SOLAR ENERGY RESOURCES NOT ACCOUNTED IN BRAZILIAN NATIONAL ENERGY BALANCE

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Abstract. *The main development vector of a society is the energy. The solar energy is the main energy source on the planet earth. Brazil is a tropical country and the incident solar energy on its soil (15 trillion MWh / year) is 20,000 times its annual oil production. Several uses of solar energy are part of our lives in a so natural way that it despised in the consumption and use energy balance. In Brazil, solar energy is used directly in many activities and not accounted for in Energy Balance (BEN 2007), consisting of a virtual power generation. This work aims to make a preliminary assessment of solar energy used in different segments of the Brazilian economy.*

Keywords*: Solar Energy, Solar Collector, Brazilian Energetic Balance*

1. INTRODUCTION

O mistério das cousas? Sei lá o que é mistério!
O único mistério é haver quem pense no mistério.
Quem está no sol e fecha os olhos,
Começa a não saber o que é o sol
E a pensar muitas cousas cheias de calor.
Mas abre os olhos e vê o sol,
E já não pode pensar em nada,
Porque a luz do sol vale mais do que os pensamentos
De todos os filósofos e de todos os poetas.
A luz do sol não sabe o que faz
E por isso não erra e é comum e boa.
Alberto Caeiro (Fernando Pessoa)

Brazil is a tropical country with high insolation, with all regions receiving more than 2,200 sunshine hours. The solar energy incident on Brazilian surface (15 trillion MWh / year) is 20,000 times the annual oil production, or 50,000 times the national electricity consumption (2007). Despite this large energy availability, several uses of solar energy are present in our lives in a so natural way that it despised in the consumption and use energy accounts. The Brazilian Energy Balance [BEN EPE-2008] accounts especially the energy used in intensive form or that passes through the commercialization steps. The solar energy is free, widespread and universal, and the total amount is not counted. In Brazil, solar energy is used directly in many activities and not accounted in the national energy balance [BEN EPE-2008], consisting of a virtual power generation.

Table 1. Evolution of Brazilian energy supply (10^3 toe).

IDENTIFICATION	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**
Non Renewable Energy	**102,893**	**107,137**	**109,275**	**112,376**	**117,655**	**116,828**	**113,728**	**120,103**	**121,350**	**124,464**	**129,102**
Oil and Derivatives	82,561	86,346	87,417	86,743	87,975	85,284	81,069	83,648	84,553	85,545	89,239
Natural Gas	6,495	6,813	7,761	10,256	12,548	14,838	15,512	19,061	20,526	21,716	22,199
Coal and derivatives	12,673	12,455	12,705	13,571	13,349	13,005	13,527	14,225	13,721	13,537	14,356
Uranium (U3O8) and Derivatives	1,164	1,522	1,391	1,806	3,783	3,700	3,621	3,170	2,549	3,667	3,309
Renewable Energy	**77,790**	**78,442**	**79,958**	**78,239**	**76,272**	**81,118**	**88,206**	**93,642**	**97,314**	**101,880**	**109,656**
Hydraulics and Electricity (*)	27,461	28,444	28,623	29,980	26,282	27,639	29,477	30,804	32,379	33,537	35,505
Wood and Charcoal	21,668	21,265	22,130	23,060	22,443	23,545	25,973	28,203	28,468	28,589	28,628
Sugar cane derivatives	25,378	25,284	25,235	20,761	22,916	24,980	27,093	28,775	30,147	32,999	37,847
Other Renewables (**)	3,283	3,449	3,970	4,439	4,631	4,954	5,663	5,860	6,320	6,754	7,676
TOTAL	**180,683**	**185,578**	**189,233**	**190,615**	**193,927**	**197,946**	**201,934**	**213,744**	**218,663**	**226,344**	**238,758**

Source: Balanço Energético Nacional, 2008 [EPE-BEN 2008].

Solar energy is not a single technology but a technologies set. This work aims to detect various forms of solar energy natural use, and quantify this value to be considered together, or included in the Brazilian energy balance.

Brazil, has large part of the territory located in latitudes between the equator and the Capricorn Tropic, and has a high solar energy incidence. The maximum solar energy incident at any Earth location is about 1000 W/m^2. The average annual energy incident in Brazil varies between 4 and 5 kWh/m^2.day.

Table 2. Solar Radiation in Brazilian Main Capital Cities.

Capital City	Year Average Temperature (ºC)*	Incident Radiation (kWh/m^2.year)*	Insolation (hours/year)**
Aracaju	25.5	1892	
Belém	26.9	1783	2200
Belo Horizonte	21.5	1896	2500
Boa Vista	27.8	1938	
Brasília	21.4	1934	2500
Cuiabá	26.8	1775	
Curitiba	17.6	1656	2000
Florianópolis	20.8	1495	
Fortaleza	26.7	1992	2800
Goiânia	22.7	1928	
João Pessoa	25.7	1968	2800
Macapá	26.8	1714	
Maceió	25.5	1959	
Manaus	27.4	1663	
Natal	25.9	2013	2800
Porto Alegre	20.1	1594	2300
Porto Velho	26.2	1604	
Recife	25.9	1956	2600
Rio de Janeiro	23.7	1602	2100
Salvador	25.1	1830	2600
São Luís	27.4	1929	
São Paulo	23.0	1674	2000
Teresina	28.0	1982	
Vitória	24.4	1675	

Source: INMET, *Quinteros, 2001; **Manual Cumulus.

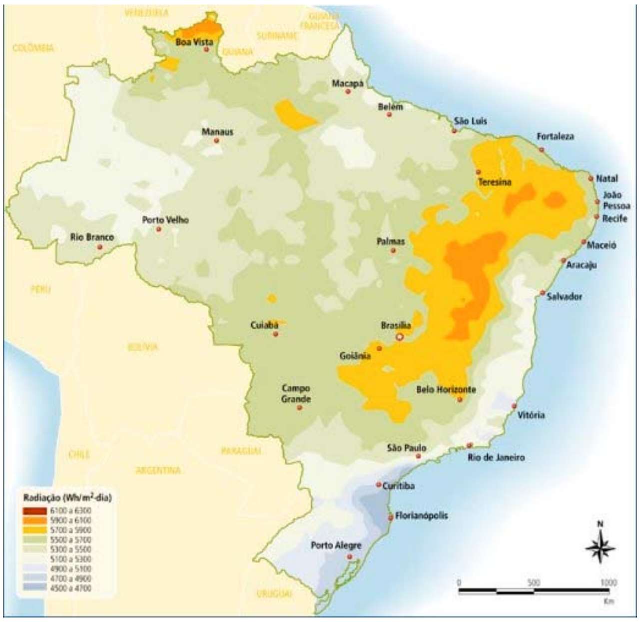

Figure 1. Daily Solar radiation in Brazil

2. WATER HEATING BY SOLAR COLLECTORS

The solar collector is the most representative solar technology, and it uses solar energy to heat water between 40 and 60°C, mainly for residential use. Only 0.4% (2005) of Brazilian households uses solar energy for water heating [Procel, 2007]. Despite the small solar collectors use in Brazil (Table 3), in comparison of the world market, the Brazilian industry has approximately 140 manufacturers (30 with Inmetro certification). The Brazilian solar collectors production has grown annually more than 10% (Figure 2). In December 2006 [MME], there were 661,322 solar collectors systems installed with a 3.1 million m^2 total area, and in 2007 approximately 3,673,000 m^2 [ABRAVA, 2008].

Table 3. Solar Collectors Worldwide (2005).

Installed Capacity		Market Penetration	
Country	GWt	Country	MWt/ 100,000 hab
China	43.4	Cyprus	63.0
Japan	5.5	Israel	52.0
Turkey	5.1	Barbados / Greece	19.2
Germany	4.0	Austria	18.8
Israel	3.4	Germany	4.8
Brazil	1.6	Brazil	0.9 – (1.2)

Source: Faria (Abrava), 2008

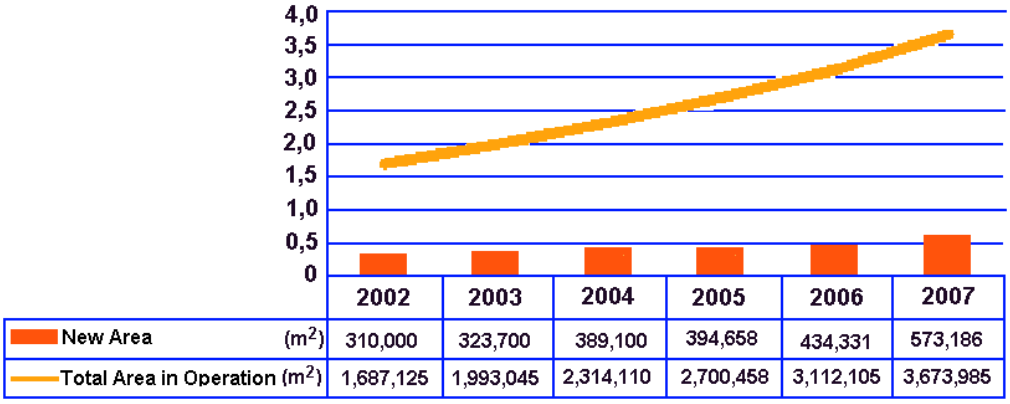

Figure 2. Solar collectors production and total area installed in Brazil. Source: Abrava, 2008

Assuming an average production of 80 kWh/m^2. month [Procel, 2007] has been:

Solar Collector Energy = 3,673,000 m^2 * 80 kWh/ month * 12 month /year = 3,526 GWh/year

3. WATER PRE-HEATING FOR BATH AND SHOWER

Brazil is a country with a unique profile, where all population takes more than one shower per day (Prado, 1991). The shower time has 7 minutes average duration [Prado, 1991], or 7 minutes and 45 seconds [Island, 1991]. The electric shower is widespread due to the low cost acquisition and easy installation, in 2005 it was installed in 73.1% of Brazilian households [Procel, 2007]. The people use the electric shower predominantly in the electrical system peak hours (18h to 21h). According Procel 80.9% of Brazilian households heat the shower water in some way, and only 18.2% not heat. 73.5% of heating systems use electricity as a heating source and 5.9% gas. Only 0.4% use solar energy. The electric shower is 99.6% of systems that use electricity as a heating source. In the households that use gas for heating, 57.6% use distributed gas (mainly natural gas), and 42.4% LPG.

Table 4. Electric Shower Utilization in Brazil (2005)

	Homes with Electric Shower	Electric Shower / home
North	4.0 %	0.02
Northeast	30.3 %	0.55
Central West	85.1 %	1.04
Southeast	90.7 %	1.10
South	98.6 %	1.17
BRAZIL	73.1 %	0.91

Source: Procel/Eletrobras, 2007.

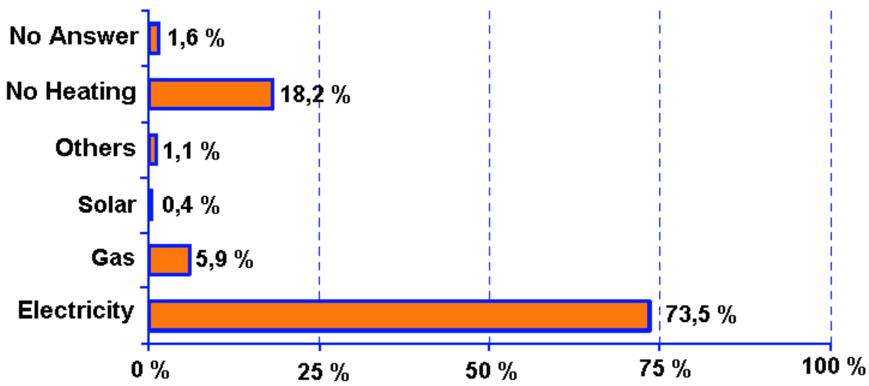

Figure 3. Sources of Water Heating for Residential Bath [Procel, 2007]

Near to 6% of all Brazilian electricity consumption (377,234 GWh in 2007, EPE) and 26% of residential electricity (90,881 GWh in 2007, EPE) is consumed in electric showers [Procel, 2007]. The average consumption of an electric shower is estimated at 70 kWh / month [Procel, 2007].

The Brazilian environmental average temperature is 25°C, while the average world temperature is 15°C. This gain in the average world temperature is due to environment solar heating (indirect heat). Thus, any heated water use in Brazil has a Δ10°C preheated due to solar energy.

The electric showers typically raise the temperature from 25 to 40°C (ΔT=15°C). Whereas the environment water preheated is 10°C. In this way the energy consumption in the preheated water is:

Consumption of electricity in Electric Showers: 0.26% * 90,881 GWh/year = 23,630 GWh/year

Preheating energy in Electric Shower = 10°C/15°C * 23,630 GWh/year = 15,750 GWh/year

The 18.2% of homes that do not heat the water for shower, especially in the North-Northeast, is due to the fact that water is already naturally heated. In Europe water is distributed at an average temperature below 15°C which impossible to take a bath/shower without heating. In the European directives (75/440 June, 16 1975 and 80/778 July, 15 1980), was established the recommended value of 12°C [Mulot, 2002].

Energy in the Cold Shower = 18.2% / 73.5% * 23,630 GWh/year = 5,850 GWh/year

4. PHOTOVOLTAIC SYSTEMS

The photovoltaic systems, or photovoltaic cells, use semiconductor materials to convert directly sunlight to electricity. Since 1998 the global market for solar energy has grown 35% annually. In 2006 the photovoltaic panels world production has reached of 1,200 MW and total installed capacity 6,500 MW.

The potential for photovoltaic systems to be connected to the Brazilian electric grid is estimated at 10,000 MWp. In Brazil, the use of photovoltaic systems was intensified since 1992, initially with the some project implementation in international cooperation with Germany (Eudorado Project) and USA (DOE). The implementation of PRODEEM in 1994 (States and Municipalities Energy Development Program, MME), the fall of international prices, and the environmentally green conscious, made the photovoltaic systems an alternative to electricity supply in isolated areas not served by distribution services. Until 2002 the PRODEEM installed 8742 systems with 5.2 MWp total power (Table 3), and aims to serve 100,000 communities and installation of 35 MWp. The Bahia State government, through the Solar Electrification Program - CAR installed from 1998 to 2000 10,302 photovoltaic systems in Bahia rural homes. The IEE-USP estimated that in Brazil are 12 MWp in photovoltaic systems installed in isolated communities and the other 80 kWp integrated power network [FAPESP, 2003].

The only photovoltaic plant registered by ANEEL is the Araras Plant, in Nova Mamoré city, Rondônia, in operation since April 2001. It is a solar-diesel hybrid system, with 3x54 kW diesel engines and 320x64 W photovoltaic panels, giving a capacity of 20.48 kW and occupying an area of 300 m^2.

Table 5. Photovoltaic Systems installed by PRODEEM until 2002.

SYSTEMS	Phase 1		Phase 2		Phase 3		Pumping		Phase 4		Phase 5	
	Qtd	kWp	Qtd	kWp	Qtd	kWp	Qtd	kWp	Qtd	kWp	Qtd	kWp
Energetic Systems	190	87	387	195	843	526	-	-	1660	972	3000	2172
Water Pumping	54	78	179	213	224	165	800	235	1240	696	-	-
Public Lighting	137	7.5	242	17	-	-	-	-	-	-	-	-

Source: Aneel, 2005

Assuming 0.1 kWh/month for each 1Wp installed, the electricity generation in Brazil is through photovoltaic systems are:

Generation = 12 MWp * 0.1 kWh/ month.Wp * 12 months = 14.4 GWh/year

5. SPACE HEATING

The amount of energy used for space heating in Brazil is near zero, due to the tropical climate. Meanwhile, in the European Union, the energy consumption for space heating in the service sector represents 52% of total buildings energy consumption and more than 57% of the residential sector [STOYKOVA, 2002, PAAR, 2003]. In Canada, the energy consumption is about 63.8% of residential consumption, in New Zealand 34% and 30% in China [TONOOKA, 2003].

The United States has 111.1 million households, of which only 1.2 million don't have space heating system, 109.1 million using space heating and 0.8 million have space heating, but do not use, with an average consumption of 43.9 million Btu/home.year (12.8 MWh/home.year) [EIA-DOE, 2005] (10.1 MWh/home.year, EIA-DOE, 2001). This energy consumption is similar many other developed countries.

Brazil has 56.3 million households [IBGE, 2007]. Assuming an half of energy consumption for space heating, used in the United States and Europe:

Energy for Space heating = 0.5 * 12.0 MWh/home.year * 56.3 x 10^6 homes = 337,800 GWh/year

A more precise calculation of the annual energy demand needed for space heating, ensuring comfort levels, can be calculated using degree-days method. The degree days are a parameter used to calculate the energy required to space heating. The degree-days for each day is calculated by subtracting the average daily temperature to the reference temperature (usually 18°C). The each day value is accumulated for each month and the each month value is accumulated for the annual amount. The amount of energy needed for space heating is proportional to this value. The degree-days is a simple and suitable method for energy analysis, if the building use and heating equipment efficiency are constant. For this methodology, the days which have average temperatures higher than the reference are not considered, because the value can not be negative, however this heating amount is obtained by solar energy.

6. CLOTHES DRYING

In Brazilian residential sector, almost all laundry is dried in open air, and only a small portion of the population uses the laundry services where the drying is done by artificial way.

In different way, in temperate countries, most times are need an electro/mechanic device for clothes drying. The clothes dryers have high electrical power consumption, with consumption between 1.8-5.0 kW. In the United States 60% of households have electric clothes dryers and 20% natural gas dryers [EIA-DOE, 2001], and the dryers electrical consumption account about 5.8% of household in the United States [DEANS, 2001, EIA-DOE, 2001]. The U.S. consumption in clothes dryers is about 1.079 MWh/home.year [EIA-DOE, 2001] and in Canada 0.914 MWh/home.year [NRCAN, 2001 and 2003]

The clothes dryers efficiency is measured by the Energy Factor (EF, pounds of laundry / kWh of electricity). The American standards provide a 3.01 EF minimum for electric dryers and 2.67 for gas dryers (Table 6).

Table 6. Energy Consumption for Clothes Drying:

Dryer Type	Energy Factor (EF)	
	lb wet clothes / kWh	kg wet clothes / kWh
Electric	3.01	1.36
Gas	2.67	1.21

Source: http://www.consumerenergycenter.org/home/appliances/dryers.html

Considering the same energy consumption for Brazil:

Energy for Clothes Drying: 0.914 MWh/home.year * 56.3 x 10^6 homes = 51,450 GWh/year

It should be noted that the U.S. and Canada have a great program for energy savings, and the clothes dryers consumption fell 18% between 1990 and 2003 [NRCAN, 2003]. Brazil, as a developing country, surely it would use a technology more obsolete with high energy consumption.

7. SALT PRODUCTION

The production of salt can be done by solar evaporation or artificial evaporation of sea water or by extraction in salt mines (mineral salt). Worldwide the mineral salt is the most exploited, because in some regions is found in large quantity and the weather does not interfere with its production. The all types world salt production, totalized 210 million tons/year, and the major producers are United States, China, Germany, India and Canada.

Brazil is the 8th place in the ranking of the largest salt producers, accounting for 3.5% of world production. The total Brazilian salt production in 2005 was 7,297 million tonnes, which 5,739 million tonnes of sea salt and 1,559 tons of mineral salt. The use of salt in Brazil: 31% for human consumption and animal production, 23% for the chemical sector and 46% for other sectors (refrigerators, leather, Charqueadas, textile and pharmaceutical industries, oil exploration, water treatment). The mineral salt is mostly used in the manufacture of caustic soda. The Rio Grande do Norte state is the main national producer, with 5,345 million tonnes produced, accounting almost 73% of the total salt production, and approximately 93% of Brazilian sea salt production.

Table 8. World Salt Production (10^6 t)

Country	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2004	2005
USA	37.0	36.4	36.1	39.3	39.8	42.2	42.3	41.5	41.3	45.0	45.6	45.1	46.5	45.9
China	20.0	24.1	28.1	29.5	29.7	29.8	29.0	30.8	22.4	28.1	31.3	32.0	37.1	38.0
Germany	15.7	14.9	12.7	12.7	10.5	15.2	15.9	15.8	15.7	15.7	15.7	15.8	16.0	18.7
India	9.5	9.5	9.5	9.5	9.5	12.5	14.5	14.3	12.0	14.5	14.5	14.5	15.0	15.5
Canada	11.3	12.0	11.2	10.9	11.7	11.0	12.2	13.3	13.3	12.7	11.9	12.5	14.1	13.3
Mexico	7.14	7.5	7.4	7.5	7.5	7.7	8.5	7.9	8.4	8.2	8.9	8.6	8.2	8.2
Australia	7.23	7.8	7.7	7.7	7.7	8.1	7.9	8.8	8.9	10.0	8.8	8.0	11.2	10.0
France	6.61	6.5	6.1	7.0	7.5	7.5	7.9	7.1	7.0	7.0	7.0	7.1	7.0	7.0
Brazil	5.37	4.9	5.3	6.2	6.0	5.8	5.4	6.5	6.5	6.9	6.0	7.0	6.6	7.3
England	6.43	6.8	6.1	6.8	7.0	6.7	6.6	6.6	6.6	5.8	5.8	5.7	5.8	5.8
Rest World	45.59	60.6	53.8	41.0	53.1	52.5	53.8	54.4	59.1	58.0	58.5	57.7	40.5	40.3
Total	183.0	191.0	184.0	187.0	190.0	199.0	201.0	207.0	200.0	211.0	214.0	214.0	208.0	210.0

Source: DNPM, Sumário Mineral Brasileiro 2006.

The sea salt in Brazil is produced almost exclusively by water evaporation by solar energy. The production of table salt by solar evaporation is not the main form of production in the "developed" Countries. In the United States, major world producers (45 million ton / year), only 5.5 million tons are produced by solar way. The remaining salt production is by extraction in underground mines and mechanical evaporation, or saturated brine boiling in "vacuum pans," other energy forms recorded in the U.S.A. energy balance.

Table 9. Brazilian Sea Salt Production (10^6 t)

Discrimination			2003	2004	2005
Production	Sea Salt	t	5,144,000	5,205,968	5,738,483
Importation	Sea Salt	t	2,476	8,407	25,507
Exportation	Sea Salt	t	571,249	486,539	804,122
Aparent Consuption	Sea Salt	t	4,575,227	4,727,836	4,959,868

Fonte: DNPM, Sumário Mineral Brasileiro 2006.

In Brazil, production of 5.7 million tonnes / year is obtained by solar energy, which is not accounted in the energy balance. Considering a salinity of 35 ppt (3.5 g / kg water) and evaporation enthalpy of 2441 kJ/kg, the energy required to produce the salt in Brazil is:

Production = 1 / 0.035 kg salt/kg water * 5.7 millions tons salt/year * 2441 kJ/kg water
= 495EE12 kJ/year = 137,500 GWh/year

8. WOOD DRYING

Brazil is a larger wood producer and consumer. According to the IBGE, in 2007 the Brazilian wood production was 121,520,350 m^3, the majority (86.5%) from cultivated forests and the remainder (13.5%) collected in native vegetation (16,388 million m^3) [IBGE, 2008]. According to FAO, in 2007 the Brazilian production was 244,962 million m^3. According the BEN the wood production in 2007 was 96,527 million tonnes, about 14% of Brazilian energy consumption.

The firewood used in the industrial sector can be in direct way (wood and waste combustion) or indirect way (charcoal production). The wood used in residential sector especially for food cooking, comes from native forests: rainforest, caatinga and cerrado. Beyond the firewood there is a large wood consumption for cellulose production, furniture, construction etc.

The moisture content of a living tree, depending on the species, the year season and tree location, varies from 60 to 200% [TYREE, ZIMMERMANN, 2002]. The moisture in green wood is presented in three forms: constitution water (fixed in living cells protoplasm); impregnation water (which saturates the cell wall) and free or capillary water (which fills the channels of wood). After the harvest, exposed environment, the wood loses moisture. Initially the free or capillarity water is evaporated. The capillary water end of evaporation is called the fiber saturation point. The saturation point, in general, corresponds to moisture contents between 20% and 30%. At this point the wood is called environmentally dry. Below this point the wood contains only impregnation and constitution water. Following drying, evaporation continues with less intensity, until the wood reaches an equilibrium point, which depends of the atmospheric humidity and temperature, thus is called the dry air. The wood dry in air shows a moisture content between 10% and 30%.

Unlike the procedures used for determine the fuels moisture content, where the humidity is expressed as a function of wet material initial mass (wet basis), the wood moisture content is usually expressed in terms of the dry weight (dry base).

$$U\,(wb) = \frac{M_{wet} - M_{dry}}{M_{dry}}$$

Table 10. Initial Moisture Content.

Wood	Initial Moisture (%, wb)	
Eucalyptus cloeziana	63.9	68.1
Eucalyptus grandis	102.3	94.0
Eucalyptus pilularis	86.3	63.6
Eucalyptus citriodora	62.6	---
Eucalyptus urophylla	96.2	---
Cerrado Wood	---	93.5
Source	Oliveira, 2005	Martins, 2001

Considering the evaporation enthalpy of 2441 kJ/kg water, that 90% of wood used in Brazil is naturally dry, the water content is 75% (wb) and final moisture 25% (wb) and the conversion factor of 390 kg/stereo for wood with 25% moisture content (as BEN 2007, COBEN 04/88):

Energy for Wood Drying = 2441 kJ/kg * 0.90 * 121,520,350 m^3 * (0.75-0.25)/1.25 *390 kg/m^3 = 41,646*10^{12} kJ
Energy for Wood Drying = 41,646*10^{12} kJ * 1 Wh/3.6 kJ = 11,570 GWh/year

9. AGRICULTURAL PRODUCTS DRYING

Drying is the commercial process most widely used for the agricultural products quality preservation. These products are dried until to a determined moisture content, so it can be stored in environmental conditions for over 3 years without loss of nutritional and organoleptic properties [Roa and Rossi 1980]. The drying also allows the early harvesting, allowing a harvest planning, losses reduction caused by insects, birds, rodents and weather conditions.

the agricultural products can be classified into four groups from the initial moisture content:

- Initial high moisture content (80-90%): fruits, potato, tobacco leaves, vegetable and animal waste, etc.
- Initial high moisture content (60-80%): coffee, cassava, etc.
- Initial intermediate moisture content (35-60%): cocoa, peanuts, etc.
- Initial low moisture content (15-35%): cereals, pulses and oilseeds.

Drying is generally the reduction of moisture content for around 14-11%

The agricultural products water vaporization latent heat is inversely related to its moisture content, can be adopted, in general, the value of 2,930.20 kJ/kg for products with moisture content between 15 and 35% wb and 2,720.20 kJ/kg for products between 35-60% wb [HALL, 1980].

The amount of moisture removal (db) (kg water / kg dry product) during the drying process (**M_{db}**) depending on the initial moisture (**U_{wet}**) and final moisture (**U_{dry}**) on wet basis (wb) is given by:

$$M_{db} = \frac{U_{wet}\,(\%wb)}{100 - U_{wet}\,(\%wb)} - \frac{U_{dry}\,(\%wb)}{100 - U_{dry}\,(\%wb)}$$

The amount of grain moisture removal in storage conditions (kg water/kg product stored) is:

$$M_{wb} = \frac{M_{db}}{1 + M_{db}}$$

Table 11. Energy Needed for Drying of Some Agricultural Products.

Culture	Average Initial moisture (% wb)*	Moisture storage (% wb)*	Energy to reach moisture storage kJ/kg dry product	Harvest 2008** (t)	Energy required for drying (MJ)
Soybean	20	11	328.8	59,916,830	19,702,177,773
Maize	30	13	639.5	59,017,716	37,739,064,110
Rice	25	13	455.2	12,100,138	5,507,700,873
Beans	20	13	267.8	3,460,867	926,726,206
Wheat	20	13	267.8	5,886,009	1,576,113,381
Sorghum	20	11	328.8	1,965,865	646,426,416
Peanuts	45	7	1159.5	296,600	343,901,628
Coffee	65	11	1725.1	2,790,858	4,814.461,119
Cocoa	50	7	1306.9	208,386	272,342,108
TOTAL					71,528,913,615

Source: *Roa and Rossi, 1980. ** IBGE, 2008a

About 80% of Brazilian national grain production is dried using the traditional solar drying [Roa and Rossi, 1980].

Energy for Agricultural Product Drying = 0.80 * 71,500,000,000 MJ = 57,200,000,000 MJ
Energy for Agricultural Product Drying = 57,200,000,000 MJ* 1 kWh/3.6 MJ = 15,900 GWh/year

In Brazil the grains are collected, with 20% average moisture content, while in the United States it are harvested with 28-30% moisture content [Rossi and Roa, 1980], which implies a approximately 10% difference in moisture. This difference can be attributed due to natural drying made in the plant, which results in a lower energy consumption for the final drying. This value also can be added to the energy not computed in the Brazilian energy balance due to grain drying.

10. CONCLUSIONS

Was not the objective of this study to determine the exact consumption/production of the various solar energy uses not accounted in Brazilian National Balance, but make a preliminary survey, to take a magnitude order of the solar energy amount used in Brazil and allow better knowledge and planning of their use. The table 12 shows the compilation of the values obtained this work.

Table 12. Solar Energy use not accounted in Brazil

Use	**GWh/year**	**TOE/year**
Solar Collectors	3,526	303,236
Preheated electric shower	15,750	1.354,500
Cold Bath	5,850	503,100
Photovoltaic Systems	14.4	1,238
Space Heating	337,800	29,050,800
Clothes drying	51,450	4,424,700
Sea Salt Production	137,500	11,825,000
Wood Drying	11,570	995,020
Grain Drying	15,900	1,367,400
Total Brazil	**579,360**	**49,824,994**

Conversion Factor: 0.086 TOE/MWh [EPE-BEN 2008]

The total energy supply in Brazil in 2008 was 238,758,000 toe, which 109,656,000 toe from renewable sources [BEN EPE-2008]. The solar energy is not accounted in these renewable sources. Solar energy is used in a so natural way that it is not accounted in the National energy balance. This use of solar energy is very important, and represented about 21% of Brazilian available energy. Thus, the Brazilian energy matrix is much more renewable than currently recorded.

Moreover, the accounting of these solar energy resources on balance shows the inefficient energy use in Brazil, and the huge energy waste.

Many other solar energy uses were not included in this work: lighting, tobacco, fruit and meat drying, industrial water pre-heating etc.

And finally as Drummond says: "*O sol nos serve, mas não nos obedece*". [The sun serves us, but it doesn't obey us]

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