Renewable Energy and Sustainable Development*

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ABSTRACT

This article develops the renewable energy and sustainable development theme, a topic that is much and much important since the problems that face the fossil fuels related to reserves exhaustions, the high price of new explorations and exploitations, the pollution levels and their impact on climate change (consequence of GHG emissions). Among the aims and objectives of this paper we discuss the renewal energies' adoption or investments and their implications on sustainable development.

Keywords: Renewal Energy, Sustainable Development, Energy Security, Energy Access, Climate Change, Global Warming.

Energía renovable y desarrollo sostenible

RESUMEN

Este artículo desarrolla el tema de las energías renovables y el desarrollo sostenible, un tema que es cada vez más importante atendiendo a los problemas que los combustibles fósiles tienen que enfrentar y que se relacionan con el agotamiento de las reservas, el prohibitivo precio de las nuevas prospecciones y exploraciones, las poluciones y sus efectos o impacto en el cambio climático (consecuencia de las emisiones de gases con efecto invernadero). Entre otros objetivos de este artículo también se encuentra la discusión sobre la adopción de las energías renovables y sus implicaciones para el desarrollo sostenible.

Palabras clave: Energía renovable, desarrollo sostenible, seguranza energética, acceso a energía, cambio climático, calentamiento global.

JEL Classification: Q42, Q43, Q48, Q50

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1. INTRODUCTION

Renewable energy (RE) and sustainable development (SD) are two key expressions for human being since fossil fuels tend to exhaustion, have higher and higher prices that are going to be unbearable for humanity and are the main responsible for GHG emissions and unsustainable development. Renewable energies, on the contrary, among other things, are clean and almost safe and are fundamental for SD, the one that preserves resources for the future generations. Some topics that are important and need discussion are renewable energy, SD, the United Nations Development Programme (UNDP), the Millennium Development Goals (MDG), the concept of SD, the interactions between SD and renewable energies, the SD goals for renewable energy, some SD indicators, the social and economic development in this framework, the question of energy access to the whole humanity, the question of energy safety, the climate change mitigation and the reduction of environmental and health impacts.

As pointed out by A. M. Omer buildings consume approximately 40% of the total world annual energy needs, most of it for lighting, heating, cooling and air-conditioning. A better understanding of the environmental impact of CO_2 and NOx emissions and CFCs generated a renewed interest in environmental friendly technologies (cooling and heating). Under the 1997 Montreal Protocol, Canada, governments agreed to phase out refrigerants that destroy ozone cover. It was considered desirable to reduce energy consumption and the depletion rate of world energy reserves and pollution of the environment. One way of reducing building energy consumption is to plan more efficient buildings in terms of energy use for heating, lighting, cooling, ventilation or hot water supply. Inactive measures (namely natural or hybrid ventilation) rather than air-conditioning can strongly diminish energy consumption. However, the utilization of renewable energy in buildings and agricultural greenhouses can give a good contribution to reduce fossil fuels' dependency. Thus, promoting innovative renewable applications and reinforcing the renewable energy market will preserve the environment. This will improve ecological conditions by replacing conventional fuels with renewable energies that produce no air pollution or greenhouse gases, too. The provision of good indoor environmental quality though achieving energy and cost efficient operation for heating, ventilating and air-conditioning represents a problematic question. The general purpose is to provide a high level of building performance (interior environmental quality, energy efficiency and cost efficiency).

A recent World Energy Council study found that without any change in our current practice, the world energy demand in 2020 would be 50-80% higher than the 1990 levels. Annual energy demand will almost duplicate the energy needs by 2020 (DOE - USA Department of Energy report). The world's energy consumption is expected to increase from the today's 22 billion kWh per year to

53 billion kWh by 2020. Such ever-increasing demand could place significant tension on the current energy infrastructure and potentially damage world environmental health by CO, CO_2, SO_2, NOx effluent gas emissions and global warming. Finding solutions to the environmental issues that we face today requires long-term planning actions for SD, and RE resources are the most efficient and effective solutions given the close relationship between RE and SD. Rational energetic use is an important way to convert the today's fossil fuel world to another world of clean and safe fuels, and advanced technologies-photovoltaic, wind and fuel cells or other renewable energy sources (WEO, 1995). As these renewable energy sources are stochastic and geographically disseminated, their capability to go with demand is determined by the acceptance of two methods (EUO, 2000): the utilization of an arrest area greater than that occupied by the community to be supplied, or the reduction of the community's energy demands to levels corresponding to locally disposable renewable resources.

Hence, the objective is to use energy efficiency measures in order to reduce the general energy consumption and to adjust the demand shapes to be faced by renewable energies. This approach can be applied to greenhouses which use solar energy to provide interior ecological quality. The greenhouse effect is a result of the properties of heat radiation when it is produced at different temperatures. Objects within the greenhouse or other building, as flora, either re-emit the heat or absorb it. Because the objects in the greenhouse are at a lower temperature than the sun, the re-radiated heat is of longer wavelengths, and cannot penetrate the glass forcing the temperature inside the greenhouse to rise. Atmosphere close to the earth behaves itself as a large greenhouse around the world. Changes to the gases in the atmosphere, such as increased carbon dioxide level from firing fossil fuels, operate as akin to a cover of glass and decrease the quantity of heat that the planet earth would re-radiate back into space. The greenhouses, thus, contributes to global warming. The application of greenhouses for plants growth can be considered one of the measures in the success of solving this problem. Maximizing the efficiency gained from a greenhouse can be achieved using various approaches, employing different techniques that could be applied at the design, construction and operational phases. The development of greenhouses can be a solution to agricultural industries and food safety.

Energy security, economic growth and environment defense are the national energy policy drivers of any country of the world. As the world population grows faster than the average (2%), the need for more and more energy is more and more important. Improved lifestyle and energy demand grow together and the prosperous industrialized economics, with 25% of the world's population, consume about 75% of the world's energy supply. About 6.6 billion metric tons carbon equivalent of GHG emission are threw to the atmosphere to face this energy demand (Bos *et al,* 1994). Approximately 80% is due to carbon emissions from the combustion of energy fuels. At the current rate of usage, taking into consideration population increases and higher consumption of energy by developing countries, oil resources, natural gas and uranium will be exhausted within a few decades.

The structure of this article is as follows: section two presents an overview of the RE and SD problematic; section three presents a quick description of some recent contributions to this topic; and section four, the last one, ends with the presentation of some concluding remarks and of some policy recommendations.

2. THE RENEWABLE ENERGY AND SUSTAINABLE DEVELOPMENT PROBLEMATIC

2.1. Renewable Energy, Sustainable Development, and the Millennium Development Goals

According to the UNDP, energy is a central key to achieve SD and poverty reduction as it affects the social, economic and environmental development aspects, including livelihoods, access to water, agricultural productivity, health, population levels, education and sex-related issues. Without major improvements in the quality and quantity of energy services, namely in the developing countries (DC), the Millennium Development Goals (MDG) can be faced (UNDP, 2013).

The UNDP's efforts in energy for SD support the accomplishment of universal access to modern energy for the poor and improved quality, security and affordability of modern energy. The access to sustainable sources of clean, unfailing and reasonably priced energy is very important for human development, is related to physical infrastructure (e.g. electricity grids), but also to energy affordability, reliability and commercial viability.

The UNDP helps developing countries to increase access to reliable and modern sources of energy in order to reduce poverty, to improve the citizen's health, to promote economic growth and to moderate climate change through an integrated development approach. Investing in clean, efficient, affordable and reliable energy systems is compulsory for a prosperous and environmentally sustainable future. Ensuring energy security requires the diversification of the energy sources, with increasing focus on consumer needs, on indigenous energy supplies, energy efficiency and regional interconnections.

The UNDP helps the developing countries in achieving the up-referred outcomes through the provision of sound policy advices and a focus on three key areas of intervention: (i) strengthening policy and institutional frameworks consistent with low-emission, climate-resilient development, the basis of the UNDP strategy; (ii) mobilizing and expanding financing options aimed at achieving market transformation to catalyze public and private finance, including creating, enabling policies, regulatory frameworks and removing barriers to energy efficiency, renewable energy and sustainable urban transport; and (iii) developing effective approaches to increase energy service delivery, using a combination of field-proven and innovative business models that are financially and institutionally sustainable (UNDP, 2013).

Through the provision of sound policy advices, development and implementation of programs, the UNDP has promoted a wide range of clean energy technologies. Program funding includes the UNDP regular resources, the Global Environment Facility (GEF), the GEF Small Grants Programme, the Governments, the private sector and the civil society partners. Through its portfolio of energy and climate mitigation projects funded by this GEF, the UNDP is assisting countries to remove barriers to energy efficiency, renewable energy and sustainable transport and improve access, quality, security and affordability of clean energy around the globe (UNDP, 2013).

2.2. The concept of SD and the two paradigms of weak and strong sustainability

As pointed by Sathaye *et al.,* (2011), the concept of SD appeared in 1972 and 1987, with the Founex Report, and the publication of the World Commission on Environment and Development (WCED) report "Our Common Future" - also known as the "Brundtland Report", respectively; SD pretends to meet the needs of the present generation without compromising the ability of future generations to meet their own needs (WCED, 1987; Bojö *et al.,* 1992). Many competing frameworks for SD have been put forward since then (Pezzey, 1992; Hopwood *et al.*, 2005). SD is strongly tied with climate change and therefore the IPCC at the United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil in 1992 that aimed to stabilize atmospheric concentrations of greenhouse gases at levels considered to be safe.

Economy, Ecology and Society, known as the three-pillar model for sustainability are considered to be interconnected and relevant for sustainability (BMU, 1998). The United Nations General Assembly (UNGA) aims to promote the integration of the three pillars of SD -economic development, social development and environmental protection- as interdependent and mutually reinforcing components (UN, 2005a). This point of view underlies the understanding that a certain set of actions (e.g., substitution of fossil fuels with RE sources) can accomplish all the development goals simultaneously.

SD can be oriented along a continuum between the two paradigms of weak sustainability and strong sustainability whose assumptions about the substitutability of natural and human-made capital differ (Hartwick, 1977; Pearce *et al.,* 1996; Neumayer, 2003). Weak sustainability (WS) has been viewed as the substitutability paradigm - only the aggregate stock of capital needs to be conserved, i. e., natural capital can be substituted with man-made capital without compromising future well-being, and can be interpreted as an extension of neoclassical welfare economics (Solow, 1974; Hartwick, 1977, Neumayer, 2003). WS also implies that environmental degradation can be compensated for more machinery, transport infrastructure, education and information technology, the man-made capital. WS assumes that the economic system flexibly adapts to varying availability of forms of capital. (Sathaye *et al.,* 2011)

Strong sustainability (SS), on his turn, starts from an ecological perspective with the intent of proposing guide rails for socioeconomic ways and it can be viewed as the non-substitutability paradigm (Pearce *et al.*, 1996; Neumayer, 2003). In this case, natural capital cannot be substituted, either for production purposes or for environmental provision of regulating, supporting and cultural services (Norgaard, 1994). Limited sinks such as the atmosphere's capacity to absorb GHG emissions may be better captured by applying the constraints of the SS concept (Neumayer, 2003; IPCC, 2007b). In one important interpretation, the physical stock of specific non-substitutable resources (the 'critical natural capital') must be preserved (Ekins *et al.*, 2003, Sathaye *et al.*, 2011).

Protections for remaining within the limits of sustainability are often justified or motivated by nonlinearities, discontinuities, non-smoothness and non-convexities (Pearce *et al.,* 1996). Natural scientists alert and describe specific tipping points, critical limits at which a small perturbation can qualitatively alter the state or development of Earth systems (Lenton *et al.*, 2008). The precautionary principle claims for keeping a safe distance from guardrails, putting the burden of proof for the non-harmful character of natural capital reduction on those taking action (Ott, 2003).

RE can contribute to develop the three-pillar model goals and can be assessed in terms of both weak and strong sustainability. While consumption of non-RE sources (fossil fuels and uranium), reduces natural capital directly, RE, in contrast, maintains natural capital since its resource use does not reduce the future potential. (Sathaye *et al.,* 2011)

2.3. Connections between RE and SD

The relationship between RE and SD can be viewed as a hierarchy of goals and constraints that involve both global and regional or local considerations. A starting point is that mitigation of dangerous anthropogenic climate change will be one strong driving force behind increased use of RE technologies worldwide.

RE plays a central role in most GHG mitigation strategies which must be technically feasible and economically efficient so that any cost burdens are minimized. Knowledge about technological capabilities and models for optimal mitigation pathways are therefore important. However, energy technologies, economic costs and benefits, and energy policies, depend on the societies and natural environment within which they are embedded. Sustainability challenges and solutions crucially depend on geographic setting (solar radiation), socioeconomic conditions (inducing energy demand), inequalities within and across societies, fragmented institutions, and existing infrastructure (electric grids) (Holling, 1997; NRC, 2000), but also on a varying normative understanding of the connotation of sustainability (Lele and Norgaard, 1996). Analysts therefore call for a differentiation of analysis and solution strategies according to geographic locations and specific places (Wilbanks, 2002; Creutzig and Kammen, 2009) and a pluralism of epistemological and normative perspectives of sustainability (Sneddon *et al.,* 2006).

These aspects underline the need to assess both the social and environmental impacts of RE technologies to ensure that RE deployment remains aligned with overall SD goals. Some of these important caveats, like the extent to which RE technologies may have their own environmental impact and reduce natural capital, for example, by upstream GHG emissions, destroying forests, binding land that cannot be used otherwise and consuming water. Evaluating these impacts from the perspectives of the weak and strong sustainability paradigms elucidates potential tradeoffs between decarbonization and other sustainability goals.

Therefore, efforts to ensure SD can impose additional constraints or selection criteria on some mitigation pathways, and may in fact compel policymakers and citizens to accept trade-offs. For each additional boundary condition placed on the energy system, some development pathways are eliminated as being unsustainable, and some technically feasible scenarios for climate mitigation may not be viable if SD matters. However, the business-as-usual trajectories to which climate mitigation scenarios are compared are probably also insufficient to achieve SD. (Sathaye *et al.,* 2011).

2.4. SD targets and indicators for RE and SD

Energy indicators are important for monitoring progress made in energy subsystems consistent with sustainability principles, and its measurement and reporting can have a pervasive effect on decision making (Meadows, 1998; Bossel, 1999). Measuring energy sustainability raises either technical and conceptual issues (Sathaye *et al.,* 2007) or updated methodologies (Creutzig and Kammen, 2009).

Recently, some progress has been made towards developing a uniform set of energy indicators for SD (taking in account the economy, society and environment components (Vera and Langlois, 2007)). Quantitative indicators for RE technologies, include generated electricity price, GHG emissions, availability of renewable sources, efficiency of energy conversion, land requirements and water consumption (Evans *et al.*, 2009). Other approaches compare the different RE subsystems based upon their performance, net energy requirements, GHG emissions and other indicators (Varun *et al.,* 2010).

A variety of SD indicators have been suggested to substitute GDP, or per capita GDP, as the only item to quantify economic development. Among them there are WS aggregate indicators that include green net national product, genuine savings (Hamilton, 1994; Hamilton and Clemens, 1999; Dasgupta, 2001), the index of sustainable economic welfare (ISEW) and the genuine progress indicator (GPI) (Daly, 2007). The ISEW and the GPI were also proposed as intermediate steps by proponents of SS. More consistent indicators with SS include loading capacity, ecological footprint and resilience (Pearce *et al.,* 1996), sustainable national income and sustainability gaps (Hueting, 1980; Ekins and Simon, 1999, Lawn, 2003).

The use of aggregated indicators for economic development like the Human Development Index (HDI) or the ISEW (Fleurbaey, 2009), are very challenging since resulting values are related to uncertainty and they are often challenged on methodological and epistemological grounds (Neumayer, 2003). Aggregate indicators of sustainability integrate many aspects of social and economic development, and hence, ignore the specific sustainability impact of RE development.

Sustainability assessment requires a battery of indicators (Stiglitz *et al.,* 2009). The four SD goals defined previously, are used to assess the contribution of RE to SD.

Quantitative indicators are a suitable framework to assess the existing literature that might be conciliated with achieving a comprehensive and consistent measure of SD.

2.5. Economic and social development and human well-being

The energy sector is a major key to economic development; the correlation between economic growth and energy consumption is high in almost all over the countries. Per capita GDP has been a proxy for economic development and the HDI is correlated with per capita energy use. The HDI, used to compare levels of development among countries, includes as main items the purchasing power parity-adjusted income, the literacy and the life expectancy at birth. HDI is also used to measure society well-being and also as a proxy indicator of the development level. One of the advantages of these two indicators is the certain availability of data time series. But per capita GDP and HDI are insufficient to measure sustainability of social and economic development. Another technological development indicator is the decreasing energy intensity, i.e., the amount of energy needed to produce one constant dollar of GDP.

The increased employment rate is an additional macroeconomic benefit potentially associated with RE. Moreover, financial commitments have been established by wealthier nations to help developing countries with climate change mitigation measures under the Copenhagen Agreements (CA, 2009). Positive or negative effects depend on regional issues and on the implemented policies. (Sathaye *et al.,* 2011)

2.6. Energy access to modern energies

Access to modern renewable or nonrenewable sources' energy services, has a high correlation with development levels. The Johannesburg Plan of Implementation (JPI), developed in the World Summit on Sustainable Development (WSSD) in 2002 (IEA, 2010b), established that a link between adequate energy services, achievement of the Millennium Development Goals (MDGs) and providing access to modern energies (e.g., electricity or natural gas) to the poorest persons is crucial for the achievement of the eight MDGs (Modi *et al.*, 2006; GNESD, 2007a; Bazilian *et al.,* 2010; IEA, 2010b). In 2010 almost 20% of the world population, especially in rural areas, still doesn't have access to electricity, and 20% cook mainly with traditional biomass gathered in an unsustainable manner (IEA, 2010b). It is necessary to increase energy access of these persons to electricity and modern cooking possibilities.

Other concrete indicators are per capita final energy consumption related to income, electricity access breakdowns (in rural and urban areas), and number of people that use coal or traditional biomass for cooking.

Energy access is also related to the need for models that can evaluate the sustainability of future energy system pathways with relation to the decreasing disparity between rural and urban areas (energy forms and quantities used or infrastructure reliability) within countries or regions.

2.7. Renewable Energy, SD and Energy Security

The energy security expression is highly context-dependent (Kruyt *et al.*, 2009, Sathaye *et al.,* 2011) and can best be interpreted as robustness against breakdowns of energy supply (Grubb *et al.*, 2006). Energy security varies with time and geography (Bazilian and Roques, 2008). There are two themes that are relevant to energy security, either for current systems or for the planning of future RE systems: the availability and distribution of resources, and the variability and reliability of energy supply.

Given the interdependence of economic growth and energy consumption, access to a stable energy supply is a major political preoccupation and a technical and economical challenge for the developed and developing countries since long breakdowns are no long admissible economic and functional problems. (Larsen and Sonderberg Petersen, 2009).

The fossil fuel scarcity and decreasing quality of fossil reserves is a good reason for changing to a sustainable RE system. Recoverable fossil fuel resource amounts is controversial: there are optimist views (Greene *et al.*, 2006) and pessimistic views (Campbell and Laherrere, 1998) and there are projections of lacking investments falling between both of them (IEA, 2009). Nevertheless, the increasing substitution of Fossil fuels by RE what is good for the existing reserves of fossil fuels since this means that they are depleted less rapidly and their exhaustion is delayed or postponed for the future (Kruyt *et al.,* 2009).

The reduced availability and the distribution of resources are critical concerns of energy security. The more dependent is an energy system on a single energy source, the more susceptible the energy system is to breakdowns.

Dependence on energy imports (either fossil fuels or technology needed for implementing RE), is also a potential source of energy insecurity. RE resources have a less concentrated distribution around the globe than fossil fuels (WEC, 2007) and are less traded on the world market reason why it is urgent to increase the ER as a way of diminishing the dependence on actual energy imports (Grubb *et al.,* 2006). Thus RE sources contribute to the diversification of the portfolio of energy supply options and to reduce the economy's vulnerability to price volatility (Awerbuch and Sauter 2006); and help to increase energy security (at the global, national or local levels) (Awerbuch and Sauter, 2006; Bazilian and Roques, 2008).

The introduction of renewable technologies adds new preoccupations to energy security, not only by disruption of supplies by unfriendly agents, but also by the vulnerability of energy supply to random and nature uncertainties and to extreme events like dryness. However, RE can increase the reliability of energy services, in particular in remote and rural areas that lack grid access. A miscellaneous range of energy sources, together with good management and system design can improve security levels.

It is not easy to identify specific indicators for security. Among them, there are the magnitude of reserves, the reserves-to-production ratio, the share of imports in total primary energy consumption, the share of energy imports in total imports, and the share of RE resources.

2.8. Climate change improvement and reduction of environmental and health impacts

Reducing GHG emissions with the aim of mitigating climate change is one of the key driving forces behind a growing demand for RE technologies.

However, to evaluate the overall incidence from the energy system on the environment, and to identify potential trade-offs, other impacts and categories have also to be taken into account, for instance, mass emissions to water and air, and usage of water, energy and land per unit of energy generated; all of them must be evaluated across technologies (Sathaye *et al.,* 2011).

While some parameters can be rigorously quantified, other overall data or useful indicators may be lacking as well as, deriving generic impacts on human health or on biodiversity is a challenging task as they are mostly specific to given sites, exposure pathways and circumstances, and often difficult to attribute to single sources.

The multiple methods to evaluate environmental impacts of projects include the environmental impact statements and the risk assessments. Most of them are site-specific, and often limited to direct environmental impacts associated with operation of the facility. Lifecycle assessment (LCA) is a bottom-up measure, complemented by a comparative assessment of accident risks to account for troubles resulting from outside normal operation that provides a clear framework for comparison. Most published LCAs of energy supply technologies only gather lifecycle stocks, quantifying emissions to the environment (or use of resources) rather than reporting effects (or impacts) on environmental quality. Literature reporting lifecycle impacts or aggregate sustainability indicators is scarce, partly due to the incommensurability of different impact categories. Attempts to combine various types of indicators into one overall score (i. e., by joining their impact pathways into a common endpoint, or by monetization) have been made; however worries associated with such scoring approaches are often so high that they preclude decision making (Hertwich *et al.*, 1999; Rabl and Spadaro, 1999; Schleisner, 2000; Krewitt, 2002; Heijungs *et al.*, 2003; Sundqvist, 2004; Lenzen *et al.*, 2006).

3. LITERATURE REVIEW: SOME RECENT CONTRIBUTIONS

This contribution goes on with a quick review of the state of the art of the renewable energies and SD topic published in important world international journals.

Kaygusuz and Kaygusuz (2002) and Keles and Bilgen (2012) study RE and SD in Turkey. They indicate that, the best potential solution for the current environmental problems is applying RE technologies; moreover, they assert that, Turkey´s geographical location has the advantages for broad use of many sources, especially hydropower and biomass. Tanatvanit *et al.,* (2003) investigate RE and SD in Thailand. In this study, the authors review the energy use patterns in industrial, transportation and household sectors, and suggest that energy conservation policies and expansion of electricity generation would be implemented in order to reduce imported energy and environmental pollution.

Bugaje (2006) review RE usage in South Africa, Egypt, Nigeria and Mali, showing that South Africa provided an encouraging model in order to solve energy crisis, and Egypt provided a good effort; Mali needs more efforts to accelerate the construction of primary infrastructures, and finally Nigeria, a country with large energy sources, both conventional and renewable, but that are not sufficiently harnessed; the author suggests that these African countries need to pool resources together in information sharing and the development of a resource base for training and sharing skills in order to achieve SD. Zhou *et al.,* (2008) study the rural household energy consumption structure in N. China and its impact on SD. They indicate that, share of straw, firewood and coal consumption in total energy consumption remained at 88%-91% during 1996 to 2005; however, the share of modern RE is still very low, the main challenge for the SD of these regions. In order to solve this challenge, the authors suggest more focus on energy efficiency programs, optimizing the structure of energy consumption, developing RE resources and protecting the environment during the process of exploitation of energy source and use. Economou (2010) explores RE and SD in Mykonos (Greece). In this study, the author focuses on the consequences of using RE sources on environment as well as on the economic sector; he concludes that, the current regulations for RE sources in Greece can contribute to the protection of the environment and to the economic development of the area. Michalena and Tripanagnostopoulos (2010) examine the impact of solar energy on sustainable tourism development in Mediterranean islands, concluding that solar energy systems can be a driver for specific types of tourism development and consequently for local economic development; however, special social needs and aspirations should be considered. Golusin *et al.,* (2010) study the role of RE for SD in Serbia showing that Serbia will be able to respond to the European rules of SD by exploitation of geothermal energy. Ahiduzzaman and Sadrul Islam (2011) investigate RE and SD in Bangladesh, indicate that per capita emission in Bangladesh is only 0.2667 tones per person, a level that is below the world leading countries' emission such as the USA with 19.8 tons per capita; nevertheless, the authors assert that Bangladesh is a very vulnerable country to the climate change effect in the world; they suggest that Bangladesh with its specific geographical location has the advantage for broad using of RE sources especially grid connected solar electricity and stand-alone solar PV system. Shah *et al.,* (2011) study SD through RE in Pakistan; the authors indicate that, the low level of awareness regarding the potentials of renewable energy, leads to the fundamental policy mistakes to achieve SD in Pakistan. They recommend that, to avoid such policy mistakes, more importance should be given to community participation for the promotion of SD concepts through renewable energy. Kaygusuz (2012) explores the role of energy for SD in developing countries such as the Sub Saharan Africa, China, India and Latin America; the author indicates that, there are 1.4 billion people around the world without access to electricity services, of which 85% of them live in rural areas, and with the current policies until 2030 this number only will reduce to 1.2 billion. Therefore, he adds that changing this situation requires a new financial, institutional and technological framework under world commitment and setting targets to monitor the progress in order to enhance the access to modern energy services. Nautiyal and Varun (2012) study the progress of RE under SD mechanism in India; the authors specify that, India is an emerging country, also in this sector; however, the government of India is trying to increase the energy generation through renewable energies and carbon trading to achieve SD goals. Bakhoda *et al.,* (2012) review the energy production trend from different energy sources in Iran and its effect on SD; the authors mention that 99% of energy production in Iran comes from fossil fuels, oil and gas, and only 1% comes from RE sources, which shows the little attention that has been paid to explore these recent sources of energy production; however, they assert that continuing this trend will lead to path away from the goals of SD that are planned for the country. Oyedepo (2012) examines the role of energy for SD in Nigeria. In this study, the author addresses the role of promotion RE resources and application of energy conservation policies in different sectors such as manufactory, households and transportation in Nigeria.

Koh Mok Poh and Hoi Why Kong (2002), outline "the development of RE in Malaysia and the institutional framework to support it", where the incentives provided for RE are grouped into two categories, depending on the modality of the investment that an investor can opt for several types of incentives which can also be given to transportation, communications and utility projects, whereby promoters under this category can enjoy tax exemption and investment allowance. The authors also discuss the barriers to the promotion of RE technologies, the measures to overcome them and the source-specific concerns and recommended measures to develop RE (Koh Mok Poh and Hoi Why Kong, 2002). J. Goldemberg, S. T. Coelho (2004), note that RE is basic to reduce poverty and to allow SD, but the concept of RE must be carefully established, particularly in the case of biomass, they said. To this aim they "analyze the sustainability of biomass, comparing the ''traditional'' and ''modern'' biomass, and discusses the need for statistical information, which will allow the elaboration of scenarios relevant to RE targets in the world. R.J. Fuller (2005), argues that we need to reaffirm the meaning of sustainability and use its defining principles to guide our advocacy and practice, adding that if we ignore these principles, we run the danger of generating unrealistic expectations and mistrust, and becoming involved in practice that is questionable from a sustainability perspective. Using the principles of sustainability our goals will be more achievable, our credibility will increase and our practice will become more ethical. The author uses a model of sustainability to evaluate RE advocacy and practice.

Alphena *et al.,* (2006), assessed the projects by analyzing whether or not they strengthen the local RE Innovation System in an Island like the Maldives, showing that these RE programs strengthen most of "the key processes necessary in an Innovation System conducive to technology transfer" and that more attention has to be paid to local entrepreneurial activities and the creation of a domestic market for RE technologies (RET), because the process of RET transfer "might run the risk of stagnation after completion of the RE programs". Ursula Kazarian (2007) wrotes that regardless of the importance of national implementation, international legal institutions can play a significant role in facilitating the national promotion of RETs, including deployment and exports: domestic subsidies for RETs development are currently not actionable under World Trade Organization (WTO) law. However, modifications can be made during future Doha Round negotiations regarding environmental goods and services by targeting the removal or lowering the barriers to trade in RETs. Additionally, RETs could be acknowledged and incorporated into standing treaties, and clearly and thoroughly addressed in the language of new international agreements and treaties. Thus, international legal institutions have the potential to play a significant role in facilitating the national promotion of RETs. (Kazarian, Ursula, 2007). Woodrow W. Clark II an Larry Eisenberg (2008), focus on the energy programs for the Los Angeles Community College District (LACCD) campuses, consider the overall energy situation in California and the S. California region, primarily Los Angeles, look at the state and regional energy contexts which lay the ground work and rationale why LACCD and other communities must act on their own to counteract climate change and global warming, and discuss how a community becomes either sustainable and energy independent. They argue that by doing so, any community can generate its own energy through the production or acquisition of its energy from renewable sources such as solar, wind or biomass among other local resources, and expect more significant consequences in terms of carbon control, lower impact on the environment and reduced global warming (Woodrow W. Clark II and Larry Eisenberg, 2008). Morgan Harper (2009), note that thirty years after celebrating the 1st Earth Day, with the intention of marking the conservation and restoration of the environment, carbon emissions, oil consumption, natural gas, and coal extraction increased as a result of the growth of the global motor vehicle population, human carbon emissions and, of course, GHG and global warming. The author concludes that the problem is not going to go away, that it is difficult to finding Canada's place within the policy paradigm of SD and environmental awareness taken in account that the country is a federalist state and that environmental policy falls under the jurisdiction of the provincial government, making it increasingly hard to adopt a policy framework that works consistently across the country's political, social and economic landscapes (Morgan Harper, 2009). Alexandru *et al.,* (2009), discusses the potential for RE in Romania and the results of the national research project PROMES for promoting renewal energies whose objective is the development of energy generation from RE sources (RES) by drawing up scenarios and prognosis harmonized with national and European targets, RES development effects modeling, research of the impact of the penetration of RES into the main, implementation of an advanced software system tool for RES information recording and communication, experimental research based on demonstrative applications. The expected results, as well as the social, economic and environmental impact, are presented.

Atmanand, A. K. Gupta, and R. Raman (2009), explore the energy challenges of India, the cause and effect relationship between energy and economic development, and the sustainability of its environment for its enormous poor population, concluding that energy security and SD are critical issues to ensure India's economic growth and its human development objectives and adding that the issue of sustainability is larger compared to OECD countries as India has to address the basic needs of teeming millions today, before it can start thinking about tomorrow and that this country should focus on holistic energy policies, diversification of fuel mix, clean technologies, R&D, energy efficiency, creating awareness and strengthening governance for SD at the local and national levels (Atmanand, A. K. Gupta, and R. Raman, 2009). As said by A. M. Omer (2010), the wind machine offers an early way of developing drive power. In considering the atmosphere and the oceans as energy sources, the four main competitors are wind power, wave power, tidal and power from ocean thermal gradients. The RE resources are particularly appropriate for the provision of rural power supplies and a major advantage is that equipments such as flat plate solar driers, solar power, wind machines, geothermal energy, wave, tidal, power from ocean gradients, etc., they can be constructed using local resources and without the advantage results from the feasibility of local maintenance and the general encouragement such local manufacture gives to the buildup of small scale rural based industry. This article gives some examples of small-scale energy converters, noting that small conventional engines are currently the major source of power in rural areas and will continue to be so in the future. There is a need for some further development to suit local conditions, minimize spare holdings and maximize interchangeability both of engine parts and of engine application. Emphasis should be placed on full local manufacture (A. M. Omer, 2010). Boyu Zhu (2010), says that that there is great potential for exploitation of RE sources in China, but the strength of policy support and stimulation measures is far from being enough. However, many practices in foreign countries to lead and standardize the development of RE sources were used as sources of reference in China, where the RE Law and relevant supporting regulations have stimulated and promoted exploitation of RE sources. Loraima Jaramillo-Nieves and Pablo del Río (2010), also affirm that RE sources (RES) have significant potential to contribute to economic, social and environmental energy sustainability of small islands since improving access to energy for most of the population, (…) reduces emissions of local and global pollutants and creates local socioeconomic development opportunities. The Mata *et al.,* (2010) paper, reviews the current position of microalgae use for biodiesel production, including their cultivation, collecting, and processing. The microalgae species most used for biodiesel production are presented and their main advantages described in comparison with other available biodiesel raw materials. The various aspects associated with the design of microalgae production units are described, giving an overview of the current state of development of algae cultivation systems. Other potential applications and products from microalgae are also presented such as for biological sequestration of CO_2, wastewater treatment, in human health, as food additive, and for aquaculture. (Mata *et al.*, 2010). O. Awogbemi and C.A. Komolafe (2011), say that Nigeria is facing an energy crisis, that crude oil has been the major source of energy and revenue for the country, but since environmental degradation, instability of oil prices in the international market, global warming, and the crisis in the Niger Delta area where the bulk of crude oil is derived has further made the choice of RE inevitable. To surpass this problem they look at solar energy, hydropower, and wind energy as the major RE sources in Nigeria and concludes that for this country to meet the energy needs of its citizens, the abundant RE potentials must be availed, but for this it is necessary to invest in research and development in RE technologies, workable policies, and collaboration with relevant international agencies (O. Awogbemi and C.A. Komolafe, 2011). Amjid *et al.,* (2011), says that the biogas energy in Pakistan is a good solution for this country and for other DC to face the energy crisis; the authors say that the advantages of this country are the number of animals (10^6 cattle and buffalo), the sugarcane industry that can produce 3000 MW energy, domestic biogas plants since 1959 and a public biogas support program. Women's opportunity cost, with introduction of biogas units reportedly increased, impacting positively on household income, biogas energy generation systems are in demand and their number is increasing steadily, since they are low-cost and can be run with very small budget. Biogas energy corridor can be a good substitute for most of country's population residing in rural areas, installation of plants to bottle the biogas can be an additional opportunity and a national policy to bring this technology at farmer's doorstep is necessary (Amjid *et al.*, 2011). Eswarlal *et al.,* (2011) in a World RE congress 2011 held in Sweden presented a paper in which they determined "the key variables of RE implementation for SD, on which the top management should focus" using a "an interpretive structural modeling (ISM) - based approach employed to model the implementation variables of RE for SD, categorized under enablers that help to increase the implementation of RE for SD. A major finding of this research is that public awareness regarding RE for SD is a very significant enabler. In this paper, an interpretation of variables of RE for

SD in terms of their driving and dependence powers has been examined. For better results, top management should focus on improving the high driving power enablers such as leadership, strategic planning, public awareness, top management support, availability of finance, government support, and support from interest groups (Eswarlal *et al.*, 2011). Islam *et al.,* (2011) say that RE technologies (RETs) can help reduce poverty, energy shortage and environmental degradation such as desertification, biodiversity depletion and climate change effects in Bangladesh. This country being an underdeveloped country, global initiative would be helpful in transferring RETs for the village households. The paper describes the glimpses of RETs in Bangladesh in terms of its policy issues, implementation, dissemination, marketing, and research and development activities even if modern RETs are still in the research, development and demonstration phase in the country, there is a niche market for new RETs (Islam *et al.*, 2011). Jip Engels (2011), in his PhD thesis, discusses the requirements for a harmonized support scheme in EU, by examining the developments in the EU electricity sector, exploring the legal framework for the promotion of green electricity and investigating the economic effectiveness of the support schemes applied by the member states, concluding that they should establish a framework to provide conditions for support schemes in the EU. In his work he also identified some requirements in order to provide a good starting point noting that standardization between the support schemes in the EU is now mainly driven by state aid legislation and that the establishment of a new directive to clearly identify the conditions for the different support schemes applied in the EU could generate more legal certainty thus benefiting the economic performance of the support schemes. M. Z. Jacobsona and M. A. Delucchi (2011), analyze the feasibility of providing worldwide energy for all purposes from WWS - wind, water, and sunlight. Such a WWS infrastructure reduces world power demand by 30% and requires only 0.41% and 0.59% more of the world's land for footprint and spacing, respectively. The authors suggest producing all new energy with WWS by 2030 and replacing the pre-existing energy by 2050 adding that barriers to the plan are primarily social and political, not technological or economic and that the energy cost in a WWS world should be similar to the today's one (M. Z. Jacobsona, M. A. Delucchi, 2011). This article investigates the progress and challenges for decentralized electricity generation by palm oil biomass according to the overall concept of SD (Bamzy *et al.*, 2011). The increasing fossil fuel prices, its scarcity and the inevitable energy crises points the importance and necessity of changing the current system of production and consumption of energy and replacing fossil fuels with RE resources to meet future global energy needs for survival, evolution and development" Narciss Aminrashti and Cyrus Hezhabri (2012). The authors evaluate the impact of RE and on SD, recognizing the status of renewable energies in electricity production and achieving SD, through using "a panel data -

fixed effects" approach for a period of 7 years (2001-2007). "The findings of this study show that the variables in the model, the expectations are that there is a connection between RE and SD, that RE in terms of technical, environmental and economic benefits plays an important role in the world's future energy combination and that renewable energies are one of the most effective and influential ways on developing sustainable energy (N. Aminrashti and C. Hezhabri, 2012). Bhutto *et al.,* (2012), investigate the progress and challenges for solar power in Pakistan according to the overall concept of SD, and identifies the regionwise potential of solar power in Pakistan and its current status and examines barriers over the whole solar energy spectrum and policy issues and institutional roles and responsibilities are discussed (Bhutto *et al.,* 2012). Hasan *at al.* (2012), note that although Indonesia encourages utilizing renewable energy, its share is only 3%. Nevertheless, the country has a great potential of RE such as solar energy, wind energy, micro hydro and biomass energy; the government must pay more attention on how to utilize RE. Besides the many efforts that have been done to promote RE such as to create energy policy and regulations, yet it still did not give any satisfactory result, reason why, Government, non-government agencies and the public should be more proactive in order to promote and use RE in order to achieve the secure and environmentally sustainable energy resources (Hasan *at al.,* 2012). Palmas *et al.,* (2012), proposed a method to assess changes and to identify the best solution in terms of SD. In methodological terms the evaluation of spatial variations in the available energy potential was based on the combination of existing methods adapted to the local scale and data availability, in assessing the bioenergy potential, a new method was developed and other environmental criteria for deciding about sustainable locations were identified through a survey of more than 100 expert respondents. This survey involved pairwise comparisons of relevant factors, which were then translated into relative weights using the Analytical Hierarchy Process. Subsequently, these weights were applied to factor maps in a Geographical Information System using a weighted linear combination method. In the eastern metropolitan area of Sardinia, Italy, this analysis resulted in the designation of proper areas for new settlements and preferred locations for micro-renewable technologies. Based on expert preferences, a number of alternatives for future housing development were identified, which can be integrated in the early stages of land use or development plans. The method proposed can be an efficient tool for planners to assess changes and to identify the best solution in terms of SD (Palmas *et al.*, 2012). Alam *et al.,* (2013), tried to highlight the development of RE usage in Malaysia as well as in the world, addressing initiatives taken to nurture the development of sustainable energy in Malaysia. As the country is well rich within its huge potential of the use of sustainable natural resources due to an extremely moderate climate around the year, the authors conclude that a minor adaptation and mitigation strategies need to be taken to push a popular and effective use of safe and renewable energy, that it is necessary to develop a proper plan by the local government as well as the central government of Malaysia for the SD of RE in Malaysia expecting to garner a better understanding of how the topic of RE can be better reflected as a growing and strengthening filed of research (Alam *et al.*, 2013). As pointed by Baltierra *et al.*, the aim of this work is to analyze the political, regulatory, economic and technical issues that have determined the use of primary energies for power generation in Mexico from 1965 to 2008, and its perspectives for the next 10 years, in particular the prospects of using renewable energies. In the 1960's, hydro was the preferred source of energy to produce electricity for economical and technical reasons. Under the oil boom in the 1970´s, the transition to hydrocarbons resources (fuel oil) was progressive. As a result of implementing environmental policies, electricity has mainly been generated with natural gas since the early 2000. In the last years, the Mexican Government has adopted new policies to extend use of renewable energies. For the period 2010-2020 and by virtue of recently adopted policies, renewable energies would increase in the Mexican generation portfolio, while the natural gas would continue to dominate the energy scene. A. M. Omer (2013), notes that the increased availability of reliable and efficient energy services stimulates new development alternatives discussing the potential for such integrated systems in the stationary and portable power market in response to the critical need for a cleaner energy technology. Anticipated patterns of future energy use and consequent environmental impacts (acid precipitation, ozone depletion and the greenhouse effect or global warming) are comprehensively are also discussed. Throughout the theme several issues relating to renewable energies, environment and SD are examined from both current and future perspectives, concluding that renewable environmentally friendly energy must be encouraged, promoted, implemented and demonstrated by full-scale plan especially for use in remote rural areas (A. M. Omer, 2013).

4. CONCLUDING REMARKS AND POLICY RECOMMENDATIONS

This article intents to discuss the RE and SD problematic taking in account that the traditional fossil fuels, that dominate the international supply market since long time ago, are more and more expensive - due to the expensive costs of exploration and exploitation, namely in profound sea; they also verify a very high degree of depletion and are responsible for almost all of the quantity of pollution that is sent to the atmosphere, either CO_2, NOx,…, reason why they are responsible for the worldwide climate change and global warming.

The United Nations Millennium Development Goals are eight goals that all 191 UN member states have agreed to achieve by the year 2015. The United

Nations Millennium Declaration, signed in September 2000 commits world leaders to combat poverty, hunger, disease, illiteracy, environmental degradation, and discrimination against women. The MDGs are derived from this Declaration, and all have specific targets and indicators (MDG, 2013).

The success of the Montreal Protocol shows that action on climate change (the eight UNDP Millennium Development Goal "Ensure environmental sustainability" is within grasp: the 25th anniversary of the Montreal Protocol on Substances that Deplete the Ozone Layer came in 2012, with many achievements to celebrate. Most notably, there has been a reduction of over 98% in the consumption of ozone-depleting substances. Further, because most of these substances are also potent GHG, the Montreal Protocol has contributed significantly to the protection of the global climate system (UNDP, 2013). The reductions achieved to date leave hydrochlorofluorocarbons (HCFCs) as the largest group of substances remaining to be phased out. Given the Protocol's successful track record, and status of universal ratification, governments have been considering an amendment that would take on HFCs, a class of global warming chemicals that are often used as substitutes for certain ozone-depleting substances. The parties to the Protocol are now hoping to achieve universal ratification of all of the Protocol's amendments as well. Failure to ratify all the amendments by the end of the year could lead to the imposition of trade sanctions on non-parties, which in turn would preclude them from procuring HCFCs needed for a measured, thoughtful phase-out (UNDP, 2013).

The article made an overview of several aspects of renewable and sustainable energy (RE) and SD, the UNDP and the MDG, the interactions between RE and SD, RE and social and economical development, the contribution of RE to reduce the rate of exhaustion of fossil fuels, the SD aims for RE and their indicators, the social and economic development and the contribution of RE to safe energy appraisal and secure access to clean energy (including for those living in the rural areas), the reduction of RE and SD to climate change mitigation and global warming of the planet, RE and the cutback of environmental and health impacts.

The paper also presents a literature review of recent articles published by the main renewable and sustainable energy journals, especially those that have a higher impact factor.

The article concludes that renewable environmentally clean and friendly energy must be encouraged, promoted, implemented and demonstrated by full-scale plan all over the world. These create new jobs for young people, reduce the GHG emissions of CO, CO_2, SO_2, NOx effluent gas emissions, frame the planet global warming, mitigate climate change and produce clean and safe energy distributed to all human beings. These goals can be developed in the rural and isolated areas, and preserve resources for future generations in respect to the principles outlined by "Our Common Future" also known as "Brundtland or Founex Report", published by the World Commission on Environment and Development (WCED, 1987).

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