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ENERGY SUSTAINABILITY: presentation and discussion of the indicators

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ABSTRACT

Energy is considered one of the main resources for the development of sites, as well as for economic sectors and activities, however, their generation and use forms of may have negative consequences for development, particularly for social and environmental issues. In this context, there is a need to explore energy issues from the perspective of sustainability and implementation of indicators. Similarly, the objective of this article is to identify in the academic and institutional sources of energy sustainability indicators that can be used to measure the energy sustainability of most generating energy sources. In methodological terms, it is a literature search, which eight of these are used ANEEL (1999), AFGHAN (1999); ISED (2001); BERMANN (2002), HELIO INTERNATIONAL (2005), Oliveira et al. (2006), Souza (2010) and BORGES (2012). The results show a total of 135 indicators which, after analysis within specific criteria, completed a total of 61 indicators divided into the following dimensions: social, environmental, economic, technological, political, territorial and cultural.

PALAVRAS-CHAVE: Sustainable, Checklist, Development.

SUSTENTABILIDADE ENERGÉTICA: apresentação e discussão de indicadores

RESUMO

A energia é considerada um dos principais recursos para o desenvolvimento, bem como para os setores e atividades económicas, no entanto as suas formas de geração e uso pode ter consequências negativas, particularmente para questões sociais e ambientais. Neste contexto, existe uma necessidade de explorar questões de energia a partir da perspectiva da sustentabilidade e implementação de indicadores. Da mesma forma, o objetivo deste artigo é identificar nas fontes acadêmicas e institucionais de indicadores de sustentabilidade de energia que podem ser usados para medir a sustentabilidade energética da maior parte das fontes de energia geradora. Em termos metodológicos, é uma pesquisa bibliográfica, que foram identificados, analisados e selecionados os principais estudos e pesquisas realizadas na área acadêmica e instituições envolvidas com o assunto. Os resultados mostram um total de 135 indicadores que, após a análise dentro de critérios específicos, completou um total de 61 indicadores divididos nas seguintes dimensões: sociais, ambientais, econômicos, tecnológicos, políticos, territoriais e culturais.

KEYWORDS: Sustentabilidade, Checklist , Desenvolvimento.

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1 INTRODUCTION

Energy resources are in a recurring theme when considering the multiple possibilities and ways to achieve sustainable development. In this context it is that come the energy sustainability indicators as capable of providing a better understanding of the phenomenon tools. However, these indicators are found in the literature broadly diversified, which brings the need to present such indicators more compact and specific shape.

The basic energy access has been shown not only essential for meeting basic human needs, but also reveals the global dependence on fossil fuels for power generation. The economic expansion process is linked to an increase in electricity supply generated by the investments in the energy sector and therefore to an increase in consumption. By analyzing the history of the relationship between energy and development, it was shown that centralized policies guided exclusively in the energy supply are inadequate to the basic demands, cause damage to the environment and provide the autonomous growth of some sectors over others, causing social disparities within the same region (REIS et al.2005).

Quality of life and development are traditionally associated with the growth of energy consumption. In this context, the current vision of development requires that this occurs in a sustainable manner in all its dimensions. Therefore it is necessary to establish objective technical criteria to assist in decision-making to define better ways to generate and use energy for different scales of communities. Among these forms arise sustainability indicators, which are intended to provide a flexible tool for analysts and decision makers so that they can better understand their situation and trends, as well as the impact of recent policies and the potential impacts of policy changes.

The discussion on relations between energy and development is being promoted by several national and international organizations. In this perspective, it appears that the formulation of public policies for the energy sector as one of the driving bases of socio-economic development depends on building indicators. From these considerations, the article aims to identify academic and institutional sources of energy sustainability indicators that can be used to measure the energy sustainability of most energy-generating sources.

In methodological terms, a literature search was conducted, which were first identified in theoretical and conceptual basis, studies and research related to work carried out on energy sustainability indicators; such works were divided between set of indicators for economic activity and for corporations, being used in this work the sets for energy economic activity, discarding items that used corporative indicators. After the selection of articles, for reasons of importance and availability, the indicators for each dimension were selected; for it there was an analysis on the indicators that were repeated, as well as the indicators that had different nomenclature, but with the similar measurement objective.

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In addition to this introductory content, the article consists of theoretical foundation based on the energy relationship with sustainable development, as well as important issues for the subject, as indicators of sustainability and energy sustainability. The following section presents the methodological procedures, and then the results of the work are presented and, after, the final considerations.

2 THEORETICAL FOUNDATION

2.1 Energy and Sustainable Development

The supply of adequate and affordable energy has proven critical to economic development and for the transition from subsistence agricultural economies for industrial societies oriented to modern services. This is the central point for the improvement of social and economic welfare, and indispensable for the generation of industrial and commercial wealth. The energy has proven to be the key to alleviating poverty, improving human welfare and raising living standards, however it is only a means to an end (IAEA,2007).

The process of economic expansion of a country binds to an increase of electricity supply generated by the investments in energy and therefore an increase in consumption (BORGES,2012). However, although power consumption grow more and results in a number of benefits, the access to the amount and form of energy consumed varies dramatically from developed to developing countries, and also the richest portion for poor of population of a country or region. Countries with the highest Human Development Index - HDI's, are characterized by a higher consumption of energy per capita, as the regions most affected by the lack of electricity are those with lower IDH's (PNUD, 2004).

The civilization of fossil fuel, which began in the nineteenth century had its apogee in the late twentieth century and tends to decline in a few decades. The security of energy supply is strategic for development. Recent aspects related to dependence on foreign energy supply serve as a warning, such as those related to oil and natural gas. This is a concern of countries that have strong dependence on fuel imports, mainly fossil (SOUZA, 2010). The reduction in fossil fuel inventories will require companies to change their energy matrix towards renewable energy and at low environmental impact. To be sustainable and ensure the necessary food to human population, development must be based on food consumption patterns and energy that do not exhaust sources of human sustenance. In other words, sustainable development must be based on a sustainable energy matrix, relying on a base of renewable resources. However, when choosing energy fuels and associated technologies for production, delivery and use of energy services, it is essential to take into account the economic, social and environmental consequences (RIBEIRO, 2003).

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The importance of energy for sustainable development is related to three elements: the efficient supply of energy is considered one of the basic conditions for economic development; several ecological disasters and recent human is closely related to the power supply, offering arguments in favor of sustainable development; the need for equity in the energy sector, which can be translated into universal access to energy (REIS et al. 2005). The following aspects might be identified in an energy policy based on sustainable development: supply guarantee through diversification of sources, new technologies and energy production of decentralization; use, adaptation and rational development; minimum cost of energy; added value from the use generated by optimization of resources (UDAETA, 1997).

Energy remains a fundamental dilemma to achieve sustainable development goals, because their use is necessary prerequisite for economic and social development, while production and use are associated with adverse impacts on public health and environment. In this sense, it is important for policy decisions understand the implications and impacts of different energy programs, alternative policies, strategies and development plans in training within their country, and the feasibility of making sustainable development over time (IAIE,2005). Thus, sustainability indicators arise as a mechanism to assess the level of sustainability of territorial areas and economic sectors and activities.

2.2 Sustainability Indicators

Since the publication of the Brundtland Report in 1987, several national and international organizations have developed sets of indicators to measure and evaluate one or more aspects of sustainable development. These efforts received a major boost following the adoption of Agenda 21 at the Earth Summit in 1992, in Chapter 40, specifically asks countries and international governmental and non-governmental organizations to develop the concept of sustainable development indicators and harmonize them at national, regional and global levels (IAEA, 2005). In the context of sustainable development, the use of indicators may have different purposes depending on the objectives that are proposed. The following purposes stands out: allocation of resources; local classification; compliance with legal standards; trend analysis (CAMPOS, 2005).

The need to use indicators is on the possibility of achieving information about a particular reality and has as main feature the potential to concatenate a complex set of information, retaining only the essential meaning of the studied aspects, and these sustainability indicators show the variations values or certain variable states that, presenting different time, signalize fundamental or priority areas in the development process, particularly in relation to variables that affect sustainability (CAMARGO et al.2004). Indicators extend beyond description of current trends or conditions. They create an understanding and insight into how the human and / or environmental systems work; they suggest the nature of the intensity of connections between different components of the studied systems and provide a better understanding of how the actions affect different

dimensions of sustainability: economy, environment and social issues (RAMETSTEINER et al.2011).

Indicators have as main objective to aggregate and quantify information in a way that its significance becomes more apparent, synthesizing complex information about a phenomenon, improving them. Given the importance of measuring the sustainability arise energy indicators for sustainable development as a strategic issue, being an important planning tool to achieve sustainable development. Bringing this to the energy issue, the use of indicators is one of the methodologies applied in the analysis of sustainability of the energy sector. It is believed that, through these, it can be better to understand relationships, movements and results of actions.

The main criterion for the process of creation of sustainability indicators was their ability to address issues related to energy. In addition, indicators help evaluate the effectiveness of energy policies for action on sustainable development. It is designed as an aid to guide the implementation of various actions, and in particular: integrate energy into socioeconomic programs; combine more renewable energy, energy efficiency and advanced energy technologies to meet the growing need for energy services; increase the share of renewable energy options; reduce flaring and venting of gas; establish national programs for energy efficiency; improve the functioning and transparency of information on energy markets (IAIE,2005).

The indicators, when properly analyzed and interpreted, can be useful tools for communication of data on energy and sustainable development issues for policy makers and the public. They provide a way to structure and clarify statistical data to give a better insight into factors that affect the energy, environment, economy and social welfare (IAIE,2007).

In the specific case of energy and related technologies for production, delivery and use of services, it is essential to take into account economic, social and environmental consequences. Policymakers need methods for measuring and assessing current and future effects of energy use on human health, human society, air, soil and water. They need to determine whether the use of current energy is sustainable and if there is, how to change it to be so.

2.3 Energy Sustainability

The power generation comprises the entire process of transformation from a primary energy source into electricity and is a very significant part of the environmental, socioeconomic and cultural impacts of electric power systems. Given its importance, the electricity sector is developed through policies which generally seek to demonstrate that investments aim at economic growth and improved living conditions of population. The socio-economic development of a country is directly linked to the development of its energy sector, in that energy is the basic input for improvement of several key factors such

as health, education, nutrition and sanitation. Energy sustainability depends on the way to meet the demand requirements, according to criteria of environmental sustainability, socially equitable, economically viable (OECD,1997). It has three basic aspects: paradigm shift in relation to current consumption patterns; search for greater energy efficiency of current production processes; development and integration of clean energy technologies (ANDRADE; MATTEI,2013).

Energy sustainability is divided into three dimensions: economic determines directly the profit rate of productive activity; social dimension is checked by identifying basic levels of needs, and is characterized by the possibility of using energy inputs in minimum conditions; and finally the environmental dimension is identified by deterioration level that energy use can cause to the environment (BERMANN,2003).

The concept of energy sustainability incorporates the analysis of the environmental dimension, i.e. if production and consumption process has at the same time at its input a power source whose acquisition is environmentally cyclical and renewable and pollutants related to production and consumption does not exceed the environmental average absorption capacity, and how it acts as a means of action to reduce emissions of polluting gases in the atmosphere, the intensive use of water and extensive resources of land and waste production, as determined by scientific standards. It also incorporates social dimension, i.e., if production and consumption process affects health and well-being of people directly related, and is inclusive, quantitatively and qualitatively, in terms of generating jobs and income. Finally, also the analysis of the economic dimension, i.e., at what point real price of energy for end use influence on national and international energy demand and, consequently, the force exerted on the environment by production activities and energy consumption (MACHADO ET AL,2006).

However, to achieve energy sustainability is important to emphasize that energy efficiency and use of renewable sources must be supported by public policies. There are three goals that can lead to the creation of these policies, they are: accessibility, availability and acceptability. These objectives are essential so that policy and planning for energy sector can start from insights, implications and impacts of different energy programs, alternative policies, strategies and development plans in training within their countries, and the feasibility of making development sustainable over time (WORLD ENERGY COUNCIL,2007). In this context, the need to use energy sustainability indicators in order to provide subsidies for the development of energy policies and plans to drive greater sustainability for the sector and for generating regions and power users arises.

3 METHODOLOGY

The developed research can be classified as descriptive and exploratory. Its viability was based on the identification, reading, analysis and discussion of theoretical and conceptual basis of a more academic bias on issues related to energy sustainability, as well

as by the study done by institutions involved with the issues of energy and sustainability, based scholar used the Scholar Google and periodic capes with the keywords "sustainability indicators" and "energy activity" since 1999 by 2015. After the bibliographic study were found separated set of indicators of sustainable energy for economic and corporative activity, i.e., study that assessed sustainability in energy projects. For the research were used only studies that contain specific sets about energy indicators for economic activity, as were also considered important, with citations in other studies about the theme.

After analysis of studies, were selected those who brought energy sustainability indicators focused on measuring the same for economic activity, considered seminal and most representative research on this issue; they were: ANEEL; AFGAN et al.; ISED; BERMANN; HELIO INTERNATIONAL; OLIVEIRA et al; SOUZA and BORGES. From the sets of indicators found in these studies were identified 134 indicators, divided into seven dimensions. These indicators have been through analysis, and were selected those that were repeated in works, as well as in which dimension these indicators fit. Another point checked is related to indicators that are not repeated as nomenclature, but had their goals or descriptions similar. Because of such procedures, the set of indicators was reduced to 61, divided into dimensions: social, environmental, economic, technological, political, territorial and cultural.

4 ANALYSIS AND RESULTS

Energy indicators for sustainable development represent an important planning tool to achieve sustainable development. Therefore, several authors and institutions have developed a set of indicators to measure how energy policies are contributing to energy sustainability. The proposal corresponds to a set developed through the joint energy sustainability indicators cited below.

4.1 Aneel (1999)

The first study used was that created by ANEEL in 1999, which highlights that energy indicators are instruments of communication between decision makers and general public; Quantitative information on the sustainability of energy systems; integration use and waste reduction. The indicators presented by ANEEL were developed from guidelines of the Latin American Energy Organization - OLADE in 1996. The indicators developed by ANEEL may be noted in (Table 1) below:

Chart 1 - Energy Sustainability indicators prepared by ANEEL

DIMENSION	*INDICATORS*
Political	• Security of supply • Decentralization of Government
Economic	• Financial Balance • Revenue generation • Income appropriation
Social	• Job creation • Regional inequality
Environmental	• Impacts on the physical environment and biotic • Incentives for renewable energy
Technological	• Quality and supply reliability • Work accidents

Source: Adapted from ANEEL (1999)

4.2 Afghan et al. (1999)

The authors select, define and implement a set of sustainability indicators for evaluation of power system. Starting from general concept of sustainability, a set of indicators is defined reflecting specific criteria for evaluation. Special attention is devoted to resource, environment, social and economic criteria. One can observe the study indicators in Table 2 below:

Chart 2 - Energy sustainability indicators developed by AFGHAN *et al* (1999)

DIMENSION	*INDICATORS*
Economic	• Economic efficiency • Capital invested • Community contribution
Social	• Job creation • Income generation • Number of enterprises / potential installed
Environmental	• Fuel consumption in power generation • Carbon dioxide emission • Copper waste generation • Aluminium waste generation • Water consumption • GHG emission

Source: Adapted from Afgan *et al*. (1999)

The set of indicators is defined and determined in order to demonstrate the method of decision-making procedure. It has been shown that there is the possibility to define a coherent set of sustainability indicators to be used in the evaluation of power system. In this respect, four groups of indicators were presented that reflect the resources, environment, social and economic criteria.

4.3 Ised (2001)

In 2001, energy sustainability indicators have been drawn up by the International Atomic Energy Agency, and adopted the pressure type approach, state and response developed by the Organization for Economic Cooperation and Development (OECD) in 1993, which favors its use, as it has causal pressures view that human activities have on the environment by modifying quality and quantity of natural resources. It is provided a full description of each indicator in the set of EISD center, being those designed to provide a user all necessary information to develop indicators. The energy sustainability indicator system is divided into three dimensions [7] (See Table 3).

Chart 3 - Environmental dimension of energy sustainability indicators developed by ISED (2001)

DIMENSION	*INDICATORS*
Social	Energy access, percentage of income spent on energy, energy consumption, labor accidents.
Economic	Energy consumption per capita, energy intensity, energy efficiency, total reserve of total production, total funds on total production, industrial energy intensity, energy intensity in agriculture, familiar energy intensity, energy intensity in transport, share of fuels in energy, energy generation by carbon stations sources, energy generation from renewable sources, energy prices, energy dependence, total energy stock.
Environmental	Greenhouse gas (GHG) emissions, pollutant concentration in urban areas, discharge of contaminants in effluents, soil acidification, deforestation rate, per unit of energy waste generation rate, total solid waste properly stored, total radioactive waste per unit of energy, total radioactive waste properly disposed.

Source: Adapted from IAIE (2005)

The social dimension was divided into two themes: health and equity, which is divided into accessibility and disparity. The economic dimension focuses on the issue of patterns of production and consumption, being subdivided into general use, productivity,

efficient sources,production, energy security and pricing The environmental dimension is divided between: air, water, earth, these being divided into subtopics such as climate change, air quality, water quality, soil quality, forest and solid waste generation and its management.

4.4 Bermann (2002)

Bermann (2002) in *Proyecto Cono Sur Sustentable: Propuestas From Politicas Energeticas Sustentables Para El Cono Sur* consider the indicators as necessary tools for operationalization of purposes in the context of sustainable development and fundamental references in decision making. The indicators proposed by Bermann are shown below in Table 4.

Chart 4 - Environmental dimension of energy sustainability indicators developed by Bernamm

DIMENSION	*INDICATORS*
Economic	• Energy Independence • Supply ratio and energy demand
Social	• Electrification Indices • Energy Shortage • Income spent on energy • Regional Equity • Training human resources
Environmental	• GHG emission • non-renewable energy Replacement • Local Impacts / regional
Political	• Promoting environmental education • Participation of agencies of regulation • Society's participation in decision-making
Technological	• Losses Reduction • Energy efficiency • Development of new energy technologies • Technological capability of industries

Source: Adapted from Bermann (2002)

The author elaborated indicators that address the dimensions: dependency and vulnerability, security and energy quality, energy and equity, energy and the environment, energy and democracy, energy and potential of sustainability.

4.5 Helio international (2005)

The Helio International, a non-governmental network established in 1997, in their analysis of sustainability, use a set of eight indicators divided into four dimensions: environmental, presenting as indicators of global impacts (emissions per capita carbon in energy sector) and local (level of the most significant local pollutants related to energy); social, pointing as indicators of households with access to electricity (percentage of households with access to electricity) and investments in clean energy, as an incentive to create jobs (investments in renewable energy and energy efficiency in end uses, as a percentage of total investments in energy sector). The aforementioned indicators are explicit below in Table 5.

Chart 5 - Sustainable Energy Watch (SEW)

DIMENSION	*INDICATORS*
Economic	• Investment in fossil energy • Energy Resilience
Social	• Access to electricity • Investment in renewable energy
Environmental	• CO2 emissions per capita • Local Impacts
Technological	• Energy intensity • Development of renewable energy
Political	• State participation • Energy information Quality

Source: Adapted from Helio International (2005)

The researchers in this network also highlight the need for comparison between previous and future situations in an effort to assess the degree of socioeconomic development process, in order to enable guidance to the decision-making process in electricity sector.

4.6 Oliveira et al (2006)

The authors draw up a set of indicators in the survey entitled The Sustainable Brazilian Electric Sector Expansion from the Sustainability Indicators Use as Instrument Decision Support. The set of indicators is presented below in Table 6.

Chart 6 - Energy sustainability indicators developed by Oliveira et al (2006)

DIMENSION	*INDICATORS*
Economic	• Specific investment • Value Index • Percentage of imported inputs

Social	• Employment and Income • Average level of remuneration • Seasonality of jobs
Environmental	• GHG emission • Water consumption • Land occupied by the enterprise • Soil Acidification • Land use Percentage
Technological	• Generation of liquid Efficiency • Availability annual average • Construction time • Provision of inputs

Source: Adapted from Oliveira et al (2006)

The authors sought to present a proposal for an integrated assessment methodology for electricity supply expansion, considering, in addition to technological and economic aspects, also environmental and social aspects. The proposal is based on the establishment of a set of indicators for electricity generation to generation from: small hydropower (SHP), bagasse sugarcane, biodiesel, wind energy, urban solid waste (USW) and natural gas.

4.7 Souza (2010)

Souza (2010) developed a set of indicators of sustainable energy explained in Table 7 below exposed, divided into five dimensions: social, economic, environmental, territorial and cultural.

Chart 7 - Energy Sustainability indicators developed by Souza (2010)

DIMENSION	***INDICATORS***
Economic	• Supply ratio and energy demand • Increase energy reserves • Energy Independence • Industry Technological Training • Reasonable tariffs
Social	• Generating employment and income • Electrification Indices • Society's participation in decision-making • Training human resources
	• GHG emission • Ground contamination • Ground pollution • Loss of biodiversity

Environmental	• Incentives for renewable energy • Promoting environmental education
Territory	• Regional Equity • Local Development • Reduction of rural exodus
Cultural	• Increase of endogenous sources • Balance between innovation and tradition • Technological Diffusion

Source: Adapted from Souza (2010)

This research was conducted by analyzing official documents, technical visits, interviews with experts and consultations with environmental impact reports, wind technology has been evaluated through the prism of five dimensions of sustainability, as an alternative to electricity generation considering the prospects for climate change in the Northeast of Brazil.

4.8 Borges (2012)

Finally, we selected the study of Borges (2012) which drew up a set of indicators for sustainable energy, which considered the economic, social, environmental and political. It was analyzed the indicators set forth below in Table 8.

Chart 8 - Energy Sustainability indicators developed by Borges (2012)

DIMENSION	***INDICATORS***
Economic	• GDP / energy consumption • Energy consumption / Amount invested • Variation in electricity tariff / Amount invested
Social	• Formal Jobs / amount invested • Average income / energy consumption
Environmental	• GHG emission in power generation • Energy efficiency / energy consumption
Political	• Frequency of interruptions / variation rate • Duration of interruption / variation rate

Source: Adapted from Borges (2012)

This research proposes mechanisms for construction and analysis of electrical energy sustainability indicators, able to guide the power sector investments aiming to sustainability. The construction design and analysis of energy sustainability indicators of the need to develop new tools that support the management of public policies for

sustainable development, planning systems and operational models for various strategic segments such as the electricity sector.

4.9 Energy Sustainability Indicator Set

After checking the indicators existing in the studies 8 were accounted indicators 122, these filtrates were compared to repeat questions and indicators containing the same definition, causing the selected set of indicators making a total of 62. These were divided into seven social dimensions (9 indicators), environmental (15 indicators), economic (20 indicators), technological (6 indicators), political (7 indicators), territorial (3 indicators), cultural (2 indicators).

In the analysis of energy sustainability indicators, it is clear that the social and environmental dimensions there is a greater symmetry, having a larger number of indicators that are repeated between the assessed studies, it shows that for these dimensions there is greater agreement on the vision of energy sustainability. While in other dimensions there is a greater differentiation in relation to the proposed indicators to measure them, this may be due to the fact some studies have territorial scope or localized time, however this may be positive to the point that extends the dimensions and vision for energy sustainability.

4.9.1 Social Dimension

The availability of energy has a direct impact on poverty of opportunity, employment, education, demographic transition, indoor pollution and health, so indicators of the social dimension have to evaluate how the enterprises of wind production chain has contributed to local development (IAIE,2005).

Chart 9 - Indicators of the social dimension of sustainable energy

SOCIAL SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
SOCIAL	Generating employment and income, Seasonality of jobs, average income / energy consumption, labor accidents, electrification indices, Energy Shortage, training human resources, Income spent on energy, average level of remuneration.

Source: The author

In the social dimension it is possible to see the relationship between indicators, involving those related to local development; in particular, human development within this theme can relate to indicators generation of employment and income; training of human resources; average level of remuneration; seasonality of jobs. They seek to measure

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initially inserting a source of power generation in due place is generating jobs and income, for generation of electricity is a capital intensive activity and does not have the intrinsic characteristic generate employment. However, with a view to sustainable development, all opportunities for job creation and income distribution should be potentiated.

Another important issue will be whether this job will have considerable durability or will be only a circumstantial activity, as well as questioning whether these jobs are of average quality, so that they have an adequate income, and finally it is noticed that energy activities require a high professional so it is important the development of knowledge hub in places where energy projects are implemented. Another issue that this dimension seeks to measure is the impact of the inclusion of energy development as improving access to energy quality, i.e., improvement in energy services. It also measures how much this deployment reduced spending of the local population with energy, and that consumption had increased relative to these questions, this issue comes under the social foundations of sustainable energy which states that every citizen should have access to energy quality at a fair price. Finally, if it has indicators that analyze state investment.

4.9.2 Economic Dimension

Modern economies depend on a viable and adequate energy supply, and developing countries need to ensure that as a prerequisite for industrialization. All sectors of the economy require modern energy services, being need to measure issues such as efficiency and energy intensity. These services, in turn, promote economic and social development at local level, increasing productivity and enabling local income generation.

Chart 10 - Indicators of the economic dimension of energy sustainability

ECONOMIC SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
ECONOMIC	GDP / energy consumption, energy independence, investment in fossil energy, energy consumption / amount invested, low tariffs, energy resilience, variation in electric charge / amount invested, specific investment, energy independence, relationship supply and energy demand, cost-effective index, economic efficiency, increase energy reserves, percentage of imported inputs, contribution to community, financial balance, generation revenues, income appropriation, investment in renewable energy, numbers of enterprises / potential installed.

Source: The author

It is possible to check that the main component in measuring energy sustainability, as well as most current factors, is still the economic issue, which is responsible for 21 of the 64 indicators. The economic dimension to energy sustainability could be named also strategic because the measurement of these indicators have relations with issues necessary for developing countries, among these is energy independence; energy reserves; regional equity; energy resilience, investment in renewable energy and fossil energy.

These indicators are related to strategic issues. Energy independence evaluates how a region can develop without relying on another or exhaustible resources, this requires that investments in fossil energy to be reduced and investments in renewable energy to be encouraged. Energy reserves are important so that in times of crises in energy generation, a region can pass through this phase without the economy and the population being affected.

4.9.3 Environmental Dimension

The production, distribution and use of energy create pressures on the environment in home, in workplace and the city, and the national, regional and global levels. Environmental impacts may depend heavily on how energy is produced and used, being related to the structure of power systems and regulatory actions energy system and pricing structures. There are several impacts on energy projects, so there is no energy production or conversion technology without risk or without waste. Somewhere along the way - from extraction of resources to provision of energy services - they are pollutant produced, emitted or disposed of, often with serious impacts on health and environment. Even if a technology does not emit harmful substances at the point of use, emissions and waste can be associated with its manufacture or other parts of their life cycle.

Chart 11 - Indicators of the environmental dimension of sustainable energy

ENVIRONMENTAL SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
ENVIRONMENTAL	GHG emissions in power generation, water consumption, deforestation rate, energy efficiency / energy consumption, area occupied by the enterprise, pollutant concentration in urban areas, soil contamination, soil acidification, waste generation rate per unit energy, biodiversity loss, land use percentage, proper disposal of solid waste, promoting environmental education, local impacts, impacts on physical and biotic environment

Source: The author

The indicators of the identified environmental dimension seek to cover the maximum range of potential environmental impacts related to different sources of energy. Among these indicators some are more obvious such as emissions of greenhouse gases, present in all studies assessed in this checklist. This is because the problem with global warming is a more debated issue and currently widespread. However, the environmental dimension also seeks to evaluate vital resources for the environment, such as water, flora and fauna, soil. Finally, if it has the indicator promoting environmental education, which is extremely important so that it can give due importance as the impacts generated by this economic activity, so that the environmental dimension is not considered irrelevant towards the economic dimension.

4.9.4 Technological Dimension

This dimension is strongly related to some indicators of the economic dimension, as this is the technological indicators that respond if there is technology or facility for the acquisition of equipment necessary for the implementation of new energy generation in domestic industry, thus enabling a sustained expansion of energy sources . The technological dimension (see Table 6) has a strong connection with the above dimensions, as this plays a key role for some of the previously stated indicators be analyzed positively. In this dimension will be measured how are being developed technologies that favor the development of renewable energy, as well as the issue of reducing losses in energy transport, which means that there is greater efficiency, then requiring fewer impactful projects.

Chart 12 - Indicators of technological dimension of energy sustainability

TECHNOLOGICAL SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
TECHNOLOGICAL	Liquid generation efficiency, construction time, technological capabilities of industries, average annual availability, availability of raw materials, waste reduction, renewable energy development, quality and supply reliability.

Source: The author

The development of energy technology establishes an internalization of production technology factor that increases energy independence, as well as local inputs, so enhancing the generation of employment and income, as well as reducing transportation costs of imported equipment. It is notable that the technological dimension has its importance on quality setting and reliability of the source, to the point that resolves possible failures in energy sources.

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4.9.5 Dimension Policy

The electricity sector is developed through policies that seek to demonstrate that investments aim at economic growth and improve living conditions of the population. The socio-economic development of a country is directly linked to the development of its energy sector, as energy is the basic input for improvement of several key factors such as health, education, nutrition and sanitation.

Chart 13 - Indicators of the political dimension of energy sustainability

POLICY SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
POLITICAL	Frequency of outages, power information quality, security of supply, duration of interruptions, public power decentralization, participation of regulatory agencies, society's participation in decision-making

Source: The author

Public actions can be built with the intention to create mechanisms to promote potential of the energy inputs, such as the generation of GDP, and other mechanisms to assist incomplete aspects generated from electrical input. So the political dimension seeks to measure how the agencies of regulation has influenced the development of energy sector, and also how this energy source has been able to develop without the presence of the state, or if the State aid for the establishment is required. However there are two indicators that have been shown to be highly relevant, quality information and the participation of society as well as society has been included in political decisions.

4.9.6 Territorial Dimension

The territorial dimension, despite having a few indicators and still not be very present in measuring energy sustainability, highlights issues relevant today, as rural exodus and regional equity. Energy allows regions to develop, however, depending on public policies for energy sector, some areas may develop more than others, bringing with it the problem of rapid population growth, and many urban problems. Another issue that this regional inequality brings is the output of the countryman, called rural exodus, which seeks the city developed for better opportunities.

Chart 14 - Indicators of the territorial dimension of sustainable energy

TERRITORIAL SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS

TERRITORIAL	Equity between regions, decrease the rural exodus, local development Promotion

Source: The author

4.9.7 Cultural Dimension

This dimension will assess the relationship of communities (local energy projects, withdrawn by the energy enterprise or surrounding energy development). This relationship often leads to environmental conflicts, so if the measurement of balance between tradition and innovation is necessary, this indicator checks how the enterprises were implemented in regions, emphasizing respect for the customs of community over the implementation of innovation, which would be the energy enterprise. Also with respect to these conflicts, these communities have a distrust of renewable energy because most of the time these people do not understand how this source will help local development, so it is important the indicator previously mentioned, which is environmental education.

Chart 15 - Indicators of the cultural dimension of energy sustainability

CULTURAL SUSTAINABILITY INDICATORS SET OF ENERGY

DIMENSION	INDICATORS
CULTURAL	Balance between tradition and innovation, population increase confidence in alternative energy

Source: The author

These indicators can serve to measure the energy sustainability in diverse energy sources, where the dimensions should be analyzed interconnected way, so that it can be developed public policies consistent with sustainable energy. This research gathered key indicators selected through various set of indicators, however it is necessary that in future studies, to be made a validation carried out by experts in the field, where they would choose indicators that add the best way to energy sustainability, obtaining so a set of indicators for sustainable energy grounded in a more systematic way.

5 CONCLUSION

From the research it is noted that energy sustainability has been measured since the 90s, where several sets of indicators for this were created. Among these sets of indicators stands out those developed by Bermann, ISED, and Helio International, as these studies have served as basis for most studies on energy sustainability. However there was a need for a study to examine the indicators proposed by these studies, as well as other sets of energy sustainability indicators, making it possible to create a database of indicators for sustainable energy.

Therefore this research analyzed 8 studies on energy sustainability indicators in which 135 indicators were identified. These indicators have been through an analysis as repetitions and description of the indicators, and then it got a set of 61 indicators, divided into seven dimensions (social, environmental, economic, technological, political, territorial and cultural), each dimension being justified in relation to its importance for energy sustainability.

The importance of completing the study is related to creation of a base of indicators that can be used by a set of social actors directly and indirectly involved in the generation, transmission and distribution of energy, which facilitates more consistent analysis of the industry, minimizes the risk in decision-making by public and private entities linked to this economic activity.

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