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INTEGRATING SOCIAL CONCERNS INTO ELECTRICITY PLANNING

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Scope



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- The work describes part of an on-going doctoral research study aimed at proposing an integrated electricity planning model, combining financial, economic and social objectives.

Objective



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- To establish a possible way of allocating weights to the most important social impacts of the electricity generation options and to extend these results to the evaluation of future electricity plans.

Presentation



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- Overview of the research
- Methodology
- The Portuguese electricity generation system
- Application of the proposed methodology:
 - Hierarchical structure formulation
 - Delphi implementation
- Results
- Discussion of the results
- Conclusions

Overview of the research



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- Ensuring a sustainable society for future generations rests, to a large extent, on designing and implementing a sustainable energy sector.
- Sustainable energy planning should 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.

Overview of the research



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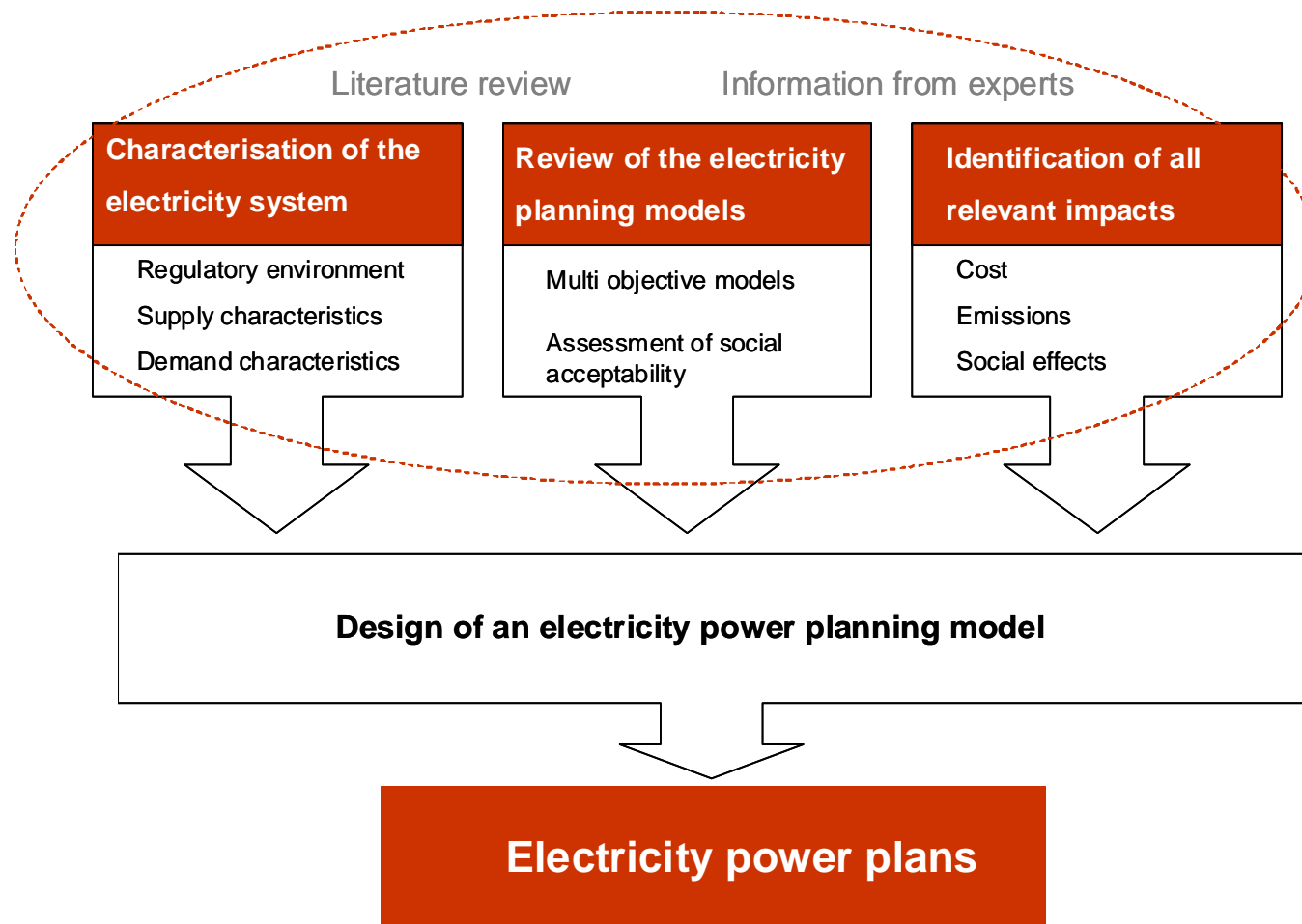
- Traditionally much emphasis is being put on the environmental and financial aspects of energy planning and the socioeconomic impacts have not received a comparable attention.
- This study aims to address this matter and deals with the complexity of the social issues surrounding electricity planning.

Overview of the research



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- **Goal:** obtaining feasible and sustainable electricity power plans.



Methodology



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- The core elements of the study are the Delphi survey and the AHP analysis. The process involved:
 1. The characterisation of the existing electricity system and the identification of possible electricity generation alternatives to be added in the future.
 2. The identification of difficult to quantify attributes to take into consideration.
 3. 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.

Methodology



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4. 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.
5. Testing the consistency of the data collected from the experts.
6. 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.
7. Combining 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.

The Portuguese electricity system



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2006 (REN, 2005)

2016 (REN, 2007)

Total demand
52 764 GWh

4.4 %/ year

Total demand
82 070 GWh

Installed capacity
13 660 MW

Installed capacity
22 833 MW

Wind capacity
1 681 MW

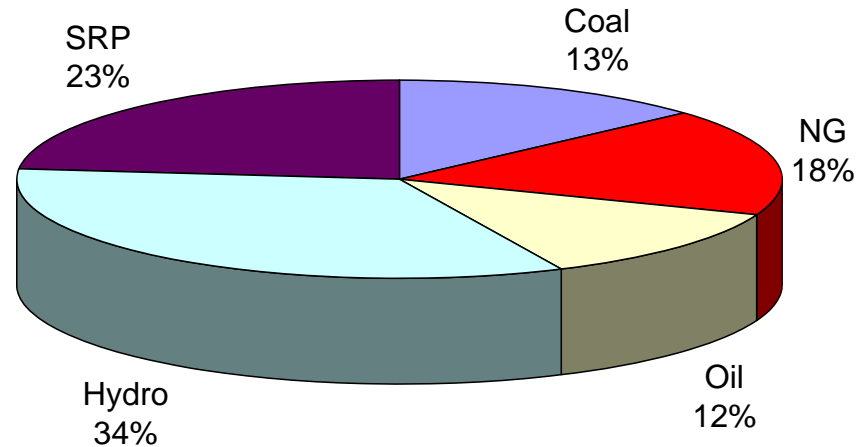
Wind capacity
> 5 000 MW

The Portuguese electricity system

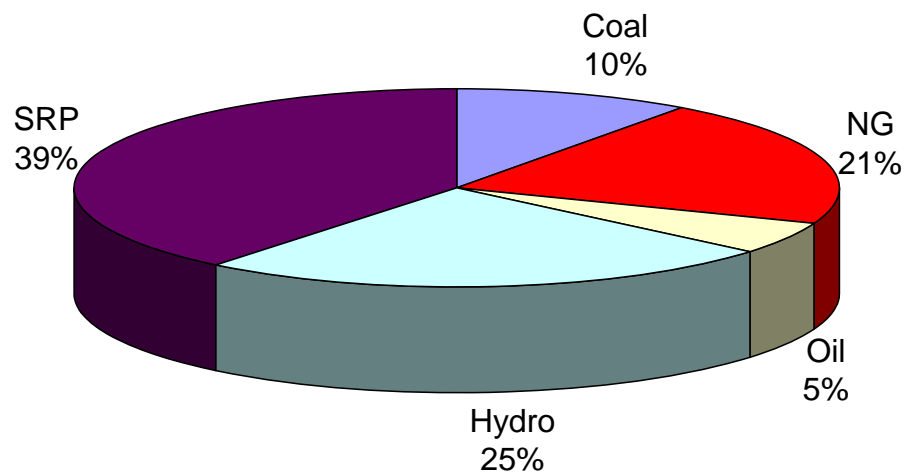


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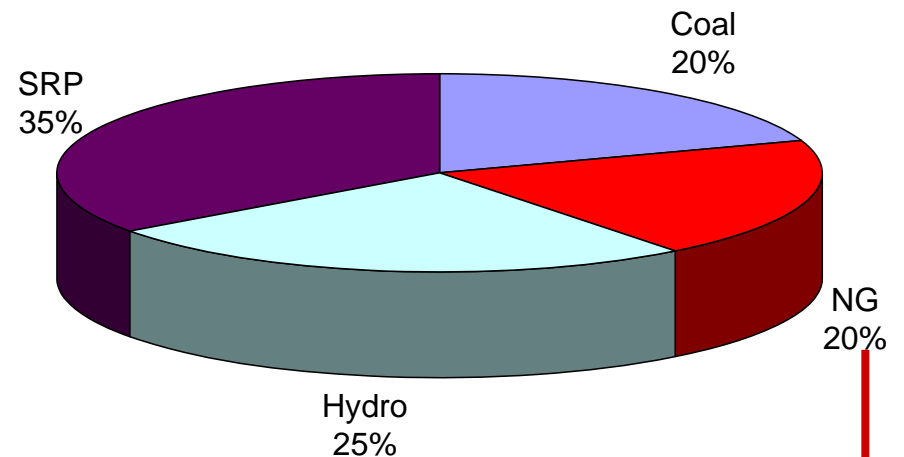
2006
Total installed power: 13660 MW



2011
Total installed power: 18433



2016
Total installed power: 22833 MW

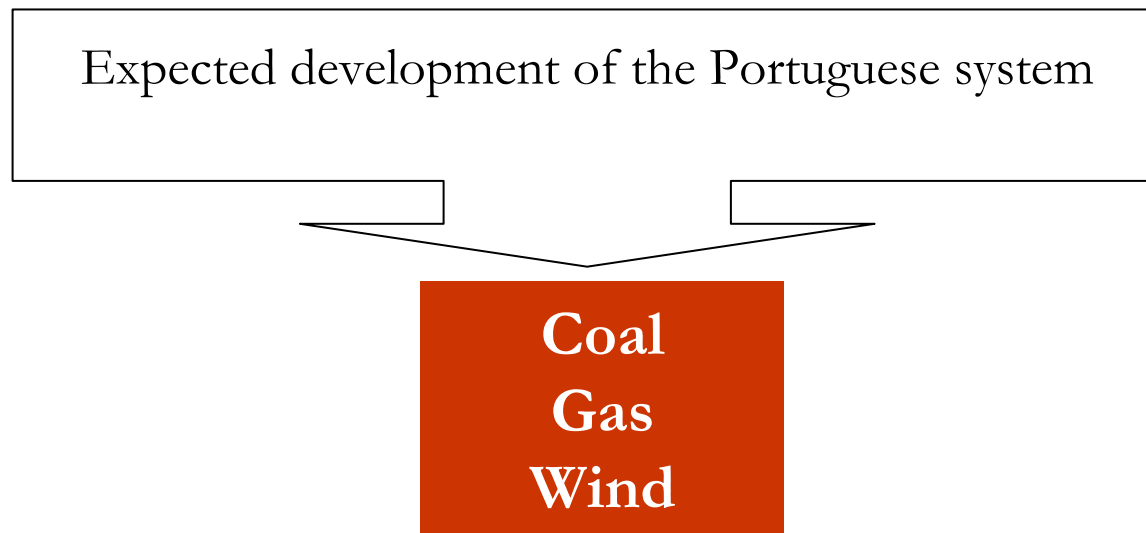


Application of the methodology



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Electricity generation options



For a marginal increase of 1000 MW of the electricity demand, the corresponding increase of the generation options was described.

Application of the methodology



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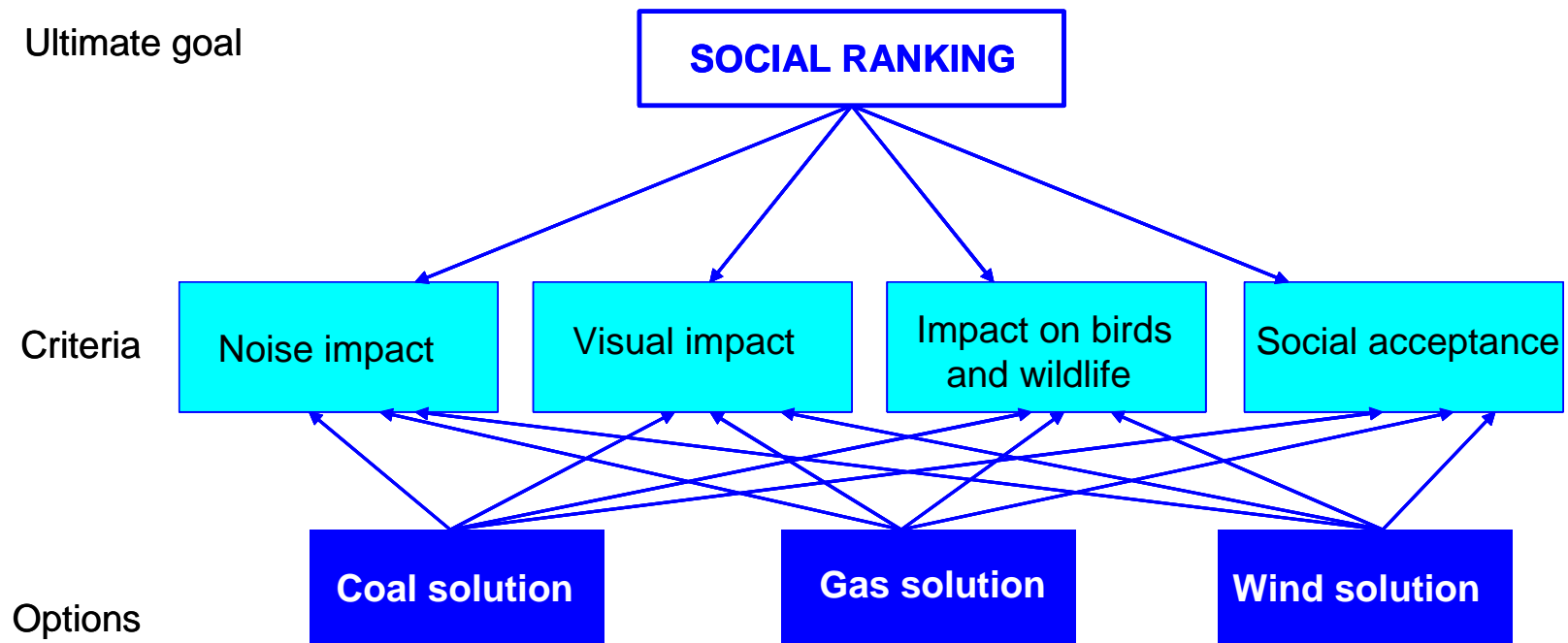
Social criteria

Literature review followed by structured interviews with experts from the academic field, energy consultants, members of environmental associations, environmental public organisms' staff and researchers

Noise impact
Impact on birds and wildlife
Visual impact
Social acceptance

Application of the methodology

AHP model for the prioritisation of electricity generation options





Delphi implementation

- The questionnaire was written using a pairwise comparison structure and Saaty scale of response.

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

- 12 experts were selected from Portuguese universities.
- The questionnaire included: a description of the power plants presently operating in Portugal, a description of the options and a description of the criteria.

Application of the methodology

Delphi implementation

➤ Example:

- a) The visual impact of the coal solution is to the gas solution.
- b) The visual impact of the coal solution is
- c) The visual impact of the gas solution is

Absolutely superior
Very strongly superior
Strongly superior
Moderately superior
Equal
Absolutely inferior
Very strongly inferior
Strongly inferior
Moderately inferior

➤ The questionnaires were sent electronically.

➤ The Delphi implementation involved two iterations and lasted for about three months.

➤ 9 of the 12 experts concluded the process.

Delphi results

- The results of the Delphi analysis revealed difficulty on reaching consensus among experts in some questions.
- The visual impact of the wind solution comparatively to both the coal and the gas solutions seems to be the least consensual aspect.
- The broad diversity of interests and values of the decision makers turns consensus to be very difficult to achieve in the energy planning process (Hobbs and Meier, 2003).

Results



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Weights of the electricity generation options

- The pairwise comparisons of each expert were used as input for the AHP software SuperDecisions.
- Only the relative scores of individual matrices passing the consistency test were included in the final aggregation process.

Solution	Social impact
Coal	0.455
Wind	0.355
Gas	0.219

Results



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Incorporating the social index into the electricity planning process

- Weights were aggregated using an additive function:

$$ASI = \frac{IP_{\text{coal}} W_{\text{coal}} + IP_{\text{gas}} W_{\text{gas}} + IP_{\text{wind}} W_{\text{wind}}}{IP_{\text{coal}} + IP_{\text{gas}} + IP_{\text{wind}}}$$

Results



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Incorporating the social index into the electricity planning process

➤ Examples from Ferreira (2008):

		Plan 1	Plan 2	Plan 3	Plan 4
Total installed power (MW)	Coal (new)		2400		600
	Coal (existing)	1820	1820	1820	1820
	Natural gas (new)	5040	1860	5110	3720
	Natural gas (existing)	2916	2916	2916	2916
	Wind (new)	3225	6514	3225	6500
	Wind (existing)	1515	1515	1515	1515
	Large hydro	5805	5805	5805	5805
NWSRP	3245	3245	3245	3245	
Total		23566	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		0.284	0.328	0.284	0.303



Discussion of the results



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- The renewable directive (2001/77/EC) imposes a minimum amount of wind power in the system. Even for plans with lower installed wind power, this technology still represents about 18% of the total installed power in the system.
- The system already possesses substantial coal and gas power capacity, diluting, even more, the effect of new entrances.
- The differences on the ASI of each plan seem to be mainly influenced by the installed power of coal power plants.
- Plan 2 presents 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.



Discussion of the results



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

- 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.

Conclusions



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- Translating qualitative and very subjective opinions over a matter as complex as energy planning is a difficult process.
- The group of experts consulted should be seen as a pilot group. 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 characterization, allows to present the decision maker with a selected number of feasible electricity generation plans characterized by the mix of technologies, total cost, total CO₂ emissions, ASI and external energy dependency.

Conclusions



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- This analysis allows the decision maker to recognize 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.

- 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 process may be complemented with interviews and by presenting the feasible plans to the experts.

References



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