BRAZILIAN SCENARIOS OF SOLAR ENERGY APPLICATIONS USING SWERA OUTPUTS

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ABSTRACT

Solar and Wind Energy Resource Assessment is a project financed by the United Nations Environment Program (UNEP) aiming to provide reliable data of the solar and wind energy resources. During the project a satellite-derived solar radiation mapping of Brazil was made, and obtained results were organized in maps of monthly average daily sums. These maps were georeferenced and added to a database including other geographic and socio-economic data. In the present work, this dataset is used to simulate different scenarios for solar energy applications. Solar hot-water, PV-systems and concentrated solar power plants were discussed in terms of the solar energy resource and potential market. The results show a large potential for all studied applications, highlighting some very economically attractive conditions.

1. INTRODUCTION

The Solar and Wind Energy Resource Assessment (SWERA) project main focus was to create a reliable and high-quality database to help in planning and developing public policies for solar and wind energy projects, and to attract capital investment from private sector to this area. Such information includes maps and digital data of solar and wind energy as well as detailed infrastructure and socio-economic parameters. The database is compatible with Geographical Information Systems (GIS) and can be employed in feasibility studies during project development. This work show some information provided by the SWERA Country Report of Brazil [1].

Along the Brazilian territory, the solar irradiation is fairly uniform. The maximum mean daily solar irradiation value – 6.5 kWh/m^2 – occurs in the Northern part of Bahia close to the border with the Piauí and the lowest mean daily global solar irradiation – 4.25 kWh/m2 – occurs on the North shore of Santa Catarina [2]. The annual mean of daily horizontal global solar irradiation in any region of the Brazil is larger than in most of the EU countries where solar applications are greatly disseminated, some of which with huge government incentives.

Table 1 present some information about the Brazilian Domestic Energy Supply [3]. It is remarkable that the Brazilian renewable energy supply (44.7%) is among the highest in the world, which significantly contrasts with the global average of 13.3%.

TABLE 1: STRUCTURE OF THE DOMESTIC ENERGY SUPPLY IN BRAZIL IN MILLIONS OF TOE (2005)

SOURCES	TOE	%
Non Renewable	120,953	
Oil and Derivatives	84,020	38.4
Natural Gas	20,393	9.3
Mineral Coal and Derivatives	13,940	6.4
Uranium (U_3O_8) and Derivatives	2,600	1.2
Renewable	97,695	44.7
Hydroelectricity	32,691	15.0
Firewood and Charcoal	28,560	13.1
Sugar Cane Products	30,441	13.9
Others Renewables	6,002	2.7
Total Supply	218,648	100.0

2. THERMAL SOLAR ENERGY FOR WATER HEATING APPLICATIONS

The most developed application of solar energy in Brazil is the solar water heating. In this case, despite the high initial investment, the payback time is short. Brazil has a particular characteristic that sets it apart from other countries regarding water heating for residential use: electric showerheads are widely used. Fig. 1 clearly shows that the total demand has a pronounced peak during the early nighttime hours, which is reproduced in the residential curve. It is exactly during this peak period that the shower is most used, and therefore, its substitution is considered an efficient measure to rationalize the use of electricity.

A well-developed market already exists for solar heating systems in Brazil; however, it is small when compared to that of countries where the solar energy resource and the population are smaller. Fig. 2 shows the installed capacity in thermal megawatts per group of 100,000 inhabitants in several countries. It can be observed that Brazil has a very low ratio which indicates the large market still available in the country [4].

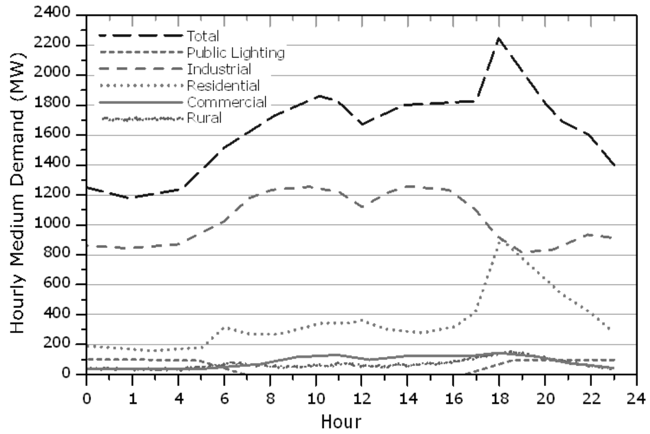

Fig. 1: Average hourly demand of electric energy per sector in Brazil.

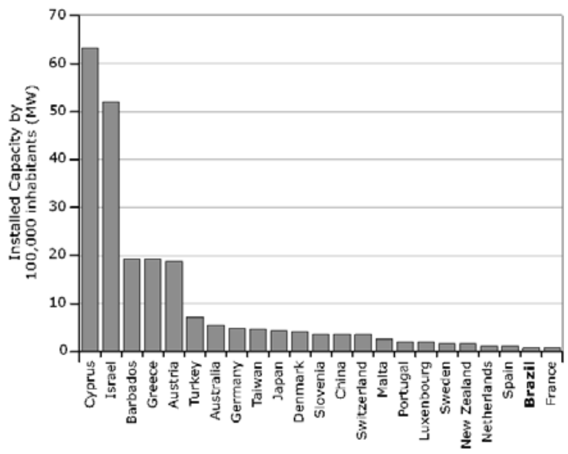

Fig. 2: Installed capacity of solar collectors for water heating per group of 100,000 inhabitants in 2004.

2.1 Residential Solar Heating in Brazil

The most remarkable characteristic of the solar energy market in Brazil is that the main customers are higher income families. For lower income residences, the most common option ends up being the electric showerhead, where no cost is required for hot water distribution, since the heating is done directly at the consumption point and, therefore, the costs of a solar heating system becomes even more unfavorable.

Fig. 3 shows the percentage of energy saved of a typical family which consumes around 300 liters of hot water per day. The simulation was conduct using the F-chart method [5] and the simulated system used high standart flat-plate solar collectors with a single glass cover and 4 m^2 of area, and a reservoir volume equal to 300 liters.

Fig. 3: Percentile energy savings of a typical residential heating system in Brazil.

2.2 Solar Heating of Pools in Brazil

In most cases, solar heated pools compete with pools with electric heat pumps or firewood boilers. In terms of necessary investiments, solar heated pools do not need a thermal reservoir (it is the pool itself) and low cost plastic panels can be used. Fig. 4 shows what the annual energy savings would be for a heated pool, maintained at a temperature of 28°C, with an area of 50 m^2, where a solar heating system with the same area was installed. The performance characteristics used in the simulation were those for a plastic solar flat-plate collector without cover and thermal insulation.

3. PHOTOVOLTAIC SYSTEMS

In most of the large countries of the developing world, it is widely acknowledged that distributed resources are the only way of providing electricity. Long distances and relatively small energy demands make transmission and distribution costs prohibitive. Mini-grids fed by Diesel generator sets are commonly used to supply electricity in remote villages, but the running costs are high and reliability and service quality are low. Because of this hybrid Diesel / PV power plants without storage can be a market option.

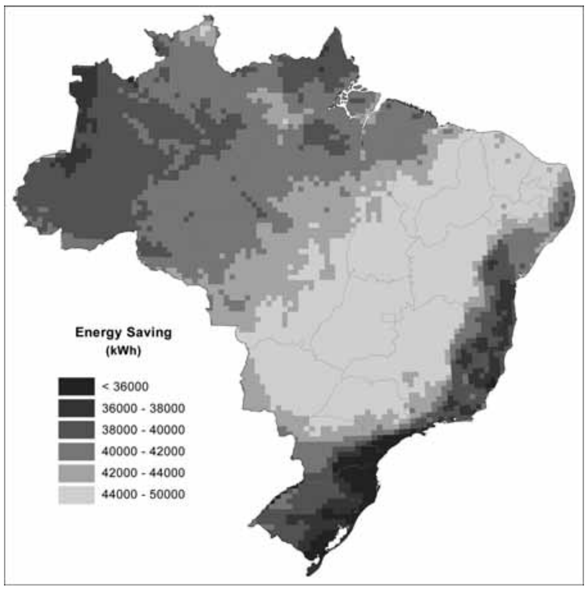

Fig. 4. Energy savings for a pool having an area of 50 m^2 with a solar heating system with the same collector area.

Grid-connected PV systems in the urban environment of developing countries can also have an important role to play especially in sunny areas, where high annual energy yields make PV generation more competitive.

3.1 Photovoltaics in Remote Areas

Energy supply to dispersed populations in the Brazilian rainforest assumes a number of configurations: no service at all, small PV solar home systems, and mini-grids supplied by Diesel generator sets are examples. There are hundreds of mini-grids in the Amazon, which cover the main share of this demand. The potential for using PV is huge, and can be estimated in tens to hundreds of MWp in the Amazon region, even if only a fraction of the existing Diesel would adopt some PV to an optimum Diesel / PV mix [6]. Fig. 5 shows the results for the daily average PV generation yields, in kWh/kWp, that can be expected for the amorphous silicon thin-film PV technology deployed at latitude-tilted arrays in the Amazon region, together with the location of villages/towns and Diesel generation units in the region.

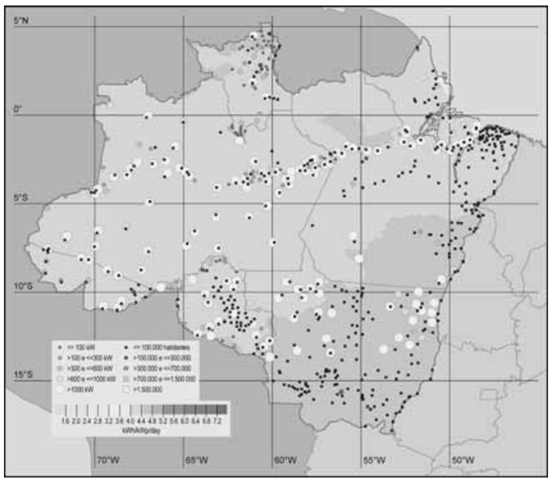

Fig 5: Daily yield, in kWh/kWp, of latitude-tilted amorphous silicon thin-film PV, together with the Diesel generation sites and villages in the Amazon region.

3.2 Grid-Connected PV Systems in Urban Areas

Brazil is particularly well suited for the application of grid-connected PV due to both the considerable solar resource availability, and to the high value that can be attributed to PV in commercial areas of urban centers [7].

Commercial regions with high air-conditioning loads have a demand curve in a good synchronism with the solar irradiance [8, 9]. Utility feeders in these areas present daytime peak demand curves. To add value to the distributed nature of solar generated electricity, it is important to know the PV capacity of the different regions of a city in order to select the feeder with the greatest capacity credit to install the PV power plant. In this context, the concept of the Effective Load Carrying Capacity (ELCC) of PV was defined to quantify the capacity credit of a strategically sited PV installation [8, 10]. Fig. 6 shows, for a typical daytime peaking utility feeder in an urban center, the peak-shaving effect of adding a small amount of PV. To determine the capacity benefits of PV, knowledge of the solar radiation resource distribution on an hourly basis is necessary.

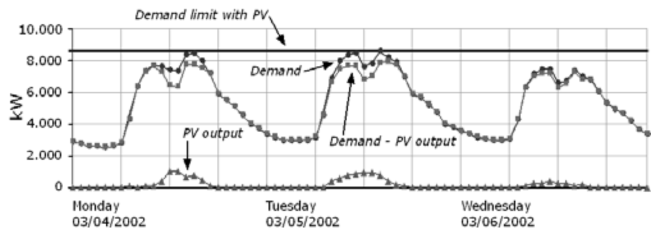

Fig. 6: Demand behavior of a typical commercial feeder in Brazil for three consecutive days (partly overcast, clear and overcast) [8].

4. CSPP – CONCENTRATED SOLAR POWER PLANTS

Regarding technical features, the conversion path of solar energy relies on four basic elements: concentrator, receiver, transport-storage and power conversion. Temperatures up to 500°C are achieved in the receiver which absorbs the concentrated solar radiation transferring its heat to a working fluid. The heat stored by the working fluid is used to generate steam employed to move a turbine. The two most developed technologies to concentrate solar radiation are the "parabolic throughs" and the "solar towers". The main requirements for both techonologies are very high direct solar irradiation (higher than 2,000 kWh/m^2/year), hydro resources accessibility and proximity to electricity distribution grid [11].

Fig. 7 presents the cumulative direct beam solar energy in

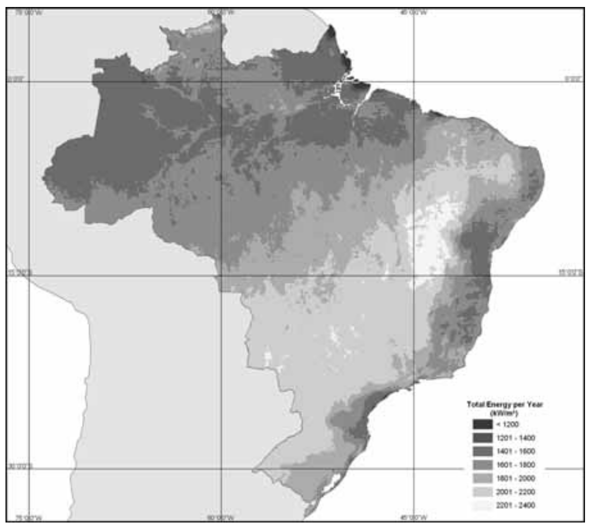

Fig. 7: Map for annual total for solar energy from direct beam irradiation.

MWh/m^2 in the Brazilian territory. The cumulative solar energy reaches values larger than 2,000 kWh/m^2 in the most of the Brazilian territory. Values larger than 2,200 kWh/m^2 were found mainly at the semi-arid region of the Brazilian Northeast where the low precipitation and large number of insolation hours are the key climate characteristics.

5. CONCLUSIONS

The objective of this work is show some results obtained during the SWERA project. The complete information with more detailed analysis and including other case studies can be found in the SWERA Country Report of Brazil (1). A brief explanation of the potentiality of SWERA products to create scenarios of large scale use of solar energy was conduct. Detailed individual analysis for the same or other kind of solar energy applications can be carried out using the same database.

6. REFERENCES

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