Renewable energy infrastructure. A challenge for Venezuelan industrial construction

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ABSTRACT

The relevance of renewable energy has grown significantly in our global society. Important efforts are oriented to sustain it. Renewable energy depends on different technical, financial environmental and social complex processes. From the point of view of industrial construction sector this research evaluates some of the current trends in energy generation and use in Venezuela as well as environmental consequences and risks that derive from these. Additionally, authors highlight the importance of infrastructure as key issue to sustain renewable energy generation and use. The study present references of some energy renewable projects in process in Venezuela and the main problems that constrain their performance. Conclusions evidence the complex nature of industrial construction and suggest the need to improve industrial construction competitivenes as a strategy oriented to enhance renewable energy offer in the country. Additionally it is proposed to all stakeholders to work toghether to correct the conditions that currently limit industrial construction development. This is part of ongoing research.

Keywords: Renewable energy, industrial construction, infrastructure, Venezuela

1. INTRODUCTION

The awareness about the limited availability and the severe impact of fossil energy on the environment has been growing in different countries. This has generated an increasing interest about renewable energy generation and consumption to support a sustainable long term development.

To be available the renewable energy requires the investment of important resources on R+D+i as well as the development of the infrastructure needed to generate, distribute and maintain it. Important efforts are required from the engineering and construction sector to build and maintain such facilities. From society additional efforts are requested to deepen the knowledge and culture oriented to fostering new sustainable energy use patterns.

The development of renewable energy facilities is not easy. The technological constrains, the complex infrastructure required, the huge investments necessary, the economic and political conflicting interests that may arise, and the environmental concerns - among other factors - show the intricate conditions that make any new project a big challenge for every country.

Those complications are especially evident in some "Megaprojects" as for example the construction of a new hydroelectric plant.

Because of their complexity, the infrastructure projects are affected by several construction problems that cause re programming, costs overruns and delays thus affecting the start up or the operations of the renewable energy facilities.

The objective of this research is to present some new references about energy production and consumption patterns in Venezuela, their environmental consequences, and the important relation between such trends, energy infrastructure projects performance and the construction problems in the country.

As main conclusions and from the perspective of Venezuelan industrial construction author's present basic knowledge about Venezuelan renewable energy trends and construction performance, point the infrastructure a key issue to increase the renewable energy offer in Venezuela as well as the current challenges that face industrial construction competitiveness.

Because such issues have been little studied in Venezuela this research can contribute to the general awareness of the importance of industrial construction to support the final goal to enhance the renewable energy supply.

Present information is result of an on-going research.

The main constrain acknowledged by authors is the lack of Venezuelan official data regarding the energy projects. This is an important limitation for this research.

2. RESEARCH METHOD

The research method included a literature review and the compilation of data regarding primary energy production and use, CO_2 emissions, infrastructure stock, problems affecting construction performance and energy projects in Venezuela.

Databases revised include: World Bank, International Energy Agency (IEA), CEPAL/ ECLAC, Venezuelan Electricity Corporation (Corpoelec) and Venezuelan Construction Chamber (Cámara Venezolana de la Construcción).

3. ENERGY TRENDS - VENEZUELAN ENERGY PRODUCTION AND CONSUMPTION PATTERNS AND ENVIRONMENTAL CONSEQUENCES.

Venezuelan energy tradition started at the end of ninetieth century with the oil discovery. In 2010 occupied the 8th place as world producer of crude oil and current oil and gas reserves make it one of countries with main hydrocarbons potential in the world. Additionally to the fossil energy resources, Venezuela is also known for being the 8th world producer of hydro electric energy. (World Energy Outlook 2010).

Moreover the fossil and hydro electric energy richness, Venezuela also present huge renewable energy resources coming from wind and sun available most of the year because of it privileged geographical location. As it will be explained below, this potential is still to be exploited.

To develop it fossil and hydrological resources Venezuela created an important infrastructure to extract, produce, refine, transport, compress and sell oil, derivates and gas and to use water to produce hydroelectricity and distribute it all over the country (Clemente, Puente 2001). The maintenance, improvement and enlargement of this infrastructure demand important efforts from engineering and construction sectors.

Since the oil discovery Venezuela developed a particular culture around the energy richness. In fact a long term policy of subsidies and control prices - that make the gasoline, diesel and energy in general cheaper than bottled water - the dependence on oil revenues as one of the main country incomes and other particular policies, has created an unusual attitude regarding the production and use of energy as will be explained below. (El Nuevo Herald 2011). This particular vision about energetic resources impacts the Venezuelan living patterns with consequences that are not yet fully assimilated by Venezuelan society.

Evidencing the dependence to fossil energy sources Figure 1 demonstrates that Venezuela presents a primary energy consumption tendency per capita that exceeds the world tendencies.

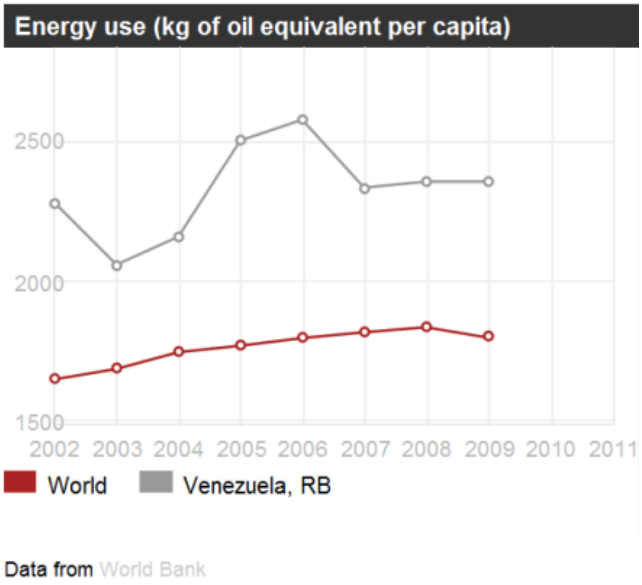

Figure 1: Primary energy use. World Bank. Feb 2012

The same trend about energy use may be seen on Figure 2 Electric power consumption that evidence that Venezuelan averages exceed the world ones.

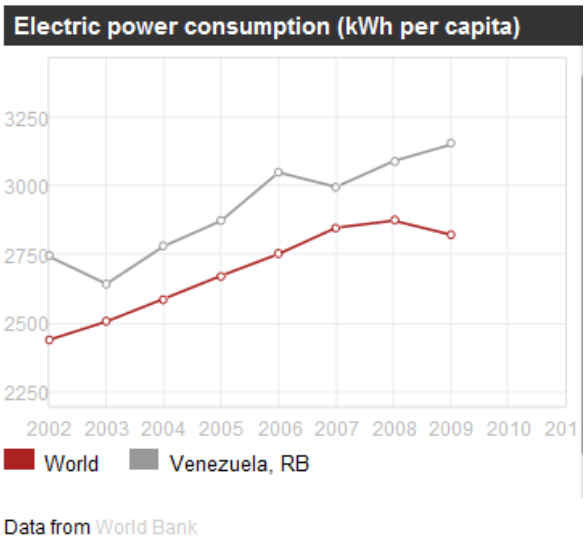

Figure 2: Electric power consumption. World Bank. Feb 2012

As it happens in Venezuela, our global society has kept the oil and the coal as the main sources of energy during decades. Researchers agree that because of it costs, technological advances, subsidies given and availability of fossil energy this will be an unchanged tendency in the following years. This means that substitute oil and coal will not be an easy goal. In fact, even with the continuous development of eolic, solar, biofuel, hydroelectric,

tidal, nuclear, biomass or geothermic energy among others, experts forecast an increase in use of clean energies from 6,4% in 2009 just to 13,5% in 2035 as may be seen on Table N 1.

Table 1: Primary energy use evolution

Primary energy use evolution %					
	1985	1995	2005	2009	2035
Renewable	6,1	6	6	6,4	13,5
Nuclear	4,6	6	6	5,3	6,4
Gas	20,4	22	23	23,1	21,9
Coal	28,4	26	26,7	28,7	27,9
Oil	40,5	40	38,3	36,5	30,3
Total	100	100	100	100	100

Adaptation from Hernández, N. 2010. BP/EIA. Pietrosemoli, L, Rodriguez Monroy, C, 2011

The severe dependence to the fossil energy brings undesired consequences to the environment. The increasing impact of natural disasters: floods, extreme drought or winter remember society about it. Regarding some of such consequences, Figure 3, evidences that Venezuela presents CO2 emissions averages superior to the world thus creating additional risks for an already fragile environment.

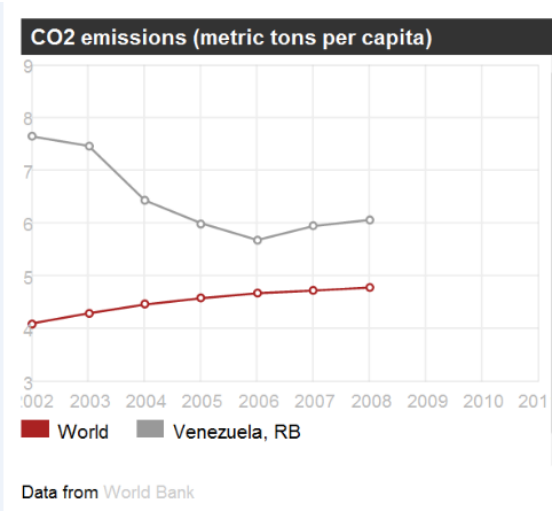

Figure 3: CO2 emissions. World Bank. Feb 2012

Recent oil spills in Venezuela, as the one happened in Guarapiche River in Monagas state in February 2012 - the extent of which damages are still in evaluation - evidence some other environmental consequences related to the current fossil energy dependence. All such consequences must be considered because of their impact over the quality of life of Venezuela and other neighbour countries and the planet itself.

Considering all the risks related to the fossil energies in terms of global warming and pollution - evidenced by the rising natural and human catastrophes - different countries are oriented to change their energy consumption patterns. By this reason some of them invest important knowledge, efforts and capitals to develop alternative renewable energies and increase sustainable energy sources.

But development of alternative energy is not easy. In fact the EIA projections of world energy consumption to 2035 evidence that the fossil fuel capacity will increase in the developing countries in following years, and such

countries will cover the main part of their growing energy needs basically from oil and coal sources (World Energy Outlook 2010).

Table 2 shows the evolution of the renewable energy offer for the diverse countries in South America. The expected behaviour for this group results disappointing considering that Brazil is the 3rd and Venezuela the 8th renewable electricity world producers.

Table 2: Evolution of renewable energy offer for South America

Evolution of renewable energy offer for South America *

	2002	2004	2006	2008	2009
Argentina	10,8	8,6	10	8,7	9,4
Bolivia	20,6	18,1	15,5	16	17,7
Brazil	36,7	38,7	41	42,4	43,6
Chile	22,3	21,1	21,1	21,1	23
Colombia	28,6	24,8	25,5	24,9	23,5
Guyana	41,8	41,6	48	43,1	42,7
Paraguay	64,3	66,4	67,7	65,8	67,5
Peru	31,4	30,5	31,2	25,3	22,5
Uruguay	43	34,3	30,1	33,8	33,6
Surinam	20,4	20,3	20,2	20,2	20,2
Venezuela	9,7	10,5	9,4	12,8	11,5
All Latin America and Caribbean countries	22,4	22,5	22,3	23	23,2

* % share over total energy supply

CEPAL/ECLAC UN. 2010 Statistical Yearbook for Latin America and the Caribbean

Summary: Pietrosemoli, L, Rodriguez Monroy, C

Corresponds to offer of the following energy sources: geothermal, hydro, wood whose use is considered sustainable, cane products and other renewable sources (such as solar and wind).

Accordingly with such data, from 2002 to 2009 Brazil increased it renewable energy offer in 6,9%, followed by Paraguay with 3,2% and Venezuela with an 1,8%, just followed by Guyana and Chile with positive variations that were inferior to 1%. The rest of the South American countries decreased in their renewable energy offer.

Moreover the fossil and hydro electricity richness, the alternative energy Venezuelan potential is huge. In fact due to the vast extension of coast and geographical location the country has an important potential to develop solar, eolic, bio, geothermic or oceanic energy, among other (Hernández, 2010).

So, why do the renewable energy production in general do not increase faster? Evidently no easy answers can be given to this question because the energy production and consumption patterns depend on a combination of factors including public policies, R+D+i, funds availability, fossil fuel prices and subsidies, political and international interests, construction performance as well as because of agreements and governments & consumers attitudes, among other factors.

Understanding the complexities of a problem that cannot be simplified (i.e. in Venezuela the scarcity of railroads is a variable that create a dependence on land transportation) for current case authors desire to highlight a behaviour that from a global perspective seems contrary to long term sustainable goals. This critic analysis is intended to invite stakeholders to the revision of some factors that may be a limitation to the development of alternative energy sources.

4. THE ENERGY INFRASTRUCTURE PROJECTS. IMPORTANCE AND SITUATION IN VENEZUELA

Among other key factors related to the development of renewable energy sources we find the infrastructure needed to generate and distribute it. The development of such infrastructure - for the improvement of existing facilities or the construction of new ones - demand a lot of engineering and construction efforts.

Table 3 (Fay, Yepes, 2003) shows the evolution of some of the world´s infrastructure stocks in the last 50 years and evidences the relevance of energy - in this case electricity - that since the eighties occupies the main investments efforts, together with the roads.

Table 3: Evolution of some infrastructure stock

How the composition of infrastructure stocks has changed in 50 years, all countries

	1960	1970	1980	1990	2000	2010
Electricity	22%	32%	40%	43%	44%	42%
Roads	47%	46%	45%	44%	44%	43%
Rails	29%	19%	13%	9%	6%	5%
Telecom	2%	3%	3%	4%	6%	10%
Total	100%	100%	100%	100%	100%	100%

Excludes: Oil, gas, ports, airports, water and sanitation

Fay, Yepez, 2003. Investing in infrastructure: What is needed from 2000 to 2010

Summary: Pietrosemoli, L, Rodriguez Monroy, C, 2011

The steady increase of electric generation importance for developing countries may be seen on Figure 4 Changing infrastructures stocks per capita (Fay and Yepes, 2003). Together with population growth this trend permit to conclude the huge amount of investments and construction projects needed by the energy sector for the building of new facilities and for revamping and maintenance of existing ones. These efforts include the need to improve energy efficiency, especially for industry as the main energy world consumer.

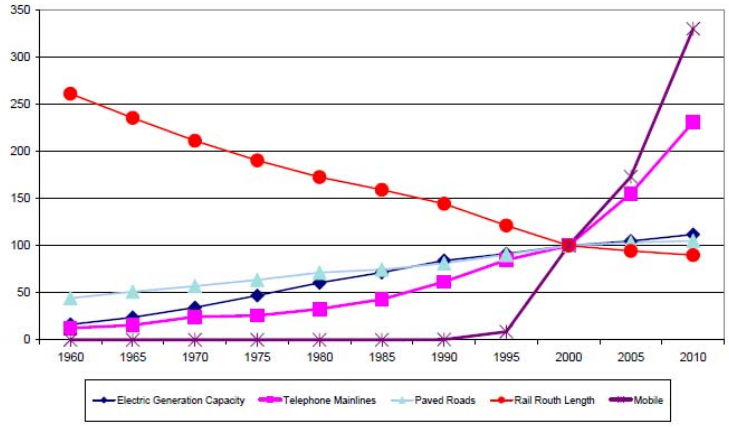

Figure 4. Changing infrastructure stock. (Fay, Yepes, 2003)

During the last years an important effort to increase alternative energy sources has been done as evidenced in Figure 5 (World Bank Indicators, 2012).

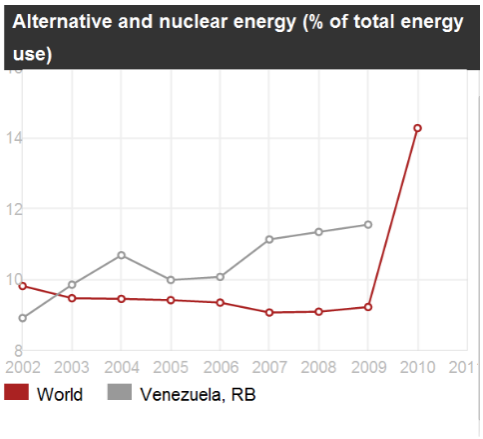

Figure 5: Alternative and nuclear energy. World Bank. Feb 2012

In accordance with such trend Tables 4 and 5 present the main infrastructure projects planned to be developed in Venezuela during the period 2008-2014 to generate energy from hydro and eolic sources.

Table 4: Main Hydro electricity generation projects

Plant	Project	State	Capacity MW	Planned start up	% of advance to Sept 2011
Macagua I	Rehabilitation	Bolívar	120	Mar 2014	43,60%
Simón Bolívar (GURI)	Modernization	Bolívar	700	Dec 2014	35%
Manuel Piar (TOCOMA)	Construction	Bolívar	2160	Dec 2014	17%

Corpoelec 2009. Proyectos estructurantes en marcha del sector eléctrico. http://www.corpoelec.gob.ve/proyectos revised 17 Sept 2011, 19 Feb 2012
Summary: Pietrosemoli, L, Rodriguez Monroy, C, 2012

Table 5: Venezuelan eolic generation projects

Project	Location	Type	Capacity MW	Planned start up	% of advance to Sept 2011
Paraguaná wind project. PDVSA. 76 wind turbines.	Falcón	Eolic	100	2011	N/A. In construction
La Guajira Wind Project. 24 MW. Building 2012. ENELVEN. 12 wind turbines	Zulia	Eolic	24	2012	N/A. In construction
Chacopata Wind Project. Sucre state. 24 MW. Corpoelec.	Sucre	Eolic	24	N/A	N/A
Nueva Esparta Wind Project (Islas de Margarita y Coche). 24 MW. Building 2012. ENELVEN. 12 wind turbines	Nueva Esparta	Eolic	24	2013	N/A
Total			172		

Hernández Nelson 2010. Las energías alternativas. Universidad Simón Bolívar
Adaptation Pietrosemoli, L, Rodriguez Monroy, C, 2012

Authors were not able to confirm current project advances since official data verified present the same status than in September 2011 in exception to Manuel Piar (TOCOMA) plant which construction reports an advance of 66,26% to February 2012. No data was found for the eolic projects.

Accordingly with energy experts the planned advance of the Venezuelan infrastructure projects has been altered by different conditions related to management and administrative problems, including the deskilling and political

orientation of the energy companies that has generated the lack of financial resources, the preeminence of political over technical decisions, problems with workers, suppliers and contractors that impede the projects continuity as scheduled (Portillo, 2011).

In addition to this situation, Construction chamber (2012) report that Venezuelan contractors suffer the effect of legal, and financial constrains and in general particular working conditions marked by frequent violence on jobsites, low productivity, technical, labour, knowledge or material constrains that makes harder to finish the projects contracted.

This situation causes important waste of time and resources and in general results on poor overall performance, clients' disappointment and a lot of claims that generate severe competitiveness problems for the constructors (Cámara Venezolana de la Construcción, 2012) and additional distress for Venezuelan society. As well as for all the construction projects, this situation has direct effect over the Venezuelan renewable energy projects that are delayed and present important cost overruns.

Venezuelan constructors face problems quite common in construction jobsites all over the world, as explained in Table 6.

Table 6: Construction problems

Financial
Client not paying in time + High costs, inflation
Lack of capital/ credit facilities
Excess of costs over budget
Difficulties to recover over costs with clients
Difficulties in arranging guarantees
Technical conditions
Technical/ specification shortages + Change orders
Contract documentation problems
Jobsite conditions/ Interferences
Project extention of time
Quality deviations/ Quality control problems
Physical Resources
Material and equipment availability
Material and equipment costs
Material and equipment looses
Intangible resources/ Knowledge
Planning and design problems
Lack of leadership and responsibility
Lack of workmanship/ technical/ business management skills
Productivity levels
Knowledge, knowledge management & communication shortages
Construction problems understanding + Data shortages
Regulations, understanding, interest & or capacity about sustainability
Defficient management and organization/ Informal systems
General conditions
Poor quality of general performance
Change in regulations/ Economic-Political instability/Poverty/ Weather
Low investment on urban & or Construction sustainability
Table 1. Main problems affecting construction performance. Global perspective. Different authors

In addition to the delays and costs overruns caused, the consequences of such inadequate conditions are clearly evident in Venezuela (Pietrosemoli and Rodríguez, 2011). Among other problems, ample sectors of the country frequently face energy scarcity and power outages that hurt citizen's quality of life as well as industrial and commercial production. This generates the need to rely on emergency power plants for industrial and commercial purposes, create resources loses, cost overruns and create social stress.

Besides such immediate consequences the long term impact over environment, quality of life and country competitiveness seems not to be completely assumed by all Venezuelan stakeholders.

In order to find long term solutions with the reliable increase of energy generation and transmission, Portillo (2011) proposes to the energetic companies in Venezuela to strengthen their human capital, rely on professional management and timely make the investments needed to recover the thermo and hydro electric plants, as well as the transmission and distribution lines.

Additionally he proposes to strengthen the programs to reduce the serious losses for illegal use of electricity and to impulse the development of energy saving and renewable energy projects with shared efforts from governments, constructors and society.

5. CONSTRUCTION COMPETITIVENESS. A CHALLENGE TO SUPPORT RENEWABLE ENERGY INFRASTRUCTURE IN VENEZUELA. CONCLUSIONS

Because of the severe outages happened in the last 2 years - situation that continues in 2012- Venezuelan government has recently started a campaign to re-educate energy consumption patterns and to reinforce the need to develop renewable energy sources.

Change energy generation and consumption patterns are one of the solutions but this is a long term goal. In the short time there is a lot of work to do to reduce the factors that generate delays with energy projects in Venezuela.

Preliminary results from research showed the tight correlation between construction competitiveness and the renewable energy offer as well as the current challenges that Venezuelan industrial construction sector face.

Based on this reality main efforts must be made by Venezuelan stakeholders to improve construction competitiveness and consumers' attitudes and be able to take advantage of the huge hydro, wind and solar resources to progressively substitute the fossil energy main dependence. This will sustain a full orientation toward renewable energy development.

To obtain such goals, from a general perspective it is needed to correct the policies that generate legal uncertainties, affect infrastructure investments, generate inadequate labor conditions, or limit the availability of material or financial resources. It is basic to have public policies that sustain investments with long term orientation, based on technical and financial conditions, so the construction companies in charge of the generation or distribution projects find satisfactory circumstances for a better performance of their energy projects.

Moreover, from an individual viewpoint construction companies must work to improve their own performance with support from available resources such as knowledge management, quality processes, BIM (Building Information models), construction supply chain collaborative practices or any different strategy oriented to perform better the contracted projects.

Other than the Venezuelan case - that deserves further research - this is not a problem confined only to country borders. In fact, literature and empirical experiences demonstrate that construction constrains are present in most developed and developing countries with main impact on industrial and energy projects.

This means that a lot of opportunities to improve the performance of the projects to support the development of renewable energy for the long term sustainable goals. This is the challenge.

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