DEVELOPMENT OF A TOOL FOR ASSESSMENT OF ENERGY FOR SUSTAINABLE CITIES – APPLICATION CAMBARÁ DO SUL AND CRISTAL

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1 Introduction

Until the industrial revolution, renewable sources of energy such as biomass, sunlight, hydropower and wind, were widely used and since then have been replaced by coal. In mid-twentieth century, oil has become widely used, coming to be the main energy source used by mankind. These changes prompted the development, however, because they are non-renewable energy sources, brought major environmental damage.

Moreover, because they concentrated their shells and be considered cheap and inexhaustible, it is not your concern finitude, motivated the development of current models of urban settlements, making cities and megacities, which grew so disorderly and chaotic (Bristot, 1990).

Quality of life and development are traditionally associated with increasing consumption of energy. The current vision of development requires that this occurs in a sustained ways in all its dimensions. Difficulties are encountered, so it is necessary to establish objective technical criteria, to assist in decision making to define the best ways to generate and use energy, that for different scales of communities. The relevance of this work is precisely in its bid to create subsidies that support decision making, guiding the planning and showing the potential of each source and setting indicators for the sustainable use of energy.

This work deals about the implementation and evaluation of a tool designed to "Energetic Sustainability Assessment of the Municipalities" and had as a case study of the municipalities Cambará do Sul and Cristal. The result of this study was the adjustement of a serie of indicators of energy sustainability, the which ones can be applied with public´s data base. Some improvement actions were proposed too, they are applied by hypothetical way and the result was a change in the current value of general indicator of sustainability.

2 Literature Review

Today the energy issue is a central theme in global discussions on climate change, due to the fact that the world is extremely dependent on fossil fuels, or non-renewable resources (Reis, 2011). Practices aimed at sustainability are increasingly urgent in order that there is a collapse in the future due to the depletion of energy sources.

The concept of sustainability according to the World Commission on Environment and Development is "development occurs supplying the needs of today without compromising the ability of future generations to meet their own needs", may still be added to it the idea of Agenda 21, which conceptualizes term as "development with long-term perspectives, integrating local and regional effects of global change in the process and using the best available scientific and traditional knowledge" (Afgan, Carvalho, Hovanov, 2000). As Sachs (1993a, 2004b) sustainability can be achieved by respecting the five dimensions.

The five dimensions of sustainability are specified as follows:

1. Social Sustainability: building a civilization with more equitable distribution of income in order to improve the rights and conditions of the broad masses of the population and reduce the gap in living standards classes.

2. Economic Sustainability: location and more efficient management of resources and a regular flow of public investment. Economic efficiency must be assessed by considering macro-social criteria more than just through corporate profitability criteria.

3. Ecological Sustainability: is achieved by limiting the use of fossil fuels and other exhaustible resources easily and environmentally harmful. For this you need to increase the use of renewable energy and reduce the volume of waste through the increased use of natural resources and recycling, and to strengthen the research and the definition of rules and guarantee instruments for environmental protection.

4. Spatial Sustainability: a proposed rural and urban settings more balanced and better territorial distribution of human settlements and economic activities.

5. Cultural sustainability: it is the use of integrated rural production systems, cultural changes and propose to introduce the concepts of economic development and to respect the specificities of each ecosystem, from every culture and every society.

According to WRI (1998), good indicators should meet the following characteristics:

• Representation: to represent the relevant product or process identified;

• Comparability: to be comparable in both space and time;

• Data collection: there must be reliable sources to supply the data;

• Clarity and synthesis: to transmit information in a simple synthesis being identified;

• Forecast and Targets: anticipate problems and seeking solutions being instrumental in setting targets.

In defining the indicators and their importance as the agents decision-makers usually have conflicting views and different value judgments, so it is necessary that these differences are integrated (Schmoldt, Peterson, Smith, 1995). To define the importance of each indicator compared to the others, multicriteria methods for decision support (MMAD) appear as an option for achieving this purpose (Vilas Boas, 2004).

The MMAD AHP (Analytic Hierarchy Process) is applied to systematize a wide range of decision problems in contexts: economic, political, social and environmental. This method is based on the ability of information and experience to estimate the relative magnitudes using pairwise comparisons. Its use is indicated for situations involving prioritization by assessing a set of criteria (Vilas Boas, 2004). The application of AHP can be divided into two phases: structuring and evaluation.

The structure, comes from the decomposition of the problem in a structure that presents the criteria that express the goals and sub-goals, and alternatives that involve the decision. The evaluation is characterized by defining the type of problem to be adopted, thereby determining whether the criteria are: a) analyzed relative or absolute, b) ordered or chosen, c) accepted or rejected (Vilas Boas, 2004).

3 Methodology

The steps of the study were: to determine the energy potential of each locality, as well as local energy demands and to evaluate the alternative energy sources by locality, checking the potential exchange of conventional sources by renewable sources. Considering changes in consumption patterns guided by the actions of rational energy use and perform the weighting of the results to be obtained through socio-economic indicators, energy and environment. With this, get to the general indicator of sustainability of the city studied. Simulate the implementation of actions aimed at improving this index, and, finally, the evaluation tool developed, which consists of a series of indicators as well as actions to be developed in order to improve energy sustainability of municipalities.

The purpose of defining the indicators was to relate the concept of sustainability to the characteristics that should guide the selection of good indicators and dimensions of sustainability as Sachs (1993).

The indicators used were defined and then the consultation MMDA AHP was conducted at 25 experts in areas whose activities were related to the subject of energy in order to determine the importance of each indicator, resulting in an individual weight. These experts evaluators working in universities, municipalities or in companies of generation, transmission, distribution and regulation of energy. They are: seven (7) electrical engineers, five (5) mechanical engineers, four (4) civil engineers, three (3) administrators, three (3) biologists, two (2) agronomists and one (1) chemical.

The proposed indicators, include parameters related to shares of the society with respect to the rational use of energy; to the type of energy source, about the yield and the environmental changes that generate the sources used; about the use of energy and the economic feasibility of changing the energy matrix.

As a means of assessing the efficiency of the indicators, two cities located in the state of Rio Grande do Sul, southern Brazil, were used as references, ie, case studies, which applied the indicators. The results were an energetic diagnosis and presentation of possible measures or improvement actions to be implemented in both cities. Always aiming at the sustainable use of energy.

The two communities were evaluated Cambará do Sul and Cristal, the first located in the northern state of Rio Grande do Sul, a region of hills, the second located in east-central. Municipalities are small in terms of economy, but with peculiar characteristics in terms of their structures, types of terrain and different economic vocations as well as potential for some type of energy source available, such as: biomass, wind, hydro, etc..

This choice becouse was the two cities have a different level of dependence on external power, namely, in Cambará do Sul there a energy production and no in Cristal. In both cities the production does not meet local needs, thus, the energy balance is negative. The data used are public data and the characterization of Cambará do Sul and Cristal takes towards energy assessment, analyzing the consumption of energy: electricity, liquid fuels such as ethanol, gasoline and the diesel oil, besides, the use of LPG. Also evaluate the potential energy in agriculture, with an overview of the main local crops (temporary or permanent) with the possibility of power generation, also the potential of wind, solar and hidric. Simulations are also made of the possibilities of generating energy locally, aimed at sustainable energy in the municipality.

4 Energy Sustainability Indicators and Actions for Improvement

In the definition of indicators for energy systems is important to take into account the society's shares related to the use of energy, energy sources available locally with an interesting potential of technically evaluating, their performance and the environmental changes that its use will cause. In addition to assessing whether such exploitation is economically viable. The indicators can assess the current situation and for reach a sustainable situation in future, improvement actions were determined.

Eleven indicators of energy sustainability have been created, divided into three areas. The first area is related to the Shares of the Society and the Energy Use, deals about the society relationship with the energy, which relates to programs to encourage the conscientious use of energy, the ratio of energy consumed locally, it is renewable or not and whether planning in relation to zoning and environmental projects for the municipality. The second area refers to the potential of local energy production, if there are municipalities in some source of energy that can be explored, such assessments have a technical nature, taking into account the issues of environmental and physical location. An economic evaluation of the local power generation is needed and the third area is about it, evaluating whether there is a need in terms of development and if this investment in power generation will not be difficult because of lack of technology and / or manpower.

The indicators were submitted to evaluation of experts connected to the energy field and this resulted in a weight to each indicator. This weight is a multiplier that is applied to the result obtained in the assessments. These results obtained for each indicator in the study of sustainable energy will always be: +1 (plus one), 0 (zero) or -1 (minus one). This is done to make the tool easy to use.

In the application of indicators, those indicators on the Society and the Use of Energy (I_A) are the society evaluators therefore they appear only once in the final scope. The indicators Sources of Energy and Economy

(I_B), evaluate local sources of energy on an individual basis, adding the results at the end, that is, if the location has 5 (five) usable energy sources, will be applied indicators for each of the sources and the results combined. The sum of the product by weight will result in the indicator value. Equations 1 and 2 show the calculation of the indices.

$$I_A = V_{INDICATOR} \cdot W_{INDICATOR} \qquad \text{(eq. 1)}$$

$$I_B = \left(\sum_{1}^{n} V_{IND\_SOURCE}\right) \cdot W_{INDICATOR} \qquad \text{(eq. 2)}$$

Where: I_A and I_B are the results of the indicators, V_{IND_SOURCE} and $V_{INDICATOR}$ are the indicator values (+1, 0 or -1) and $W_{INDICATOR}$ the weight of the indicator.

Table 1 shows the organization of the following indicators will be discussed individually.

Table 1: Energy Sustainability Indicators

Area	Indicators	Weight (%)
Society and Energy Use	1. Program to encourage the conscientious use of energy Local = +1 National / State = 0 No = -1	11,69
	2. Ratio of the renewable energy x non-renewable energy Renewable = +1 Equal = 0 Non-renewable = -1	7,36
	3. Zoning and environmental project Zoning and environmental project = +1 Zoning = 0 No = -1	3,19
Energy Sources	4. Potential of location Renewable = +1 Non-renewable = 0 No = -1	10,22
	5. Geophysical features Soil, land, material - enough spot = +1 Soil, land, material - enough in the region = 0 Soil, land, material - possible exhaustion = -1	16,91
	6. Waste Generation Positive balance = +1 Equal = 0 Negative balance = -1	5,62
	7. Environmental Impact Acceptable environmental and social benefits = +1 Aggressive, environmental and social benefits = 0 Aggressive, no environmental benefits = -1	5,62
Economics	8. Current demand Local generation meets every local demand = +1 Local generation partially meets local demand = 0 No local generation = -1	7,78
	9. Technology Local or regional = +1 National = 0 Imported = -1	8,82
	10. Marginal cost of expansion – CME Low - technology and manpower available = +1 Moderate - manpower available = 0 High - technology and manpower unavailable = -1	11,63
	11. Marginal cost of operation – CMO Low - technology and manpower available = +1 Moderate - manpower available = 0 High - technology and manpower unavailable = -1	11,16

4.1 – Indicators related to the Society and Energy Use

1. Program to encourage the conscientious use of energy - indicates whether the community encourages information and knowledge about the need for rational and efficient use of energy. If there are local

programs the indicator value is 1 (plus one), if in the city there are only state or national programs, the value is 0 (zero), or if no there is any kind of information or campaign the value is -1 (minus one).

2. Ratio of the renewable energy x non-renewable energy - the proximity of the desired patterns of energy consumption, ie, the use of energy from renewable sources. If the energy consumed locally has a higher percentage from renewable sources the indicator value is 1 (plus one), if the ratio is half or near 50%, the value is 0 (zero), or if higher percentage of energy from sources non-renewable, the value is -1 (minus one).

3. Zoning and Environmental Project - this indicator seeks to assess municipal organization in relation to urban, commercial, industrial and rural areas and this will reflect on the development of projects and actions aimed at sustainable use of energy in the localities. Existing of the municipal zoning and the environmental project the indicator value is 1 (plus one), if there is only the municipal zoning, the value is 0 (zero), or there is no projects, the value is -1 (minus one).

4.2 – Indicators related to the Energy Sources

How is it possible that there are more than one technically interesting potential in the localities, indicators 4, 5, 6, 7.8, 9, 10 and 11 should be repeated for each type of energy source. For example, if there are potential coal generation and soybean, the above indicators will be used twice. The following are the descriptions of the indicators 4, 5, 6 and 7.

4. Potential of Location - assesses whether there is local energy potential exploitable, or being exploited. This indicator takes into account not only the renewable sources, but any potential. If the local potential that renewable is the indicator value is 1 (plus one), if the potential is non renewable, value is 0 (zero) if there is or is not being exploited, the value is -1 (minus one). It is considered minus one, because the local energy balance will remain negative, ie, there is no sustainability.

5. Geophysical Characteristics - The indicator assesses whether the municipality is able to have power generation with the local potential, whether through soil suitable for planting, area available for the generating plant - space and the environmental permit, and the material needed to generation if it not deplete with use. If the characteristics are sufficiently available in the local, the indicator value is 1 (plus one), if there is a need to seek support from the neighboring municipalities the indicator value is 0 (zero) and if there is the possibility of exhaustion, the value is -1 (minus one).

6. Generation of waste (solid, NOx, SOx, CO2, toxic and radioactive waste, etc..) - Indicates the impact of power generation in the greenhouse effect, acid rain, emissions of particulate matter in the atmosphere, etc.. If there is the generation of waste without proper treatment (filtration or recycling) the balance is negative, the value is -1 (minus one), where there is no adequate treatment or potential with no power generation, the value is 0 (zero) and if, exist generation and proper residue treatment, the value is +1 (plus one).

7. Environmental Impact - If the carbon balance is positive, the capture of carbon in the process of power generation is greater than the emission in the use of this energy or if the installation does not invade areas used for crops or communities already installed, the impact environment is acceptable. Thus the indicator value is 1 (plus one). If there is a reasonable impact, damage to the community, but there is a higher return for the environment, the indicator has value 0 (zero). If the impact of local generation will bring social problems and did not a good return to the environmental, -1 (minus one) is the indicator value.

4.3 – Indicators related to Economics

8. Current demand - the indicator assesses whether the investment in local energy sources establishes a positive balance in energy terms, ie, enables the energy sustainability of the municipality. If the local generation to meet all current demand, the indicator value is +1 (plus one). If the local generation partially meet the demand, the value is 0 (zero). If theres no local generation, the indicator value is -1 (minus one).

9. Technology - that indicator show the facility found to acquire the equipment necessary for deployment of the new generation. If the equipment can be found in own location or in the State, the indicator value is +1 (plus one). Being a national manufacturing equipment, the value is 0 (zero). The indicator has value -1 (minus one) when the necessary equipment has to be imported.

10. Marginal Cost Expansion - CME - indicates the economic viability of investment in electricity generation. The CME is the cost per MWh of reference stipulated by ANEEL (2011) for investment in power generation. If the cost of the project is less than the CME the indicator value is 1 (plus one), if the cost is higher than the CME, the value is 0 (zero). If there is no possibility of local generation the indicator value is -1 (minus one).

11. Marginal Cost of Operation - CMO - indicates the economic viability of investment and the maintenance and operation. The CMO is the cost per MWh of reference stipulated by ANEEL (2011) for maintenance and operation of projects in power generation. If the cost of maintenance and operation of the enterprise is less than the CMO the indicator value is 1 (plus one), if the cost is higher than the CMO, the value is 0 (zero). If there is no possibility of local generation the indicator value is -1 (minus one).

4.4 - Improvement actions for the sustainable use of energy

1. Investing in local education campaigns aimed at the rational use of energy. For example, the use of public transport, maintenance of electrical equipment, automotive, etc..

2. Awareness campaigns on the use of equipment with better energy efficiency. For example, appliances with consumption pattern A (efficient) Procel, cars with better performance, high efficiency electric motors, etc..

3. Tax incentive for products with improved energy efficiency. Products with the certificate of energy efficiency or waste reduction that should have differential taxes to encourage use by consumers and the development by manufacturers.

4. Establishment of one or more local committees for the development and evaluation of projects and programs aimed at sustainability. As a multidisciplinary structure that represents all segments of local interest such as industry, commerce, government and society, that (s) committee (s) (s) must be free to propose and veto municipal or regional projects.

5. Investing in the use of local generation based on renewable sources. The use of renewable sources should take into consideration the environmental impact, followed by the social and economic order. That is, one must observe the local and regional environmental impact first. If the impact is considerable use should be discarded.

6. Programme to support the replacement of non-renewable energy inputs for renewables. For example, replacement of oil boilers with biomass or biodiesel, heating water by solar panels, etc..

7. Develop programs to encourage the use of waste which has potential energy generating facility within the same, be it residential, commercial or industrial. For example, use rice husks as a source of heat, using organic waste as fertilizer, etc..

5 CHARACTERIZATION OF MUNICIPALITIES

Through the characterization of Cambará do Sul and Cristal, it became evident that the potential energy is quite pronounced (eg through biomass and hydro) and this causes them to have the expectation that with the use of local sources the energy balance will be positive.

The city of Cambará do Sul is located north of the state has an area of just over 1200 km ^{2} and a population of 6550 inhabitants. Its economy is based on farming and tourism. There is still a great pulp industry in the city. The town of Cristal is located in the central-eastern region of the State, has an area of 681.2 km ^{2} and a population of 7280 inhabitants. Its economy is based on farming.

Table 2 presents the energy consumption of Cambará do Sul and Cristal in 2008.

It is important to note the portion of the energy consumed in the two locations from non-renewable resources and renewable. In Cambará do Sul there is a distortion in the consumption of energy, because there is a company that owns power generation based on renewable energy, which accounts for 53.5% of all energy consumed in the municipality. Table 3 shows this relationship x Non-Renewable Renewable Energy.

Table 2: Energy Consumption of Cambará do Sul and Cristal in toe in 2008.

	Cambará do Sul	Cristal
Electricity Consumption *		
Commercial / Services	185,07	186,87
Industrial**	7030,41	32,16
Residential	253,52	159,27
Rural	41,19	421,65
Liquid Fuels		
Ethanol	46,44	61,02
Diesel Oil***	2306,45	3080,78
Gasoline****	862,01	739,20
Gas		
LPG	668,65	665,93
Biomass		
Firewood	642,02	29,76
Total	**12035,79**	**5376,66**

* The electricity used in Rio Grande do Sul is 86.4% from renewable sources (Capelette, 2010).
** In Cambará do Sul there a company that produces its own electricity from a PCH and a TPP biomass. Generation in 2008 was 6439.68 toe;
*** In 2008 all diesel used in the country was 2% biodiesel B100 (Capelette, 2010);
**** In 2008, the gasoline used in the country had 25% ethanol (Capelette, 2010).

Table 3: R relationship Renewable x Non-Renewable Energy

	Renewable	Non-Renewable
Cambará do Sul	69,1%	30,9%
Cristal	19,1%	80,9%

Excluding energy production of the pulp company that exists in Cambará do Sul the relationship would Renewable 33.5% and Non Renewable 66.5%. In Cristal there a high consumption of diesel due to agriculture and the road which crosses the city. That road connects the state capital until the port of Rio Grande.

To despite the existing use in Cambará do Sul, the energy potential is evident in the two cities suggests that it may have a considerable increase of energy from renewable sources. Table 4 shows that the potential energy of the city of Cambará do Sul and Cristal are superior to local consumption presented in Table 3.

Table 4: Energy Potential of Cambará do Sul and Cristal in toe

Energy Potential	Cambará do Sul	Cristal
Electricity Consumption		
Hídric*	3477,42	6671,49
Thermal – Biomass**	24825,05	2573,29
Wind***	44,49	32,21
Liquid Fuels		
Biodiesel (soy)		0,21
Thermal Energy		
Biomass**	24825,05	2573,29
Solar****	0,18	0,01
	28347,14	**9277,21**

* The river Camisa is valued at Cambará do Sul and river Camaquã in Cristal;
** In Cambará do Sul the availability of wood and Cristal is wood and rice husk. Biomass is counted only once for electricity or heat;
*** The average wind speed at 50m height is 6.0 ms^{-1} in Cambará do Sul and 5.4 ms^{-1} in Cristal. Wind turbines of 330kW;
**** Assuming the use of 1% of the municipal area. Global radiation 14 MJ / m^2. Day and Daily Insolation: 5.4 hours.

Sources: Ana (2007); Ceee (2009); Fee (2011); Tiba (2000); Camargo et al (2002); Ibge (2011).

6 APPLICATION AND EVALUATION OF SUSTAINABILITY INDICATORS FOR CAMBARÁ DO SUL AND CRISTAL

Although the socio-economic scale of the two cities are similar, and also in both cases the economy based on agriculture and livestock, the fact Cambará do Sul has a local base generation from renewable sources means that the municipality has index sustainable energy - Isc above the Cristal. Table 5 presents the results of the indicators applied to municipalities.

Table 5: Sustainability index of the current energy Cambará do Sul and Cristal for the year 2008.

Area	Indicators	Weight (%)	Cambará do Sul	Cristal
Society and Energy Use	1. Program to encourage the conscientious use of energy	11,69	-1	-1
	2. Ratio of the renewable energy x non-renewable energy	7,36	+1	-1
	3. Zoning and environmental project	3,19	0	0
Energy Sources	4. Potential of location	10,22	+2	-2
	5. Geophysical features	16,91	+4	+4
	6. Waste Generation	5,62	+2	0
	7. Environmental Impact	5,62	+3	+5
Economics	8. Current demand	7,78	+1	+1
	9. Technology	8,82	+3	+5
	10. Marginal cost of expansion - CME	11,63	+3	+2
	11. Marginal cost of operation - CMO	11,16	+3	+1
	General Sustainability Index (Isc)	100,00	**5,64**	**3,75**

The list of indicators related to shares of society demonstrates that the concern with the rational use of energy is not yet reality in both locations, at least with regard to attitudes from their administrations. As for indicators related to the type of source, the rate of Cambará do Sul is better due to the fact that a large portion of its consumption be produced locally and using renewable sources (biomass and hydro). This is directly reflected in Isc with a difference of more than 50% between the two cities.

Solid waste produced in these energy generations today available are not bringing great harm to the environment, due to the fact that in all the systems involved there are filters for this type of pollutant. But about the CO2 production, Cristal has a zero rate due to the fact that almost half the energy consumed in the county of origin is not renewable (diesel oil) and, unlike Cambará do Sul, there is no use of renewable source to energy production enough to make this positive indicator.

Operating some changes in the energy profiles of the two cities, as well as proposing actions aimed at efficiency in energy consumption, one can obtain a significant increase in the rates of energy sustainability of Cambará do Sul and Cristal.

Using the table 6 may be observed changes in these indicators due to the actions proposed, discussed next.

Regarding the attitudes of society, the hypothetical situation is that the community and Government to engage in actions and incentives aimed at the energy and environmental sustainability. Encouraging the use of renewable energy and organizing the location to provide for increases in energy demand and enabling sustainable projects.

Table 6 - Simulated indexes of energy sustainability to Cambará do Sul and Cristal for the year 2008, applying actions to improve

Area	Indicators	Weight (%)	Cambará do Sul	Cristal
Society and Energy Use	1. Program to encourage the conscientious use of energy	11,69	+1	+1
	2. Ratio of the renewable energy x non-renewable energy	7,36	+1	+1
	3. Zoning and environmental project	3,19	+1	+1
Energy Sources	4. Potential of location	10,22	+4	+6
	5. Geophysical features	16,91	+4	+5
	6. Waste Generation	5,62	+4	+6
	7. Environmental Impact	5,62	+3	+4
Economics	8. Current demand	7,78	+1	+1
	9. Technology	8,82	+3	+5
	10. Marginal cost of expansion - CME	11,63	+3	+2
	11. Marginal cost of operation - CMO	11,16	+4	+3
	General Sustainability Index (Isc)	100,00	**7,47**	**8,76**

Taking the indicators related to energy sources, using local generation in the case of electricity and thermal needs, whether industrial, trade or residential, for the city of Cambará do Sul identified as potential interesting use of hydro potential River Camisa, the wood produced in the region. These potentials of energy already has a partial use, but in addition of this exist good potential to the utilization of solar energy for water heating and use the wind to generate electricity. In Cristal was work based on hydro generation, solar heating, the use of wind, biomass use for heating or generating electricity (wood and rice husk) and obtaining biodiesel (soy).

Regarding the economy, it is normal that the cost of power generated has a higher value after the changes, this is due to the small size generating plants, which increases the cost of installation, operation and maintenance. However, the fact that the wood in the two cities analyzed have a significant impact when it is treated as energy, the values of the indicators have not been great variation. In Cambará do Sul the potential of wood corresponds to more than double the energy currently used in the locality, the impact of Cristal is smaller, but significant, adding to the wood with the rice husk produced in the city comes to a potential slightly less than 50% of the current energy consumption. All technology used for power generation with biomass is found locally and the costs of CME and CMO are low.

The difference in rates of overall sustainability of the current situation for the simulate with improvement actions is a function of change in attitudes to energy use and implementation of local generation, making positive the energy balance of the two localities, ie produce more energy than consume. In the real data Cambará do Sul has an index of 5.64 and with the implementation of improvement actions, hypothetically would reach 7.47, an increase of 32%. Already in the city of Cristal, the change the overall index would be much more significant, of 3.75 to 8.76, a percentage improvement of 233%. This is because of Cambará do Sul already has a energy use local, and Cristal dont have, but they have a greater amount of potentially usable energy.

6.1 Results

The results were the development of indicators of energy sustainability and the improvement actions to use in the pursuit of sustainability and consolidation. This is because the changes made in the current version against the previous one, since this tool was initially developed and first applied at five sites that had some kind of potential is very marked. Table 7 shows the sustainability indicators developed and Table 8 provides the proposed improvement actions.

Table 7: Energy Sustainability Indicators

Area	Indicators
Society and Energy Use	1. Program to encourage the conscientious use of energy
	2. Ratio of the renewable energy x non-renewable energy
	3. Zoning and environmental project
Energy Sources	4. Potential of location
	5. Geophysical features
	6. Waste Generation
	7. Environmental Impact
Economics	8. Current demand
	9. Technology
	10. Marginal cost of expansion - CME
	11. Marginal cost of operation - CMO

Table 8: Improvement Actions for Sustainability Municipal Energy

	Improvement Actions
1	Investing in local education campaigns aimed at the rational use of energy. For example, the use of electrical equipment when necessary, the use of public transport, maintenance of electrical equipment (eg, change the rubber on the refrigerator), automotive (eg engine tuning), etc..
2	Awareness campaigns on the use of equipment with better energy efficiency. For example: efficiency label with appliances, cars and high performance electric motors, etc..
3	Tax incentive for products with improved energy efficiency. Products with the seal of Procel, with greater energy efficiency or waste reduction that similar business models must have a different tax rate to encourage use by consumers and the development by manufacturers.
4	Establishment of one or more local committees for the development and evaluation of projects and programs aimed at sustainability. Be in the social, industrial, commercial or public. As a multidisciplinary structure that represents all segments of local interest such as industry, commerce, government and society, that (s) committee (s) (s) must be free to propose and veto municipal or regional projects.
5	Investing in the use of local generation based on renewable sources. The use must take into consideration, especially, environmental impact, followed by the social and economic order. That is, being the replacement of one type of non-renewable source or location away from the generation, one must observe the local and regional environmental impact first. If the impact is significant its use should be discarded.
6	Programme to support the replacement of non-renewable energy inputs from renewable sources. For example, the replacement of oil boilers with biomass or biodiesel, heating water by solar panels, etc..
7	Develop programs to encourage the use of waste which has potential energy generating facility within the same, be it residential, commercial or industrial. For example, use rice husks as a source of heat in the process or within the plant, using organic waste as fertilizer, etc..

With the implementation of improvements compared to local consumption of energy from renewable sources over from non-renewable sources would be as shown in Table 9. Not considering the existing power generation in Cambará do Sul, both municipalities had an increase in the share of energy from renewable sources in their consumption of more than 14%.

Table 9: Relationship Renewable x Non-Renewable Energy, with actions for improvement

	Renewable	Non-Renewable
Cambará do Sul	75,8%	24,2%
Cristal	29,2%	66,5%

7 CONCLUSION

The results were satisfactory with regard to the development and adjustment of the tool, ie, indicators of energy sustainability. These indicators assess the current situation in relation to local sources and profitable economic issue, checking for feasibility of investing in local sources for power generation. Also give a clear and simple advantage of improvements made for sustainability, assisting in decision making on the subject.

In applying the tool in cities, there is a need to make an assessment on the socio-economic data, energy consumption data in the area and researching the sources and potential for energy generation within the city itself. Much of this data are public, which facilitates the application of the tool, but it is important update the data in their own locality.

The local power generation, with use of sources available there, makes the energy balance becomes positive in most cases. Besides, if given preference for use of renewable sources, percentage of energy "used / generated" in the locality is now environmentally friendly and sustainable. Of course, not all renewable energy generated will be used in their own locality, but the energy balance of the relationship "generation / consumption" could become positive, and the relationship between the consumption of renewable versus nonrenewable energy will tend to the side of renewables.

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