ENERGY INDICATORS: CRUCIAL TOOL TOWARDS SUSTAINABILITY ASSESSMENT

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KEYWORDS

Sustainable Development, Energy Indicators, Renewable Energy Sources

ABSTRACT

Energy has been considered an intrinsic factor to attain Sustainable Development (SD). However, it has not always been viewed, projected or recognized within sustainability's scope. To address this issue, the use of indicators, namely Energy Indicators for Sustainable Development (EISD), allows to convey to policy-makers multidimensional implications of energy related decision-making. Besides contributing to assess current energy trends at a national level, this tool, contextualized within a country's economic and energy mix, allows to establish a comparison between different countries. This effectively contributes to identifying common concerns and strategies to overcome barriers towards sustainable development. This paper compares the path to SD in Portugal and Brazil by making use of the EISD framework.

KEYWORDS

Energy Indicators for Sustainable Development (EISD), Sustainable Development, Renewable Energy Sources (RES).

INTRODUCTION

Energy has been considered an intrinsic factor to attain Sustainable Development (SD), being internationally recognized as a driving force to reduce worldwide disparities, contributing to boost economic and social aspects, hence improving overall living standards (Ferreira, 2007; Vera and Langlois, 2007; Vera, Langlois, Rogner, Jalal and Toth, 2005). In this sense, countries need to develop new strategic approaches to energy and energy planning, where redirecting and realigning them with SD goals should be a major objective (Vera and Langlois, 2007). Yet, energy development has not always been viewed, projected or recognized within the scope of sustainability.
The role of energy within the sustainability concept has suffered many changes, and more specifically the perception of energy has evolved over time, becoming more holistic. This progress becomes quite patent when considering energy and energy planning using a SD perspective. The need to adopt a more integrative approach to energy planning by incorporating environmental, social and economic aspects into decision-making process is a tendency that tends to replace decision-making exclusively based on economic premises (Ferreira, 2007). This shift is perfectly attuned with the concept of sustainability, emphasizing interaction between society and surrounding natural environment (Environmental Protection Agency (EPA), 2012), while meeting current needs without jeopardizing the needs of future generations (Singh; Murty; Gupta and Dkshit, 2009; Ferreira, 2007; Sheinbaum-Pardo; Ruiz-Mendoza; Rodríguez-Padilla, 2012; and Mainali; Pachauri; Rao, and Silveira, 2014). Notwithstanding, in spite of this acknowledgement, current energy system reflects unsustainable patterns (UN as cited in Vera et al., 2005; Ferreira, 2007; Streimikiene, Ciegis and Grundey, 2007; and EPA, 2012) with repercussions for achieving sustainable development objectives.
Despite early recognition of energy's vital role within SD, worldwide energy gap has been continuously increasing, showing conflicting trends. Along with an increase in world energy demand (estimated between 27% and 61% by 2050) there is still a significant percentage of people without basic energy needs (WEC, 2013). According to Kaygusuz (2012) and WEC (2013), projections estimate that up to 1.2 billion people will continue to not have access to electricity services in 2030, whereas 2.8 billion will endure lack of access to clean cooking facilities. This paradox is aligned with Bierbaum and Matson (2013) perception of energy as an essential factor for development while yet being, to a large extent of the population, still a mere aspiration, consequently turning it into a challenge in terms of sustainability. This challenge is exacerbated by the unpredictability of current energy policy trends, where

technological improvements can contribute either to shift energy policies towards fossil fuels or renewable energy sources (RES). Regarding this issue, WEC (2013) emphasizes pivotal role played by energy policy makers, potentially instigating or preventing access to sustainable energy systems. Therefore a sustainably driven decision requires an understanding of different implications of energy policies on social, economic and environmental dimensions (Vera et al., 2005; and Vera and Langlois, 2007).

Therefore, as a result of increasing recognition of pivotal role of energy to achieve SD goals, a series of international institutions [International Atomic Energy Agency (IAEA) in cooperation with International Energy Agency (IEA) and United Nations Department of Economic and Social Affairs (UNDESA), the Statistical Office of the European Communities (Eurostat) and the European Environment Agency (EEA)] joined efforts to develop a set of Energy Indicators for Sustainable Development (EISD) with worldwide applicability (Vera and Langlois, 2007; Abdalla, 2005; Vera et al., 2005 and IEAE, 2005). By accounting for socio-economic and environmental nexus, EISD framework contributes to integrating the concept of sustainable development into energy policy (Streimikiene et al., 2007). According to Abdalla (2005) this initiative filled a gap by developing a globally standardized energy focused indicators, totalizing 30 EISD, classified into 7 themes and 19 subthemes distributed within social, economic and environmental dimensions (Vera and Langlois, 2007).

This study assesses the potential applicability of EISD framework to the Portuguese energy sector, verifying its compatibility with national energy indicators. This analysis took into consideration main international (e.g. EU level) and national energy policy concerns, cross-referencing them with SD principles, emphasizing common underlying themes throughout sustainability dimensions and contributing to determine focal EISD. Once, core indicators have been identified in accordance to main policy priorities, reflecting both its objectives as well as its main concern areas, adequacy of national statistical basis was verified, allowing to determine existence of potential data barriers towards apllicability. Besides contributing to assess current energy trends at a national level, this tool, contextualized within the country's economic and energetic matrix allowed, as emphasized by IEAE (2005), to establish a comparison between Portugal and Brazil, enhancing energy system's inherent discrepancies.

This paper is organized as follows. Section 2 focuses on the importance of indicators as tools for assessing progress towards sustainability goals. Section 3 establishes the applicability of EISD framework to Portuguese energy context. Section 4 features relevant themes for a cross-country application of EISD taking into consideration identified energy policy concerns. The final section draw the main conclusions of the paper and presents future lines of research.

ENERGY INDICATORS FOR SUSTAINABLE DEVELOPMENT (EISD)

The recognition of the relevance of indicators to inform decision-making with regard to SD has been associated to increasing international exposure of energy subject, along with its acknowledgment as a key factor towards deployment of SD objectives (Vera and Langlois, 2007). Its increasing importance is therefore associated with shifts in perception of the role of energy and power planning. Contrasting with traditional energy planning, integrated energy planning incorporates all dimensions of sustainability aligning it with sustainable development concept. As this shift takes place, new tools and methodologies are required to integrate supply and demand options and, in order to promote an accurate integration of available alternatives, it is necessary to contemplate different aspects of energy use within economic, social and environmental dimensions. Hence, within this context, indicators can be a useful tool, promoting communication between stakeholders regarding energy issues and sustainable development (Vera and Langlois, 2007 and Vera et al., 2005). By providing means to clarify statistical data, energy indicators elucidate different aspects affecting energy, environment and socio-economic welfare and their intricate connections, allowing to establish causality nexus that would be otherwise overlooked (Vera and Langlois, 2007 and Vera et al., 2005). Furthermore, besides monitoring implementation of sustainable policy strategies (Vera and Langlois, 2007, Vera et al., 2005 and Abdalla, 2005), it allows establishing a comparison between different countries, enhancing energy system's inherent discrepancies (IEAE, 2005).

EISD framework is energy focused, contemplating for instance, through energy prism, social, environmental and economic issues, evidencing that indicators are not independent. Although initially considering four main dimensions of influence (economic, social, environmental and institutional), practical refinement of this tool implied the abandonment of institutional indicators due to their qualitative and hardly quantifiable nature (Vera et al., 2005 and IEAE, 2005). Notwithstanding, as illustrated in Figure 1, in practice these four dimensions are still connected, since institutional dimension is no longer viewed as an input to the system's assessment but as a response, validating interconnectivity and cause-effect nexus. Environmental dimensions suffers pressure from both social and economic dimensions, which in turn create the conditions for the evolution of economic and social dimensions, triggering a response from institutions through the development of corrective policies affecting all previously mentioned dimensions (Vera et al., 2005 and IEAE and UNDESA, 2007). Regarding this issue

IEAE and UNDESA (2007) further state that despite this shift of framework, determination of cited causality and interrelationships are at the core of this sustainable development assessment tool.

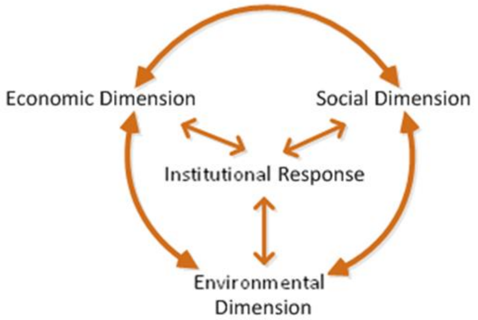

Figure 1- Sustainable Dimensions Interaction (Based on: Vera et al., 2005 and IEAE and UNDESA, 2007).

Vera et al. (2005) and IEAE and UNDESA (2007) identified main issues within each of these dimensions with the purpose of defining universal energy indicators.

Social Dimension

Energy’s connection to social dimension is unequivocal, since its accessibility in a secure, reliable and affordable manner determines, whether directly or indirectly, overall social welfare. The extent of this interconnectivity and multiplicity of its implications was exposed by Vera et al. (2005, p. 276) and Vera and Langlois (2007, p. 878), allowing to draw a comparison between developed and developing countries on subject matters as diversified as “poverty, employment opportunities, quality of life, education, demographic transition, indoor pollution, health and gender and age-related” issues. This reflects simultaneously how universal access to modern energy services shapes crucial aspects of every day life, that are sometimes taken for granted, and the need to achieve sustainable development worldwide. Indicators featured within this dimension are divided into equity and health themes, with sub-themes such as accessibility and affordability to modern energy services (see Annex 1). These are considered crucial to achieve SD goals by contributing to extinguish poverty while promoting social and economic development.

Economic Dimension

Relevance of modern energy services, and particularly electricity, in fostering economic growth while promoting social and environmental improvements, made several authors (Cima 2006, Vera and Langlois, 2007, Vera et al., 2005 and Abdalla 2005) view energy availability and accessibility as crucial issues that should be taken into consideration in the energy planning process. Energy indicators within this dimension are divided into use and production patterns and security of supply (see Annex 1). According to these main aspects, they are sub-divided into the following sub-themes: overall use and productivity, supply efficiency, production, end use, fuel mix and prices and dependency on imports and strategic fuel stocks for security of supply (Vera et al., 2005). These indicaotrs aim to determine how overall energy and its national status and trends affect economic development and potentially redirects it towards sustainability.

Environmental Dimension

Widespread environmental awareness, has resulted in greater prominence of environmental issues, which were progressively featured and integrated in national development policies, such as the case of the energy sector (Antunes, Santos, Martinho and Lobo, 2003). This entails in a multiplicity of impacts that can be ascribed throughout energy's life cycle, which varies greatly according to technology and ultimately affects different natural resources on multiple levels. Environmental effects resulting from energy production, transport and use should not be neglected, potentially raising climate change, deforestation and resource depletion issues (Vera and Langlois, 2007). Therefore, energy indicators within this dimension (see Annex 1) focus precisely on energy-related impacts on the atmosphere, water and land (Vera and Langlois, 2007).
The indicators associated with the economic, environmental and social dimensions are listed in Annex I.

APPLICABILITY OF THE EISD FRAMEWORK TO THE PORTUGUESE ENERGY CONTEXT

Applicability and implementation of EISD on a national level is a country-specific process, requiring informaion about the inputs to the energy system and the identification of national energy and sustainability priorities. This requires an adequate, consistent and available statistical energy database (Vera and Langlois, 2007). Effectively, convergence between main national objectives, political guidelines and the main principles underlying EISD application facilitates the identification of a set of indicators more apropriate for a national context within each sustainability dimension, as illustrated in Figure 2 (see Annex I). Largely because, for the case of Portugal, main national energy priorities (e.g. entailing a reduction of foreign energy dependence, promoting energy efficiency and CO_2 emission reduction – DGEGa, 2014) are shaped by European Union (EU)’s energy strategy. Consequently, as Vera and Langlois (2007) emphasized, there is an alignment between core energy indicators and policy priorities that might become useful to promote future monitoring of progress towards sustainability goals.
Taking into consideration the previously mentioned complementary nature, national statistical database can serve as basis for an EISD sustainability assessment.

Portuguese energy system is a reflex of the current socio-economic context. It is characterized by a very pronounced dependency on external energy sources, a high economic energy intensity and an increasing incorporation of RES into the energy matrix. Current concerns regard energy use patterns that are illustrated in both Figures 3 and 4, which depicts energy use per capita (ECO1) and energy use per GDP (ECO2), respectively. These indicators reflect the relevance of energy, and particularly electricity, for socio-economic welfare. Although, as shown in Figure 3, electricity consumption has grown substantially in recent years, that is not driven by increasing population, simultaneously implying an improvement of quality of life as well as a substantial increase in resource consumption, and adverse environmental effects from energy production and use. Resorting to RES incorporation in energy mix contributes towards SD goals, improving environmental aspects of energy consumption and use.

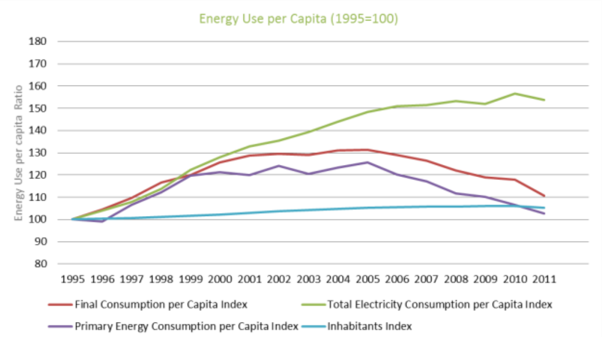

Figure 3- Energy Use per Capita (source: DGEG, 2014).

The recent socio-economic recession is also patent in Figure 4, illustrating energy intensity, portraying the relationship of energy use to economic development. Both primary and final energy consumption have peaked in 2005 and have since then declined, contrasting with electricity consumption, which shows an increasing consumption trend towards 2012 while GDP and energy consumption decreased. This reflects the recent economic crisis and points towards an unsustainable electricity consumption trend that may have social and environmental repercussions. Notwithstanding, according to IEAE (2005) there is room for improvements in energy efficiency and decoupling of energy consumption and economic development, which could contribute towards sustainability.

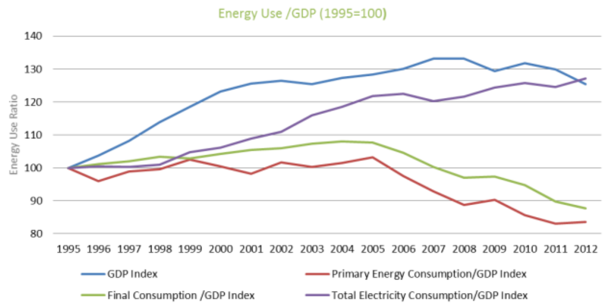

Figure 4- Energy use per GDP (source: DGEG, 2014).

Other major concern regarding the energy system is foreign energy dependency. This indicator is of extreme importance, since external energy dependency is one of the major energy challenges that Europe, in general, and Portugal, specifically, have to contend with. It has numerous implications on economic and environmental dimensions. Therefore, it is measured by an EISD, namely, the Net Import Dependency Indicator (ECO15). According to IEAE (2005, p.83) it reflects "the extent to which the country relies on imports to meet its energy requirement".

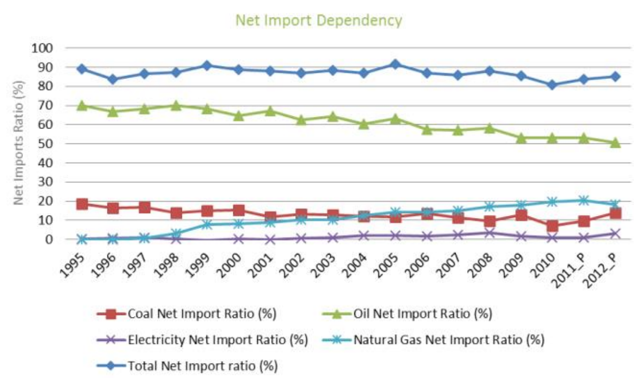

Figure 5- Evolution of Net Import Dependency. (source: DGEG, 2014)

National key statistics show a high external energy dependency, where dependency on oil prevails. However, a decreasing trend in favour of natural gas and also coal, in 2012. The later was due to an adverse hydrological period that affected hydropower production. The observed high vulnerability to conventional energy sources, such as oil, and more recently natural gas, can be limited, however, by adoption of policies that stimulate domestic energy production, diversify the energy mix and increase energy efficiency (IEAE, 2005).

Despite the main national domestic energy sources being of renewable nature, namely hydropower, national energy system is still largely dependent on fossil fuel, namely oil and coal. In order to revert this trend, the Portuguese Environmental Agency (APAa) (2013) further states that increasing incorporation of RES is required to simultaneously contribute to diversifying national energy mix, as portrayed in Figure 6.

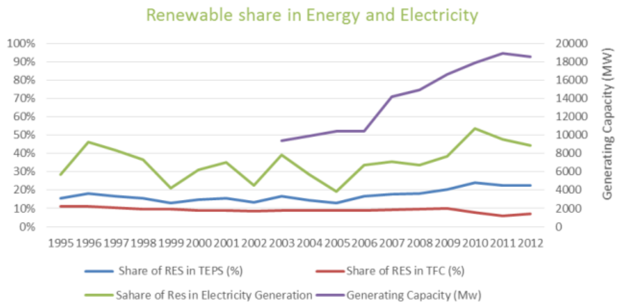

Figure 6- Evolution of RES share in energy and electricity (sources: DGEG, 2014 and REN, 2014). Note: Generation capacity information only available since 2003.

Although there has been a recent decrease in electricity production from RES (see Figure 6), essentially due to climatic reasons, the Portuguese domestic energy production is essentially renewable based. In spite of this decrease, in 2011 Portugal was considered the third country within EU-15 with the greatest incorporation of RES in electricity production (APA, 2013), making an important contribution towards sustainability, while increasing energy security grounded on RES based diversification of energy mix and reducing energy related environmental impacts.

ELECTRICITY SECTOR: RELEVANT THEMES UNDER EISD FRAMEWORK

Despite the analysed countries – Portugal and Brazil - being inserted in different geo-political and economic contexts, a comparative analysis of each conutry's electricity sector is not only possible but desirable. For Portugal, similarly to remaining EU countries, the 2020 Strategy answers the current need to adopt an energy model that promotes a more efficient and sustainable use of energy, simultaneously contributing to reduce foreign energy dependency and mitigate climate change (Sustainable Economy Act, Law 2/2011). Overall it envisages on a European level, 20% GHG emission reduction, considering 1990 level; 20% of energy from RES in final energy consumption, and a reduction of 20% of primary energy consumption, from 2007 baseline (Council of Ministers Resolution, n.º 20/2013). Current Government has strived for implementation of an energy model based on economic rationality and sustainability principles, through adoption of energy efficiency measures and use of endogenous energy sources, as well as a reduction of additional costs that increase energy price.

Portuguese Government further states that among its main objectives is the reduction of GHG emissions in a sustainable manner, along with reinforcement of diversification of primary energy mix, hence increasing the country's security of supply (ADENE, 2014). This strategic approach also envisages measures beyond the supply side, focusing on an efficient use of energy resources, which contributes to improving economic competitiveness through reduction of consumption and costs (ADENE, 2014)., This, in turn, releases resources for new investments, hence stimulating internal demand. These concerns have been translated into lines of action by developing a set of plans and programs, among which: the Action Plan for Renewable Energy (PNAER); the Action Plan for Energy Efficiency (PNAEE); and the Program for Energy Efficiency in Public Sector (ECO. AP). Meanwhile, PNAER, establishes main national goals and guidelines regarding share of renewables incorporated in transportation, electricity and air conditioning sectors, ensuring accomplishment of both energy and climate change goals at national and international level. Among which ensuring by 2020 that "31,0% of RES in final energy consumption, 55,3% in electricity production, 30,6% in air conditioning and 10,0% in transportation" (INESC Porto and AT Kearny, 2012). In spite of this, above cited authors (INESC Porto and AT Kearny, 2012) also emphasize a complementary set of goals aiming to reduce external energy dependency by 74% in 2020, resorting to RES; reduction of 25% of net imports, entailing a reduction of imports estimated in 60 million barrels of oil; development and consolidation of clusters promoting RES technologies. These measures promote SD by ensuring accomplishment of goals regarding GHG emissions, through the use of RES and energy efficiency (INESC Porto and AT Kearny, 2012). Although set in a different socio-economic context, Council of Ministers Resolution, n.º 20/2013 advocates a joint revision of both plans in order to ensure accomplishment of both socio-economic and environmental objectives. Namely by realigning reduction of primary energy consumption and contribution of the energy sector towards GHG emission reduction, further contributing to make options about investment in energy efficiency or in RES a clearear decision.

Although not within the EU context, Brazilian energy system also establishes environmental protection and energy conservation as major goals within National Energy Policy (Law nº 9.478, 6 August 1997), requiring an energy model that contemplates, among other objectives, energy security; universal accessibility and affordability as well as diversification of energy mix (Junior, 2012). Given this policy overview, common concerns among both OECD and non-OECD countries enhanced the need to diversify national energy mix, constituting a mutual objective between Portugal and Brazil. Although resulting from different policy frameworks, these countries have a confluent perspective for its accomplishment, envisaging complementary actions on both supply and demand side, namely through investment in RES and promoting end-use efficiency. Regarding this issue, Cima (2006) further underlines an alignment between these two suggestions and sustainability purposes. RES deployment is considered a crucial contribution to reduce external energy dependency, while simultaneously promoting environmental and energy sustainability. Energy efficiency, in turn, contributes towards a better use of available resources (see Geller as cited in Cima, 2006). Notwithstanding, despite overall common targets, diversification requires a country level approach, given that different countries possess different endogenous resources. Regarding this issue, and largely reflecting electricity generation composition, final energy mix will never result from a combination of different alternatives in a unique solution, since there is a multiplicity of pathways to low carbon economy. The final composition of a country's energy mix will, therefore, be determined by a combination of several factors among which "political choices, market forces, available resources and public acceptance" (Ristori, as cited in European Comission (EU, 2011b, p.24). Therefore, given these converging points within different countries' energy strategies, the energy comparison here presented will focus on main concern areas encompassing energy intensity and energy dependence, in view of the abovementioned interconnection to RES deployment and efficiency. Ultimately, the EISD analysis should help policy makers to ponder different energy sources based on a sustainability perspective encompassing different dimensions. This analysis can, therefore, help assess the consequences regarding safety, security and affordability of energy supply.

Overall regarding the share of RES in electricity generation, a trend was identified among the two countries that is in line with abovementioned context. For the featured countries it was observed a progressive reduction in oil contribution to electricity generation and a progressive increase of natural gas and non-carbon renewables, including hydropower, as well as other RES sources namely wind, biomass, and solar. This progression relates to the main aspects regarding energy within sustainability scope, encompassing diversification of energy mix through the increase of non-carbon and renewable alternatives having positive repercussions at "environmental, security and diversification of supply" levels. Both focused countries (Portugal and Brazil) revealed dominance of hydropower within RES, as illustrated in Figures 7 and 8.

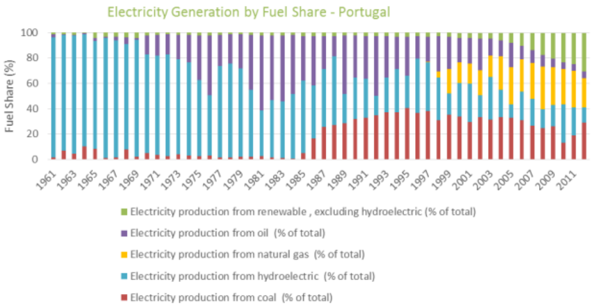

Figure 7- Electricity Generation by Fuel Share in Portugal. (Source: World Bank, 2014)

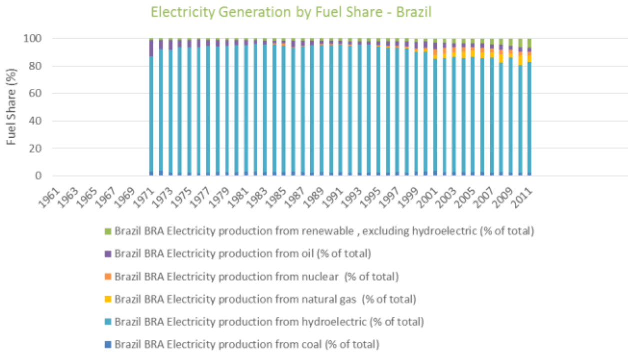

Figure 8- Electricity Generation by Fuel Share in Brazil. (Source: World Bank, 2014)

Despite Portugal's commitment towards renewables being considered as a significant contribution towards system's diversification and sustainability (MEID, 2010) and of the significant contribution from hydropower and wind power, the Portuguese energy mix still presents a significant external dependence in fossil fuel (in Figure 9). Although recently there has been a decrease in both net imports and energy use, most likely associated with current economic recession and despite the increasing incorporation of RES in national energy mix, Portugal still requires contribution from fossil sources in order to fulfill its energy requirements. While Portugal has consistently presented high dependency values as a result of their lack of endogenous fossil fuels, as illustrated by Figure 9, Brazil presents a contrasting tendency, with the reduction in the dependency on foreign energy sources, coinciding with an increase in endogenous energy sources, resulting from a series of oil discoveries.

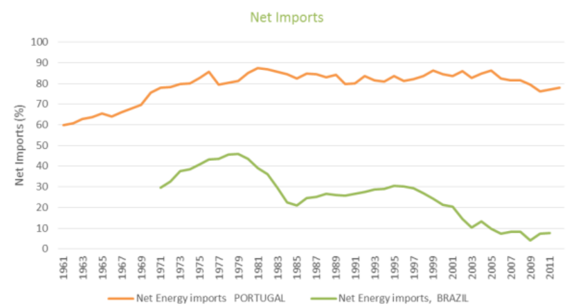

Figure 9- Comparative Net Imports Evolution (Portugal and Brazil). (Source: World Bank, 2014)

Investments in hydropower, fossil fuels and biofuels have increased significantly Brazil's capability to reduce external energy dependency while increasing supply (MME and EPE, 2007). Therefore, although Portugal has adopted several policies to decrease risks associated to import dependency, namely by promoting domestic energy production, resorting to RES, ultimately resulting in a more diversified energy mix comparatively to Brazil, still dependency rates were higher. This apparent contradiction is explained by two main factors, related to the nature of endogenous resources. Portugal's domestic resources are of a renewable nature, being considered intermittent energy sources, making energy systems highly dependent on climatic conditions as well as energy imports, to ensure security of supply. This necessarily implies in an increased foreign energy dependency. Whereas Brazil, despite being less diversified, presents lower net import dependency also as a consequence of the nature of their domestic energy sources, since as previously mentioned, the availability of petroleum resources and development of production has led to a sharp decrease in net import dependency and an increase in energy security. Notwithstanding, prioritizing investments in alternative energy sources has major repercussions not only on energy mix diversification and energy security but also on the environmental dimension, especially regarding the reduction of emissions associated with climate change. Regarding global warming, antropogenic emissions' resulting from energy sector constitute one of the greatest GHG emission sources, mainly CO_2 resulting from fossil fuel combustion (Lucena, 2006). In spite of this, progressive reduction is observed in both countries regarding GHG emissions (resulting from CO_2, CH_4 and NO_2) as illustrated by Figures 10 and 11. Although, on a worldwide level, due to larger share of renewables in national energy mix, Brazil tends to present lower emission rates (MME and EPE, 2007), despite being self-sufficient regarding fossil fuels, since 2006.

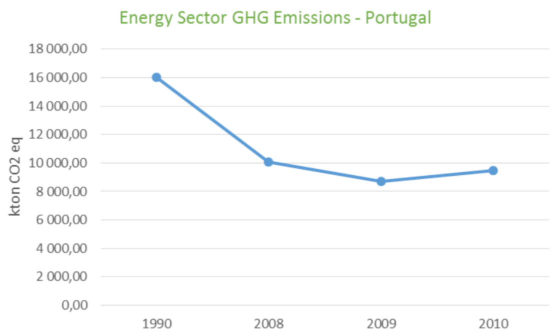

Figure 10- Evolution of GHG emissions in Portugal. (Source: APAb, 2014).

According to Joint Research Center (JRC) (2013) recent decrease in global emission trend points towards a paradigm shift regarding human related energy-use. Overall, a series of measures have been implemented aiming to promote sustainable development while accomplishing legal obligations regarding environmental protection (Antunes, et al., 2003), among which reduction of fossil fuels through the use of RES is emphasized. Regardless, JRC (2013) emphazisis despite increasing RES growth rate, fossil fuel consumption has not decreased either, further requiring implementation of previously mentioned policies, favoring progressive incorporation of natural gas and RES.

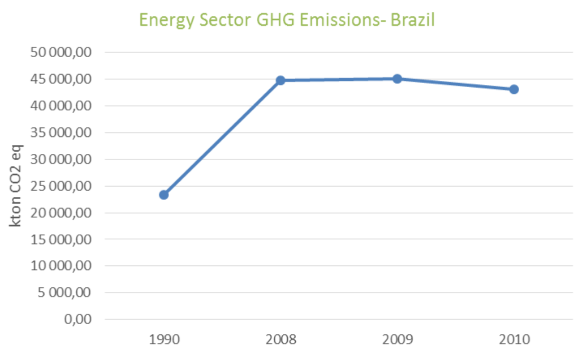

Figure 11- Evolution of GHG emissions in Brazil. (Source: Observatório do Clima, 2014)

The vital role of energy for socio-economic development has already been established in Vera and Langlois (2007). This interconnection is reflected in the energy intensity ratio, which establishes the energy required to promote development.

Therefore, as established throughout this comparative analysis, adoption of policies favoring energy efficiency should have positive reflections on electricity and energy intensity, since its use is associated to "technological progress, induced by economic growth and by modernization of installations in all sectors of the economy, thereby improving the efficiency of the energy system" (Ferreira, 2007, p.22). Furthermore, APA

(2013) claims that from the 2005 onwards, Portugal's energy intensity has decreased, attempting to reach EU's level. This decreasing trend from 2005 to 2009, visible in Figure 12, is associated with an efficiency gain motivated by technological improvements and rather modest investments in energy efficiency (Melo et al., 2013). The most significant drop, from 2010 onwards, is associated with several factors, from which Melo et al. (2013) highlight the economic crisis leading to a reduction in production and shut down of several activities, allied to increasing energy prices, making energy conservation and efficient measures appealing.

Effectively there is an overall tendency for a decrease in enery intensity which is a positive result, since less energy is used to generate wealth (GDP), as shown in Figures 12 and 13. This is the case of Portugal, as shown in Figure 12, where a progressive trend towards a reduction of energy intensity is registered. In spite of a decreasing trend, further end-use efficiency is challenging since it involves behavioral aspects rather than the technical adjustments realized in the previous period.

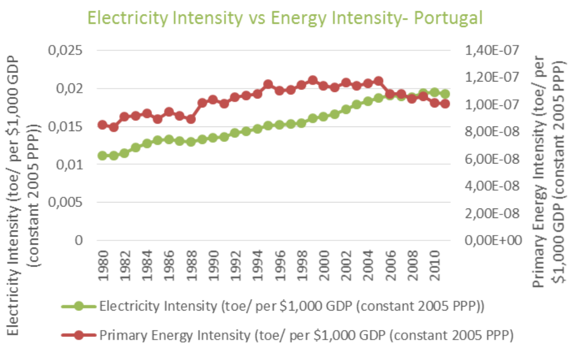

Figure 12- Electricity Intensity and Energy Intensity in Portugal. (Source: World Bank, 2014)

Brazil has, comparatively to Portugal, presented a fluctuating behaviour (see Figure 13) associated with both a better energy use and changes to production structure (MME and EPE, 2007). Overall, there has been a slight increase in the level of primary energy intensity after the 1990's associated with economic development. In terms of electricity, Brazil has constantly increased its energy intensity, which is a result of socioeconomic develpment and policies for the universalization of access undertook throughout the period. This result should not, however, be analyzed from a purely energy point of view, since, from the social and economic perspective, it constitutes an important improvement in social welfare and quality of life in lower income segments of the population.

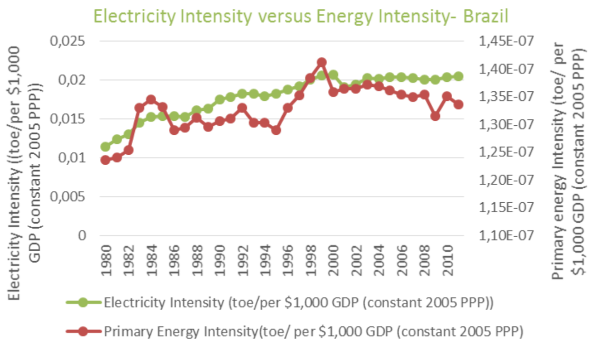

Figure 13- Electricity Intensity and Energy Intensity in Brazil. (Source: World Bank, 2014)

Overall, the need to integrate energy within sustainable development framework, has led countries to adopt different energy models based on international pledges and national energy policies in order to improve and achieve established goals, helping them to reduce foreign energy dependency through different available alternatives, increasing RES deployment and reducing energy consumption. Apodtion of energy driven indicators such as EISD, allows for this type of interconnective exposition, helpign to evaluate the causality nexus between policy sphere and different sustainability dimensions.

CONCLUSIONS AND FURTHER RESEARCH

Energy and particularly electric power have been rightfully considered at the core of SD. Notwithstanding, in order to ensure its sustainability it is necessary to promote an accurate and inclusive assessment, encompassing three main sustainability dimensions (social, economic and environmental) while promoting participatory approach from decision-makers. This requires an in-depth and multi-dimensional analysis to encompass multiplicity of linkages that characterize it, making the use of indicators a crucial tool in sustainable decision-making process. In this context, EISD framework has been suggested for being an energy focused indicator that provides means not only to clarify statistical data, but to help establishing causality nexus allowing to elucidate about different aspects related to energy's influence in multiple dimensions (Vera and Langlois, 2007 and Vera et al., 2005). However, the applicability and posterior implementation of EISD on a national level is a very country-specific process, entailing how complex and diverging energy systems can be. Overall national key statistics database seems to be consistent with the application of important EISD framework for assessing energy sustainability. This trend is supported by convergence between main national energy objectives and political guidelines and main principles underlying EISD application, facilitating identification of a set of indicators more apropriate for national context within each sustainability dimension. This enables as well cross-country assessment, facilitating identification of main common concerns and strategies to overcome barriers towards sustainable development. Universal energy sustainability assessment revealed among both OECD and non-OECD countries underlies common concerns regarding, for instance, diversification of energy matrix and resorting to RES deployment, which are converging strategies to achieve the mutual goal of sustainable development. Future adoption of EISD would allow improvements on several levels, contributing to a better understanding of the reasoning behind recent evolution of energy trends and its influence on different socio-economic and environmental segments. Improvements in the analysis sould be achieved by adopting a decomposition approach to energy intensity indicators. Such an approach would contribute to reinforce the basis for future decision making as a way to reduce energy system's existing concerns.

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ANNEX I

Table 1: EISD listing (Own Elaboration, Adapted from: Vera and Langlois, 2007 and Vera et al., 2005)

	Theme/Sub-theme	Initials	Energy Indicator
Social	**Equity**		
	Accessibility	SOC1	Share of households (or population) without electricity or comercial energy, or heavily dependent on noncommercial energy
	Affordability	SOC2	Share of household income spent on fuel and electricity
	Disparities	SOC3	Household energy use for each income group and corresponding fuel mix
	Health		
	Safety	SOC4	Accident fatalities per energy produced by fuel chain
Economic	**Use and Production Patterns**		
	Overall Use	(ECO1)	Energy use per capita
	Overall Productivity	(ECO2)	Energy use per unit of GDP
	Supply Efficiency	(ECO3)	Efficiency of energy conversion and distribution
	Production	(ECO4-5)	Reserves-toproduction Ratio Resources-to production ratio
	End Use	(ECO6-10)	Industrial energy intensities Agricultural energy intensities Service/comercial energy intensities Household energy intensities Transport energy intensities
	Diversification	(ECO11-13)	Fuel shares in energy and electricity Non-carbon energy share in energy and electricity Renewable energy share in energy and electricity
	Prices	(ECO 14)	End-use energy prices by fuel and by sector
	Security		
	Imports	(ECO15)	Net energy import dependency
	Strategic Fuel Stocks	(ECO16)	Stocks of critical fuels per corresponding fuel consumption
Environmental			
	Atmosphere		
	Climate Change	(ENV1)	GHG emissions from energy production and use per capita and per unit of GDP
	Air Quality	(ENV2-3)	Ambient concentrations of air pollutants in urban áreas Air pollutant emissions from energy systems
	Water		
	Water Quality	(ENV4)	Contaminant discharges in liquid effluents from energy systems including oil discharges
	Land		
	Soil Quality	(ENV5)	Soil area where acidification exceeds critical load
	Forest	(ENV6)	Rate of deforestation attributed to energy use
	Solid Waste Generation and Management	(ENV 7-10)	Ratio of solid waste generation to units of energy produced Ratio of solid waste properly disposed of to total generated solid waste Ratio of solid radioactive waste to units of energy produced Ratio of solid radioactive waste awaiting disposal to total generated solid radioactive waste

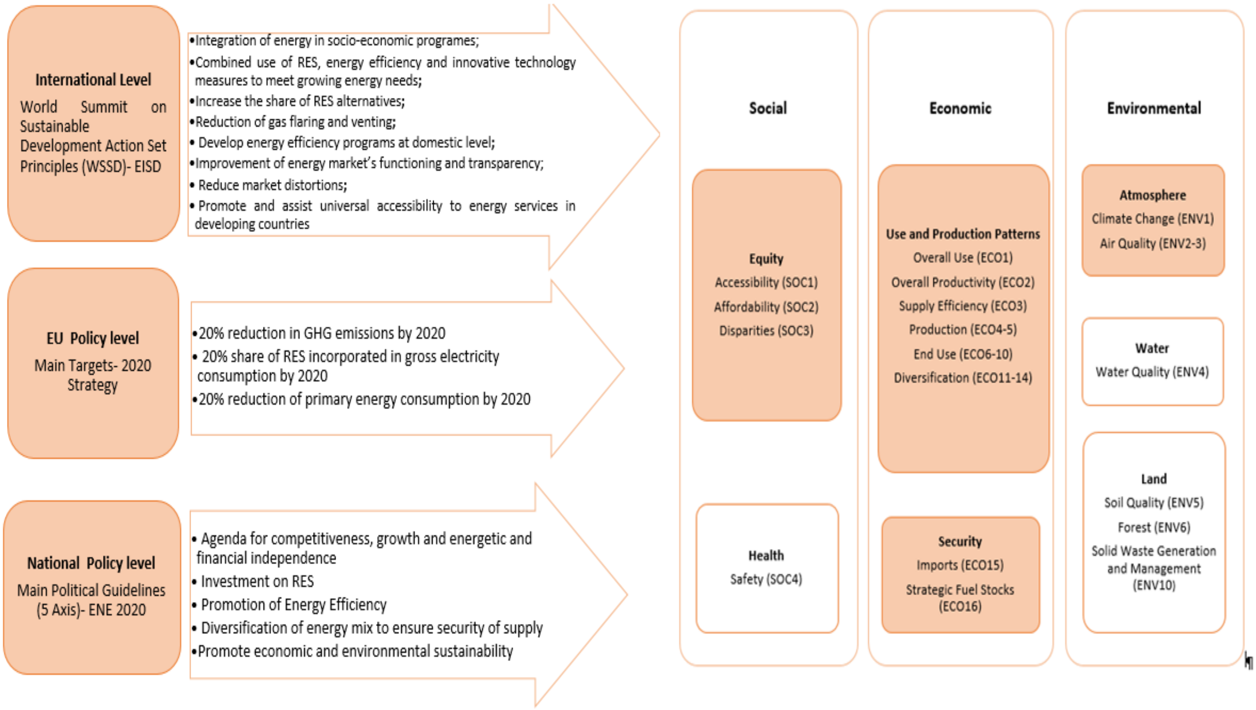

Figure 2- Convergence of Main International and National Objectives and Political Guidelines and Main Principles underlying EISD application. (Own Elaboration. Sources: DGEG, 1012 and Vera and Langlois, 2007)