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INTEGRATING SOCIAL CONCERNS INTO ELECTRICITY PLANNING.

This paper deals with the complexity of the social issues surrounding electricity planning. A methodology is presented establishing a possible way of allocating weights to the most important social impacts of the electricity generation options and extending these results to the evaluation of future electricity plans. The process combined Delphi method with the Analytic Hierarchy Process, for the pairwise comparison of the electricity generation technologies against the social criteria. A social impact score was then derived and assigned to each technology. In order to obtain a final ranking of future feasible plans, these overall social scores of the electricity generation alternatives were aggregated using an additive function. The final output of the social analysis is an Average Social Index of each possible electricity generation mix.

1 Introduction

There exists a strong link between energy, environment and sustainable development. Energy is a key factor for the development of economies. It has a direct impact on the economic performance of companies and it is also a driving force for social welfare. It is fundamental to have a good balance between the use of energy for development and environment preservation, as inefficient use leads to negative ecological impacts. Greenhouse gas emissions represent a particularly relevant global problem that has been catching governments' attentions for more than a decade. No less important are the local and regional environmental impacts, related to the emissions from fossil fuel combustion, the deforestation, or the loss of fauna and flora. In addition, although energy projects can create important local development opportunities generating positive incomes for local communities, these projects frequently also have to face strong social opposition.

Ensuring a sustainable society for future generations rests, to a large extent, on designing and implementing a sustainable energy sector. According to Hepbasli (2007), “a sustainable energy system may be regarded as a cost-efficient, reliable, and environmentally friendly energy system that effectively utilizes local resources and networks.” In line with this definition, Jefferson (2006) provided the four key elements of sustainable energy: sufficient growth of energy supplies to meet human needs, energy efficiency and conservation measures, addressing public health and safety issues and the protection of the biosphere. The reduction in the use of fossil fuels, the increase in energy efficiency and the promotion of the exploitation of renewable energy sources (RES) are, then, fundamental measures to meet the goal of sustainable energy development. These measures were already highlighted in the Kyoto protocol document, and reinforced in the European Commission policy documents for the energy sector (Commission of the European Communities, 2007).

The rising trend of electricity demand, the volatility of fossil fuel prices, the external energy dependency and environmental concerns have been major drivers for an increasing interest in RES. The integration of renewable resources is expected to play a major role for the attainment of the sustainable development goal, and it is a key element of the European and Portuguese strategies for the energy sector.

The creation of clear energy strategies merging cost effectiveness with environmental and social issues is the main challenge for energy planners. Cost oriented approaches, where the monetary assessment is the only basis for the decision making, are no longer an option, and information on the ecological and social impacts of the possible energy plans, needs to be combined with traditional economic monetary indicators. The existence of different perspectives and values must also be acknowledged and fully incorporated in the planning process, avoiding centralised decisions based on restricted judgements. The evolution of the market conditions and the increasing concerns with sustainable development have brought about profound changes in the approach to the energy decision process and to the priority assigned to each objective, during the energy planning process. Sustainable energy planning should now be seen as a multidisciplinary process, where the economic, environmental and social impacts must be taken into consideration, at local and global levels, and where the participatory approaches can bring considerable benefits.

The thinking about social sustainability is not yet as advanced as for the other two pillars (World Bank, 2003). Until recently, sustainable development was perceived as an essentially environmental issue, concerning the integration of environmental concerns into economic decision-making (Lehtonen, 2004). For example, for the particular case of the role of RES to sustainable development, Del Río and Burguillo (2007) support the view that much emphasis is being put on the environmental benefits while socioeconomic impacts have not received a comparable attention. This paper aims to address this matter and deals with the complexity of the social issues surrounding electricity planning.

A methodology is presented establishing a possible way of allocating weights to the most important social impacts of the electricity generation options and extending these results to the evaluation of future electricity plans. The proposed methodology was applied to the particular case of electricity power planning in Portugal for a ten year planning period. The following Section 2 presents the methodology followed during this study. Section 3 provides an overview of the Portuguese electricity market, putting in evidence the importance of the wind power sector. Section 4 describes the hierarchical structure formulation including the options analysed and criteria considered. Section 5 details the implementation of the Delphi study based on a questionnaire sent to a pilot group of experts. Section 6 combines the information obtained from the Delphi process with AHP in order to derive a social index ranking the electricity generation alternatives. The incorporation of the social index in the overall planning process is presented in Section 7. Section 8 discusses the results obtained. Section 9 draws the conclusions of the chapter pointing out the main limitations of the work and indicating directions for future research.

2 Methodology

The core elements of the study are the Delphi survey and the AHP analysis. By subdividing the problem into its constituent parts (Analytic Hierarchy), the problem is simplified and allows information on each separate issue to be examined. The relative strength or priority of each objective can be established (Delphi process) and the results synthesised, to derive a single overall priority for all activities (Hemphill et al., 2002). The process involved the following steps:

- The characterisation of the existing electricity system and the identification of possible electricity generation alternatives to be added in the future.

- The identification of difficult to quantify attributes and options to analyse. This step corresponds to the definition of the social criteria to select the best electricity generation options, from the social point of view.

- The establishment of a hierarchical structure. The top of the hierarchy is the main goal corresponding to the social index and the lower levels describe the criteria. On the bottom level we have the discrete alternatives of the problem, corresponding to the electricity generation options.

- Selection of a group of experts and establishment of the pairwise comparison of the elements of the hierarchical structure. The Delphi method is used to collect this information.

- Testing the consistency of the data collected from the experts.

- Aggregation of the scores collected from the experts. From this step results the relative weights of the elements of each level of the hierarchical structure, reflecting the group judgment.

- Combine the relative weights of the elements of each level of the hierarchical structure, obtaining the final scoring of the electricity generation options against the overall social objective.

3 The Portuguese electricity generation system

The Portuguese electricity sector heavily relies on fossil fuel imports and the main domestic resource for electricity production is hydro power, making the system highly dependent on external energy resources and on rainfall conditions. In addition, the increase of electricity consumption shows a trend much stepper than most of the other EU countries and the electricity intensity of the economy is still rising. Predictions for the next years indicate that the electricity consumption will continue rising, reaching in 2016 a value 55% higher than in 2006.

At present, the Portuguese electricity generating system is basically a mixed hydrothermal system. The total installed power reached in 2006 about 13619 MW, distributed between thermal power plants (coal, fuel oil, natural gas and gas oil), hydro power plants and Special Regime Producers (SRP[1]), as presented in Table 1. In addition, the Portuguese system is interconnected with Spain and the available capacity for commercial electricity transactions is 800 MW. In 2006, the total electricity consumption reached 52764 GWh (DGGE, 2007).

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[1] SRP- Includes the small hydro generation, the production from other non hydro renewable sources and the cogeneration.

Table 1- Distribution of installed power and electricity production in mainland Portugal, 2006. Source: REN(2007)

	Installed power (MW)	Electricity production (GWh)[1]
Thermal power plants	5896 (43%)	25478 (57%)
Large hydro power plants	4582 (34%)	10204 (23%)
Special regime producers	3141 (23%)	8752 (20%)
Total	13619 (100%)	44434 (100%)

[1] Injected in the public grid.

Based on REN (2005) forecasts, an increase of about 35% of the total installed electricity generation capacity between 2006 and 2011 may be expected, followed by an additional 24% increase in the period 2001-2016. According to these forecasts there will be a reduction of both thermal and large hydro power quotas and a large increase of the SRP quota, in percentage terms. All the energy sources will grow in absolute terms, with the exception of oil power due to the dismantling of the power plants presently consuming it. Thermal power will increase exclusively due to the growth of the natural gas power groups up to 2013. After that, REN (2005) scenarios assume new investments both in coal and natural gas. The growth of the SRP will be mainly driven by the increase of the renewable energy sector, in particular wind. According to these scenarios, the wind sector will achieve about 25% of the total installed power by 2011.

The move towards renewable energy technologies is strongly stressed in the government policy for the sector and the response of the industry has been positive, in particular in regard to wind power. During the next decade, the structure of power generation is expected to change significantly in favour of renewables. Large hydro is still the dominant renewable energy resource in Portugal but wind power is closely following it and the RES development is mainly driven by the high growth rates of wind energy. At the end of 2006, the total wind power capacity reached a value close to 1700 MW, putting Portugal amongst the top European wind power producers. Forecasts for the sector clearly indicate that this trend will continue, with the installed power in Portugal expected to overcome the current Danish values within a decade[2].

4 Hierarchical structure formulation

The hierarchical structure formulation started with the identification of the options to analyse. Based on the expected development of the Portuguese electricity system, three electricity generation options were included: coal, gas and wind. For comparison of the alternatives it was decide that, instead of building combined scenarios, the evaluation would focus on the marginal increase of the demand and the corresponding increase of each one of the generation options. For a marginal increase of 1000 MW of the electricity demand, the corresponding increase of the generation options was defined. From the AHP analysis, a social index representing the social evaluation of these options is obtained. The overall social evaluation of the possible combined scenarios will be drawn from these individual indices.

4.1 Social criteria

From existing literature addressing the social impact of the electricity generation technologies and from discussions with experts in the energy field, the criteria considered relevant to the evaluation process were defined.

[2] The role of wind power on the Portuguese electricity system is longer debated in Ferreira et al. (2007).

The public perception of wind power is addressed by several authors for a number of countries or regions. Some examples of research studies on this field include Ek (2005), Wolsink (2000), Manwell et al. (2005) or Bergmann et al. (2006), among many others. Most of the studies identified as positive aspects the renewable characteristic of wind power and the avoided emissions. On the other hand, in most of the publications there is a predominant emphasis on the negative visual impact on the landscape. Other identified negative impacts include: the impacts on wildlife, the noise pollution, the unreliability of wind energy supply and the possible financial cost, with particular emphasis on the first two aspects.

Studies addressing the coal and gas power plants impacts deal mainly with the cost and environmental emissions (see Rafaj and Kypreos, 2007 or Söderholm and Sundqvist, 2003). The environmental impact usually focuses on the damages caused to health and on the impact on climate change. In the ExternE project, the external effects from coal and natural gas power plants were mainly associated with their pollutant emissions and their impact on public and occupational health, agriculture and forests. The noise problem was also pointed out, including operational and traffic impact.

Following the literature analysis, structured interviews were conducted with experts from the academic field, energy consultants, members of environmental associations, environmental public organisms' staff and researchers, aiming to evaluate the importance of each of the criteria or to identify some others relevant for the Portuguese society.

The main conclusions from the interviews seem to indicate that the Portuguese population is still ill informed about the electricity generation options and have no clear opinion on this subject. Most of the experts believe that there is a global support for wind power and that it will be possible to increase the installed power without strong opposition from the population. Based on the literature and on the interviews, the following non quantitative criteria were chosen for the social evaluation process: noise impact, impact on birds and wildlife, visual impact and social acceptance.

As the questionnaire will involve pairwise comparisons, the number of criteria included was limited, avoiding a long and complex process that might reduce the experts' willingness to participate. The AHP analysis will only focus on the qualitative subjective criteria. Aspects like cost, energy external dependency and pollutant emissions, although mentioned by the experts, may be quantified and included in a mathematical formulation[3]. Combining the options and the criteria, the hierarchical structure of the problem may be represented as in Figure 1.

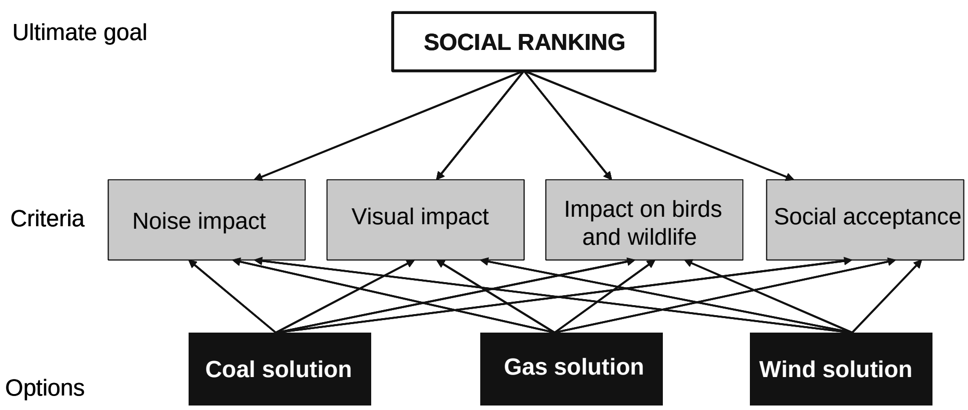

Figure 1 - AHP model for the prioritisation of electricity generation options.

[3] See Ferreira (2008).

5 Delphi implementation

The focus of the Delphi process was on the comparison of three electricity generation technologies (wind, coal and natural gas) in what concerns their major impacts from the social point of view. The experts were selected from Portuguese universities. The procedure identified 12 experts who would be appropriate to include in the pilot group. Although all the experts came from the same professional field they have different backgrounds, opinions and hold a variety of positions for and against each one of the options analysed.

The results obtained with the questionnaire were meant to be used in the AHP analysis. As so, the questionnaire was written using a pairwise comparison structure and Saaty scale of response. For this particular research, the aim was to address the negative social impact of each generating technology[4] . For the comparison, a scale based on Saaty (1980) proposal was used, detailed in Table 2. Two of the experts tested the questionnaire was tested before sending it to the pilot group.

Table 2- Scale preferences with numerical score

Score	Pairwise evaluation
9	Absolutely superior
7	Very strongly superior
5	Strongly superior
3	Moderately superior
1	Equal
1/3, 1/7, 1/5, 1/3	Reciprocal values

The questionnaire asks the experts to assume the need to increase the available power in about 1000 MW. This may be done by increasing the number of coal, natural gas or wind power plants, described as follows:

Coal solution	
Description	2 new coal power plants, one with installed capacity equal to 700 MW and another one with installed capacity equal to 450 MW.
Placement	Close to large electricity consumption centres.
Characteristics	In each power station there will be one chimney 225 m high and one cooling tower. It may occupy an area of about 1.5 ha (0.015 km^2). It burns imported coal.
Examples	Presently two power stations operate in Portugal: one in Sines and another one in Pego.

Gas solution	
Description	2 new combined cycle natural gas power plants, one with installed capacity equal to 660 MW and another one with installed capacity equal to 400 MW.
Placement	Close to large electricity consumption centres.
Characteristics	The 660 MW power station will have two chimneys. The 400 MW power station will have 1 chimney. All the chimneys will be 80 m high. Each power station will have a cooling tower. Each power station may occupy an area of about 1.5 ha (0.015 km^2). It burns imported natural gas.
Examples	Presently two CCGT operate in Portugal: one in Ribatejo (Carregado) and another one in Tapada do Outeiro (Gondomar).

4 A particular technology assigned with a higher score is considered “worst” from the social point of view than a technology assigned with lower score.

Wind solution	
Description	250 new wind farms, with total installed capacity equal to 3800 MW.
Placement	Spread across the country, but with some particular relevance in the inland North hills.
Characteristics	Each wind farm will have between 10 and 15 turbines, about 65 m high and may occupy an area of about 100 ha (1 km^2).
Examples	Presently there are about 1000 turbines operating in the mainland, some examples may be seen in Marão, Açor, Barroso among many others.

In the first part of the questionnaire, the experts were asked to pairwise compare the three solutions regarding each one of the described aspects. For example, question 1 presented the description of the visual impact and than asked the experts:

a) The visual impact of the coal solution is [▼] to the gas solution.
b) The visual impact of the coal solution is [▼] to the wind solution.
c) The visual impact of the gas solution is [▼] to the wind solution.

The second part of the questionnaire focuses on the comparison of the relative importance of the four social criteria. The experts were asked to pairwise compare these criteria, using again Saaty scale.

At the end of the questionnaire the expert was invited to comment. This might include justification of the responses, suggestions for the inclusion of other aspects or for improving the questionnaire or any other information that the expert wanted to share. The questionnaires were sent electronically, in an effort to speed the iterative process and to allow the expert to answer directly in the computer.

5.1 Delphi results

The Delphi implementation involved two iterations and lasted for about three months. 9 of the 12 experts concluded the process, although it was necessary to encourage their involvement through electronic and telephone reminders.

In general, the results of the Delphi analysis revealed lack of consensus among experts in some questions. In particular, the visual impact of the wind solution comparatively to both the coal and the gas solutions seems to be the least consensual aspect. It was also difficult, or even impossible, to reach consensus regarding the pairwise comparison of the importance of all the criteria. However, the results seem to be stable with only few response changes between the first and second round.

The results indicate that it is not easy to reach consensus for the issues in question and it is the researchers' belief that the complexity and subjectivity of the theme would make a third iteration a time consuming task that would be unlikely to bring new valuable information to the model. It was however possible to achieve consensus in 12 of the 18 questions.

It should be highlighted that the difficulty on reaching consensus and consistent results is not a completely unexpected result. As Hobbs and Meier (2003) pointed out, trading off attributes often involves conflicting, strongly held values, leading to unstable weights. Based on their experience, the authors state that many energy planners and decision makers are uncomfortable with trade-off questions, therefore it is important to check consistency. Also, the broad diversity of interests and values of the decision makers makes consensus very difficult to achieve in the energy planning process. The research is dealing with highly subjective aspects, which relative importance depends on the awareness and individual perception of the experts.

Consensus may be very difficult or even unachievable, yet often the search for consensus will establish at least some common ground (Hobbs and Meier, 2003). Based on this, it seemed reasonable to proceed with the study, applying the obtained results to an exploratory model to draw a methodology to incorporate non quantitative aspects in the electric planning process.

6 Determination of weights for the electricity generation options

This phase of the research combines the information obtained from the Delphi process with AHP, in order to convert pairwise comparison of the elements of the hierarchical structure in an overall social index, allowing for the ranking of the alternatives. The pairwise comparisons of each expert were used as input for the SuperDecisions[5] software using the scale presented in Table 2. The consistency of each comparison matrix was tested and the relative weights of the elements on each level were computed for each expert.

Following studies like Hon et al. (2005), Wu et al. (2007) or Banuls and Salmeron (2006), the geometric mean method was used for the aggregation of the experts' opinions into the final judgement. As the consistency is low for some of the resulting matrices, only the relative scores of individual matrices? passing the consistency test were included in the final aggregation process.

Combining the relative weights of the elements at each level of the hierarchical structure, the final scoring of the electricity generation options against the overall social objective is obtained. Table 3 synthesises the overall normalised priorities for the three solutions.

Table 3- Aggregated score for the average social impact of the electricity generation options.

Solution	Social impact
Coal	0.455
Wind	0.355
Gas	0.219

According to the results of the group judgment, the coal solution presents the highest social impact followed by the wind solution. The gas solution seems to be the one ranking better from the global social point of view. The high weight of the social acceptance criterion combined with the low social acceptance of coal comparatively to gas or wind solutions, led to a score translating high negative social impact for the coal solution. The gas solution ranked in last for all but social acceptance criteria, resulting in a low (thus good) overall social impact for this option.

7 Incorporating the social index into the electricity planning model

In order to obtain a final ranking of the available solutions, the overall social scores of the three alternatives must be aggregated by means of a mathematical algorithm. The aim is to get a final index for each possible plan, combining more than one of the available electricity generation technologies. For this the weights were aggregated using an additive function, described by equation 1.

[5] This software was developed by the Creative Decisions Foundation and is freely available on the internet (http://www.superdecisions.com).

$$ASI = \frac{\sum_t (IP_{4t} + IP_{1t}) W_{coal} + \sum_t (IP_{5t} + IP_{2t}) W_{gas} + \sum_t (IP_{9t} + IP_{3t}) W_{gas}}{\sum_t (IP_{4t} + IP_{1t} + IP_{5t} + IP_{2t} + IP_{9t} + IP_{3t})} \qquad (1)$$

Where W_{coal}, W_{gas}, W_{wind}, represent the overall normalised weights for the coal, gas and wind solutions, described in table 3.

This additive function assumes that the weights assigned to each electricity generation option are constants and do not depend on the relative levels of each option. This means that the attribute value of an electricity plan may be computed directly from the scores of each individual solution. Although this independence is hard to prove, the additive value model offers a simple way of evaluating multiattribute alternatives. This simplicity makes it widely used in energy planning and policy, as described by Hobbs and Meier (2003).

To illustrate the process a set of possible plans for 2017 were drawn from Ferreira (2008). All these plans ensure that the average Kyoto protocol limits imposed to Portugal would not be overcome, and are consistent with the objective of reaching 39% share of electricity produced from RES, in line with Directive 2001/77/EC. Table 4 describes these plans[6] , detailing the expected total installed power, the share of RES, average cost, average CO_2 emissions and ASI.

Table 4- Possible electricity plans obtained from Ferreira (2008).

		Plan 1	**Plan 2**	**Plan 3**	**Plan 4**
Total installed power (MW)	Coal (new)		2400		600
	Coal (existing)[1]	1820	1820	1820	1820
	Natural gas (new)	5110	1860	5110	3720
	Natural gas (existing)[1]	2916*	2916*	2916*	2916*
	Wind (new)	3225	6514	3225	6500
	Wind (existing)[1]	1515	1515	1515	1515
	Large hydro	5805	5805	5805	5805
	NWSRP	3245	3245	3245	3245
	Total	23636	26075	23636	26121
Share of RES (%)		39	45	39	46
External dependency (%)		65	58	65	57
Cost (€/MWh)		33.627	34.961	34.365	36.950
CO_2 (ton/MWh)		0.379	0.379	0.332	0.332
ASI		**0.292**	**0.341**	**0.292**	**0.316**

[1]Existing at the end of 2006

The results indicate that the ASI values are not much different from one plan to another. This is due to some factors that condition the differences between electricity plan options:

- The renewable constraint imposes a minimum amount of wind power in the system. Even for plans with lower installed wind power, this technology still represents more than 20% of the total installed power in the system. For large wind scenarios (Plans 2 and 4) this share reaches a little more than 30%, meaning that the maximum difference between plans is only about 10% in what concerns installed wind capacity.

- The system already possesses substantial coal and gas power capacity, once more diluting the effect of new entrances. For example, for Plans 1 and 3 although not any new coal power plants are projected, the installed coal share still represents about 8% of the total installed power in the system.

[6]For additional information on the electricity plans characterisation and design see Ferreira (2008).

- The Kyoto protocol, imposes maximum CO_2 levels. Plans characterised by high coal shares, which might lead to higher ASI are not included in the analysis. Likewise, plans with very low CO_2 levels (and lower ASI) represent a cost increase not acceptable for most of the population[7].

- The differences on the ASI of each plan are low and, when existing, seem to be mainly influenced by the installed power of coal power plants.

- Plans 2 and 4 present the worst outcome from society's point of view, because of the high values for the installed wind and coal power and lower installed power of gas plants.

- Plans 1 and 3 present the lower ASI due to the reduced share of coal and high share of gas power plants.

8 Discussion of the results

The difficulties on using the ASI as another criterion for electricity planning decision making should not be interpreted as a sign of its unimportance but rather as a clear indication that this matter must be further explored. Translating qualitative and very subjective opinions over a matter as complex as energy planning is a difficult task that led authors to focus more on the clarification and understanding of tradeoffs and less on the production of numerical scales (see for example Hobbs and Meier, 2003). In fact, if the exercise was conducted maintaining weights at individual level, for some experts the results would be different from the aggregated weights. The explicit determination of the social indexes may be difficult and even questionable for some authors but may also help to make the decision process more tangible and operational.

It is also important to keep in mind that the group of experts was composed of only nine elements, and as so extreme answers or changes on even just one or two expert responses can have important effects on the statistical results and may influence the decision of consensus or stability. For larger groups, if there is no agreement, Hobbs and Meier's (2003) suggestion may be followed, using cluster analysis or factor analysis to define a few sets of weights or rank options summarising the positions of various stakeholders.

The group of experts consulted should be seen as a pilot group; nevertheless even if a broader group of social agents is consulted, difficulties and divergence of opinions on the subject are always to be expected. The different responses obtained reflected very different opinions, even using a relatively homogeneous group, with all elements belonging to the academic sector. On a more general level, the study would greatly benefit from increasing the number of experts consulted and from the inclusion of other social groups.

Incorporating the data collected in the participative process in the electricity plans characterisation, allows to present the decision maker with a selected number of feasible electricity generation plans characterised by the mix of technologies, total cost, total CO_2 emissions, ASI and external energy dependency. For example, with respect to the plans described in Table 4, the results reveal that it will be possible to achieve average CO_2 emissions equal to 20 Mton/year at a minimal cost of 33.6 €/MWh, investing mainly on new natural gas power plants (Plan 1). As natural gas is a socially well accepted solution, the social impact of this strategy should be low but the external dependency of the electricity

[7] The results of the European Commission survey "Attitude towards energy" (European Commission, 2006) revealed that 70% of the Portuguese consumers were not willing to pay more for energy produced from RES and only 6% would accept to pay 6 to 10 % more. The results clearly indicate that Portuguese citizens are reluctant to make efforts in energy consumption demanding higher charges.

generation sector will remain high. If the decision maker is willing to increase cost by about 4% (Plan 2), it will be possible to keep CO_2 emissions at the same level and the external dependency of the electricity production sector may be reduced by 7%. Also, a more balanced mix between coal and natural gas may be achieved resulting in considerable advantages from the security of supply point of view. However, as this strategy requires less natural gas power plants and additional investments in new coal and wind power plants the ASI of Plan 2 is higher than the expected value for the Plan 1.

This analysis allows the decision maker to recognise the differences between possible electricity generation alternatives and foresee their estimated impacts. The final selection of an electricity strategy for the future depends on the priority that the decision maker chooses to assign to each one of the objectives considered.

9 Conclusions

The complex nature of different generation options has been highlighted by this analysis. The combination of Delphi and AHP methodologies was used to illustrate a possible process of social evaluation of the future electricity plans assigning a numerical scale to each individual option.

The research included only three generation options. The results led to a high negative social impact assigned to the coal solution, mainly due to low social acceptance. However, the energy markets are dynamic and the social perception of each technology is highly influenced by strong stakeholder groups and in particular media (Shackley et al., 2005). The new clean coal technologies and the prices development may easily change this general opinion. Likewise, the spreading of wind power plants may demonstrate that the social impacts of this technology are more or less important than these experts assumed.

The combination of social, environmental and economic evaluations will benefit the energy plan formulation, ensuring the robustness of the process and leading to a defensible choice aimed to reduce conflict. A mixed model of subjectivity and objectivity is ultimately needed for the best ranking tool (Nigim et al., 2004). The experiment conducted revealed that the process is long and difficult: it is not easy to obtain answers to such subjective issues. This becomes even more complex if the analysed options do not correspond to a particular case or scenario and the final aim is the generalisation of the results. Regardless of these implementation difficulties, based on the opinions of a group of experts, the model recognises the overall social impact of each electricity generation option, identifies their major reported impacts and assesses the relative importance of these impacts for the society.

The implementation of the model was achieved through a pilot experiment, but considerable research is still required. In particular, the research must surpass the pilot experiment by including possible additional social criteria and by increasing the number of participants in the questionnaire phase. The identification and inclusion of participants representing different stakeholder groups may add new information to the process. A broader analysis can contribute for the identification of the major sources of concern for each stakeholder group, giving also further insight into aspects of acceptance and critical factors for success in developing electricity generation projects and strategic plans. This would bring more views to the discussion and would make the statistical analysis less sensitive to individual extreme positions. The research revealed that the responses are some times inconsistent and consensus among experts is difficult to achieve. The process may be complemented with interviews and by presenting the feasible plans to the experts. This may help to clarify experts' judgments contributing also to obtain an additional insight of their opinions on the electricity generation technologies in the context of the overall electricity plan.

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