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ECONOMIC VIABILITY ANALYSIS OF CSP TECHNOLOGY IN THE STATE OF RIO GRANDE DO NORTE

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Abstract. *This work presents an economic viability analysis of the installation of solar power plants with Concentrating Solar Power (CSP) for the cities of Assú, Caicó and Mossoró of the state of Rio Grande do Norte in Brazil. The cities chosen have normal direct irradiation above 2,000 kWh/m^2/year. The System Advisor Model (SAM) software was used for the simulations. In the analysis have been considered that there is or there is not Thermal Energy Systems (TES). The CSP plants analyzed have been of Parabolic Trough Collector (PTC) technology with dry cooling system without TES and with TES, PTC plants with wet cooling without TES and with TES, Central Receiver System (CRS) technology with dry cooling without TES and with TES and CRS with wet cooling without TES and with TES. The parameters Levelized Cost of Electricity (LCOE), which is the price per kWh of the electric power generated at the plant, and the Solar Multiple (SM), which relates the solar generation with the power generation of the plant, were analyzed. According to the results found, Caicó and Mossoró had better conditions of CSP installation in relation to Assú, however Caicó, does not yet have enough Sistema Interligado Nacional infrastructure to receive CSP plants.*

Keywords: *Economic Viability, Concentrating Solar Power, Renewable Energy*

1. INTRODUCTION

Many activities in today's society depend on electricity and consumption increases every year. According to the International Energy Agency (IEA, 2018), more than 23,000 TWh were generated in 2015, led by China and the US, with Brazil occupying the eighth position. Brazil is the main generator of renewable energy, being led by hydroelectric plants. In 2008, the country generated approximately 89% of electricity from renewable sources according to the Operador Nacional do Sistema Elétrico (ONS, 2018), as presented in Table 1, with renewable sources having wind turbine technology since 2006, but the percentage of wind energy has only become considerable when it reached the third largest source in 2015, when it produced more than nuclear power plants, it has since only grown.

Table 1. Generation of electricity in Brazil in 2008 and 2017 (ONS, 2018).

Generation Source / Year	Hydroelectric	Thermoeletric	Wind	Nuclear	Solar
2008	88.61%	8.15%	0.12%	3.11%	-
2017	69.94%	19,83%	7.37%	2.74%	0.11%

At the beginning of the 20th century there is the first application of Concentrated Solar Power (CSP) technology as it is known today (Burgi, 2013), but there is not continuity. Just in the 1970s, there was a resurgence of studies and development in the generation technology of Concentrating Solar Power (CSP) and facilities of the first CSP plants in the USA and years later in Spain. There are few studies in Brazil on CSP, Lodi (2011) analyzed the prospects of generating a heliothermic plant in Brazil and made simulations for Bom Jesus da Lapa, Bahia. Soria (2011), evaluated energy generation scenarios and the influence of storage and hybridization in the CSP plant, commented on incentive and regulatory laws around the world and made simulations with CSP plants in Campo Grande, Mato Grosso do Sul. Malagueta (2013), also cites laws applied by the world and presents more detailed studies evaluating the alternatives with a case study also in Bom Jesus da Lapa. Burgi (2013) evaluated the technical potential of generation in Brazil from CSP plants, simulates fourteen Brazilian cities, and concludes that in Brazil, CSP plants can play a significant role in the generation of electricity in Brazil. Everyone here used to do simulations the System Advisor Model (SAM) software developed by the National Renewable Energy Laboratory (NREL). Azevedo and Tiba (2013) evaluated the energy potential of the semi-arid region of northeastern Brazil and reached the same conclusion, in which only 10% of the area studied by them in the state of Piauí can generate up to a third of the national electricity generation. Castro (2015), analyzed the energy costs generated with thermal storage in the Sistema Interligado Nacional (SIN), the software used for the studies were SAM and PLEXOS® Integrated Energy Model.

The CSP technologies known are four, Parabolic Trough Collector (PTC), Central Receiver Systems (CRS), Linear Fresnel Reflector (LFR) and Dish Parabolic System (PDS), with PTC and CRS being developed on a large scale throughout the world. The CSP technology only works by incidence Direct Normal Irradiation (DNI), the solar rays do not suffer deviation in their path through the atmosphere to the reflecting mirror and one of its advantages is that CSP plants can have Thermal Energy Storage systems (TES), for be dispatched when there is no irradiation in the solar field.

According to the Solar and Wind Energy Resource Assessment (SWERA) database, the state of Rio Grande do Norte has high DNI values, as shown in Fig. 1. For this study, the cities Assú, Caicó and Mossoró were chosen to evaluate the implementation of CSP plants, since they have DNI more than 2,000 kWh/m²/year, localities with this DNI range can receive CSP plants, according to (Purohit and Purohit, 2017).

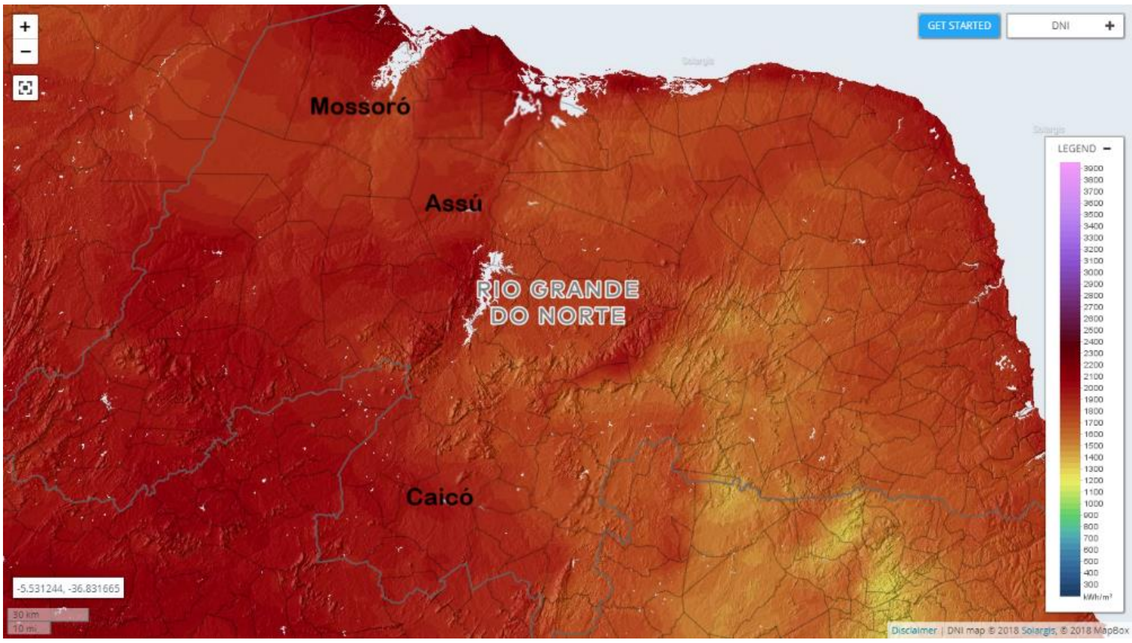

Figure 1. DNI map in the state of Rio Grande do Norte (SWERA, 2018).

The present study aims to find the minimum value of Levelized Cost of Electricity (LCOE) related to Solar Multiple (SM), these parameters allow to analyze the technical and economic viability for the implantation of CSP plants in the regions chosen. The LCOE is the price of electricity required by the CSP plant, or any power generation plant (Burgi, 2013), as seen in Eq. (1), where I_t is the investment in the year t, $O\&M_t$ is the cost with operation and maintenance in the year t, F_t is the cost with fuel in the year t, E_t is the generation of electricity in the year t, r is the discount rate and n is the life of the system. The LCOE presents the degree of competitiveness of a heliothermic plant in relation to other sources of electric power in relation to the same applied financial investment, but the LCOE does not differentiate the moment of the day in which the generation of electric energy occurs (Castro, 2015). The LCOE value is between 0,10 ¢/kWh e 0,29 ¢/kWh, the lowest value is in the U.S.A. and Spain in places with high rates of irradiation (Soria, 2011). Solar Multiple is a dimensionless parameter, represents the proportion of the area of the solar field constructed in relation to the area of the solar field required to operate the power block at full load under irradiation conditions of the project, thus the value of SM equal to one, represents the area of collectors needed to operate at 100% load (Malagueta, 2013), according to Lodi (2011), the importance of calculating SM is in the fact that the solar field represents the largest part of financial investment.

$$LCOE = \frac{\sum_{t=1}^{n} \frac{I_t + O\&M_t + F_t}{(1+r)^t}}{\sum_{t=1}^{n} \frac{E_t}{(1+r)^t}} \tag{1}$$

2. METHODOLOGY

The study on the potential of CSP solar fields was carried out in the SAM software version 2017.9.5, which allows simulating the defined parameters, both of a technical and financial nature, but the use of this software is limited when it comes to projects outside the USA (Soria, 2011). In fact, it was not possible to size all the factors related to the CSP technology, since it only exists in the design phase in Brazil. Some products are not yet manufactured in series in the country, which increases costs and there is no skilled labor for specific sectors of the CSP solar plant, which makes precision inaccurate, although some sectors have the potential to be nationalized (Retorta *et al*., 2018).

Three important cities in the state of Rio Grande do Norte, Assú, Caicó and Mossoró, they are the largest cities in their microregions, together with a population estimated in 2017, of more than 420,000 people, according to the Instituto Brasileiro de Geografia e Estatística (IBGE, 2018). After the metropolitan region of Natal, Mossoró, Assú and Caicó, respectively, are the cities that most consume electric energy in the state, in 2015 they consumed 39.1% of a total of 5,516 GWh. The industry is the sector that consumes the most electric energy in the region of Assú and Mossoró, approximately 52% and 45% respectively. The sector that consumes most electricity in the Caicó region is residential, with approximately 47%, where the region presented a variation of the electric energy consumption rate of 7.6% between 2010 and 2015, the third largest Average Annual Growth Rate (AAGR). The region that Mossoró is located, presented the highest AAGR of the Gross Domestic Product (GDP) and the consumption of electricity between the years of 2010 and 2015 (Furtado *et al*., 2017).

2.1 Technical and geographical criteria of local potential

The technical criteria for spatial restriction of potential sites to receive installations from a CSP plant that Soria (2011) and Burgi (2013) cited in their studies were applied, but the declivity of the sites was not considered, as well as the existence of indigenous lands, environmental conservation units and urban areas.

Transport logistics is relevant, as highways need to be adequate to carry fragile equipment, for example, mirrors (Azevedo and Tiba, 2013). From the state capital Natal to Assú are 214 km, to Mossoro it is 281 km, both traveling on BR-304, which according to the Departamento Nacional de Infraestrutura e Transporte (DNIT, 2018) is good for travel, with stretches in maintenance and Natal for Caicó is 273 km, traveling BR-226, considered to be good for travel, with a regular level of conservation and BR-427 which is also considered by DNIT, good for travel.

Regarding the water availability of the region, the three cities are located in the eastern northeastern Atlantic basin, which according to the Agência Nacional de Águas (ANA, 2018) is the hydrographic region with the lowest water availability in the country characterized by prolonged droughts, this is important because is necessary mainly for the wash of mirrors and cooling system, this system was analyzed.

The distance to the electricity substations of the Sistema Interligado Nacional (SIN) infrastructure is also a determining factor in the cost of the project because the further away of transmissions line is necessary one biggest installed power (Soria, 2011) and potential deployment. According to (ONS, 2018), the SIN is the integration of resources of generation and transmission to serve Brazilian energy market and in Assú and Mossoró it has substations and transmission lines of 230 kV, for Caicó the nearest substation with greater power is in the city of Currais Novos with a transmission line of 138 kV, as can be observed in Fig. 2.

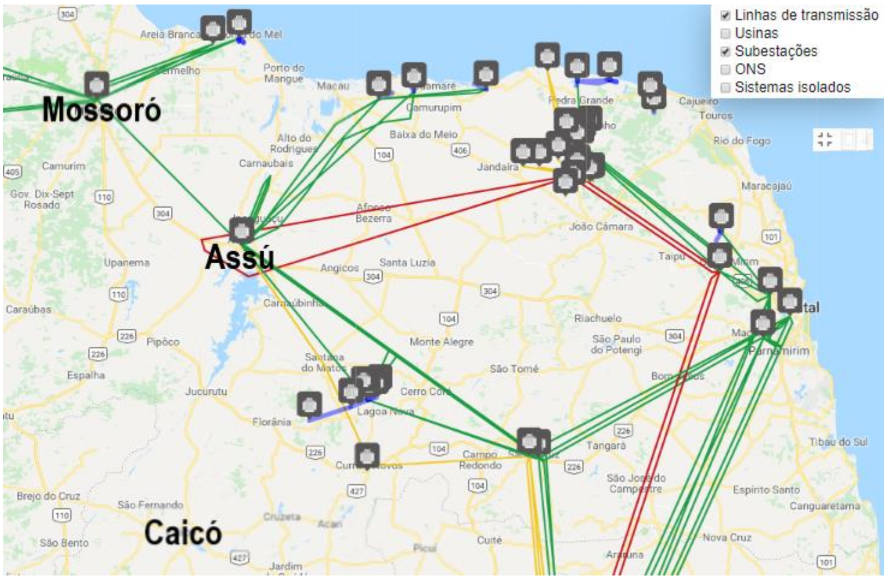

Figure 2. Map of SIN substations and transmission lines in Rio Grande do Norte (ONS, 2018)

2.2 Data for simulation

According to Azevedo and Tiba (2013), the ideal is that the chosen site has measurements of solar resources for a period of at least five years. The SAM in your library provides DNI data from some places in the world, but there is no data from any city in Rio Grande do Norte, so the software provides Geographic Information Systems (GIS) tools. In this work, we used the National Solar Radiation Database Viewer (NSRDB Viewer) to have information of the chosen cities, presented in Tab. 2. There has been downloads of information in CSV files and was attached to the software library, it was necessary refresh the datas of software to start the simulations. The data provided by GIS are organized hourly over a period of five years between January 1, 2010 and December 31, 2014.

Table 2. Data of DNI, Diffuse Horizontal Irradiance (DHI), average temperature, average wind speed and elevation from cities used in SAM (NSRDB Viewer/NREL, 2018).

City	DNI (kWh/m²/year)	DHI (kWh/m²/year)	Average Temperature (ºC)	Average Wind Speed (m/s)	Elevation (m)
Assú	2,354.25	653.35	28.0	4.0	42
Caicó	2,409.00	638.75	27.9	3.6	149
Mossoró	2,401.70	642.40	28.7	4.0	48

The simulations were carried out in the financial model SAM provides from Power Purchase Agreement (PPA), which are types of projects that sell energy involving one or two parties, thus simplifying the financial calculations of the simulations.

The SAM allows some forms of analysis of CSP plants and simulations were made for PTC and CRS technologies, because these are the more development in the world. The PTC technology used the two types of analysis provided by the software, the physical model characterize many of system components as of the principles of heat transfer and thermodynamics, and the empirical model uses a set of equations in curve fit based in regression analysis of measured datas as of equipament of SEGS (Solar Electric Generating Station) plants, so the results will be limited the modeling of systems measured empirically (SAM, 2017). The CRS technology the analysis was used where the Heat Transfer Fluid (HTF) is the molten salt, in the solar field and in the TES system when it exists, because this fluid is more used in CSP plants of type CRS in the world.

3. RESULTS

Four simulations were performed for each CSP plant, parabolic trough technology and central receiver, first with dry cooling system and without TES, second with dry cooling system with 8 hours of TES, third with cooling systems without TES and fourth, with 8 hours wet cooling systems of TES, thus comparing the LCOE variation for each simulation in relation to the SM, for each chosen city. In the simulations were considered 50 MW turbine output power, because a few simulations are based in plants of Spain and this is maximum value for that they have incentive program and 45 MW net output power, because correspond the one standard value of efficiency of turbine in the software and the boiler operating pressure in the power block was considered to be 100 bar.

3.1 Technology parabolic trough

For the simulations of PTC technology, in the physical model available in the SAM, data were used, shown in Table 3, which correspond to the Arenales and Olivenza 1 plants located in Spain. The HTF chosen for the solar field is the Therminol VP-1, because it is used in large scale in CSP plants in the world, the HTF of the TES system, Hitec Solar Salt, because the mixture this fluid is used in large scale too. The number of Solar Collector Set (SCA) per loop chosen was 6, also correspond also the Arenales and Olivenza 1 plants.

Table 3. Data used in PTC plants in the physical model (NREL, 2018).

CSP Plant	SCA Manufacturer (model)	HCE Manufacturer (model)	Solar-Field Inlet and Outlet Temp.	Length of Collector Assembly
Arenales	Siemens (SunField 6)	Siemens (UVAC 2010)	293°C and 393°C	96 m
Olivenza 1	Siemens (SunField 6)	Siemens (UVAC 2010)	293°C and 393°C	96 m

Figures 3, 4 and 5 show that the lowest LCOE found is when the plant has a wet cooling system with TES and SM equal to 6. In Fig. 3, for these conditions, Assú has LCOE of 22.2 ¢/kWh, the highest value of LCOE in relation to other cities for this type of plant. In Fig. 4 and 5, Caicó and Mossoró have LCOE of approximately 21.6 ¢/kWh. Despite the lower values found, the SM equals 6 is high. Then, for the same plant type and SM equal to 3, it was observed that the LCOE is below 30.0 ¢/kWh in Figs. 4 and 5, where have, respectively, that the LCOE value of Caicó for these conditions is 28.7 ¢/kWh and Mossoró has LCOE of 29.7 ¢/kWh. In Fig. 3, Assú has LCOE of 30.5 ¢/kWh for the mentioned conditions.

For the plants with dry cooling system with TES, the lowest value of the LCOE found was also for the SM equal to 6, Assú presented its lowest value in Fig. 3 for this type of plant and SM mentioned, when the LCOE was equal at 23.7 ¢/kWh. In Fig. 4 and 5, Caicó and Mossoró presented LCOE of 23.1 ¢/kWh, however as it was exposed the SM equal to 6 is considered high, then it was observed that when SM equals 3, to Assú in Fig. 3, the LCOE is equal to 32.9 ¢/kWh, in Fig. 4, Caicó has LCOE equal to 31.1 ¢/kWh and Mossoró in Fig. 5, has LCOE of 32.0 ¢/kWh, all still above 30,0 ¢/kWh, which is considered a high LCOE value, but there was a reduction of the SM, which means a reduction in the construction and operation costs of the CSP plant, thus there is a potential for its installation.

The plants with dry cooling system without TES presented their lowest LCOE values when SM equals 2. In Assú, in Fig. 3, LCOE is equal to 63.9 ¢/kWh, the highest value for this type of compared to other cities for the same SM. Fig. 4 shows the LCOE of 61.0 ¢/kWh for this type of CSP plant, Mossoró in Fig. 5, presented the lowest LCOE value, being 60.1 ¢/kWh.

Plants with a wet cooling system without TES had their lowest LCOE values for SM equal to 2. In Fig. 3, in Assú the LCOE found was 56.9 ¢/kWh, the highest for this CSP plant configuration, in relation to the other cities, Caicó and Mossoró, Fig. 4 and 5 presented LCOE of approximately 53.8 ¢/kWh, being the lowest value found for this type of plant. However, the LCOE prices found for CSP plants with dry cooling system without TES and with wet cooling systems without TES for this simulation model are not competitive for potential deployment.

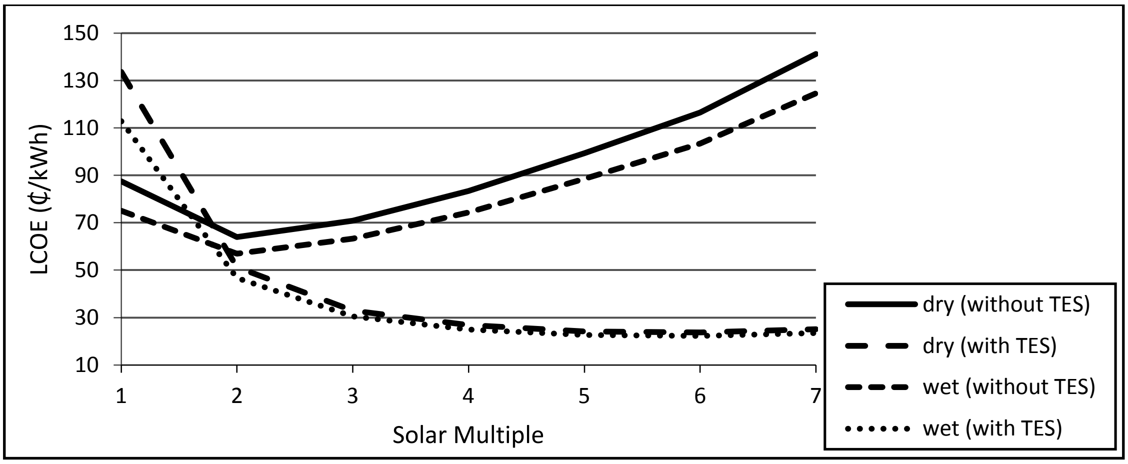

Figure 3. Relation of the Solar Multiple with LCOE to the city of Assú for PTC technology in the physical model.

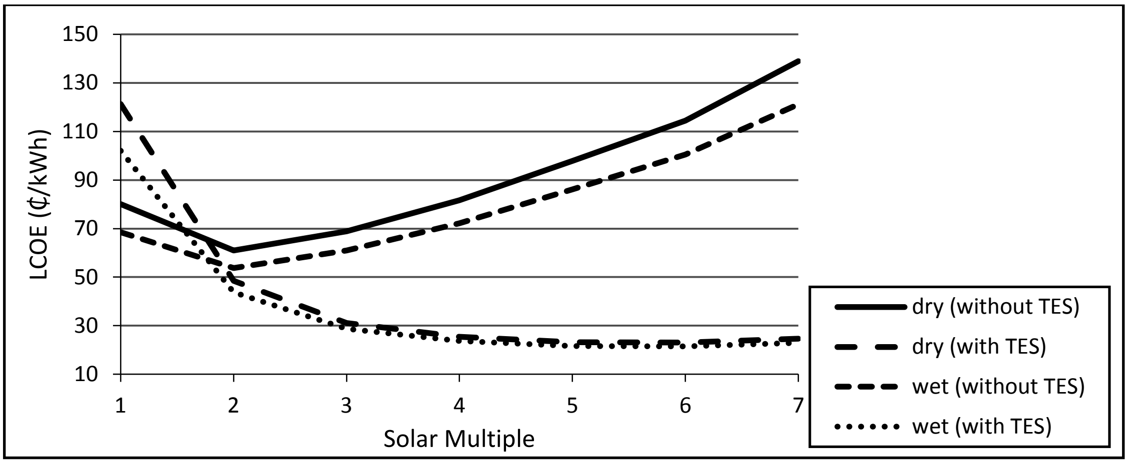

Figure 4. Relation of the Solar Multiple with LCOE to the city of Caicó for PTC technology in the physical model.

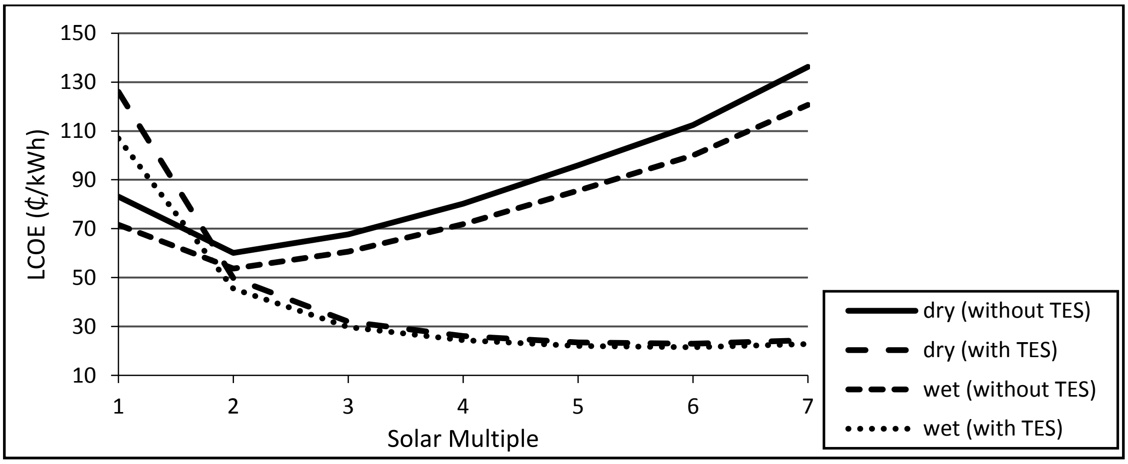

Figure 5. Relation of the Solar Multiple with LCOE to the city of Mossoró for PTC technology in the physical model.

In the simulations for PTC technology, from the empirical model of the SAM, data based on the SEGS VIII and SEGS IX plants, located in the USA, are presented in Table 4. The HTF chosen for the solar field was the Therminol VP-1, because the SEGS plants use a derivative of Therminol, but it do not found in software, so the VP-1 was used, HTF in the TES system was the Hitec Solar Salt and the Heat Collection Element (HCE) model was the Solel UVAC3 Vacuum, all available in the SAM library, the SEGS use other HCE of this manufacturer, but unavailable in software.

Table 4. Data used in PTC plants in the empirical model (NREL, 2018).

CSP Plant	SCA Manufacturer (model)	HCE Manufacturer	Solar-Field Outlet Temp.	SCA Lenght
SEGS VIII	Luz (LS-3)	Solel Solar Systems	390 °C	99 m
SEGS IX	Luz (LS-3)	Solel Solar Systems	390°C	99 m

The lowest LCOE value found for Figs. 6, 7 and 8 was for CSP plants with wet cooling system with TES and SM equal to 3. In Fig. 6, Assú presented LCOE 10.6 ¢/kWh in Fig 7, Caicó has LCOE of 11.0 ¢/kWh and Mossoró, in Fig. 8, had the lowest value found, LCOE equal to 10.4 ¢/kWh. The difference in LCOE between cities was small for SM equal to 3, it is considered all with the same potential for this type of plant and SM.

It was observed that for SM equal to 2, for the plants with wet cooling system without TES have their lower values. In Fig.6, Assú has an LCOE value of 11.7 ¢/kWh, Caicó in Fig.7, has LCOE equal to 12.2 ¢/kWh and Mossoró in Fig. 8 has the lowest LCOE value for these conditions, being equal to 11.5 ¢/kWh. These values are considered good, but the plant does not have the TES system, which is considered an advantage of the CSP technology.

For CSP plants with dry cooling system with TES they present their lowest LCOE value when SM is equal to 3. In Assú, in Fig. 6, the LCOE is equal to 11.7 ¢/kWh in Fig.7, for Caicó the LCOE is equal to 12.1 ¢/kWh and Mossoró in Fig.8, the LCOE is 11.4 ¢/kWh, the lowest in relation to other cities, these prices for plants with a dry cooling system make it possible potential for the region as it has low water resources.

The plants with dry cooling system without TES have the lowest values for SM equal to 2, whereas in Fig. 6, for Assú, LCOE is equal to 13.3 ¢/kWh, in Fig. 7, for Caicó LCOE is equal to 13.9 ¢/kWh and Mossoró, in Fig. 8, has an LCOE value of 12.9 ¢/kWh. Although it does not have a TES system, these values are good and important because the region has low water availability.

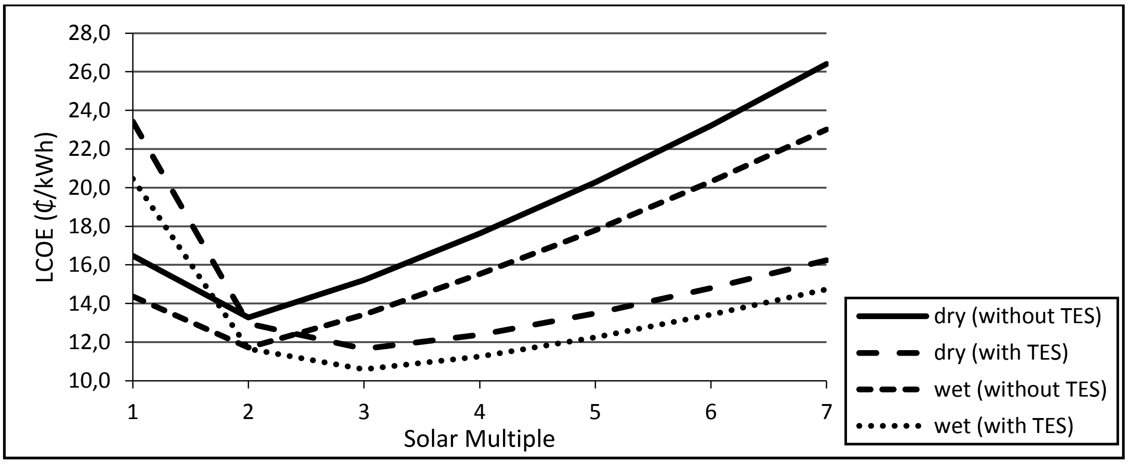

Figure 6. Relation of the Solar Multiple with LCOE to the city of Assú in the empirical model.

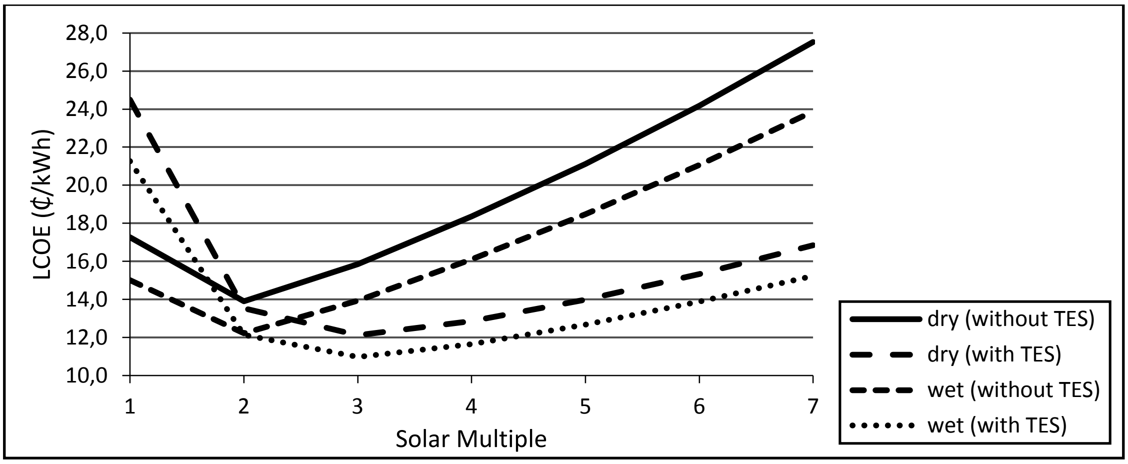

Figure 7. Relation of the Solar Multiple with LCOE to the city of Caicó in the empirical model.

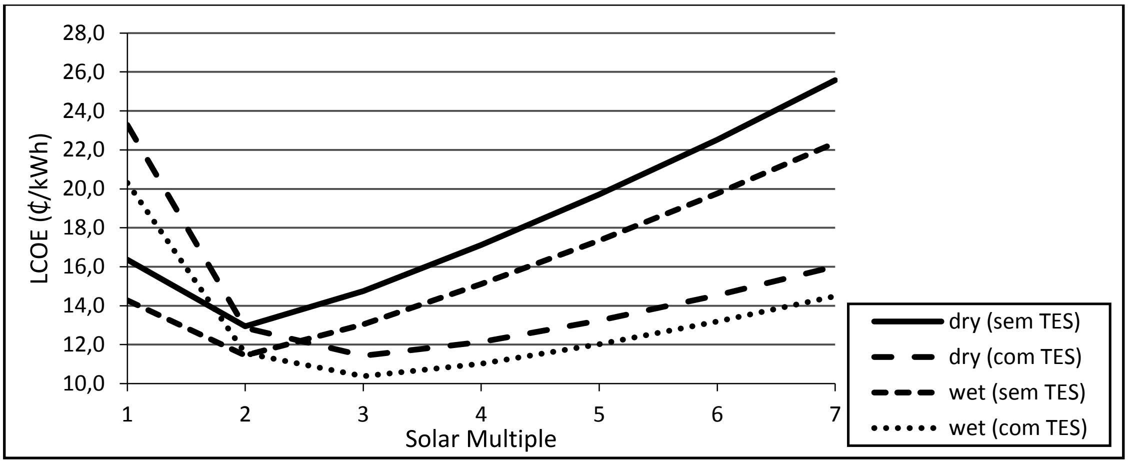

Figure 8. Relation of the Solar Multiple with LCOE to the city of Mossoró in the empirical model.

3.2 Technology central receiver

For simulations using central receiver technology, the HTF used is the molten salt, 60% sodium nitrate ($NaNO_3$), and 40% potassium nitrate (KNO_3), one of models available in software in software and it is used in Gemasolar plant, located in Spain that also establish the data presented in Table 5. The receiver height was defined as 14 meters, the receiver diameter was 11 meters, with 4,136 heliostats in the solar field, this is last datas was optimized in software for the datas below.

Table 5. Data used in CRS plants (NREL, 2018).

CSP Plant	Tower Height	Heliostat Aperture Area	Solar-Field Inlet and Outlet Temp.
Gemasolar	140 m	120.0 m²	290 °C e 565°C

For Figures 9, 10 and 11, it is observed that when SM equals 1.5, the value of LCOE is lower for plants wet cooling system with TES. For Fig. 9, in Assú for this type of plant and SM of 1.5, the LCOE has a value of 18.2 ¢/kWh, in Fig. 10 for these conditions, Caicó has a LCOE value of 17.0 ¢/kWh , the minimum value found for these results and in Fig. 11, Mossoró presented LCOE of 17.4 ¢/kWh. It can be considered by the small difference between the values, that all cities have good potential for implantation of CSP plant of this configuration.

For plants with dry cooling system with TES, the lowest values are when SM equals 1.5. In Fig. 9, Assú presented LCOE equal to 19.3 ¢/kWh, Caicó in Fig. 10, has LCOE for these conditions of 18.1 ¢/kWh, the lowest value between cities and Mossoró, in Fig. 11, has LCOE equal to 18.4 ¢/kWh. These values are more expensive in relation to plants wet cooling system with TES, about 1.1 ¢/kWh, thus considered to be competitive and with good implantation potential, since the region has low water availability and this type of plant consumes little water in its operation.

Plants with a wet cooling system without TES have lower values of LCOE also in SM equal to 1.5. In Fig. 9, for these conditions in Assú the LCOE is equal to 30.3 ¢/kWh, in Fig. 10, for Caicó, the LCOE equals 28.3 ¢/kWh and in Mossoró, in Fig. LCOE equals 28.5 ¢/kWh, thus practically Caicó and Mossoró with equal potentials, despite the high LCOE price.

The plants with dry cooling system without TES, when the SM equal to 1.5 also presents the lowest values. Fig. 9, Fig. 10, Caicó for the same conditions has LCOE equal to 30.7 ¢/kWh and LCOE equal to 32.6 ¢/kWh, as shown in Fig. Fig. 11 has a LCOE of 30.6 ¢/kWh.

For plants with dry cooling system without TES and with wet cooling system without TES in Fig. 9, 10 and 11, it is only possible to calculate the LCOE value, until SM equals 4. For SM greater than 4, it is change the input parameters.

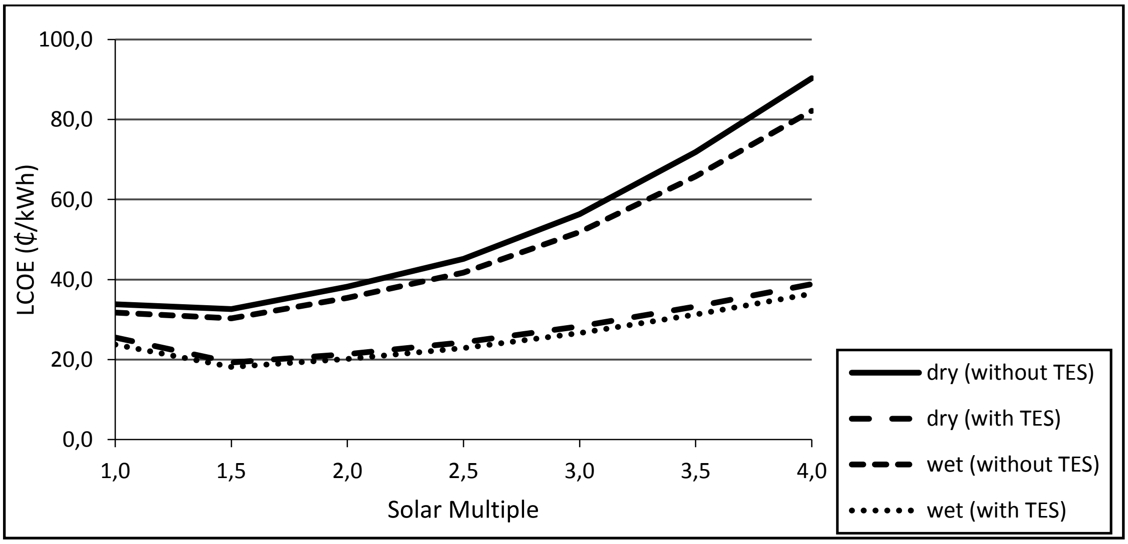

Figure 9. Relation of the Solar Multiple with LCOE to the city of Assú for central receiver.

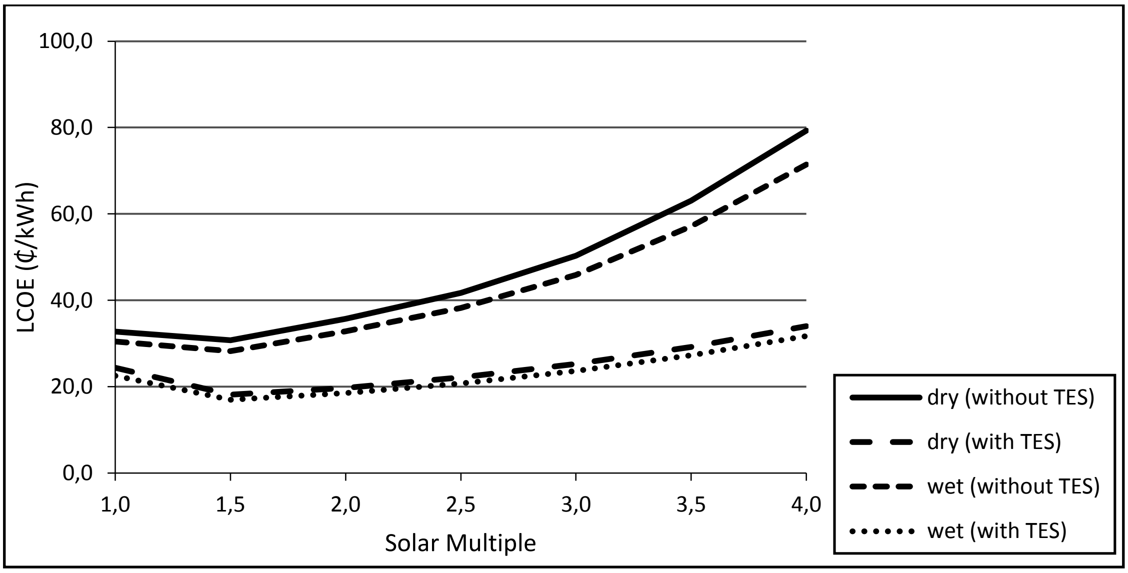

Figure 10. Relation of the Solar Multiple with LCOE to the city of Caicó for central receiver.

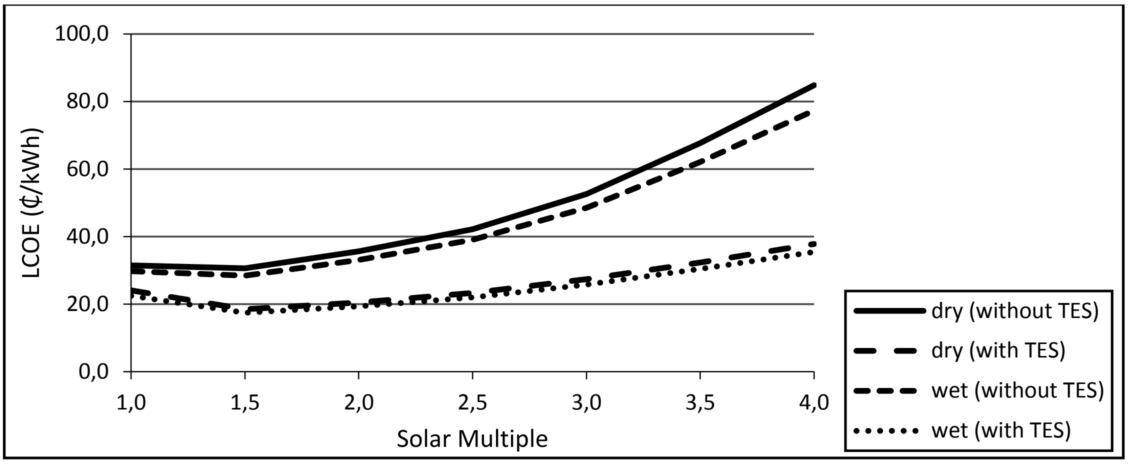

Figure 11. Relation of the Solar Multiple with LCOE to the city of Mossoró for central receiver.

4. CONCLUSIONS

From the results obtained it can be observed that for a possible CSP plant with PTC technology, the SM is between 2 and 3, and CRS technology, the SM is between 1.5 and 2, depending on factors of a project, such as generation of desired electric energy, provision of water resources, etc. Among the selected cities, Caicó and Mossoró have greater technical and economic potential, for PTC technology there is best LCOE for 75% of simulatios and Caicó for 25%, for SM equal 2 and 3, however Caicó has lower value for physical model and Mossoró for empirical model, for CRS technology, Caicó presents best LCOE in 75% of simulations and Mossoró just 25%, for SM equal a 1.5 and 2. But Assú should not be ruled out because it had higher LCOE values in most of the results. The Assú region currently has a photovoltaic solar plant and another is planned for the region, which makes it predict that the region will be the target of new photovoltaic solar power projects. According to Rodrigues (2017), when a CSP plant is hybridized with photovoltaic technology the value of LCOE decreases becoming more competitive.

The hydrographic basin of the region has the lowest availability in the country, systems with dry cooling should theoretically have preference in the installation despite the higher LCOE value in relation to the system with humid cooling. But for empirical PTC technology simulations, the LCOE value for the dry cooling plant with TES in Mossoró was 11.4 ¢/kWh, for Assú of 11.6 ¢/kWh and for Caicó de 12.1 ¢/kWh, all for SM equals 3, these values are on average 1.2 ¢/kWh more expensive than the LCOE value for the wet cooling plant with TES for the same cities and SM, thus considered good for the region. And for CRS simulations with SM equal to 1.5 and plants with dry cooling with TES, Caicó has a LCOE value of 18.1 ¢/kWh and Mossoró and Assú for the same plant configuration has respectively 18.4 ¢/kWh and 19.3 ¢/kWh, averaging 1.1 ¢/kWh above the LCOE value of the wet cooling plants with TES and SM equals 1.5.

The study also showed that heliothermic plants with TES, besides being an advantage over other renewable energy sources, always have lower values of LCOE compared to the systems without TES, giving preference to a probable implantation of these. According to Purohit and Purohit (2017), developing research on new technologies already underway can reduce the cost from the present LCOE of TES of 5 ¢/kWh to 1 ¢/kWh by 2020.

Assú and Mossoró have better installations for transmission lines and electrical substations in relation to Caicó. This situation will improve in the coming years with projects and investments in substations mainly in the region of Assú, so far there are no projects for the region in relation to Caicó. In spite of the government forecast of the highest AAGR of the industrial class in the region of Caicó until 2026, between the three analyzed regions and the second largest AAGR of the GDP, being surpassed only by the region of Mossoró (Furtado *et al*., 2017) that is currently the second largest city in the state.

The potential for generation of electric power from Rio Grande do Norte from CSP plants is high, together with strong generation from wind farms, where Rio Grande do Norte is the first in the ranking in installed capacity in the country (ONS, 2018), can generate more industrial development and income for the entire region, reducing dependence on hydroelectric power, strengthening the local SIN and being a solution for drought periods, especially dry cooling systems, without the need to use capacity thermoelectric plants. So in the near future, CSP plants are alternatives for the generation of electric energy in the region, reducing the amount paid to the consumer, for the operator, because the fuel is free and contributing to the sustainability of the environment by emitting less CO_2 in the atmosphere.

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6. RESPONSIBILITY NOTICE

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