SUSTAINABLE ELECTRICITY POWER PLANNING

The Social Dimension of Electricity Planning Decisions: A Literature Review from 2000 onwards

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Abstract: *Over the last decade, the EU members have been promoting structural changes in their electrical systems, in order to meet Kyoto and the 20-20-20 strategy goals imposing greenhouse gases (GHG) emissions cuts. However, the EU members also follow the so-called EU Sustainable Development Strategy (EUSDS), which underlines the importance of the social concerns, besides the economic and environmental ones. Given the complexity and the importance of the electricity sector, new planning models have to be formulated addressing these concerns. On this paper a number of theoretical aspects of the so-called Social Sustainability are reviewed. Also, the EUSDS indicator database is analyzed and linked to a survey of papers addressing the social aspects of electricity generation. Given the importance of public opinion for energy policy decisions, public perceptions on electricity technologies and related projects are also critically reviewed, as well as methodologies for channeling this information. Based on the collected information, we propose guidelines for future projects focusing on the social dimension of electricity related decisions.*

1 – Introduction

In 1997, the Kyoto Protocol was adopted. One decade later, the European Union proposed the so-called "20-20-20" package, which goals are (i) to cut in greenhouse gases (GHG) emissions to at least 20% below the 1990 levels, (ii) to reach 20% of renewables share in the energy mix and (iii) to cut 20% in primary energy consumption, until 2020. The electricity sector is of major importance for the energy decision makers, as it accounts with, roughly 20% of the total energy consumed in the aggregate of the 27 countries of the EU[1]. Also, it still relies mainly on fossil fuel power plants responsible for high GHG emissions. Although some of these older power plants are to be dismantled within the next decades, the consumption of energy is also expected to increase around 15% during this period (Commission 2008). Therefore, replacing and installing new power plants decisions integrating the social, economic and environmental impacts, or in other words, sustainable electricity power planning is a key issue for all the EU members. In the context of this study, electricity power planning shall be perceived as the process of (i) setting goals for the electricity sector, (ii)

[1] Data retrieved from http://epp.eurostat.ec.europa.eu/portal/page/portal/energy/introduction

designing strategies and policies and (iii) decommissioning and building infrastructures in order to achieve the proposed goals.

As a result of the uncertainty involved, with the economic conjuncture playing a major role, the planning of the electricity power system on a long-range term (10 or more years) is a challenging issue. For example, before the 70's, no big effort was placed on planning. This view substantially changed after the first oil crisis, at the level of searching for efficient supply options, based mainly on cost optimization objectives (Georgopoulou, Sarafidis et al. 1998). Later, in the 80's, as the public became aware of environment devastation, decision-makers started to include environmental issues on the models (Pohekar and Ramachandran 2004). The generalization of multi-criteria decision analysis (MCDA) methods gave planners the possibility to address other issues such as land use, human health and reliability of the system (Hobbs 1995) and allowed for the explicit integration of the social dimension of the decision making process (Ferreira, Araújo et al. 2010).

As time passes by, the share of energy generated in EU-27 from renewable energy sources (RES) is increasing and is expected to increase even more (baseline scenario indicate 17.4% in 2010, 20.2% in 2020 and 22.8% in 2030 (Commission 2008)). Some specific characteristics of these sources of power, namely, the fact of being spread over large geographical areas which coincides often with rural and underdeveloped areas, calls for planning models that can address both worries and opportunities for the affected populations.

Although the Kyoto Protocol and the 20-20-20 are important strategies for the EU, they must be framed in a broader picture, the EU Sustainable Development Strategy (see chapter 2). Although the literature related to energy often mentions “sustainability” or “sustainable development”, few works actually refer to its social aspects on electricity planning. Therefore, this paper aims to present a comprehensive and multidisciplinary review of the recent literature on this theme, focusing on (i) the concept of Social Sustainability and public perceptions of these technologies, both within the scope of the social sciences, (ii) the bridge between theory and practice, which relies mainly on institutional instruments (in this case, indicators), and (iii) planning and technical aspects, within the borders of engineering.

The remainder of the article is as follows: in chapter 2 the theoretical aspects of Social Sustainability are reviewed, presenting an overview of how these have been addressed in the literature, along with a brief exposition of the EUSDS; in chapter 3 the literature addressing the social impacts of energy generation is analyzed; chapter 4 presents some of the methodologies most frequently used to assess public acceptance of electricity generation technologies; based on the critical review of the literature, in chapter 5 guidelines for future research are discussed and proposed.

2 – Sustainable Development and Social Sustainability

Every citizen of the developed world has been increasingly faced with the expression “sustainable development”, whether it happens in the context of climate change, or when one gets conscious that some resources in which we base our society are finite. The most influential definition for sustainable development was presented in the Brundtland Report, where it is presented a pattern of resource use that “meets the needs of the present without compromising the ability of future generations” (Brundtland 1988).

It is widely accepted that Economy, Environment and Society are the three pillars for sustainable development**.** However, these pillars are often interconnected in real world situations. It should be reminded that Copenhagen’s goals address emissions of GHG, which, although related with social impacts (for example, health), is mainly an environmental aspect. No similar global conference exists proposing goals for Social Sustainability.

The European Union has addressed this issue and is monitoring its development in terms of Sustainability. The document of Declaration on Guiding Principles for Sustainable Development state that the European Union aims to “create a society which is based on freedom, democracy and respect for fundamental rights”, respecting the inter-generational principle already declared in the Brundtland Report. The means to achieve these goals include (Communities 2005):

> (i) Balanced economic growth, (ii) Price stability, (iii) Highly competitive social market economy, (iv) Full employment, (v) High level of education, (vi) Social progress, (vii) High level of protection and improvement of the quality of the environment.

Every two years, the EU issues a monitoring report to assess the current state of the Strategy, which compiles important indicators in the context of sustainable development, in a comparative way for its 27 member states. According to the

International Institute for sustainable development[2], an indicator quantifies and simplifies phenomena and helps us understand complex realities, by aggregating raw and processed data. According to the UN (UN 2007), indicators "can help incorporate physical and social science knowledge into decision-making".

The aim of this research on the official indicators is mainly to understand if and how social concerns have been translated to a more operational degree of sustainability assessment. The indicators can be integrated in tools to both aid decision-making on large scale policy and institutional problems, and to monitor its effects of the decisions taken and options selected. The electricity planning problem, being complex and strongly connected with sustainability concerns, is a clear example that can benefit from the effective implementation of these set of indicators and metrics.

The indicators presented in the 2009 report are obtained statistically[3] and cover ten themes (EUROSTAT 2009):

(i) Socioeconomic development, (ii) Climate change and energy, (iii) Sustainable transport, (iv) Sustainable consumption and production, (v) Conservation and management of natural resources, (vi) Public Health, (vii) Social inclusion, (viii) Demographic changes ,(ix) Global partnership and (x) Good governance

The interconnection between two pillars of the sustainable development is highlighted in the first theme, which addresses both social and economic issues. This is why the assessment indicators were divided in ten groups, and not the three which generally mentioned in sustainable development issues (Economy, Society and Environment).

At a general level, it is assumed that the "unsustainable trends described in the 2001 Strategy still persist" although the performances in the ten themes vary a lot.

Each theme, with the exception of "natural resources" and "climate change and energy" is resumed in one so-called "headline indicator". The only two themes which are assumed to be on target path are the "socioeconomic development" and "sustainable consumption and production". Close to target path are: "sustainable transport", "abundance of common birds" (headline indicator for "natural resources"), "public health", "social inclusion" and "demographic changes".

Far from target path are the "greenhouse gas emissions" and "consumption of renewables", both headline indicators for "climate change and energy". Even worse, assumed as clearly moving away from the target path, are the "conservation of fish stocks" (headline indicator for "natural resources") and "global partnership".

[2] From http://hostings.diplomacy.edu/baldi/malta2001/statint/Statistics_Int_Affairs-27.htm

[3] For more information, see http://epp.eurostat.ec.europa.eu/portal/page/portal/sdi/indicators

Other indicator databases exist. An example of national level is the SIDS[4] (*Sistema de Indicadores de Desenvolvimento Sustentável*) in Portugal, which also allows for regional and sectoral sustainability assessment.

The International Atomic Energy Agency (Agency 2005) has developed, together with the United Nations Department of Economic and Social Affairs (UNDESA) and the European Environment Agency (EEA), a set of indicators with the overall objective of revealing key figures of energy use and prices, relating them with economic activity, greenhouse gases emissions and social issues. The main aim of this project was the development of guidelines and methodologies for the development and worldwide use of a single set of energy indicators, ultimately useful for comparing countries' performances.

2.1– The concept of social sustainability

Some definitions of social sustainability are now presented, as well as some related questions posed in the literature, which highlight the special characteristics of the concept.

(Black 2004) states that social sustainability is the continuation of society in the future, implying the continuation of its social values, social identities, social relationships and social institutions. This concern for the future in the long run has also been expressed on (Biart 2002), definition: "[Sustainability] aims to determine the minimal social requirements for long-term development (sometimes called critical social capital) and to identify the challenges to the very functioning of society in the long run".

Social Sustainability is also underlined by (Polese and Stren 2000), as a "development (and/or growth) that is compatible with harmonious evolution of civil society, fostering an environment conducive to the compatible cohabitation of culturally and socially diverse groups while at the same time encouraging social integration, with improvements in the quality of life for all segments of the population". (Sachs 1999) state that "sustainability must rest on the basic values of equity and democracy, the latter meant as the effective appropriation of all human rights – political, civil, economic, social and cultural – by all people".

[4] Available in http://www.apambiente.pt/Instrumentos/sids/Documents/SIDS%202007/SIDS%20Portugal.pdf

In the perspective of (Griessler and Littig 2005) social sustainability is achieved “if work within a society and the related institutional arrangements (i) satisfy an extended set of human needs and (ii) are shaped in a way that nature and its reproductive capabilities are preserved over a long period of time and the normative claims of social justice, human dignity and participation are fulfilled”. However, the authors also recognize later in the same paper that suggesting “social sustainability indicators that are drawn from sociological theory is one story. To incorporate them into policy-making and to have an impact is another one.”

A topic which has received attention lately is the Corporate Social Responsibility (CRS), whose principles include the conduction of business in a way consistent with the morals and values of society, not necessarily reflected by the law. (See (Hutchins and Sutherland 2008) for a literature review in this matter).

More recently, (Colantonio 2009) argues that during the 90’s there was an emergence of new social concerns. Based in this assumption the author divides the key themes used on approaches to assess Social Sustainability in two categories:

- Traditional: (i) Basic needs, including housing and environmental health, (ii) Education and skills, (iii) Employment, (iv) Equity, (v) Human rights and gender, (vi) Poverty and (vii) Social justice.
- Emerging: (i) Demographic change (aging, migration and mobility), (ii) Social mixing and cohesion, (iii) Identity, sense of place and culture, (iv) Empowerment, participation and access, (v) Health and Safety, (vi) Social capital, (vii) Well being, happiness and quality of life.

The author argues that social sustainability is gaining recognition as a fundamental dimension of sustainable development. His work also demonstrates that monetization and accounting techniques, which exclude participation, still dominate sustainability tools. He also states that, besides the promotion of social capital, few tools for implementing that concept exist. Social capital, although mentioned, is still not a part EUSDS report.

Besides the array of definitions, the literature also addresses some inconsistencies, which arise from them. For example, questions raised by (Murray, Dey et al. 2007): “how long something must persist for it to be called sustainable?”, “and who’s counting?”

(McKenzie 2004) points also concerns with cultural issues as a basis for achieving social sustainability; and presents a feature of a social sustainable society: “a system of cultural relations in which the positive aspects of disparate cultures are valued and protected, and in which cultural integration is supported and promoted when it is desired by individuals and groups”. We might ask: is it possible to achieve overall agreement on which are positive aspects of disparate cultures, in a multicultural society?

As stated in (Harris, Wise et al. 2001) most of the sustainable development discourse has always been focused on environmental sustainability. The same study criticized the Brundtland Report as being too narrow on social aspects, making them coincide with poverty. According to (Benaim, Collins et al. 2008) “the social dimension seems overwhelming. Unlike the environmental and economic systems where flows and cycles are easily observable, the dynamics within the social system are highly intangible and not easily modeled.” Plus, as underlined by (Missimer, Robèrt et al. 2010) the researcher is part of the social system and as so he cannot observe as an outsider.

These arguments clearly bring the problem of knowledge on social sustainability at a distinct level of the knowledge on ecosystems or climatology, where the scientific community can achieve a certain level of agreement, constructing somewhat robust models for forecasting impacts.

Last but not least, actually a major issue, as (Murray, Dey et al. 2007) puts it: if social sustainability is about equity, whose notion of equity should prevail?

Although the process of operationalizing, measuring, monitoring and effectively incorporating in decision making processes the concept of sustainability is far from being consensual and scientifically exhausted, from this part of the literature review, some basic conclusions may be drawn:

(i) Social Sustainability is a multi-dimensioned theme and no satisfactory definition has been made, since none seems to be generally accepted.
(ii) Social sustainability aspects have been changing through time, although, if a hierarchic approach is to be made, “quality of life” should prevail on top.
(iii) Although the matter of time horizon of consideration in sustainability objectives is still not fully established, sustainability definitions always envisage the future generations’ wellbeing in the long term.

(iv) Environmental issues can affect the whole planet, so they demand global response; the main example is the Kyoto Protocol, where the scientific community gathered and defined goals in terms of GHG emissions. No parallel exists in the social pillar of Sustainability.

3 – The social dimension of electricity decision making process: Literature review from 2000

One of the hottest debates of our era is the transition to a low carbon economy. Two major issues cause this debate: on one hand, the financial crisis, which is seen by the World Bank as an opportunity to invest in a shift towards renewable energy in the electricity sector, with massive job creation (Bank 2010); on the other hand, the growing acceptance of anthropogenic global warming in the scientific community represented by the Intergovernmental Panel on Climate Change. Therefore, the World Bank vision claims that the economy should serve society in a better way, while the scientific community vindicate better environment. These visions, put together, simply ask for more balance in sustainable development.

Although slightly worse than the right path to achieve its goals (as mentioned in chapter 2), changes in the electricity sector are notorious in the EU. The percentage of electricity generated from renewable sources was 11.9 in 1990, 14 in 2005 and 21 in 2010.[5]

The structural change in the electricity sector involves changes in policy (the above mentioned 20-20-20 strategy), which reflects changes in national planning. Planning must address the impacts of the candidate technologies. For a review of the decision-making stages (criteria selection, weighting, aggregation) see (Wang, Jing et al. 2009). However, the authors have reviewed significantly less papers addressing social concerns than others which are definitely more present in the literature (technical, economic and environmental). Economic concerns were the main ones from the beginning of power systems planning when decisions had to be made, so economy tools have obviously been employed for a long time for example for the minimization of cost function, risk analysis or financial project evaluation. More recently, the consensus

[5] See http://epp.eurostat.ec.europa.eu/tgm/table.do?tab=table&init=1&language=en&pcode=tsien050&plugin=1 . The data is from the sum of the 27 members).

that emerged from the Kyoto Protocol resulted in goals set for each European country at the level of GHG emissions. Thus, it became urgent for decision makers to impose limits on power systems' emissions and, as a result, it became important to model these emissions. It is clear that, being the environment such a complex system, the ecologic pillar of the sustainable development is a wider theme than GHG emissions, but we can state that, to some extent, this pillar has also been addressed in a measurable way: GHG emissions function and its institutional restrictions. As stated in the previous chapter the social pillar is traditionally the weakest one; from the literature review, one is led to agree, since less papers address it and no clear institutional restrictions exist.

Table 1 demonstrates a survey of papers published since 2000, aiming to provide the variety of methodologies which supported the selection of social impacts to be included in each study. Table 1, below, indicates also how many impacts are chosen and how they are applied. See Annex I for the complete list of social impacts surveyed.

Table 1 - Survey of papers addressing social concerns in power systems decision-making

Reference	Methodology which led impacts to be considered	Number of social impacts considered	Brief study description	Subsequent models and methods (application of the impacts as criteria / indicators)
(Kowalski, Stagl et al. 2009)	Interviews with Energy experts, community councilors, NGO's. Scenario building	5	Comparison of RES technologies	MCDA (PROMETHEE)
(Kahraman and Kaya 2010)	Literature review	4	Comparison of RES technologies	MCDA (Fuzzy AHP)
(Karakosta, Doukas et al. 2010)	Collection of official indicators	2	Evaluation of energy policy guidelines	SWOT Analysis
(Roth, Hirschberg et al. 2009)	Collection of official indicators	6	Comparison of energy technologies	MCDA
(Gamboa and Munda 2007)	Interviews, including environmentalists, governmental and industrial stakeholders	6	Wind farm location problem	Social Multi-Criteria Evaluation
(Doukas, Andreas et al. 2007)	Group work of 25 actors from both public and private energy companies	2	Comparison of innovative energy technologies	MCDA [Linguistic ordered weighted averaging (LOWA) and Linguistic weighted operator (LWO)]
(Gallego Carrera and Mack 2010)	Literature review and Delphi Group process with energy experts	20	Comparison of electricity technologies	MCDA
(Ferreira, Araújo et al. 2010)	Literature review, interviews with energy experts and Delphi Group process	4	Comparison of electricity generation technologies	MCDA (AHP)
(Beccali, Cellura et al. 2003)	(Not explicit)	3	Comparison of renewable energy technologies	MCDA (ELECTRE III)
(Cavallaro and Ciraolo 2005)	Data set elaborated by the authors (experimental phase)	5	Wind farm dimensioning problem	MCDA (NAIADE)
(Evans, Strezov et al. 2009)	Literature review	10	Comparison of renewable energy technologies	Assumed equal weight for every criteria
(Vera and Langlois 2007)	Collection of official indicator	4	Construction of a sustainable development indicator dataset	-
(Assefa and Frostell 2007)	Literature review	3	Assessment of sustainability of energy technologies	ORWARE (Swedish technology assessment tool)
(Begic and Afgan 2007)	Literature review	2	Comparison of electricity generation technologies	MCDA (ASPID – Analysis and Synthesis of Index at Information Deficiency)
(Streimikiene and Sarvutyte 2010)	Literature review	4	Comparison of electricity generation technologies	Assumed equal weight for every criteria
(Alberts 2007)	Literature review	2	Evaluation of wind power impacts	Delphi Inquires
(Krajnc and Domac 2007)	(Not explicit)	3	Socio-economic and environmental impact modeling of biomass utilization	SCORE model
(del Río and Burguillo 2008)	Data set elaborated by the authors	13	Sustainability assessment of renewable energy projects in rural areas	Elaboration and comparison of case studies (empirical study)
(Werner and Schäfer 2007)	Literature review	3	Social Sustainability of a specific location solar-power project	Interviews and questionnaires in local community

Nineteen studies were reviewed. Annex I describes the collection of 101 impacts obtained from the literature review.

Three of the studies relied on an approach based on institutional indicators datasets ((Karakosta, Doukas et al. 2010), (Roth, Hirschberg et al. 2009) and (Vera and Langlois 2007)) . On the other hand, seven included participative methodologies to obtain field information – interviews ((Gamboa and Munda 2007) and (Ferreira, Araújo et al. 2010)), or group activities ((Kowalski, Stagl et al. 2009), (Gamboa and Munda 2007), (Doukas, Andreas et al. 2007) and (Gallego Carrera and Mack 2010)). The remaining ones either retrieved the required information from the literature, don't make that information explicit or the researchers themselves built the dataset.

The choice for the participative methodology highly depends on features of the project, e.g. aspects such as geographical scope, number of participants, budget and time-frame must be considered. For a complete review of these participative methodologies see (Kilgour, Chen et al. 2010). Although surveys and household interviews are not so common in this phase, as (Gallego Carrera and Mack 2010) recalls, the direct assessment of citizen's personal options may be preferable for some indicators, however this may be difficult to implement due to large frequently large amount of data that must be collected to obtain the intended results. Also (Figueira, Greco et al. 2005), underline that these participative methods are still usually costly and time consuming processes. Besides, it is rather probable that a random citizen overestimates the possible risks of one technology, as is not well informed (while believing he is) on technical issues such as the impact of the integration of a certain amount of installed power of a certain technology on the reliability of the whole electrical system. Thus, the population is represented by well-informed groups (NGO, community councilor and energy experts which are aware of the population attitude), which is the case of (Kowalski, Stagl et al. 2009) and (Gallego Carrera and Mack 2010).

Regarding the number of indicators or criteria chosen on each work, no conclusion can be drawn, since it is fairly independent of the methodology of acquisition of indicators, and depends more on the methodology of their application. For example, AHP relies on pairwise comparison, so it is particularly suitable for a controlled number of criteria.

From the total 101 of impacts, 66 could be directly related to others in the EU SD indicator database. The addressed themes were mainly socioeconomic development and public health (18 occurrences each), followed by conservation and management of natural resources (14 times). The most referred issues are employment, 10 times, change in land cover 8 times, production of toxic chemicals 7 times. Annoyance by noise is mentioned 6 times, income inequalities 5 and investment 4 times.

Other impacts, although not matching any of the EU sustainable development Strategy indicator database, could be associated with the concept of sustainable development. These are: (i) “political stability and legitimacy”, in the context of nuclear proliferation; (ii) “reliance on participative decision-making processes”, (iii) “mobilization potential” and (iv) “potential of conflicts induced by energy systems”. All these criteria are present in (Roth, Hirschberg et al. 2009).

There are some other impacts that, although not referring to sustainable development at least at an immediate level, can influence decision-making in electricity planning. Three distinct categories seem to emerge: Social Acceptance (9 occurrences), Technical Aspects (3 occurrences) and Risk Factors (11 occurrences). Market aspects are also evoked in some works, although these fall on the economic pillar of sustainable development (for example “market maturity” and “diversity of energy suppliers”).

Due to the complexity and conflicting objectives of the thematic involving social concerns, it was found that its application on decision-making falls mostly on MCDA: 12 of the studies use it, although no repetition of methodology happened, with the exception of Analytic Hierarchic Process (AHP) ((Ferreira, Araújo et al. 2010) and (Kahraman and Kaya 2010)). The literature on MCDA techniques is abundant, and a detailed description of electricity planning with MCDA may be found in (Løken 2007).

Although MCDA techniques are the majority, other well-known policy aiding techniques are also present on the literature, such as Delphi inquires (Alberts 2007) and local interviews for project acceptance assessment (Werner and Schäfer 2007), SWOT Analysis (Karakosta, Doukas et al. 2010) and case studies (del Río and Burguillo 2008). There are also other applications which are not so widespread, such as ORWARE (Assefa and Frostell 2007) and SCORE model (Krajnc and Domac 2007).

4 – Public attitude towards electricity generation technologies and related decisions

The possibility to please all the population at the same time in a process like national electricity planning has to be discarded, given the number of citizens affected by an array of impacts and their unequal distribution among the population. The reasons for this unequal distribution are, among others, geographical (for visual and noise amenities) and economic (given the inequality of purchasing power). Formulating a unique optimal plan is unlikely to be a realistic objective and controversial decisions will always have to be taken (Ferreira 2008). Authors like (Upham and Shackley 2006) argue that, although a difficult and costly process, the enhancement of local participation in energy planning may to lead to more widely acceptable outcome.

On the other hand, (Alberts 2007) states that it can be more productive to consult technical experts than to seek consensus from all stakeholders, as the potential participants may not have sufficient experience or knowledge to effectively contribute to the decision making process.

Democracy implies pluralism, therefore policy makers must make decisions based upon the perceptions of the whole population they represent. The literature on social acceptance of electricity generation technologies is strongly related with the one on its social impacts assessment. However, the social acceptance of a certain form of energy generation is influenced by other factors than the social ones. The European Union survey (Eurobarometer 2006) reported that citizens think that energy policy should guarantee, in first place, low prices of energy, followed by a continuous supply of energy and protection of public health; independence of country's energy supply and fighting global warming appear less important for public opinion. The same study concludes that less than half of the citizens appear to support the use of fossil fuels (coal, gas and oil); in the other hand they are highly favourable to renewables, especially solar and wind (80% and 71% respectively); nuclear power is only accepted by one out of five citizens. Besides the high acceptance of renewables, citizens also anticipate its massive use in 30 years. However, they are also expecting nuclear to play a substantive role; showing that there is a gap between citizens' will and what they think will happen. This reflects the complexity of policy making that should address citizens' worries, but taking into account that objectives are often conflicting and that the stakeholders' perception may differ significantly (for example: frequently price *versus* environmental protection).

Given its rising importance, it seems that a significant number of controversies reported in the literature addresses wind power projects (see, for example, (Kaldellis 2005), (Gross 2007) and (Swofford and Slattery 2010)) where noise, visual and bird strike stand as important concerns. Despite what has been described as a general positive attitude towards renewables, some of these projects face resistance, which may delay the completion of the project (Cavallaro and Ciraolo 2005). However, other forms of energy can also face opposition, some of them involving renewable energy projects, which apparently is a contradiction, given their already mentioned high level of general acceptance. A recent example is the hydropower project in the north of Portugal which faced resistance from a civic movement[6] opposing themselves to the impacts of the dam, namely submergence of the historical train line, besides visual intrusion and consequences in the agricultural sector. Also, (Upreti and van der Horst 2004) report the oppostion to a proposal of a combined cycle biomass gasifier in the UK, mainly because of truck movements, pollution and odour. In the side of non-renewable energy projects, nuclear power has been debated for decades. See the recent example of (Sjoberg and Drottz-Sjoberg 2009), which describe the fear of the Swedish population towards waste from nuclear power plants. Other examples of technologies facing opposition such as carbon capture and storage and hydrogen are delivered in chapter 4.2.

The decentralization of the electrical systems tends to grow with the increasing integration of numerous smaller-scale power plants. These are spread according to the distribution of the renewable resources; therefore, getting closer to the consumer, possibly present in his daily life landscape (Wüstenhagen, Wolsink et al. 2007). The term NIMBY (acronym for Not In My BackYard, popularized in the 80's by the British politician Nicholas Ridley) classifies the attitude of citizens who generally agree with a given project (not necessarily related to energy), but oppose it if it is to be done in their "backyard". This term has been present in the literature associated with wind power since the 80's and is often regarded as common sense (Wolsink 2000).

(Wolsink 2000) contextualizes NIMBYism as game theory for economists and social dilemma for psychologists: the prisioner's dilemma. The consequence of the prisioner's dilemma is that, although the whole society would be better off if the public good (in that case, wind power) was produced, everyone tries to minimize private costs (in that case, wind power's negative impacts) and this stimulates the so-called free rider behavior: blocking the development of wind farms in their vicinity, which dominates the social best solution.

Other papers reviewed in (Jobert, Laborgne et al. 2007) tested the NIMBYism hypothesis of wind farms and concluded that they do not explain all the resistance that faced projects. In line with this (Maruyama, Nishikido et al. 2007) argued that community-owned wind programs review in their work (referring to Japanese examples) seem to move away from the NIMBY attitude. In fact, institutional factors

[6] See http://www.linhadotua.net/ (in Portuguese) for more information.

may be more important than NIMBYism, and building institutional capital should improve rates of wind power implementation. Institutional capital implies knowledge resources, relational resources and capacity for mobilization. (Gamboa and Munda 2007) mentions an example in Catalonia, where wind turbines siting was a successful task given the affected population's participation in the decision-making process. The same paper also proved that municipalities' income and job creation favor projects acceptance. (Kaldellis 2005) research put in evidence the conservative nature of people living in a Greek island near a wind farm development, demonstrating some public opinion divided or mostly against. The author also pointed out other parameters which negatively affected public perception, such as the great amount of concentration of wind turbines. The author believes that additional public information regarding wind energy could improve the levels of acceptance.

(Loo 2001) coined the NIMBY's opposite as PIMBY (Please In My BackYard) for the cases in which revenues for the development increase the acceptance of a particular project. Given the variety of opinions in the literature, one may conclude that the validity of NIMBYism is still an open problem.

4.2 – Methodologies to address the social dimension of electricity planning

The assessment of the public opinion, social acceptance or social opposition to projects falls in the social sciences domain. In this area, the research methodologies are frequently grouped in qualitative and quantitative approaches. "Qualitative, naturalistic approach is used when observing and interpreting reality with the aim of developing a theory that will explain what was experienced" whereas "the quantitative approach is used when one begins with a theory (or hypothesis) and tests for confirmation or disconfirmation of that hypothesis" (Newman and Benz 1998). The authors argue that, depending on the research, both types of methods can be used on their own, but also combined. Recent examples of both types of methodologies applied to particular cases in the scope of electricity planning are described in this section.

Quantitative methodologies appear to be predominant in the published literature of public perception of renewable energy. (Ellis, Barry et al. 2006) reviewed 45 public opinion and attitude surveys made in the UK and Ireland, from which 78% were quantitative, 18% qualitative and 4% mixed. (Devine-Wright 2005) collected references for the USA, Canada, Denmark, Sweden, Germany and Netherlands and corroborated that the literature in western developed countries is mostly empirical, and uses quantitative survey.

A set of common methodologies, representative of the whole literature which address public perception of electricity generation technologies are presented.

Surveys are a methodology which use, generally, closed-ended questions (example: “do you know your height?”), although they can include focused, short-answer questions (example: “what is your height?”) and multiple choice (example: “from the following list of issues, choose the two which are more important in your opinion”). In all these cases, surveys are considered a quantitative methodology. However, surveys can be open-ended, which implies that space is given to the respondent express using own words; in this case, the information obtained is qualitative.

A clear advantage of close-ended surveys’ use is the statistical treatment of data collected among large amounts of people, from which it is possible to derive patterns regarding behaviors according to respondents’ age, location and social class, among others. According to the sample size it is possible to determine validity and statistical significance of a survey.

As (Devine-Wright 2007) states, these studies tend to be successful in describing one-off snapshots of public views, given their statistical significance; but detailed explanations of their causes remain obscure, therefore are useless to build theory. The author also believes that disciplines such as psychology can be helpful in tackling this issue providing alternative frameworks for questionnaire surveys, demonstrating the necessary interdisciplinarity of future research teams. In spite the aforementioned shortcomings in explanations, the general picture taken by the (Eurobarometer 2006) survey include perceptions at various degrees: importance of the theme (“EU citizens rate energy issues far below unemployment, crime and healthcare systems”), level of knowledge (“Europeans appear to be knowledgeable of the level of energy dependence”), fears (“appear not to fear great societal changes, such as the rationing of energy consumption or not being able to buy a car”) and hopes (“45% consider that their government should make guaranteeing low energy prices a top priority in their energy prices”). Group distinctions are also perceptible (“males, the highly educated and those in managerial position seem to be more knowledgeable of energy issues”).

Surveys size can vary: while the Eurobarometer survey covers 15 topics, (Wolsink 2000) designed a survey to test the NIMBY’s hypothesis, with only five social dilemmas statements, aiming to conclude that the concept might be insufficient to explain opposition to wind power projects. In his case there were 725 respondents; the statements were related to three possible locations for a wind farm. The statements

were close-ended (“support” or “reject”) and were the following: “Only turbines here if sited elsewhere too”, “Turb’s create costs, benefits unlikely, uncertain”, “Preference for other sites, elsewhere”, “We bear costs, elsewhere they don’t accept” and “Benefits only for the electricity utilities”.
(Ansolabehere and Konisky 2009) also used surveys to perform a comparison of public perception on types of power plants: coal, natural gas, nuclear and wind farm. The authors assessed perceptions about siting the power plant near the respondents’ home, perceived environmental harm and perceived cost.
Surveys are often used in recent literature addressing acceptance of promising forms of electricity generation; see for example, (Wolsink 2010) on near shore wind, (Warren and McFadyen 2010) on tidal energy (this study was complemented with focus groups, see later in this chapter for more information on this methodology), (Itaoka, Okuda et al. 2009) on carbon capture and storage, (Achterberg, Houtman et al. 2010) on hydrogen, among others.

Within qualitative methodologies, the Q methodology, according to (Brown 1993), provides a framework for systematic study of subjectivity, personal viewpoints, beliefs and attitude. Its special feature is the aim of mitigating researcher bias. (Ellis, Barry et al. 2006) used this methodology as they claim that the literature often assumes NIMBY-ism as a valid theory, and he wanted to test in a one year case-study of an offshore wind farm in Northern Ireland. This way, instead of capturing information existing in a whole population, it rather focuses on a well selected sample of subjects. The authors analyzed texts related to public debate, both for and against wind power in general, along with government policy documents and public debate around the specific offshore wind farm. Put simply, the objective of the whole methodology was to extract 50 statements that summarize viewpoints, which participants were to sort according to their priorities. The result of this research project could deliver information such as “those who oppose the project ask whether decisions are being taken for the right reasons and question the notion that science, policy makers and economists are necessarily working exclusively for the public good”, and that “there is a fundamental disagreement over the value of wind energy and its ability to make a major contribution to the country’s energy needs”, among others. Along with the 50 statements, 8 idealized profiles (“factors”) were created and it was possible to analyze how much an interviewee falls in which factor.

(Wolsink and Breukers 2010) used Q-methodology to identify different perspectives on wind power, among stakeholders of three different countries. The author identified four different factors, one against wind power implementation and three fundamentally supportive but for different reasons. Controversial issues were found to be landscape values, participation in the project planning, local decision making, financial participation and the role of local authorities. The respondents were stakeholders from conventional energy sector, private wind project developers, cooperatives and citizen projects, wind power and renewable branches, environmentalists and landscape preservation organizations, anti-wind power groups, researchers and governmental bodies ranging from local to national bodies.

One of Q-methodology's advantages is that, although time-consuming, is an individual process, therefore easier to perform than the group methodologies presented next. This methodology fits exploratory and explanatory purposes, as shown from the two articles reviewed. The factor analysis reveals a number of limited number of different perspectives which might be helpful if cluster analysis is needed in a subsequent phase of the research. Consider that a MCDA approach is to be used after the results of (Wolsink and Breukers 2010); it may now be performed for only 4 of the experts (because there are only 4 factors), and they may be chosen according to their similarity to the idealized discourse. Results are then likely to be very different from averaging results of all stakeholders.

Among qualitative methodologies, interviews are quite popular, especially with experts. (Huijts, Midden et al. 2007) assess perceptions on carbon sequestration and storage, in two distinct phases, which involved, first, well-informed groups (industrial, governmental, energy companies, NGO) and, later, general public. In the first phase, stakeholders and experts were interviewed, after which they had group discussions; finally, the second phase was the distribution of 103 surveys in two different communities. The main conclusions presented in this work are that all the professional actors showed interest in the technology, while the general public appears to have little knowledge and little desire for more information, therefore trust (mainly on the NGO) the key for success. The main difference between surveys and interviews stands, thus, in the quality of information: while the surveys had to be representative (103 surveys handled to the population), it would have been time-consuming, costly and probably useless to use interviews, given the little knowledge presented by the general population, which would add no more information than the one presented in the surveys' responses. On the other hand, the interviews with the four well-informed groups provided information on particularly important issues (costs, technical, legal possibilities, risks), which was precisely the information that the authors were looking for. Therefore, we might emphasize interviews as particularly useful for exploratory phases.

(Jobert, Laborgne et al. 2007) used five German and French wind park case-studies to evaluate how policy frameworks influence their local acceptance. For each case, eleven and fifteen semi-structured interviews of one to two hours were carried among local actors such as city-council members, journalists, project planners, regional representatives and spokespersons of local associations. Semi-structured interviews are usually based on a guide prepared in advance with questions taking into account the information the researcher is looking for. Contrarily to surveys or structured interviews, the researcher is free to further explore some themes that arise during the conversation. The authors found it particularly helpful in case-study context, as is the main aim of the paper.

To assess public perceptions on community-based energy projects in the UK, (Rogers, Simmons et al. 2008) used both questionnaire surveys and semi-structured interviews. The data was collected among rural households: the 46 questionnaires (administrated face to face or by telephone) were used to collect both quantitative and qualitative data, from the closed and open questions, respectively; whereas the nine semi-structured interviews collected qualitative data, among households and businessmen. The interviewees had contrasting views on the theme, and that choice has been made on purpose. The authors argue that the advantage of doing interviews in this case was the possibility to explore other themes related to the main research question.

(Gross 2007) explored public perceptions regarding procedural justice on a wind farm pilot study. Having been argued that the involvement of community in the process can increase the acceptance of renewable energy projects, the aim of the study was to propose a community fairness framework, with the intent to aid community consultation and increase social acceptance levels. Twelve semi-structured interviews were made, therefore the key informants selection represented a crucial phase of the methodology implementation. In order to select individuals able to provide collective and important viewpoints, the authors resourced to snowball or networking effect.

Focus groups is another qualitative research methodology, in which a group of people is asked about perceptions or attitudes towards a certain question, and are free to discuss it. The reviewed papers show the flexibility of focus groups, since they have been successfully used on their own, or along with other qualitative or quantitative methodologies.

For the assessment of public perception of carbon capture and sequestration, the US Department of Energy used focus groups in five communities of three different regions (Bradbury, Ray et al. 2009). The study aimed to derive patterns of commonalities and divergence between the regions. In order to be properly effective as a comparative study between the locations, the protocol was built by three teams of researchers, one of each region. This way, besides seven common topics, intrinsic questions regarding the specific historical, economic and social profile of each region could be included. Also, a major issue was the choice of the communities to study. This choice was based on the prospect technology installation, so it ranged between very probable and improbable places to do it. Besides inter-regional general attitude comparison, socioeconomic status was taken into account. The authors argue that, although no statistical significance could be inferred, the focus groups methodology flexibility was a key factor to the success of the study.

Also, (Gough and Shackley 2005) used focus groups but combined with surveys to assess carbon capture and storage acceptance in the UK. The surveys were used after the focus groups process implementation, and were specifically designed according to these focus groups findings.

More recently, (Flynn, Bellaby et al. 2009) also resourced focus groups to assess public attitude towards hydrogen, in three regions within the UK which have already installed hydrogen facilities or had plans for developing them. The process consisted in two phases: nine groups in the first and seven in the second, ranging from three to thirteen elements possessing varied socioeconomic backgroundsThe first phase was more geared towards general information on energy and environmental issues. The second phase was focused in hydrogen technologies. The continuation of the project (not treated in that paper) was a series of citizen panels, carried out to engage community in a participative and deliberative process about alternative scenarios for hydrogen energy.

6 - Conclusion

The present work consisted in a review of the literature with the potential to aid the elaboration of a methodology, intended to support the explicit inclusion of the social pillar of sustainable development while planning the expansion of the generation capacity of power systems. The literature review covers fields within engineering and social sciences disciplines. As a major conclusion, interdisciplinary is seen as a tendency in sustainability issues.

The underlying theory of social sustainability was first reviewed. Theoretically, social sustainability appears as a fuzzy concept, although it can, in a very general way, be associated with the quality of life of our society (and its inequalities, health and employment issues) now and in the future.

Chapter 3 was written with the purpose of surveying a list of the most common social impacts associated with electricity generation technologies, as well as the applications in which these impacts are involved. For planning purposes and technology comparison, Multi-Criteria Decision Methodologies are the most frequent application of these indicators and often imply expert participation. The inclusion of the social dimension in power planning still seems to be an open problem, whose roots are the incommensurability of the social dimension of sustainable development. A simple example: renewable energy technologies may have better performances on health and employment issues than the conventional technologies, but if they are more expensive, will they lead to inequalities in the society? From the survey of indicators present on the literature, employment is by far the most cited, which coincides with citizen's worries about life in general, at least in the EU (Eurobarometer 2006).

A set of methodologies for assessment of public and experts opinion on electricity generation technologies are reviewed. Papers presented in this review concluded that citizens' fear about technologies, often backed by lack of knowledge, brings up the need to build trust in institutions ((Wolsink 2000) and (Wolsink 2010)). Also, the collaboration with both citizens and their representation institutions (being non-governmental organizations the preferred) can increase success in decision-making.

Upon the literature review, plans are now drawn for future work. A mixed methodology resourcing qualitative and quantitative tools is envisaged. Collaboration with experts in power systems will most likely assume the form of semi-structured interviews. This methodology appears appropriate since its openness will enable the possibility to draw guidelines. Questions like "which generation technologies are available within the next 10 years?", "how much installed power is technically feasible for each of them?", among others should be addressed. It will enable the possibility to retrieve information which appear significant in the eyes of the expert and not present in the guidelines, or explore further some themes.

The list of the social impacts to be considered and further explored is also expected to contribute for a multi-criteria decision methodology to be used with the experts, aiming to rank the technologies, projects and scenarios according to their social sustainability performance.

Annex I

Table 2 - Survey of social impacts mentioned by the papers presented in Table 1.

Number	Reference	Social impact
1	(Kowalski, Stagl et al. 2009)	regional self-determinancy
2	Ibid.	social cohesion
3	Ibid.	social justice
4	Ibid.	Quality of landscape
5	Ibid.	noise
6	(Kahraman and Kaya 2010)	compatibility with the national energy policy objectives
7	Ibid.	Political acceptance
8	Ibid.	social acceptance
9	Ibid.	Labour impact
10	(Karakosta, Doukas et al. 2010)	contribution to the net number of employed persons as a result of project implementation
11	Ibid.	improvement in the quality of life of weak populations
12	(Roth, Hirschberg et al. 2009)	Physical security
13	Ibid.	Political stability and legitimacy
14	Ibid.	social development
15	Ibid.	impacts on quality of landscape & residential areas
16	Ibid.	Impacts on human health
17	Ibid.	social components of risks
18	(Gamboa and Munda 2007)	Municipalities income
19	Ibid.	Number of jobs
20	Ibid.	visual impacts
21	Ibid.	Forest lost
22	Ibid.	Noise annoyance
23	Ibid.	avoided CO_2 emissions
24	(Doukas, Andreas et al. 2007)	contribution to employment opportunities' creation
25	Ibid.	contribution to regional development
26	(GallegoCarrera and Mack 2010)	System availability on demand
27	Ibid.	Diversity of energy suppliers
28	Ibid.	reserves and resources
29	Ibid.	Waste management
30	Ibid.	flexibility to respond to market signals
31	Ibid.	flexibility to incorporate technical developments
32	Ibid.	potential of conflicts induced by energy systems
33	Ibid.	willingness to act (mobilization potential)
34	Ibid.	reliance on participative decision-making processes
35	Ibid.	citizens acceptance of the system
36	Ibid.	perceived risk characteristics for accidents

37	Ibid.	perceived risk characteristics for normal operation
38	Ibid.	Trust in risk management
39	Ibid.	health effects from normal operation
40	Ibid.	Health effects from accidents
41	Ibid.	terrorists threat – potential for attack
42	Ibid.	effects on a successful assault
43	Ibid.	Equitable life conditions
44	Ibid.	perception of the fairness of risks
45	Ibid.	effects on the quality of landscape area
46	(Ferreira et al. (2010)	Noiseimpact
47	Ibid.	impact on birds and wildlife
48	Ibid.	visual impact
49	Ibid.	social acceptance
50	(Beccali, Cellura et al. 2003)	Labour impact
51	Ibid.	Market maturity
52	Ibid.	compatibility with political, legislative and administrative situation
53	(Cavallaro and Ciraolo 2005)	social acceptance
54	Ibid.	Impact on ecossystems
55	Ibid.	Acousticnoise
56	Ibid.	visual impact
57	Ibid.	CO2 emissions avoided
58	(Evans, Strezov et al. 2009)	Toxins
59	Ibid.	Visual
60	Ibid.	Birdstrike
61	Ibid.	Noise
62	Ibid.	Displacement
63	Ibid.	Agricultural
64	Ibid.	River damage
65	Ibid.	Seismic activity
66	Ibid.	Odour
67	Ibid.	Pollution
68	(Vera and Langlois 2007)	Accessibility of electricity
69	Ibid.	Affordability of electricity
70	Ibid.	Disparities
71	Ibid.	health/safety
72	(Assefa and Frostell 2007)	Knorwledge
73	Ibid.	Perception
74	Ibid.	Fear
75	(Begic and Afgan 2007)	Job
76	Ibid.	Diversity
77	(Streimikiene and Sarvutyte 2010)	technology-specific job opportunities
78	Ibid.	Food safety risk
79	Ibid.	fatal accidents from past experience
80	Ibid.	severe accidents perceived in future

81	(Alberts 2007)	Noise
82	Ibid.	Wild life
83	(Krajnc and Domac 2007)	possible impact on regional unemployment
84	Ibid.	Avoided costs of unemployment
85	Ibid.	self-sufficiency in electricity production
86	(del Río and Burguillo 2008)	Impactonemployment
87	Ibid.	Demographical impacts
88	Ibid.	Energy impacts
89	Ibid.	Educational impacts
90	Ibid.	impacts on the productive diversification of the area
91	Ibid.	integration in the local economy (use of local resources)
92	Ibid.	social cohesion and human development
93	Ibid.	income distribution and impact on poverty
94	Ibid.	other economic benefits (unrelated to employment)
95	Ibid.	involvement of local actors and perception of the benefits of the project
96	Ibid.	Impact on tourism
97	Ibid.	creation of a local industry
98	Ibid.	impact on the municipal budget
99	(Werner and Schäfer 2007)	Water quality and quantity
100	Ibid.	Human resources
101	Ibid.	social acceptance

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