Energy for Life

COUNTRY PROFILE

BOLIVIA 2010

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Bolivia 2010

Authors: Dr.-Ing. Johanne Hanko, Dipl.-Ing. Cindy Völler

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Istituto Oikos Onlus (Italy), DGS (Germany), Oikos Cooperação e Desenvolvimento (Portugal), Fundatión Ecología y Desarrollo - Ecodes (Spain), Terre Solidali Onlus (Italy), Nature Trust (Malta), Oikos East Africa (Tanzania), Pangea (Brazil), COMPED (Cambodia), CDEA (Laos), 2010

Figure 1 (Front cover): Map Bolivia, Source: http://www.mapcruzin.com/free-maps-bolivia/bolivia_sm_2008.gif

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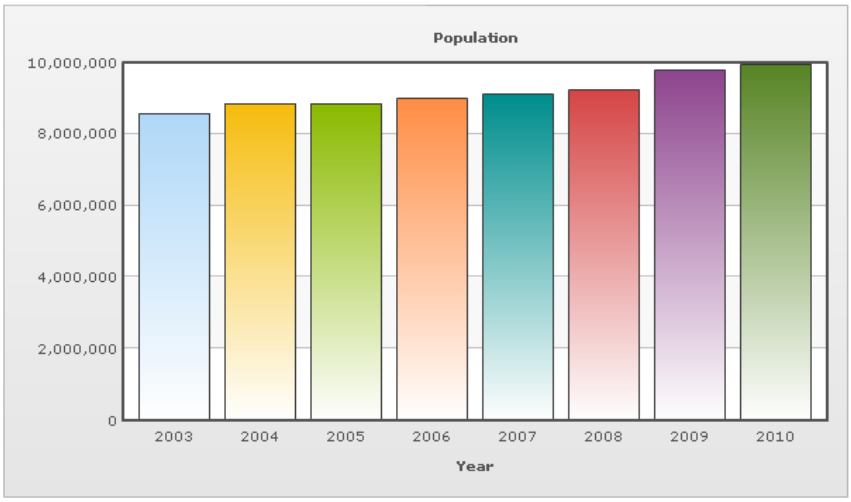
1 Background information

1.1 Country data[1]

Location of country:	Central South America, southwest of Brazil
GPS:	17 00 S, 65 00 W
Total area:	1,098,581 sq km
Capital:	Sucre (constitutional capital) (La Paz -administrative capital)
Currency:	Boliviano
Language:	Spanish 60.7% (official), Quechua 21.2% (official), Aymara 14.6% (official), foreign languages 2.4%, other 1.2%
Religion:	Roman Catholic 95%, Protestant (Evangelical Methodist) 5%
Population:	9,947,418 (2010) urban population: 66% of total population (2008).
Population density[2]:	Ranges from less than one person per square kilometre in the south-eastern plains to about 10 per square kilometre in the central highlands
Climate:	Varies with altitude; humid and tropical to cold and semiarid
Temperature[3]:	Average temperature 7.5 °C, High 35 °C and low -5°C (lower in mountainous areas)
Precipitation[4]:	564 mm (22.2 in) rainfall per year, or 47 mm (1.9 in) per month
Terrain:	Rugged Andes Mountains with a highland plateau (Altiplano), hills, lowland plains of the Amazon Basin
Elevation:	Lowest point: Rio Paraguay 90 m. Highest point: Nevado Sajama 6,542 m.
GDP[5]:	USD 4,700 per capita per year (2009)

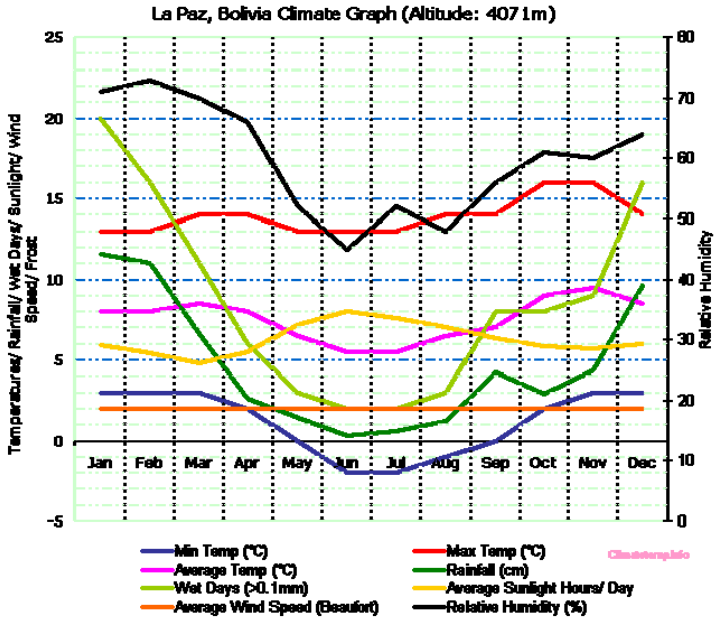
[1] The world fact book, Central Intelligence Agency (CIA), Bolivia, February 2011
[2] U.S. Department of State, May 13 2010
[3] World weather and climat graphs…, February 2011
[4] World weather and climat graphs…, February 2011
[5] The world fact book, Central Intelligence Agency (CIA), Bolivia, , February 2011

Figure 2: Population growth 2003 to 2010



Source: Index Mundi, July 2010

Figure 3: Climate and weather in Bolivia



Source: World weather and climat graphs…, February 2011

2 RES targets

In line with the National Development Plan, Bolivia's energy targets and policies regarding electricity can be summarized as follows[6]:

- Development of electricity generation and transmission infrastructure to meet the domestic and export demand
- Increase of the urban and rural electricity coverage to reach the universalization of the electrical service
- Sovereignty and energetic independence: To develop sources from renewable energy that guarantee energetic independence (hydroelectricity, geothermal, biomass, photovoltaic, wind, etc.).

More specifically, the challenge towards Bolivia's development is to ensure the supply of electricity to over 2 million people living in rural areas, currently without electricity, in the next few years. The strengthening of social and community services will only be possible with a reliable, secure, and economical access to energy[7], which can be ensured with the use of renewable energy sources.

2.1 Status of the renewable energy market[8]

Although several installations of renewable energy exist in Bolivia, the actual applications and potentials need to be further evaluated. In other words, biomass, solar, wind and geothermal alternative energies may be considered as an applicable option, once a detailed feasibility study has been conducted. Preliminarily studies have already been completed; however, the government requests further studies prior to entering these technologies in its National Development Plan.

Biomass utilization (including fuel wood, wood waste, vegetable and animal waste) are certainly a major source of energy, especial in rural areas of Bolivia. Biomass is currently used as cooking fuel in rural households, and also in the generation of electricity and in industries. Nevertheless, biomass is considered as a low efficiency fuel and is associated with environmental degradation, mainly with deforestation. To counter one of these negative factors, efficient stoves were

[6] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Esarrollo Energético, La Paz, Julio de 2009
[7] Ing. Miguel Fernández F., April 2010
[8] Arcadia Market Commentary, 2009

developed as to optimize the performance of the wood stoves. The government is encouraging the substitution of biomass with LPG on the short term and with natural gas on the long term[9].

Table 1: Evaluation by the Bolivian government on the favourability of various energy sources

Energy source	INDICATOR						TOTAL
	Efficiency	Best coverage	Cost	Health and security	Renewability and sustainability	CO2 and SO2	
Natural gas	4	4	4	3	1	3	19
Hydro electricity	4	4	3	4	4	4	23
Petroleum products	3	3	2	3	1	1	13
LPG	3	3	2	2	1	1	12
Biomass	1	2	1	1	3	4	12
Solar, Wind, Geothermal	**1**	**3**	**1**	**4**	**4**	**4**	**17**

Value scale:

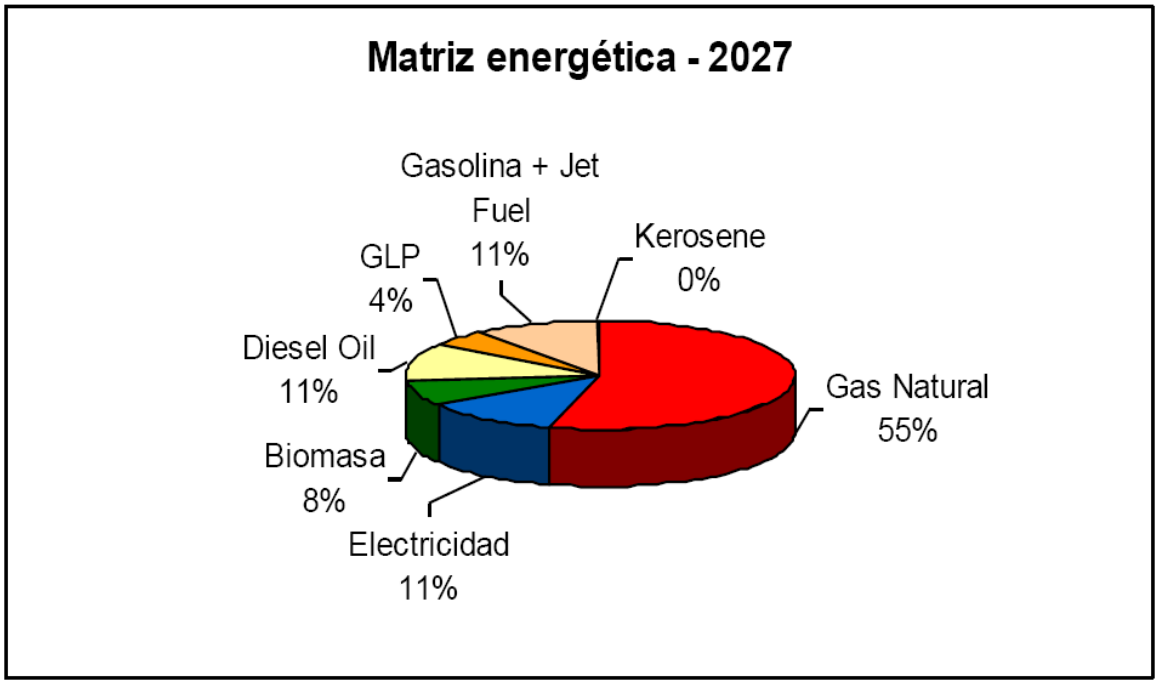
4 – Very favourable 2 – Little favourable

3 – Average favourable 1 – Not favourable

Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético La Paz, Julio de 2009

[9] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético, La Paz, Julio de 2009

Figure 4: Energy production by sources as anticipated for year 2027



Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarollo Energético, La Paz, Julio de 2009

2.2 Energy legal framework in Bolivia

The government established an energy development commission (COMISIÓN DE DESARROLLO ENERGÉTICO (CDE)) under regulation no. 394/10 passed on 21/10/2010, thus creating in an official manner, the CDE as a coordination body between public entities in the energy sector in order to contribute to a coherent development of plans, programmes and projects in this sector. Participating in this commission are[10]:

- Viceministerio de Desarrollo Energético
- Viceministerio de Electricidad y Energías Alternativas
- Viceministerio de Industrialización, Comercialización, Transporte y Almacenaje
- Viceministerio de Exploración y Explotación de Hidrocarburos
- Comité Nacional de Despacho de Carga CNDC
- Empresa Nacional de Electricidad ENDE

[10] Portal HidrocarburosBolivia.com, February 2011

- Agencia Nacional de Hidrocarburos ANH
- Autoridad de Fiscalización y Control Social de Electricidad (AE)
- Yacimientos Petrolíferos Fiscales Bolivianos YPFB

The government of Bolivia has defined three priority sectors for the implementation of new energy policies. These can be summarized as follows:

Table 2: Legal framework priorities for energy in Bolivia

Sector	Priority policies
Industrial sector	• Development of the petrochemical industry (Urea, Ammonia) • Development of the thermoelectric and hydroelectric industry • Installation of LPG plants • Substitution of LPG, Biomass and Kerosene for Natural Gas
Transport sector	• Decrease of the consumption of Diesel Oil, Gasoline, LPG for Natural vehicular gas (NVG) • Construction of infrastructure for the use of NVG at national level • Increase in the number of cars using NVG
Residential sector	• Increase in the use of household natural gas • Construction of primary, secondary networks and of internal installations • Final decision for the substitution of LPG for natural gas

Source: Portal HidrocarburosBolivia.com, February 2011

2.3 Supporting laws and policies

The Bolivian government developed a programme "Electricity to live with Dignity" (Electricidad para Vivir con Dignidad). The main objectives of this project are to be met in four stages[11]:

Stage 1: To increase electricity coverage service from 35 to 53% in rural areas, and from 87% to 97% in urban areas, thus benefiting at least 210 rural households and 460,000 urban households by end of 2010.

Stage 2: Between the years 2011 and 2015, to reach universalization of the electricity system in all urban areas and increase coverage to 70% in rural areas.

Stage 3: Before 2020, it is hoped that coverage will reach 87% in rural areas.

Stage 4: By the year 2025, to reach universalization of the service in all national territories.

2.4 Key supporting factors[12]

There exist a number of programmes to support the expansion of access to electricity and the implementation of renewable energy systems. These include:

- Close to 100% of the investment costs for network expansion made by the Government of Bolivia.
- For photovoltaic systems, it is usually a combination of subsidy and micro-credit, where the subsidy covers 40% to 60% of the system's total cost, and this for applications between 2Wp and 75Wp.
- Micro hydroelectric plants usually receive a subsidy between 70% and 80% of the total cost. The local contribution is usually in the form of working days for the excavation of channels, earth works, and manpower for simple construction parts, etc.
- Other technologies such as efficient wood stoves receive subsidies between 35% and 50% of the cost of hardware.
- Thermo solar systems receive 50% to 75% subsidies for productive and social applications (i.e. hot water for tourist housing, schools, sanitary posts, etc.).

[11] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

[12] Miguel Fernández F., Febrero 2008

2.5 CDM projects in Bolivia

The politics of Bolivia are somewhat against the UNFCCC Clean Development Mechanism (CDM) programme. This is reflected in the number of projects submitted and awarded, as can be seen in the following table. In Bolivia, to date, only 6 projects were submitted to UNFCCC. Of these, 2 were rejected and 4 were registered (1 hydro electric plant, 1 landfill gas capture, 1 reforestation and one combined cycle). The total registered projects account for a total of 563,991 tonnes per year of emission reductions.

Table 3: Status of CDM projects in Bolivia as of January 2011

Status of project	Number of projects
Projects registered	4
Projects rejected	2

Source: UNFCCC

3 Current status of RES

3.1 Energy related data

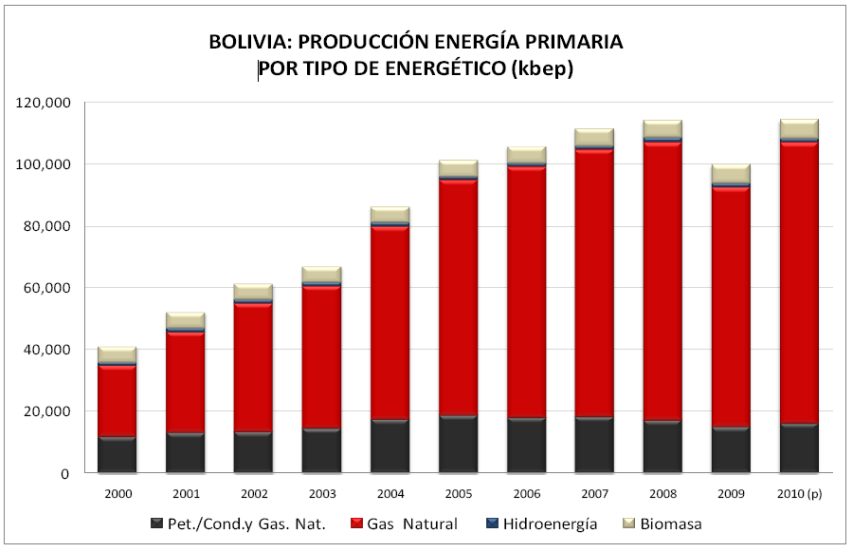
Electrification rate[13]	Approximately 71% of the Bolivian population has access to electricity, of which 89% access in urban areas and only 39% in rural areas.
Electricity consumption[14]	4.83 billion kWh (2008) 5.18 (2009)
Electricity consumption	512 kWh per capita (2009)
Electricity cost[15]	ranging between at 0.06 USD/kWh and 0.15 USD/kWh depending on the location (2009).
Electricity generation[16]	5.57 billion kWh (2008) 5.98 (2009)
Installed power in 2008[17]	1358 MW
Peak demand[18]	960 MW
Electricity projection in 2027[19]	2,250 MW installed
Main electricity generation sources[20]	Natural gas (55%), Hydroelectric (39%), Diesel oil (4%), others (biomass) 2%.

3.2 Current situation

The production of energy has more than doubled over the past 10 years, mainly through the increased production of natural gas, as seen in the following figure:

[13] Ing. Miguel Fernández F., April 2010.
[14] U.S. Department of State, May 13 2010
[15] El Deber, 2009
[16] U.S. Department of State, May 13 2010
[17] Canedo Espinoza, Walter, 2010
[18] Idem
[19] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético La Paz, Julio de 2009
[20] Idem

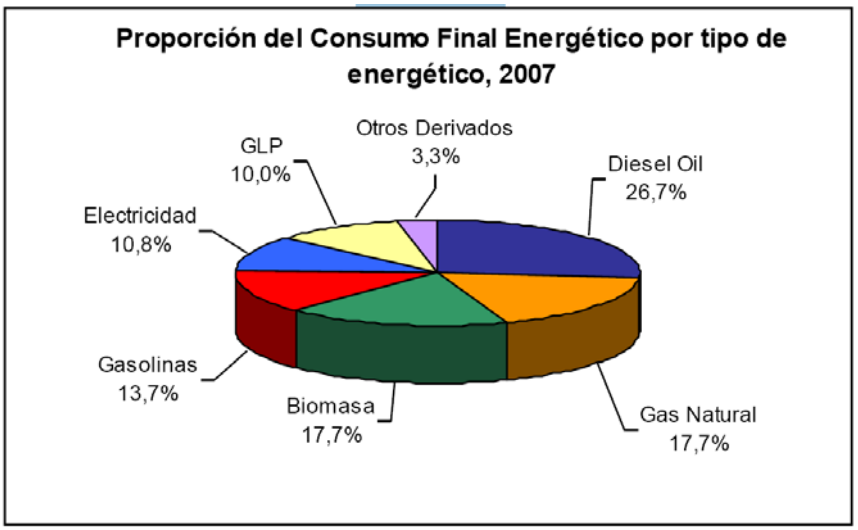
Figure 5: Primary energy production by type of energy source



Source: Portal HidrocarburosBolivia.com, February 2011

As of 2009, the main source of energy consumption was from diesel oil (26.7%) followed by Natural gas (18.7%), Biomass (mainly wood 17.7%), Gasoline (13.7%), Electricity (10.8%) and LPG (10%).

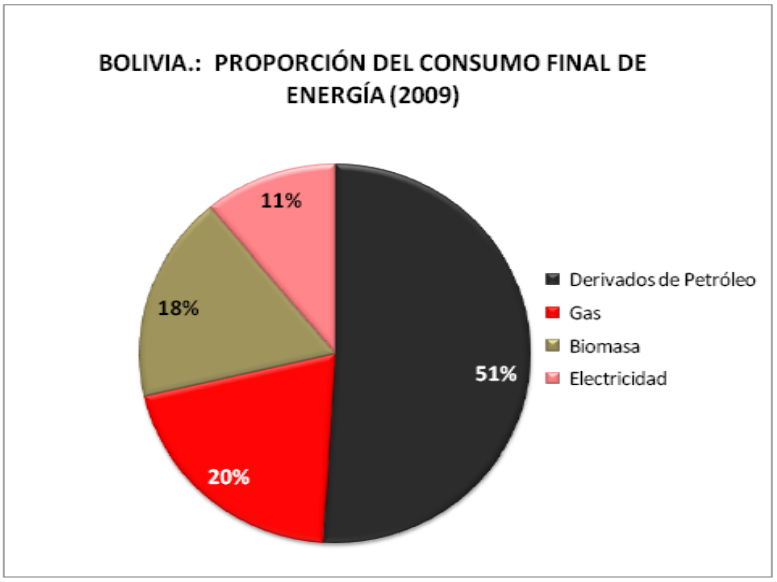
Figure 6: Consumption of energies by type 2007



Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético, La Paz, Julio de 2009

As shown in the following figure, there has been little change until 2009.

Figure 7: Total energy consumption in Bolivia by type 2009



Source: Portal HidrocarburosBolivia.com, February 2011

The following table shows the development in the production, consumption, import and export of energy between the years 200 and 2007.

Table 4: Energy balance from 2000 to 2007 (in thousand barrels petroleum equivalent)

	KBEP	2000	2001	2002	2003	2004	2005	2006	2007	TC PROMEDIO
ENERGÍA PRIMARIA	Crudo	11.457	12.906	13.059	14.218	14.432	18.229	17.510	17.710	6,8%
	Gas	23.082	32.621	41.597	46.276	62.519	76.168	81.227	86.421	21,4%
	Biomasa	5.215	5.208	5.202	5.195	5.276	5.339	5.465	5.524	0,8%
	Hidroenergía	1.488	1.649	1.706	1.539	1.664	1.521	1.669	1.796	3,1%
	Variación de existencias	173	-131	-226	675	-297	115	102	-38	8,0%
	Exportaciones	13.901	24.348	29.961	34.123	52.109	64.152	67.314	72.676	28,7%
	No aprovechado	1.561	1.038	1.680	1.571	867	783	533	458	-11,2%
	OFERTA TOTAL DE ENERGÍA PRIMARIA	25.953	26.867	29.697	32.209	30.617	36.438	38.126	38.280	5,9%
	TOTAL TRANSFORMACIÓN	-18.563	-18.046	-19.806	-20.781	-22.658	-24.202	-24.816	-26.540	5,3%
	CONSUMO FINAL DE ENERGÍA PRIMARIA	7.346	7.312	7.607	7.820	8.242	8.735	9.335	10.063	4,6%
ENERGÍA SECUNDARIA	Refinerías de Petróleo	10.111	13.758	14.537	11.926	16.365	17.081	17.448	17.839	10,0%
	Plantas de Tratamiento de Gas Natural	1.888	1.815	1.992	1.951	2.014	2.251	1.831	2.071	1,9%
	Centrales Eléctricas/Autoproductores	2.399	2.422	2.543	2.623	2.738	2.960	3.142	3.386	5,1%
	TOTAL TRANSFORMACIÓN	14.399	17.995	19.072	16.500	21.117	22.292	22.420	23.296	7,9%
	CONSUMO FINAL DE ENERGÍA SECUNDARIA	13.282	13.070	13.428	14.107	15.182	15.807	17.025	18.334	4,8%
	EXPORTACIONES	15.614	27.002	32.751	37.146	54.737	67.854	70.932	76.105	27,3%
	Gas Natural	12.608	23.407	29.286	33.132	50.313	62.535	65.789	71.637	30,6%
	Pet./Cond. y /o Gasolina Natural	1.293	941	675	991	1.796	1.617	1.526	1.038	3,6%
	Crudo Reconstituido	1.713	2.654	2.790	3.023	2.628	3.465	3.618	3.372	12,1%
	Gasolina Especial, gasolina blanca, aceites, grasas	0	0	0	0	0	237	0	0	----
	IMPORTACIONES	2.112	2.248	1.775	2.238	1.759	2.405	2.762	3.270	8,6%
	Diesel Oil	2.033	2.206	1.722	2.184	1.702	2.405	2.761	3.219	9,1%
	Gasolina Especial, Aceites y Grasa	79	41	53	54	58	0	1	51	----
	CONSUMO FINAL DE ENERGÍA	20.628	20.382	21.035	21.928	23.424	24.542	26.360	28.396	4,7%
	Sector Transporte	7.422	7.225	7.388	7.871	8.561	9.004	10.004	11.226	6,2%
	Sector Industrial	6.573	6.427	6.646	6.778	7.096	7.350	7.724	8.093	3,0%
	Sector Residencial	4.399	4.484	4.648	4.762	5.053	5.247	5.431	5.587	3,5%
	Sector Comercial	574	593	633	657	692	746	801	839	5,6%
	Sector Agricultura,pesca y minería	1.660	1.654	1.720	1.859	2.022	2.194	2.398	2.651	7,0%

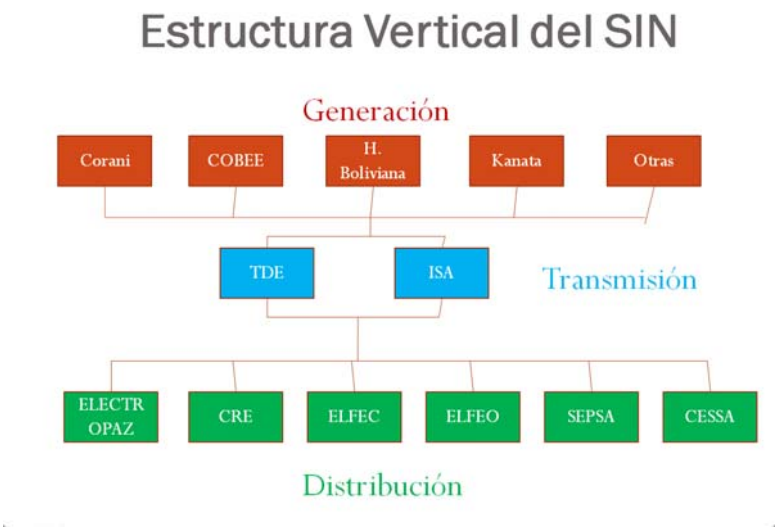
Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Esarrollo Energético La Paz, Julio de 2009

Electricity

Electricity production in Bolivia during the year 2007 was mainly from thermal systems, accounting for more than 59% of the total generated electricity, followed by hydro electrical systems 39% and finally some 2% from biomass[21]. Electricity management in Bolivia is divided into three levels: The electricity production companies, the transmission companies and the distribution companies, as shown in the following figure.

[21] Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético La Paz, Julio de 2009

Figure 8: Structure of electricity supply in Bolivia



Source: Gómez, Enrique, February 2011

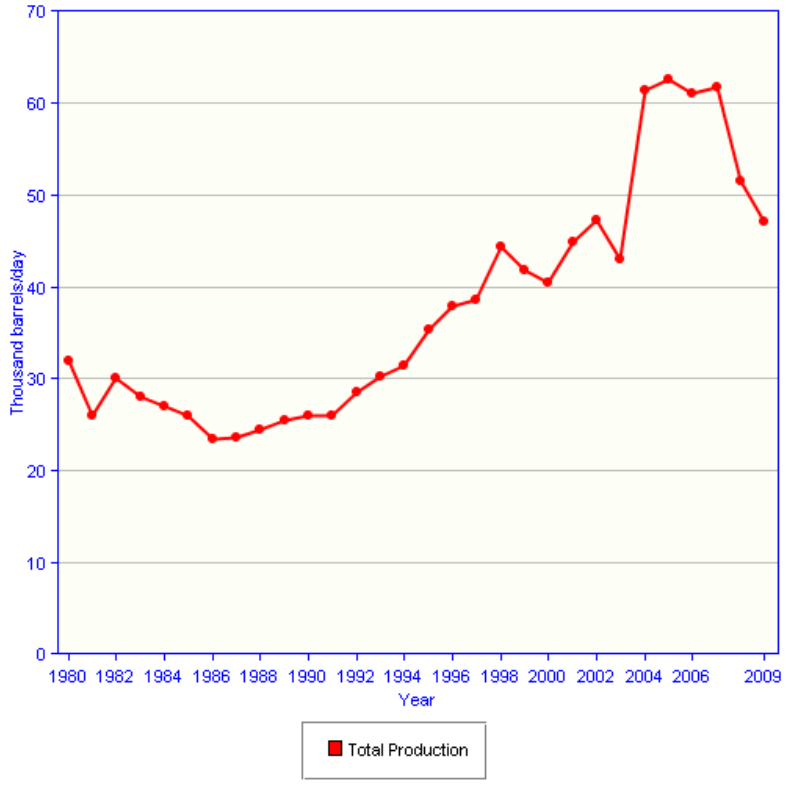
Table 5: Installed thermoelectric plants in Bolivia

AGENTE	CENTRAL	CAPACIDAD EFECTIVA (MW)
TERMOELECTRICAS		
GUARACACHI	GUARACACHI	314,27
	KARACHIPAMPA	13,91
	ARANJUEZ	43,19
	TOTAL	**371,37**
BULO-BULO	**BULO-BULO**	**89,64**
V. HERMOSO	CARRASCO	111,86
	VALLE HERMOSO	74,23
	TOTAL	**186,09**
COBEE	**KENKO**	**18,62**
GUABIRA	**GUABIRA**	**21**
TOTAL TERMOELÉCTRICAS		**686,72**

Source: Gómez, Enrique, February 2011

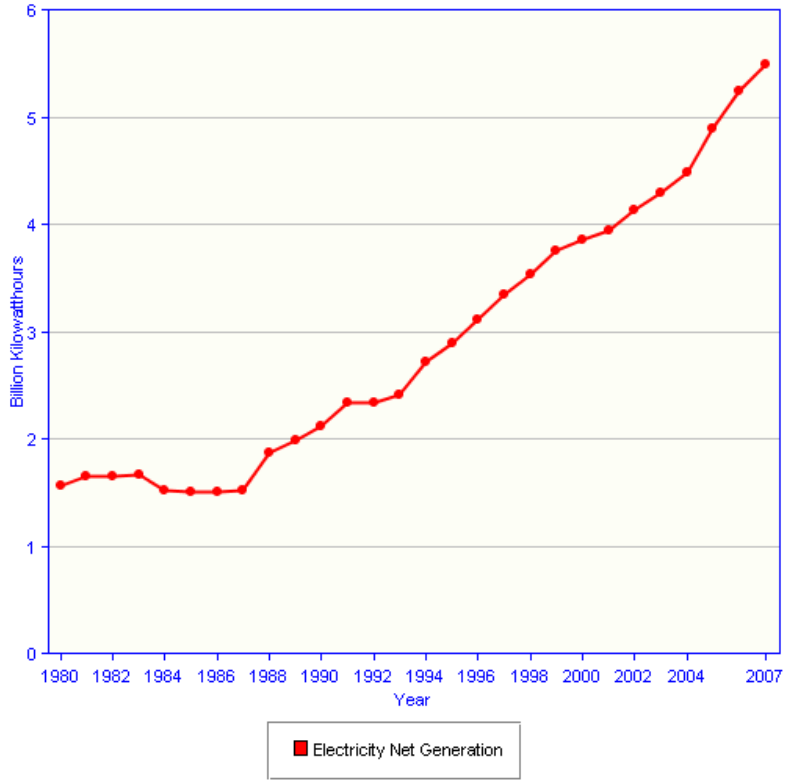
The following figures show the evolution of electricity production, generation and consumption between 1980 and 2009

Figure 9: Total electricity production 1980 to 2009



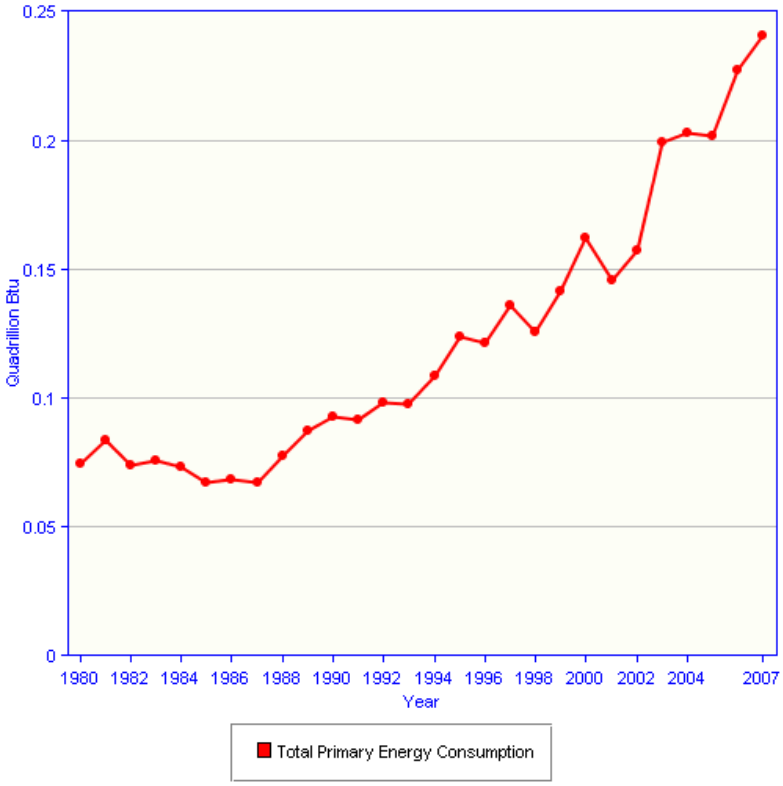
Source: U.S. Energy Information Administration, February 2011

Figure **10**: Net electricity generation 1980 to 2007



Source: U.S. Energy Information Administration, February 2011

Figure 11: Total primary energy consumption 1980 to 2007



Source: U.S. Energy Information Administration, February 2011

Transmission[22]

The length of the transmission lines for electricity around Bolivia reached 4,581.45 in the year 2007, of which 2,400 km belong to the main Interconnection system (STI) that holds the high tension installations in 69 KV, 115 KV and 230 KV.

[22] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, PLAN DE DESARROLLO ENERGÉTICO La Paz, Julio de 2009

Figure 12: Main electrical systems in Bolivia

Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, PLAN DE Plan de Desarrollo Energético, La Paz, Julio de 2009

Hydrocarbon production in Bolivia

As of the year 2005, the probable reserves for hydrocarbons could be summarized as follows[23]:

- ✓ Natural gas: 765 billion m3 (2009)
- ✓ Petroleum: 470 million barrels (2009)

3.3 Biomass energy installed and identified systems

As of the year 2010, more than 500 family size biodigesters have been installed in Bolivia, offering a renewable energy source for small rural families[24].

Biofuel

In Bolivia, 15 distilleries were built and the government authorized the mixing of 25% ethanol in the gasoline[25].

[23] U.S. Energy Information Administration, May 13 2010
[24] Technologias en dessarrollo, February 2011
[25] Eguren, Lorenzo, 2007

3.4 Hydroelectric installed and identified systems

As of the year 2008, 478 MW large hydro power plants were operational around Bolivia[26]. In 2010, an estimated 50 micro hydroelectric plants were installed, with a range between 30kW and 200kW installed power, providing power to some 6,000 families around Bolivia. Most components for hydro electric plants are made in Bolivia, except for the electrical generator[27]. Unfortunately, very little impact studies are conducted. Although the small and micro hydroelectric plants often have little impacts on the environment, the large plants often bring about serious impacts on the fauna, flora and local populations. These impacts should be carefully studied prior to the approval of any hydroelectric plant, be it large or small.

Table 6: Installed hydro electric power plants

AGENTE	CENTRAL	CAPACIDAD EFECTIVA (MW)
HIDROELECTRICAS		
COBEE	ZONGO	188.4
	MIGUILLAS	20.9
CORANI	CORANI	149.88
HIDRO. BOLIVIANA	TAKESI	90.35
RIO ELÉCTRICO	YURA	19.05
SYNERGIA	KANATA	7.6
SDB	QUEHATA	1.96
TOTAL HIDROELÉCTRICAS		478.14

Source: Gómez, Enrique, February 2011

Table 7: Micro hydroelectric plants installed

Department	**Province**	**Name**	**Families beneficiaries**	**Power**	**Financing agency**
Micro power plants				100 – 1000 kW	
Santa Cruz:	Valle Grande	Micro central Hidroeléctrica Pucará	400		KfW
Potosí:	Sud Lipes	Micro central	100		KfW

[26] Canedo Espinoza, Walter, 2010
[27] Ing. Miguel Fernández F., April 2010

		Hidroeléctrica Mallcu Villa Mar			
TOTAL			**For 500 families**	**128.8MW installed**	

Department	**Province**	**Name**	**Families beneficiaries**	**Power**	**Financing agency**
La Paz:	Inquisivi	Totorapampa	942		KfW
	Inquisivi	Kanamarca	70		KfW
	Nor Yungas	Cieneguillas	30		KfW
	Larecaja	Santa Rosa de Challana	50		KfW
TOTAL			**For 1,092 families**	**175.7 MW installed**	

Department	**Province**	**Name**	**Families beneficiaries**	**Power**	**Financing agency**
Micro power plants				10 – 100 kW	
La Paz		San José de Llojeta	355		PNUD
		Challa Jahuira	80		PNUD
		San Juan de Coripata	160		PNUD
		Santiago Siete Lomas	60		PNUD
		Inca Pucara	80		PNUD
		Quinuni	108		PNUD
		Palmeras	60		PNUD
TOTAL			**For 903 families**	**380 kW installed**	

Department	Province	Name	Families beneficiaries	Power	Financing agency
Pico power plants				1 – 10 kW	
La Paz	Murillo	Samañapampa	7		PNUD
		Challapampa	10		**PNUD**
		Yerbani	15		PNUD
	LARECAJA	Añilada	15		PNUD
TOTAL			**For 47 families**	**16 kWh**	

Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

3.5 Solar installed and identified systems

Solar PV

It is estimated that there are 4 MW of installed PV power with nearly 80,000 off grid systems around Bolivia[28].

Table 8: Selected identified project financed PV solar installations[29]

Year	Location	Number of systems	Project financing
2009	Potosi	2,648	BM
	Cochabamba	2,067	BM
	Chuquisaca	322	BM
	Santa Cruz	1,347	BM
	Oruro	2,943	BM
	TOTAL	9,327	
2009	Potosi	2,704	BM
	Cochabamba	1,211	BM

[28] Rutschmann, Ines. Photon International, Markets, Power to the people, Off-grid solar electricity has established itself in rural Bolivia while grid connected systems have enourmous potential as well. June 2010.
[29] Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

	Chuquisaca	322	BM
	Santa Cruz	1,347	BM
	Oruro	23,51	BM
	TOTAL	7,935	
	Santa Cruz	851	PNUD
	Tarija	1,107	PNUD
	Oruro	138	PNUD
	La Paz	1,079	PNUD
	Cochabamba	742	PNUD
	Chuquisaca	809	PNUD
	TOTAL	**4,726**	

Source. Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

Thermal solar

It is estimated that some 400 units of thermal solar systems are being installed each year. To date, an estimated 3,000 systems have been installed[30].

3.6 Wind energy installed and identified systems

Wind energy generators in Bolivia have power up to 10 kW each. The main equipment is imported while parts such as the towers, installation, operation and maintenance are available locally. Currently, there are about 100 wind mills in Bolivia with a power ranging between 200 W and 400 W[31].

Some hybrid systems have also been installed in Bolivia, offering a combination of solar and wind energy, as seen in the following table.

Table 9: Hybrid energy installed and identified systems

[30] Ing. Miguel Fernández F., April 2010
[31] Idem

Location	Type of hybrid system	Beneficiaries	Funding agency or programme	Total number of systems
Chuquisaca	Solar and wind	2.501	Euro-Solar	
Cochabamba	Solar and wind	481	Euro-Solar	
en Santa Cruz	Solar and wind	1,228	Euro-Solar	
Oruro	Solar and wind	158	Euro-Solar	
Potosí.	Solar and wind	155	Euro-Solar	
TOTAL		**4,523**		**45**
Various	Solar and wind	3,439	Euro-Solar	
TOTAL		**3,439**		**14**

Source: Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

3.7 Other renewable energy sources installed and identified systems

Geothermal

There is currently no geothermal installed capacity. However, Bolivia's government is beginning to move to develop its geothermal resources to help meet increasing energy demand[32]. Currently, the geothermal resources are being used mainly for bathing, sauna and recreational purposes.

Wave and tidal

Bolivia is a landlocked country and as such, has no wave or tidal systems.

[32] Developing Renewables, 2006

4 Potentials of RES in Bolivia

Biomass Energy Resource potential

The potential of non wood biomass from direct combustion can be estimated from three main sources[33].

Table 10: Energy potential for non wood biomass

Source	Energy from combustion of non wood	GWh per year (0.28 GWh/1TJ)
Animal dung	3,270 TJ	915.6
Sugarcane bagasse	10,458 TJ	2928.24
Crop residues	307 TJ	85.96
TOTAL	**14,035**	**3929.8**

Source: World Energy Council, 2004 Survey of energy resources, 20th Edition, Elsevier, 2004

4.1 Hydro Energy Resource potential

It is estimated that Bolivia has a gross hydropower potential of 334,000 MW of which 39,870 MW can be utilized. To date, some 10,700 MW has been verified[34].

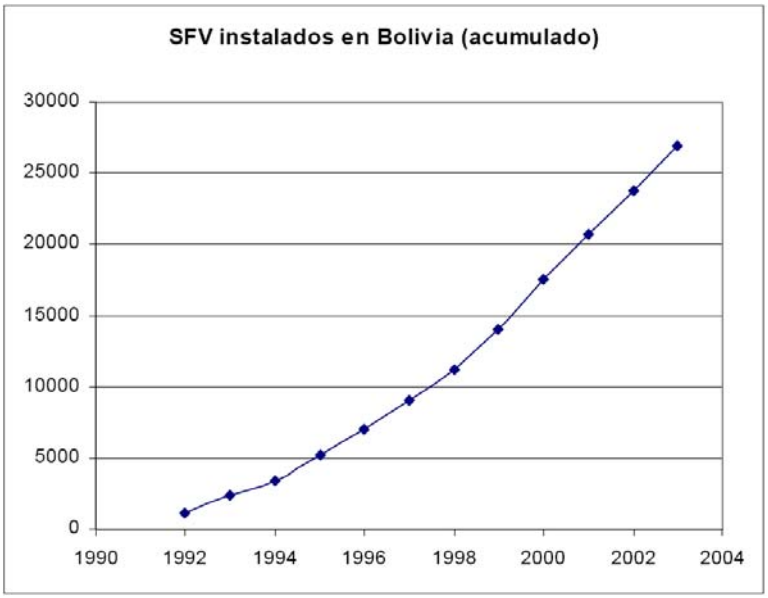
The National Electricity Company (Empresa Nacional de Electricidad- ENDE) has 6,400 MW hydroelectric projects for the next few years[35].

4.2 Solar Energy Resource potential[36]

Sunlight hours per year	2,292 hours
Average sunlight hours per day:	6.3 hours
Average lowest sunlight hours:	4.8 hours average per day in March
Average highest sunlight hours:	8 hours average per day in June
Direct radiation per year[37]:	1460 and 2190 kWh/m² per year
Average radiation per day:	4 to 6 kWh/m2 per day

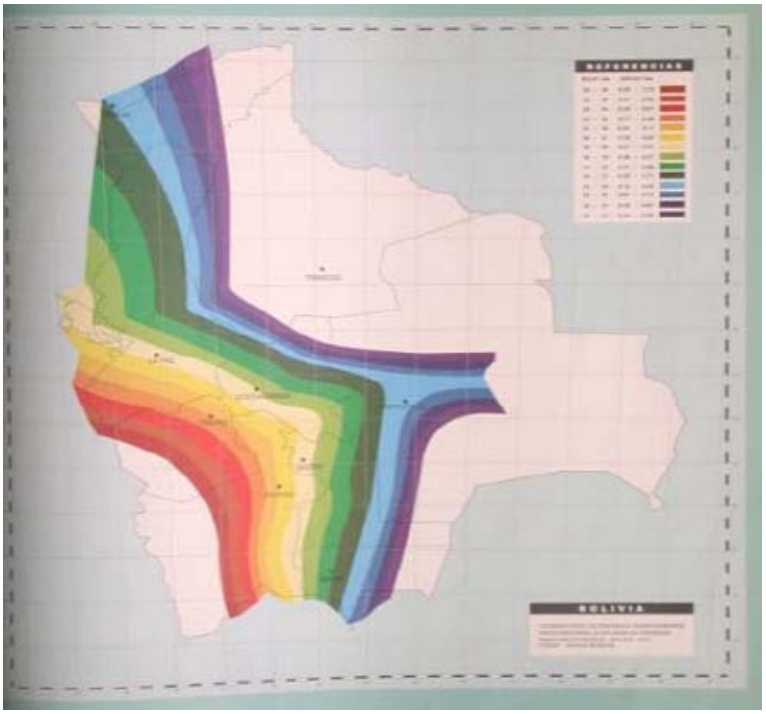
[33] World Energy Council, 2004 Survey of energy resources, 20th Edition, Elsevier, 2004.
[34] Canedo Espinoza, Walter, 2010
[35] Idem
[36] World weather and climat graphs…, February 2011
[37] Rutschmann, Ines, June 2010

Figure 13: Evolution of PV systems installed from 1992 to 2003



Source: Canedo Espinoza, Walter, 2010

Figure 14: Solar radiation map



Source: Canedo Espinoza, Walter, 2010

A study determined that there is a potential for 200,000 family units of thermal solar systems in the cities alone[38].

4.3 Wind Energy Resource potential

A number of studies have been conducted on the potential of wind energy. The following table is a summary of the observation station.

Table 11: Summary Validation Statistics by Observation Station

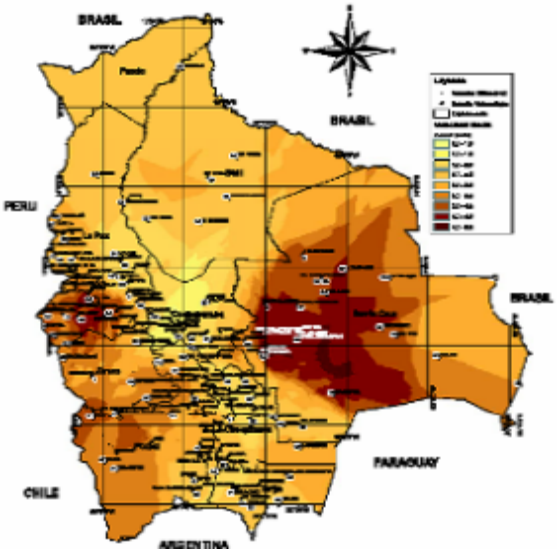
Station ID	Station Name	Lat. (Obs.)	Long. (Obs.)	Lat. (Model)	Long. (Model)	Start date	End date	Model overlap with Obs. (hours)	Obs. mean wind speed (m/s)	Model mean wind speed (m/s)	% Error (Model-Obs.) / Obs.
SLCB	Cochabamba, Bolivia	-17.45	-66.10	-17.4583	-66.0917	1998/03/31	2007/02/26	2888	3.22	3.00	-7.0
SLCO	Cobija, Bolivia	-11.08	-68.87	-11.0750	-68.8750	1998/08/16	2007/02/26	1942	2.85	2.23	-21.7
SLCP	Concepcion, Bolivia	-16.25	-62.10	-16.2583	-62.0917	1998/08/16	2007/02/26	1608	4.08	4.10	+0.7
SLET	Santa Cruz/El Trompillo, Bolivia	-17.80	-63.17	-17.8083	-63.1750	1998/08/16	2007/02/26	2807	6.03	5.87	-2.6
SLJE	San Jose De Chiquitos, Bolivia	-17.83	-60.75	-17.8250	-60.7417	1998/08/16	2007/02/26	1490	3.46	4.18	+20.8
SLJO	San Joaquin, Bolivia	-13.07	-64.67	-13.0750	-64.6750	1998/08/16	2007/02/10	1574	3.32	2.42	-27.2
SLLP	La Paz/Alto, Bolivia	-16.52	-68.18	-16.5250	-68.1750	1998/03/31	2007/02/26	7178	3.34	3.75	+12.3
SLOR	Oruro, Bolivia	-18.05	-67.07	-18.0583	-67.0750	1998/08/16	2007/02/26	1833	4.03	5.19	+28.8
SLPO	Potosi, Bolivia	-19.53	-65.72	-19.5250	-65.7250	1998/08/26	2007/02/26	1365	4.60	4.79	+4.0
SLPS	Puerto Suarez, Bolivia	-19.00	-57.73	-19.0083	-57.7250	1998/08/16	2007/02/26	2354	3.55	3.07	-13.6
SLRB	Robore, Bolivia	-18.32	-59.75	-18.3250	-59.7417	1998/08/16	2007/02/26	1609	4.29	4.01	-6.4
SLRI	Riberalta, Bolivia	-11.02	-66.12	-11.0250	-66.1250	1998/08/16	2007/02/26	1515	2.95	2.03	-31.1
SLRY	Reyes, Bolivia	-14.30	-67.37	-14.3083	-67.3750	1998/08/16	2007/02/26	1874	3.44	2.97	-13.8
SLSA	Santa Ana, Bolivia	-13.72	-65.58	-13.7250	-65.5750	1998/08/16	2007/02/26	2867	4.22	2.53	-40.1
SLSI	San Ignacio De Velasco, Bolivia	-16.37	-60.95	-16.3750	-60.9417	1998/08/16	2007/02/26	2182	3.71	4.12	+11.2
SLSU	Sucre, Bolivia	-19.02	-65.27	-19.0250	-65.2750	1998/08/16	2007/02/26	1929	3.11	4.30	+38.5
SLTJ	Tarija, Bolivia	-21.53	-64.72	-21.5250	-64.7250	1998/03/31	2007/02/26	1965	4.29	4.26	-0.6
SLVR	Viru-Viru, Bolivia	-17.65	-63.13	-17.6583	-63.1250	1998/03/31	2007/02/26	6441	5.30	5.48	+3.4
SLYA	Yacuiba, Bolivia	-22.02	-63.70	-22.0250	-63.6917	1998/08/16	2007/02/26	1966	4.00	3.77	-5.8

Source: 3TIER Environmental Forecast Group, Inc, Final Report, Bolivia Wind Atlas A project for the International Finance Corporation (IFC), June 5, 2009

Based on the above table, the average wind speed is calculated at 3.88 m/s. This number is based on the average wind speed calculated at various altitudes around the country, the country's altitude extremes ranging from 90 meters above sea levels up to 6,542 meters above

[38] Ing. Miguel Fernández F., April 2010

Figure 15: Average wind velocity map



Source: Canedo Espinoza, Walter, 2010

4.4 Other renewable energy sources potentials

Geothermal[39]

It is estimated that Bolivia has a geothermal potential of 280 to 370 MW.

Wave or Tidal

Bolivia is a landlocked country and therefore has little or no wave or tidal energy potential.

[39] Developing Renewables, 2006

4.5 References

Books

Canedo Espinoza, Walter, Centro de información en energías renovables, Bolivia, 2010, Experiencias latinoamericanas en el desarrollo de proyectos de electrificación rural, empleo de energías renovables y uso productivo de la electricidad, Experiencias en proyectos de electrificación rural con energías renovables en Bolivia, Lima, 23 de abril de 2010

Eguren, Lorenzo, CEPAL, Mercado de energías renovables y mercado del carbono en América Latina Estado de situación y perspectivas. Naciones Unidas, GTZ, Santiago de Chile, febrero de 2007.

El Deber, lunes 12 de enero de 2009, Energía Eléctrica en Bolivia

Ing. Miguel Fernández F., Energías Renovables en Bolivia, ENERGÉTICA- Energía para el Desarrollo, Cochabamba, Bolivia, April 2010

Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Plan de Desarrollo Energético, La Paz, Julio de 2009

Ministerio de hidrocarburos y energía, Estado Plurinacional de Bolivia, Programa Electricidad para Vivir con Dignidad, Memoria informe, 2009

Rutschmann, Ines. Photon International, Markets, Power to the people, Off-grid solar electricity has established itself in rural Bolivia while grid connected systems have enormous potential as well. June 2010.

World Energy Council, 2004 Survey of energy resources, 20th Edition, Elsevier, 2004.

Internetsources

Arcadia Market Commentary, Renewable Energy August 2009 Development in Emerging Markets, http://www.arcadia4u.com/commentaries/200908-Arcadia%20Market%20Commentary.pdf, August 2009
Developing Renewables, Renewable Energy that benefits all, Country energy information Bolivia, http://www.energyrecipes.org/reports/genericData/Latin%20America/061129%20RECIPES%20country%20info%20Bolivia.pdf, September 2006
Gómez, Enrique; Política hidroeléctrica en Bolivia, http://plataformaenergetica.org/system/files/PRESENTACIONENRIQUEGOMEZ.ppt, February 2011

Index Mundi, Bolivia Population, http://www.indexmundi.com/bolivia/population.html, July 2010 est.
Miguel Fernández F., Desafíos para las Energías Renovables en el Área Rural de Bolivia, http://archivo.ecodes.org/pages/especial/energias_renovables/MF_ENERGETICA.pdf, Cochabamba, Febrero 2008
Portal HidrocarburosBolivia.com: Permanece conectado y mucho, www.HidrocarburosBolivia.com, February 2011
Technologias en dessarrollo, www.tecnologiadesarrollo.tk, February 2011
The world fact book, Central Intelligence Agency (CIA), Bolivia, https://www.cia.gov/library/publications/the-world-factbook/geos/bl.html, February 2011
U.S. Department of State, Background Note: Bolivia, 2010Bureau of Western Hemisphere Affairs http://www.state.gov/r/pa/ei/bgn/35751.htm, May 13 2010
U.S. Energy Information Administration, Countries, Bolivia, http://tonto.eia.doe.gov/country/country_energy_data.cfm?fips=BL, Stand: February 2011
World weather and climat graphs…, Bolivia, What is the Climate, Average Temperature/ Weather in Bolivia?, World weather and climat graphs…, February 2011, February 2011

4.6 Related links

Government organizations

Organization	Web site
Presidencia del Estado Plurinacional de Bolivia	www.presidencia.gob.bo
Vicepresidencia del Estado Plurinacional de Bolivia	www.vicepres.gov.bo
Honorable Congreso Nacional de la República de Bolivia	www.congreso.gov.bo
Poder Judicial de Bolivia	www.poderjudicial.gov.bo
Instituto Nacional de Estadística (INE)	www.ine.gov.bo
ADSIB	www.adsib.gob.bo
Servicio Nacional de Administración de Personal (SNAP)	www.snap.gov.bo
Prensa de Palacio	www.comunicacion.presidencia.gob.bo
Corte Nacional Electoral	www.cne.org.bo
Servicio Nacional de Impuestos	www.impuestos.gov.bo
Banco Central de Bolivia	www.bcb.gob.bo
Escuela de Gestión Pública Plurinacional	www.egpp.gob.bo
Contraloría General de la República	www.cge.gob.bo
Fondo Nacional de Desarrollo Regional	www.fndr.gov.bo
Gaceta Oficial de Convocatorias	www.gacetaoficialdebolivia.gob.bo
SICOES	www.sicoes.gov.bo
YPFB	www.ypfb.gov.bo

Ministries

Ministerio de Relaciones Exteriores	www.rree.gob.bo
Ministerio de la Presidencia	www.presidencia.gob.bo
Ministerio de Gobierno	www.mingobienro.gob.bo

Ministerio de Defensa Nacional	www.mindef.gov.bo
Ministerio de Economía y Finanzas Públicas	www.economiayfinanzas.gob.bo
Ministerio de Planificación del Desarrollo	www.planificacion.gov.bo
Ministerio de Justicia	www.justicia.gob.bo
Ministerio de Hidrocarburos y Energía	www.hydrocarburos.gob.bo
Ministerio de Educación	www.minedu.gov.bo
Ministerio de Salud y Deportes	www.sns.gov.bo
Ministerio de Obras Públicas, Servicios y Vivienda	www.oopp.gov.bo
Ministerio de Desarrollo Rural y Tierra	www.agrobolivia.gov.bo
Ministerio del Minería y Metalurgia	www.mineria.gob.bo
Ministerio de Defensa Legal del Estado	www.defensalegal.gob.bo
Ministerio de Desarrollo Productivo y Economía Plural	www.produccion.gob.bo
Ministerio de Autonomías	www.autonomia.gob.bo
Ministerio de Medio Ambiente y Agua	www.mmaya.gob.bo
Ministerio de Trabajo y Previsión Social	www.mintrabajo.gob.bo
Ministerio de Culturas	www.minculturas.gob.bo
Ministerio de Transparencia y Lucha contra la Corrupción	www.transparencia.gob.bo

Other Bolivia web sites

Bolsa Boliviana de Valores	www.bbv.com.bo
Fundación Cultural del BCB	www.culturabcb.org.bo
En la Red Municipal	www.enlared.org.bo
Empresa Nacional de Electricidad Bolivia ENDE	www.ende.bo/
Transportadora de Electricidad S.A. - TDE	www.tde.com.bo
ELECTROPAZ	www.electropaz.com.bo/
Empresa de Luz y Fuerza Eléctrica Cochabamba	www.elfec.com/

(ELFEC)	
Cooperativa Rural de Electrificación (CRE)	www.cre.com.bo
SETAR (Servicios Eléctricos Tarija, S.A.)	http://setaryacuiba.com/index.php

International organizations

World Bank	www.worldbank.org
International Monetary Fund	www.imf.org
Banco Interamericano de desarrollo	www.iadb.org
United Nations Development Programme	www.undp.org
Food and Agriculture Organization of the United Nations	www.fao.org
JICA - Japan International Cooperation Agency	www.jica.org
International Energy Agency	www.iea.org

Other information sites

Climate & temperature	www.climatetemp.info
Internet World Stats	www.internetworldstats.com
Central Intelligence Agency, USA	www.cia.gov
NASA Atmospheric Science Data Center	http://oesweb.larc.nasa.gov
Index Mundi	www.indexmundi.com
Probe International	www.probeinternational.org

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