexicana de Energía Eólica, Proyectos eólicos en operación en México, 2 páginas. Disponible en: http://amdee.org/Proyectos/ProyectosEolicosenMexico2012dic.pdf. Consultado el 14 de agosto de 2013.

ANES (2011), Asociación Nacional de Energía Solar A.C., Disponible en: http://www.anes.org/anes/index.php?option=com_wrapper&Itemid=13. Consultado el 20 de agosto de 2013.

Bertani, R. (2007), World Geotermal Generation in 2007, páginas. 8-19 in: Oregon Institute of Technology, Geo-Heat Center Quarterly Bulletin, *Sustainability World Generation Australia,* Volume: 28, No.3, 28 pag., ISSN: 0276-1084. Disponible en: http://geoheat.oit.edu/bulletin/bull28-3/bull28-3-all.pdf. Consultado el 14 de agosto de 2013.

BP (2011), British Petroleum, Energy Outlook 2030, 80 páginas. Disponible en: http://www.bp.com/liveassets/bp_internet/globalbp/globalbp_uk_english/reports_and_publications/statistical_energy_review_2008/STAGING/local_assets/2010_downloads/2030_energy_outlook_booklet.pdf. Consultado el 14 de agosto de 2013.

BP (2013), BP Statistical Review of World Energy June 2013. Disponible en: http://www.bp.com/en/global/corporate/about-bp/energy-economics.html Consultado el 03 de junio de 2014.

CFE (2012), Comisión Federal de Electricidad, Programa de obras e inversiones del sector eléctrico 2012-2026, 370 páginas.

CFE (2011), Comisión Federal de Electricidad, Programa de obras e inversiones del sector eléctrico 2011-2025, 312 páginas.

CEPAL (2009), Comisión Económica para América Latina, Situación y perspectiva de la eficiencia energética en América Latina y el Caribe. Documento de proyecto, 294 páginas. Disponible en: http://www.eclac.org/publicaciones/xml/1/3 7451/lcw280e.pdf. Consultado el 14 de agosto de 2013.

CONUEE (2013) Comisión Nacional para el Uso Eficiente de la Energía, Normas Oficiales Mexicanas en Eficiencia Energética Vigentes. Disponible en: http://www.conuee.gob.mx/wb/CONAE/CONA_1002_nom_publicadas_vigen. Consultado el 20 de agosto de 2013.

DCLG (2008), Department for Communities and Local Government, Energy Performance Certificates (EPCs) and Renting Homes: A tenant's guide, 8 pages, Disponible en: http://webarchive.nationalarchives.gov.uk/20120919132719/http://www.communities.gov.uk/documents/planningandbuilding/pdf/925424.pdf. Consultado el 14 de agosto de 2013.

DOF (2007), Diario Oficial de la Federación, Ley Federal de Derechos en Materia de Hidrocarburos, 10 de enero de 2007.

DOF (2008), Diario Oficial de la Federación, Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética, 28 de noviembre de 2008.

DOF (2008a), Diario Oficial de la Federación, Ley de Promoción y Desarrollo de los Bioenergéticos, 01 de febrero de 2008.

DOF (2008b), Diario Oficial de la Federación, Decreto que reforma y adiciona el artículo la Ley Orgánica de Administración Pública Federal, 28 de noviembre de 2008.

Esteban. A., (2012), Japón abandonará la energía nuclear en la década de los 30, Diario *El País,* 14 de septiembre de 2012.

Global CCS Institute, (2011), The Global Status of CCS: 2011, 156 páginas, ISBN: 978-0-9871863-0-0. Disponible en: http://cdn.globalccsinstitute.com/sites/default/files/publications/22562/global-status-ccs-2011.pdf. Consultado el 14 de agosto de 2013.

Global CCS Institute, (2012), CCS Ready Policy and Regulations. The State of Play, 81 pages,Disponible en: http://cdn.globalccsinstitute.com/sites/default/files/publications/44161/ccsreadydraftfinal10aug.pdf. Consultado el 14 de agosto de 2013.

GWEC (2014), Global Wind Energy Council. Global Wind Report. Annual Market Update 2013, GWEC. Disponible en: http://www.gwec.net/wp-content/uploads/2014/04/GWEC-Global-Wind-Report_9-April-2014.pdf. Consultado el 2 de junio de 2014.

Hall, J. M.Severino,L. Beltrao,N.(2009), Brazilian biofuels and Social Exclusion: Established and Concentrated Ethanol versus Emerging and Dispersed Biodiesel. *Journal of Cleaner Production,* Volume: 17, Supplement 1, páginas S77-S85.

Huacuz, Jorge M. (2010), La energía del viento, ¿cómo aprovechas su valor?, *Ciencia y Desarrollo*, febrero de 2010, páginas 36-50.

H. Cámara de Diputados (2008). Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética, 16 páginas, Disponible en: http://www.diputados.gob.mx/LeyesBiblio/pdf/LAERFTE.pdf. Consultado el 14 de agosto de 2013.

IEA (2007), International Energy Agency, Solar Heating & Cooling Programme 2007, Annual Report, 128 páginas. Disponible en: http://www.iea-shc.org/Data/Sites/1/publications/shc_annual_report_2007.pdf. Consultado el 14 de agosto de 2013.

IEA (2008), International Energy Agency, Energy Efficiency Requirements in Building Codes, Energy Efficiency Policies for New Buildings, 85 páginas. Disponible en: http://www.iea.org/publications/freepublications/publication/Building_Codes.pdf. Consultado el 14 de agosto de 2014.

IEA (2010), International Energy Agency, Energy Performance Certification of Buildings: A Policy Tool to Improve Energy Efficiency, 64 páginas. Disponible en: http://www.iea.org/publications/freepublications/publication/buildings_certification.pdf. Consultado el 14 de agosto de 2013.

IEA (2013), International Energy Agency, Renewables Information. IEA, Francia.

IGA (2012), International Geothermal Association, What is Geothermal Energy? Disponible en: http://www.geothermal-energy.org/geothermal_energy/what_is_geothermal_energy.html. Consultado el 04 de junio de 2014.

IPCC (2005), Intergovernmental Panel on Climate Change, Special Report on Carbon Dioxide Capture and Storage, Cambridge University Press, 443 páginas. Disponible en: http://www.ipcc.ch/pdf/special-reports/srccs/srccs_wholereport.pdf. Consultado el 14 de agosto de 2013.

IPCC (2012), Intergovernmental Panel on Climate Change, Special Report on Renewable Energy Sources and Climate Change Mitigation, Full Report, New York, Cambridge University Press.

ITC (2010). International Training Centre, Estrategias Territoriales Innovadoras para Empleos Verdes, Centro Internacional de Formación de la Organización Internacional del Trabajo,124 páginas. Turín, Italia. Disponible en: http://www.oitcinterfor.org/sites/default/files/edit/docref/estra_emverdes.pdf. Consultado el 14 de agosto de 2013.

II-UNAM (2011), Proyectos. Disponible en: http://www.iingen.unam.mx/es-mx/SitiosWeb/Laboratorios/LIPC/Investigacion/Lists/Proyectos. Consultado el 14 de agosto de 2013.

Le Bert, G., (2009), Potencial energético del Alto Golfo de California, Boletín de la Sociedad Geológica Mexicana, Volumen: 61, Núm. 1, páginas 143-146. Disponible en: http://boletinsgm.igeolcu.unam.mx/bsgm/vols/epoca04/6101/%2813%29Hiriart.pdf. Consultado el 14 de agosto de 2013.

López-Gonzalez J. et al (2010), Cuantificación de Energía de una Planta Mareomotriz, Ingeniería Investigación y Tecnología, Volumen: XI, No. 2, páginas: 233-245, ISSN 1405- 7743, FI-UNAM.

Lucas, W. Davis, (2011), Prospects for US Nuclear Power After Fukushima, Energy Institute at Haas, El@HaasWP128, 21 páginas. Disponible en: http://ei.haas.berkeley.edu/pdf/working_papers/WP218.pdf. Consultado el 14 de agosto de 2013.

Lu, Xi, Michael B. McElroy, Juha Kiviluoma (2009). Global potential for wind-generated electricity. Proceedings of the National Academy of Sciences of the United States of America, 106 (27), 10933-10938.

Masera. O., Fuentes. A., (2010), La bioenergía para un desarrollo nacional sustentable, Red Mexicana de Bioenergía y Centro de Investigación en Ecosistemas, UNAM, página 8.

National Petroleum Council (2007), after Craig, Cunningham and Saigo.

NEI (2013), Nuclear Energy Institute, Nuclear Energy´s Economics Benefits-Current and Future, 6 páginas. Disponible en: http://www.nei.org/CorporateSite/media/filefolder/Nuclear-Energy-s-Economic-Benefits-Current-and-Future.pdf?ext=.pdf. Consultado el 14 de agosto de 2013.

NREL (2009). National Renewable Energy Laboratory, Solar Resources By Class Per Country. Disponible en: http://en.openei.org/datasets/node/498 Consultado el 5 de junio de 2014.

OKSolar (2013), World Solar Radiation. Disponible en: www.oksolar.com/abctech/world_solar_radiation.pdf.Consultado el 14 de agosto de 2013.

Paish, O., (2002), Small Hydro Power: Technology and Current Status, Renewable and Sustainable Energy Reviews, Volume: 6, Issue: 6, páginas: 537-556.

REN21 (2012), Renewable Energy Policy Network for the 21st Century. Renewables 2012 Global Status Report, Paris, REN21 Secretariat, 76 páginas. Disponible en: http://www.ren21.net/Portals/0/documents/Resources/GSR2012_low%20res_FINAL.pdf. Consultado el 14 de agosto de 2013.

Santoyo-Gutiérrez, Edgar y Torres-Alvarado, Ignacio S. (2010), Escenario futuro de explotación de la energía geotérmica: hacia un desarrollo sustentable. Revista Digital Universitaria [en línea]. 1 de octubre 2010, Volumen:. 11, No.10. 26 páginas. Disponible en: http://www.revista.unam.mx/vol.11/num10/art95/art95.pdf. Consultado el 14 de agosto de 2013.

SENER (2011a), Secretaría de Energía, Balance Nacional de Energía 2011,59 páginas. Disponible en: http://www.sener.gob.mx/res/PE_y_DT/pub/2012/BNE_2011.pdf. Consultado el 14 de agosto de 2013.

SENER (2011b), Secretaría de Energía, Estado que Guardan las Tecnologías de Captura y Almacenamiento de Carbono y su Aplicación en México, 45 páginas. Disponible en: http://co2.energia.gob.mx/res/Estado%20que%20guardan%20las%20tecnologias%20de%20Captura%20y%20Almacenamiento%20de%20Carbono%20y%20su%20aplicacion%20en%20Mexico.pdf. Consultado el 14 de agosto de 2013.

SENER (2010), Secretaría de Energía, Prospectiva del sector eléctrico 2010-2025,227 páginas. Disponible en: http://www.sener.gob.mx/res/1825/SECTOR_ELECTRICO.pdf. Consultado el 14 de agosto de 2013.

SENER (2012a), Secretaría de Energía, Prospectivas de Energías Renovables 2012-2026,156 páginas. Disponible en: http://www.sener.gob.mx/res/PE_y_DT/pub/2012/PER_2012-2026.pdf. Consultado el 14 de agosto de 2013.

SENER (2012b), Secretaría de Energía, Estrategia Nacional de Energía 2012-2026, 179 páginas. Disponible en: http://www.sener.gob.mx/res/PE_y_DT/pub/2012/ENE_2012_2026.pdf. Consultado el 14 de agosto de 2013.

UNEP (2012), UNEP Collaborating Centre for Climate and Sustainable Energy Finance, Global Trends in Renewable Energy Investment 2012, 82 páginas, 2012. Disponible en: http://fs-unep-centre.org/sites/default/files/publications/globaltrendsreport2012.pdf

US DOE/EIA (2013), US Energy Information Administration. Annual Energy Outlook 2013 with projections to 2040, 244 páginas. Disponible en: http://www.eia.gov/forecasts/aeo/pdf/0383(2013).pdf. Consultado el 14 de agosto de 2013.

Wadia, C.(2009), Alivisatos, A.P. y Kammen, D.M., Materials availability expands the opportunity for large-scale photovoltaics development. Environmental Science & Technology, Volume: 43, No. 6, páginas: 2072-2077.

WB (2013), World Bank, World Development Indicators 2013. Disponible en: http://data.worldbank.org/data-catalog/world-development-indicators

WEA (2011), Wind Energy Association, World Wind Energy Statistics, Half-year Report 2011, 7 páginas. Disponible en: http://wwindea.org/home/images/stories/publications/half_year_report_2011_wwea.pdf. Consultado el 14 de agosto de 2013.

Weiss, W., Mauthner,F. (2011), Solar Heat Worldwide, Markets and Contribution to the Energy Supply 2009, Solar Heating and Cooling Programme, International Energy Agency, 58 páginas.Disponible en: http://www.cansia.ca/sites/default/files/sites/default/solar_heat_worldwide-2011.pdf. Consultado el 14 de agosto de 2013.

Weiss W. and Mauthner F., (2012), Solar HeatWorldwide – Markets and Contributions to the Energy Supply 2010, Solar Heating and Cooling Programme, International Energy Agency, 63 páginas. Disponible en: http://www.ecowrex.org/document/solar-heat-worldwide-2012-0. Consultado el 14 de agosto de 2013.

WNA (2013), World Nuclear Association, Nuclear Power in the United Arab Emirates. Disponible en: http://www.world-nuclear.org/info/Country-Profiles/Countries-T-Z/United-Arab-Emirates/#.UhP_i2CI7IU. Consultado el 20 de agosto de 2013.

WWF (2010),World Wild Fundation, Planeta vivo. Informe 2012. Biodiversidad, biocapacidad y propuestas de futuro, 164 páginas. Disponible en: http://awsassets.panda.org/downloads/informe_planeta_vivo_2012.pdf. Consultado el 14 de agosto de 2013.

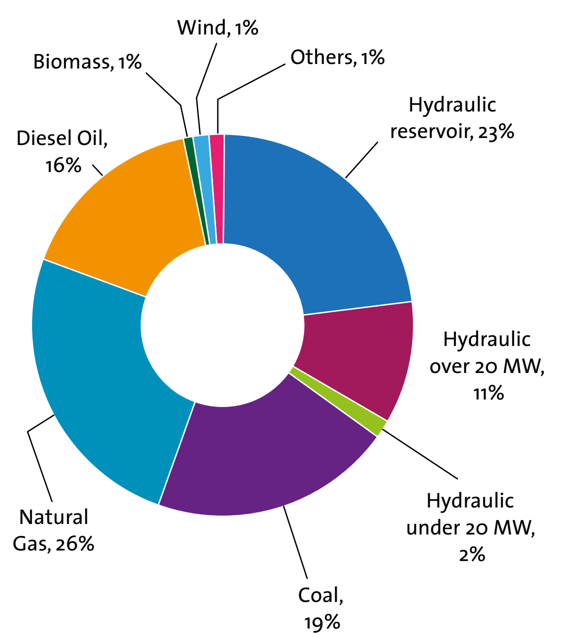
Box
Atacama: Another Bright Spot for Chile

Miguel Kiwi[1] | Chile

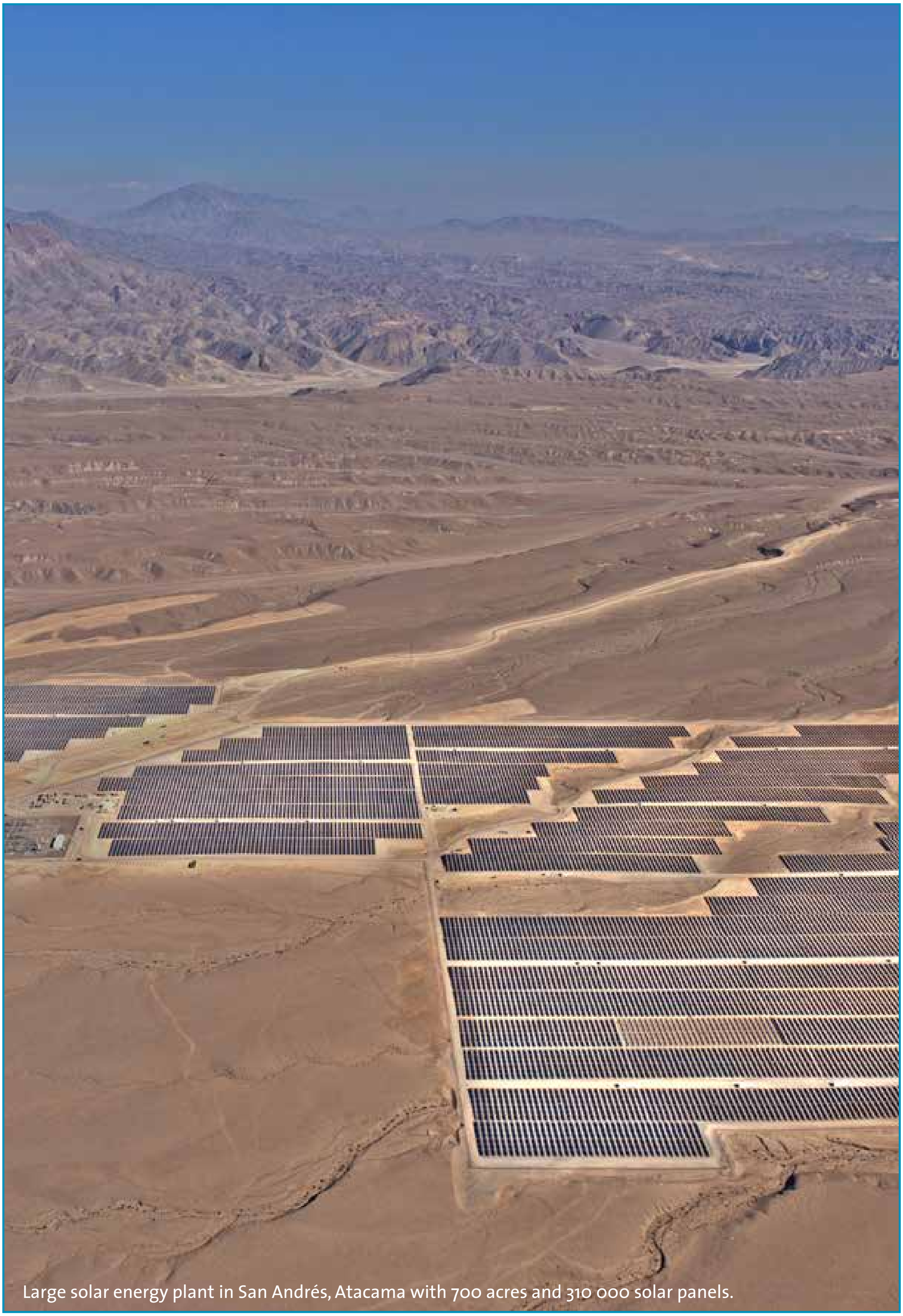
The fact that Chile needs to reinforce its energy supply, especially electric power, is a widely accepted fact. There are many studies on the subject matter and little disagreement on the basics. Chile needs, in the near future, to increase the electric power supply by approx. 7 GW. The problem arises because no state energy planning has been adopted during the last quarter of a century. In other words, and in spite of the accepted facts of life, energy policy has been left to suppliers (in other words, to free enterprise). This has had at least two major consequences: the building of several contaminating carbon plants, a strong public opposition to them, and also an opposition to the use of hydro-electricity on the basis of the large Patagonia rivers, which are located some 2000 km south of Santiago, and almost 4000 km from the mining industry, which is the major power consumer. This not only creates environmental problems in the Patagonia region, but requires the building of very long transmission lines, that are also opposed by environmentalists.

A bright light developed in Chile with the appointment of Minister for Energy, Mr. Máximo Pacheco, who in the past has been the CEO of major companies in Chile and abroad. He has started, what seems, a promising efforts to develop an energy policy based on the support of both public opinion, and of the large companies that urgently need a major amount of energy supply. I am quite optimistic that some progress will be achieved shortly. He also has mentioned his interest in the consumer efficiency improvement.

A bright spot in the scene was the inauguration, in 2014, of a large solar energy plant in the Atacama desert, on some 700 acres, where 310 000 solar panels will generate up to 100 MW. This alone represents 10% of the goal of achieving 1000 MW of renewable non conventional energy by 2018. This still leaves another 6 GW necessary to satisfy demand.



1. Dr. Miguel Kiwi got his Mechanical Engineering degree at the Technical University in Valparaiso, Chile and his PhD on Physics at the University of Virginia, USA. Dr Kiwi is Full Professor at the Pontificia Universidad Catolica de Chile, and Universidad de Chile. Wrote more than 120 ISI papers in condensed matter physics (mainly superconductivity, magnetism and Nano science) Dr. Kiwi is Fellow of the American Physical Society among some other recognitions.


Large solar energy plant in San Andrés, Atacama with 700 acres and 310 000 solar panels.

Box
Current Status and Prospects for Energy in Mexico

Jorge M. Islas Samperio[1] | Mexico

In 2014, Mexico, whose official name is the United Mexican States, had just over 119 million inhabitants (CONAPO, 2015) and was the world's 14th largest economy, with a GDP of $924.440 million 2007 USD (INEGI, 2015a). It is located in the northern hemisphere, in relation to the Equator, and in the Western Hemisphere in relation to the Greenwich Meridian. It borders with the United States of America (USA) in the north, Guatemala and Belize in the south, the Gulf of Mexico and the Caribbean Sea in the east and the Pacific Ocean and the Gulf of California in the west. It has a total area of 1,964,375 km², of which 1,959,248 km² are mainland and 5,127 km² insular and owns 3,149,920 km² of the Exclusive Economic Zone of patrimonial sea (INEGI, 2013), occupying 14th place worldwide. Mexico boasts a great variety of climates: arid in the north of the country, warm humid and sub-humid in the south and southeast and cold or temperate in the mountainous regions (INEGI, 2015b).

Current Status

In Mexico, as one can see from Figure 1, the domestic supply of primary energy (DSPE) is dominated by the use of fossil fuels (88.7%), mainly hydrocarbons (81%). Renewable energies account for less than 10% of this offer, with biofuels constituting the highest proportion (5.4%), especially traditional biomass, firewood and bagazo- and to a lesser extent, biogas, which has recently begun to be used. This is followed by hydropower, representing 2.1% of supply and lastly other renewables, which only provide 2.4% and consist mainly of geothermia and wind and solar power. A summary of the status of each energy source is given below, beginning with fossil fuels.

Petroleum: current total reserves in Mexico amount to 37.405 million barrels of oil equivalent (MMboe), of which 34.8% (13.017 MMboe) correspond to proven reserves, 26.6% (9,966 MMboe) to probable reserves and 38.6% (14,421 MMboe) to possible reserves (PEMEX, 2015). At the level of current production, 3,538 barrels of crude oil equivalent per day (Mboed), the ratio of proven reserves/production is low: barely 10.1 years (PEMEX, 2015). It should be noted that nearly half of Mexico oil production was exported in 2014 (SENER, 2015a), mainly to the US. It is also worth pointing out that, despite its significant oil production, Mexico imports up to 30% of the petroleum products it consumes, mainly gasoline used in the transport sector, where consumption has increased dramatically in recent years.

Natural Gas: Nationwide consumption of this fuel has rapidly increased in Mexico; however, current total reserves of this fuel stand at 43.713 billion cubic feet (Bcf), of which 26% (11,447 Bcf) are proven reserves, which, at the current production rate of 6,532 thousand cubic feet, would last for just 4.8 years. Probable reserves account for 28% (12,358 Bcf), and possible reserves for the remaining 46% (19.907) (PEMEX, 2015).

Coal: Mexico does not have large coal reserves, since it has 1.211 million tonnes (Mt) of which 860 Mt are mainly bituminous coal and 351 Mt mostly sub-bituminous coal (BP, 2015). A total of 15.2 Mt were

1. Instituto de Energías Renovables, Universidad Nacional Autónoma de México, Privada Xochicalco S/N, Colonia Centro, 62580 Temixco, Morelos.

produced in 2014 and at this rate of production, reserves/ production are high: 87 years. Approximately 83% of national production is assigned to power generation and the remainder to coke coal used primarily in the steel industry (Wallace, 2007). However, in 2014, given the increase in the use of coal in power generation and its relatively low production in Mexico, approximately 40% of the amount used nationwide was imported.

Renewable energies: the diversity of climates in Mexico give it a significant potential in terms of renewable resources (see Table 1). However, despite this level of renewable resources, the participation of these sources in domestic consumption of primary energy at the national level is still low (see Figure 1). In the case of electricity generation, the use of these energy sources is more important since it accounts for 25.1% of the current electricity capacity, particularly due to a significant installed hydroelectricity capacity, as shown in Figure 2.

In a context of diversifying the energy matrix, given the problems of declining oil reserves and climate change, in 2008, a legislative framework was created for the promotion and use of renewable energy (RE) and bioenergy. In this regard, the Law of Promotion and Development of Bioenergy Fuels (DOF, 2008a) was passed, which forced the Ministry of Energy to establish the Bioenergy Introduction Program. In fact, in 2012, a number of programs were established to introduce anhydrous alcohol as a gasoline oxygenate; however, they failed to be implemented because all the bids were declared void. A Proof of Concept Program was launched to promote the use of anhydrous ethanol at 5.8% (E6) on a small regional scale and in 2014, calls for tenders were issued for eight distribution terminals in the states of San Luis Potosí, Tamaulipas and Veracruz. This test is associated with the aim of producing and introducing ethanol over the next 10 years (SENER, 2015b).

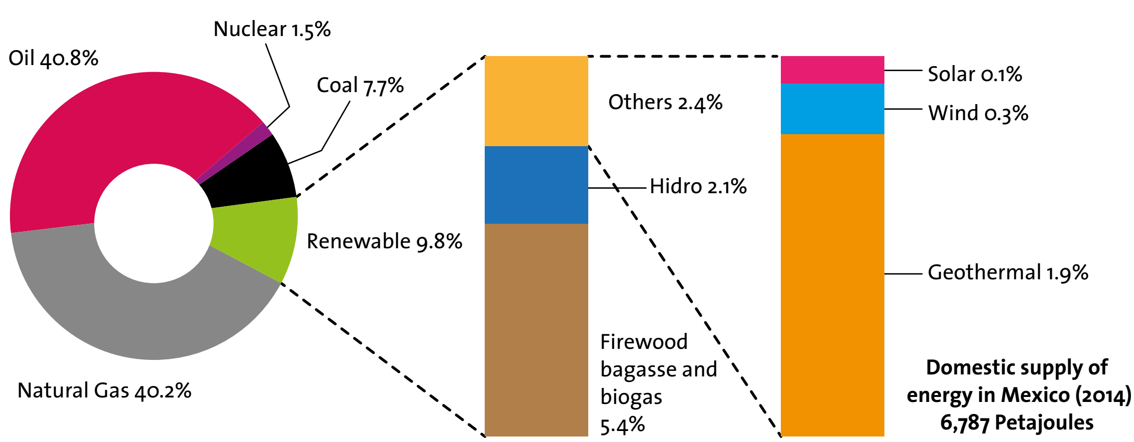
As regards RE legislation, in 2008, the Law on the Use of Renewable Energy and Energy Transition Financing (LUREETF) (DOF, 2008b) was passed, establishing a target of maximum participation of fossil fuels in

Table 1. Capacity of power stations based on RE in 2010 and national potential in Mexico

Generation technology	Total (MW)	National potential (MW)
Hydroelectric > 30 MW	11,126	49,750-52,600
Hydroelectric < 30 MW	344	
Geothermal	965	9,686-13,110
Wind power plants	425	44,350-70,00
Biomass	229*	9,183-13,472
Biogas	149	898-1,404
Solar	3.5	650,000 GWh
Total	13,241	

Source: Islas *et al.* (2015)

Figure 1. Domestic supply of primary energy in Mexico in 2014 by type of source



Source: Compiled by the author based on SENER (2015a).

power generation of 65% by 2024, 60% by 2030 and 50% by 2050. Moreover, the Act mandated SENER to establish the Special Renewable Energy Program (SREP 2014-2018) which established the goal for 2018 of generating 36.8% of electricity with RE and clean energies. In 2012, the General Law on Climate Change (GLCC) (DOF, 2012) was passed, which sets a goal of reducing greenhouse gases (GHG) emissions by 30% of the baseline by 2020, and halving them in relation to the emissions in 2000. Moreover, at COP21, Mexico recently established an unconditional target of reducing its emissions by 22% by 2030 and conditionally by 36% for that year within the Intended Nationally Determined Contributions (INDCs) (Gobierno de la República, 2015).

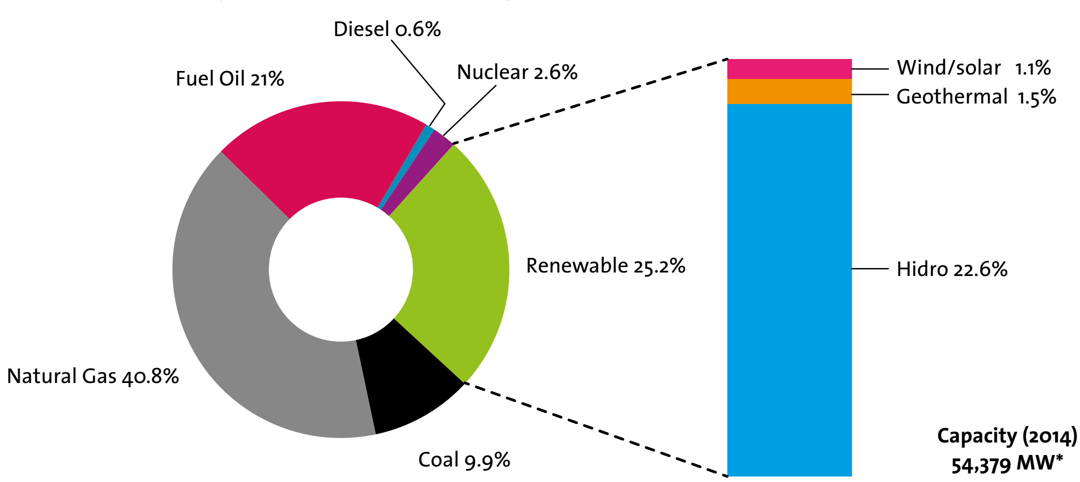
The Energy Transition Law (ETL) (DOF, 2015a) repealing the LUREETF was recently passed enacted, but takes up the target for 2024 of a 35% minimum share of clean energy (CE) in electricity generation, such as RE and others regarded as clean. However, it no longer incorporates the long-term goals of 2030 and 2050 contained in the now repealed LUREETF. Instead, it establishes short-term goals, namely a minimum share of 25% of clean energies by 2018 and of 30% by 2021.

Prospects

In Mexico, there is a new institutional framework derived from the energy sector reform in late 2013, which ended in late December 2015 with the enactment of the ETL. The proposed institutional changes create a new architecture for the organization of the Mexican energy sector in which the public monopoly model with limited openness to private investment, is replaced by a model of widespread openness in virtually all segments of the energy sector (Islas et al., 2015). In view of this new institutional framework, the new mechanisms included to promote clean energies such as renewable energies and others regarded as clean are as follows:

1. The creation of a market for clean energy certificates (CEL) that will permit RE and other efficient technologies such as efficient cogeneration to compete with each other to meet the goals at a lower cost in accordance with the enactment of the Electricity Industry Law (EIL) (DOF, 2014b) .
2. The establishment of calls for long-term auctions to supply power and energy and CEL to achieve the clean energy goals of the National Electricity System Development Program (NESDP) which mandates the EIL.
3. The creation of the Universal Electric Service Fund mandated by the EIL, designed to provide clean power to communities in marginalized rural and urban zones at the lowest cost. This fund will comprise resources from surplus revenue from the management of technical losses of the Wholesale Electricity Market and donations from third parties.

Figure 2. Participation by source of installed capacity in Mexico in 2014



*Excludes capacity for self-generation, importation and exportation. Source: Compiled by the author based on SENER, 2015a

4. The amendment to Article 77-A of the Income Tax Law (ITL) (DOF, 2015b), which allows companies exclusively dedicated to producing energy with RE and efficient co-generation to access dividends without paying taxes, except for the retention of 10% as final payment of income tax.
5. The incorporation of negative externalities into the costs associated with the operation and expansion of the electricity industry, once the method of calculation has been established by the Ministry of Energy (SENER) according to the LET, which will favor electric power generation with lower negative externalities.

On the other hand, the 2015-2029 Renewable Energy Prospects (SENER, 2015b), published in late 2015, which will be the last prospective ER mandated by LUREETF which was, as mentioned earlier, repealed by the new ETL, provides the latest official perspective on the development of RE in Mexico. For the period 2015-2029, this planning document considers an addition of 20,950 MW based on RE by 2029, of which 57.3% (11.952 MW) will be wind energy power stations, 26% (5,450 MW) hydroelectric power stations, 8.7% (1,822 MW) solar power stations (mainly photovoltaic) and 7.8% (1,618 MW) geothermal power stations, with the remaining 0.5% fueled by biomass (108 MW).

Of this total, and as regards power generation distributed with RE, the PEAER 2014-2028, the last program focusing specifically on RE by LUREETF mandate, which also provides the latest official perspective on the development of RE in Mexico, suggests that by 2028, up to 2,233 MW of generation distributed with RE could be achieved, of which 1,273 MW would be from photovoltaic solar energy, 402 MW from bioenergy, 395 MW from wind power, 150 MW from hydroelectric power stations under 30 MW, 57 MW from geothermal energy, and lastly, 1.1 MW fromconcentrated solar power.

Wind power plant in La Ventosa, Oaxaca.

Hydroelectric power station Sanalona, Sinaloa.

Biogas plant, El Ahogado, Jalisco.

Hydroelectric power station Chicoasén, Chiapas.

Lastly, a recently published study involving the participation of researchers from the UNAM Institute of Renewable Energy (Islas et al., 2015), proposes a transition scenario towards a Mexican low-carbon energy system, considering the large-scale use of renewable energy, energy saving measures and efficient use, while undertaking the technical, economic and greenhouse gas reduction evaluation by demand sector, namely, residential, commercial, public, transportation, engineering evaluation and the hydrocarbon and electric transformation sectors.

One of the most important results of this study is the cumulative reduction of 6.517 million tonnes of CO2 by the year 2035. The alternative scenario, based on the large-scale use of renewable energies, savings measures and efficient energy use, manages to meet the goals of the GLCC to reduce CO2 emissions by 2020. By 2030, this scenario will have reduced CO2 emissions by 52%, which is 34% higher than the unconditioned goals of the INDC recently proposed by Mexico and actually 22% higher than the conditioned contributions of INDC referred to. Lastly, 55% of electricity generation would also be achieved from RE in 2020, which exceeds the goal of clean energy of the ETL by 20%. Given these data, the study shows that expectations for the development of renewable energy are much greater than those established to date in the official planning documents of the Mexican energy sector.

Acknowledgements

Thanks are due for the technical support provided by Dr. Genice K. Large Acosta, an academic at the UNAM Institute of Renewable Energy, in the search for data and the production of the graphs that were extremely useful for the production of this document.

References

BP, British Petroleum (2015). Statistical Review of World Energy 2015. [On line] Available at: http://www.bp.com/en/global/corporate/energy-economics/statistical-review-of-world-energy.html [Last accessed January 15 2015].

CONAPO, Consejo Nacional de Población (2015). México en cifras. Proyecciones de la población 2010-2050. Mexico. [on line] Available at: http://www.conapo.gob.mx/es/CONAPO/Proyecciones [Last accessed January 12 2016].

DOF, Diario Oficial de la Federación (2008a). Ley de Promoción y Desarrollo de los Bioenergéticos. Published February 1 2008. HCU, Mexico [pdf] Available at: http://www.cddhcu.gob.mx/LeyesBiblio/pdf/LPDB.pdf [Last accessed December 21 2015].

DOF, Diario Oficial de la Federación (2008b). Ley para el Aprovechamiento de Energías Renovables y el Financiamiento de la Transición Energética. Published November 28 2008. HCU, Mexico [pdf] Available at: http://www.diputados.gob.mx/LeyesBiblio/pdf/LAERFTE.pdf [Last accessed December 22 2015].

DOF, Diario Oficial de la Federación (2012). Ley General de Cambio Climático. Published June 6 2012. HCU, México. [pdf] Available at: http://www.diputados.gob.mx/LeyesBiblio/pdf/LGCC_130515.pdf [Last accessed January 10 2016].

DOF, Diario Oficial de la Federación (2014a). Programa Especial del Aprovechamiento de Energías Renovables 2014-2028. Published April 28 2014. HCU, Mexico. [On line] Available at: http://www.dof.gob.mx/nota_detalle.php?codigo=5342501&fecha=28/04/2014 [Last accessed January 10 2016].

DOF, Diario Oficial de la Federación (2014b). Decreto por el que se expiden la Ley de la Industria Eléctrica, la Ley de Energía Geotérmica y se adicionan y reforman diversas disposiciones de la Ley de Aguas Nacionales. Published August 11 2014. HCU, México. [On line] Available at: http://dof.gob.mx/nota_detalle.php?codigo=5355986&fecha=11/08/2014 [Last accessed January 15 2015].

DOF, Diario Oficial de la Federación (2015a). Ley de Transición Energética. Published December 24 2015.

HCU, México. [On line] Available at: http://dof.gob.mx/nota_detalle.php?codigo=5421295&fecha=24/12/2015 [Last accessed January 10 2016].

DOF, Diario Oficial de la Federación (2015b). Decreto por el que se reforman, adicionan y derogan diversas disposiciones de la Ley del Impuesto sobre la Renta, de la Ley del Impuesto Especial sobre Producción y Servicios, del Código Fiscal de la Federación y de la Ley Federal de Presupuesto y Responsabilidad Hacendaria. Publicado el 18 de noviembre de 2015. HCU, Mexico. [On line] Available at : http://dof.gob.mx/nota_detalle.php?codigo=5415878&fecha=18/11/2015 [Last accessed January 15 2016].

Gobierno de la República, México, 2015. Compromisos de mitigación y adaptación ante el Cambio Climático para el periodo 2020-2030. SEMARNAT, Gobierno de la República. [pdf] Available at at: http://www.inecc.gob.mx/descargas/difusion/2015_mex_indc_presentacion.pdf [Last accessed December 22 2015].

INEGI, Instituto Nacional de Estadística y Geografía (2013). Conociendo a México. 3ª. Ed. INEGI, Mexico. 92 pp.

INEGI, Instituto Nacional de Estadística y Geografía (2015a). Banco de Información Económica. México. [On line] Available at: http://www.inegi.org.mx/sistemas/bie/ [Last accessed January 12 2016].

INEGI, Instituto Nacional de Estadística y Geografía (2015b). Recursos Naturales. Climatología. México. [On line] Available at: http://www.inegi.org.mx/geo/contenidos/recnat/clima/default.aspx [Last accessed January 14 2016]. INEGI, 2015.

Islas, J., Manzini, F., Macías, P., Grande, G. (2015). Hacia un Sistema Energético Mexicano Bajo en Carbono. 1ª. Ed. Mexico. 224 pp.

PEMEX, Petróleos Mexicanos (2015). Memoria de Labores 2014. PEMEX, Mexico. [pdf] Available at: http://www.pemex.com/acerca/informes_publicaciones/Documents/memorias/completas/Memoria_de_Labores_2014.pdf [Last accessed January 15 2016].

SENER, Secretaría de Energía (2015a). Balance Nacional de Energía 2014. SENER, México. [pdf] Available at: http://www.gob.mx/cms/uploads/attachment/file/44353/Balance_Nacional_de_Energ_a_2014.pdf [Last accessed January 8 2016].

SENER, Secretaría de Energía (2015b). Prospectiva de Energías Renovables 2015-2029. SENER, México. [pdf] Available at: http://www.gob.mx/cms/uploads/attachment/file/44324/Prospectiva_Energ_as_Renovables_2015_-_2029_VF_22.12.15.pdf [Last accessed January 14 2016].

Wallace, R.B. (2007). El carbón en México. Rev. Economía Informa (259), pp. 138-160.

Box
Research and development in the energy sector in Argentina

Miguel Laborde and Roberto Williams[1] | Argentina

Main research & development activities in the energy sector follow strategic plans defined by the following institutions: a) Ministry of Science, Technology and Innovation (MINCyT), b) Secretary of Energy, c) Y-TEC: association between YPF (51%) and the National Research Council (CONICET, 49 %), d) National Atomic Energy Commission (CNEA). Only Energy Programs linked with those defined by IANAS are described in what follows.

1. Roberto JJ Williams holds a PhD in chemistry, with a specialization in chemical technology (National University of La Plata). He is a tenured professor of the National University of Mar del Plata and CONICET senior researcher at the Institute for Research in Science and Materials Technology (INTEMA). He is an expert on polymeric materials (with over 220 publications and 2 books). He is a full member of the National Academy of Exact, Physical and Natural Sciences and a corresponding member of the Academy of Engineering. He has received a number of distinctions such as the Konex Platinum Award (1993), the Bunge y Born Prize (2007), the Bernardo Houssay Lifetime Achievement Award (2011) and the Researcher of the Nation Distinction (2011).

Miguel Angel Laborde holds a PhD in chemistry, with a specialization in chemical technology (National University of La Plata), Tenured professor at the University of Buenos Aires and CONICET principal investigator at the Institute of Hydrogen Technologies and Sustainable Energy. He is an expert on renewable energy, particularly hydrogen production and purification. (80 publications and 5 books). He is a full member of the National Academy of Exact, Physical and Natural Sciences and currently vice president of CONICET Technological Affairs. He received the Interscience-HydroQuebec Award in the Energy Category and the Hydrogen Ambassadors Contest Prize. Hannover Fair, Germany

1. Ministry os Science, Technology and Innovation (MINCYT)

The Ministry of Science, Technology and Innovation of Argentina has launched a national plan for the sector up to 2020. The following strategic areas were identified:

1. Solar energy

Use of solar energy for the heating of fluids in the following thermal ranges: low (60 – 100 °C), medium (100-150 °C) and high (150-350 °C). The availability of fluids heated to low or medium ranges would enable the substitution of natural gas in commercial sectors and residential areas. The following specific projects are being carried out:

- National assessment of solar energy: Design and implementation of an Argentine evaluation system of solar radiation, with stations across the country interconnected in real time.
- Development and construction of a thermoelectric prototype plant (Dish-Stirling technology) connected to the network of the Argentine Interconnection System (SADI). This project is placed in the Province of Catamarca (Thermoelectric solar park of Intihuasi).

2. New Sources of Bioenergy

The aim is to develop processes to produce 2nd generation biofuels or biogas, using crops that are useless for human feeding or using industrial byproducts or wastes. The following specific projects are being carried out:

- Start-up of a plant that generates electricity and heat from biomass, provided with a purification stage for the biogas resulting from the process and, development a 10 MW power plant from forest biomass ("Salicaceae" sown).
- Installation of a multipurpose biodiesel plant able to generate high value-added products using sunflower feedstock.

3. Distributed Generation of Electricity (Smart Networks)

The following specific projects were defined:

- Development of smart networks for the transmission and distribution of electricity, with interconnection with renewable energy sources.
- Improving the efficiency of existing electrical networks.

4. Rational Use of Energy

Developments of systems, equipment and materials enabling the reduction of energy consumption in buildings and industrial processes.

2. Secretary of Energy

Two recent laws promote the use of biofuels (No. 26093) and hydrogen (No. 26123), with the Department of Energy as the application authority. While biodiesels are already in the market, hydrogen is not. The Department of Energy has recently released the National Plan for Hydrogen, written and reviewed by national expert and structured around the Promotion Fund of Hydrogen (FONHIDRO). R & D programs based on about 200 researchers and PhD students should enable to insert hydrogen in the market (including PEM and SOF fuel cells), within a period of 20 years. Argentine industry has also large experience in the use of hydrogen as a feedstock for petrochemicals (ammonia and methanol) as well as for the oil, steel and glass industries.

3. Y-TEC

Y-TEC has created a Department of Renewable Energy that is implementing the following projects:

Small-scale (kW) electrical power storage through the development of lithium batteries, including the lithium extraction and purification from lithium salts (with large availability in Argentina).

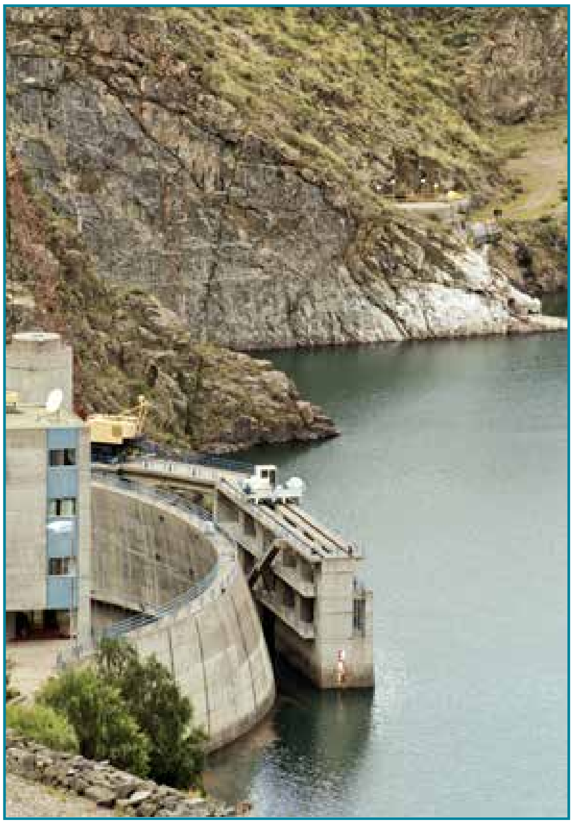
Large-scale (MW) electrical power storage through the development of energy flow batteries. These are rechargeable batteries in which the electrolyte flows through the electrochemical cell and converts chemical energy into electricity.

Production of hydrogen from water: a) from modulated electrical pulses (PWM), and b) using photocatalysts and solar energy.

Y-Tec is also developing projects for the use of geothermal energy and ocean energy.

4. Comisión Nacional de Energía Atómica

National Atomic Energy Comission (CNEA) is mainly focused on nuclear energy but has R&D activities on photovoltaic panels, fuel cells (PEM) and hydrogen storage and purification.



Hydroelectric power station Los Reyunos, Mendoza, Argentina.

Box

The Cuban Experience: Using Renewable Energy Sources of Energy to Improve the Quality of Life in accessible Rural Areas

Luís Berriz[1] | Cuba

The nonprofit NGO CUBASOLAR, established in November 1994, now comprises over 800 members organized in provincial delegations throughout the country. It seeks to promote the use of renewable energy sources to replace non-renewable, polluting sources, savings, energy efficiency and environmental protection, with an emphasis on education. It encourages the organization of events, seminars and other ongoing training courses for both professionals and non-professionals, in coordination with the Technical University of Renewable Energy (UTER). CUBASOLAR also makes a special effort to develop mountain universities and leveraging their scientific potential to disseminate appropriate knowledge to all the regions of the country, however inaccessible.

Another of its main tasks is to introduce the use and knowledge of all forms of renewable energy sources at junior high schools in the national education system for training purposes, with the participation of students and teachers, focusing on Pedagogical Institutes, Pre-university Science Institutes, and technological and polytechnic institutes.

Special attention is paid to the publication of books and other materials that contribute to promoting the use of renewable energy sources, as well as relevant specialized books.

Cuba's social development after the triumph of the revolution has led to the almost total electrification of the country, exceeding 96% nationwide. However, there are still rural areas, mainly inaccessible ones in the hills and mountains, that have no electricity. Development plans have considered the establishment of schools, health clinics and social circles even in the most isolated areas far away from the national grid.

Undertaking demonstration projects that provide energy solutions with a positive impact on improving the quality of life, the environment and local or territorial sustainable development is one of the areas of CUBASOLAR's work that has contributed to raising environmental awareness in the various sectors of Cuban society linked to national and territorial development programs and strategies. A list of some of the most significant actions undertaken is given below:

- The Photovoltaic Solar Electrification Program has been undertaken at family doctors' clinics, located in inaccessible mountainous areas. This project provides clinics and housing with lighting, refrigeration, television, radio-recorders, electromedical equipment and radio communication. To date, 491 home-clinics have been electrified.
- CUBASOLAR collaborated with the formation of brigades for the electrification of 2364 rural schools in the Audiovisual Program funded by the Cuban state, with 4728 installations for lighting, television, video and computer use.
- Four mountain boarding schools have been electrified with photovoltaic systems.
- The audiovisual program also contributed to the electrification of 1864 television and video rooms with solar panels for the enjoyment of the rural population in remote, inaccessible areas.
- 93 mountain social circles have been electrified with solar energy.

1. Luis Berriz is a Professor at the Center for Studies of Renewable Energy Technologies. Vicepresident of the World Wind Energy Association, WWEA and member of the Board member of the Latin American Wind Energy Association and Board of the Cuban Associatiaon for the Promotion of Renewable Energies or in Spanish Junta Directiva de la Sociedad Cubana para la Promoción de las Energías Renovables CUBASOLAR.

- Various social and economic targets in inaccessible areas outside the scope of the national grid, mainly mountain hospitals, have also been electrified.
- In 1999, the Demonstration Wind Farm on Turiguanó Island was completed, with two 225 kW turbines each (total: 450 kW). This facility has been connected to the National Electric System for 16 years and serves as a Wind Energy Training Center.
- Efforts have focused on the installation or rehabilitation of mini, micro and small hydroelectric plants to contribute to electricity generation and water supply by gravity, with positive results for food production and social welfare. The hydroelectric plant in Guaso, Guantánamo was also reconstructed.
- Construction and installation of 1, 093 efficient cook stoves and 201 biomass ovens for schools. (Photo 12)
- Efforts have focused on the drinking water supply in remote communities, using photovoltaic solar systems, with 27 solar pumps having been installed in inaccessible areas.
- A National Program was established for the photovoltaic electrification of farm workers' dwellings in isolated areas, in compliance with the guidelines of our Revolution to electrify all Cuban homes, regardless of where they are located. To date, over 500 farm workers' houses have been electrified.
- Emphasis has been placed on territorial solarization projects, conceived as the integral development of a territory or municipality, based on solar energy. The latter is understood as energy based on the use of renewable energy sources, energy efficiency and energy and resource saving, in harmony with nature, and therefore covers the use of eolic or wind, hydraulic or water, biochemistry or biomass, thermal solar, photovoltaic solar, photochemical solar, marine or ocean and sea, and light energy.
- Construction of more than 100 biogas digesters at schools, farm workers' homes, tourist facilities and particularly factories and highly polluting places.

From these examples, it is clear that CUBASOLAR has been the country's main promoter of rural electrification in inaccessible areas through demonstration projects and local development ventures in which business and state and community participation have combined to improve the quality of life in the country's most remote areas. For over twenty years, CUBASOLAR has been at the forefront of an environmental movement based on energy efficiency and environmental protection. This earned it a place among the Global 500 recognized by UNEP as leading institutions worldwide in the efforts to achieve sustainable development.


Home solar panel, Cuba.

Chapter 4

Women, energy and water

The effects of gender and culture on the roles and responsibilities of women

Katherine Vammen | Nicaragua
Frances Henry | Canada
Nicole Bernex | Peru
Patricia Taboada Serrano | Bolivia
Mario Jiménez | Nicaragua
Gustavo Sequiera | Nicaragua
Tomás Bazán | Panama

Summary

This chapter on Women, Energy and Water focuses on women and their capacity to access, use and control water and energy resources.

It also explains how water and energy are two resources that are interlinked and should be managed on the basis of the synergies that benefit both in achieving a sustainable energy future and watershed management.

The crucial role of environmental management is seen in case studies in developing countries in Latin America and special emphasis has been placed on the role of rural women in the production and use of energy.

The health aspects of the incorrect use of energy sources such as charcoal and firewood for cooking on a global scale have been reviewed. This leads to a broad analysis of how energy availability is one of the main limitations on social and economic development and the importance of involving women in future management and planning for improving energy planning.

1. Introduction

This chapter is about the relationship of gender, and specifically women, and their ability to access, use and control the water and energy resources available to them in their countries. The emphasis will, of course, focus on the Americas but especially on the countries of Central and South America including the Caribbean. We hope to demonstrate that women, particularly those in developing countries and those who are described as 'underserved' with respect to energy and water are, in many instances, the primary users of these resources yet they have little control over their management or their development. It will also be shown that the heavy burdens imposed on women to manage, and in some instances even find these resources, severely limits their ability to access education and generally to improve their lives and that of their families. The "Women for Science" advisory report of the Inter Academy Council (2006) which is being implemented in the Americas by the IANAS Women for Science program, deems engagement and empowerment of these underserved women in development projects to be of the essence.

Most of the contemporary globalized world concentrates on increasing the supplies of energy in the form of oil and gas; and much of modern geopolitics is based largely on where these energy sources are found. Witness the importance of Middle Eastern oil producing states and emirates; the close attention paid to populist led countries such as Venezuela and most recently the Russian military incursions into the oil producing region of the Crimea. Even in North America, the political battles over oil carrying pipelines has influenced important decision making. Moreover, enormous financial resources are also expended on experimentation with alternate sources of energy including nuclear, wind, solar and others. This intense concentration on maintaining, finding and exploiting sources of traditional and modern scientific energy largely overlooks the fact that many millions of people, primarily women, live in circumstances off the electrical grid where even older sources of energy such as wood, and various forms of biomass are used primarily for domestic purposes. (Taboada-Serrano, 2011)

With respect to water, most of the world's 1.2 billion poor people lack access to safe and reliable water, two thirds of whom are women. Diversion of water for industry, agriculture, and power generation reduces the availability of water for domestic use, making it even more difficult for the poor to access water. Worldwide, over 2.6 billion people still lack access to flush toilets or other forms of improved sanitation and difficulties with access to usage of water often lead to health problems primarily affecting women. Lack of water or unsafe water generates a very large range of water-borne, water-based, water-related, water-washed and water-dispersed diseases. In most cultures, women and men have different roles and responsibilities in the use and management of water. Women use water for production, consumption and domestic purposes, including cooking, cleaning, health and hygiene, and, if they have access to land, also for growing food. In rural areas, women and girls walk long distances to fetch water, often spending 4 to 5 hours a day carrying heavy containers and waiting in lines. The burden of fetching water (and firewood) inhibits their access to education, income generation, cultural and political involvement, and rest and recreation. (UNCTAD, 2011; BOTH ENDS, 2006).

Before presenting a more detailed discussion of women and their role in the use of energy/water, this chapter will begin with a brief discussion of terminology and the important role of culture in shaping and even determining the roles of men and women in human societies.

Women washing clothes in the lake shore Atitlán, Guatemala

We will then move onto a more comprehensive analysis of how water and energy resources impact the lives of women.

- beginning with a discussion of the relationship or nexus between water and energy;
- followed by an in-depth case study of Peru and the Andes region.
- a case study of innovative programs for rural women and energy production
- a specific case study on the effects of the use of firewood on women's health.
- and finally, the crucial importance of 'how and why' women must be included in development and planning initiatives undertaken in many areas of the world.
- A general conclusion.

a. Culture and Gender

There are many definitions of culture but a fairly comprehensive one states that "Culture… is… the whole complex of distinctive spiritual, material, intellectual and emotional features that characterize a society or a social group. It includes not only arts and letters, but also modes of life, the fundamental rights of the human being, value systems, traditions and beliefs." (World Conference on Cultural Politics, 1982) Gender, originally a linguistic term categorizing masculine, feminine and neuter, became used by anthropology to refer to the social roles of men and women in society. Although traditionally it was traditionally assumed that the roles of men and women were naturally or even biologically determined by one's sex, anthropological cross-cultural studies established that while sex, male or female,[1] is a natural condition of the human species, gender roles vary across human societies. Thus, the attributes of men and women, the behaviors and relations appropriate to each other and their overall approach to life and living are largely determined by the cultural history and patterning of the many societies inhabiting this world. Gender is one of the most essential dimensions of human life because it influences not only daily life as lived in families but also the wider community, and indeed the wider world of which it is part. Gender is thus a fundamental organizing principle of human societies which goes far beyond the biological differences between men and women.

b. Importance

In studying the culturally defined ways in which gender functions in society, we are therefore exploring the many roles of both men and women. Traditionally, women's domestic and reproductive roles as wives and mothers have been the focus of most attention but even the ways in which these roles are culturally defined varies considerably from group to group. Of critical importance in many societies is the division of labor between the sexes. In most societies, women's and men's work are differentiated by cultural patterns and explanations. In many developing and modern societies, changes in these roles have been at the forefront of social and cultural transformation. Consider, for example, how the traditional roles of women have changed from domestic and agricultural responsibilities to wage labor in increasingly industrialized areas of the world. Their relationship to energy and water have changed and in fact in some areas where women do both types of labor, their needs have become greater.

In order to understand the relationship between energy, water and women's roles in modern and traditional societies, we will first explore the complex relationship between energy and water.

2. The Link between Energy and Water

a. Introduction

Energy and water are linked in two primary ways. Water is used in the production of almost all types of energy, and energy is necessary to assure the supply and provision of water as well as wastewater treatment. The availability of water has an impact on the quantity of energy supply while the generation of energy affects the availability and quality of water.

The use of water for energy is becoming a global challenge. As the world economy grows at a faster pace, the demand for water will increase and will

1. We wish to acknowledge and recognize the roles of transgendered people in some countries today. For the purposes of this chapter, however, we focus on the more traditional male and female roles.

accelerate more rapidly than population growth. In some parts of the world, water is continuously underpriced or simply extracted without payment and there is constant wastage and overuse of the resource without plans for improving efficiency. Groundwater is being pumped without goals for its sustainability. This will obviously affect the water needs of the future and would also mean that there will not be sufficient water to serve all needed economic operations if it continuing in the same inefficient manner. It is always good to remember that, as opposed to energy, water has no substitutes or alternative ways to produce the resource with the same quality. Water is also a very important link between humans, their environment and most all components of the economic system. (World Economic Forum, 2011). Water security has been and in many cases is becoming in many cases the central political issue in regional and global conflicts. With increasing climate change, the impacts of drought conditions could be more severe, also affecting the management of the two way link and interdependence between energy and water.

The world's water and energy resources are already proving to be critical due to seasonal change caused by climate change and this will increase considerably as populations and consumption grow as a result of the expansion of economies. To maintain a prosperous, growing economy and increasingly rapid urbanization of world populations, it is obvious that more energy and water resources will be needed to meet increasing needs.

Global statistics show that freshwater extraction worldwide has grown faster than the increase in global population. This would definitely mean that by 2030 with a rising global population, growing consumption and an acceleration of the economy, water extraction will accelerate even more. (World Economic Forum, 2011; McKinsey and Co., 2009). There is a recent prognosis that globally a 40% deficit between water demand and availability could be observed in 2030 and "more than 40% of the global population is projected to be living in areas of severe water stress through 2050" (UN World Water Development Report, 2014a). As demand grows, competition for water will intensify between economic sectors and of course more conflicts will occur.

"Rising pressure on resources calls for new production and consumption models. We need to better understand the connections between water and energy, because choices made in one area impact – positively or negatively – the other." (Irina Bokova, Director-General of UNESCO in UN World Water Development Report, 2014).

This interdependence also has a poverty and developmental dimension as the developing world still has the same groups of the population without water or energy. Challenges are different in industrialized countries and the developing world, therefore trade-offs in the management of different options of water and energy synergies need to be analyzed and introduced to bring negative impacts under control. "Water and energy have crucial impacts on poverty alleviation both directly, as a number of the Millennium Development Goals depend on major improvements in access to water, sanitation, power and energy sources, and indirectly, as water and energy can be binding constraints on economic growth – the ultimate hope for widespread poverty reduction". (UN World Water Development Report, 2014a).

b. Water for Energy

Energy production relies on water to function. It is well known that there is currently a strong increase in the demand for energy. The International Energy Agency predicts that the world economy will need at least 40% more energy by 2030 compared to today (World Economic Forum, 2011) and this of course implies higher rates of water use for production of energy.

Demand for water in energy production is expected to increase sharply as regional economies grow from 2000 to 2030 (56% in LA, 63% in West Asia, 65% in Africa, 78% in Asia. (World Economic Forum, 2011). The question is how to achieve this balance when already 70% of water is already allocated to agriculture.

Today, water use for energy production has been estimated at 8% of freshwater extraction globally and up to 40% in some developed countries.

The use of water in energy production passes through three operational phases: 1) the production of raw materials used in the generation of energy, 2) the process of transformation of raw materials into energy and 3) the delivery of energy for consumption. (U.S. Department of Energy, 2007).

As far as the water used to produce *natural gas and liquid* is concerned, some examples of water consumption for some examples in the production of raw materials and transformation to energy are given below:

1. In **enhanced oil recovery techniques and oil sands** large amounts of water are needed for raw material mining. In the case of oil sands, steam is used to separate the oil from the surrounding clay and sand and therefore high quality water sources are needed to produce the steam. In the case of traditional oil and gas resources, minimal quantities of water are used for producing raw materials and water is produced along with the release of oil and gas. In the case of oil reservoirs the water is re-injected to reinforce oil recovery. Uncertainties persist over the potential risks to water quality, human health and long-term environmental sustainability from the development of unconventional sources of gas ('fracking') and oil ('tar sands'), both of which require large quantities of water. (World Economic Forum, 2011). Recent results of paleolimnological studies from the Paleoecological and Environmental Assessment and Research Laboratory at Queens University in 50 lakes in areas of oil sand mining in Alberta, Canada have shown definite evidence of impacts on water quality observed in lake sediment cores where higher concentrations of polycyclic aromatic hydrocarbons appear corresponding to the time of initiation of oil sand mining; Obviously in comparison to control lake cores in areas not being used for oil sand mining (Kurek et al, 2013).
2. **Petroleum** refining uses large amounts of water for the cooling process and additionally contaminates water with oil, suspended solids, ammonia, sulfides and chromium which is in many cases is treated at on-site wastewater treatment plants.
3. The production of **gas by "fracking"** uses water to fracture the surrounding formations which release gas into the well. But the water needed for the transformation of gas for domestic consumption is minimal.
4. Water use intensity for the production of raw material for **biofuel** is of course different depending on the crop and whether the crop is irrigated or not. For example, grain and oil seed crops are much more water intensive than petroleum. Sugar cane depends on whether or not it is irrigated. There are many water pollution issues caused by biofuel production due to fertilizer application which brings nutrients through run off to surface water bodies, causing water eutrophication, which induces algae blooms and anoxic conditions in water. The transformation of raw material to biofuel consumes much less water than the production of raw material.

   "As biofuels also require water for their processing stages, the water requirements of biofuels produced from irrigated crops can be much larger than for fossil fuels. Energy subsidies allowing farmers to pump aquifers at unsustainable rates of extraction have led to the depletion of groundwater reserves." (UN World Water Development Report, 2014a).

The water needed for **coal mining** is not considerable but the main issue is the impact on water quality. Acidic water produced in the mine drainage and piles of waste dissolves metals from rock and soil which bring such metals as lead, zinc, copper, arsenic and selenium into the water and eventually passes from the drainage system to the surrounding watershed tributaries. The water intensity needed to transform coal to liquids is considerable and is used for water to cool process streams but depends on the technical design of the plant. The delivery of these natural gas and liquid fuels does not involve water consumption.

Water use in the direct production of electricity is concentrated in the transformation phase mainly for the cooling of **thermal electric generation plants** where two types of systems are being used, closed loop and open loop. Open loop cooling withdraws water in large quantities and returns a high percentage to the source but at a higher temperature, which causes environmental damage to aquatic life in the water bodies used as a source. Closed loop systems withdraw less water but in reality consume more water since it is all lost to evaporation. (Kelic, 2009). The use of dry cooling without water is an advantage but the process is not as efficient as when water is involved. Seventy eight percent of the world's electricity generation is thermoelectric which means coal, natural gas, oil and nuclear as an energy resource; most require cooling and as mentioned earlier, water is the most common means of achieving this. In energy generation 80 to 90% of the water consumed is for cooling. (World Economic Forum, 2011) It is important to mention that combined-gas turbines reduce water use by half using the least water per unit of power produced. But there is concern in some countries that they create a dependence on gas imports and prices. (U.S. Department of Energy, 2007). More initiatives for the replacement of cooling systems with new technology designed to achieve water efficiency and economical generation of power are definitely needed considering the large percentage of electricity generation in thermoelectric.

Nuclear energy needs very high amounts of water in both uranium mining and in the process to prepare the uranium as a usable fuel for energy production. Nuclear is the energy form which uses the highest amount of water per unit of power produced. The problems of water pollution are similar to those in coal mining.

Renewable energy forms such as hydroelectricity, wind, geothermal and solar require little water for raw material production. Even better is the fact that wind and solar energy use almost no water in the production stage of power except for equipment washing activities. But in the conversion of raw material to usable energy for consumers, concentrated solar energy forms are usually water intensive.

"From a water perspective, solar photovoltaic and wind are clearly the most sustainable sources for power generation. However, in most cases, the intermittent service provided by solar photovoltaic and wind needs to be compensated for by other sources of power which, with the exception of geothermal, do require water to maintain load balances" (UN World Water Development Report, 2014a).

It is well known that investments and economic subsidies for the development of renewable energy, are below those that for the use of fossil fuels. These investments for research and economic support in setting up new systems "will need to increase dramatically before it makes a significant change in the global energy mix" and therefore reduces water demand in the water energy interdependence.

Moreover, geothermal energy in power generation is underdeveloped and has potential. "It is climate independent and has the advantage that it produces minimal or near-zero greenhouse gas. (UNESCO, 2014).

Hydroelectric power which contributes 20% to the world electricity generation is a special case as the loss of water is due to evaporation. It is well known that there is a higher water evaporation rate from reservoirs than from naturally flowing river systems due to a higher surface area exposed to evaporation. It is important to note that Latin America and the Caribbean have the second largest hydropower potential of all the regions in the world – about 20% (of which almost 40% is in Brazil). There has been a massive expansion of hydroelectric projects to the point where hydropower supplies 65% of total electricity in Brazil, Colombia, Costa Rica, Paraguay and Peru and even more in Venezuela. In comparison, the world percentage of total electricity is 16% (IEA, 2012b; OLADE, 2013). Climate change will undoubtedly reduce the continuity and reliability of this energy supply in the future.

c. Energy for Water

About 7% of commercial energy production is used globally for managing the world's freshwater supply. Specifically, energy is needed to provide water supply and to treat wastewater systems after the water has been used and it requires recicling. Specifically energy is required for water extraction, purification and distribution, which represents 80% of costs for municipal water processing and distribution in the USA. (EPRI, 2000).

The amount of energy used to secure drinking water depends on the water source. Due to the costs of pumping, groundwater requires more energy than surface water. But the advantage of groundwater is that it is usually of good quality which needs little for treatment. Water pumping over long distances requires more energy.

Desalinization is highly energy consumptive in providing drinking water. The consumed energy depends on the water quality; of course generating drinking water from seawater requires more energy than it would do from brackish groundwater.

Table 1. Summary of Water Consumption related to Energy Form

Energy Form	Specific Form	Consumption + Form of use	Impact on water
Production of Raw Materials, Mining			
Natural gas and liquid	Oil	Large amounts in form of steam separating oil from soil	Proven impact on water quality by paleolimnological studies
	Trasitional oil and gas	Minimal amounts, sometimes water is generated in release of raw material	Impact on water quality
	Fracking for gas production	Large amounts in drilling and fracturing horizontal shale gas	Impact on water quality
Biofuel		Amount of water used dependent on type of crop if irrigated or not	
	Oil Seed or Grains	Large amounts under irrigation	Can cause depletion of groundwater; Eutrophication of surface waters
	Sugarcane	If irrigated large amounts	Can cause depletion of groundwater; Eutrophication of surface waters
Coal		Not considerable	Impact on water quality through acidic water dissolving metals into surround watersheds
Nuclear		Large amounts used	Impact on water quality similar to above
Renewable Energy Forms			
Hydroelectric		Little or no water	
Wind		Little or no water	
Geothermal		Little or no water	
Solar		Little or no water	
Refining of raw materials			
Petroleum		Large amounts in cooling process	Water pollution, sometimes in the local treatment plants
Biofuel		Less water than production of raw materials	Less water than production of raw materials
Process of transformation of raw materials into energy			
Thermal electric generation plants (coal, natural gas, oil and nuclear)	Open loop cooling system	Withdraws large amounts but returns at higher temperature	Environmental damage to aquatic life in water bodies
Generation plants (coal, natural gas, oil and nuclear)	Closed loop cooling system	Withdraws less water but consumes more as lost to evaporation	
Thermal electric generation plants (coal, natural gas, oil and nuclear)	Dry cooling, disadvantage less efficient	No withdraw but actual technology less efficient	
Thermal electric generation plants (coal, natural gas, oil and nuclear)	Combined - cycle gas	Less water for energy unit but dependence on gas imports and prices	
Nuclear		Large amounts in transformation of uranium as usable fuel; Highest amounts of water per unit of power produced	
Renewable Energy Forms			
Hydroelectric		Almost no water except for equipment washing activities	
Wind		Almost no water except for equipment washing activities	
Geothermal		Almost no water except for equipment washing activities	
Solar		Almost no water except for equipment washing activities	

Disposal of the left over brine is a problem that which affects the receiving water body.

Although in Latin America and the Caribbean there has been progress in the provision of water and sanitation services (94% of population has access to improved water sources and 82% to improved sanitation) (WHO/UNICEF, 2013), growing energy costs pose challenges for the water industry which is often the highest operational cost (30 to 40%) for water supply services. (Rosas, 2011) This has multiple causes from designs with failure of attention to energy efficiency, loss of water in distribution system, insufficient coverage of domestic metering, expansion of waste water treatment and heavy reliance on groundwater with higher pumping costs associated with declining levels in aquifers.

d. Energy Production limited by drought and competing users

In the last decade we have seen an increase in the occurrence of droughts and local water scarcities have increased, meaning that the lack of water has interrupted power generation, causing serious economic consequences while on the other hand limitations on energy have constrained water services. The global situation is marked by the fact that available surface water supplies have not increased in 20 years and groundwater tables and supplies are dropping at an alarming rate. The impact of climate change will reduce available freshwater supplies even more. Past drought events have led to the shutting down of generating plants or the reduction of operation when water levels become too low for cooling water withdrawal or if the temperature of cooling water discharge exceeds permitted limits. There are many examples of drought causing low water levels accompanied by demand from other uses such as irrigation (Colombia Basin News, 2006) which have limited the ability of power plants to generate power.

Changes in rain patterns in the hydrological cycle and their effect on river flows which have affected the operation of reservoirs and hydroelectric plants are one of the biggest concerns of the energy industry. In 2001, the drought in Northwestern USA reduced hydroelectric power production which led to the loss of thousands of jobs in the energy intensive aluminum industry due to its high use of energy (Washington State Hazard Mitigation Plan, 2004).

As pointed out in the United Nations World Water Development Report 2014-Water and Energy "droughts are threatening the hydropower capacity of many countries; and several reports conclude that low water availability could be a constraint for the expansion of the power sector in many emerging economies, especially in Asia". (IEA, 2012a; Bloomberg, 2013)." This points to the need to address extreme climate events through the management of floods and droughts for energy and water security, which should include storage for both energy and water.

e. Conclusions. Goal of Energy and Water Program of IANAS

In dealing with the interdependence of water and energy, it is essential to realize that the link on both sides is different; energy has alternative forms for its generation but water has no substitutes. (Clausen, 2013) It is a crucial connector between humans, our environment and all aspects of our economic system.

As we have seen in this synthesis of the two way link between water and energy, the use of water in the different forms of energy generation limits its production. Most renewable energy forms in most phases of its production use much less water and in some instances do not need water. It has also been emphasized that some forms of energy production such as mining, fracking and cooling, pollute water sources.

It is notable that policies or economic policies favoring one of the domains can mean "increased risks and detrimental effects in another, but they can also generate co-benefits" (UN World Water Development Report, 2014a). It is often necessary to analyze and introduce different trade-offs in order to receive benefits for multiple sectors such as water, energy, agriculture, needs of the population, healthy ecosystems that help sustain human well-being and economic growth and more. Climate change is and will irreversibly affect the dependence of energy on water while energy is needed to secure access to good quality water. In all this there is a strong need to review the system and analyze the actions taken in both water and energy management. (Bazilian et al, 2011)

As mentioned in the United Nations World Water Development Report for 2014 "The challenge for the twenty-first century governance is to embrace the multiple aspects, roles and benefits of water, and to place water at the heart of decision-making in all water dependent sectors, including energy".

Synergy between water and energy infrastructure and technologies can co-produce energy and water services that benefit both sides of the link, protect the environment and at the same time benefit the population. There are examples that combine renewable energy generation used in desalination plants or energy recovery from wastewater.

But that will not be sufficient, as noted by the Director-General of UNESCO in the foreword to the UN Report 2014 Water and Energy "Clearly, technical solutions will not be enough to address stakes that are, above all, political, economic and educational. Education for sustainable development is essential to help new generations create win–win equations regarding water and energy. Private sector engagement and government support for research and development are crucial for the development of renewable – and less water intensive – energy sources". It is necessary to promote mutually reinforcing evaluations of the use of energy and water management on both sides of the link. To do all this, it is of course necessary to have more information to develop systems based on synergy that benefits both energy production and water management in order to find the best solution. Consequently, it is necessary to promote and build new capacities in water resource managers and energy and water experts, to assure benefits for participating communities in the development of new solutions which integrate the management of both water and energy based on knowledge of their interdependence.

The goal of the Energy and Water Programs of the Inter-American Network of Academies of Science is orientated in this direction to promote a sustainable energy future and watershed management in the Americas with the contribution of scientists from all the countries involved.

The following three sections present case studies of specific aspects of how the roles of women especially in rural societies, are affected by their need to access and produce energy and water in order to fulfill their domestic responsibilities. The first presents data on Peru and the Andes region followed by an overview of traditional energy use and model programs to improve the lives of rural women and ends with a specific analysis of the impact of using firewood use on women's health.

3. Energy, Water and Gender: Case Study of Peru and the Andes Region

Introduction

"Women play a crucial role in environmental management and development. It is therefore essential that they be fully involved in order to achieve sustainable development." (Principle 20. Río de Janeiro 1992.) During the past two decades, despite significant changes in access to drinking water and energy, these changes have not been matched in the sphere of gender equality, or on an urban or rural scale or by socioeconomic status and continent. In subsistence economies, women spend much of the day carrying out domestic tasks such as fetching water or collecting firewood to use as fuel

Table 2. Average hours per week that the population above 12 years old devotes to the collection of firewood, manure or coal to cook food in their homes

		Average	Men	Women
Total		**3.17**	**3.4**	**2.88**
Area of Residence	Urban area	2.23	2.17	2.28
	Rural area	3.47	3.73	3.13
Region	Coast (does not include Lima)	2.78	2.83	2.77
	Mountains	3.48	3.83	3.12
	Jungle	2.63	2.80	2.40
	Metropolitan Lima and Callao	1.78	0.93	2.17

Source: INEI-National Survey of use of time (Encuesta Nacional del uso del tiempo, pp. 200 and 201)

(Global Partners in Action, (2009). The FAO (2013:6) specifies that "women are not always the principal wood collectors, … and in the case of Latin America, men are mainly responsible for this task." In Latin America, it is recognized that "firewood continues to be the most common form of energy for cooking, and sustainability of its use is fundamental for environmental and social reasons" (Van den Hooven, 2006). It is also important to highlight the existing gap between rural and urban areas, and rural and urban women.

Section 1: Case Study: Peru

Table 2 shows the reality in Peru and indicates the average number of hours devoted to the collection of wood, manure and/or coal as an energy source for domestic cooking by the population over 12 years old. Though this task is carried out by both men and women, the former tend to devote more hours to it, in particular in the mountains, where a greater average number of hours are needed to collect firewood, coal and/or manure, 3.48 hours/week, in comparison to 2.78 hours/week on the coast and 2.63 hours/week in the jungle. In the three natural regions, men spend the highest average number of hours a week on this activity, though the task is more equally shared on the coast.

It is worth noting that in this area of Latin America, there is more male participation in the collection of energy than in other reported areas where it is predominately undertaken by women and girls.

The capital city has not been spared this reality, which is experienced daily in its main centers and poor outskirts. Indeed, in the districts belonging to Southern Lima, 1.3% of houses do not have basic services; in other words, electric lighting, water supply and drains. Pachacamac is the district with the highest percentage of houses with deficiencies in all these categories. The lack of a water supply network indicates that it is necessary for these populations to go out and collect water for their daily requirements. As these districts belong to the Metropolitan Lima area, according to Table 2, women are mainly responsible for this task. In urban zones, even the poorest families tend to purchase the wood that they require.

Regarding the domestic supply of water, which in the majority of cases is not drinkable, the United Nations Environmental Program (UNEP, 2007) specifies that, on a global level, women and children "take the responsibility of responding to their families' needs for water, a time-consuming task that also demands a great deal of energy. In rural zones, they have to travel large distances on foot to obtain water, which they carry home. In urban zones, women have to queue for undetermined lengths of time, awaiting the intermittent deliveries of water. This gives them less time for other necessary, age-appropriate activities, such as education, paid work or cultural and leisure activities."

Section 2: Case study: Amazonian Jungle and Andean Mountains

The situation is very different in the case of the Amazonian jungle and the Andean mountain ranges. In the Andean Amazon, from 2,300 meters above sea level downstream, Table 4 shows a difficult situation, in which 80% of villages with fewer than 2,000 inhabitants; that is, 17,787 small and scattered communities and villages, do not have access to a safe source of water. This area includes

Table 3. Percentage of homes based on type of scarcity: electricity, water and drains. Scale: Southern Lima

	Lima Sur	Lurín	Pachacamac	San Juan de Miraflores	Villa el Salvador	Villa María del Triunfo
Lack of water supply, drains and electric lighting	1.3	1.8	5.3	0.7	0.9	1.4
Lack of water supply and a drainage system	7.9	19.4	32.8	3.1	5.6	7.5
Lack of access to a water supply network or well	22.1	32.7	79.5	10.2	18.7	23
Lack of access to a water supply network	21.2	44.1	84.9	8.3	16.8	20.3
Cooking using kerosene, coal, firewood, manure and other types of fuel without a chimney in the kitchen	21.1	20.9	32.1	16.8	21.7	22.2

Source: INEI, Censos Nacionales 2007: Censo XI and Censo VI de Vivienda. MINTRA-Pobreza y Desarrollo Local en Lima Sur, p. 20

approximately 7 million inhabitants. Over half of these, in other words, 3,423,057 inhabitants, live in the low jungle area at an altitude of between 400 and 700 meters. This extreme atomization results in isolation and natural exclusion, in addition to posing a technical and financial challenge to achieving the Millennium Goals. Though it is the basin with the highest availability of water on earth, obtaining water is an everyday task mainly carried out by women and children.

In the Andean region, inaccessibility, the increase of natural disasters related to environmental decline and climatic variability; in addition to decades of exclusion, lack of state and market presence, lack of proposals to overcome poverty and an impoverishing dependence on state handouts have increased the vulnerability of the poorest sectors. This has occurred in particulary during crisis, in which low-income women, work longer hours and accept less favorable working conditions than higher-income women, simply to ensure the survival of their families.

Studies carried out with the Guamán Poma de Ayala Center demonstrate the significant differences in the time devoted to the principal activities by zone and gender, in the Southern Valley of Cusco.

Women are more vulnerable in times of stress situations brought on by external factors such as drought, excessive rain, extreme cold or heat. The amount of time spent in collecting wood and water and caring for their properties is probably determined by the nature of the crisis. Moreover, in these periods of crisis, not only do women devote more time to collecting water, firewood or manure and domestic tasks, but a common strategy is to first reduce women's food supply, and only in the worst situation to reduce the food supply of all the family's members, as demonstrated in the study carried out by Aparco Balboa in the Cusco mountain region. It is also worth noting that at least in this region, women have absolutely no access to paid work even in the urban part of the mountainous area of Cusco.

Women carrying firewood. http://www.planeterra.org/blog/care-cookstoves

Table 4. Population without water, by country and village

Location	Amazonian Population	Number of villages	Lacking access to drinking water	%
Total	**6.786.775**	**18,098**	**4.163.238**	**61%**
Distribution by Country				
Bolivia	912.089	3 307	500.200	55%
Colombia	1.357.003	1,738	903.083	67%
Ecuador	561.852	960	398.731	71%
Peru	3.951.911	12 044	2.358.088	60%
Distribution by Villages, by population range				
0 - 500	2.856.590	16 374	2.285.272	80%
500 - 2000	1.454.552	1 413	1.163.640	80%
2000 - 5000	500.573	147	306.543	61%
Over de 5000	1.975.060	164	407.783	21%

Source: NIPPON KOEI LAC CO., Ltd., 2005

Conclusion

This case study of Peru provides a telling example of how women's lives are affected by their domestic responsibilities in the collection of energy resources such as firewood and manure. In addition to the fact that much of their time is also spent on the collection of water and in times of stress, women's food resources become more limited. It also demonstrates the important role of geographic and environmental factors which place enormous demands on women's time, energy and health.

4. Role of rural women in energy production and use

a. Introduction

For many years, the role of women in energy production and use has focused mainly on the home, particularly the burning of biomass to cook food. Globally women today have expanded this role, empowering themselves and their communities to use other sources of renewable energy, participating in technical projects and assuming roles traditionally performed by men.

There are a number of references to studies on the issue of gender and energy. Among these is the Latin-American Organization for Energy (Spanish acronym: OLADE, Organización Latinoamericana de Energia), showing that the different energy needs of men and women means that access to energy may therefore have a varying impact on them. Whereas men usually work the land and produce agricultural products for sale, women plant, weed and harvest products for family consumption, cook, process food, transport products and devote themselves to the well-being of their children and families.

It is suggested that in order to perform their role in the home and society, women's needs and interests should be included in the energy policies of their respective countries. In this respect, formulating gender-specific objectives providing for women's needs is essential to ensure the following:

- A simpler more enjoyable life, without the need to neglect their home or community activities.
- The ability to produce more and better products to generate income without challenging their fundamental role in society.
- Greater equity with respect to men and the opportunity to be self-sufficient.

In 2012, with cooperation from Canada, OLADE launched a project called "Developing Gender Equity in the Energy Sector's Decision-making Process". The objective is to design a strategic political framework for energy and gender that will enable governments to create gender-sensitive plans, strategies, policies and regulatory measures for energy use in Latin American and the Caribbean (Larrea, 2013).

Table 5. Percentage of time devoted to the principal activities by zone and gender, in the Southern Valley of Cusco

Activities	Rural zone		Urban zone	
	Men	Women	Men	Women
Agriculture	12.3%	12.4%	-	-
Fishing	-	16.5%	1.1%	1.3%
Commerce or trade	11.0%	-	12.7%	3.6%
Domestic	1.4%	36.0%	1.8%	32.2%
Family relationships	13.7%	-	23.6%	25.1%
Communal activities	19.2%	16.5%	18.1%	20.1%
Paid work	26.0%	-	30.8%	-
Leisure	13.7%	12.4%	3.6%	7.6%
Helping children with homework	2.7%	6.2%	8.3%	10.1%
	100%	**100%**	**100%**	**100%**

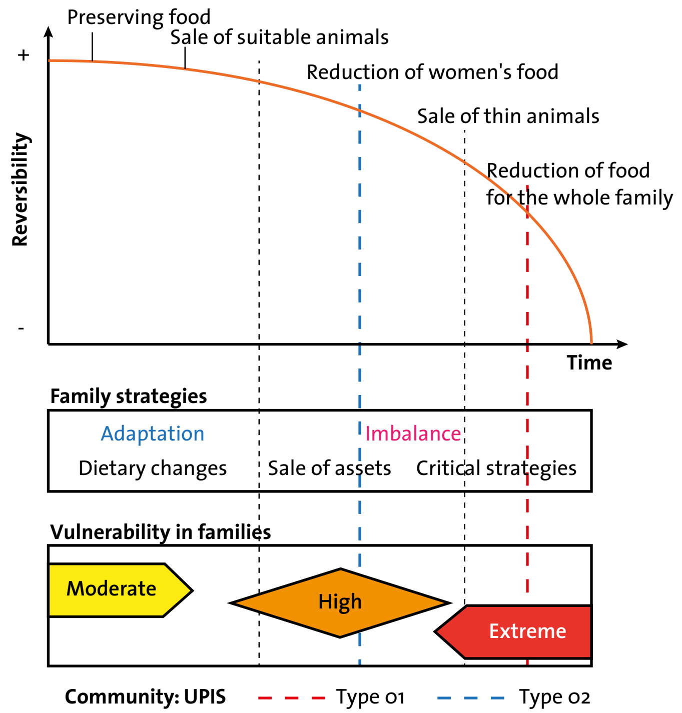
Source: Diagnóstico de la situación de las mujeres y las relaciones de género. Centro Guamán Poma de Ayala.

b. Technological advances in renewable energy with the greatest impact on the socioeconomic development of rural women

Although including gender-specific needs and interests in country-wide energy policies is a high priority issue yet to be addressed, the absence of such policies has not hindered the active participation of rural women in developing and implementing technology, which, in general terms, has had a positive impact on their lives. These women have been supported by national and international businesses and organizations. Notable contributions include:

- Improved wood-burning stoves that have had a positive impact both on health and the amount of time and effort spent collecting and carrying firewood.
- Wind and solar power pump systems for supplying water, thereby reducing the time and effort spent extracting and transporting water.
- Electricity to improve conditions in the home, making it possible to work and study at night, refrigerate food for consumption and sale, and provide lighted roads and access to radio, television and the Internet.

Figure 1. Family vulnerability and decrease in the food supply of women, Community of Upis, Ocongate-Cusco.



b.1 Firewood as domestic fuel

Many studies recognize the widespread use of firewood as fuel for cooking and heating in many regions and countries throughout the world. Food preparation technologies in developing countries are still generally less than 15% efficient, whereas in developing countries, technology utilizes up to 80% of the energy potential of fuel. Furthermore, during the combustion process, a high volume of carbon monoxide is produced, creating health problems, particularly for women and children (Mejia, 2011) (see section IV of this chapter).

For example, 14% of the population in Colombia depends on firewood as its primary source of fuel for food preparation. Projects such as "Efficient Stoves" have contributed to improving the quality of life and the efficient use of energy in the rural areas of Antioquía and Santander. The first stage of this project, overseen by Organización Natura, seeks to replace open fires and traditional stoves with more efficient technologies for 2,000 families (Aristizabal, 2013).

In Nicaragua, the "Solar Project for Nicaraguan Women" Foundation (FUPROSOMUNIC) finances the purchase of improved cookers to complement solar

Photo 1. Using an improved cook stove

Source: FUPROSOMUNIC, 2014

Figure 3. Solar cooker training program for rural women (Cuvi, 2005)

power when climatic conditions render solar cookers useless. These use 50% less firewood then a normal open stove. Moreover, they have an integrated chimney that draws smoke outside the home, as shown in Photo 1 (FUPROSOMUNIC, 2014).

b.2 Solar cookers' potential for reducing firewood dependence

Solar cookers are currently used to produce a variety of foods, including, in many cases, staples of a typical diet such as meat, vegetables, rice, beans and plantain. They can also be used for drying food. Nevertheless, the fact that solar cookers cannot be used in the absence of sunshine, in addition to the fact that certain foods cannot be prepared in them, explains why the majority of women continue to use their wood or gas burning fires (Grupo Fenix, 2008).

There are many and varied benefits for rural women who use solar cookers; they save fuel and money since firewood consumption is reduced by up to 50%; food is cleaner and healthier, and women have more time to do other things while food is cooking because it will not burn. These cookers keep people healthy since they use a clean technology that does not leave soot on the pots, cooking utensils or walls of the home. Solar cookers also provide the opportunity to earn additional income by selling prepared food.

Since 1989, the Instituto Ecuatoriano de Investigación y Capacitación de la Mujer (IECAIM), in collaboration with the UN International Research and Training Institute for the Advancement of Women (UN-INSTRAW) and Solar Cookers International, has given training courses to rural women on how to use new energy sources such as solar, biomass, wind and geothermal energy. The project of developing, constructing, using and selling solar cookers has benefited over 400 women and their families. Women build the solar cookers themselves and can sell them if they wish (Cuvi, 2005). Figure 2 illustrates the participation of rural women in a training program where the goal is to found an artisan industry around producing solar cookers and reducing firewood use in Ecuador.

In Nicaragua, the FUPROSOMUNIC Foundation benefits nearby communities through the use of solar cookers by reducing the presence of smoke in the surrounding environment (FUPROSOMUNIC, 2014).

b.3 Waste digesters

Anaerobic digesters for organic waste are another unconventional energy source that can minimize firewood dependence. It is important to highlight how the participation of rural women has been important in disseminating this technology. For these women, the waste digester has meant less effort and time spent gathering firewood and better use of farm animal excrement (from milking cows, horses and goats) while simultaneously providing an inexpensive source of organic compost for grass, vegetables, fruits and decorative garden plants.

Likewise, the digesters reduce the presence of unpleasant odors, bothersome insects and smoke from wood burning in the house, enable fish to be bred in small ponds to improve the family's diet and even provide the opportunity to charge tourists to see an environmentally-friendly production system. For these reasons women promote the construction of waste digesters by participating in workshops and learning how to manage and instal them (Lopez, 2008).

b.4 Solar energy

Women also increasingly participate in renewable energy technical projects and are adopting roles traditionally performed by men, such as installing electricity in their communities, businesses and homes.

Another important group is Las Mujeres Solares de Totogalpa, Nicaragua. This group is a cooperative comprising nineteen women and two men who collaborate in the development of their communities by producing and using renewable energy. They actively participate in the research and development of new products and applications. In addition, they design, build and sell solar stoves and solar thermal systems (used for drying), and design and build various types of photovoltaic panels using recycled solar cells.

They also produce a variety of goods processed through use of renewable energy, such as cookies, fruit preserves and coffee. They have even opened their own solar restaurant. Sale of these products provides a sustained income and the women are constantly exploring new opportunities such as working with improved wood-burning stoves, biogas and solar-powered water pumps (Dolezal, 2012).

Solar energy is synonymous with economic improvement, especially in regions where only a small percentage of the rural community has access to electrical power. In Mali, the Program for Renewable Energy for the Advancement of Women (PENRAF) was founded by the government in 2003 and financed by UNDP. The program, whose goal is to make renewable energy accessible to all, has benefitted over 30,000 people to date, primarily women and youth. Many women have been able to generate income thanks to new work opportunities derived from this project.

Likewise, through this project, a women's association was founded with responsibilities ranging from horticulture or making ice for food use, to supervising health centers and two of the town's schools. Their crops are now irrigated with solar pumps, which has increased the profitability of their gardens. Additionally, women no longer have to purchase charcoal or petroleum for their domestic tasks (UNDP, 2003).

Another situation worth mentioning, where women have been empowered to lead local development, took place in Burkina Faso with the 2007 United Nations Development Program and financial support from banks. Within the framework of this project, alternative energy initiatives were supported and rural women were taught to use solar technology according to the Barefoot College, India, method. This project has created leadership positions in the production of solar panels and related areas all filled by women. Extended hours of electricity have improved life in villages, increased learning opportunities, productivity in sewing workshops and the sale of products uncontaminated by smoke from low-quality oil lamps (Reche, 2011).

Figure 4. Using a solar cooker

Source: La Prensa.com.ni

It is also important to note that the Barefoot School in India was created with the idea of educating illiterate and semiliterate, rural young people and women in the practical technologies that could improve the quality of life in their communities. Here, students learn to produce circuits and solar lamps, correctly connect modules, batteries, lamps and charge regulators and fix and maintain stationary solar lighting units. Seeing the success achieved in India, the college decided to globalize by opening the training program to other developing countries. Consequently, the institution has been a pioneer in bringing electricity to rural areas since 1989 (Reche, 2011).

c. Conclusions

All these examples show the great potential of these new technologies for women which promotes their active engagement in economic activiites and strengthens their own economic power through the creating, constructing and selling of these new technologies, all of which are examples of the positive application of renewable energy.

5. Firewood Use in Latin America and its Effects on Health

a. Introduction

Biomass, including firewood, charcoal and crop residue, is a broad concept that refers to the use of all types of organic matter for producing energy for either personal or industrial use.

Using charcoal or firewood for cooking is not bad in itself. After all, they are both renewable, entirely natural fuels. However, their main problem lies in the way they are used in poor households, since their incorrect usage harms the health of users while failure to renew forests has a lasting impact on the environment (Pobreza energética: La biomasa como combustible, 2014).

b. Socioeconomic Factors in Latin America

In 2012, poverty levels across Latin America reached 28.2%, while the percentage of those living in extreme poverty reached 11.3%. (CEPAL, Panorama Social de América Latina, 2013)

The Mexican government estimated that in 2013, 33% of the country's population lived in conditions of moderate poverty, while another 9% lived in conditions of extreme poverty (1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012, 2013).

Within the Central American Isthmus, the poorest countries are Honduras and Nicaragua, where over half the population lives below the poverty line (55%) and almost a third lives in conditions of extreme poverty (32%). (W*hat Have We Learned about Household Biomass Cooking in Central America?*, 2013)

In the Southern Cone, the four countries with the highest poverty index, according to the 2013 CEPAL report were: Bolivia with 42.2%, Colombia with 34.2%, Ecuador with 35.3% and Paraguay with 49.6%. (CEPAL, Panorama Social de América Latina, 2013).

c. Use Of Firewood As An Energy Source In Latin American Households

The census sample for living conditions and firewood use from the XII Mexican General Population Census 2000 revealed that over half of rural households and occupants (59%) use firewood as cooking fuel (XII Censo de Población y Vivienda , 2000).

In Central America, twenty million people cook with biomass on open fires or rudimentary stoves. Approximately 86% or seventeen million of the people who consume firewood in both urban and rural areas within the region are concentrated in three countries: Guatemala, Honduras and Nicaragua. Meanwhile, in Costa Rica, Panama and El Salvador, firewood users are primarily rural inhabitants (What Have We Learned about Household Biomass Cooking in Central America?, 2013).

The 2011 Continuous Household Survey (ECH) undertaken by the Nicaraguan National Institute of Information and Development reported that 42.7% of rural households and 15.6% of urban households exclusively use firewood to prepare food. (Encuesta Continua de Hogares , 2011)

Xiaoping Wang's report, published by the World Bank, reported that in Honduras, 37% of the urban population sector and 96% of the rural population use firewood as fuel in their homes.

In contrast to the situation in Central America, the Permanent Household Survey in Argentina (EPH/INDEC) reported that 72.11% of households cook with piped gas, while only 0.13% use kerosene, firewood or charcoal to prepare their meals. (Encuesta Permanente de Hogares - EPH, 2013).

In 1998, 36.22% of households in Bolivia used firewood, a percentage that had fallen to 17.05% by 2011. The reduction in firewood use was offset by a 20% increase in the use of liquefied gas during the same period. (Encuesta de Mejoramiento de Condiciones de Vida (MECOVI 2000-2002), Encuesta Continua de hogares 2003-2004, Encuesta de Hogares. 2005-2011, 2011).

d. Indoor Firewood Use and its Effect on Human Health

Wood smoke is a complex mix of volatile and particulate substances, including organic and inorganic elements. Over 200 chemical compounds have been identified in wood combustion; the primary ones being carbon monoxide, nitrogen dioxide and particulate matter, all of which are toxic for the respiratory system. There is growing evidence that exposure to indoor wood smoke causes respiratory disease, especially amongst women and children, who are the most vulnerable groups. Three respiratory diseases in particular have been strongly associated with long-term exposure to wood smoke: acute lower respiratory tract infections in children under the age of five, chronic obstructive pulmonary disease (COPD) and lung cancer. (Enfermedad Pulmonar Obstructiva Crònica - EPOC, 2013)

COPD, generally caused worldwide by tobacco use and air pollution, is now considered the fourth leading cause of death throughout the world, and is expected to become the third by 2020. (Enfermedad Pulmonar Obstructiva Crònica - EPOC, 2013)

The Proyecto Latinoamericano de Investigación en Obstrucción Pulmonar (Latin American Pulmonary Obstruction Research Project-PLATINO) found that COPD figures for Chile, Uruguay, Venezuela and Brazil, were over 12% (Venezuela 12.1%, Brazil 15.8%, Uruguay 19.7%, Chile 15.9%) compared with the average in Europe of less than 10%. (Recomendaciones para el Diagnósticoy Tratamiento de la Enfermedad Pulmonar Obstructiva Crónica (EPOC), 2011)

Despite having reported a 7.8% prevalence of the disease, 88% of COPD patients in Mexico with wood smoke exposure were female. (1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012, 2013),

e. Alternative Solutions

Proper, controlled use of biomass fuel, for example, the production of crop residue pellets, which provide energy generated by the agrifood industry, is an alternative that can provide sufficient energy to cover household needs such as food preparation or small industry. However, their use must be combined with efficient cookers (that do not permit the accumulation of indoor smoke).

6. Gender as a Component in Energy Planning

a. The Energy-Poverty-Gender Nexus

Energy does not in itself constitute a development priority, as identified in the Millennium Development Goals (MDGs). (Khamati-Njenga & Clancy, 2003) The MDGs are: (1) Eradicating extreme poverty and hunger, (2) Achieving universal primary education, (3) Promoting gender equality and empowering women, (4) Reducing child mortality, (5) Improving maternal health, (6) Combating HIV/AIDS, malaria and other diseases, (7) Ensuring environmental sustainability, and (8) Developing global partnership for development. However, energy availability is one of the main contributors to underdevelopment. In fact, energy has been identified as one of the WEHAB priorities for development (Water, Energy, Health, Agriculture, and Biodiversity). (UNDP, 2004). What is called the energy-poverty nexus stems from the fact that the poorest people in the world have access to the least efficient, lower-energy-density energy sources or lower fuels in the energy ladder. (The World Bank, 2012) The energy ladder includes, from the lower to the higher fuels: (1) wood, dung and biomass; (2) charcoal, coal, kerosene; (3) electricity, liquefied petroleum gas (LPG); and (4) modern biofuels, solar and wind. (Lambron & Piana, 2006)

The majority of low-income people and those living in extreme poverty are located in rural areas, where water and energy resources are not readily available for use. In 2008, 2.15 billion people lived on $ 1.25 per day with 350 million people living in extreme poverty mostly in rural areas (The World Bank, 2012), of which an earlier estimate indicates that 70% were women (Khamati-Njenga & Clancy, 2003)[2] Therefore, women constitute 50% or more of the target population for the MDGs (Dersnah, 2013). Additionally, women and children, usually girls are largely responsible for energy harvesting in rural communities, which is part of the domestic responsibilities (cooking and heating). Energy harvesting involves collecting firewood, dung or other forms of biomass (the lowest fuels in the energy ladder). (Figure 5).

One of the main consequences of this fact is that girls are more likely to drop out of school after the primary level. The number of female out-of-school adolescents on average (including urban and rural areas) in Latin America is 20% of the total female population eligible for secondary education, which is disproportionally large when compared to male adolescents (UNESCO, 2012). Poor women and girls, mostly in rural communities, do not have the same education opportunities as their male peers. Based on poverty and education alone, there is clearly an energy-poverty-gender nexus. Another element of the energy-poverty-gender nexus is the health component. According to the World Health Organization (WHO), the world's poorest suffer from chronic exposure to the detrimental effects of firewood, dung or biomass burning for cooking and heating, leading to 1.6 million deaths per year, mostly women and children under five, due to pneumonia,

2. There are no disaggregated data in terms of gender distribution among people in low income and extreme poverty groups as reported by MDG progress indicators published in 2012, so an earlier estimate of population distribution was cited.

chronic respiratory disease and lung cancer in developing countries; the "killer in the kitchen" is responsible for 1 death every 20 seconds. (Takada, Rijal, & Clemens, 2007) The energy contribution and the cross-cutting gender perspective towards meeting MDGs and targets are summarized in Table 6.

Since energy resources and availability are major contributors to sustainable development, and gender a cross-cutting issue in all development challenges and goals, one cannot isolate energy planning from development. "There is a pressing need for nations and regions to develop sustainable energy strategies that address integrated development goals" (Lambron & Piana, 2006). Therefore, analysis during energy planning must respond to the needs of the poorest, which are determined by their context (culture, income, social class, religion, family status, geographical location and gender roles and disparities). Energy planning must be demand-focused, and therefore be based on the needs, priorities, impacts and effects of energy initiatives on all population sub-groups, including women (ENERGIA, 2006).

b. Incorporating gender in energy planning

Gender mainstreaming is defined as "a strategy for making women's as well as men's concerns and experiences an integral dimension of the design, implementation, monitoring and evaluation of the policies and programmes in all political, economic and societal spheres, so that women and men benefit equally and inequality is not perpetuated" (Takada, Rijal, & Clemens, 2007) and it should be an integral part of energy planning. In order to do so, the following elements must be present in all stages of energy planning (policies, programmes, projects, etc): (Lambron & Piana, 2006).

1. Gender-disaggregated data which reflect a clear differentiation of energy needs between men and women, and impacts of different energy policies, programs and projects on both populations. "It is worth noting that gender issues are shaped by affluence/poverty levels, age, caste systems and other cultural components which should be captured during information gathering" (Khamati-Njenga & Clancy, 2003).

Figure 5. Women fetching firewood. Nicole Bernex

Table 6. Millenium Development Goals (MDG's) goals and targets, related to energy and gender

Goal	Target	Energy contribution towards goals and targets	Gender perspective
MDG 1: Eradicate extreme poverty and hunger	Target 1: Halve the proportion of people living on less than one dollar a day	• More efficient fuels and fuel-efficient technologies result in reduction of time and household income spent on energy needs. • Reliable and efficient energy promotes enterprise development and productive activities. • Lighting extends productive day.	• Availability of more efficient fuels and energy technologies allow for women and girls, who are mainly responsible for fuel collection, to engage in productive activities, income-generating enterprises and access education.
	Target 2: Halve the proportion of people who suffer from hunger	• More efficient energy technologies increases availability of cooked foods. • Energy enables fresh water access for house hold use and farming. • Mechanical energy can be used for food production machinery. • More efficient energy technologies reduce post-harvest losses and water needs.	• More efficient fuels and energy technologies enable women, who are mainly responsible for cooking, feeding their families and subsistence agriculture, to improve the nutritional status of their families. • Access to energy promotes economic opportunities for women in the agricultural sector.
MDG 2: Achieve universal primary education	Target 3: Ensure that all boys and girls complete a full course of primary schooling	• More efficient energy technologies frees up children's time that would be otherwise spent collecting fuel and water. • Energy creates a child-friendly environment. • Lighting in schools enables night classes.	• Girl's enrollment in primary school would increase, since they are usually the ones tasked with collecting water and fuel.
MDG 3: Promote gender equality and empower women	Target 4: Eliminate gender disparity in education	• Electricity enables access to information. • Lighting improves safety in communities, allowing citizens to attend night school and participate in community activities.	• Women are more likely than men to be illiterate, and therefore benefit from larger education and participation in community life opportunities.
MDG 4: Reduce child mortality	Target 5: Reduce by two thirds the mortality rate among children under five	• Cleaner fuels and more efficient energy technologies reduce indoor air pollution resulting in lower fatal respiratory infections among children. • Cooked food, boiled water and space heating contributes to improved nutrition and health.	• Women and girls are usually responsible for caring for young children (their health, sustenance, and hygiene). Clean fuels would contribute to the improvement of health conditions among women, girls and young children.
MDG 5: Improve maternal health	Target 6: Reduce by three quarters the maternal mortality ratio	• Energy services would enable better equipped medical facilities with medicine refrigeration, instruments sterilization, and access to information.	• Release from the grueling task of collecting fuel and water improves pregnant women's health. • Medical facilities will allow for more women to deliver children under better conditions.
MDG 7: Ensure environmental sustainability	Target 9: Reverse loss of environmental resources Target 10: Reduce by half the proportion of people without sustainable access to safe drinking water	• Availability of cleaner fuels and energy-efficient technologies reduces demand for fuel wood and charcoal, promotes the use of agricultural waste and dung as fertilizers, and reduces greenhouse emissions • Energy allows for water to be pumped for consumption, household and production use.	• Women can improve the use of land for subsistence and productive agriculture and contribute to forest preservation and better water management.

Source: INEI, Censos Nacionales 2007: Censo XI and Censo VI de Vivienda. MINTRA-Pobreza y Desarrollo Local en Lima Sur, p. 20

2. Participatory assessment of target populations in terms of their needs, priorities, and expected outcomes in terms of development and how different energy policies, programs and projects may impact them. It is worth noting that women and men may benefit differently from energy interventions. While large-scale, capital-intensive energy technologies targeting improving of formal sectors of the economy including cash crops and mechanical production of goods may be largely beneficial to men, small-scale, household-centered energy technologies may be more beneficial to women. (Khamati-Njenga & Clancy, 2003)
3. Utilization of gender indicators and gender-based impact assessments during the evaluation stage of energy policies, programs and projects, in addition to other indicators used to evaluate the effectiveness of energy interventions.

i. Gender in energy planning. Policy level

Usually, the focus of conventional energy policies is energy supply. However, successful energy policies must be focused on promoting people's welfare (men and women alike) via sustainable, multi-dimensional strategies that respond to a multi-sectorial perspective. Energy policies must be linked to policies in sectors such as agriculture, environmental protection, social welfare, economic development, etc., (Havet, 2003) (Skutsch, 2005). Table 7 presents an example of a gender-aware policy matrix that summarizes how different issues related to sustainable development can be addressed within different dimensions.

ii. Gender in energy planning. Program level

Incorporation of the gender component or perspective into energy programs can be included In all stages of program planning, starting with the logical framework.

In general, incorporating the gender perspective into energy programs and projects involves identifying the following issues before any planning activity (Khamati-Njenga & Clancy, 2003):

a. NEEDS: differentiated needs between men and women that will help them achieve more sustainable livelihood strategies
b. CONSTRAINTS TO PARTICIPATION: factors that might constraint the participation of men and women in any given energy program or project (e.g. gender roles, cultural background, etc.)
c. ABILITY TO PARTICIPATE: different stakeholder's in the energy intervention capacities to participate and contribute to the success of the energy program or project
d. BENEFITS FROM PARTICIPATION: different ways in which men and women may benefit from energy programs and projects.

Early identification of these issues may direct energy planning of programs and projects to viable alternatives. For example, an energy-related development program with an activity consisting of planting trees for firewood in a sustainable manner in Kenya failed because women of a certain ethnic group are not allowed to plant trees while their husbands are alive and men's role involves cattle care and no sort of agriculture activity. (Khamati-Njenga & Clancy, 2003).

Table 7. Gender-aware energy policy matrix

Dimension / Issue	Political	Economic	Environmental sustainability	Social equity
Availability	Instruments to provide wide choice of energy forms	Mechanisms to stimulate energy sector	Promotion of clean energy sources	Equal distribution and access to energy services
Affordability	Mechanisms to reflect women's incomes and cash flows in fuel price	Pricing reflects women's income and cash flows	Mechanisms to make renewable energies affordable	Increased purchasing power among all social groups through reduced energy bills
Safety	Regulations on safety applied to household, labor-saving equipment	Pricing policies and tariffs encourage switch to safer fuels and technologies	Promotion of non-polluting technologies	Promotion of increased well-being and personal safety

Source: Table 2.5, p. 32 (UNDP, 2004)

Table 8. Examples of energy projects to address women's needs and interests using different gender analytical frameworks

Energy Form	Women's needs and interests		
	Practical needs	Productive needs	Community tasks
	Practical interests	Strategic interests	
Electricity	• Water pumping • Mills and/or other food processing equipment • Lighting at home	• Increase possibility of activities during evening hours • Refrigeration for food production and sale • Power for specialized activities	• Safer streets allow participation in community activities • Access to information (TV, radio, internet)
Improved biomass (supply and conversion technology)	• Improved health less effort spent collecting fuel such as firewood	• More time for productive activities, lower cost of processing heat for income generating activities	• Control of natural forests in community forestry management networks
Mechanical	• Milling and grinding • Water pumping for consumption and crops	• Increased variety of enterprises	• Transport allowing access to commercial and social/political opportunities

Source: (Clancy, Skutsch and Batchelor 2002)

iii. Gender in energy planning. Project perspective

In terms of energy-project planning, two situations may arise: (1) integrated gender-perspective into the development of an energy project, or (2) single-energy technology project.

1. Integrated gender-perspective in energy projects

Gender considerations and a gender perspective are integrated in all stages of the project. During the conceptualization stage, gender-disaggregated data and other cross-cutting social variables will are used to identify potential stakeholders in the energy intervention and the role of energy in improving men's and women's livelihoods. It is important that stakeholders participate in identifying and formulating how energy will impact their lives and which of their needs can potentially be met by an energy intervention. Table 8 presents an example of women's needs and interests as related to possible energy sources.

During the project formulation, the community and project planners must clearly identify the role of energy in the MDG priorities as identified by the community itself. Secondly, all stakeholders must participate in an iterative analysis on how different energy technologies will impact all groups in the community from the household to the community as a whole perspective. Finally, all stakeholders and representatives of end-users must define their roles during the project implementation and the maintenance of the project for an extended period of time. Once the choice of energy technologies has been narrowed down to viable candidates, a more detailed appraisal of how well all technology proposals match or enable the development priorities as whole must be performed. During project implementation, gender balance in all activities must be carefully monitored. And, monitoring, evaluation and impact assessment of the project must be performed using indicators that will cover all gender issues, and generate gender-disaggregated data.

The following indicators for project impact assessment including a gender perspective and framed within the MDGs have been suggested (UNDP, 2004):

1. MDG1 (eradicate extreme poverty and hunger) = i. number of poor households benefited (households led by women vs men); ii. Income increase/productive activities increase due to project
2. MDG 2 (achieving universal primary education) = primary/secondary school enrollment, permanence and performance for boys/girls after project started
3. MDG 3 (promoting gender equality and empowering women) = i. effect of project on women's daily work load; ii. Literacy and skills training for women and men; iii. Overall effect on women's income or productive activities
4. MDG 4, 5, 6 (improving health) = i. changes in numbers of visits to health clinics; ii. Reduced indoor air pollution

5. MDG 7 (ensuring environmental sustainability) = i. increased access to clean/pumped water due to the project; ii. Impact of project on sanitation; iii. Impact of project on forest land preservation and management; iv. Reclamation of eroded agricultural land.

Table 9 summarizes examples of successful energy projects with an integrated energy perspective.

2. Single-energy technology project

In this situation, the gender perspective is usually integrated during the consultation of potential or actual impact of the technology on community's development priorities, at either the planning/ implementation stage or during the evaluation stage, respectively. Unfortunately, this approach is usually used to identify reasons for the underperformance of energy projects. For example, the biogas project in Fateh Singh Ka Purwa India meets 25% or less of the cooking/heating needs of the community. (UNDP, 2004) The community was not consulted prior to the installation of a community biogas plant. The energy technology of choice (biogas) does not meet men's energy needs (mechanical energy for water pumping, grains milling, etc.), and women do not use biogas for cooking because the gas is available from 8:00 am to 10:00 am, when the women of the community are working in the fields alongside the men.

iv. Incorporating gender into energy planning. Capacity building needs

Incorporating a gender component, or any other component, into energy planning requires methods and tools at all levels, from policy makers to stakeholders in energy projects in rural communities. A brief summary of capacity-building requirements

Table 9. Examples of successful energy projects

Project location and title	Project description	Project impact
Kenya Fuel efficient stoves (UNDP, 2004)	Women were trained in assembly, pricing, record keeping and costumer care for commercializing fuel efficient stoves first used in their homes	Improved cooking conditions in participant's households and generation of an entrepreneurial activity leading to additional income
Mali Multi-functional platform project, UNDP and UNIDO the multi-functional platform initiative (Khamati-Njenga & Clancy, 2003) (UNDP, 2004)	Diesel engines on platforms provide off-grid energy for rural villages. The engines can be connected to equipment for grinding, milling, husking, pumping, charging batteries and powering tools	Replacement of firewood and manual labor for mechanized equipment leading to improvements in living conditions and the development of productive activities of men and women alike
Bulevata, Islas Salomón Micro hydro systems	Women trained in the operation and maintenance of the community-owned micro-hydro systems	Utilization of electricity and mechanical work in household and production activities, and empowerment of women in community-service and leadership roles

Table 10. Gender-aware energy policy matrix

Target group	Capacity building needs	Means
National Policy Makers	• New methods and tools • Strengthen women staff	• Well-structured interaction with researchers and NGOs
Implementers of Energy Programs	• Gender issues • Practical tools to address gender issues	• Exposure visits to other projects and experiences • Focus group discussions • Visitors
Villages/Communities	• Milling and grinding • Water pumping for consumption and crops	• Increased variety of enterprises
NGOs	• Tools and techniques to incorporate women into energy projects and initiatives	• Local-level workshops • Interaction with researchers and policy makers

Source: Table 2.4, p. 26 (UNDP, 2004)

for mainstreaming gender into energy planning is presented in table 10.

This gender aware policy matrix includes some important dimensions but several other "means" should added. One of the difficulties with development projects in general is that they are often not informed by the expert knowledge of cultural anthropologists who have researched the culture of a society of area facing development. Therefore the addition of anthropologists as consultants, facilitators and staff on these projects should be encouraged.

Visits to other projects should be clearly specified as to the kinds of projects and where they are taking place. There is also need to specify the focus groups in terms of who should be included, who does the facilitation and what the general aims of these discussions are. Women scientists and engineers should also be included as visiting speakers to the local groups. Local level workshops might also include women teachers and social scientists such as anthropologists and sociologists knowledgeable in the area. In terms of capacity building, more women engineers should be educated and employed in these projects. Specific training of both men and women in the operation and repair of machinery used in projects should also be undertaken.

7. Summary and Conclusions

This chapter has presented the facts about the plight of women in poorer countries whose access to water and energy is limited and it has stressed that a gender perspective or gender mainstreaming is required in development planning to ensure the equality of women and men. It has also presented some important facts about how water use and conservation and energy generation and consumption are interrelated and play an important role in development and especially impact women. The chapter also emphasizes the fact that gender is a cross-cutting issue to water and energy use, since women are the main population group affected by underdevelopment, poverty and the water-energy nexus. Women are among the leading users of energy and water yet they are still rarely integrated into the development and planning processes of many countries. It has also been shown that the quality of life of women and young girls is often inhibited by the constraints placed upon them by the burden of accessing energy supplies and clean water. What is called the energy-poverty nexus stems from the fact that the poorest people in the world have access to the least efficient, lower-energy-density energy sources or lower fuels in the energy ladder. (The World Bank, 2012) The energy ladder includes, from the lowest to the highest fuels: (1) wood, dung and biomass; (2) charcoal, coal, kerosene; (3) electricity, liquefied petroleum gas (LPG); and (4) modern biofuels, solar and wind (Lambron & Piana, 2006).

The time expended on efforts to access energy and water often impedes the educational development of women and increases the cycle of poverty so evident in many areas of the world. One of the main consequences of this fact is that girls are more likely to drop out of school after the primary level. The number of female out-of-school adolescents on average (including urban and rural areas) in Latin America is 20% of the total female population eligible for secondary education, which is disproportionally large when compared to male adolescents (UNESCO).

Based on poverty and education alone, there is clearly an energy-poverty-gender nexus. Another element of the energy-poverty-gender nexus is the health component. According to the World Health Organization (WHO), the world's poorest suffer from chronic exposure to detrimental effects from firewood, dung or biomass burning for cooking and heating, leading to 1.6 million deaths per year, mostly women and children under five, due to pneumonia, chronic respiratory disease and lung cancer in developing countries; the "killer in the kitchen" is responsible for 1 death every 20 seconds (Takada, Rijal, & Clemens, 2007). The aims and objectives of proper gender based development planning should produce results for women such as.

- A simpler more enjoyable life, without the need to neglect their home or community activities.
- The ability to produce more and better products to generate income without challenging their fundamental role in society.
- Greater equity with respect to men and the opportunity to be self-sufficient.
- Improved wood-burning stoves that have had a positive impact both on health and the amount of time and effort spent collecting and carrying firewood.

- Wind and solar power pump systems for supplying water, thereby reducing the time and effort spent extracting and transporting water.
- Electricity to improve conditions in the home, making it possible to work and study at night, refrigerate food for consumption and sale, and provide lighted roads and access to radio, television and the Internet.
- Energy planning must be demand-focused, and therefore be based on the needs, priorities, impacts and effects of energy initiatives on all population sub-groups, including women.

Energy and water planning is a key component of overall sustainable development programs in many countries. However, the specific needs of women in these areas are often not recognized or given due emphasis. Development planning must therefore include gender mainstreaming so that women's concerns as well as those of men become an integral part of the design, implementation, monitoring and evaluation of all policies and programs, so that women and men benefit equally and inequality is not perpetuated. More attention must be paid to the general perspectives of gender equality and specifically the needs, issues and concerns that are particular to women. To facilitate this process, the IANAS Women for Science has made available and maintains on its web page extensive references and links to the gender aspects of each of the IANAS Programs, including those on Water and Energy.

PUNA. Cotos. Typical food. Lake Titicaca. Puno. Photo Nicole Bernex

Katherine Vammen

PhD with specialty in biochemistry and microbiology of water from the University of Salzburg (Paris Lodron), Austria. Specialist in water quality and management. Dean of the Faculty of Science, Technology and Environment of the University of Central America in Nicaragua. Co-Chair of the Inter-American Network of Academies of Sciences (IANAS) Water Program and National Focal Point for Nicaragua. Co-editor of Urban Waters Challenges in the Americas, IANAS publication 2015. Former Deputy director of the Nicaraguan Research Center for Aquatic Resources at the National Autonomous University of Nicaragua (CIRA/UNAN). Founder of the Central American Regional Master's Program in Water Sciences. **katherinevammen@yahoo.com.mx**

Frances Henry

Dr. Frances Henry is a social anthropologist and one of Canada's leading experts on race, racialization and racism in Canadian society. Her anthropological cultural area of study is the Caribbean where she began her life long research on African derived religious movements. Now retired as a Professor Emerita from York University in Toronto, she also taught at McGill University in Montreal for many years before moving to Toronto. She has had, and continues to have, a significant research and writing career and is now at work on her fifteenth book. Henry has also been active in applied community oriented work especially in race and ethnic relations in Canadian society. She is a member of the prestigious Royal Society of Canada. She has been married for fifty four years to Trinidadian born Jeff Henry, has two children and five grandchildren.

Nicole Bernex Weiss

PhD in geography (Paul Valéry University, Montpellier, France). Principal Professor in the Humanities Department of the Pontifical Catholic University of Peru. Academic Director of the Applied Geography Research Center at the Pontifical Catholic University of Peru (CIGA-PUCP). Member of the Technical Committee of the Global Water Partnership (GWP). Numerical Member of the National Academy of Sciences of Peru. National Focal Point for Peru in the InterAmerican Network of Academies of Sciences (IANAS) Water Program. **nbernex@pucp.edu.pe**

Patricia L. Serrano-Taboada

Dr. Patricia Taboada-Serrano received her B.S. in Chemical Engineering from the Universidad Mayor de San Andrés (Bolivia), her M.S. from the Universidad Simón Bolivar (Venezuela) and her Ph.D. from the Georgia Institute of Technology. She joined as a post-doctoral researcher at the Environmental Sciences and the Nuclear Sciences Divisions at Oak Ridge National Laboratory where she expanded her research interests towards the exploitation and utilization of gas hydrates. She also serves in two Committees for the promotion of the participation of women in science, engineering and medicine: (1) the Inter American Network of Academies of Science (IANAS) Women for Science Working Group, and (2) the Committee for Women in Science, Engineering and Medicine (CWSEM) of the U.S. National Academies (NAS) and the National Research Council (NRC).

Mario Jiménez García

BA in education sciences with specialty in Biology. PhD in Medicine and Surgery and MS in Epidemiology from the National Autonomous University of Nicaragua (UNAN). Full Professor with Master's Degree at UNAN. Former research Professor at the Nicaraguan Research Center for Water Resources (CIRA/ UNAN) in Water and health. Participant as author in the recent publication of IANAS, Urban Waters Challenges in the Americas. **mjimenezgarcia72@yahoo.com**

Gustavo Sequiera Peña
PhD in Medicine and Surgery from the National Autonomous University of Nicaragua, Leon Campus (UNAN Leon). PhD in medical sciences with honorable mention in immunology from Friedrich-Schiller University, Germany. Specialist training in immunology, and sub-specialty in allergology from the General Medical Council of Thuringia, Germany. Former research Professor at the Nicaraguan Research Center for Water Resources (CIRA/ UNAN) in water and health. Participant as author in the recent publication of IANAS, Urban Waters Challenges in the Americas. **gustavoseq@gmail.com**

Tomás Bazán
Ph.D in Engineering, University of Florida, USA, 1990. Major in Energy Engineering Sciences and Minor in Environmental Engineering. Master of Science in Mechanical Engineering, University of Wisconsin, Madison, USA. 1982. Current academic activities: Chairman of the Energy and Environment Department, School of Mechanical Engineering, Universidad Tecnologica, tenure professor at undergraduate and graduate level. Recent research work: "Combined effects of evapotranspiration and solar shading by arborization on the cooling load of single housing". "Energy Efficient Design of high buildings (grant awarded by SENACYT)", "Analysis of Desiccant Heat Recovery Wheels impact on latent load reduction and partial-load control under humid climates operation". "Thermal and acoustic characterization of natural fiber boards for building insulation applications". **tbazan51@yahoo.com**

References

Animal Político. 1.4 millones de mexicanos dejan la pobreza extrema entre 2010 y 2012, 29 de Julio de 2013. *Animal Político*. Retrieved July 31, 2014, from http://www.animalpolitico.com/2013/07/hay-53-3-millones-de-pobres-en-mexico/#axzz2afm3acCw

Aparco Balboa, Juan Pablo (2005). "Caracterización singular de familias vulnerables y comparación de los niveles de riesgo a la inseguridad alimentaria-nutricional en dos comunidades rurales del distrito de Ocongate-Cusco. Año agrícola 2004-2005". Thesis to obtain undergraduate degree. Facultad de Medicina Humana, Universidad de San Marcos.

Aristizábal H., Javier D. (2013). "La energía renovable en el hábitat rural: calidad de vida y progreso". Coordinador técnico – Proyecto IICA-ATA. Colombia.

Bazilian, M., Holger R., Howells, M., Hermann S., Arent, D., Gielen D., Stteduto, P., Mueller, A,m Jinirm O,m Tik R, and Ymkella, K. (2011). Considering the Energy, Water Food Nexus: Towards an Integrated Modeling Approach. *Energy Policy*. Vol. 39, No. 12. pp. 7896-7906.

Bernex Weiss, Nicole (2005) (Ed. and co-author). "Amanecer en el bajo Huatanay". *Diagnóstico de Both Ends and Water,* Amsterdam, 2006 http://www.bothends.org/en/Themes/Water/ Recursos Naturales del Valle de Cusco. Lima: Guamán Poma de Ayala Center.

Bloomberg (2013). China's power utilities in hot water. *Bloomberg New Energy Finance*. http://about.bnef.com/files/2013/03/BNEF_ExecSum_2013-03-25_China-power-utilities-in-hot-water.pdfCEPAL, Panaroma Social de América Latina (2013). Cepal, Naciones Unidas. Retrieved August 1, 2014, from http://www.asocamerlat.org/CEPAL_PanoramaSocial2013_AmericaLatina_diciembre2013.pdf

Clancy, J., Skutsch, M., & Batchelor, S. (2002). *The gender-energy-poverty nexus: finding the energy to address gender concerns in development*. London: United Kingdom's Department for International Development, DFID.

David, P. (2013). Energética. Retrieved July 26, 2014, from http://www.energetica21.com/descargar.php?seccion=articulos&archivo=ApHH385PMoGUMlsaemy7Vt6T4fTobToFbF8XMk9T6K5mkYlMMhh7b.pdf

Dersnah, M. (2013). *A review of national MDG reports from a gender perspective - background paper for the Expert group meeting on "Structural and Policy Constraints in Achieving the MDGs for Women and Girls"*. Mexico City: ECLAC & UN Women.

Encuesta Continua de Hogares (2011). INIDE. Retrieved August 1, 2014, from http://www.inide.gob.ni

Encuesta de Mejoramiento de Condiciones de Vida (MECOVI 2000-2002), Encuesta Continua de hogares 2003-2004, Encuesta de Hogares. 2005-2011. (2011). Instituto Nacional de Estadísticas.

Encuesta Permanente de Hogares - EPH (2013). Instituto Nacional de Estadística y Censos (INDEC).

ENERGÍA (2006). *Incorporating women's concerns into energy policies*. Washington D.C.: United Nations Development Fund, UNDP.

Enfermedad Pulmonar Obstructiva Crónica - EPOC (Octubre de 2013). Retrieved May 1, 2014, from http://www.minsalud.gov.co/Documentos%20y%20Publicaciones/epoc.pdf

Havet, I. (2003). Linking women and energy at the local level to global goals and targets. J. *Energy Sustainable Development,* 75 - 79.

Khamati-Njenga, B., & Clancy, J. (2003). Concepts and Issues in Gender. ENERGIA, *The Gender Face of Energy - Training Manual* (pp. 1 - 82).

Lambron, Y., & Piana, G. (2006). *Energy and Gender in Rural Sustainable Development.* Washington D.C.: Food and Agriculture Organization of the United Nations - FAO.

Mejía Barragán, Fabiola (2011). "Implicaciones ambientales del uso de la leña como combustible doméstico en las zonas rurales de USME". Master's thesis on Environment and Development, Universidad Nacional de Colombia

Pobreza energética: La biomasa como combustible (12 de junio de 2014). *Punto Cero*.

Recomendaciones para el Diagnóstico y Tratamiento de la Enfermedad Pulmonar Obstructiva Crónica (EPOC). (01 de Enero de 2011). ALAT. Retrieved May 7, 2014, from http://www.alatorax.org/

Schaaf, T. (2008). *Material educativo para los países situados en zonas secas*. UNESCO Publishing .

Skutsch, M. (2005). Gender analysis for energy projects and programmes. J. *Energy Sustainable Development,* Vol. IX, No. 1.

Takada, M., Rijal, K., & Clemens, E. (2007). Gender mainstreaming - a key driver of development in environment and energy. In U.N. Fund, *Energy and Environment Practice - Gender Mainstreaming Guidance Series*. United Nations Development Fund, UNDP.

The World Bank (2012). *2012 World Development Indicators*. Washington, D.C.: The World Bank.

UK's Department for International Development (DFID) (2002). *Energy for the Poor: Underpinning the Millennium Development Goals*. London: DFID.

UNDP (2004). *Gender and Eenrgy for Sustainable Development: A toolkit and resource guide*. Washington DC: United Nations Development Programme, UNDP.

UNESCO (2012). *World Atlas of Gender Equality in Education - Gender Atlas 2012*. Washington DC: UNESCO.

What Have We Learned about Household Biomass Cooking in Central America? (January 1, 2003). The World Bank. Retrieved July 31, 2014, from Documents & reports: http://documents.worldbank.org/curated/en/2013/01/17524967/learned-household-biomass-cooking-central-america

XII Censo de Población y Vivienda (2000). Conapo. Retrieved July 31, 2014, from www.conapo.gob.mx

Box

Two way link between Energy and Water

Katherine Vammen[1] | Nicaragua

1. Introduction

Energy and Water are linked in two primary ways. Water is used in the production of almost all types of energy and energy is necessary to assure the supply and provision of water and also treatment of wastewater. The availability of water has an impact on the quantity of energy supply and the generation of energy affects availability and quality of water. The use of water for energy is becoming a global challenge. As the world economy grows at a faster pace the demand for water will increase and will accelerate more rapidly than population growth. In some parts of the world, water is continuously underpriced or simply extracted without payment and there is a constant wasting and overuse of the resource without plans for improving efficiency. Groundwater is being pumped without goals for its sustainability and this will obviously affect the water needs of the future and would also mean there will not be adequate water to serve in all needed economic operations if continued in the same inefficient manner. It is always good to remember that as opposed to energy, water has no substitutes or alternative ways to produce the resource with the same quality. Water is also a very important link between humans, their environment and most all components of the economic system. (World Economic Forum, 2011). Water security has been and is becoming in many cases the central political issue in regional and global conflicts. With increasing climate change the impacts of drought conditions could be more severe also affecting the management of the two way link and interdependence between energy and water.

1. Katherine Vammen is PhD with specialty in biochemistry and microbiology of water from the University of Salzburg (Paris Lodron), Austria. Specialist in water quality and management. Dean of the Faculty of Science, Technology and Environment of the University of Central America in Nicaragua. Co-Chair of the Inter-American Network of Academies of Sciences (IANAS) Water Program and National Focal Point for Nicaragua. Co-editor of Urban Waters Challenges in the Americas, IANAS publication 2015. Former Deputy director of the Nicaraguan Research Center for Aquatic Resources at the National Autonomous University of Nicaragua (CIRA/UNAN). Founder of the Central American Regional Master's Program in Water Sciences. katherinevammen@yahoo.com.mx

The world's water and energy resources are already proving to be critical in certain phases due to seasonal change caused by climate change and this will increase considerably as populations and consumption grow with the expansion of economies. To maintain a prosperous growing economy and increasingly rapid urbanization of world populations, it is obvious that more energy and water resources will be needed to confront increasing needs.

Between 1990 and 2000 the global population increased four times, but freshwater extraction grew nine times. This would definitely mean that until 2030 with a growing global population, growing consumption and an acceleration of the economy, water extraction will accelerate even more. (World Economic Forum, 2011). There is a recent prognosis that globally a 40% deficit between water demand and availability could be observed in 2030 and "more than 40% of the global population is projected to be living in areas of severe water stress through 2050" (UN World Water Development Report, 2014a). As demand grows competition for water will sharpen between economic sectors and of course more conflicts will occur between geographical areas.

"Rising pressure on resources calls for new production and consumption models. We need to better understand the connections between water and energy, because choices made in one area impact – positively or negatively – the other. Every production model in energy has consequences on the quantity and quality of available water." (Irina Bokova, Director-General of UNESCO in UN World Water Development Report, 2014).

This interdependence also has a poverty and developmental dimension in that the developing world still has the same groups of the population without or with deficient water/sanitation and energy meaning that the challenges are different in industrialized and developing world. Trade-offs in the management of different options of water and energy synergies need to be analyzed and introduced to bring negative impacts under control. "Water and energy have crucial impacts on poverty alleviation both directly, as a number of the Millennium Development Goals depend on major improvements in access to water, sanitation, power and energy sources, and indirectly, as water and energy can be binding constraints on economic growth – the ultimate hope for widespread poverty reduction". (UN World Water Development Report, 2014a).

2. Water for Energy

Energy production relies on water for operation. It is well known that there is currently a strong increase in demand for energy. The International Energy Agency forecasts that the world economy will need at least 40% more energy by 2030 compared to today (World Economic Forum, 2011) and this of course implies accelerating rates of water use for production of energy.

Demand for water in energy production has been predicted to increase severely as regional economies grow from 2000 to 2030 (56% in LA, 63% in West Asia, 65% in Africa, 78% in Asia. (World Economic Forum, 2011). So how to achieve this balance when already 70% of water is allocated to agriculture.

Today, energy use for water has been estimated at 8% of freshwater extraction globally and as 40% in some developed countries.

The use of water in energy production passes through three operational components: 1) in the production of raw materials used in the generation of energy, 2) in the process of transformation of raw materials to energy and 3) delivery for consume. (U.S. Department of Energy, 2007).

As far as the water used to produce natural gas and liquid fuels, water consumption for some examples in the production of raw materials and transformation to energy:

1. In enhanced oil recovery techniques and oil sands large amounts of water are needed for raw material mining. In the case of oil sands, steam is used to separate the oil from surrounding clay and sand and therefor high quality water sources are needed to produce the steam. In the case of traditional oil and gas resources minimal quantities of water is used for producing raw materials and water is produced along with the release of oil and gas; in the case of oil reservoirs the water is re-injected to

reinforce oil recovery. Uncertainties persist over the potential risks to water quality, human health and long-term environmental sustainability from the development of unconventional sources of gas ('fracking') and oil ('tar sands'), both of which require large quantities of water. (World Economic Forum, 2011). Recent results of paleolimnological studies from the Paleoecological and Environmental Assessment and Research Laboratory from Queens University in 5 lakes in areas of oil sand mining in Alberta, Canada have shown definite evidence of impacts on water quality observed in sediment cores where higher concentrations of polycyclic aromatic hydrocarbons appear corresponding to the time of initiation of oil sand mining; this of course compared to control lake cores in areas not being used for oil sand mining (Kurek et al, 2013).

2. Petroleum refining uses large amounts of water for the cooling process and additionally contaminates water with such substances as oil, suspended solids, ammonia, sulfides and chromium which is in many cases is treated at wastewater treatment plants on-site.
3. The production of gas by "fracking" uses water to fracture the surrounding formations which release gas to the well. But the water needed for transformation of gas for consume is minimal.
4. The water use intensity for the production of raw material for biofuel is of course different depending on the crop and if irrigated or not. For example, grain and oil seed crops are much more water intensive than petroleum. Sugar cane is different as it is usually not irrigated. There are many water pollution issues caused by biofuel production due to fertilizer application which brings nutrients into run off to surface water bodies provoking water eutrophication which induce algae blooms and anoxic conditions in water. The transformation of raw material to biofuel consumes much less water than production of raw material.

"As biofuels also require water for their processing stages, the water requirements of biofuels produced from irrigated crops can be much larger than for fossil fuels. Energy subsidies allowing farmers to pump aquifers at unsustainable rates of extraction have led to the depletion of groundwater reserves." (UN World Water Development Report, 2014a).

The water needed for coal mining is not considerable but the main issue is the impact on water quality. Acidic water produced in the mine drainage and piles of waste dissolves metals from rock and soil which bring such metals as lead, zinc, copper, arsenic and selenium into the water and eventually passes from the drainage system to surrounding watershed tributaries. The water intensity needed to transform coal to liquids is considerable and is used for water to cool process streams but depends on the technical design of the plant.

The delivery of these natural gas and liquid fuels does not involve consumption of water.

Water use in the direct production of electricity is concentrated in the transformation phase mainly for cooling of thermal electric generation plants where two types of systems are being used, closed loop and open loop. Open loop cooling withdraws water in large quantities and return a high percentage to the source but at a higher temperature which causes environmental damage to aquatic life in the water bodies used as a source. Closed loop systems withdraw less water but in reality consume more water since all is lost to evaporation. (Kelic, 2009). The use of dry cooling without water is an advantage but the efficiency of cooling is not so efficient. 78% of world electricity generation is thermoelectric which means coal, natural gas, oil and nuclear as an energy resource; most require cooling and as mentioned water is the most common media. In energy generation 80 to 90% of water consumed is for cooling (World Economic Forum, 2011). It is important to mention that combined-cycle gas turbines reduce water use by half using the least water per unit of power produced. But there is concern in some countries that they create a dependence on gas imports and prices. (U.S. Department of Energy, 2007). More initiatives for the replacement of cooling systems with new technology designed to achieve water efficient and economical generation of power are definitely needed considering the large percentage of electricity generation in thermoelectric.

Nuclear energy needs very high amounts of water in both uranium mining and in the process to prepare the uranium as a usable fuel for energy production; it is the energy form which uses the highest amount of water per unit of power produced. The problems of water pollution are similar to those in coal mining.

Renewable energy forms such as hydroelectricity, wind, geothermal and solar require little water for the raw material production. Even better is that wind and solar use almost no water in the production stage of power except for washing activities. But in the conversion of raw material to usable energy for consumers, concentrated solar energy forms are usually water intensive.

"From a water perspective, solar photovoltaic and wind are clearly the most sustainable sources for power generation. However, in most cases, the intermittent service provided by solar photovoltaic and wind needs to be compensated for by other sources of power which, with the exception of geothermal, do require water to maintain load balances" (UN World Water Development Report, 2014a).

It is well known that investments and economic subsidies for the development of renewable energy, is below that for the use of fossil fuels. These investments for research and economic support in setting up new systems "will need to increase dramatically before it makes a significant change in the global energy mix" and therefore reducing water demand in the water energy interdependence.

Also geothermal energy in power generation is underdeveloped and has potential. "It is climate independent and as the advantage that it produces minimal or near-zero greenhouse gas. (UN World Water Development Report, 2014a).

Hydroelectric power which contributes 20% of world electricity generation is a special case as the water use is due to loss through evaporation. It is well known that there is a higher water evaporation rate from reservoirs than from naturally flowing river systems due to higher surface area exposed to evaporation. It is important to note that Latin America and the Caribbean has the second largest hydropower potential of all regions in the world – about 20% (where almost 40% is in Brazil). There has been a massive expansion in hydroelectric projects to the point that hydropower supplies 65% of total electricity and Brazil, Colombia, Costa Rica, Paraguay and Venezuela even more. In comparison, world percentage of total electricity is 16% (IEA, 2012b; OLADE, 2013). Climate change will undoubtedly reduce the continuity and reliability of this energy supply in the future.

3. Energy for Water

Energy is needed to provide water supply and in wastewater treatment systems. Specifically energy is required before use for water extraction, purification and distribution. Additionally after the use of water, energy is needed for treatment and recycling. So energy is an input to pump water from its source, for treatment, then to pump for distribution to consumers and also treatment after use. Electricity is involved in 80% of costs for municipal water processing and distribution in the USA. (EPRI, 2000). About 7% of commercial energy production is used globally for managing the world's fresh water supply.

The amount of energy used to secure drinking water depends on the water source. Due to the costs of pumping, groundwater requires more energy than surface water. But the advantage of groundwater is the usual good quality which needs little energy for treatment. Water pumping over long distances requires more energy.

Desalinization is highly energy consumptive in providing drinking water. The consumed energy depends on the water quality; of course generating drinking water from seawater requires more energy than brackish groundwater. Disposal of the left over brine is a problem which affects the receiving water body.

Although in Latin America and the Caribbean there has been progress in the provision of water and sanitation services (94% of population has access to improved water sources and 82% to improved sanitation (WHO/UNICEF, 2013), growing energy cost present challenges for the water industry which is often the highest operation cost (30 to 40%) for water supply services. (Rosas, 2011) This has multiple causes from designs with failure of attention to energy efficiency, loss of water in distribution system, failure to have coverage on domestic metering, expansion of waste water treatment and heavy reliance on groundwater with higher pumping costs associated with declining levels in aquifers.

4. Energy Production limited by drought and competing users

In the last decade we have seen increasing occurrence of droughts and local water scarcities which have interrupted power generation causing serious economic consequences and on the other hand limitations on energy have constrained water services. The global situation is marked by the fact that available surface water supplies have not increased in 20 years and groundwater tables and supplies are dropping at an alarming rate. The impact of climate change will reduce available freshwater supplies even more. Past drought events have observed the shutting down of generating plants or shortening of operation when water levels become too low for cooling water withdrawal or if the temperature of cooling water discharge would exceed permitted limits. There are many examples of drought causing low water levels accompanied by demand from other uses such as irrigation (Colombia Basin News, 2006) which have limited the ability of power plants to generate power.

Changes in rain patterns in the hydrological cycle and their effect on river flows which have affected the operation of reservoirs and hydroelectric plants are one of the biggest concerns of the energy industry. For example in 2001, the drought in the Northwestern USA reduced hydroelectric power production which led to the loss of thousands of jobs in the energy intensive aluminum industry (Washington State Hazard Mitigation Plan, 2004).

As pointed out in the United Nations World Water Development Report 2014-Water and Energy "droughts are threatening the hydropower capacity of many countries; and several reports conclude that water availability could be a constraint for the expansion of the power sector in many emerging economies, especially in Asia". (IEA, 2012a; Bloomberg, 2013)." This points to the strong need for addressing extreme climate events in the management of floods and droughts for energy and water security which should include storage for both energy and water.

5. Conclusions - Goal of Energy and Water Program of IANAS

In dealing with the interdependence of water and energy, it is elemental to recognize that the link on both sides is different; energy has alternative forms for its generation but water has no substitutes. (Clausen, 2013) It is a crucial connector between humans, our environment and all aspects of our economic system.

As we have seen in this synthesis of the two way link between water and energy, the use of water in many forms of energy generation is limiting to the production. Most renewable energy forms in most phases of production are much less water intensive and in some instances do not need water. It has also been emphasized that some forms of energy production cause pollution to water sources such as mining, fracking and cooling.

It is notable that policies or economic policies favoring one domain can mean "increased risks and detrimental effects in another, but they can also generate co-benefits" (UN World Water Development Report, 2014a). It is often necessary to analyze and introduce different trade-offs in order to receive benefits for multiple sectors meaning water, energy, agriculture, needs of the population, healthy ecosystems that help sustain human well-being and economic growth and more. Climate change is and will irreversibly affect the dependence of energy on water and vice-versa the energy needed to secure access to good quality water. In all this there is a strong need for a system view to analyze actions taken in both water and energy management. (Bazilian et al, 2011)

As mentioned in the United Nations World Water Development Report for 2014 "The challenge for twenty-first century governance is to embrace the multiple aspects, roles and benefits of water, and to place water at the heart of decision-making in all water dependent sectors, including energy".

Synergy between water and energy infrastructure and technologies can co-produce energy and water services that benefit both sides of the link, protect the environment at the same time and benefit the population. Examples are combined renewable energy generation used in desalination plants or energy recovery from sewage water.

But that will not be sufficient as noted by the Director-General of UNESCO in the forward to the UN Report 2014 Water and Energy "Clearly, technical solutions will not be enough to address stakes that are, above all, political, economic and educational. Education for sustainable development is essential to help new generations create win–win equations for water and energy. Private sector engagement and government support to research and development are crucial for the development of renewable – and less water intensive – energy sources". It is necessary to promote mutually reinforcing evaluations of the use of energy and water management on both sides of the link. To do all this, it is of course necessary to have more information to develop systems based on synergy benefiting both energy production and water management in order to find the best solution. For all this, it is of course necessary to build new capacities in water resource managers and energy and water experts who are focused on assuring benefits for participating communities in the development of new solutions and with a vision and experience in dealing with the interdependence between energy and water

The goal of the Energy and Water Programs of the Inter-American Network of Academies of Science is orientated in this direction to promote a sustainable energy future and watershed management in the Americas with the contribution of scientists from all participating countries.

Chapter 5

Understanding Bioenergy

José Rincón | Colombia

Luís Cortez | Brazil

Summary

The following text presents the state-of-art of biomass conversion technologies, considering the production of solid, gas and liquid products and gives the perspectives for the most promissing alternatives (pellets, biogas, biodiesel and bioethanol). In the chapter it is also analyzed the relative importance of these conversion technologies and respective products in the Americas, with special attention to Latin American and Carribean countries and their markets. An Analysis is also made on the potential market for biofuels for aviation and the possibilities to reduce GHG emissions in the transport sector.

Introduction

The need to reduce the continuous global warming caused by the indiscriminate use of fossil fuels makes it necessary to increase the use of renewable energy sources such as solar and wind energies and bioenergy from biomass.

Bioenergy was the main heat source used by man until the start of the industrial revolution in the 18th century. Thereafter, people began to utilize fossil resources such as coal and oil, formed during the storage and geothermal transformation of biomass over millions of years. When used as fuel, they released the stored carbon as carbon dioxide (CO_2), the main cause of the global warming phenomenon known as climate change.

Biomass is basically a source of solar energy stored by plants through photosynthesis. The term 'biomass' therefore covers a wide range of organic materials produced from plants and animals, and can be collected, stored and used as useful bioenergy (IEA, 2014). At present, the main biomass products used as fuel are secondary forests-planted or natural-, dedicated crops such as corn, sugarcane and oilseeds and short rotation forests. Also of interest are agricultural crop residue, food processing and forestry debris, urban solid waste (USW), and animal, including human, waste-(IEA, 2014). Using biomass as fuel in any form-whether solid, liquid or gaseous-produces carbon dioxide and water and releases the stored chemical energy; it is the only fuel that provides carbon and can be stored and transformed to replace oil and its derivatives.

An analysis of the use of primary energy worldwide shows that 10% comes from bioenergy -50 EJ- which, due to its versatility, is used in the production of heat and electricity and as transport fuel, meaning that it is likely to play a major role in the near future and to be the raw material that will produce the chemicals we now obtain from fossil fuels in the medium term. Figure 1 shows the various ways of using bioenergy depending on its initial source.

Biomass is one of the renewable resources with the greatest potential for use in the intertropical zone (equatorial belt from 23° north to 23° south), for the production of electricity and heat, due to the appropriate environmental conditions in the area such as year-round humidity, temperature and solar radiation.

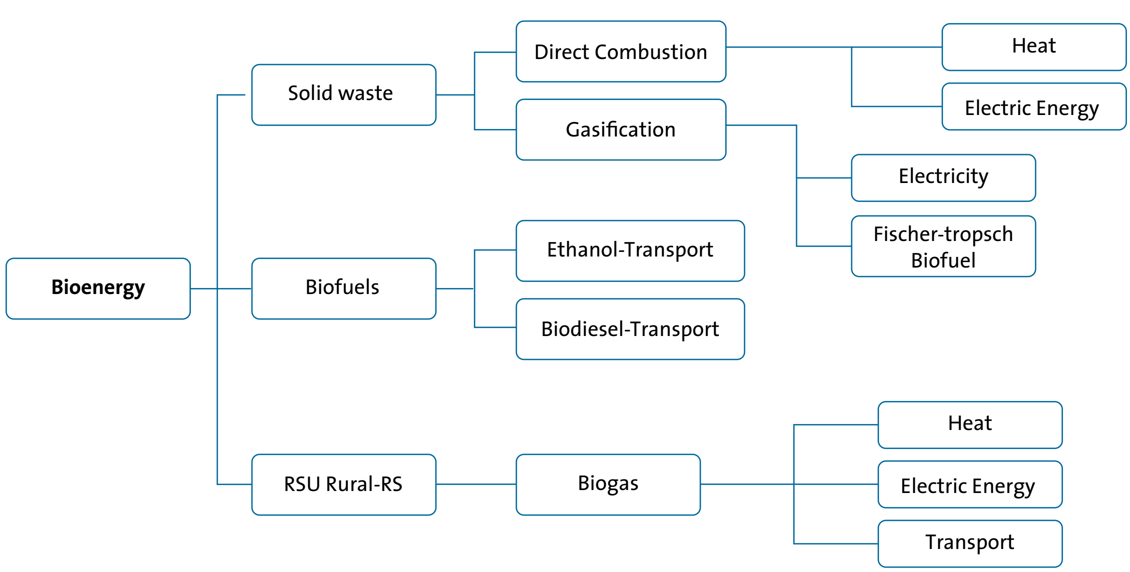
Bioenergy use varies by country and region: it accounts for 3% to 15% in industrialized countries, increasing to 22% in developing countries, where it is mainly used in heating systems and for cooking. China used 9 EJ of biomass for energy in 2008 followed by India (6 EJ/year), the United States (USA) (2.3 EJ/year) and Brazil (2 EJ/year) (GBEP, 2011). Overall, bioenergy has a growing market in industrialized countries (G8), particularly in Northern Europe, for the generation and cogeneration of electricity and heat with solid biofuels (firewood). Due to their low industrial development, countries located in the tropics only use biomass for traditional uses, i.e. cooking and heating. However, they have the opportunity to establish an industry of both solid and liquid biofuels for power generation and transport-modern use, which will provide high social, economic and environmental benefits both locally and for global decarbonization.

1. Energy assessment of biomass, uses and trends

From an energy point of view, biomass is commonly used in power plants or those for combined heat and power production (CHP) -cogeneration-, either as gaseous fuels, usually at scales of 10 kW-5 MW or as solid fuel for up to several hundred MW. It also serves as a raw material in the production of liquid biofuels used in transport (see Figure 2).

Biomass demand grew slowly at an average annual rate of 1.3% during the period 1990-2010. In view of the new EPA regulations (EPA, 2014), forcing power plants to reduce CO_2 emissions by 30% by 2030, power companies are developing ways of using biomass to replace coal such as the co-combustion

Figure 1. Use of different sources of bioenergy



Source: Rincón J.M., Gastón R., Islas J.M.,Lizarde J.E., 2014 and co-gasification of biomass-coal, or transforming their power plants so that they run solely on solid biomass.

Biomass demand is therefore expected to increase at an annual rate of 10% until 2020. It is also estimated that biomass energy production will be competitive and no longer require subsidies in many countries after 2020. The demand for wood pellets and briquettes in Europe is likely to reach 29 million tons in 2020, as opposed to 8 million in 2010, although the majority will have to be imported from North America, Russia and Brazil.

Global demand for biomass for energy purposes is estimated at 53 EJ (1,265 Mtoe, million tons of oil equivalent) (IRENA, 2014). Approximately 86% of this production is used in the production of heat for cooking and in industrial applications as "traditional" energy through direct burning and usually in extremely inefficient devices. The remaining 14% is used as modern biomass in power generation, CHP cogeneration and liquid biofuel production for road transport. In the past five years, liquid biofuels production increased to an average annual rate of 17% ethanol and 27% biodiesel. The solid biomass industry also has expanded rapidly, producing an increasing amount and variety of biomass fuels as well as equipment and processes to convert it into useful energy.

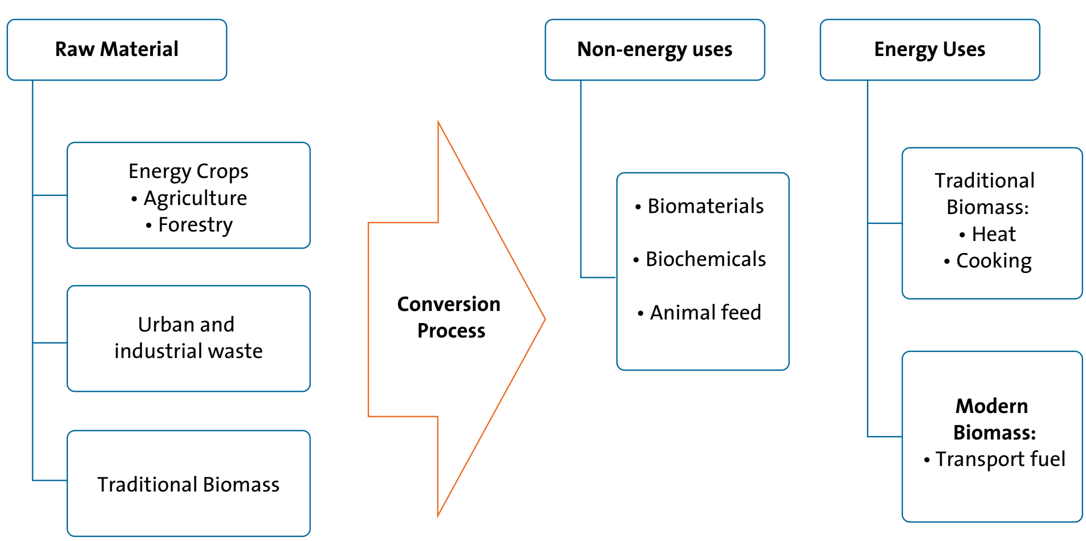
1.1 Solid biofuels

Due to the properties of biomass, such as its low calorific value, high capacity for moisture retention and susceptibility to microbial attacks, energy densification methods have been developed as such as roasting, briquetting and pelletization, which, because of their high density and the uniformity of the products obtained, make them ideal for use in automated combustion systems and permit their mass transportation over long distances.

Some countries have established a solid biofuels industry based on pellets, such as Austria, Switzerland and Germany in Europe; and the United States and Canada in America, which have developed quality standards guaranteeing the use of a uniform product on the market. Table 1 shows the main features of the standards adopted in European countries.

Wood pellet production companies have a capacity of 2000 to 150,000 t/year and are found in virtually all European countries. Prices vary

Figure 2. Conversion from Biomass to Energy



Source: Rincón J.M., Gastón R., Islas J.M., Lizarde J.E., 2014 by country. In 2006, a GJ was worth 17.8 Euros in Germany, 15.5 in Austria and Switzerland and 8 in Spain. Pellets are mainly used as biofuel to replace gasoil in small boilers, usually less than 100 kW, and in heating furnaces in urban areas.

Due to the United States' need to reduce CO_2 emissions, it is estimated that 5 million tons of biomass/day will be utilized. Energy crops and forest residues will therefore have to be used, together with all kinds of cellulosic waste.

In Germany, pellets are expected to account for 8% of the heating systems market, which will involved an expected expenditure of 1.35 billion euros/year on fuel. Of the American countries, the USA and Canada have a pellet industry serving both the domestic and the export market. US pellet prices fluctuate between $120 and $200 dollars per ton (Peksa-Blanchard, 2007). China has appropriated the technology: it produces all the required machinery locally, it has managed to drive production costs below those of imports and ensure that electricity prices compete with that obtained from local, low-rank coal, and has an ambitious program designed to cover 10% of total energy consumption from biomass by 2020. In South America, Brazil, Argentina and Chile have a small pellet production capacity to meet their internal needs, yet lack export capacity (European Commission, 2013).

1.2 Solid biofuels

Solid fuels provide most of the world's bioenergy, follwed by liquid biofuels, used primarily in the transport sector. Net trade in liquid biofuels -ethanol and biodiesel- reached about 20 million barrels of oil equivalent (120-130 PJ) in 2009, equivalent to the amount of energy obtained from pellets. For liquid biofuels in the transport sector, the region with the highest ethanol consumption in 2011 was North America, followed by Latin America. Europe consumes the highest percentage of biodiesel.

Biofuels obtained from energy crops such as ethanol from sugarcane and biodiesel from palm not only help mitigate greenhouse gas (GHG) emissions, but are also important for reducing harmful air emissions such as carbon monoxide and particulate matter from poor combustion of gasoline and diesel, which also benefits urban dwellers' health.

Sections 3.3.1. and 3.3.2 provide detailed information on bioethanol and biodiesel respectively.

The production of liquid biofuels of agricultural origin, such as those mentioned above, creates solid waste –bagasse from sugar cane and palm fruit waste- from which electricity is obtained for the core network and waste heat to obtain biofuel in the processing plants, through modern cogeneration methods, with yields of over 60% compared with 30% from coal-fired thermal power plants. These

Table 1. European Quality Standards for Pellets

Property	Unit	EN-PLUS (FprEN 14961-2)			Standard M 7135	DIN 51731	DIN plus
		A1	A2	A3			
Origin		Non chemically treated wood	Non chemically treated wood	Any type of wood or bark			
Diameter	mm	6(±1) y 8(±1)	6(±1) y 8(±1)	6(±1) y 8(±1)	4 a 10	4 a 10	
Long	mm	3.15<L<40	3.15<L<40	3.15<L<40	5*D	<50	5*D
Density	kg/dm^3	>0.6	>0.6	>0.6	> 1,12	1,0 < D < 1,4	> 1,12
Moisture	%	<10	<10	<10	<10	<12	<10
Ashes	%	<0.7	<1.5	<3.0	<0,50	<1,50	<0,50
PC	MJ/kg	>16.5	>16.3	>16	>18	17,5<PC<19,5	>18
Sulfur	%	<0.03	<0.03	<0.04	<0,04	<0,08	<0,04
Nitrogen	%	<0.3	<0.4	<1.0	<0,3	<0,3	<0,3
Chlorine	%	<0.02	<0.02	<0.03	<0,02	<0,03	<0,02

Source: CONCEREAL, 2011.

processes are the most effective means of increasing the competitiveness of biofuels and global decarbonization.

1.3 Gaseous biofuels

Biomass storage in an anaerobic medium involves decomposition and the generation of biogas containing at least 50% methane, a greenhouse gas that is 21 times more potent than carbon dioxide and can be purified for the production of biomethane, and injected into the natural gas grid or used directly in urban transport. The use of biomass for biogas production is also significant in power generation and the mitigation of GHG emissions.

China and India are the two countries that have most used biogas: millions of household digesters have been installed for the treatment of bovine excrement.

The biogas market is also important in Europe. Germany accounts for approximately 61% of the total gas consumed as primary energy in 2010. The total heat produced by this country without differentiating the type of substrate (sewage sludge, biological, agricultural or industrial waste, landfills) was 12,930 GWh/year and in 2020, its potential is expected to reach 36.4-61.5 TWh/year (Bernd Linke Leibnitz, 2015). More than half of Europe's energy production from biogas is of German origin. In 2011, this production stood at 10.1 million oil equivalent tons, constituting half the energy from liquid biofuels worldwide (Business, 2014).

Figure 3. Pellet, solid biofuel

In early 2012, approximately 186 US biogas plants were operating in commercial livestock production farms. Bio-methane (purified biogas) is produced in 11 European countries, and injected into the natural gas network in nine of them. Its use in cogeneration plants, together with other applications, is well established in these countries, with Germany in the lead.

Section 3.3.3 provides key information on biogas, such as the concept, and its advantages and disadvantages, among other features.

2. Biomass in America

Across America, nearly 80 million people rely on traditional biomass for heating and cooking, the majority of whom are located in Central and South America. Lack of access to energy is primarily a rural problem; only about 1% of the urban population lacks electricity, as opposed to 28% of the rural population. Due to geographical limitations, the most viable solution for most people living in isolated regions is power generation from renewable sources, especially biomass, since it is a reliable energy source throughout the entire time it is generated and can be combined with other energies.

Estimating the energy potential of biomass in America is important for determining its uses, which will depend on its chemical composition and type. Tables 2 and 3 show bioenergy production in 2011 and the potential of bioenergy for each of the countries in the Americas.

3. Processes for Converting Biomass into Energy

In determining the need to use bioenegy for improving the environmental conditions caused by fossil fuel use, especially monoxide and particulate emissions, it is also important to expand its use in

Table 3. Energy Potential of the Main Crops in the Americas

Country/energy potential (TJ)	Sugar cane	Jatropha	Palm Oil	Sugar cane	Coffee	Corn	Rice	Banana	Plantain
Argentina	-	-		-	-	340676	-	-	-
Bolivia	3047	-	-	-	523	15768	626	54130	1179
Brazil	32425536	-	-	-	138578	852029	151902	24950	-
Colombia	1066058	-	20222	56054	33491	9144	27836	1022	9888
Cuba	382	-	-	-	-	5556	907	5707	1796
Ecuador	225332	-	45324	-	1815	12596	12793	28929	1904
Guatemala	91572	-	6997	-	2769	15324	334	9413	663
Mexico	338	57	121	-	-	-	-	-	-
Nicaragua	357879	-	1310	-	4598	8661	-	169	421
Venezuela	368811	-	8090		3937	32065	9550	-	1071
USA	1325054	-	-	-	-	1651808	2089552	-	-
Canada	-	-	-	-	-	181479	-	-	-

Source: Adapted from Rincón J.M., Gastón R., Islas J.M., Lizarde J.E., 2014.

Table 2. Summary of Bioenergy Production in the Americas

Country	Solids			Gases	Liquids (thousands of barrels per day)		
	RSU (TJ)	IW(TJ) Industrial Waste	Primary S. (TJ)	Biogas (TJ)	Total liquid biofuels	Bioethanol	Biodiesel
Argentina	0,00	0,00	92648,00	0,00	50,34	3,00	47,34
Bolivia	0,00	0,00	7474692,00	0,00	0,00	0,00	0,00
Brazil	0,00	0,00	2711814,00	1644,00	438,06	392,00	46,05
Canada	5229,00	4914,00	426237,00	9921,00	32,70	30,00	2,70
Chile	0,00	85,00	204913,00	362,00	0,00	0,00	0,00
Colombia	0,00	0,00	151279,00	0,00	15,00	6,00	9,00
Costa Rica	0,00	0,00	30741,00	4,00	0,40	0,40	0,00
Ecuador	0,00	0,00	29371,00	0,00	0,10	0,10	0,00
Spain	14612,00	0,00	201458,00	12040,00	20,00	8,00	12,00
Guatemala	0,00	0,00	274756,00	0,00	4,01	4,00	0,01
Honduras	0,00	0,00	86645,00	0,00	0,02	0,00	0,02
Mexico	0,00	0,00	344075,00	2154,00	0,40	0,30	0,10
Nicaragua	0,00	0,00	51850,00	0,00	0,20	0,20	0,00
Panama	0,00	0,00	19493,00	0,00	0,00	0,00	0,00
Paraguay	0,00	0,00	97208,00	0,00	2,22	2,20	0,02
Peru	0,00	0,00	123420,00	0,00	2,70	2,10	0,60
Uruguay	0,00	0,00	53399,00	0,00	0,40	0,20	0,20
United States	296096,00	140155,00	2075523,00	230446,00	971,73	908,62	63,11
Venezuela	0,00	0,00	27918,00	0,00	0,00	0,00	0,00

Source: Statistical Data Taken from the IEA and EIA.

order to reduce the greenhouse gases that cause climate change. It is therefore worth evaluating the various routes for converting biomass in order to have the principles for selecting appropriate technologies for its use in a particular region.

3.1 Biomass preparation

The main problem of using biomass "in its natural form" as energy, either for power generation or directly as fuel, is its low energy density (which corresponds to about half the calorific value of thermal coal). The second problem is its high moisture retention capacity and the third its biological degradation. Transporting biomass over long distances is therefore not profitable, meaning that it should be used near the production site, which determines the plant size and scale of use. Plant size is also a determining factor in the efficiency and cost savings during the operation. The production of pellets and biomass roasting therefore seek to increase energy density and therefore expand the radius of the economical transport of pellets and even export it to international markets as is currently the case with coal.

In industrial processes, there are common requirements for achieving efficiency such as having manageable physical sizes of the raw material and a high calorific value per volume (high energy density). In the case of crop residues such as the stem and ear of rice, gramineae, grass, tree branches and/or any other low density biomass, the biomass is subjected to pre-drying, followed by size reduction and agglomeration at high pressure to form pellets or briquettes with better properties.

Figure 5 presents an overview of the different processes used in the conversion. It shows two main groups: thermochemical processes and biological processes.

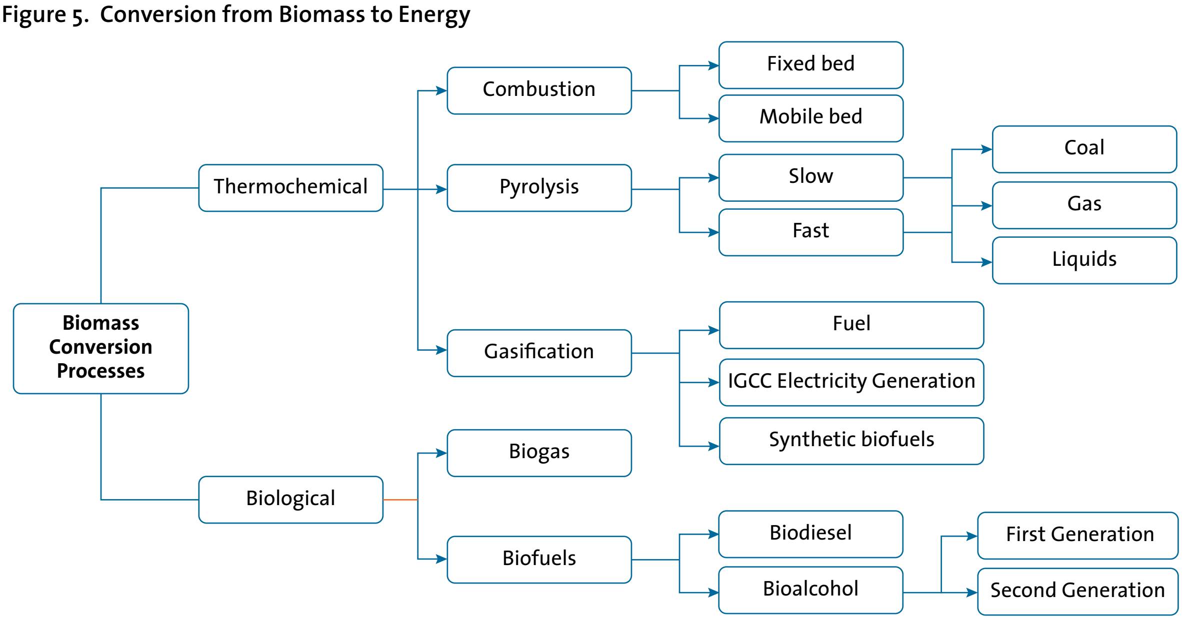
3.2 Thermochemical Processes

Thermochemical processes are classified as direct combustion, gasification and pyrolysis. A description is given below.

3.2.1 Combustion

Of all the biomass conversion technologies, combustion is the most widely used and the one that is continuously being developed (Loo, 2014). There is a large commercial supply of combustion plants and various integration options for both small and large scale plants. To maintain its competitiveness with regard to other processes such as gasification and pyrolysis, combustion technology has been continuously developed (Bauen, 2009). For economic

Figure 5. Conversion from Biomass to Energy



Source: Rincón J.M., Gastón R., Islas J.M., Lizarde J.E., 2014.

Table 4. Classification of Gases by Calorific Power

Product	Characteristics
Low BTU gas (150-300BTU/foot3)	Made with air Contains 50% nitrogen, a mixture of H_2, CO and traces of other gases such as methane (CH_4)
Synthesis or medium BTU gas (300-500BTU/foot3)	Made with oxygen. Its composition is predominantly H_2 and CO with some methane (CH_4) and non combustibles gases.
High BTU gas (980-1080 BTU/foot3)	Made from synthesis gas Nearly all methane.
Óxidos de azufre (SOX)	GEI, origina lluvia ácida, afecta crecimiento de vegetación.

Source: Rincón J. , Capitulo 7: Biomasa, 2010

and environmental reasons, co-firing of coal and biomass is an option that has recently received the greatest interest worldwide.

The transformation efficiency of biomass into electricity in thermal plants using the steam cycle is approximately 25% and may be as high as 30% in co-firing with coal or 60%-80% in thermal plants that engage in congeneration. This increased efficiency provides an opportunity to change technologies worldwide and reduce the pressure of the greenhouse gas effect. The combination of these alternatives, together with the storage of the carbon dioxide produced in IGCC plants, is expected to reduce the concentration of greenhouse gases in the atmosphere (NETL, 2008).

The environmental advantage of using biomass makes it necessary to establish strategies that permit its use in power generation without severely affecting its costs in comparison with other energy source. The most commonly used strategies are:

- Coal/biomass cofiring
- Building plants in areas requiring a low capacity for generation.
- Increasing efficiency by using waste heat from steam and co-generation (Combined Heat and Power, CHP). Examples of this are to be found in the sugar mills of Colombia and Brazil, where excess energy is sent to the grid and thermal energy is used for the plant's sugar production processes, whereby it is possible to achieve efficiencies of over 60%.

The costs of biomass as fuel is the most important parameter in the simulation of generation costs of any technology based on generation with biomass, which depend on many parameters, including the location of the project, the type of biomass used as raw material, the amount required and the calorific power.(Rincón J. & Guevara P., 2013).

Since waste biomass from industrial crops has an extremely low commercial value and in some cases, its storage can cause environmental or logistic problems, this waste is used in the generation of power which, as explained earlier, is generated for the use of the plant. The surplus is sent to the electricity grid, as in the case of electricity generation from sugarcane, palm and rice waste, which occurs in most countries with this sort of crops. Since this use of biomass does not compete with land use or the food supply, it should therefore be evaluated in most countries in the Americas.

3.2.2 Gassification

The gassification of solid fuels such as biomass and/or mineral coal is not a new process and has been used on a commercial scale for over 150 years (Zhou, H., Jing, B., Zhong, Z., & Hiao, R., 2005). The development of gassifiers continues and has led to progress in gassification under pressure for combined cycle energy production (IGCC) with global efficiencies of up to 50%, making it possible to save fossil fuel and therefore protect the environment from the greenhouse effect caused by CO_2 emissions. Gassification products may be classified as gas with a low, medium and high calorific power, as shown in Table 4 (FNCE).

Gas with low calorific power is important as fuel or a raw material for ammoniac and methane production. Gas with medium caloric power, also called synthesis gas, has a similar chemical composition to gas with low calorific power but without nitrogen. It is considerably more versatile than gas with low calorific power and can be used as gas for gas and combined cycle turbines. It is also used as synthesis gas for obtaining methane, methanol, fertilizers, hydrocarbons (biogasoline and biodiesel) through Fisher-Tropsch Process reactions (F-T) and the production of another large variety of chemical products. It is obtained by replacing air with pure oxygen in the reactor, thereby preventing

Figure 4. Bioethanol sugarcane production. Ingenio Providencia, Cerrito Valle del Cauca, Colombia

the presence of nearly 80% of nitrogen. Gas with a high calorific power is essentially methane, also called natural gas substitute (NGS) and is obtained from synthesis gas through a stechiometric adjustment to $3H_2/CO$ using nickel as a catalyzer.

Table 5 shows, by way of an example, the capital costs associated with the biomass gassifier; two representative sizes of 100 kW are presented for mini grids and 20 MW for the applications connected to the network. These costs are modified as progress is made in technological development.

Both gasoline and diesel can be obtained from synthesis gas, through the gassification of solid organic waste and subsequent reaction through conventional methods such as those used in the SASOL plant (synthesis gas from coal) in South Africa. This synethesis technology is well-known and there are currently pilot plants in Germany, Japan, China and the United States. The process of converting biomass to gasoline and diesel is known as Biomass to Liquid (BTL) and once synthesis gas is obtained through calorific power, the next step is the Fischer-Tropsch condensation reaction (F:T reaction), whose principles are the same as those used in the production of liquid fuels from coal. The problem here is the size of the reactors, which are smaller than those used commercially with coal. At present, several research groups are seeking to reduce costs through economies of scale. Table 6 shows the plants required to achieve the goals set by the EU for 2020 in BTL processes.

In Colorado in the United States, there are BTL pilot plants that supply aviation fuel to the US Air Force.

For its part, Canada recently built a methanol construction plant through the gassification of USW (Enerkem, 2014).

3.2.3 Pyrolysis

Pyrolysis involves heating biomass to about 600°C in the absence of air and is well established in industrialized countries. It yields pyrolysis gas, which is normally used as a heating source in the same process, tar or bio-oil that can be used as motor fuel (processed bio-oil) or char or charcoal, a fuel that burns without producing smoke and is suitable for domestic and industrial use as a reductant. When this charcoal is amorphous, as is the case when it is obtained from sawdust or other soft material, it can be briquetted for easier handling (see Figure 4). The heating rate during pyrolysis is extremely important in selecting the final product. High pyrolysis rates and low residence times (flash pyrolysis) produce liquid tar rates of above 60%, which may be hydrogenated to improve their calorific value. When the heating rate is slow, the highest performance product is char or charcoal.

3.3. Biological processes

Biological processes are mainly used in the production of first-generation bioethanol and biogas. Modern methods for obtaining liquid biofuels employ various raw materials such as sugar, starches, vegetable oil, paper waste and biomass, which can be processed by chemical or biotechnological methods. The main biotechnological processes are fermentation for obtaining alcohol and biogas. The trans-esterification reaction of vegetable oils with methanol or ethanol is also important in biodiesel production.

3.3.1 Bioethanol

Several processes exist for the production of fuel alcohol. The traditionally used or first-generation process involves the glucose fermentation of raw materials such as cane juice, corn starch and sorghum, from which alcohol fuel is obtained after their distillation and dehydration.

Sugarcane is a fast-growing grass as well as the most efficient way to obtain sugars, and the raw material used in Latin America for ethanol production. The United States is the world's largest producer of bioethanol from cornstarch, Brazil being the second as well as the leading producer of bioethanol from sugar cane. The combined costs with those of electricity generation are competitive with those of fossil fuels when obtained from sugarcane whereas production costs from starch are higher (C&EN, 2011). Cellulose is the most abundant natural organic chemical product on Earth, so obtaining glucose from cellulose for the production of fuel alcohol is an ideal solution that does not compromise food security for humanity or compete with the use of fertile soils. Alcohol derived from cellulose hydrolisis is the most widely promoted second-generation fuel from an environmental standpoint. It is estimated that fast-growing plants such as *switchgrass* in North America, elephant grass in the tropics and other cellulose-rich crops will be the raw material for this process and are likely to enter the market in this decade. There is already a commercial plant in Italy and another one is under construction in Brazil that will use sugarcane bagasse.

Table 5. Capital costs (US$/kW) for the gassification generation system

Capacity	100 kW	20 MW
Cost of equipment	2,781	1,943
Civil costs	134	123
Engineering	78	45
Assembly cost	78	67
Contingency costs	145	111
TOTAL	3.216	2.289

Source: Rincón J., 2010.

3.3.2 Biodiesel

Biodiesel is used in engines and has a performance comparable to petroleum diesel. It is produced from trans-esterification with methanol or ethanol in the triglycerides present in vegetable oils such as those obtained from palm oil, soya, rapeseed, sunflower and castor bean. This process is undertaken in the presence of a basic catalyst to obtain the methyl or ethyl esters (depending on the alcohol used) forming biodiesel and glycerol, which can be purified and used in other industrial fields (cosmetic, pharmaceutical and food). In Europe, biodiesel is mainly obtained from canola oil; in the US, Brazil and Argentina, soybean oil is used whereas tropical countries such as Indonesia, Malaysia and Colombia utilize palm oil. As a result of government financial support and incentives, these biofuels are now competitive with fossil fuels.

Second-generation biodiesel is obtained by other methods such as the gasification of biomass for the production of synthesis gas and the subsequent Fischer-Tropsch reaction, whereby F-T biofuels with a similar structure to the corresponding fossil fuels are obtained. This technology will be important in the future and is currently being promoted for use in the production of aviation biofuels by the US company Rentech (Biofuels Digest, 2011).

Third generation biofuels mainly comprise oils derived from algae and other aquatic species and can be processed to be used as jet fuel (NEXTFUEL, 2015). Hydrocarbons of these fuels generally have a higher energy density than first- and second-generation ones and do not compete for land use for food or harm the environment.

3.3.3 Biogas

Biogas is a mixture of gases (methane, carbon dioxide, carbon monoxide and a smaller proportion of others) generated by the biodegradation reactions of organic matter (wet manure, human or food waste) through the action of methanogenic microorganisms in an anaerobic environment (absence of oxygen).

The quantity and quality of biogas–the amount of methane that can be produced-depends mainly on the type of organic material used and the operating temperature.

The main advantages of biogas are summarized below:

- Decreased logging, which reduces deforestation.
- Diversity of uses (lighting, cooking, electricity production, motor transport and others).
- The solid by-product is used as a nitrogen-, phosphorus- and potassium-rich fertilizer, able to compete with chemical fertilizers.
- Use of organic waste.

Disadvantages:

- Presence of methanogenic microorganisms.
- Risk of explosion unless proper precautions are taken.
- The microbial metabolic process is extremely sensitive to environmental changes such as pH, temperature and quality of organic matter. Small impurities may affect the survival of microorganisms.

3.4 USW use (Waste to Energy)

The use of USW in WtE (Waste to Energy) electricity generation is not new, the first trials being conducted at the beginning of the last century. The main difficulty encountered is complying with environmental regulations such as emissions control, including heavy metals in the inorganic part, dioxins and furans in the organic part and acid control. Compliance with environmental standards increases the costs and technological aspects of the process, but due to problems encountered with landfill -release of methane into the environment, leachates and odors- incineration with heat recovery for power generation has experienced an upsurge, especially in Europe: 431 plants in 2005, and 89 in the United States in 2004. This process is of interest from an environmental point of view.

There are several WtE processes such as gasification, pyrolysis, combustion and fermentation and biotechnology, each with its advantages and disadvantages. It is therefore necessary to conduct technical and environmental feasibility studies to demonstrate the advantages and disadvantages, including probable investment, before deciding on the kind of technology.

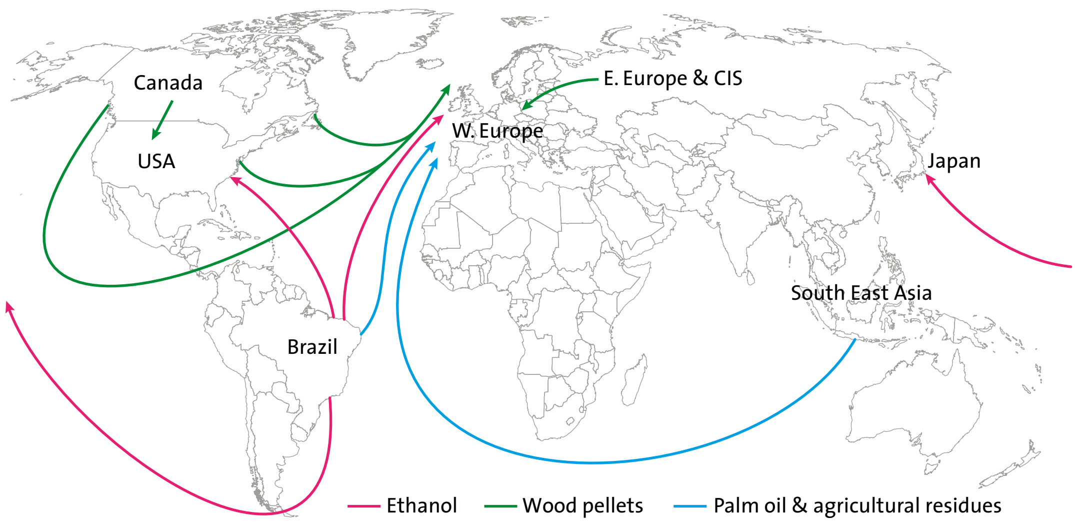
Recently, on June 4, 2014, the first industrial-scale plant for bio-energyproduction from municipal solid waste was opened in Edmonton, Canada. This plant is designed to process approximately 100 tons of waste per year, with biofuels as the main product and useful biochemicals as by-products. It is estimated that Edmonton will produce 38 million liters of clean fuels and chemical compounds of interest, initially to be used for methanol production (Clean Technica). Enerkem, the company responsible

Table 6. Number of BTL plants required to reach production targets for EU-25 biofuels, proposed in the period 2015-2020, depending on the production capacities of first-generation diesel plants.

Target year		Biomass iput (MWth)	Reference	Capacity (bblday)	Capacidad (bbldia)
2015	2020				
1	6	BTL plants	8.500	Qatar carcasse	70.000
2	12	BTL plants	4.100	Qatar sasol	34.000
4	28	BTL plants	1.800	Malaysia Carcasse	14.700
31	199	BTL plants	250	Future biomass	2.100
154	997	BTL plants	50	Typical biomass	410

Source: ECN, 2006.

Figure 6. Main Biofuel Transport Routes.



Source: IEA, 2009.

for processing biomass, says that this is a sustainable process, performed in just three minutes. Residues are thermally gasified and subsequently subjected to a reaction to produce methanol.

4. Technology selection

The process is selected on the basis of the raw material involved: Thermal processes are generally used for wood, because the high content of lignin hinders the development of the microorganisms involved in the biotechnological process. For fats and food waste, the biological route has advantages, whereas for compounds high in sugars, chemical and biological pathways are equally effective. Moreover, thermal processes require biomass with a low moisture content while for biological processes, moisture content is less important. Other factors to consider when selecting technology are handling logistics, transport, storage, and the site and quality of the raw material.

According to some experts, flash pyrolysis has advantages over other technologies for producing gasoline, diesel and jet fuel; acid hydrolysis has the problem of disposal and environmental control, while the scale of the project should also be considered. Fermentation tanks are economical while high pressure reactors are too costly.

5. International biomass market

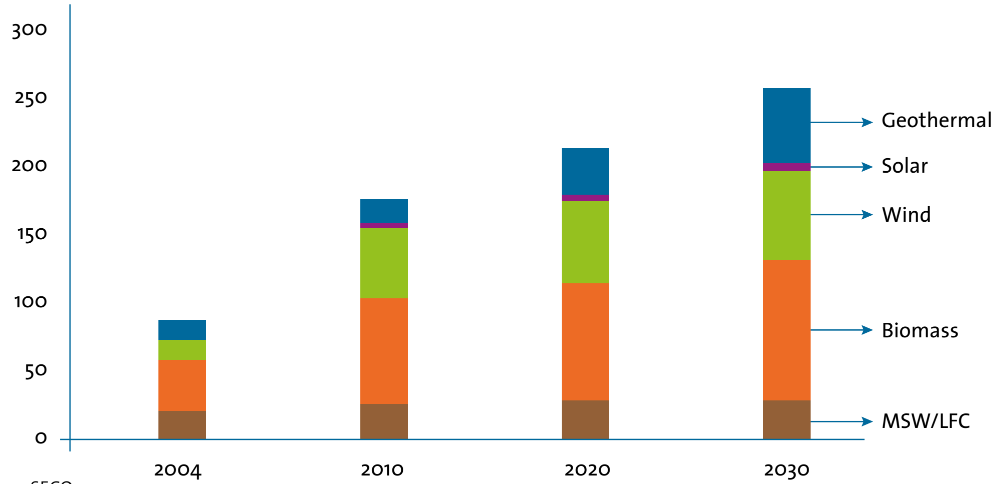
There is a growing international market for biomass fuels. Figure 6 shows the main biofuel transport routes. Brazil, the United States and Canada are the major producers, with Europe and Asia (China and Japan) being the consumers.

As Figure 7 shows, by 2030, biomass is expected to be the largest source of renewable electricity generation in the United States. The Department of Energy (DOE) estimates that 45,000 MW of electricity will be able to be generated by 2020, for which it would employ 190,000 people, mainly in rural areas (SECO, 2010).

5.1 Biofuels for overland transport

Vehicle transport is one of the activities producing the greatest degree of environmental pollution due to the exhaust gases emanating from vehicles as a result of internal combustion (Rincón, J, M., Romero, G., Camacho, A., & Montenegro, E., 1996). This, coupled with the unsustainable, unstable condition of the oil market, has prompted countries to make enormous efforts to counteract and mitigate these effects. The use of renewable energy sources of natural origin (bioenergy) enjoys the greatest support from technological development and popular acceptance.

Figure 7. Electricity generation estimated on the basis of FNCE for the United States



Source: SECO, 2010.

Within this trend, fuel alcohol and biodiesel have emerged as a real, viable and reliable alternative for reducing carbon dioxide emissions, improving environmental conditions, alleviating problems of oil availability, promoting agricultural development and generating employment with fair levels of remuneration, which, as mentioned, are the main goals of biofuels. Nowadays, both types of fuels are produced massively in different countries and there is a large international market for these new commercial *commodities*. There is an ongoing debate over the need for food versus fuel, but in fact, countries that have established the cultivation and use of biofuels have overcome poverty barriers and their farm workers are better able to purchase their food. Now that agriculture has joined the energy business, there are more people working to produce the equivalent of the energy extracted from oilfields, which in turn leads to better wealth distribution.

5.1.1 Fuel Alcohol

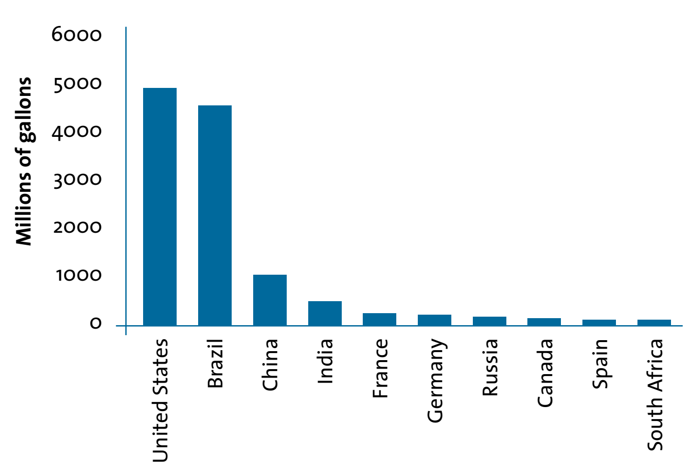
Ethanol is a chemical compound with many different uses. Globally, ethanol is primarily used as fuel in industry and in the manufacture of beverages (Peruvian Ministry of Foreign Trade and Tourism, 2010).

World alcohol production for use as fuel is subsidized. The main manufacturers are the United States and Brazil (see Figure 8), responsible for over 70% of all ethanol production, followed by China, India and France.

5.1.2 Biodiesel

The use of biodiesel dates back to 1900, when Rudolph Diesel used vegetable oil in his ignition engine, paving the way for the future use of biofuels (Censolar, 2004). During World War II, research was conducted on this field in Brazil, but it was not until 1970, with the energy crisis and the high cost of petroleum, that the idea significantly evolved. Germany and Austria conducted the first scale tests with biodiesel in 1982 and in 1985, the first Rapeseed

Figure 8. Major Ethanol Producers Worldwide



Source: RFA, 2008.

Methyl Ester (RME) plant was built in Austria, (Censolar, 2004). Today, countries such as Germany, Austria, Canada, the United States, France, Italy, Malaysia and Sweden are pioneers in the production, testing and use of biodiesel in automobiles.

World biodiesel production will accelerate, boosted by programs for the mandatory blending of biofuel with diesel to protect the environment in Europe, Brazil, Colombia, Thailand and Argentina. Table 7 shows biodiesel production in 2009. In May 2013, biodiesel production in the US reached a record high of 111 million gallons (EIA, 2014).

In Europe, biodiesel is mainly produced from the oil of the canola seed (also known as rapeseed), sterified with methyl or ethyl alcohol and commercially known as RME biodiesel. It is used in diesel engines either pure or blended with diesel oil, in proportions ranging from 5% (B5) to 20% (B20). In Germany and Austria, it is used pure (B100) to maximize environmental benefits.

Globally, in addition to rapeseed in Europe, in recent years, biodiesel has been produced from soybean, sunflower and palm, the latter being the main plant source used in Malaysia and Colombia for the production of PME and PEE (Palm Methyl Ester and Palm Ethyl Ester) biodiesel.

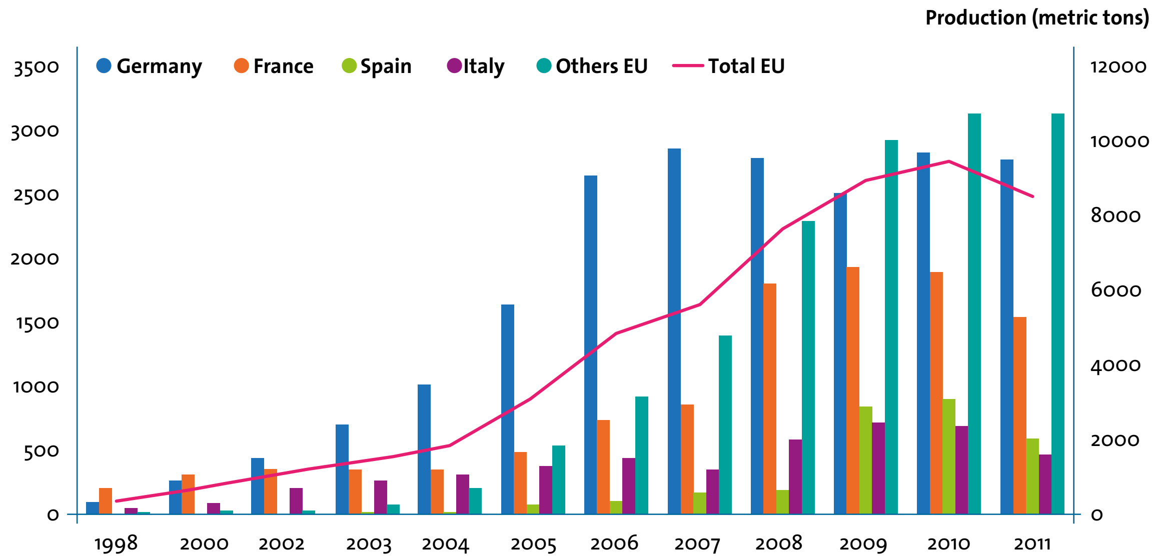
Biodiesel production in the European Union for the year 2010 was 9.5 million metric tons. The top

Table 7. Biodiesel Production in 2009

Region	Million liters	Raw materials
EU	9.848	Rapeseed (50%), soybean oil (40%), palm (5%), tallow (%)
USA	1.682	Soybean (40%), tallow (20%), canola (20%), palm (20%)
Brazil	1.386	Soybean (80%), tallow (10%), other vegetable oils (19%)
Argentina	1.250	Soybean
Thailand	614	Palm
Malaysia	284	Palm
Colombia	205	Palm
China	191	Vegetable oil sludge
South Korea	182	Palm (33%), soybean (33%), vegetable oil sludge (33%)
Indonesia	170	Palm
Singapore	124	Palm
Philippines	108	Coconut
Canada	102	Tallow
South America	63	Palm
W. Europe	58	Colza
58	Rapeseed	Sebo
Australia	57	Tallow
Taiwan	43	Palm (33%), soybean (33%), vegetable oil sludge (33%)
W, N and C. America	38	Palm
India	23	Vegetable oil sludge
W. Oceania	6	Vegetable oil sludge
W. Asia	5	Vegetable oil sludge
The World	**16.436**	

Source: S&T2, 2009.

Figure 9. Biodiesel Production in the European Union



Source: EEBB, 2009.

producing countries are Germany, France, Spain and Italy. These four countries are responsible for over 60% of biodiesel production in Europe (see Figure 9).

In recent years, Germany has led the biodiesel production, significantly increasing it, followed by France and Italy. The United States is one of the countries with the highest production worldwide. where it has significantly increased from 100 million gallons in 2005 to 700 million gallons in 2008 and is mainly used in school buses and public transport. Colombian biodiesel production is approximately 426,000 tons a year.

5.1.3 Biogas production

China and India are the countries that use the most biogas. Millions of household biogas digesters have been installed for treating cattle and swine manure. According to a World Bank report (Martinot; Planete-Engies, 2007) there are approximately 10 million households in developing countries using biogas for lighting. At the same time, several European countries have built centralized methanization facilities (Denmark, Italy, Spain, the Netherlands, Germany).

Asia has a high potential for biogas because the continent has a large amount of palm oil waste, sewage and manure. The countries with highest power generation using this technology are India, the Philippines, Malaysia, Thailand, Indonesia and China. China's biogas production target is to send 3 GW to the electricity grid by 2020.

In Malaysia, there are approximately 400 palm oil extraction mills producing approximately 45 million tons of effluent (Palm Oil Mill Effluent-POME). It is estimated that the potential for power generation from these effluents is above 300 MW (Rcogenasia, 2009). In Thailand, the installed capacity of biogas plants was above 40 MW in 2008 while the estimated potential was over 300 MW.

In Europe, recent years have seen an increase in biogas generation. By 2010, nearly 5,900 biogas plants with an electrical capacity of 2,300 MW had been installed and were operating. However, over the next five years, over 3,000 biogas plants with a capacity of 1,700 MW will be built. Germany has become the world's leading biogas generator: it built 820 plants in 2006, increasing the total number of installed production units to 3,700 and expanding production from 1.6 to 1.9 million TOE (tonnes of oil equivalent). In 2006, total biogas production in Europe stood at 5.35 million TOE, 58% of which was obtained from landfills, 18% from wastewater treatment plants and 24% from other sources (agricultural biogas, methanization of municipal waste and co-digestion units).

In the United States, manure is used to produce 6,332 MWh/year, of which 3,148 MWh/year are obtained from waste from pig farms. North Carolina and Iowa are the states with the largest contribution (see Figure 10). The remaining 3,184 MWh are mainly obtained from livestock farms, where California is the state with the highest production.

In the United States, other raw materials have been sought such as whey, a residue from cheese manufacturing, as in the case of the Fairview factory in Pennsylvania, owned by John Koller & Son, who, with an investment of $2.2 million USD, hope to produce 40 million cubic feet of biogas (28 million cubic feet of natural gas), equivalent to 22.4 GJ (Merrett, 2007).

In Brazil, Mexico and Colombia, projects are underway to obtain biogas from landfill waste, where the methane produced is recovered and used for power generation. Projects are also being undertaken in conjunction with the EPA to install biodigesters in pig farms, seeking to reduce greenhouse gas emissions equivalent to more than 100,000 tons of carbon dioxide a year while giving each farm renewable energy. At the same time, projects exist to build small biodigesters designed for domestic sewage treatment and supply families with biogas (IRRI, 2010).

In South American countries, small projects are being developed to obtain biogas for energy production. One of these is Chile, where Metrogas and Aguas Andinas process biogas plant at the Farfana Wastewater Treatment Plant. This project benefits 30,000 customers and is expected to be reduce annual CO_2 production by 22,000 tons, equivalent to preventing the burning of over 8,200 tons of coal a year or reforesting 3000 hectares of forest. In Argentina, the Citrusvil company has begun large-scale production of energy from biogas. That is the first biogas plant in the Argentinian provinces and the first one worldwide to use lemon waste as raw material (GreenMomentum, 2009).

5.2 Biofuels for Air Transport

The current worldwide aviation fuel market (jet fuels or kerosene) is approximately 5.5 million bpd ~ 875 million liters/day (a 4.9% annual increase). According to Freire (2011), jet fuels are responsible for 3% of global GHG emissions, a figure that is expected to triple by 2050.

Nowadays, there is growing concern about emissions from the aviation industry. It has been pointed out that it should make an effort to alleviate GHG emissions from jet fuels. The main efforts include:

- Development of more efficient engines and reduction of fuel consumption, in other words, greater passenger-mile efficiency
- Optimization of airlines
- Replacement of jet fuels by biofuels (biojet fuels)

According to the IEA (2009), by 2030, nearly 30% of air transport energy consumption is expected to be replaced by Biojet fuels. Moreover, there are agreements within the aviation industry on the issue, which should be fulfilled in the coming decades. Obviously, one important aspect to consider is the fact that the biofuel used in this replacement should meet all technical requirements such as the following:

- High calorific value (min 42.8 MJ/ kg)
- High Density at 15°C (between 775 and 840 kg / m^3)
- Suitable volatility (atmospheric distillation temperature of between 200 and 300°C)
- Low freezing point (max - 47°C)
- Viscosity at -20°C (max 8 mm^2/ s)
- Flash point above 38°C.
- Freezing index of less than or equal to minus 47°C (-47°C)
- Viscosity (cSt) at -20°C and -40°C should be less than 8.0 cSt and 12.0 cSt, respectively.
- Sulfur content of less than 30 ppm
- Density of 775 -840 kg/m^3
- Non water soluble
- Chemically stable with low corrosion potential.

Other considerations for replacing jet fuels are:

- Fossil fuel should be completely replaceable by Biojet Fuel (drop-in fuels, ASTM D4054), meaning that it can be blended without having to adapt or modify existing infrastructure.
- Low level of CO_2 emissions throughout the entire production cycle, from raw material

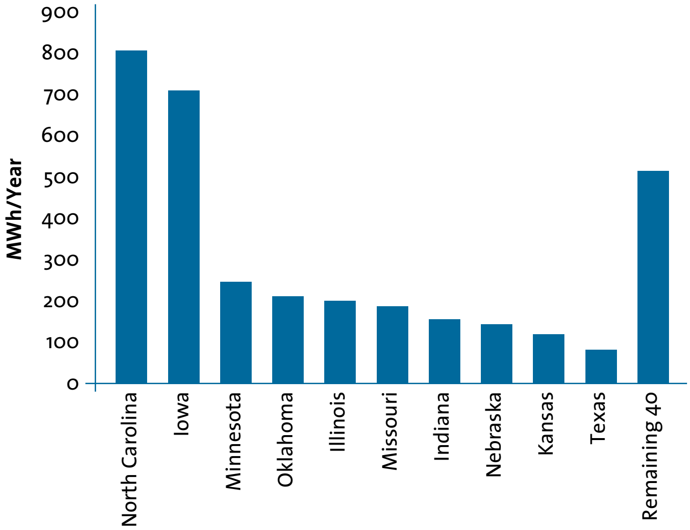
growth through transportation, processing, refining, distribution to end use. This is one of the main research and development topics in Biojet fuels.

- Biojet fuel production should be sustainable, in other words, it should not compete with food production or land use. It should improve socioeconomic conditions, involve low water consumption, produce low air and water contamination, and create a low negative impact on biodiversity and soil.

Since these considerations are feasible, global sustainability of biofuels for the aviation industry is expected in the near future.

Recent studies on aviation biofuels conducted in Brazil provide an overview of the research required for the production of sustainable biofuels for aviation.

Figure 10. Power Generation by States in Pig Farms



Source: Rcogenasia, 2009.

6. Biomass Outlook

The increase in bioenergy production is related to the policies and economic assistance provided to promote it. Due to the environmental problems caused by its disposal and its low cost, agricultural and livestock biomass waste is the source of renewable energy for power generation of choice. The synergy between food production and bioenergy leads to a reduction in food prices, an increase in the supply of energy sources, a regulatory effect on fossil fuel prices and prevents the excessive generation of GHG and other pollutants (Rincon J.M., Gastón R., Islas J.M., Lizarde J.E., 2014).

In the case of wood energy from dedicated crops, competition for land used for food should be avoided, since this could reduce the food supply by displacing food crops. It is essential to have clear policies for regulating food chains and sustainable energy, and evaluating the effect of the use of agricultural waste and establishing possible synergies in food production and bioenergy generation.

This chapter has discussed several routes permitting the conversion of biomass into electricity, heat or chemical energy stored in the production of liquid biofuels. Heat production through the direct combustion of biomass is currently the main application of bioenergy worldwide, since it can sometimes have competitive prices with fossil fuels (Eh C) such as the aforementioned examples of the use of agro-industrial waste to generate electricity and cook food in the countryside.

There are very few gasification and commercial F-T synthesis plants because of the complexity and cost of this technology. It is possible that in the long term, however, this type of operation will be profitable due to the use of new catalysts and the development of high efficiency reactors for smaller volumes of synthesis gas, which would be important as this technique results in lower emission than other pollutants using biomass as fuel. Other technologies for producing energy from biomass, such as the organic Rankine cycle and Stirling engines are currently operating on a small scale.

In the transport sector, first generation biofuels are widely used in several countries, such as biodiesel from oil crops, waste oils and fats, or bioethanol whose main sources are starch- and sugar-rich crops. Current biofuel production costs vary significantly, depending on the demand for raw material and production costs. First-generation biofuels have great social and environmental challenges, although these can be mitigated by regulating and ensuring sustainability. The development of technology is also advancing the obtainment of second-generation biofuels, based on non-food biomass, such as lignocellulosic raw materials including organic waste, high-yield forest residues, wood and energy from crops and algae. The use of these raw materials for the production of second-generation biofuels can significantly reduce potential pressure on land use, improve the reduction of greenhouse gas emissions in comparison with certain first-generation biofuels, and create lower environmental and social risks.

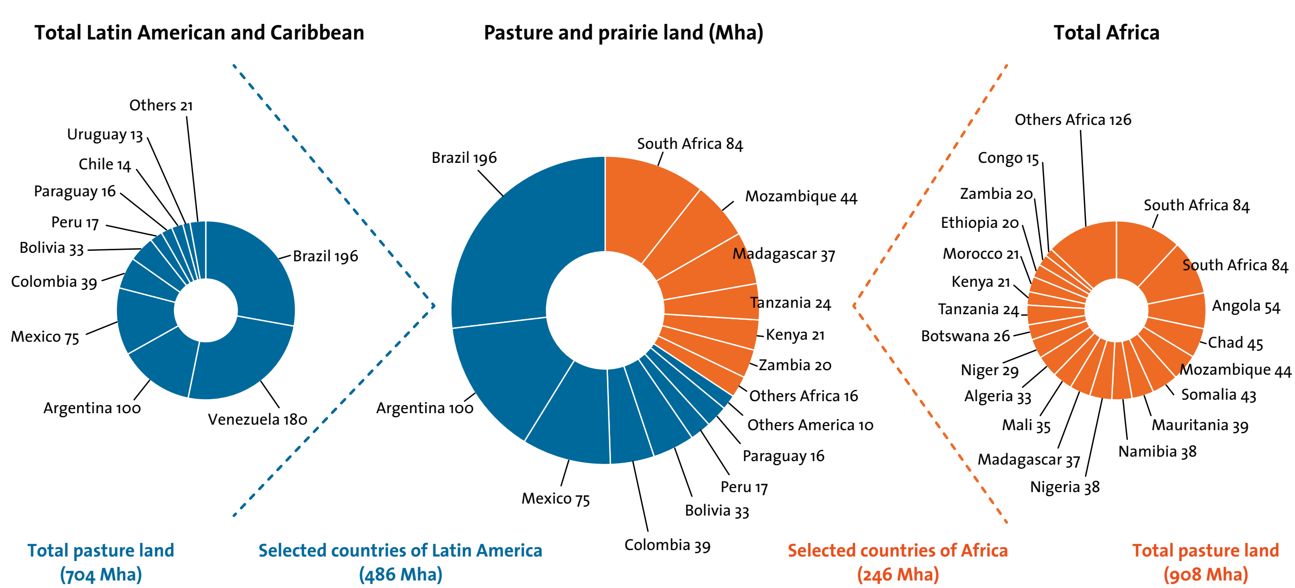
It is necessary to develop new biofuel technologies, and strengthen existing or emerging technologies to improve the efficiency, reliability and sustainability of bioenergy chains. This would lead to cleaner systems in the field of combustion; the development of smaller and more profitable electricity or cogeneration systems, which could better adapted to the availability of local resources, in the electricity sector; while in the transport sector, improvements would result in better quality and generally more sustainable biofuels.

There are a number of barriers to implementing biomass as a permanent source of energy. Among the most common is the dependence on energy infrastructure and institutions, financial barriers, including the cost of clean energy technologies, the difficulty of finding sources of funding, fuel prices and regulatory practices that prevent the absorption of bioenergy. In our part of the world, there is very little knowledge appropriation coupled with a need for pilot and demonstration plants to train human resources with experience. Sugar mills are located on the best land and, although they produce alcohol to transport electricity to the grid and enough sugar for human consumption, there are pressure groups protesting the lack of policies to avert a food crisis (Rodríguez, 2008).

The technology employed in bioenergy use is easy to learn and develop, and specific to each application. The development of processes for using biomass permits the creation of companies in the various links in the chain, which boosts the economy-especially in rural areas, since the use of biomass is labor intensive throughout the chain from planting, harvesting, transport and adaptation to generation, and is therefore considered a source of job creation.

In the case of bioenergy, it is suggested that biomass be used in combination with the integration

Figure 11. Available land in Africa and Latin America



Source: FAO, 2008.

of the rural, energy and environmental sectors through process research and the development of demonstration plants. This will make it possible to show the competitive advantages in the short term and install commercial plants in the medium and long term, for widespread use in electrical and thermal generation and biofuel production.

According to Doornbosch and Steenblik (2007), 60% of the world's potentially available land could be used for bioenergy products in 2050 (440Mha), of which about 60% (250Mha) will be in Latin America and the Caribbean, and 40% (180Mha) in Africa. Since the land available for bioenergy will largely be provided by rangelands, Figure 11 provides an estimate by country, based on FAO data.

The global scale of bioenergy production will depend on the availability of fertile land with good climate conditions. If food production is increased to meet future needs and protect biodiversity, the world will obviously basically depend on Latin America and the Caribbean as well as Africa, the most suitable continents for the future expansion of bioenergy.

The LACAf-Caña project, a joint action by the Bioenergy Program (BIOEN) of FAPESP and IANAS, focuses on these two continents and will assess ethanol production from sugar cane for four countries: Colombia, Guatemala, Mozambique and South Africa. A diagnosis of the energy and food situation will initially be carried out, followed by an evaluation of the agricultural and ethanol production potential and, lastly, an assessment of the bioenergy production model in these countries. The production of bioelectricity from sugarcane will also be considered important because of its impact on rural development and its synergy with ethanol and sugar production (LACAF).

7. Proposal for the reduction of emissions in transportation fuels

Nowadays, transport biofuel production, both first- and second-generation, is more expensive than that of fossil fuels and no immediate change is in sight. Given the large amount of fossil fuels recently obtained through processes such as *fracking*, the United States is now the world's largest oil producer and does not need to import this resource. This has increased supply in the domestic market, driving prices down (Portafolio, 2013).

It is therefore necessary to find mechanisms to make sustainable biofuel production viable. Given these considerations, biofuel financing is proposed through the following scheme:

Create a program to reduce emissions from the use of fossil fuels for transport, which will have a global economic fund for biofuel research and development. This will be financed by a tax on consumers and will be collected through all the producers of fossil fuels for transport, including those derived from oil, coal and gas. This R & D fund will contribute to research on and the economic sustainability of the world's biofuels production plants.

Although this might sound like wishful thinking, on the basis of the following assumptions, it is a feasible proposal:

1. Since emissions are universal, the part of the world where emissions are produced or mitigated is immaterial.
2. Countries and economic organizations have signed the emissions reduction program.
3. Fossil fuel users recognize the environmental impact, and establish prices associated with an international monitoring body, which will create the proposed fund.
4. The producers of biofuels for transport enrolled in the program receive a grant through the R&D fund that has been created.

On the basis of the above assumptions, we can assume the following scenarios for the countries or organizations involved: (I) a country or organization, which, because of its size or policy, does not produce biofuels, becomes a contributor to the fund, (ii) a country or organization where all transportation fuels are biofuels, becomes a recipient of the fund, and (iii) a country or organization that produces biofuels (regardless of whether they are for domestic consumption or export) and uses fossil fuels, is both a recipient of and contributor to the fund. Needless to say, this mechanism for the development of biofuels can be applied in any country or organization regardless of the level of development.

Similar proposals to this already exist, such as the one put forward by J. Richards and Boom (2014), who propose charging the major operating companies of fossil fuels a tax in order to obtain $55 billion USD annually. This fund would be used for programs to repair the environmental damage due to climate change, in developing countries (the ones most affected by the use of such fuels). This proposal could serve as the start of a discussion of feasible mechanisms to achieve energy security and mitigate the GHG emissions caused by fossil fuels, and thus achieve the reduction of GHG emissions through the research and development of biofuels and of renewable energies in general.

José María Rincón Martínez

Chemist graduated from the National University of Colombia (1964), he studied Master of Science Fuels at the University of Manchester Institute of Science and Technology, England. He served as chief of Manuelita Sugar Mill Laboratory and director of Shell chemical plant in Colombia. He was Professor of Chemistry Department at the National University from 1971, where he created the research Laboratory of Fuels and named honors as an associate professor emeritus. He is Tecsol Industries founder, company dedicated to research and development of chemical processes in the energy and environmental area, cofounder of Corpoema, an organization dedicated to consulting in public and private energy sector, he also created the Latin American Network of Bioenergy, and was participant the international editorial board of the journal Fuel. Member number of the Colombian Academy of Sciences, he has made more than 80 publications, Editor of the Energy book: their prospects, their conversion and uses in Colombia, and co-editor of the Bioenergy book: sources, conversion and sustainability. Currently he is a contributor to the Sugar Mills Industries in the evaluation of Biofuel Potential and develops rural electricity generation projects from renewable energies.

Luís A. B. Cortez

Full Professor at the Faculty of Agricultural Engineering at UNICAMP and Vice-Rector of International Relations of UNICAMP. At São Paulo State Research Foundation-FAPESP acts as Adjunct Coordinator for Special Programs. Coordinated projects in Bioenergy such as a study on sugarcane ethanol expansion in Brazil; the FAPESP Public Policy Ethanol Project in R&D for sustainable ethanol production - book “Sugarcane Bioethanol: R&D on sustainability and productivity” published in 2010. Coordinated the Project “Roadmap on Sustainable Biofuels for Aviation in Brazil” - book published in 2014. Presently coordinates the FAPESP/LACAf-I Project to promote bioenergy in Latin America and Africa and is also involved in organizing a new initiative in Bioeconomy in São Paulo State, the Agropolo Campinas-Brazil..

Glossary

Climate Change: The alteration of the Earth's climate due to natural factors or as a result of human activity, including the burning of fossil fuels and deforestation, resulting in a high concentration of greenhouse gases.

Bioenergy: This is a type of renewable energy produced from the use of organic and industrial materials formed by a biological or mechanical process, usually substances that are living organisms or their remains and debris.

Fossil fuels: Geological deposits of buried combustible organic materials, formed by the decomposition of plants and animals, subsequently converted into crude oil, coal, natural gas or heavy oils when subjected to the heat and pressure of the crust for hundreds of millions of years.

Pellets: Agglomerated material, such as solid biomass, biomasa sólidaconsisting of very small cylinders a few millimeters in diameter.

Wood energy: Energy obtained from solid, liquid and gaseous biofuels derived from primary and secondary forests, trees and other forest vegetation.

Second generation fuels: fuels produced from raw materials that are not food sources.

Co-firing: Joint combustion of two types of fuel in a single device, e.g. biomass-coal.

F-T synthesis process: Converting a fraction of synthetic fuels formed by carbon monoxide and hydrogen into light hydrocarbons such as gasoline, kerosene and gas oil through a metal catalyst.

BLB: Barrels of liquid biomass per day

MIBK: Methyl Isobutyl Ketone

Bpd: Billion tons per day

IGCC: Integrated Gasification Combined Cycle

CHP: Combined Heat and Power

References

Biofuels Digest (2011). *The world's most widely read biofuels daily*. Retrieved from: http://www.biofuelsdigest.com/bdigest/2011/05/09/ontario-picks-rentech-for-1-3m-tonne-wood-biofuels-to-jet-fuel-project-can-the-us-catch-up/

(S & T) 2 (November 23, 2009). *GHG emission reductions from world biofuel*. Retrieved from http://www.globalrfa.org

REGLE (2004). Retrieved July 25, 2010 from http://www.reegle.info/countries/germany-energy-profile/DESjaak

REGLE (2004). Retrieved July 25, 2010 from http://www.ieabcc.nl

ECN (2006). Retrieved in 2014 from http://www.ecn.nl/docs/library/report/2006/c06019.pdf

Planete-Engies (2007). Retrieved in 2010 from http://www.planete-energies.com

NETL (2008). Retrieved in 2011 from http://www.netl.doe.gov/

S&T Emission Reductions from World Biofuel. (2009). Retrieved in 2010 from http://www.globalrfa.org

Asocaña (2010). Retrieved in 2010 from El futuro del alcohol de segunda generación en el sector sucro - alcoholero colombiano: http://www.asocana.org/

Censolar (2010). Retrieved in 2010 from http://www.eco2site.com

Ministerio de Comercio Exterior y Turismo de Perú (2010). Retrieved in 2010 from http://www.mincetur.gob.pe

SECO (2010). Retrieved in 2010 from http://www.seco.cpa.state.tx.us

Rentech (2013). Retrieved in 2013 from www.rentechinc.com

Clean Technica (2014). Retrieved in 2014 from http://cleantechnica.com/2014/06/09/first-industrial-scale-municipal-solid-waste-biofuel/

EPA (2014). Retrieved (falta mes) 6, 2014, from 2. http://www2.epa.gov/sites/production/files/2014-05/documents/20140602proposal-cleanpowerplan.pdf

Bauen, A. B. (05 de 2009). *Bioenergy- A sustainable and reliable energy source*. Retrieved from http://www.ieabioenergy.com

Bernd Linke Leibniz, I. f.-B (2015). *IEA Bioenergy Task 37*, Berlin, Germany. ATB.

Boom, J. R. (2014). Carbon majors Funding loss and Damage.

Business, T. G. (June de 2014). *ie Business School*. Retrieved from Be ahead of the energy future: http://www.ie.edu/executive/management/IEP%C2%B4S/RENEWABLE%20ENERGY/The%20Global%20Renewable%20Energy%20Business%20brochure%20June%202014.pdf

C&EN, C. a. (2011). Retrieved from http://cen.acs.org/magazine.2011.all.asc.0.html

Censolar ((Falta mes) 2, 2004). *Biodiésel en el mundo*. Retrieved from http://www.eco2site.com

CONCEREAL (2011). *Norma Europea sobre la calidad del pellet: EN 14961-2*. Retrieved from http://www.concereal.es/norma_EN14961-2

Cortez, L. (2014). *Roadmap for sustainable aviation biofuels for Brazil*. (Blucher, Ed.) Retrieved from http://blucheropencacc ess.com.br/issues/details/4

EEBB (2009). *The EU biodiesel industry*. Retrieved from http://www.ebb-eu.org

EIA (s.f.). Retrieved in 2014, from http://www.eia.gov/todayinenergy/detail.cfm?id=12331

EIA (s.f.). Retrieved in 2014, from http://www.eia.gov/cfapps/ipdbproject/iedindex3.cfm?tid=79&pid=79&aid=1&cid=r1,r2,&syid=2007&eyid=2011&unit=TBPD

EIA (2014). *U.S. Energy Information Administration*. Retrieved from http://www.eia.gov/forecasts/aeo/

Energy. Gov. (undated). Retrieved from http://www.energy.gov/

Enerkem (2014). Retrieved June 2015, de http://enerkem.com/

EPA(June2,2014).*RegulatoryImpactAnalysisfortheProposed Carbon Pollution Guidelines*. Retrieved from www2.epa.gov/sites/production/files/2014-06/documents/20140602ria-clean-power-plan.pdf

European Commission, E. (2013). *Producción e importaciones de energía*. Retrieved from http://epp.eurostat.ec.europa.eu/statistics_explained/index.php/Energy_production_and_imports/es

FAO (11 de 2008). Food and Agriculture Organization of the United Nations. *Climdata Rainfall Database. Rome United Nations Food and Agriculture Organization, Sustainable development department, agrometeorology group, 1997. In: BNDES & CGEE; Bioetanol de cana-de-azucar*. Rio de Janeiro

GBEP, G. B. (December 2011). *The Global Bioenergy Partnership Sustainability Indicators for Bioenergy*. Retrieved from http://www.globalbioenergy.org/fileadmin/user_upload/gbep/docs/Indicators/The_GBEP_Sustainability_Indicators_for_Bioenergy_FINAL.pdf

IEA (11 de 06 de 2010). IEA. Retrieved in 2014, from http://www.iea.org/aboutus/glossary/b/

IEA (2014). *Renewable Energies*.

IRENA, I. R. (September 2014). *Global Bioenegy Suppy and Demand Projects*. Retrieved from https://www.irena.org/remap/IRENA_REmap_2030_Biomass_paper_2014.pdf

IRRI (2010). *Biodigestores para familias rurales*. Retrieved from http://www.irrimexico.com

LACAF (s.f.). *Bioenergy contribution of Latin America & Caribbean and Africa to the GSB Project*. Retrieved from http://bioenfapesp.org/gsb/lacaf/

Loo, S. v. (June 2014). *Biomass Combustion and Cofiring*. Retrieved from http://www.ieabcc.nl

Merrett, N. (2007). *Cheese waste offers whey for energy cost cutting*. Retrieved from http://www.foodproductiondaily.com

NETL (November 2008). *Carbon Sequestration Atlas of the United States and Canada*. Obtained from: The U.S. Department of Energy .

NEXTFUEL (February 26, 2015). *Portal de información y noticias sobre biodiesel y energías renovables*. Retrieved from Biojet, aerolíneas de Japón valorán con biocombustibles at 2020: http://biodiesel.com.ar/8999/biojet-aerolineas-de-japon-volar-an-con-biocombustibles-en-2020

Parveen Fatemeh Rupani, R. P. (2010). Review of Current Palm Oil Mill Effluent (POME) Treatment Methods. World Applied Sciences Journal, 70-80.

Peksa-Blanchard, M. (2007). *Global wood pellets markets and industry: policy drivers, market status and raw material potential*. Minnesota: I.B.T. 40.

Planete-Engies (2007). Retrieved from http://www.planete-energies.com

Portafolio (November 12, 2013). *EE.UU. será el mayor productor mundial de petróleo en 2015*. Retrieved from http://www.portafolio.co/internacional/el-mayor-productor-mundial-petroleo-2015

Rcogenasia (2009). *Your search for sustainable solution in energy and environment ends here*. Retrieved from http://www.rcogenasia.com

RFA (2008). *Producción mundial de combustible etanol*. Retrieved from http://www.ethanolrfa.org

Rincón J. & Guevara P. (2013). *Generación de electricidad con biomasa*. CREG.

Rincón J. & Mejía R. & col. (2014). *Bioenergía: fuentes, conversión y sustentabilidad*. Bogotá: Red de Bioenergía .

Rincón J.M., Gastón R., Islas J.M.,Lizarde J.E. (2014). Potencial de la biomasa y perspectivas en diferentes paises. In R. M. Electo (Ed.), *Bioenergía: Fuentes, conversión y sustentabilidad*. Bogotá, Colombia: Red Iberoamericana de Aprovechamiento de Residuos Orgánicos en Producción de Energía.

Rincón, J, M., Romero, G., Camacho, A., & Montenegro, E. (1996). *Combustibles de transporte y medidas para reducir la contaminación. Uso de combustibles oxigenados a la altura de Bogotá*. Bogota: Universidad Nacional.

Rincón, J. (December 30, 2010). *Capítulo 7: Biomasa*. Retrieved from Formulación de un plan de desarrollo para las fuentes no convencionales de energía en Colombia PDFNCE: http://www.upme.gov.co/Sigic/DocumentosF/Vol_2_Diagnostico_FNCE.pdf

Rincón, J. (2013). Formulación de un Plan de Desarrollo para las Fuentes No Convencionales de Energía en Colombia (pdfnce) . *Volumen 3 - Elementos de política, riesgos ante el cambio climático, complementariedad entre las FNCE y el sin, y costos indicativos de l.*

Rincón, J., & Guevara, P. (2013). *Generación de electricidad con biomasa; Creg*. Creg.

Rodríguez, M. (2008). *Los biocombustibles en Colombia a debate*. Foro de Biocombustibles.

SECO (2010). Retrieved from http://www.seco.cpa.state.tx.us

Zhou, H., Jing, B., Zhong, Z., & Hiao, R. (2005). Airsteam coal partial gasification in an atmosphere fludized bed. *Energy and Fuels*, 1619-1623. iedindex3fm?tid=79&pid=79&aid=1&cid=r1,r2,&syid=2007&eyid=2011&unit=TBPD

Box

Renewable Energy projects in the Dominican Republic

Julian Despradel | Dominican Republic

Projects Developed to be integrated to the National Grid:

1. Solar:

a. Monte Plata Solar farm (to start operation in April 2016). Location: Monte Plata. Capacity: 30 mW first phase / 30 mW second phase
Contact person:
Ing. Alfonso Rodriguez Villalba
a.rodriguez@soventix.com

2. Wind:

a. Quilvio Cabrera
Location: Quancho, Perdenales
Capacity: 8 mW

b. Los Cocos wind farm
Location: Quancho, Perdenales
Capacity: 80 mW

c. Larimar wind farm (to start operation in Mid 2016)
Location: Quancho, Perdenales
Capacity: 50 mW

Contact person: (to all projects)
Ing. José Rodríguez: rodriguezj@egehaina.com

3. Biomass:

San Pedro BioEnergy (to start operation in Mid 2016)
Location: San Pedro de Macoris
Capacity: 30 mW
Contact person:
Ing. Cesar Santos
cesar.santos@spbesa.com

Projects integrated with the "Net Metering Regulation: (started in 2012)

This projects are Solar PV systems installed in homes and commercial buildings

Animal waste Biodigestors (Porc and chiken farms)

About 20 biodigestors of different sizes and capacities have been built and others are under construction in pigs and chicken farms for self electricity generation.

Contact person:
TerraLimpia: www.terralimpia.com
Ing. Carlos Porrello: cporrello@terralimpia.com

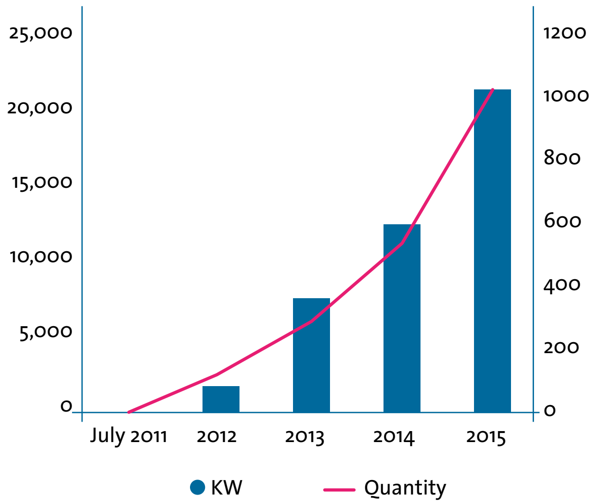
Total Projects installed until December 2015

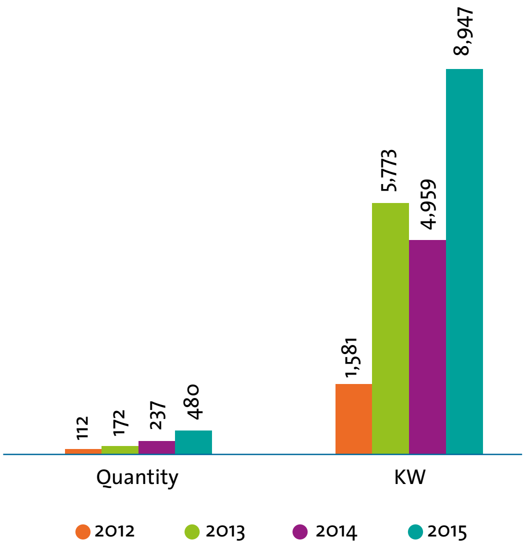
Company	Clients	Installed Capacity kW
Cap Cana Caribe	2	33
CEB	2	10
CEPM	33	896
Corp. Punta Cana	6	240
Costasur Dominicana	1	8
EDEESTE, S.A.	86	1,662
EDENORTE Dominicana, S.A.	475	10,127
EDESUR Dominicana, S.A.	325	7,884
El Limón	8	26
Luz y Fuerza	63	325
Puerto Plata Electricidad	1	50
Total	**1002**	**21,260**

Source: National Energy Comision (CNE). www.cne.gob.do

1. Renewables Energies and Energy Efficiency Consultant. julian_despradel@yahoo.com

Monte Plata Solar farm. Capacity 30 mW





Source: National Energy Comission (CNE): www.cne.gob.do

Chapter 6

Trucks loaded with sugarcane plants enter the mill at Unidade Industrial Itamaraty SA's processing plant, Nova Olimpia, Mato Grosso, Brazil

Bioenergy

Current status and perspectives for bioenergy in Latin America & Caribbean: addressing sugarcane ethanol

Carlos Brito-Cruz | Brazil

Luís A. B. Cortez | Brazil

Luiz. A. H. Nogueira | Brazil

Ricardo Baldassin Jr. | Brazil

José M. Rincón | Colombia

Summary

The availability of land for agriculture expansion in the world is highly concentrated in two continents: Latin America and Africa. This work analyzes the perspectives for the production of modern and sustainable bioenergy in Latin America, a region that already boasts successful examples of national programs such as Brazilian sugarcane ethanol and Colombian palm oil. This work also analyzes the current status of Latin American countries concerning energy and food securities.

It shows that, in general, the region has made significant progress in increasing both energy and food securities and that many countries are even prepared to play a more important role globally in the areas of energy and food supplies. The text also highlights the potential to increase sugarcane bioenergy, specifically bioethanol and bioelectricity, which can play an important role in the socio-economic development path.

A brief summary is given of each country's energy situation and the way sugarcane bioenergy can positively impact these economies. Lastly, a brief introduction is given to the Global Sustainable Bioenergy Initiative, more specifically the LACAf Project, a joint collaborative project involving FAPESP and IANAS, among other research institutions.

1. Bioenergy in the World and Latin America & Caribbean

Bioenergy can be divided in traditional biomass[1] and modern bioenergy,[2] according to the efficiency and sustainability in its production and use. Traditional biomass has played an important role in developing countries, including Latin America and the Caribbean (LAC). In 2012 the population relying on fuelwood and biomass residues for cooking in developing countries and LAC reached 49% and 15%, respectively (REN21, 2015). However, modern bioenergy is expanding its contribution to the global energy matrix.

In 2012 bioenergy[3] represented 10.1% of total energy world demand (IEA, 2014), while traditional bioenergy still accounts for 5.7% of total worldwide or 56.4% of total bioenergy (Figure 1).

For 2040 bioenergy energy demand is projected to 1,933 Mtoe (10.9% of total energy demand), while modern bioenergy will be responsible for 11.7% of total worldwide or 70% of total bioenergy (IEA, 2014).The participation of modern and sustainable bioenergy has been increasing its share but its growth is more concentrated in developed countries of Europe, North America, Southeast Asia, but also in few countries of Latin America such as Brazil, Colombia, and Argentina (Figure 2).

One of the best examples of modern bioenergy use in large scale is the Brazilian sugarcane ethanol program (Proálcool) launched in 1975. In 2014, sugarcane in Brazil responded for 34% of liquid fuel for light vehicles (ethanol) and 18% of the primary energy production (EPE, 2015).[4] Other important examples in the continent are the cases of US corn ethanol, the Argentina's soya biodiesel and the Colombian palm oil biodiesel. Several other Latin American countries, such as Paraguay, Peru, Costa Rica, Jamaica, Ecuador, etc, implemented official bioenergy programs with the intention to decrease energy dependence and boost economic development by creating new jobs and helping the rural sector (IRENA, 2014; REN21, 2015). These efforts have achieved varied, in most cases limited, degrees of success.

It is recognized that modern and sustainable bioenergy production may be an effective way to substitute substantial portions of energy demand for transportation in the future (IRENA, 2013). Among the biofuels initiatives on a global level are: regulatory policies on transportations biofuels with several blending levels in progress in 64 countries (REN21, 2015); and an ambitious targets for addressing carbon emissions on aviation by 2050 (including, among other, drop-in biofuels) (IATA, 2013). In terms of potential biofuels production and supply, a study confirmed the potential for Brazil alone to substitute 5% of global gasoline demand in 2025 using sugarcane bioethanol (CERQUEIRA LEITE et al., 2009), and an important global project, the Global Sustainable Bioenergy - GSB Initiative (http://bioenfapesp.org/gsb/index.php) is investigating the possibility of substituting as much as 25% of global energy demand by modern sustainable bioenergy by 2050. The potential for LAC contribution in these efforts is considered to be very important both because of availability of land and climate conditions and favorable demographic and technological capabilities encountered in the region and will be treated in this chapter.

1. Refers to the use of wood, charcoal, agricultural resides and animal dung for cooking and heating in the residential sector, typically with very low conversion efficiency (10% to 20%) and often unsustainable supply.

2. Modern bioenergy or biofuels refer to biomass converted to higher value and more efficient and convenient energy carriers, such as pellets, biogas, ethanol and biodiesel.

3. Bioenergy: energy content in solid, liquid and gaseous products derived from biomass feedstocks and biogas. It includes solid biomass, biofuels and biogas. The value 10.1% includes traditional and modern uses of biomass, according agregated values presented in IEA (2014).

4. More about the Brazilian Ethanol Program in Cortez et al. (2016).

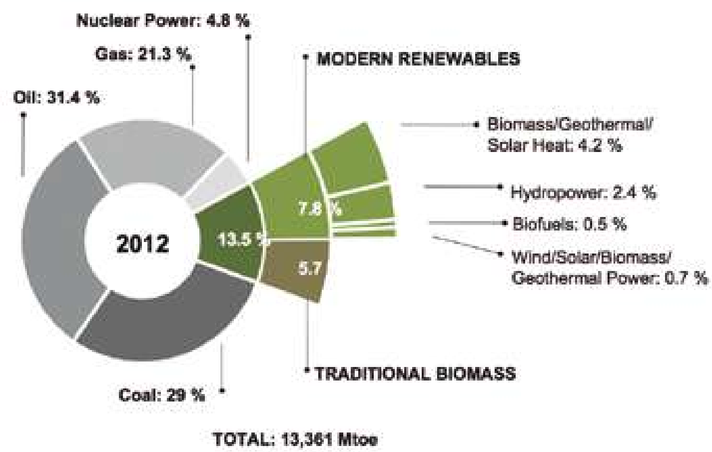
2. Sustainability challenges for bioenergy

Although it is widely accepted that modern bioenergy can help to alleviate energy dependence and increase rural development, the large scale use of bioenergy can lead to, or aggravate, environmental or socio-economic problems in situations where, for example the poor choice of feedstock does not bring a positive energy and CO2 balance or leads to loss of biodiversity or impairment of food security (IPCC, 2014; REN21, 2015; SOUZA et al., 2015).

Modern bioenergy is not necessarily a synonym to good bioenergy. Modern and unsustainable bioenergy may be as predatory as traditional extractive bioenergy possibly creating more harm by depleting natural resources than the fossil energy it tries to substitute (GOLDEMBERG and COELHO, 2004). An essential issue is to understand thoroughly the life cycle of the energy generating process and adopt sound policies that lead to a successful implementation of a modern sustainable bioenergy system. Sustainability, in its broad sense, involves not only the project economics, but overall integrated analysis considering physical, social and environmental aspects.

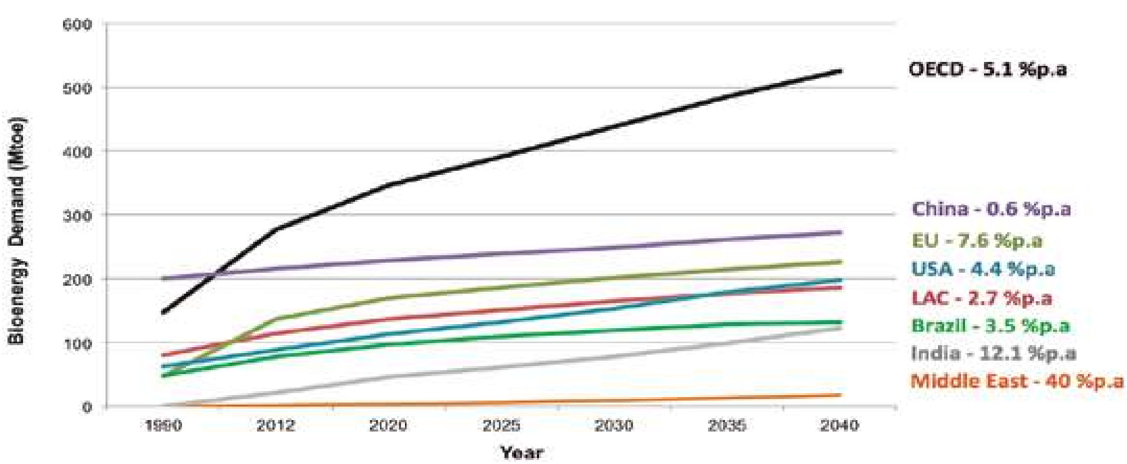
Scientific knowledge, of basic and applied nature, can helps on many sustainability related issues. For example, crop production in arid lands is a major drawback for agriculture. It is known how to grow crops using rainfed fertile land but it is necessary to make advances beyond irrigation, considering the improvement of plants to use more effective the available water. There are important challenges in plant physiology and its relation to genomics and metabolomics. Modern molecular biology knowledge might allow for the development of plants adapted

Figure 1. World primary energy supply in 2012



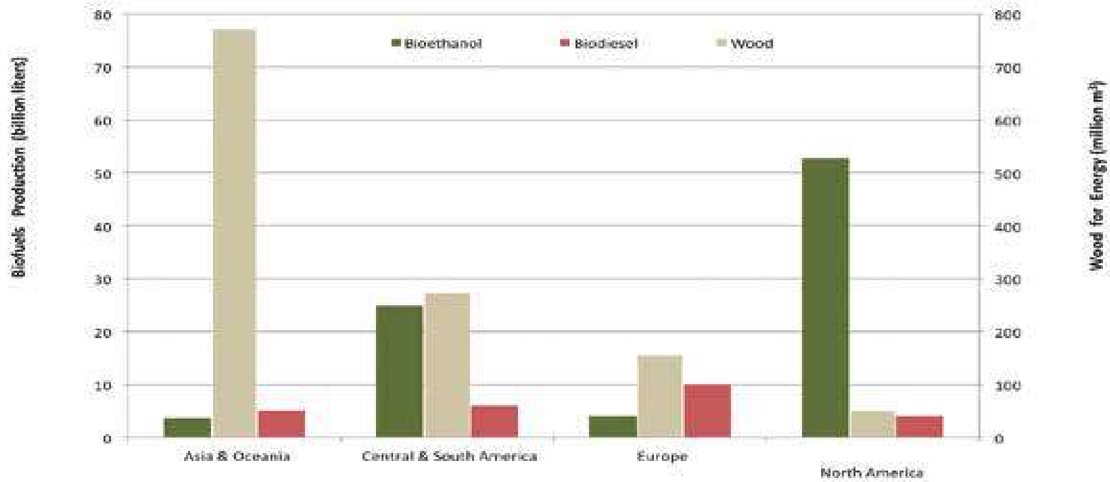
Source: IEA, 2014.

Figure 2. Bioenergy demand (1990-2040: New Policies Scenarios)



Source: IEA, 2014.

Figure 3. Biofuels and wood for energy productions (2012)



Note: wood for energy include: wood fuels (coniferous and non-coniferous), wood charcoal, wood pellets, and wood residues. Source: EIA, 2012; FAO, 2012.

for enduring rough environments. Another example relates to lignocellulosic conversion either using biochemical route such as hydrolysis or thermal route such as biomass to liquid – BTL. Despite the existence of a large base of knowledge in this area, there are still significant barriers to be overcome to enable large-scale bioenergy production worldwide.

3. Setting the perspectives of Bioenergy in Latin America

Countries in LAC make abundant use of bioenergy, traditional and modern bioenergy. In most LAC countries, traditional bioenergy use (from firewood and charcoal) shows a decreasing trend, mostly due to urbanization, although the pace varies and the regional total without modern cooking facilities remains above 60 million people. The latest data reveals notable improvements in Brazil, Colombia, Peru, and Argentina (IEA, 2015). Today, planted forests (eucalyptus and pine trees) play small role in supplying firewood and charcoal to residential sector – where traditional use occurs. On the other side, traditional biomass use impact on deforestation is not at all clear; most of land clearing is due to crops or livestock expansion, shifting cultivation, and other causes. Traditional bioenergy involves low-efficiency end-use technologies that can be improved regarding sustainability. A small number of suggestions are made on R&D to this purpose, including the efforts from The Global Alliance for Clean Cook Stoves (THE WORLD BANK GROUP, 2015). So, it is probably correct to say that there are still important challenges related to traditional bioenergy both upstream and downstream. However, in general, the major sustainability impacts of traditional biomass are upstream.

Regarding modern bioenergy the situation is more stimulating. The region has produced in the last decades several good examples of modern sustainable bioenergy production. The most important initiatives are related to biofuels and energy wood production, more specifically ethanol from sugarcane and biodiesel from soybeans and palm oil, and wood fuels, pellets and charcoal from planted forests. In 2012, LAC responded for around one quarter of world ethanol, biodiesel, and wood for energy, mostly modern bioenergy production (Figure 3).

The unsustainability regarding traditional biomass use is spread in all three sustainability pillars (social, environmental and economic). In the social sphere, the main negative impact are on human health, as results of the intensive work for collecting wood (semi-slave labor), and indoor pollution (cooking), mainly affecting women, children, and elderly. In the environmental sphere, the main impacts are the native forest degradation (deforestation, biodiversity decline, and soil degradation), and GHG emissions. In economic sphere, the low efficiencies of wood burning cook stoves and the low income generation are the main negative impacts (IPCC, 2014; LYND et al., 2015; REN21, 2015).

Among modern energy, sugarcane has a large number of positive sustainability indicators proving to be one of the most efficient bioenergy crops grown in the world (GOLDEMBERG et al., 2008; SMEETS et al., 2008; IPCC, 2014; SOUZA et al., 2015).

Table 1. Oil data: World regions and LAC selected countries (2012)

Country	Crude Oil (billion liters)					Gasoline (billion liters)				
	Production (P)	Consumption (C)	Import (I)	Exports (E)	(E-I)/C %	Production (P)	Consumption (C)	Import (I)	Exports (E)	(E-I)/C %
World	**5,252.4**	**5,398.8**	**2,634.0**	**2,487.6**			**1,312.1**	**210.5**	**233.6**	
Middle East	1,619.9	718.3	33.1	934.6	126	67.4	84.5	18.8	4.7	-17
Africa	576.3	149.7	51.5	478.1	285	22.9	51.9	26.8	1.5	-49
Europe	231.6	810.0	720.5	142.1	-71	170.9	121.7	40.5	99.4	48
Asia & Oceania	1,319.8	587.0	150.0	882.8	125	392.0	371.5	72.8	87.5	4
North America	1,040.2	1,412.3	613.0	240.9	-26	581.7	595.2	28.0	31.8	1
Central & South America	464.6	407.2	119.8	177.2	14	69.1	87.3	23.7	8.7	-17
Argentina	42.0	36.7	0.0	5.3	14	7.3	7.7	0.1	0.0	-1
Bolivia	3.3	3.3	0.0	0.0	0	0.9	1.2	0.2	0.0	-19
Brazil	154.0	145.2	21.8	30.5	6	26.8	30.8	3.8	0.2	-12
Chile	1.0	10.7	9.7	0.0	-90	3.2	3.6	0.1	0.1	0
Colombia	56.3	34.7	0.0	21.5	62	4.6	4.8	0.7	0.5	-3
Costa Rica	0.0	0.5	0.5	0.0	-96	0.0	1.0	1.0	0.0	-100
Cuba	3.0	10.5	7.5	0.0	-72	0.6	0.6	0.0	0.0	0
Ecuador	29.3	9.9	0.0	19.4	195	1.9	3.8	2.3	0.2	-54
El Salvador	0.0	1.0	1.0	0.0	-100	0.1	0.6	0.5	0.0	-89
Guatemala	0.9	0.2	0.0	0.7	400	0.0	1.3	1.3	0.0	-100
Guyana	0.0	0.0	0.0	0.0		0.0	0.2	0.2	0.0	-100
Honduras	0.0	0.0	0.0	0.0		0.0	0.7	0.7	0.0	-100
Jamaica	0.1	1.5	1.4	0.0	-92	0.2	0.6	0.4	0.2	-41
Mexico	170.8	97.0	0.6	74.3	76	23.5	45.1	21.8	0.0	-48
Nicaragua	0.0	1.0	1.0	0.0	-100	0.1	0.3	0.2	0.0	-74
Panama	0.0	0.0	0.0	0.0		0.0	0.9	0.9	0.0	-94
Paraguay	0.1	0.1	0.0	0.0	0	0.0	0.5	0.4	0.0	-87
Peru	9.3	14.0	5.8	1.1	-34	4.3	2.1	0.2	2.4	105
Uruguay	0.1	2.3	2.2	0.0	-97	0.6	0.6	0.1	0.1	0
Venezuela	156.1	71.2	7.7	92.6	119	14.5	15.7	0.5	0.5	0

Source: EIA, 2012.

4. Energy and Food Security in Latin America & Caribbean

Energy supply

The quest for energy security in LAC has encouraged many countries to implement policies to create markets for bioenergy as substitute, or as a complement, to gasoline, diesel, and also for electricity. Table 1 displays the recent situation for oil and gasoline in the world's regions and selected countries in LAC, and Table 2 shows the biofuels policies in progress in LAC. In general, just few countries have a relatively comfortable situation due to oil independence, including Venezuela, Argentina, Brazil, and Colombia. In South America, probably due to its large oil production, just Venezuela does not have any biofuels policy or program.

Electricity production is an important aspect of the energy situation in LAC (Table 3). Some countries in the region, such as Brazil, Colombia, Paraguay, and Argentina have a relatively comfortable situation due to its abundant hydroelectric generation. In some cases, the hydroelectricity traded between countries favored integration in the region, such as Brazil-Paraguay partnership in the Itaipu Binational Hydroelectric Power Plant. In other countries such as Mexico, Cuba, Jamaica, and practically all other countries in Caribbean the relative importance of renewables energies for electricity production are not as comfortable, with a significant dependence on fossil fuels for power production. For the case of bioelectricity, probably Brazil is the country in the region with best performance, particularly due to co-generation in the large existing sugar-ethanol industry. In 2014, the bioelectricity produced in sugarcane co-generation mills from bagasse represented 5.5% of whole Brazilian electricity production (EPE, 2015). The current trend to increase bioelectricity in Brazil is quite auspicious news to counterbalance the negative aspects of hydroelectricity expansion

Table 2. Biofuels Policies in LAC selected countries

Country	Biofuels Law/Program [1]	Ethanol and Biodiesel Blending Mandate [1]	Mandate Blend (%)
Argentina	in progress	in progress	E10, B10 [1,4]
Brazil	in progress	in progress	E27, E100, B7 [1]
Chile			E5 [3], B2
Colombia		in progress, subnational level	E8 [1,4], B8-B10 [1]
Costa Rica	in progress	expired, superseded or inactive	E0-E8, B0-B5 [1]
Ecuador	in progress	subnational level, in progress	E5 [1], B5 [1,4]
Guatemala		in progress	E0-E10 [2]
Honduras	in progress		
Jamaica		in progress	E10 [3,4]
Mexico	in progress	expired, superseded or inactive	E2 [3]
Nicaragua	in progress		
Panama	in progress	expired, superseded or inactive	E5 [1]
Paraguay	in progress		E24, B1 [3]
Peru	in progress	in progress	E7.8, B5 [1]
Uruguay	in progress	in progress	E5, B5 [1,4]

Notes: Colombia: E8 (mandate), E10 (target), B8 and B10 (different regionals levels); Chile: up to E5 (voluntary blending); Costa Rica: up to E8 (voluntary), up to B5 (voluntary); Guatemala: ethanol use as additive, Mexico: Guadalajara (mandate), Mexico City and Monterrey (target).
Sources: 1 – (IRENA, 2015), 2 – (GUATEMALA, 2015), 3 – (GRFA, 2015), 4 – (REN21, 2015)

Table 3. Energy Security: Electricity in World regions and Latin America & Caribbean selected countries (2012)

Region/ Country	Production (GWh)					Import (I)	Export (E)	Consumption (C)	(E-I)/C
	Total	Renewable		Biomass & Waste		(GWh)			%
World	21,530	4,716	22%	383	2%	681	669	19,713	-0.1
Middle East	907	23	3%	0	0%	19	16	793	-0.4
Africa	680	120	18%	2	0%	37	32	601	-0.8
Europe	5,063	1,287	25%	152.7	3%	453	463	4,620	0.2
Asia & Oceania	8,760	1,561	18%	97	1%	50	37	8,108	-0.2
North America	4,944	949	19%	83	2%	71	71	4,592	0.0
Central & South America	1,177	776	66%	49	4%	52	51	999	-0.1
Argentina	128	32	25%	2.4	2%	8.1	0.5	117	-6.5
Bolivia	7.3	2.6	36%	0.2	3%	0	0	6.5	0.0
Brazil	538	451	84%	35	7%	41	0.5	484	-8.4
Chile	67	25	37%	4.9	7%	0	0	63	0.0
Colombia	58	48	83%	0.5	1%	(s)	0.7	49	1.4
Costa Rica	10	9.3	93%	0.2	2%	0.4	0.4	9	0.0
Cuba	17	0.7	4%	0.6	4%	0	0	14	0.0
Ecuador	22	12	55%	0.3	1%	0.2	(s)	19	-1.1
El Salvador	6.2	3.8	61%	0.4	6%	0.2	(s)	5.7	-3.5
Guatemala	9.2	6.3	68%	1.6	17%	0.4	0.3	8.2	-1.2
Guyana	0.8	0	0%	0	0%	0	0	0.6	0.0
Honduras	7.3	3.3	45%	0.2	3%	(s)	(s)	5	0.0
Jamaica	4	0.4	10%	0.1	3%	0	0	3	0.0
Mexico	279	44	16%	2.8	1%	0.6	1.3	234	0.3
Nicaragua	4.2	1.7	40%	0.5	12%	(s)	(s)	3.6	0.0
Panama	8.4	5.4	64%	(s)	0%	(s)	(s)	7.1	0.0
Paraguay	60	60	100%	0	0%	0	48	8.1	592.6
Peru	39	23	59%	0.7	2%	(s)	(s)	36	0.0
Uruguay	10	6.5	65%	0	0%	0.7	0.2	9.6	-5.2
Venezuela	123	81	66%	0	0%	0.5	0.7	98	0.2

Source: EIA, 2012. (s) = too small

in the Amazon region, where to avoid large flooded areas when the reservoirs are created, electricity supply is being provided almost intermittently. Also in Guatemala and Nicaragua the contribution of bioenergy to electricity production is high (Table 3).

4.2 Food security

A critical issue related to bioenergy production is food security. According to (FAO, 1996), *"Food security exists when all people, at all times, have physical and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life"*.

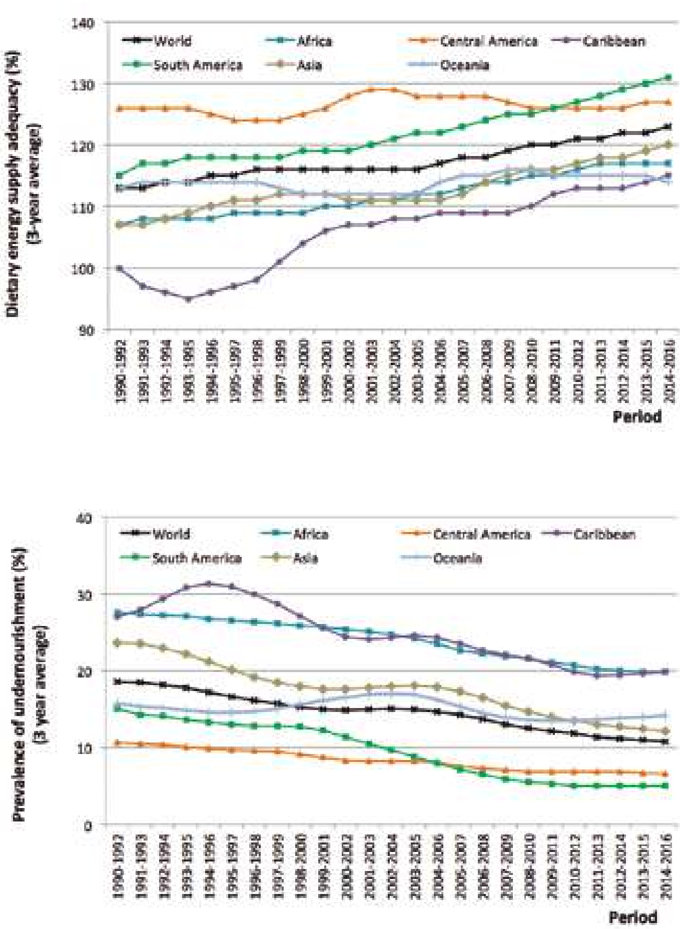
According to (FAO, 2006), food security is a complex combination of factors, including:

- Food availability: sufficient quantities of food of appropriate quality, supplied through domestic production or imports, including food aid;

- Food access: by individuals to adequate resources (entitlements) for acquiring appropriate foods for a nutritious diet;
- Utilization: utilization of food through adequate diet, clean water, sanitation and health care to reach a state of nutritional well-being where all physiological needs are met. This brings out the importance of non-food inputs in food security;
- Stability: To be food secure, a population, household or individual must have access to adequate food at all times. They should not risk losing access to food as a consequence of sudden shocks or cyclical events.

In terms of food availability, since 1997-1999 FAO's data has been showing that dietary energy supply adequacy are higher than 100% in all developing regions (Figure 4). However, the prevalence of undernourishment levels show that around 20 % of African and Caribbean people still suffer with food deficit today. According to World Hunger (2015), using data from United Nations Food and Agriculture Organization, about 795 million people (or one in nine) has been suffering from chronic undernourishment in 2014-2016. Concerning to Central and South America the undernourishment levels are around 6.6% and less than 5%, respectively. Thus, it is clear that the world hunger may be not due to food deficit, but due to lack of adequate conditions for people acquires food (no or low access).

Figure 4. Evolution of food security indicators: dietary energy supply adequacy and prevalence of undernourishment



Source: FAO, 2015.

To analyze the current situation of food security in the region, grains and cereals were taken as indicators and analyzed its production and imports by world's regions and selected countries in LAC. Table 4 summarizes the main quantities produced. In general, the LAC region is a net exporter of grains and cereals (highly influenced by Brazil and Argentina), however several Caribbean and Central America countries present high dependence of imported grains and cereals. In South America, the dependence of imports is crucial in Colombia, Chile, Peru, and Venezuela.

To illustrate the current situation of energy and food security in LAC countries, Figure 5 and Figure 6 show agriculture in(dependence) to crude oil (in)dependence and to gasoline (in)dependence, respectively. The countries with best food and energy situation are in the upper-right quadrant and the bubble size represents the area occupied with pasture and prairie land. In general, just Brazil, Argentina, and Bolivia have comfortable indicators.

In 2012, South & Central America and Caribbean responded by 51% of world sugar production from sugarcane (Figure 7). Considering the expressive production and technological/agriculture domain in sugar production (Table 5), LAC reveals a great capacity and potential to supply net quantities of agricultural commodities. This indicates also, the potential capacity presented by the region to increase production of sugarcane ethanol by converting part of its molasses and "C sugar",[5] helping to alleviate its gasoline imports, particularly in LAC countries.

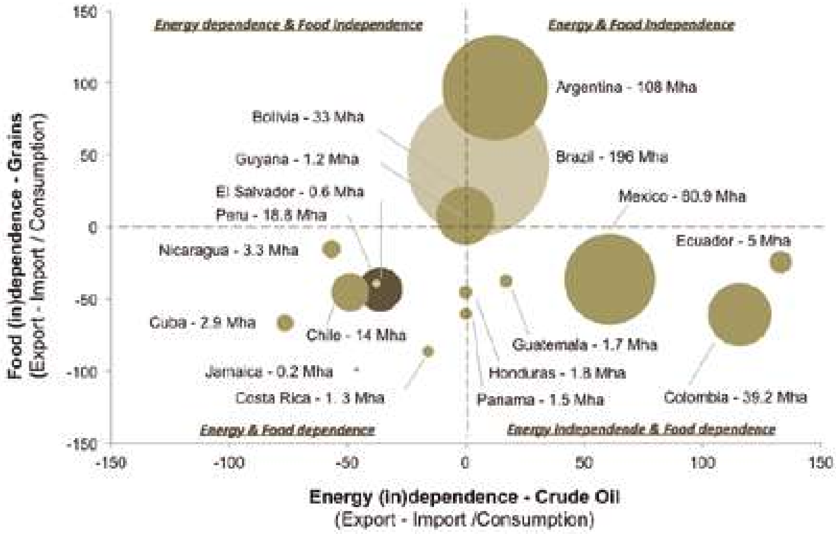
5. C sugar is the low quality dark sugar, produced exhausting the sucrose content in the sugarcane juice

Table 4. Food security: Grains and cereals in World regions and Latin America & Caribbean selected countries (2012)

Region/ Country	Grains						Cereals					
	Production (P)	Import (I)		Export (E)		(E-I)/C	Production (P)	Import (I)		Export (E)		(E-I)/C
	(Mt)	(Mt)	(billion $)	(Mt)	(billion $)	(%)	(Mt)	(Mt)	(billion $)	(Mt)	(billion $)	(%)
World	**2,862.10**	**469.6**	**215.3**	**478.5**	**200.8**	**0**	**2,563.40**	**375.9**	**133.6**	**384.2**	**125.1**	**0**
Africa	**177.4**	**75**	**28.7**	**5.3**	**4.5**	**-28**	**169**	**75**	**27.5**	**4**	**1.7**	**-30**
Europe	**431.9**	**90.1**	**37.8**	**136.2**	**45**	**12**	**421.1**	**75.9**	**26.3**	**134.7**	**41.4**	**16**
Asia & Oceania	**1,423.60**	**238.1**	**126.4**	**87.8**	**43.6**	**-10**	**1,359.80**	**161.4**	**1.8**	**89.6**	**33.7**	**-5**
North America	**498.5**	**7.9**	**4.2**	**134.2**	**61.8**	**34**	**408.7**	**9.1**	**4**	**85.5**	**28**	**23**
Caribbean	**2.61**	**5.1**	**2.2**	**0.02**	**0.01**	**-66**	**2.3**	**5.1**	**2**	**0.05**	**0.03**	**-69**
Central America	**41.1**	**25.5**	**10.2**	**1.63**	**0.8**	**-37**	**38.8**	**21.6**	**7.3**	**1.8**	**0.6**	**-34**
South America	**287**	**27.8**	**9.7**	**113.3**	**31.92**	**42**	**163.5**	**27.7**	**8.8**	**68.5**	**19.3**	**33**
LAC	**363.71**	**78.9**	**30.2**	**116.45**	**33.33**	**12**	**238.2**	**71.278**	**23.6**	**71.911**	**20.43**	**0**
Argentina	86.9	0.04	0.07	42.8	13.2	97	43.3	0.014	0.04	37.4	9.9	632
Bolivia	4.6	0.1	0.06	0.44	0.2	8	2.16	0.417	0.1	0.118	0.1	-12
Brazil	159.8	8.9	2.8	56.9	25.9	43	89.9	9.307	2.6	23.3	6.6	18
Chile	3	2.6	0.9	0.1	0.3	-45	3.5	2.597	0.8	0.151	0.3	-41
Colombia	4.1	6.3	2.2	0.002	0.01	-61	3.9	5.98	1.9	0.003	0.01	-61
Costa Rica	0.2	1.3	0.5	0.006	0.004	-87	0.2	0.955	0.3	0.03	0.01	-82
Cuba	1.1	2.2	0.9	0	0	-67	1	2.094	0.8	0.002	0.001	-68
Ecuador	3	1	0.4	0.03	0.03	-24	2.9	1.012	0.4	0.019	0.02	-26
El Salvador	1.2	0.8	0.4	0.02	0.01	-39	1.1	0.822	0.3	0.078	0.03	-40
Guatemala	2.1	1.3	0.5	0.03	0.04	-38	1.8	1.342	0.5	0.014	0.008	-42
Guyana	0.7	0.07	0.04	0.1	0.2	4	0.6	0.084	0.04	0.111	0.2	5
Honduras	0.7	0.6	0.3	0.02	0.01	-45	0.6	0.691	0.3	0.042	0.02	-52
Jamaica	0.003	0.4	0.2	0	0.007	-99	0.003	0.42	0.2	0.012	0.005	-99
Mexico	33	20.5	8.1	1.5	0.6	-37	33.6	16.878	5.5	1.561	0.5	-31
Nicaragua	1.2	0.3	0.2	0.08	0.07	-15	1	0.376	0.2	0.041	0.02	-25
Panama	0.4	0.6	0.2	0	0	-60	0.4	0.57	0.2	0	0	-59
Paraguay	9.6	0.04	0.1	7.4	2.7	329	5.2	0.02	0.07	4.222	1	421
Peru	5.3	4.1	1.6	0.04	0.06	-43	5.2	4.013	1.4	0.046	0.08	-43
Uruguay	6.5	0.2	0.08	5.5	2.4	442	3.6	0.155	0.06	3.013	1.1	385
Venezuela	3.1	4.3	1.6	0.003	0.001	-58	2.9	4.063	1.4	0	0	-58

Source: FAO, 2012.

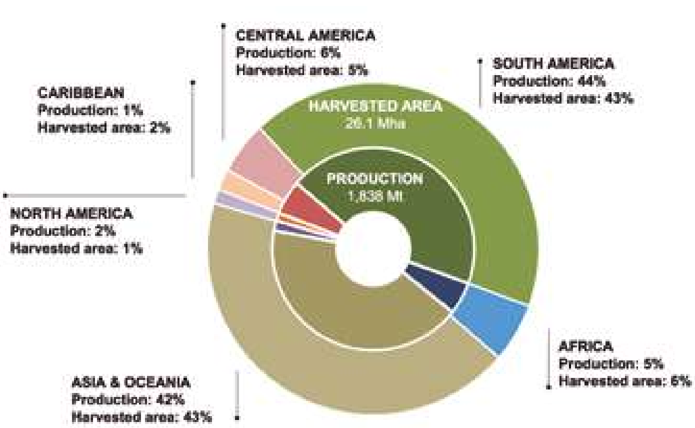
Figure 5. Oil and Grains (in)dependence plot in Latin America



Source: (EIA, 2012; FAO, 2012) based on (AYARZA, 2012).

An important issue to consider is that, with proper selection of feedstocks and process technologies, modern sustainable bioenergy production can help countries in LAC region to improve its current food and energy security situation, by improving standards of technology used in agriculture and increasing income in rural areas while producing more energy to boost the economy.

Figure 7. World sugar production and sugarcane harvested area (2012)



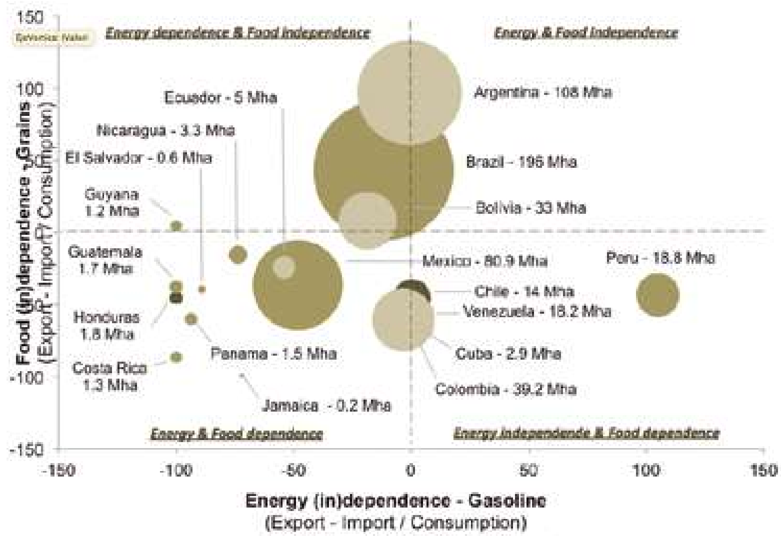
Source: FAO, 2012.

5. Latin America & Caribbean: Current scenario and perspectives of ethanol from sugarcane

Because of the growing concerns about greenhouse gas emissions, foreign oil dependence and the need for modern energy alternatives that contribute to rural prosperity, bioethanol emerges as a sustainable and renewable product with the capacity to replace a substantial portion of global gasoline demand. According to LONG et al (2015), sugarcane has a well-established agricultural production system and processing infrastructure to make it among the most advanced feedstocks for bioenergy, as well as, of the four largest feedstocks used for biofuels production (soybean, rapeseed, maize and sugarcane) only sugarcane appears to have a secure future.

The tropical regions in LAC, as presented by FAO in 1997, have natural conditions favoring bioenergy production, such as high solar energy incidence, appropriate temperatures, suitable soils and topography, especially between the parallels of latitude 35° North and South. In addition to water availability, there is potential for increasing arable lands and a tradition of sugarcane industrialization.

Figure 6. Gasoline and Grains (in)dependence plot in Latin America



Source: (EIA, 2012; FAO, 2012) based on (AYARZA, 2012).

In other research, SMEETS et al (2006) showed that these regions have the greatest potential for energy crop production. Depending on the scenarios proposed by authors, potential energy production reaches from 90 to 280 EJ/year in LAC, and from 50 to 350 EJ/year in Sub-Saharan Africa.

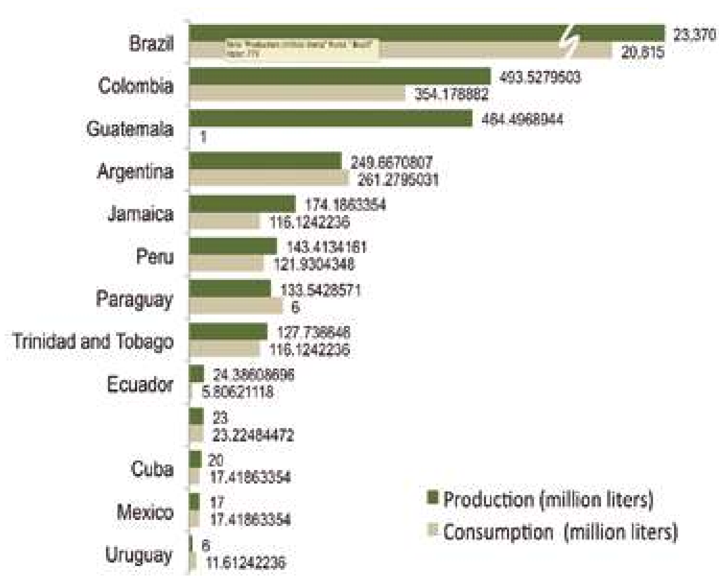
In LAC, ethanol production is still very concentrated in few countries as shown in Figure 8. According 2012 data, the main producers were: Brazil, Colombia, Guatemala and Argentina.

In the following items are presented a summary of the situation of production and use of sugarcane fuel ethanol in the main LAC countries.

Argentina

Produced 670 million liters of ethanol in 2014 and the projection for 2016 are forecast up at 900 million liters. In 2016, the bioethanol production is expected to be half from sugar industry (sugarcane) and half from grains industry (corn). The official mandate is current E10, but the industry is working to increase it to E12 in the short term. The ethanol production is focused to domestic market demand and no exports are projected in the short term. There are nine sugar mills participating in the official mandate program and five grain ethanol plants (all inaugurated during 2012-2014) with a capacity around 1 billion liters per year. There are new projects been planned, but it is not expect a significant expansion capacity over the next 18 months. Sugar mills in Argentina generate part of their energy needs from bagasse. Four sugar mills have new and high efficiency generation systems which allow them to cogenerate energy for

Figure 8. Bioethanol production in LAC countries in 2012



Source: EIA, 2012.

their own needs and to sell to the local energy grid. The total capacity of these plants is approximately 100 MW (JOSEPH, 2015a).

Bolivia

Although the Bolivian government does not have a clear position regarding biofuels, currently there are some advances for the sugarcane industry development, given their great production potential. It is estimated that 17 million hectares are suitable for sugarcane production, and today only 0.12 million hectares are used by five sugar mills and one autonomous distillery. The E10 mandate is the principal option for the fuel ethanol policy.

Table 5. Sugarcane products and trade: World regions and Latin America & Caribbean

Countries	Sugarcane		Sugar (1,000 t)				Molasses (1,000 t)	
	Production (1,000 t)	Harvested area (1,000 ha)	Production	Consumption	Import	Export	Import	Export
World	**1,838,535**	**26,085**	**179,087**	**176,558**	**32,305**	**34,835**	**6,850**	**6,259**
Africa	**94,306**	**1,509**	**10,595**	**14,683**	**5,436**	**1,348**	**272**	**615**
Europe	**5**	**(s)**	**26,635**	**30,830**	**4,702**	**507**	**3,165**	**2,102**
Asia & Oceania	**776,352**	**11,241**	**73,110**	**81,924**	**18,216**	**9,402**	**2,318**	**2,568**
North America	**29,236**	**365**	**8,280**	**11,243**	**3,045**	**82**	**966**	**253**
Caribbean	**23,440**	**540**	**2,239**	**1,334**	**204**	**1,109**	**84**	**68**
Central America	**101,465**	**1,320**	**10,079**	**7,508**	**2**	**2,573**	**26**	**597**
South America	**813,730**	**11,109**	**48,148**	**29,035**	**701**	**19,813**	**19**	**56**
Argentina	19,766	360	2,189	2,089	(s)	100	(s)	3
Barbados	278	6	18	21	3	(s)	17	(s)
Bolivia	7,692	159	575	568	(s)	7	0	0
Brazil	721,077	9,705	40,219	12,569	(s)	27,650	5	(s)
Chile	0	0	0	85	85	0	0	0
Colombia	33,364	409	2,078	1,927	0	151	(s)	1
Costa Rica	4,440	58	420	295	(s)	125	20	(s)
Cuba	14,700	361	1,467	639	0	828	(s)	2
Dominican Republic	4,866	107	561	396	0	165	(s)	66
Ecuador	7,379	95	570	570	(s)	(s)	10	(s)
El Salvador	6,487	73	687	627	(s)	60	(s)	207
Guatemala	23,653	256	2,464	949	(s)	1,515	1	161
Guyana	2,709	49	218	64	6	160	0	39
Haiti	1,200	19	10	99	89	0	0	0
Honduras	5,861	70	483	424	(s)	60	(s)	80
Jamaica	1,475	28	131	62	35	103	28	(s)
Mexico	50,946	735	5,048	4,866	1	184	5	64
Nicaragua	6,732	67	689	459	0	230	0	62
Panama	2,276	33	173	173	0	(s)	0	(s)
Paraguay	4,186	115	250	250	0	(s)	(s)	3
Peru	10,369	81	1,106	1,109	55	53	0	10
Suriname	120	3	7	25	18	(s)	0	(s)
Uruguay	368	7	9	53	44	(s)	2	0
Venezuela	6,690	126	568	1,060	492	0	0	0

Notes: 2012 Data. (s): too small. Consumption = Production + Imports – Exports. Source: FAO – FAO Stat

Brazil

Is the world´s largest sugarcane ethanol producer with strong tradition on using ethanol as a fuel in its fleet, as a blend with gasoline (E27) or as hydrous ethanol (E100), with very good potential for expanding current production with no harm to food production nor causing damage to ecosystems such as the Amazon and Pantanal. In 2015, around 29 billion liters were produced in approximately 360 sugarcane mills. Ethanol mills capacity depends on annual decisions made by individual plants to produce sugar and/or ethanol. The industry responds to the ratio of 40:60 to switch between sugar to ethanol production or vice versa from harvest to harvest. The high penetration of flex fuel vehicles in the Brazilian market in last ten years, the blend mandates changes, and the growth of gasoline consumption have been responsible for the steep increase in Brazilian ethanol demand (BARROS, 2015). The flex fuels vehicles responded by 93.5% of the 2,7 million light's vehicle sold in 2014 (ANFAVEA, 2015). In terms of second generation bioethanol, Brazil was pioneer in LAC. In 2014-2015, Granbio and Raízen inaugurated their plants in Alagoas State (São Miguel dos Campos city) and São Paulo State (Piracicaba city) with capacity of 82 million liters and 40 million liters per year, respectively. However, up to now, the production of second generation bioethanol is not economically feasible (BARROS, 2015). More about the history and perspecives of sugarcane ethanol production and use in Brazil at CORTEZ et al., (2016).

Colombia

Is the world's second-largest ethanol producer from sugarcane after Brazil, which started in late 2005. In 2008, the Colombian government set a policy framework for the biofuels sector that guarantees a minimum price to producers, tax exemptions for feedstock growers, and an overall commitment from the government to support biofuels production and development, and today Governmental regulations established a mandatory blend of E8 with gasoline. In 2015, the bioethanol production reached 425 million liters, and the current production is unable to fulfill the E8 blend mandate (around 90% of the local needs comply with the mandated blending). However, sugar production sufficiently exceeds local demand creating a production surplus for ethanol and/or sugar exports. Ethanol production has displaced 48 percent of sugar exports with little impact on domestic sugar prices. All of Colombia's ethanol production is supplied by five ethanol distilleries near the city of Cali, in south central Colombia. The ethanol distilleries are clustered within larger industrial sugar production and milling facilities. A new ethanol plant at the Riopaila-Castilla sugar mill should be operational towards the end of the 2015, adding about 120 million liters per year supporting an increase in the average domestic production to 1.65 million liters per day. Ethanol imports represent about 1% of Colombian ethanol biofuel consumption, main from U.S. and Ecuador. Following incremental increases in gasoline consumption, it is estimated that 2015 ethanol consumption will reach 430 million liters, increasing to 510 million liters in 2016. As a result of trade protectionist policies, Colombian ethanol consumption is almost entirely dependent on domestic ethanol production to fulfill the E8 blend mandate. The calculations based on annual ethanol production show that current ethanol facilities only produced at full capacity for a 325 days in 2014, supporting the claim that Colombian ethanol production cannot, and did not, meet the E8 blend. However, the new ethanol plant that is expected to come online at the end of 2015 will support national production likely meeting the E8 blend mandate in 2016 (GILBERT; PINZON, 2015).

Costa Rica

There is no implemented biofuels policy for internal use, since the early attempts in 1981. Therefore, efforts were directed towards external market, mainly for the U.S. Currently, it has recommenced the studies for internal market development. Costa Rica produces 3.5 million tons of sugarcane from 54 thousand hectares, industrialized by 15 sugarcane mills.

Cuba

Is a traditional sugar producing country, and was the top three world producers of sugarcane from 1950 to the late 1980s. However, Cuba's industry is facing strong difficulties in the last decades. Cuba's sugarcane production declined from a little more than 1 million hectares in 2000 to 330,000 ha in 2007, a decline that forced the closing of more than half of the nation's sugar mills. The sugarcane area has slowly increased to 506,000 ha in 2011 taking advantage of higher global sugar price and increased demand. A general government mandate from 1993 presented that biofuels cannot compete with food production. However, recent studies have showed the possibility of ethanol fuel blends up to 8%. For ethanol production from nonfood competing feedstock, Havana Energy announced in December 2012 an investment of US$ 50 million in a Ciro Redondo sugar mill for the production of ethanol from the marabu weed (Dichrostachys cinerea), which is an invasive species on idle farmland (LUDENA, 2014).

Guatemala

Is the strongest potential leader in Central America for the production, trade, and consumption of biofuels. Currently the country is the number one producer of sugarcane in the region. In 2012, Guatemala produced 2.5 million tons of raw sugar, of which 1.6 million tons were exported. It has a combined milling capacity of 130,000 tons per day from its fourteen sugar mills. At present, five out of the fourteen sugar mills are also producing ethanol, whose production reached 269 million liters in 2011 (TAY, 2013). In 2012, 464 million liters of ethanol were produced (EIA, 2012). All of the dehydrated ethanol is exported, mainly to Europe and the U.S. The domestic market for biofuels has not been developed. The Guatemalan sugar industry could easily supply the ethanol required for E10 for domestic consumption, and has the potential to supply ethanol for the whole Central American region. There are several obstacles that Guatemala must overcome in order to implement a viable biofuels policy, where the various involved sectors need to reach consensus (TAY, 2013). However, Guatemala's Energy and Mines Ministry conducted a pilot ethanol test (E5) with 23 vehicles and five motorcycles during four months in 2015, and there are in progress efforts from the APAG (Asociación de Productores de Alcohol de Guatemala) to start a bioethanol blending mandate in 2016 (Guatemala, 2015 http://www.mem.gob.gt/2015/09/mezcla-de-5-de-etanol-con-primeros-resultados/). In November 2015, it was announced a blending permission of anhydrous ethanol up to 10% (E10) as an additive in gasoline in order to substitute manganese octane enhancer additive (GUATEMALA, 2015).

Guyana

Is traditional sugarcane producer. Guyana has eight sugar mills that in 2009 processed 3.5 million tons cane, from 50 thousand hectares. The ethanol capacity production reaches 30.8 million liters per year. Despite interest on E10 mandate, there is currently no biofuels promotion program. The current potential demand of anhydrous ethanol would be 11.6 million liters for an E10 blend.

Jamaica

Is the first ethanol exporter and the second largest sugar producer in Caribbean. In 2012, 174 million liter of sugarcane ethanol was produced. In November 2009, an E10 mandate was implemented, effectively creating a domestic market for ethanol. The Jamaican government has set a Country Strategy for the Adaptation of the Sugar Industry 2006–2020, which outlines a roadmap to produce sugar, molasses, and ethanol. There are three ethanol dehydration plants in total, with a combined capacity of 830 million liters per year. The plants produce ethanol for local consumption and export to the U.S. The ethanol market in Jamaica is extremely influenced by international events. The production increased from 114 to 400 million liters between 2005 and 2009, but declined sharply to 116 million liters in 2010 and 170 million liters in 2011. Prices of raw materials imported from Brazil and fuel-grade ethanol in the U.S affect the viability of Jamaica's ethanol industry. The revival of the sugarcane industry in Jamaica tied to the production of ethanol will also depend on these economic dynamics. Although much of the focus in Jamaica's biofuel industry has been on ethanol (LUDENA, 2014).

Mexico

Is the second largest sugarcane and sugar producer in LAC. There is currently no specific biofuels promotion program operational in Mexico. In 2008, it was launched The Bioenergy Law (Ley de Promoción y Desarrollo de los Bioenergéticos). The plan established the general aim of reducing fossil fuel dependency, lowering GHG emissions in the cities, and boosting sustainable development in the countryside. In terms of biofuels, two key documents were released: Sustainable Production of Feedstocks for Bioenergy and Scientific and Technological Development Program (Programa de Producción Sustentable de Insumos para Bioenergéticos y de Desarrollo Científico y Tecnológico) and the Bioenergy Introduction Program (Programa de Introducción de Bioenergéticos en Mexico). Both envisioned that the biofuel industry would developed from 2007-2012. In 2010, The Government planned start-up the use of ethanol as a gasoline oxygenate (at 6%volume) in gasoline consumed in three major cities (Mexico City, Monterrey, and Guadalajara). The initial production target was planned as 176 million liters, reaching 802 million in 2012. However, because the first tender for the purchase of ethanol to meet the Biofuel Introduction Program was canceled, due to the low price set by PEMEX (the sole buyer), the government had to redefine the strategies, objectives, and scope of the Biofuel Introduction Program. The new government, under President Enrique Peña Nieto, recently brought out its National Development Plan for the period 2013–2018 and, in reference to renewable energy, it states that appropriate targets will be established. These includes the gradual introduction of biofuels (starting with ethanol) in the transport sector and the government work on the identification and dissemination of technological packages, including the selection of crops for biofuel production and information on how to produce them. Despite the problems encountered in the implementation of biofuels, Mexican experts agree that sugarcane has the greatest potential as a biofuel feedstock for the production of ethanol. This is because the country already produces nonfuel ethanol as a byproduct of sugarcane milling and Mexico has substantial experience with the sugarcane industry (eighteen of its 57 sugar mills have ethanol distilling capabilities, but of these only eight are currently producing ethanol for the beverage and pharmaceutical industries. Over recent years, strong fluctuations in the price of sugar have prompted some producers to explore schemes for fuel ethanol production. The current sugarcane production in Mexico would potentially replace 22% of Mexico's 2011 gasoline consumption, and an additional 2.9 million hectares of land could be planted with sugarcane without negatively affecting agricultural land, forests, or protected areas (EASTMOND et al., 2014).

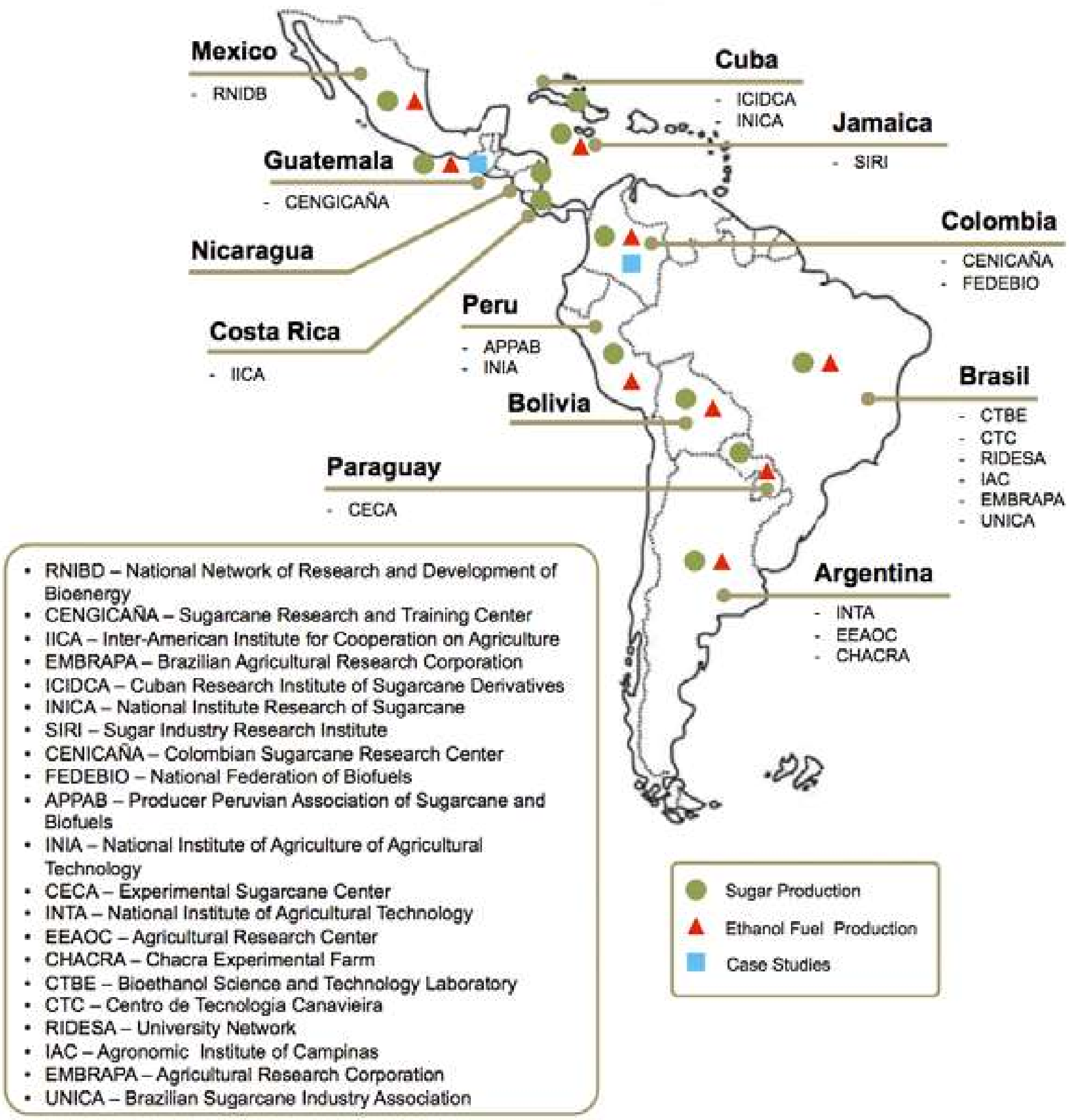
Nicaragua

The country has a production of 5.46 million tons of sugarcane from 65 thousand hectares, being the second largest producer in Central America after Guatemala. However, there is currently no specific biofuels promotion program operational in the country. The sugarcane industry has four mills with an average milling capacity of 34 thousand ton per day.

Paraguay

After Brazil, Paraguay was the second country to use ethanol blended with gasoline in LAC. However, only in 2005, a biofuels policy enabling an E18 mandate was approved, and today an E25 mandate is in progress. In 2016, Paraguay projected to produce a record of 215 million liters of bioethanol. There are 12 bioethanol plants in Paraguay, with a total production capacity of 340 million liters per year. Only 3 plants produce exclusively from sugarcane, including state-owned Petropar. The other 9 plants have the flexibility of using sugarcane and/or grains as feedstock. The smallest plant has a production capacity of 5 million liters per year, while the largest (by far) has a capacity to produce 150 million liters. Most of these plants are located to the east of Asuncion, Paraguay's capital city. The largest plants usually own cane plantations and have higher productivity than most independent farmers. It is estimated that 65 percent of the ethanol produced in Paraguay in 2016 will be produced from sugarcane, while the rest will be from grains (mostly corn). In 2014 these percentages were the opposite. This switch is the result of the recently passed law determining that bioethanol has to be produced from sugarcane and that once this is no longer available, it can be produced from other feedstocks. This clearly provides a significant advantage to sugarcane and it is aimed at helping small cane producers. There are eight sugar mills in Paraguay, of which two have distilleries that produce anhydrous ethanol. In addition, there are two distilleries which produce hydrated ethanol. There are 12 autonomous distilleries and 10 dehydrators in Paraguay. Paraguay has approximately 110,000 hectares of sugarcane, with approximately 23,000-25,000 small cane producers. Productivity is low compared to neighboring countries due to the use of marginal soils, degraded soil, and old, low productive sugarcane varieties. Through Law 5444 of July 2015, the Government has to implement a National Program to improve the efficiency of sugarcane at the farmer (small) and industrial levels. As long as the government maintains the current mix mandate and the growth of flex fuel cars expands slowly, the total consumption in the short term will basically be tied to the increase in gasoline demand. However, with new policies in place, the importation (tax free) of E85 and flex fuel cars, and the conversion of many engines to flex fuel, the use of gasoline (and thus, ethanol) is expected to gain share. Currently, the proportion is estimated to be roughly 65/35. The use of flex fuel cars and E85 has promoted the use of E85 gasoline. A large increase of ethanol consumption in Paraguay would depend on an expansion of the use of flex fuel cars which today represent roughly 3 percent of the total 800,000 cars running in Paraguay. Law 5444 of July 2015 is expected to boost consumption of ethanol, especially with country wide supply coverage. Some private projections for

Figure 9. Sugar and ethanol research centers and organizations in LAC countries



Source: adapted from (CORTEZ, 2012).

2020 set dehydrated ethanol consumption at 450 million liters and hydrous ethanol (used in flex fuel vehicles) at 200 million liters (JOSEPH, 2015b).

Peru

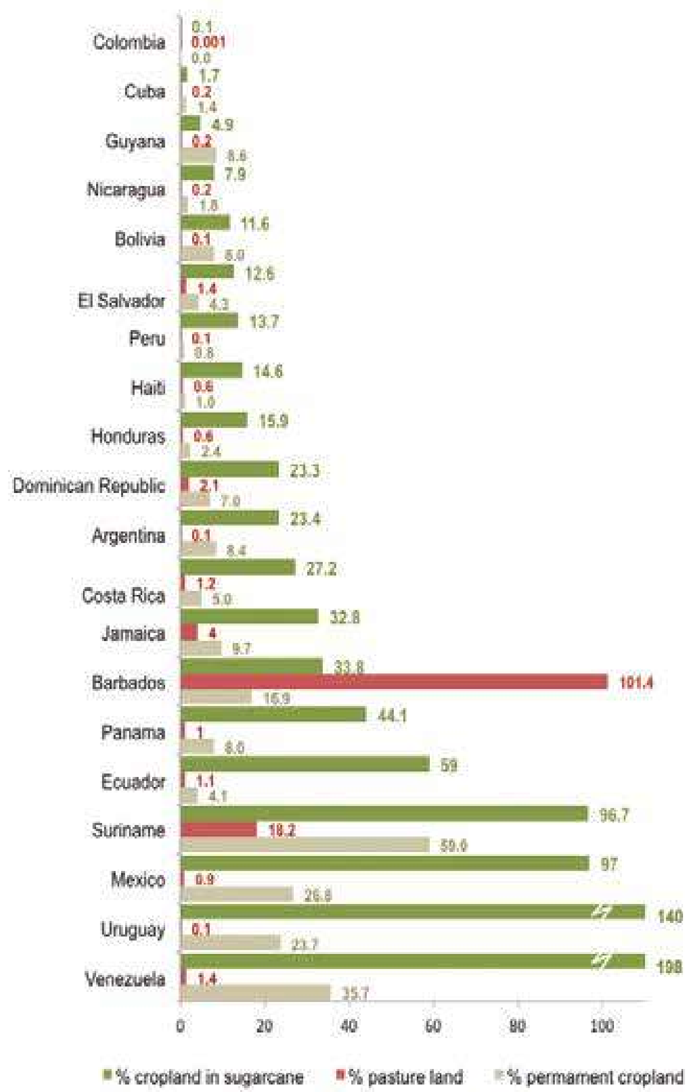
Is the 7th largest sugarcane and sugar producer in LAC (FAO, 2012), and has the highest sugarcane yields, average 140 ton per hectare (USDA, 2015). In 2015, the ethanol production reached 245 million liters, and currently there exists the E7.8 mandate. The ethanol industry is relatively new to Peru; operations commenced in August 2009. The country has two modern sugarcane ethanol production facilities, both located in the state of Piura (roughly 1,000 kilometers north of Lima). These facilities take advantage of Piura's favorable weather conditions (i.e., ample sunlight due to proximity to the Equator). Despite an average of only 25 millimeters of annual rainfall, sugarcane is cultivated year-round by these facilities thanks to modern drip irrigation technology with water drawn from the Chira River. However, a recent decommissioning of the Aurora ethanol facility (responsible for 40% of Peruvian ethanol production) will reduce the ethanol production in 2016. The Aurora's plans consider turning its 6,000 hectares of sugarcane to sugar. In 2016, the ethanol exports may reach 69 million liters, mainly for European Union and Canada. Peru's ethanol producers often find better prices in foreign markets than at home. There are a number of sugarcane growers evaluating the economic feasibility of diverting part of their crop to ethanol production. In terms of consumptions projections, if no changes occur on current blend mandate or on gasoline consumption (E7.8), the ethanol consumptions may stabilize at about 170 million liters per year (NOLTE, 2015).

Trinidad y Tobago

In 2012, 128 million liters of ethanol were produced (EIA, 2012). However, the sugarcane industry has declined, despite efforts to revive it. Since 2008, the Government of Trinidad and Tobago dismantled the sugar industry and did not consider a shift to biofuel production. Two main reasons appears unlikely for development biofuels in Trinidad and Tobago: domestic fuel sales in the country are highly subsidized, and the removal of the US government's import tariff on ethanol for non-Caribbean Basin Initiative countries, making the business of dehydrating Brazilian hydrous ethanol in the Caribbean less competitive than directly importing anhydrous ethanol from Brazil to the USA (LUDENA, 2014).

Taking into account the experience on sugarcane production, the availability of land for expansion, and the recent advances in ethanol use and incentives (blend mandates), the LAC has a strong capacity to produce and supply high amounts of bioethanol to attend the intern market and the

Figure 10. Agricultural land requirements to produce bioethanol for a 10% gasoline blend (percentages of planted sugarcane land, pasture land, and permanent cropland): 2012 base year



Source: data from FAO (2012) and EIA (2012) exports. The ethanol development in LAC may be very beneficial if closer collaborative researches and efforts occur among the research institutions dedicated to sugarcane placed in several LAC countries, as showed in Figure 9.

As an example of LAC countries potential to produce bioethanol, Figure 10 presents how much land is required for a 10% gasoline blend (E10), based on 2012 gasoline consumption. Brazil, Paraguay and Guatemala were excluded considering that these countries already produce more ethanol than the ethanol demand for attending a 10% gasoline blend. The exercise shows that, in general:

- For three quarters of the LAC countries, sugarcane expansion up to 40% of the actual sugarcane planted area would be enough to attend E10. In Mexico, which presents a high gasoline consumption (45.1 billion liters per year), the sugarcane planted area would need to double to attend E10;
- Small expansions of sugarcane over the pasture land at LAC would be enough to produce sugarcane and implement E10 (except in Barbados, Suriname, and Jamaica).

6. The IANAS Energy Project

The IANAS Energy Project is a collaboration of the Science Academies of the Americas to apply advanced science and engineering to the sustainable energy programs in the western hemisphere. The Project was inspired by a report elaborated by InterAcademy Council (IAC) in 2007 entitled "Lighting the way: Toward a sustainable energy future".

The goal of the Project is to apply the recommendations of this global report in the Americas. The Project was initiated at the IANAS Workshop on Energy convened Oct. 30-31, 2008, in Buenos Aires, Argentina. The Workshop report described:

> *The Academies of Science do not possess all the expertise required to solve these large and complex problems; part of the necessary knowledge and skill resides in the private sector, part in government. The Academies therefore need to become the hubs of networks, assembling, collating and analyzing information, and making coherent and balanced policy recommendations. The Academies also need to strengthen their understanding of the policy process, and of the social, political and economic factors that can constrain the choices available to governments.*

The IANAS Energy collaboration focuses on six priorities:

1. **Energy for Unserved Populations:** work with the S&T community of South America and the Caribbean Region through the Academies (and/or other representative institutions in countries that do not have Academies of Science) to provide the best available evidence-based advice to Government regarding energy policy;
2. **Energy efficiency**
3. **Renewable Energy**
4. **Bioenergy:** from generation to final use, and the development and deployment of renewable and low-carbon energy sources must be the core aims of all future energy policy. A technology roadmap of renewable energy technologies must become a key part of the development strategies in all countries of the region;
5. **Information and Education:** A vigorous capacity building program, addressing all levels of education, from primary school to advanced professional science and engineering focused on energy is urgently needed; this program should start immediately;
6. **Capacity Building:** It is essential to engage citizens of each country in this transition. An energy information and consciousness-raising program is urgently needed. Multilateral agencies, such as the OAS and organisms, such as the IADB and World Bank must intensify their focus on energy policies, technologies and practices.

The inaugural meetings of the IANAS Energy Project were held Dec. 6-7, 2010 and June 9-10, 2011, in Bogota Colombia, hosted by the Colombia Academy of Exact, Physical and Natural Sciences.

The meetings launched multi-country teams in each of the priority areas. The teams exchanged information on their current and planned activities, expanded participation to include additional countries, initiated collaboration activities with other national and international programs, and drafted project plans from 2011 through 2013.

The Project strategy is to integrate its work with related activities, seeking opportunities for collaboration and avoiding duplication. The ICSU Regional Office for Latin America and the Caribbean, the Energy and Climate Partnership of the Americas (ECPA), the expanded Inter-American Development Bank programs and the Organization of American States are targeting the same countries as the IANAS Project. The global Clean Energy Ministerial, post-Cancun UN Framework Convention on Climate Change activities, and World Bank Group programs also are bringing new and expanded support for sustainable programs.

In this expanding area, the IANAS role is to insert advanced science and engineering into these activities. As a multi-country initiative, it is seeking to identify the common interests of groups of countries so they can improve the effectiveness and reduce the cost of collaborative programs.

The initial participants in the Project include 16 IANAS members: the Academies of Argentina, Bolivia, Brazil, Canada, Caribbean Scientific Union, Chile, Colombia, Cuba, Dominican Republic, Guatemala, Mexico, Nicaragua, Peru, the USA and Venezuela. The scientific communities of Ecuador, Honduras, Panama and Paraguay are also participating. The Buenos Aires report points to the importance of expanding participation by scientific institutions throughout the Americas.

7. The IANAS/FAPESP Bioenergy Partnership

In 2012, IANAS and FAPESP (The São Paulo Research Foundation) signed a Memorandum of Understanding aiming to develop a partnership in order to select and fund students, investigators and research projects (http://www.fapesp.br/en/7015).

Created under IANAS Energy Program, in 2012, the IANAS/FAPESP partnership on bioenergy joined effort to the LACAf-Cane project (Bioenergy Contribution of Latin America & Caribbean and Africa to the GSB Initiative). The partnership was created aiming to integrate its work with related activities, seeking opportunities for collaboration and avoiding duplication. LACAf project was structured in association to another global effort known as Global Sustainable Bioenergy - GSB Initiative.

The Global Sustainable Bioenergy (GSB) Initiative was initiated as a project in 2009 by a group of scientists, engineers, and policy experts from universities, government agencies, and the non-profit sector from across the globe, with the overall goal of providing guidance with respect to the feasibility and desirability of sustainable bioenergy-intensive future. In the summer of 2009, a statement on behalf of GSB Initiative the organizers observed (Lynd, 2009):

> *Although there is a natural reluctance to consider change, we must do so, because humanity cannot expect to achieve a sustainable and secure future by continuing the practices that have resulted in the unsustainable and insecure present.*

Consistent with this perspective, the GSB Initiative seeks to take a different approach from the many others worthy initiatives on bioenergy. Rather than focusing on what is most probable, the GSB Initiative is focused on what is most desirable. Rather than reflecting often sharply divided expert opinion, the GSB Initiative seeks to build new understanding and consensus. And rather than having the present as a point of reference, the e GSB Initiative concentrates on developing a sustainable vision of the future.

The core objective of the Initiative is *to test the hypothesis that it is physically possible for bioenergy to sustainably meet a substantial fraction of future demand for energy services (≥ 25% of global mobility or equivalent by 2050) while feeding humanity and meeting other needs from managed lands, preserving wildlife habitat, and maintaining environmental quality.*

Important features of the GSB Initiative are:

a. To evaluate the global potential of bioenergy production;
b. To consider several possible feedstocks, including sugarcane, switch grass, agave, miscanthus and other;
c. To make a long term evaluation, using 2050 as a horizon of reference.

The GSB Initiative is structured to be implemented in three stages:

Stage 1 (completed 2010). Hold five continental conventions with outcomes as follows:

a. endorse a common resolution about the importance of bioenergy and the goals of the GSB Initiative;
b. gather input on structuring the analysis to be carried out in Stages 2 and 3;
c. approve resolutions representing perspectives on bioenergy, including key questions and opportunities, from each of the world's continents;
d. write a report encompassing a, b and c;
e. recruit participants and support for stages 2 and 3.

Stage 2. Explore whether and how it is physically possible for bioenergy to sustainably meet a substantial fraction of future demand for energy services – e.g. 150 EJ annually, corresponding to 23% of primary energy supply in the IEA Blue Map Scenario (2010) -while feeding humanity and meeting other needs from managed lands, preserving wildlife habitat, and maintaining environmental quality. Answer the question: Is it physically possible for bioenergy to meet a substantial fraction of future world mobility and/or electricity demand while our global society also meets other important needs: feeding humanity, providing fiber, maintaining and where possible improving soil fertility, air and water quality, biodiversity and wildlife habitat, and achieving very large greenhouse gas emission reductions that are not substantially negated by land use changes?

Stage 3. Analyze and recommend transition paths and policies in light of Stage 2 results, incorporating analysis of macroeconomic, environmental, ethical and equity issues as well as local-scale effects on rural economies. Stage 3 also includes:

- Transition paths
- Enabling policies
- Economics
- Ethical and equity issues
- Local-scale analysis to validate and exemplify the vision developed in stage 2
- Rural economic development aspects
- Consequences for developing nations
- Commercialization
- Other important considerations identified in the course of the project

The GSB Initiative has already conducted stage 1. The full text of the Latin America and Africa continental conventions may be found on line (http://bioenfapesp.org/gsb/index.php). On stage 2 there will be 9 tasks to be conducted, presented in Figure 11.

The LACAf-Cane Project intends to contribute to the GSB Project, with six subprojects several of them aligned with the above presented GSB tasks. Its primary objective is forecasting the sustainable production of sugarcane bioenergy (including social, environmental and economic aspects) in Latin America, Caribbean and Africa. The LACAf-Cane subprojects are:

1. Diagnosis of Energy and Food Situation in LA and AF & Integrated analysis

Address fundamental aspects (environmental, social, technological, economic and institutional) taking into account the current situation and highlighting the most evident trends, in order to assess the current context to promote sustainably bioenergy from sugarcane.

2. Determining the Physical Potential for Sugarcane Ethanol Production in Latin America and Africa

Identify potential areas to sugarcane production in African and Latin American countries and quantify the different production potential of sugarcane crops in these countries.

3. Production Models

To determine the most important items and the corresponding road map that will conduct the sugarcane ethanol production technologies from the present stage to a desired stage of performance, bearing in mind the specificities of each country under consideration.

For that it is mandatory to select an ultimate production model that take into consideration the particular conditions of each country under consideration such as:

- Strongest driving force: energy security, GHG emission reduction, support to the agriculture.
- Agricultural production model: land tenure, size of properties, and level of local capacity,

mechanization, main cultures and present agricultural practices.
- Impacts on food production: main staple food crops, land and water availability, planned biofuel production.
- Regulatory framework: biofuels support programs, renewable energy goals, and support to biofuels R&D.

4. Biofuels and Food Security in LAC and Africa

Deliver a critical assessment of the impacts that could arise from a substantial increase in the production of biofuels (primarily from sugarcane) on food security. The project has four fundamental pillars all related to the issues that impinge on food security under biofuel and bioenergy expansion potentials in Africa, based on the four programs of LACAf:

- To contribute to the assessment of bioenergy potential in LAC & Africa
- Assist in the assessment of potential impacts of fertilizer applications
- Assess the implications of biofuels on food security
- Investigate the social and economic impacts

5. Bioenergy and Food Scenarios

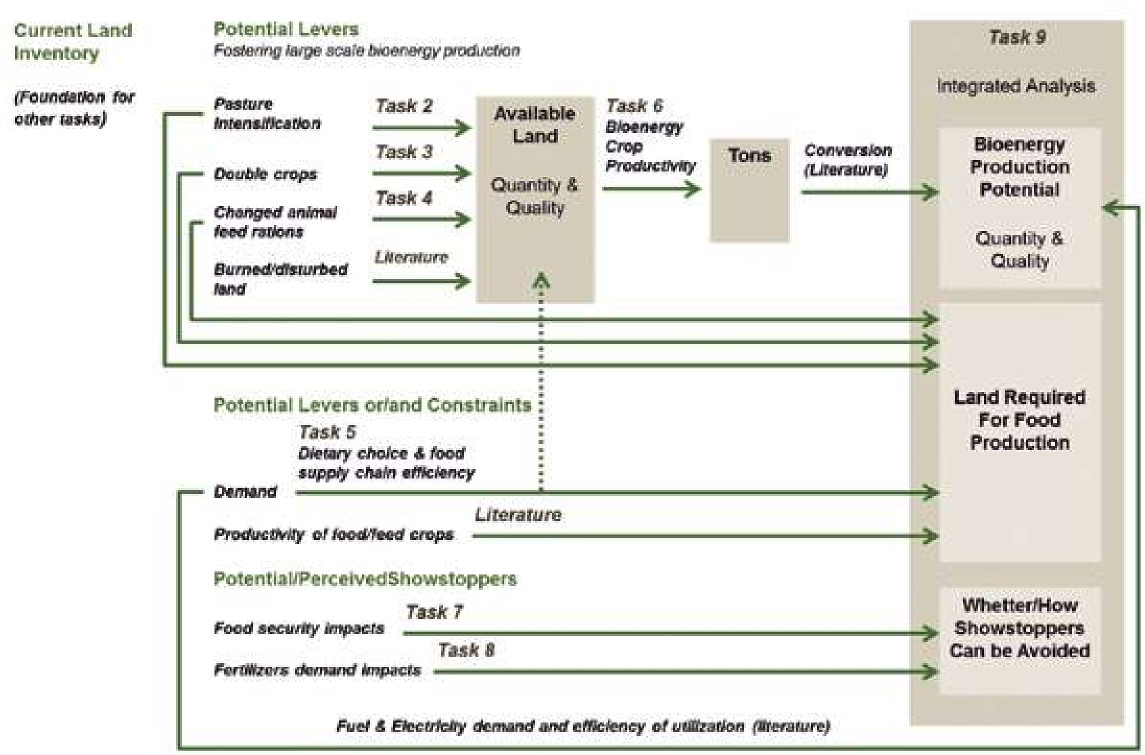
The following aspects will be focused:

- Expansion of the bioethanol production
- Expansion of the production of the main food crops
- Expected evolution of productivity
- Land expansion required
- Investments required
- Impact of these investments in the national investment and income
- Impact in the external trade balance

Questions**:**

1. What are the effective conditions of sugarcane ethanol productive expansion in a group of developing countries from LAC and Africa?
2. What could be the economic impacts of the ethanol production increase in a selected group of developing countries?

Figure 11. Interrelation of tasks for GSB Stage 2



Note: Task 1 is related to land use inventory and is the base for other tasks. Source: Lee Lynd from GSB Project.

6. Social Impacts and Economic Development

Among other issues, the project may consider:

- Issues related to the agrarian situation and land tenure in case studies countries need be considered. This will generate information to define the Productive Models
- Issues related to existence of skilled/trained people in case studies
- Existing infra-structure in selected countries.

The research team involved in the LACAf Project (to be review facing recent partnerships):

- **Brazil:** Luís A. B. Cortez (Unicamp), Luiz A. H. Nogueira (Unicamp), Manoel Regis V. L. Leal (CTBE), Edgar F. de Beauclair (USP), Antônio Bonomi (CTBE), Otávio Cavalett (CTBE), Luiz Martinelli (USP), Marcelo Cunha (Unicamp), Suani Coelho (USP), Felipe Gomes (Pedológica), Fernando Bertolani (CTC), André Nassar (Agroicone), Marco Ospina (Unicamp), Rafael A. Moraes (Unicamp), Luiz G. A. de Souza (Unicamp), João G. D. Leite (Unicamp), Simone P. de Souza (Unicamp), Ricardo Baldassin Jr (Unicamp), Marcelo Moreira (Agroicone).

- **Mozambique:** Rui da Maia (Technical Univ. Mozambique), João Chidamoio (Eduardo Mondlane University).

- **South Africa:** Annie Chimphango (Stellenbosch University), Emile van Zyl (Stellenbosch University), Johann Gorgens (Stellenbosch University), Helen Watson (University of KwaZulu-Natal).

- **Colombia:** Vyacheslav Kafarov (Universidad Industrial de Santander), Nicolás Javier Gil Zapata (CENICAÑA), Jorge Bendeck Olivella (Fedebio), Carlos Alberto Mateus Hoyos (Fedebio), Sonia Lucia Rincon Prat e José María Rincón Martinez (National University of Colombia), Jorge Alberto Valencia Marín (UPME).

- **EUA & Europe:** Lee Lynd (Dartmouth University), John Sheehan (Colorado State University) Virginia Dale and Keith Kline (ORNL) Patricia Osseweijer and Luuk van der Wielen (TU Delft/BE-Basic Foundation), Jeremy Woods (Imperial College), Stephen Long (University of Illinois), Luís Alves (Lusófona University), Bruce Dale (Michigan State University), Francisco Rosillo Calle (Imperial College).

- **NEPAD (The New Partnership for Africa's Development):** Mossad Elmissy

8. Conclusion

LAC presents excellent comparative conditions to guarantee its food security and energy security while protecting its biodiversity. These conclusions are part of the SCOPE UNESCO Report and the FAPESP/IANAS LACAf Project presented in this text.

Besides been a region with relatively low population and high fertile land availability, the region also presents good technical and scientific background (engineers and scientists with experience in the bioenergy area). Brazil for example, is the country with largest experience (40 years) of its sugarcane bioethanol program benefiting the country energy matrix, rural development, generating jobs and wealth while contributing to mitigate GHG worldwide.

Other initiatives, such as the Argentinian and Colombian biodiesel and ethanol activities are also examples of how the region has successfully making the transition from traditional to modern biomass. In fact, several other countries in Latin America are implementing programs for fossil fuel substitution by bioenergy, including feedstocks such as sugarcane, soybean, palm and energy forests using mainly eucalyptus. The continent large experience in sugarcane production, since colonial era, has created the necessary conditions to establish the first steps of biofuels production. The available background in the region includes existing research centers, graduate programs and also research financing capacity.

It is also concluded that much more is still possibly to be accomplished in the region, combining food security, biodiversity and energy security objectives. There is enough land in the continent to make more important contributions. In the LACAf Project it is presented the cases of Colombia and Guatemala. These two countries offer exceptional conditions to expand its bioenergy production. The case of Colombia is of a great importance for the region, since it presents strategic location and trading conditions. Colombia is doing considerable progress in introducing biofuels in its energy matrix and its example should be followed by other countries. The case of Guatemala is also very promising since the country still imports considerable portion of its gasoline consumption but presents very good conditions to alleviate its fuel imports.

Therefore, it is expected that, in the years to come, even with low oil prices, the region will continue to promote the bioenergy production to benefit rural development and reduce its fossil fuel dependence.

Acknowledgment

Special thanks to FAPESP (São Paulo Research Foundation) for the financial support of IANAS/LACAf Project. The authors would like to acknowledge the important contributions of Prof. José Goldemberg and Prof. José Roberto Moreira, both from IEE/USP for reviewing this text.

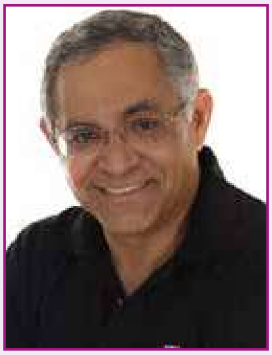
Carlos Brito-Cruz

Carlos H de Brito Cruz is a Full Professor at the Physics Institute at Unicamp and has been the Science Director at FAPESP since 2005. Brito-Cruz graduated in Electronics Engineering (ITA, 1978) and has a doctorate in Physics (UNICAMP, 1983). He was a visiting researcher at the Quantum Optics Laboratory at the Universitá di Roma, at the Femtosecond Research Laboratory at the Université Pierre et Marie Curie, and a resident researcher at the AT&T's Bell Laboratories, in Holmdel, New Jersey. He was the Director of Unicamp's Physics Institute, Pro-rector for Research, and Rector of the university. He was the President of FAPESP from 1996 to 2002. Brito Cruz is a member of the Brazilian Academy of Sciences, received the Ordre des Palmes Academiques de France, the Order of the Scientific Merit from the Federative Republic of Brazil, and the Order of the British Empire, Honorary (OBE).

Luís A. B. Cortez

Full Professor at the Faculty of Agricultural Engineering at UNICAMP and Vice-Rector of International Relations of UNICAMP. At São Paulo State Research Foundation-FAPESP acts as Adjunct Coordinator for Special Programs. Coordinated projects in Bioenergy such as a study on sugarcane ethanol expansion in Brazil; the FAPESP Public Policy Ethanol Project in R&D for sustainable ethanol production - book "Sugarcane Bioethanol: R&D on sustainability and productivity" published in 2010. Coordinated the Project "Roadmap on Sustainable Biofuels for Aviation in Brazil" - book published in 2014. Presently coordinates the FAPESP/LACAf-I Project to promote bioenergy in Latin America and Africa and is also involved in organizing a new initiative in Bioeconomy in São Paulo State, the Agropolo Campinas-Brazil..

Luiz A. H. Nogueira



Professor at Federal University of Itajubá up to 2003. Technical Director of Brazilian Agency of Oil, Natural Gas and Biofuels (1998/2004). Researcher in energy subjects, mainly on bioenergy and energy efficiency, tutor of academic works and author of several books and papers in these themes. Currently Prof. Horta is Associate Researcher at the Interdisciplinary Group of Energy Planning of UNICAMP and consultant for United Nations and governmental agencies.

Ricardo Baldassin Junior

Graduated in Mechanical Engineering (UNESP, 2002), MSc in Energy Planning (UNICAMP, 2006) and PhD in Agricultural Engineering (UNICAMP, 2015). Researcher at the Interdisciplinary Center for Energy Planning - NIPE at UNICAMP in bioenergy, biofuels and thermoconversion of biomass. Currently Ricardo is working supporting the FAPESP/LACAf-I Project to promote bioenergy in Latin America and Africa.

José María Rincón Martínez

Chemist graduated from the National University of Colombia (1964), he studied Master of Science Fuels at the University of Manchester Institute of Science and Technology, England. He served as chief of Manuelita Sugar Mill Laboratory and director of Shell chemical plant in Colombia. He was Professor of Chemistry Department at the National University from 1971, where he created the research Laboratory of Fuels and named honors as an associate professor emeritus. He is Tecsol Industries founder, company dedicated to research and development of chemical processes in the energy and environmental area, cofounder of Corpoema, an organization dedicated to consulting in public and private energy sector, he also created the Latin American Network of Bioenergy, and was participant the international editorial board of the journal Fuel. Member number of the Colombian Academy of Sciences, he has made more than 80 publications, Editor of the Energy book: their prospects, their conversion and uses in Colombia, and co-editor of the Bioenergy book: sources, conversion and sustainability. Currently he is a contributor to the Sugar Mills Industries in the evaluation of Biofuel Potential and develops rural electricity generation projects from renewable energies.

References

ANFAVEA. *Brazilian Automotive Industry Yearbook 2015*. São Paulo, 2015.

Ayarza, J. A. C. *América Latina e o Etanol de Cana-de-açúcar: Diagnóstico do Ambiente Sistêmico e dos Fatores Críticos Competitivos, 2012*. Universidade Estadual de Campinas - UNICAMP.

Barros, S. *Brazil Biofuels Annual: Ethanol and Biodiesel*. São Paulo, 2015.

Cerqueira Leite, R. C. De; Verde Leal, M. R. L.; Barbosa Cortez, L. A.; Griffin, W. M.; Gaya Scandiffio, M. I. Can Brazil replace 5% of the 2025 gasoline world demand with ethanol? *Energy*, v. 34, n. 5, pp. 655–661, 2009. Available at: <http://www.sciencedirect.com/science/article/pii/S0360544208002958>

Cortez, L. A. B. Developing a bioenergy plan in Latin America & Caribbean that incorporates advanced technologies, 2012. La Paz, Bolivia: Interamerican Network of Academies of Science - IANAS. Available at: <http://www.ianas.org/PDF/BrazilDevelopingabioenergyplaninLatinAmerica&-

CaribbeanthatincorporatesadvancedtechnologiesLuisCortes.pdf>

Cortez, L.A.B.; Souza, G. M.; Cantarella, H.; Slyus, M. A.; Maciel Fo, R.; Brito-Cruz, C. H. “Universidade e Empresa: 40 Anos do Proalcool” Editora Blücher, São Paulo (in press).

Eastmond, A.; García, C.; Fuentes, A.; Becerril-García, J. Capítulo 9 - México. En: B. D. Solomon; R. Bailis (Eds.); *Sustainable Development of Biofuels in Latin America and the Caribbean*. pp. 203–222, 2014. New York: Springer.

EIA. EIA Beta. Available at: <http://www.eia.gov/beta/international/>

EPE. *Brazilian Energy Balance 2015: year 2014*. Río de Janeiro, 2015.

FAO. World Food Summit Plan of Action. Available at: <http://www.fao.org/wfs/index_en.htm>

FAO. *Food Security*. 2006.

FAO. FAOSTAT - FAO Statistic Division. Available at: <http://faostat3.fao.org/home/E>

FAO. FAOSTAT - FAO Statistic Division. Available at: <http://faostat3.fao.org/home/E>

Gilbert, A. J.; Pinzón, L. *Colombia Biofuels Annual: Trade Protection Worsens Biofuels Shortfall. A GAIN Report*. Bogotá, 2015.

Goldemberg, J. & Coelho, S. T. Renewable energy - Traditional biomass vs. modern biomass. Energy Policy, v. 32, n. 6, p. 711–714, 2004.

Goldemberg, J.; Coelho, S. T.; Guardabassi, P. The sustainability of ethanol production from sugarcane. Energy Policy, v. 36, n. 6, p. 2086–2097, 2008.

GRFA. Global Biofuel Mandates. Available at: <http://globalrfa.org/biofuels-map/>. .

GUATEMALA. Acuerdo Ministerial Número 334-2015, 2015. Guatemala. Available at: <http://www.mem.gob.gt/wp-content/uploads/2015/06/Nomina-de-Productos-petroleros-334-2015.pdf>

IATA. Resolution on the Implementation of aviation “CNG2020” Strategy, 2013. Available at: <http://www.iata.org/pressroom/pr/Documents/agm69-resolution-cng2020.pdf>

IEA. *World Energy Outlook 2014*. París: IEA Publications, 2014.

IEA. *World Energy Outlook 2015*. París, 2015.

IPCC. *Climate Change 2014: Mitigation of Climate Change - Working Group III Contribution to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge ed. New York: Cambridge University Press, 2014.

IRENA. *Road transport: the cost of renewable solutions*. Alemania, 2013.

IRENA. *Renewable Energy and Jobs: Annual Review 2014*. Emiratos Árabes Unidos, 2014.

IRENA. *IRENA POLICY BRIEF - Renewable Energy in Latin America 2015: An Overview of Policies*. Masdar, 2015.

Joseph, K. *Argentina Biofuels Annual 2015*. Buenos Aires, 2015a.

Joseph, K. *Paraguay Biofuels Annual 2015*. Buenos Aires, 2015b.

Ludena, C. E. Capítulo 10 - The Caribbean. In: B. D. Solomon; R. Bailis (Eds.); *Sustainable Development of Biofuels in Latin America and the Caribbean*. pp. 223–239, 2014. New York: Springer.

Lynd, L. R.; Sow, M.; Chimphango, A. F. *et al*. Bioenergy and African transformation. *Biotechnology for biofuels*, v. 8, n. 1, p. 18, 2015. Available at: <http://www.scopus.com/inward/record.url?eid=2-s2.0-84924250801&partnerID= tZOtx3y1>

Nolte, G. E. *Peru Biofuels Annual*. Lima, 2015.

REN21. *Renewables 2015 Global Status Report*. París, 2015.

Smeets, E.; Junginger, M.; Faaij, A. *et al*. The sustainability of Brazilian ethanol-An assessment of the possibilities of certified production. *Biomass and Bioenergy*, v. 32, n. 8, pp. 781–813, 2008.

Souza, G. M.; Victoria, R. L.; Joly, C. A.; Verdade, L. M. *Bioenergy & Sustainability: bridging the gaps*. París: Scientific Committee on Problems of the Environment (SCOPE), 2015.

Tay, K. *Guatemala Biofuels Annual: Update on Ethanol and Biodiesel Issues*. Guatemala, 2013.

The World Bank Group. *The State of the Global Clean and Improved Cooking Sector: Technical Report 007/15*. Washington, 2015.

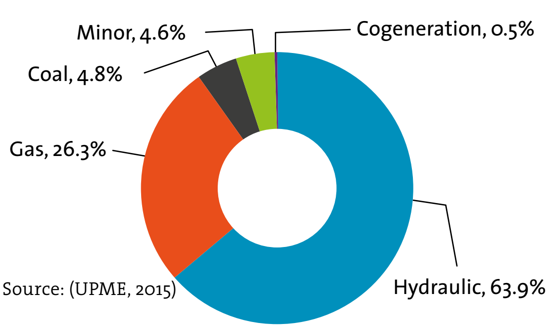
Box
Current Situation and Perspectives on Energy in Colombia

José María Rincón Martínez | Colombia

Colombia has a population of close to 49 million inhabitants. Located in the northwest corner of South America, its territory extends 1,141,748 km2 across the continent. The Andes, Latin America's most important mountain chain, divides into three ridges within Colombian territory (Arias J.J., 2009), resulting in a variety of climates that range from rain forests and tropical plains, to páramos (tropical montane grasslands and shrub lands) and areas of perpetual snow at levels of 4,000 masl (García Angélica). Climate variability is determined by altitude, and temperatures drop approximately 1°C for every 150-m increase in altitude up the slopes of the mountain chain. The climate remains relatively stable year round, with a dry season from December to January and July to August; and intense rains from April to May and October to November (Colombia).

The above mentioned geographical and climatic characteristics, with constant rains and favorable conditions for water storage benefit hydroelectric power as the source for primary energy. Figure 1 presents the distribution of installed energy capacity by source. This concentration in energy production can lead to vulnerability in the system in the short term due to the country's variable hydrological cycles. This is already occurring as a result of the increased intensity of the El Nino phenomenon due to climate change, which is significantly decreasing water supply to the extreme of having to raise electricity prices in order to lower consumption and avoid rationing.

Figure 1. Participation by source of installed capacity 2014



Source: (UPME, 2015)

In 2013, Colombia occupied 4th place in sustainability ranking as a result of significant employment of low-carbon energy resources.

Current Situation

The following is a summary of Colombia's principal sources of energy, beginning with fossil fuel:

Natural Gas. Vehicles are being converted to natural gas (NGV) thanks to incentive programs. However, uncertainty over supply and resulting signs of scarcity have decelerated the conversions and growth in NGV consumption. Consumption of energy in the residential sector represents 39% of total consumption;

hydrocarbon refining represents 37%; and the industrial sector, including the generation of electricity follows with 21%. During periods of drought, such as the current situation due to El Nino, the demand on power plants is high because the production capacity of the hydroelectric generators is low. Estimates by the Mining and Energy Planning Unit (UPME) indicate that in the supply and demand base scenario, for the short- and long-term, locally generated energy supply will be sustainable only until 2018. At the close of 2013, Colombia reported total reserves of 6.41 trillion cubic feet (Tcf), of which 5.51 Tcf correspond to proven reserves (UPME, 2013).

Petroleum. Proven, probable and possible petroleum reserves in Colombia reach 3,154 million barrels, of which 2,444 million barrels were proven reserves; this tells us that there is enough supply for 7 years.

Coal. Coal fired power plants represent only 6.52% of installed capacity. The UPME Expansion and Transmission Plan 2014-2028 contains a scenario of coal fired plants entering into operation in the country. This scenario sees an additional 1,050 MW generated from coal, which would represent participation at 12.5% of installed capacity. Coal is in abundant supply in Colombia and could potentially provide a guaranteed energy supply at low cost. Small scale mining productivity being developed in the country's interior must be improved for implementing this energy alternative.

Renewable Resources. For environmental reasons, Colombian Law 693 (2001) regarding biofuels and renewable energy requires the oxygenation of gasoline with alcohol. In 2005, as a response to fuel shortages, Colombia made the mixing of gas with ethanol (fuel alcohol) obligatory, and since 2009, diesel fuel has been mixed with biodiesel. The regulatory mixture percentage is 8% for ethanol (E8) and between 2% and 10% for biodiesel (B2-B10), depending on the region.

In 2014, Law 1715 was created to promote the development and usage of non-conventional energy sources - renewable resources - in the national energy system as a determining factor for sustainable economic development; for the reduction of greenhouse gases; and for energy supply (Congreso de Colombia, 2014) to allow for the development of distributed energy.

The country generates energy from sugar cane bagasse via cogeneration. A portion of the energy produced is used in the milling process; another portion is exported to the central network and its thermal energy is used in sugar refining. The cogeneration installed capacity for 2013 was 187 MW (Figure 2) (Asocaña, 2014).

Figure 2. Balance of cogeneration projects Installed Capacity (MW)

Source: (Asocaña, 2014)

The cogeneration potential in the Oil Palm industry is close to 300 MW (ANDI, Asociación Nacional de Empresarios de Colombia , 2014)

There is currently a wind energy plant in La Guajira with 19.5 MW of nominal power and three more parks are planned which will supply 400 Eolic MW. The perspectives for wind generated energy in Colombia are highly favorable, especially in the Caribbean and La Guajira, with an effective potential conversion of wind energy to electricity of 20,000 MW in wind parks. Evaluation of wind resources are carried out in zones with strong winds, which in national territory are found on the islands of San Andrés and Providencia, the areas around Villa de Leyva, Cúcuta, Santander, Risaralda, Valle del Cauca, Huila and Boyacá.

Perspectives

An analysis of perspectives is based on the work of UPME mentioned above. For this purpose, five specific objectives have been defined, focusing on energy supply, demand, universalization, international interconnections and the generation of value around the energy sector. There are also two cross-cutting objectives which are necessary for building on information, knowledge and human resources, as well as for synchronizing the institutional framework and facilitating the implementation of the national energy policy. The first specific objective is oriented toward energy supply, and in particular reaching a reliable supply and diversified sources of energy. The second objective promotes efficient management of the demand in all sectors and incorporates clean transportation technologies. The third objective improves the country's energy equity, an area in which the greatest advances should take place. The fourth objective stimulates investments in international linkages and in infrastructure for the commercialization of energy strategies. The fifth objective is to make value generation in the energy sector viable, for regional and population development.

The two cross-cutting objectives are focused on providing the required supports for the development of this sector. The first is aimed at creating links between information, knowledge, and innovation in the energy sector for decision-making; and to have the human capital needed for development. The second is to have a more efficient State, to update and modernize the sector's regulatory framework as well as address environmental and social challenges, to facilitate the adoption and development of the above mentioned technical and commercial changes.

Colombian Law 1715 provides a number of tax incentives to effectively promote investment in energy generation technologies using renewable resources. The law established a tax break of up to 50% of investment which can be distributed throughout the course of the five years following investment. In addition, it precludes paying sales tax on all equipment and services defined by UPME, destined for the project. As a third measure, all of that equipment, machinery, materials and supplies imported for Non-Conventional Energy Sources (FNCE) projects, not produced by national companies, will be exempt from import tariffs.

The optimistic scenario for 2028 estimates a maximum of 15% of energy being generated by renewable sources. This scenario includes energy generation projects thanks to the implementation of Law 1715 (2014), in consideration of the fact that for the period 2015-2030, an additional 1,200 MW of wind capacity could be added, along with 239 MW of solar energy, 375 MW of geothermal energy, and 500 MW from biomass and cogeneration from biomass. A network for measuring renewable resources must also be implemented to establish synergy among each of the energy sources, and to consider the possibility of defining incentives for the Reliability Charge, especially in cogeneration plants.

It is important to incorporate new sources of energy supply for the transport sector that are economically viable, while at the same time having moderate environmental impact.

Figure 4. Bioethanol sugarcane production. Ingenio Providencia, Cerrito Valle del Cauca, Colombia

In Colombia, ethanol is produced from sugar cane, largely in the Valle del Cauca. According to "Asocaña", 287 million liters were produced in 2013, as fuel alcohol destined for mixing with gasoline. This amount was sufficient for meeting national demand. Biodiesel production in Colombia utilizes palm oil and is carried out in 9 production facilities with a capacity of 591 thousand tons per year.

The production of biofuels today differs from the production of second and third generation biofuels, which use best technological processes and raw materials not intended for human consumption. Other energy crops and agricultural residues are used as the raw materials for the production of alternative transportation fuels. These crops are abundantly available in certain regions of the country which helps to reduce production costs and makes the operation of these industries more sustainable.

References

AméricaFotovoltaica . (2015). Energía solar en Colombia. Obtenido de La Guia Solar: http://www.laguiasolar.com/energia-solar-en-colombia/

Américafotovoltaica . (2015). La Guía Solar . Obtenido de Proyectos Exitosos de energía solar en Colombia : http://www.laguiasolar.com/top-5-proyectos-exitosos-de-energia-solar-en-colombia/

ANDI, Asociación Nacional de Empresarios de Colombia . (09 de 2014). Obtenido de Autocogeneración y Cogeneración : http://www1.upme.gov.co/sites/default/files/Memorias%20Eventos/Eficiencia%20Energetica/5_POTENCIAL%20DE%20COGENERACION_ANDI.pdf

Arias J.J. (26 de 06 de 2009). Absolut Colombia. Obtenido de Las Cordilleras de Colombia: http://www.absolut-colombia.com/las-cordilleras-de-colombia/

Asocaña. (09 de 2014). El sector Azucarero Colombiano, más que azúcar, una fuente de energía renovable para el país . Obtenido de Cogeneración : Los proyectos de cogeneración que se identificaron hace unos años atrás ya se han venido

Colombia. (s.f.). Clima Colombiano. Obtenido de http://www.colombia.com/turismo/guiadelviajero/indexclima.asp

Congreso de Colombia. (2001). Ley 693. Obtenido de http://www.fedebiocombustibles.com/files/Ley%20693%20de%202001.pdf

Congreso de Colombia. (2014). Obtenido de Ley 1715: http://www.upme.gov.co/Normatividad/Nacional/2014/LEY_1715_2014.pdf

CVN. (s.f.). Centro Virtual de Noticias. Recuperado el 9 de 12 de 2015, de Colombia una potencia en Energías Alternativas: http://www.mineducacion.gov.co/cvn/1665/article-117028.html

García Angélica. (s.f.). Toda Colombia, la cara amable de Colombia. Recuperado el 8 de 12 de 2015, de Pisos Térmicos en Colombia: http://www.todacolombia.com/geografia-colombia/pisos-termicos.html

Pinilla Alváro . (13 de 06 de 2009). Obtenido de Buenos vientos para energía eólica en Colombia: http://www.unperiodico.unal.edu.co/dper/article/buenos-vientos-para-energia-eolica-en-colombia.html

Subgerencia Cultural del Banco de la República. (2015). Posición astronómica y geográfica de Colombia. Recuperado el 9 de 12 de 2015, de http://www.banrepcultural.org/blaavirtual/ayudadetareas/geografia/posicion_astronomica_geografica_colombia

UPME. (2015). Plan Energetico Nacional Colombia: Ideario Energético 2050. Obtenido de http://www.upme.gov.co/Docs/PEN/PEN_IdearioEnergetico2050.pdf

Box

Sugarcane bioenergy in Brazil: current status and perspectives

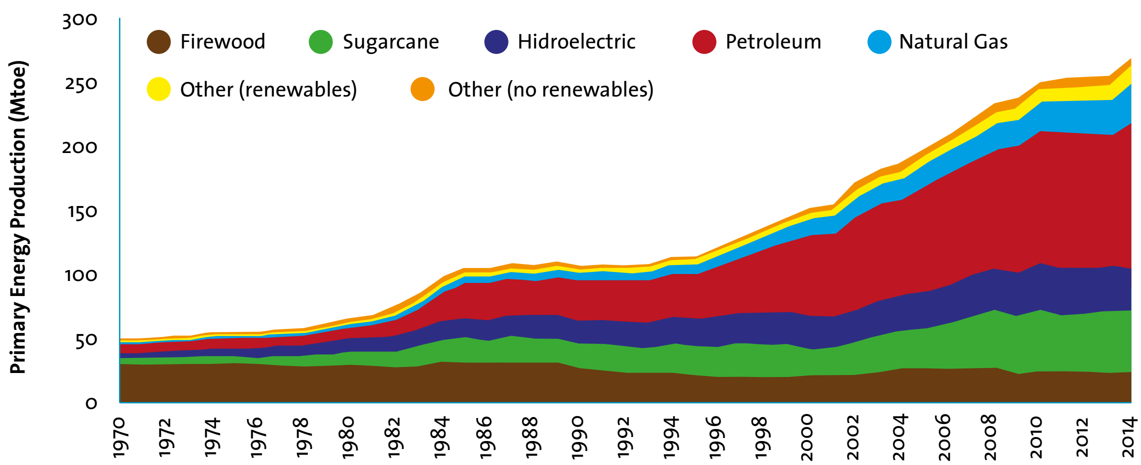
Carlos Brito-Cruz, Luís Cortez, Luiz Nogueira and Ricardo Baldassin | Brazil

Energy production in Brazil has experienced a sharp increase during the last 45 years, keeping pace with domestic consumption and maintaining energy source diversity (Figure 1). In 1970, firewood represented the base of the Brazilian Energy Matrix (64.2 % of the primary energy production), while the residential sector consumed 60% of total firewood production (EPE, 2015). That year, per capita energy consumption was approximately 0.65 tep per year, and 44% of 96 million of Brazilians lived in rural areas (FAO, 2014). Nowadays, the energy situation is completely different. Primary energy production reached 272.6 Mtep in 2014, while the contribution of firewood fell by 9.1%. This increase in energy production was driven by economic and population growth; per capita energy consumption doubled to 1.29 tep per year (EPE, 2015), and just 15% of the 202 million Brazilians now live in rural areas (FAO, 2014).

Historically, the Brazilian electricity supply has been supported by hydroelectricity power generation, and the transportation sector by petroleum. However, since 1970, sugarcane has reduced Brazilian oil dependence through sugarcane bioethanol and bioelectricity. In the 2000s, in response to economic growth, the introduction of flex fuel vehicles, and blending mandate changes,[1] the transportation sector experienced a noticeable rise in biofuel demand. Motivated by high fuel demand, and low sugar prices on the international market, the sugarcane bioethanol supply significantly increased in the domestic market, and in 2009, bioethanol (hydrated and anhydrous alcohol) accounted for approximately 45% of light vehicle energy consumption. After some years of retraction, basically due to government intervention in the fuels market, corrections were introduced in 2015 and the ethanol industry seems likely to recover. Nowadays, approximately 29 billion liters of ethanol are produced (EPE, 2015), and nine out of ten cars sold use flex fuel (Figure 2) (ANFAVEA, 2015). The National Biodiesel Production Program (PNPB) is another important initiative promoted by the Brazilian Federal Government in biofuels. Ten years after its implementation the blending mandate increased from B2 to B7, and today approximately 4.1 billion liters are produced annually, mainly using soybean (76%) and tallow (26%) (EPE, 2015).

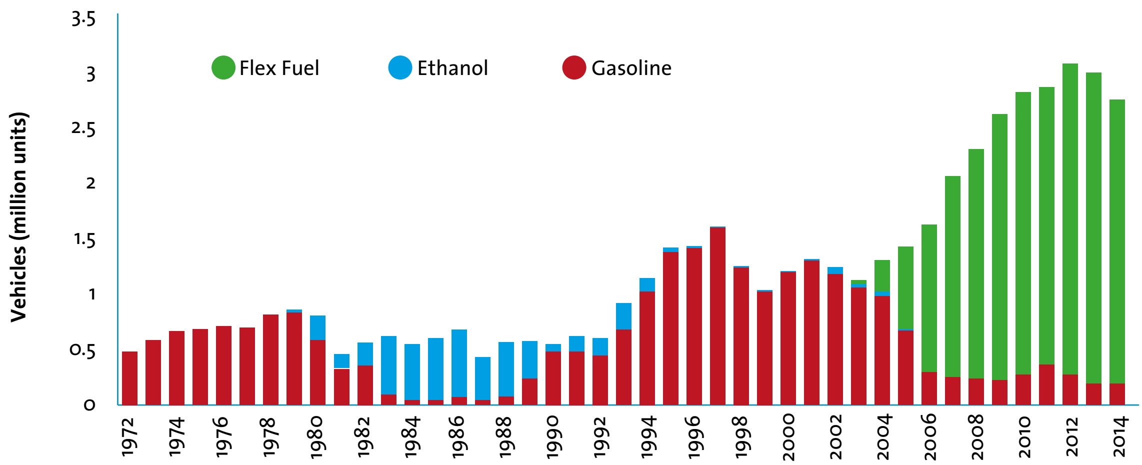
1. E20 (2000), E25 (2013), E27 (2015)

Figure 1. Brazilian primary energy production (1970-2014)



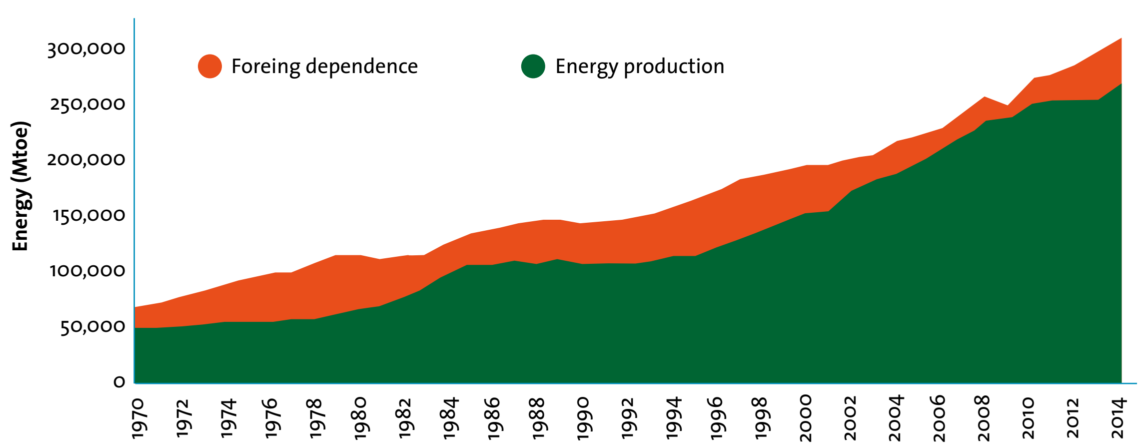
Source: EPE, 2015

Figure 2. Brazilian market sales of light vehicle (1972-2014)



Source: ANFAVEA, 2015

Figure 3a. Brazilian energy production and external dependence



Source: EPE (2015)

Sugar cane harvesting in Brazil

In 2014, dependence on energy from overseas was approximately 12.7% (39,6 Mtoe, Figure 3a), mainly oil, natural gas, metallurgical coal/steam coal, and oil products (diesel, naphtha, and liquefied petroleum gas) (Figure 3b). However, since 1997, Brazilian oil dependence has declined, following the recent discovery and exploration of oil reserves by Petrobras (Bacia de Campos and Pré-Sal). In 1975, the oil deficit was 80%, and by 2014, it had fallen to 6.3% (EPE, 2015).

Brazilian electricity generation is largely based on renewables (73.2%), and with the exception of hydro power generation, sugarcane bagasse is the most important renewable source (Table 1). The low capacity factor of sugarcane bagasse thermo plants is a reflection of the limited operating time of sugarcane mills (the sugarcane harvest season only lasts up to seven months in the year).

Today, three new important hydro power generation sites are under construction in the North of Brazil: Belo Monte (14 GW), Jirau (3.75 GW) and Santo Antonio (3.57 GW) (EPE, 2015).[2]

In 2015, there were 383 ethanol mills installed (362 in operation and 21 with permission to operate), while the total capacity of ethanol production (hydrous and anhydrous) was approximately 38 billion liters per year[3] (ANP, 2015). Currently, about 10 million ha are planted with sugarcane (UNICA, 2015), accounting for 1.2% of the total Brazilian area, and 15.4% of the area identified for sugarcane expansion[4] (65 Mha) (EMBRAPA, 2009). Approximately, half the sugarcane harvested is used for ethanol production and the other half for sugar production.

2. Total installed capacity.

3. Operation time: 8,760 h/year.

4. According to a Federal Agro-Ecological Study

Table 1. Electricity in Brazil: installed capacity, generation and capacity factor (2014)

	Installed Capacity		Generation		Capacity factor*
	(GW)	(%)	(GWh)	(%)	
Hydro	89.2	65.4	373,439	63.2	0.48
Thermo - Sugarcane Bagasse	12.3	9.1	32,303	5.5	0.30
Thermo - Other Renewables (Woodfuel)	2.5	1.8	13,895	2.4	0.64
Thermo - Non-Renewables	27.4	20.1	158,631	26.9	0.66
Wind	4.9	3.6	12,210	2.1	0.29
Total	136.3	100.0	590,478	100	0.49

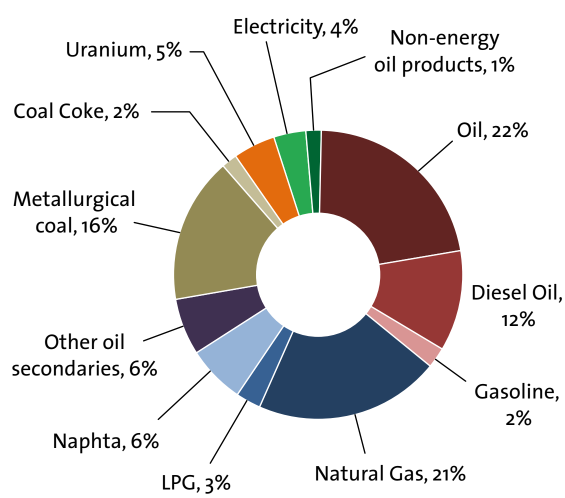
* Operation time: 8,760 h/year. Source: EPE, 2015.

Although Brazil began commercial production of advanced biofuels in 2014 (cellulosic ethanol from sugarcane residue and bagasse), it is only marginally economically feasible to produce on a large scale due to the high cost of the technology and the cost of the enzymes, among other factors. The production capacity of the two plants in operation (Granbio and Raízen) is approximately 124 million liters of cellulosic ethanol per year (BARROS, 2015).

Given the current situation of the Brazilian economy (recent currency devaluation) and the financial difficulties faced by Petrobras (high debt and low oil prices), domestic gasoline price can be expected to remain at higher levels than outside Brazil. This situation is likely to be maintained in the coming years, and will most likely create a favorable environment for the ethanol market.

In Brazil, as in a few other tropical countries such as Colombia, Guatemala and Paraguay, sugarcane is a key solar energy collector and the main vector of sustainable development, and energy generation, as well as income and welfare.

Figure 3b. Energy imports by sources in 2014



Source: EPE (2015)

References

ANFAVEA. Brazilian Automotive Industry Yearbook 2015. Brazilian Automotive Industry Association ANFAVEA, São Paulo, 2015.

ANP. Boletim do Etanol No 05/2015. Boletins ANP. Agência Nacional do Petróleo, Gás Natural e Biocombustíveis: Brasília, 29p, 2015. Available at: www.anp.gov.br/?dw=77898

Barros, S. Brazil - Biofuels Annual: Ethanol and Biodiesel. GAIN Report Number: BR15006. Global Agricultural Information Network (GAIN Report), USDA Foreign Agricultural Service. U.S Department of Agriculture: São Paulo, 31p, 2015.

EMBRAPA. Zoneamento Agroecológico da Cana-de-açúcar: Expandir a produção, preservar a vida, garantir o futuro. Empresa Brasileira de Pesquisa Agropecuária - Embrapa: Rio de Janeiro, 58 p, 2009.

EPE. Brazilian Energy Balance: Year 2014. EPE – Empresa de Pesquisa Energética: Rio de Janeiro, 292 p, 2015.

FAO. Faostat. FAO Statistic Division. Food and Agriculture Organization – FAO, 2014. Available at:http://faostat3.fao.org/home/E

UNICA. Unicadata. Brazilian Sugarcane Industry Association – UNICA, 2015. Available at: http://www.unicadata.com.br/index.php?idioma=2

Chapter 7

Capacity building in Latin America and the Caribbean

Anthony Clayton | Jamaica

Abstract

Most countries today understand the importance of capacity building; developing the skills, technologies and supporting infrastructure needed to compete in the world today. In practice, however, relatively few countries have a clear and focused strategy for channeling their investments in ways that are likely to support economic development and growth in the years and decades ahead. This paper outlines the basis for such a strategy.

Introduction[1]

Global economic transformation

Since 1985, China's GDP has increased over 16-fold, its share of global manufacturing has risen from under 3% to over 20%, it has moved from being the 10th largest economy to 2nd, and it could be 1st before 2030. However, the growth rates in Brazil, Russia, India and China have been overtaken recently by the 'N-11' group (Bangladesh, Egypt, Indonesia, Iran, Mexico, Nigeria, Pakistan, the Philippines, South Korea, Turkey and Vietnam) and the 'CIVETS' group (Colombia, Indonesia, Vietnam, Egypt, Turkey, and South Africa). Even more remarkably, of the 10 fastest-growing economies between 2000 and 2010, six were African.

As a result of these trends, by 2030 over 50% world GDP will be generated in countries recently or still classed as developing. This is probably most rapid and extensive shift in world economic power in history. It is clear, therefore, that many developing countries have transformed their productivity, economic growth rates and development prospects over the last three decades.

However, this has left another group of developing countries further behind, including a number in Latin America and the Caribbean. These are the countries that, for various different reasons, have not yet been able to achieve or sustain high growth rates. These reasons include high levels of violent crime, corruption (including the operations of vested interests), weak economic management,

1. This chapter is based on a number of previous studies undertaken by the author on various applications of development planning, foresighting and technology road-mapping. One of these studies was undertaken in collaboration with two other authors, Walter Wehrmeyer and C. Andrea Bruce. The references are given in the text.

poor planning and regulation, dysfunctional policies that discourage innovation and investment, high levels of social inequality, poverty, deficient infrastructure and a poor educational system.

It is important to resolve these issues in Latin America and the Caribbean. Limited and partial reforms cannot usually resolve such deep and systemic problems, so bold and decisive action is required if these nations are going to break out of the low-growth trap.

One important part of this strategy is to strengthen scientific and technical capacity, produce graduates that can increase the productivity and competitiveness of businesses and create new enterprises, and develop a trained, skilled workforce, certified to international standards, which will help to stimulate investment and employment and increase national productivity.

This will require significant reform in the region's universities and research centres, many of which are not internationally competitive. There is only one university in the entire continent (Sao Paulo) that is currently in the world's top 200. It will also require significant investment, as current rates of spending on research and education in the region are low by international standards. Any country that invests less than 0.5% of its GDP in research and development (either through public or private funding) is unlikely to become a world centre of innovation.

However, any investment in education, training and research capacity has to have a clear strategic focus if it is to have the necessary transformative effect. There is little point, for example, in training graduates to work in dying industries. It is, however, essential to increase the supply of trained, skilled labour in the 'sunrise' business areas that could transform productivity and prospects.

It is therefore essential to develop a clear strategic vision of where the growth opportunities will be in future.

The need for foresight

The world is being rapidly reshaped by the accelerating pace of scientific and technological advance, demographic trends, the rise of new centres of global manufacturing, surging demand for resources, rapid shifts in the pattern of environmental impacts, and changes in the nature of risk, political and economic influence, competition and conflict, and the geopolitical balance of power. How can an organization prepare for changes of this kind? What should it do, where should it invest, and should it restructure?

In times of rapid change, traditional planning processes that assume continuity and use linear projections based on the current status quo are unlikely to generate viable long-term plans, far less enable organizations to move into emerging high-growth areas. The problem is that the future will be determined by a complex combination of interacting variables, including demographics, competition, geopolitics and technological innovation, and this level of complexity makes it impossible to predict outcomes with certainty.

Given that we cannot see into the future, the only solution is to try to improve the way in which we think about and prepare for the future. Many of the changes are not technically difficult; they mostly involve a combination of better management and greater flexibility with some practical measures to improve information flow, reduce exposure to risk and increase resilience. However, preparing for the future also involves developing new sources of information, establishing when there is a need for change, building a consensus and mobilizing people and institutions around the new strategy.

There are a number of techniques that can be used to support this process. Future-oriented strategic planning tools, such as a foresight exercise, can help organizations to identify points of future competitive advantage, then to match these against their strengths and weaknesses in order to identify their optimal development strategy. It can also help to identify and then manage possible risks.

There are now a number of future-oriented strategic planning tools, including technology roadmapping, Delphi studies, foresight and backcasting exercises. All of them use some of the same techniques, which include the horizon scan (which involves examining the external environment for potential threats and opportunities, or early signs of disruptive technological change).

A technology roadmap for a firm would typically involve identifying market trends and needs for new products, then choosing the optimal technology needed to produce those products at the right price.

This kind of analysis usually involves asking questions such as:

- What are our core technologies? Could we use them more effectively?
- Could innovation make our technology obsolete? How quickly could we adapt?
- What are the trends in our sector? Could a new competitor or a new market emerge?
- What is our competitive advantage?
- What are the priorities for maintaining, upgrading or replacing our core technologies?
- What resources will be required to update our technologies and upgrade our skills?

Foresight exercises are more commonly used to address larger issues, of national concern, and therefore have to take a broader range of social and political variables into account. Foresight exercises all involve scenario planning. The main drivers of change are identified and projected forward into the future. The outcomes are tested against various possible alternatives and counter-factual challenges, then resolved into a small set (typically two to six) of the most plausible and consistent outcomes. This is sometimes done as a prelude to backcasting, which involves tracing back from a given future scenario to present day, sketching in the sequence of decisions and events that will lead to that outcome rather than another. Backcasting resembles critical path analysis, which is a standard project management tool, but it traces backwards from the future rather than from mapping forward from the present.

Another important use of foresight and scenario planning is in stress-testing policies and in contingency planning. This involves asking questions such as:

- What if this plan doesn't work?
- What would happen if more than one bank failed at the same time?
- Where are we most vulnerable to a terrorist attack?
- Could we compete if there is a surge in cheaper imports?

Using foresight in national development

Advances in science and engineering have a profoundly transformative effect on every aspect of our daily lives. All of us depend on modern agriculture, energy and water engineering, while medical science now allows us to control many infectious diseases that, in an earlier age, destroyed entire populations. However, many great challenges lie ahead. A combination of demographic growth, rapid development and rising consumption could result in global shortages of food, water and energy, as well as an extensive loss of biodiversity, and accelerate the rate of climate change.

This is a cause for action, not despair, because every major problem stimulates the search for new solutions. The pace of innovation, technological development and change continues to accelerate across a broad front, as a result of dramatic progress in fundamental science, engineering applications and new product development. This is particularly rapid in 'hot' areas such as biological science, informatics and nanotechnology, where both the fundamental science and the engineering applications are evolving simultaneously, changing basic concepts and perceptions as to what is possible.

Molecular engineering is already giving us materials with previously impossible combinations of lightness, strength, flexibility and other properties. This will allow the development of ultra-light, energy-efficient and safe vehicles, for example. In the biological sciences, there are lines of research that promise the new generations of genetically-specific pharmaceuticals, advanced biofuels, and genetically modified plants and animals that will be needed to support a far larger human population in the decades ahead.

So it is clear that the future will be very different from today - hopefully for better, possibly for worse, but certainly different. This creates a profound challenge for many organizations and even entire nations. Where is their place in the new world? Will they be winners or losers? This is where a foresight exercise can be used to map out strategies for success.

The starting point in a foresight-based formulation of a long-term strategic plan for national development will generally lie in an assessment of both internal and external factors; the former with regard to internal strengths and weaknesses, the latter with regard to changes in markets and other critical factors in the external environment. This would normally include a review of new and emerging technologies in conjunction with an analysis of the current restructuring of sectors of the global economy in order to be able to anticipate market opportunities. That would then provide the basis for a plan to build a new role as a market supplier or market-maker in a high-growth, high-value sector. This would allow an organization or a country to develop a first-mover advantage, then to translate that into a long-term strategic position within the market.

These market opportunities could, with good management, be used to demand-pull a process of economic restructuring, provide the economic impetus to support a widening skill base, attract and retain human and financial capital, and make a decisive move down the value chain, thereby escaping from low growth, low margin markets. Diversification into ancillary opportunities in related markets could then be used to fuel a long-term process of growth and development and the construction of increasingly knowledge-based business-industrial divisions or clusters, thus supporting a wider transition to a skill-based economy. Foresight can be used throughout this process to stimulate, guide and lock-in the transition.

Potential benefits

Future-scoping studies and horizon scans can help to map out the pattern of opportunities, constraints and demands that will shape future markets. It is then possible to focus resources, and to ensure that the necessary skills and technologies are assembled at the right time. More generally, foresight exercises can generate a range of benefits.

- A strategic planning process can help any organization to assess risks, threats and opportunities, clarify the issues, determine its priorities, and integrate them into a single coherent plan.
- The process of thinking about the future makes it easier to think more objectively about what the real problems are today.
- The analysis of trends indicates where it will be necessary to develop new skills or invest in new technologies in order to be competitive in future.
- The process helps an organization to identify future areas of competitive advantage. This can be used as the basis for a business development plan, withdrawing from areas in decline, and reallocating resources into likely growth areas.

The role of education and training in development

It is also essential to reconsider the role of educational and training institutions in national development; traditional 'supply-push' models of the role of educational systems in developing countries have largely ignored both the larger economic context of global change and the need to foster innovative capacity.

Educational and training systems have a crucially important role to play in supporting and enabling a transition to a skill-based economy. They cannot, however, drive this process. The distinction becomes clear when considering the failure of traditional strategies for education and training, which have tended to focus on increasing the supply of skilled and educated people into the workforce. There is little evidence, however, that the process of economic development can be directly supply-pushed by education and training. For example, an oversupply of over-qualified graduates in an economic recession can lead, instead, to a situation where many university graduates are unemployed or underemployed, and consequently disaffected, or emigrate in search of better opportunities overseas.

The evidence suggests, rather, that education is demand-pulled by economic development. As economies strengthen and diversify, they assume the inverted pyramid shape of a mature economy (in which tertiary service sectors increasingly dominate secondary processing and manufacturing sectors, which in turn increasingly dominate primary mining and agricultural sectors). As this happens, the demand for a widening range of increasingly diverse, specialist and sophisticated skills expands, which thus expands the range of opportunities and demands for educational courses. The development of India's ICT industry, for example, was made possible by the availability of a large number of underemployed mathematics graduates, but these graduates would probably have remained underemployed had it not been for the Indian Diaspora in California, who provided the link to markets, ideas and business opportunities that demand-pulled subsequent developments, as well as the investment capital and technology-transfer that triggered and accelerated the subsequent rapid growth.

This raises a number of fundamental issues. For example:

- Can the educational and training systems in developing countries make a stronger contribution to economic development? Should available resources be focused on areas where there is potential demand-pull? Given the long lead-time required to develop new courses and produce the first graduates, is it possible to identify these areas in advance? Which areas will generate the future employment opportunities, and what are the associated training needs?
- Which elements of funding for research, education and training should have priority if demand-pulled training is to succeed? What are the implications for resource allocation? Where do schools, colleges, universities and adult training agencies fit into this process? Where are the key entry points for effective intervention?
- Is it possible to support the development of increasingly knowledge-based economic activities by encouraging entrepreneurship in knowledge and service-based economic activity – particularly in countries and sectors with a relatively thin skill base in those areas?
- What are the implications of rapid technological change for generating new employment opportunities - and destroying redundant business activities?

Innovation and the labour market

The dramatic acceleration in the rate of innovation has profound implications for the job market. Every innovative new idea and technology creates new opportunities, demands and markets, but simultaneously renders old technologies obsolete and the associated skills redundant. So the status quo is constantly disrupted by innovations that restructure the competitive environment. The accelerating pace of innovation is forcing a similar acceleration in the rate of change in the market for employment and skills.

This suggests two things. First, the workforce will have to be far more mobile and flexible in

future. Second, the most important skill, in the long term, is likely to be the ability to drive, anticipate or respond positively to change.

The challenges therefore include the following:

- How can people be prepared for jobs that may not exist yet?
- How can people be trained to use technologies that are not familiar today to solve problems that are not currently well-known or understood?
- What will be the new industries and business opportunities?
- Which jobs could disappear?
- What jobs will be required in future?
- What should we be training people to do? What kind of skills will they need?

The implications of information

Information and communication technologies (ICTs) now allow many services to be delivered online, which has forced the emergence of new business models, disintermediated entire industries and changed the international balance of competitive advantage, accelerating the rate of development and growth in many countries.

The fact that many services can now be delivered on-line, for example, resolves many of the limitations imposed by distance from the world's major markets, which has allowed places such as the Cayman Islands to become exceptionally successful in off-shore banking. The rapid uptake of mobile phones in Africa and India is transforming domestic markets, as farmers can now find out prices in the city, and thereby avoid being cheated by buyers and traders. The uptake of mobile phones has also enabled the development of new services, such as universally accessible and reliable money transfers, which are now becoming the dominant form of banking in countries like Afghanistan. Better communications have helped to restore social networks, as families can now stay in contact even as the members disperse in search of work, and reintegrate home and Diaspora communities.

In time, these developments may also encourage social transformation, as repressive governments find it increasingly difficult to control all communication channels. In North Korea, the government controls all media outlets, but mobile phones can now be smuggled in from South Korea and China, allowing information to flow both ways.

It is also clear, however, that ICTs alone cannot resolve all failures of governance. In Jamaica, for example, the liberalization of the telecommunications market in Jamaica led to a rapid surge in the level of mobile phone penetration, to saturation of the market, but this was not reflected in the rate of GDP growth which remained low throughout the period. This suggests that ICTs might be a necessary but not sufficient factor in development, and that broader social problems (such as crime, corruption and dysfunctional bureaucracy) can still choke off the rate of new business development.

One of the particular challenges for any government that wants to encourage the emergence of a strong ICT sector is that the technology develops exceptionally rapidly, while legislative and regulatory frameworks usually change very slowly, and are frequently rendered obsolete by technological transformations. This is because, in any fast-moving area, there are times when the dominant architecture or platform changes, sometimes as a result of a disruptive technology that radically increases efficiency, reduces cost or enables the incorporation of a completely new set of features. One strong trend in ICT, for example, is towards convergence, where separate functions that were formerly delivered by distinct appliances such as cameras, photo albums, personal digital assistants, televisions, videos, entertainment centres, calculators, memo recorders, faxes, mobile phones and personal computers can now be incorporated into a single, hand-held appliance. When changes like this happen, firms that were previously competing in separate markets suddenly find themselves competing in the same market, but with different platforms, and established businesses can evaporate with remarkable speed.

This is likely to have even more dramatic effects in future. For example, Google has added many new functions to make itself the core of a complete information management service. This strategy may lead Google to move directly into banking services, and compete with existing corporations such as Citibank, or to move into telecommunications, and compete with companies such as Vodafone, while telecommunications firms are now the largest 'banks' in many parts of Africa (because their cellphone service offers a faster and more reliable way to transfer credit). This illustrates the point above; that technological advance can revolutionize one market by bringing it into the domain of another, so that firms that formerly competed in completely different markets, with corporate structures and products that reflected the demands of their separate markets, can suddenly find their territories invaded, their products no longer adequate and their corporate systems in need of radical re-engineering.

This can happen as a result of technological convergence; a platform or solution developed for one application generalizes to other markets. It can also happen when someone realizes that two conceptually-different problems actually have deep structural similarities, so that a solution developed for one can be readily adapted to solve the other. This process is accelerated by economic drivers; many companies now use new technologies to extract additional revenue streams from their existing infrastructure. In the UK, for example, supermarkets now offer tourism and banking services and electricity companies have become internet service providers, and many corporations now use data mining software to extract previously-inaccessible commercially valuable information from their own customer databases about correlated consumption patterns, and develop additional products and services as a result, which also leads them to compete in new areas.

One of the dominant technology trends that will have profound implications on the nature of work, and on job content and required skills, is that information is now freed from any medium (for example, a book can now be stored on a computer, mobile phone, digital reader or USB stick, on the web or on paper). Information is also fully mobile, and can be transported, stored, edited, analyzed or processed anywhere - or in multiple sites simultaneously. The mobility and accessibility of information has led to a dramatic surge in the level of access and use. About half of the population of the planet now has internet access, an 826.9% increase between 2000 and 2015 , while the rate of mobile messaging is currently tripling every year.

These changes have a number of consequences:

- Data storage costs have fallen to a fraction of the cost of producing the information. This means widespread access is now economically viable, because the costs of making information accessible are now negligible.
- The protection of information – formerly done by controlling the way data was stored and managing access – is increasingly no longer technically possible. Many newspapers and record companies are now struggling to find a replacement business model, as the information content is now free. News, for example, is no longer controlled by media groups, but disseminates rapidly through social networks. This means that the value has to be added elsewhere, which affects all the creative sectors that so far have relied on Intellectual Property Rights protection, such as music, video, pictures, writing, publishing and academia.
- Ideas of authorship are evolving, as collaborative editing and crowd-sourcing makes it harder to trace the development of concepts over time and attribute them to a sole source.
- It has become increasingly difficult to control information. It is now possible to access sensitive personal information about most people, and some have been embarrassed when unwise emails or photographs went viral and were circulated around the planet.
- It appears likely that with the increasing miniaturization and rapidly growing capability of digital devices, the boundaries between internet, mobile phone and other previously separate channels will merge. The internet will continue to grow and ramify into all areas of our lives, but it will be predominantly accessed via mobile devices. Some of these will eventually be integrated into everyday objects (such as clothing), and so will become 'invisible'.

These changes will have far-reaching implications for society, skills and jobs. For example:

- As information storage and access becomes virtually free, the challenge of researching a topic will no longer lie in gaining access to information, but in making sense of it. The successful use of information in the digital age increasingly depends on deep knowledge and experience, intelligent filtering, contextualisation and the ability to determine the relevance of information. The key skills then become critical thinking, the ability to identify trends, deep expertise in relevant subject

areas, distribution skills in disseminating the findings, and technical skills in accessing, managing and collating data.
- Product and service design will shift towards ways in which the loss of intellectual Property Rights (IPR) can be slowed or monetized. This may include charging for access, on pay-per-use or all-you-can-eat tariffs, providing a licensing scheme for aspects of the service that still can be IPR-protected (for example, offering basic information free, and offering interpretative services as a high value-added), providing insights into trends and events, analysis, providing a clearing house for the distribution of distilled information and so on. For example, the Wall Street Journal website is now free for a large section of news items but charges for access to editorials, analyses and technical pieces.
- Another alternative is to shift the value-added part of the business from material that can be accessed digitally to material that can't. For example, a manager of a major UK-based music band said recently that "we used to have concerts to promote our albums. Now we give away our albums to promote our concerts". This shifts the value-added service away from the product, which is now digital (and can therefore be distributed at very little cost and no loss of quality to many users) into the experience of seeing the live performance.

Governments that fail to realize this transformative effect of the process of technological advance, and persist with outmoded regulations, onerous requirements and dysfunctional bureaucratic systems are unlikely to emerge as high-technology hubs, no matter how many tax breaks or other inducements they offer.

The move from physical goods to services and from ownership to access

Another defining future trend is that the need to own a physical device to obtain a particular service will be removed by the servicisation of the economy. For example, apps such as WhatsApp and Skype, which run on many different kinds of devices, make it unnecessary to pay for calls. Many people no longer own their music –or even store it on their hard drives– because they can now use services such as Spotify and YouTube to access whatever track they want to hear, whenever they want.

This model has already extended to mobility. The city of Ulm, Germany, developed an innovative individual mobility system called Car2Go in 2008. This allows people to use cars whenever they want without the expense of having to own and maintain a car. Users have mobility on demand, without the need for ownership, maintenance costs, insurance or any other asset management requirements. They can take a car whenever they need one, use it for as long as they want, and leave it at a convenient location without the need for any additional effort or cost. In addition, the cars are fitted with diagnostic systems, which ensure that they are optimally maintained. This is very efficient, because it means that maintenance schedules, inventories of spare parts and so on can also be optimized, while Mercedes has gained unprecedented insights into consumer behaviour and into how drivers use their cars. The project gives a continuous flow of data which can then be used to design further improvements in urban mobility systems. Similarly, Uber is rapidly destroying the business model for taxis, while Google's driverless cars will eliminate the need for both public transport and private car ownership.

These examples illustrate several aspects of the transition away from the ownership of physical goods to access to services.
- It is clear that many consumers no longer require ownership if they want to enjoy a service. This yields a range of additional contractual opportunities for service provision, with legal models that range from hire-purchase, rentals, leasing to usufruct regimes.
- The intensity of use is much higher. In the mobility example, the hourly use of the cars is much higher than with privately owned cars, with more frequent servicing. This means increased employment, more training opportunities, wider access, greater resource efficiency and reduced environmental impact.

In this servicised economy, the successful business strategies are likely to be those that can best manage the interfaces between the different aspects of the value chain involved in the creation of services. This suggests two possible future directions. One is an increasingly specialized and narrower niche focus in the range of business services. The other is the globalization of that service offered to an increasingly large range of potential customers, in different contexts. Organizational core competence is therefore likely to become both narrow (highly specialized) and global (marketed in many countries). This means that another core business skill will be to manage the network and synergies of many different partners in a seamless way - i.e. without this becoming obvious to the customer. Highly vertically integrated businesses, due to the complex nature of the services that they offer, are unlikely to have either the managerial flexibility or the organizational range to be successful in this servicisation world.

A good example here is the mobile phone industry. The traditional business model, based on the use of landline phones, included one major operator that designed and manufactured the handsets, marketed its preferential features to potential customers, sold them through their own retail outlet, operated the network, provided technical support, managed billing and customer services, maintained and repaired the phone, and managed the disposal of discarded phones. Today, in the mobile phone market, each of these functions is managed (probably more successfully) by a separate company, in effect operating in bespoke sub-sectors.

Future competencies

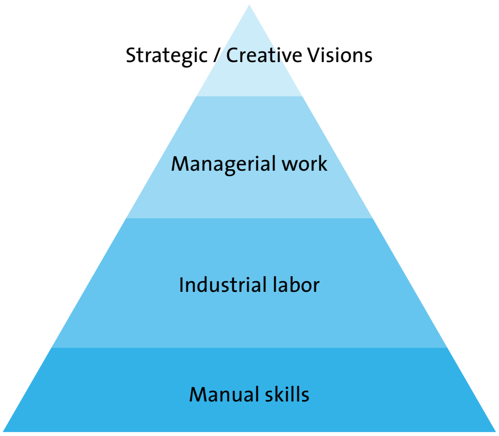
With regard to the demand for skills between today and 2030, the key points are as follows:

- The rapid and extensive nature of technological change makes it difficult to determine exactly what skills will be required in future.
- The relationship between employees and the organization is already changing profoundly,

away from traditional, more paternalistic models to independent contractors.
- The notion of core skills that will always be in demand (and thus ensure permanent employment) has vanished. Constant re-skilling and up-skilling is now essential.
- The idea that skilled people work for only one organization is rapidly becoming irrelevant; it is now seen as an outdated attempt to monopolize the skills supply. Instead, skilled workers are likely to ply their trade in a variety of organizational settings. This is already the case in many different skills. For example, there are now bricklayers who have their own business, work as subcontractors for building companies, provide experiential training in colleges, and work in teams with other building tradesmen to offer integrated construction packages. The trend to multi-tasking and multiple forms of employment is likely to become the norm across a wide range of jobs and skills.

Some forms of employment will become redundant, many will be transformed and new ones will be created. The differential impacts across different types and levels of skill, attitudes and competencies can be show in a Skills pyramid (see below).

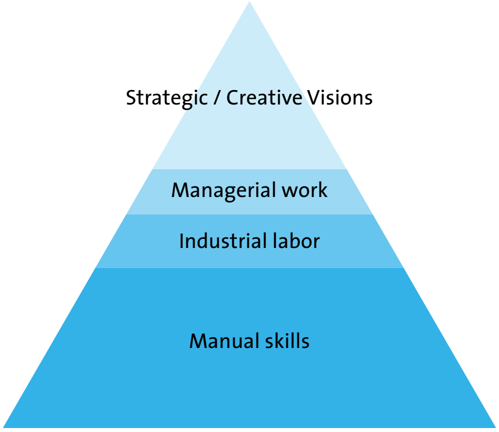
Figure 1. Pirámide de habilidades



At the lower end of the pyramid there are the manual skills of plumbers, electricians, plasterers, hairdressers, gardeners and so on. Above this level are jobs requiring manual skills in industry – factory workers, including machine fitters, tool makers, machine operators, call centre employees, initial IT support, fire fighting and so on. Above this are the managerial workers involved with supervisory, staff appraisal, performance management and quality assurance work, which includes middle managers, supervisors, human resources administration, accountants, lower-ranked HRM employees, (environmental, sustainability or information), and management systems operators. Above this in the pyramid (though not necessarily higher in the organizational hierarchy) are people who provide value-added services by developing and using ideas at the workplace. Typical jobs at this level include creative directors, graphic designers, layout specialists, web designers, organizational consultants, architects, marketing campaign consultants, interior designers, graphic artists, musicians and so on.

This model can be applied to assess the skills that will be needed for work in 2030.

Figure 2. Habilidades futuras



It is likely that many existing jobs will disappear at the lower three levels, but many new jobs will emerge, and the nature and fabric of almost all jobs will be affected by the technology-enabled social revolution.

With regard to Manual Skills, the evolution of current trends is likely to yield a dramatic change in the nature of jobs. The manual component of these jobs will reduce, and the IT component will increase substantially. Manual Skills are therefore likely to become smarter and more complex, with a substantial training requirement for up-skilling and cross-skilling. This is likely to increase demand for manual skilled work, at the expense of:

- Unskilled workers who will find it commensurately harder to engage in gainful employment
- Factory workers engaged on routine tasks, who are likely to suffer from a relentless drive towards automation and mass customization.

Manual Skills will also witness a substantial cross-over between traditionally separate work domains. For example, with the development of OLED light-emitting paint and wallpaper, the boundaries between a decorator and an electrician begin to blur, with both competing in each other's core area. In this situation, a central role will have to be occupied by the firms that can organize the appropriate skills, and organizations that can provide the necessary training.

With regard to Industrial Labour, the workers who were employed in semi-mechanized workplaces, doing routine or repetitive work, will increasingly be marginalized, finding themselves in a losing battle against increasingly smarter, flexible and faster machines. With factor costs being driven down, and technology being advanced further and further, it is likely that call centre staff - or example - will be replaced by intelligent voice-activated decision-support systems. Those that remain in these positions are likely to find their job requires up-skilling, but it is likely that the majority of staff in this segment will need new skills for new jobs, as opposed to additional skills for the changing job positions.

The third group, Managerial Work, is likely to be squeezed for similar reasons as Industrial Labour, as the greater use of IT is likely to reduce the need for human input in decisions ranging from routine to moderately complex: information gathering for Staff Development, document collation in legal cases, forensic accountancy, medical diagnostics, project management and decision-support contexts in the wider sense are domains that are likely to be performed more accurately, with higher reliability, faster and at a fraction of the cost by using intelligent information systems. Legal searches, for example, can now be done by software in far less time for at most 5% of the cost of using paralegals.

The pool of managers required for managerial jobs is likely to be reduced as the ratio shifts; ICT can allow a smaller group of managers to provide leadership and management for a larger group of supervisees.

The fourth group - Strategic / Creative Visions – includes the people with creative, thinking and entrepreneurial skills that work in innovative contexts, which would include this problem solving for specific companies, applying creative arts in the private sector and so on. This is likely to be beyond organizational boundaries: to use a current example, the environmental manager of a paper mill may actually be an employee of a technical consultancy that the mill has contracted in to perform this duty. The consultancy provides full-time environmental managers to a variety of paper mills, with the advantage that both partners can now focus on their core competencies, to their mutual benefit. This organizational model is likely to become the core of most successful business strategies.

This future will come about gradually, so it makes sense to align this discussion about the future of work to national development policies and planning cycles. There is relatively little scope for making major strategic changes in the short-term, given the need to train the academic educators and trainers, which imposes a long lead time. It is therefore sensible to focus on the medium and long-term to produce an effective set of visions for the four different skill bands. The medium-term horizon would consider the evaluation of training and skills provision in the light of known concerns, demands and identified bottlenecks. The long-term horizon would consider the large-scale changes that are likely to take effect before 2030, but knowledge about the precise nature of the events, discontinuities and challenges that will shape the world of work, employment, skills and training is inevitably less certain.

Long-term Scenarios

The further we look into the future, the less we know for certain about that future. This means that we have more scope to shape development trajectories towards our preferred outcomes. It also means that our forecasts are more likely to be wrong. However, the real choice for most countries is to either engage constructively with the global trends, or to be driven by decisions made by others, with all the negative implications that that will have for the domestic economy and the local skill base. In effect, this is a choice between taking part in the process of change, or else becoming increasingly powerless.

Taking into account future technological changes, the dynamics in the labour markets and the process of innovation that shapes jobs, companies and employees, as well as the interactions and interdependencies between them, suggests that a distinct set of skills and personal as well as interpersonal attributes are likely to be the primary determinants of the economic success (and employability) of individuals in the workplace. These skills can be categorized in a variety of ways. The increasing role of technology and innovation in the evolution of jobs and skills suggests that a more deeply stratified classification of types of skills is warranted, especially one that addresses the diversity of technology-influenced skills in a more dedicated manner. This suggests the following classification of skills:

Social Networking Skills: these are skills associated with the interaction of individuals, either online or in direct contact. It is an essential requirement for managers of digital or geographically close communities, remote teaching, team-builders, online mavens, thinkers who identify trends. Typical jobs would include webmasters, customer relation managers, trend spotters, bloggers and social media professionals.

Creative skills: these are the skills that either produce or facilitate new ideas, new perspectives and new creations (virtual or physical). Typical jobs would include website designers, decorators, architects, conflict resolution specialist, craftspeople and musicians.

Technical skills: the underlying level of complexity in our technical systems is likely to rise, not fall, as a result of the continuing process of technological and social change described and reviewed above, although most user interfaces are likely to become significantly more intuitive. The technical skills required to interact effectively with complex technology (hardware as well as software) will therefore remain an integral part of employment (and private life). Technology will continue to become easier to use, but more complex to repair, and each repair will be more dependent on specific spare parts, reducing the scope for local repairs and makeshift patches.

The extent to which it will be necessary to understand how technology works is uncertain, but is probably dependent on the cost of replacements, the speed of new (better) products coming onto the market, the ease of substitution and the dependency of other system elements on the failed part, amongst others. These parameters also shape the demand for technical services. Typical skilled activities will include fault diagnostics, the management of productive technology, the ability to interpret results and so on, with professional cadres of scientists, engineers, systems managers and technicians.

Logistical Skills: The management of the interface between jobs, as well the delineation and demarcation of technical and legal responsibility, will be critical for the successful management of services. Core activities include managing supply chains and ordering, coordinating, and integrating different projects with regard to the material and human resource flow, logistics and so on. Similar changes will affect many of the manual skills that include an element of self-direction, amongst other jobs.

Thinking Skills: Mediating access to information may not remain a competitive skill, but making sense of a sea of diverse information, condensing it into meaningful, applicable and decision-supporting insights is likely to remain a very valuable skill for a long time, especially the ability to think critically about a decision-making context or a problem. In fact, applying critical thinking and problem solving skills will probably be the single most important difference between an acknowledged expert and a functionary. Typical jobs are within the Creative Visions range, but also include business analysts, policy evaluators, researchers, innovators and problem-solvers. Individuals scoring highly on this as well as the creative skills set are in many instance highly sought (and highly paid) consultants and thinkers.

Entrepreneurial Skills: As the original definition (a 'between-taker') suggests, these skills related originally to the set-up and growth of small businesses by people who could see the opportunities created by a mismatch between supply and demand. Much has been written about the personality traits of entrepreneurs, but it is very important to understand the critically important role that business start-ups play in the economic success of a nation. The core skills of entrepreneurs include:

- self-motivation
- business sense, the ability to convert an idea

into a profitable venture
- marketing and sales skills
- risk appreciation and management skills
- financial acumen and understanding
- time management skills

Given the importance of entrepreneurship for job creation and the diffusion of technology through entrepreneurial innovation, this is likely to become one of the core skills required by employers.

It should also be noted that self-motivation is probably a most important skill involved in entrepreneurial behaviour. This is a reflection of an attitudinal observation that employees who do as they are told, then stop to await new instructions, are unlikely to find career paths as long and open as those who are self-driven and show some initiative and drive. In technology-driven and complex work environments, self-motivation becomes essential.

Generic Skills: These skills are the ubiquitous initial skills for survival in a technology-driven and information-rich world. They include fluency in ICT, multi-tasking, self-motivation skills, and appropriate language skills, where necessary.

Project managers and integrators will always be in demand. Project Management has been identified as the primary success factor in organizations that range from global business to governments and NGOs, and there is currently a widening gap between the supply and demand of skilled project managers. This is a highly transferable skill, which can be applied to projects in construction, information technology, automobiles, business management, finance, consulting and so on. Logistics and supply chain management will also be increasingly important in order to ensure that organizations can match their supply with demand.

Green industries have also been growing at a rate of about 5% annually during the last three years, mainly in areas such as construction and the services associated with 'green buildings' that meet industry standards. By 2018, green construction will directly contribute 1.1 million jobs in the USA . Ten years ago, it was unquantifiable.

The greening of industry is creating many new careers, some based on existing professions such as law and journalism. Others are engineering careers in renewable technologies like wind energy and biofuel production. In the agricultural economy, the list now includes 'green' landscapers, garden centers, florists, landscape designers, tree growers, greenhouse operators and farmers.

The transition in energy provision in Germany away from nuclear and fossil fuels to a much greater reliance on renewable energies created an employment boom. Windfarms have to be erected, solar panels installed, electricity meters fitted and calibrated, and all these physical artifacts need to be marketed, managed and distributed. It is likely, therefore, that other jobs will be created in:

- Energy saving
- Energy service contracts
- Waste minimization contracts
- Waste management
- Waste exchanges

Jobs that may disappear

There are a number of jobs that are clearly vulnerable to automation. These include:

- Low-level secretaries and accountants, as basic text processing and accounting are being replaced by software.
- Receptionists can be replaced by virtual registration systems, which maximize staff productivity
- Low-level service staff such as cashiers, bank tellers, airline check-in staff and post office attendants, as most of these tasks can be replaced by self-service points.
- Couriers are likely to be replaced by better e-document security and secure electronic signatures.
- Low-level government bureaucrats will be replaced by better on-line systems and integrated databases. This is already happening in countries like Denmark and Estonia.
- Paralegals that undertake 'discovery' (document searches) can be replaced by semantic analysis software that can determine relevance and precedents, and inferential analysis software that can identify any suspicious content or pattern of behaviour.

There are a number of jobs that are being superseded by technological advances. For example:

- Fighter pilots are being replaced by Unmanned Combat Aerial Vehicles (UCAVs), as the latest models are likely to be far more effective in combat than piloted aircraft.

- Computer chip designers are being replaced by software.
- Manufacturing operations (including construction) are likely to be replaced by 3-D printing.

All jobs that depend on information asymmetries are vulnerable, as information asymmetries are disappearing in increasingly transparent on-line markets. These include:

- Realtors, who can be replaced by searchable GIS systems that list titles and permit sales and secure transfers.
- Brokers, who can be replaced by automated transactions.
- Travel agents, who can be replaced by software that knows personal preferences and searches for best routes, dates or prices.

Future skills

Over the longer term, it is very difficult to predict the exact jobs that will be most in demand, but it is possible to identify the kind of skills that are likely to be required. These include:

- Social networking skills: This includes people who are good at managing/leading groups, i.e. people who can manage customers, fans, digital communities, moderate online discussions, mavens (people who gather information, detect trends, are trusted sources, influence networks), team-builders, managers and leaders.
- Creative skills: This includes designers, visionaries and conceptualizers.
- Technical skills: This includes scientists, engineers and technicians.
- Miners: Data mining (looking for patterns in data) is already widely used in business, retail management, sales, marketing, credit risk management and banking, the detection of fraud, policing, surveillance and counter-terrorism. This includes, for example, retailers, who can see that customers who buy product A buy product B as well, which helps them to focus their marketing strategy. The implications are, however, far more profound. For example, Google have stated that credit card spending patterns allow them to predict with 98% accuracy whether couples are going to divorce within the next two years. Data mining skills are therefore going to have very wide application.
- Logistical skills: This includes organizers, project aggregators and coordinators, open-source project managers, logistics and supply-chain strategists and managers.
- Thinking skills: This includes critical thinkers, problem-solvers, policy analysts and business strategists.
- Entrepreneurial skills: This includes people who can network between different networks, e.g. scientists, financiers, and the businesses that control the manufacturing, supply and distribution networks.
- Generic skills: This includes people who are ICT-fluent, can multi-task, network, and have high EQ (emotional intelligence).

The implications for national capacity-building strategies

No country can be insulated from change and the effect of accelerating innovation. So the real choice is between accepting and managing change - or becoming increasingly powerless. The critical success factors are likely to be:

- Understanding the possible future pathways for each nation.
- Developing a strategy for the transition.
- Developing the key skills that will be needed in the years ahead
- Disseminating the key skills into the workforce

Conclusion

This paper has outlined the basis for a strategy for developing the capacities needed to remain competitive in a world being rapidly reshaped by profound social, economic and technological change.

Anthony Clayton

Anthony Clayton is the Alcan Professor of Caribbean Sustainable Development at the University of the West Indies, Visiting Professor at the Centre for Environmental Strategy in the School of Engineering at the University of Surrey, Visiting Professor at the Institute for Studies of Science, Technology and Innovation in the School of Social and Political Studies at the University of Edinburgh, Adjunct Distinguished Professor of Sustainable Development in the Faculty of Business and Management, University of Technology, Fellow of the Caribbean Academy of Science and Fellow of The World Academy of Science. His research interests include strategic analysis and scenario planning, with particular regard to national security, energy security and food security. He has undertaken policy studies for many governments and intergovernmental agencies.
Organization: Caribbean Academy of Science and IANAS Energy Program.

Dr Walter Wehrmeyer

Centre for Environmental Strategy, University of Surrey, UK.
Dr Wehrmeyer is Reader in Environmental Business Management and Deputy Director of the Centre for Environmental Strategy at the University of Surrey; Adjunct Professor of the Graduate School of Business, Curtin University; Member of the Institute of Environmental Management and Assessment; and Fellow of the Royal Society for the Encouragement of Arts, Manufacturers and Commerce. His research interests include self-organisation as a viable method to understand corporate environmental behaviour, organisational behaviour towards sustainability and sustainability indicators, organisational approaches to innovation and sustainable development, participatory approaches to decision-making, and corporate social responsibility, in particular, the role of culture and ethics in defining and forming business strategies.

C Andrea Bruce

C. Andrea Bruce is adjunct faculty at the Caribbean Maritime Institute where she lectures in Sustainable Development, Environmental Management and Academic Research. She is currently pursuing a doctoral degree at Temple University with a focus on human capital development. She is a graduate of the University of the West Indies with a Master of Science in Economic Development Policy and a Bachelor of Science in Economics and Management Studies. Her research interests lies in human capital development with a special focus on the future of work, employment and economic development. She has extensive experience in applied research and in corporate sustainability reporting, having undertaken work for CAF Development Bank of Latin America, CARICOM, and the Government of Jamaica. Her recent projects include the preparation of the drafting guidelines for the Government of Jamaica White Paper on Planning and Environmental Regulation; developing a learning framework for the Jamaican Public Service and facilitating the Strategic Planning implementation at the Jamaica Customs Department.

This book was printed in April 2016
with a print run of 500 at Surtidora
Gráfica, SA de CV workshops

GUIDE TOWARDS A
SUSTAINABLE ENERGY
FUTURE FOR THE AMERICAS

The American hemisphere is fortunate to have abundant energy resources, but our energy future depends on wise public policy and effective investment. A key point is that adequate resources are necessary, but not sufficient to meet current and future energy needs, especially when viewed in the context of the United Nations Sustainable Development Goals 7, 11 and 13.

In response to the SDGs, the volume considers the challenges of under served populations and it assesses the special relationship between gender and the energy economy in the developing world. The book also evaluates the current and future status of renewable energy, and especially solar energy, wind and biofuels, in the Americas in meeting the goal of reducing greenhouse gas emissions.

The Inter American Network of Academies of Science (IANAS) is dedicated to bringing science-based solutions to the big challenges of the 21st century. This IANAS contribution seeks to aid policy makers in our several countries by evaluating energy choices on both national and regional scales.

ISBN: 978-607-8379-32-3

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