Chapter 4

Women, energy and water

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

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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)

Women washing clothes in the lake shore Atitlán, Guatemala

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.

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%**

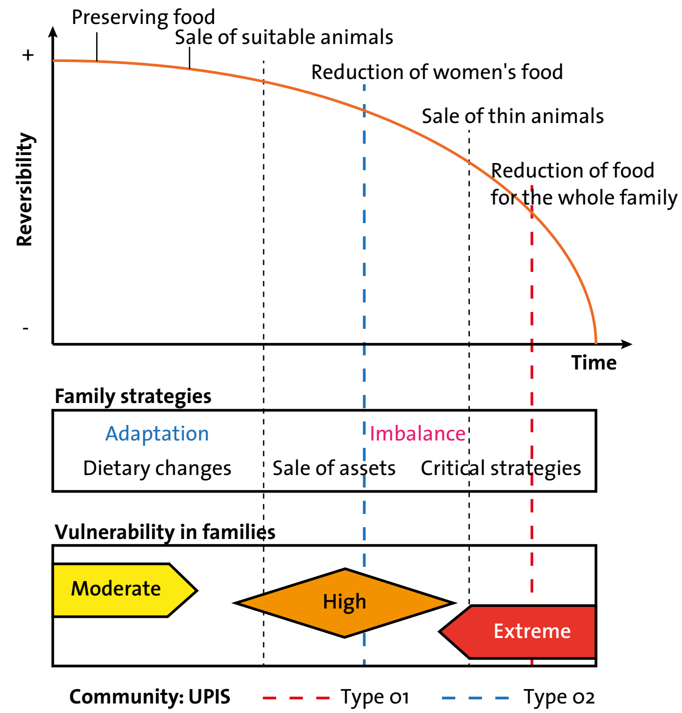
Source: Diagnóstico de la situación de las mujeres y las relaciones de género. Centro Guamán Poma de Ayala.

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

Figure 4. Using a solar cooker

Source: La Prensa.com.ni

and the sale of products uncontaminated by smoke from low-quality oil lamps (Reche, 2011).

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%). (*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, 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

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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=ApHH385P-MoGUMlsaemy7Vt6T4fTobToFbF8XMk9T6K5m-kYlMMhh7b.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

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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.

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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.