Universidade do Minho
Escola de Engenharia

CHALLENGES IN SUSTAINABLE ENERGY PLANNING: A MULTIDISCIPLINARY PERSPECTIVE

Paula Ferreira

University of Minho
ALGORITMI Research Centre
Guimarães, Portugal

http://pessoais.dps.uminho.pt/paulaf

paulaf@dps.uminho.pt

Agenda

- Introduction and motivation
- Objectives
- Proposed approach
  - Electricity planning model: cost optimization
  - Multicriteria model: scenarios evaluation
  - Social acceptance model: public opinion
- Conclusions

Introduction and motivation

One major objective of **energy decision making** is to ensure that sustainability goals are effectively taken into account and properly considered on the design of strategic energy scenarios and on the evaluation and selection of technologies and projects.

The quest for sustainable development require traditional approaches to **energy planning** to expand beyond pure financial analysis and even beyond direct environmental impact analysis.

Economic valuation provides an insufficient basis for social choice.

Design of **optimal strategies for the electricity sector.**

Complex decision making processes requiring a multidisciplinary approach.

Objectives

- To improve energy decision making process towards sustainability objectives.
- To present an approach relying on mixed-methods to address challenges related to the quest for social equity, for minimization of environmental impacts, for economic competitiveness and for security of supply.
- To show the implementation of these methods and tools to propose and analyze electricity scenarios for future electricity systems.

Proposed approach

Cost optimization for strategic planning of the electricity sector

Economic and environmental goals

Generation Expansion Scenarios

Multicriteria analysis for scenarios evaluation

Economic, environmental and social goals

Large scale survey - public opinion on renewable energy technologies

Local population scale survey - public opinion on renewable energy technologies

Social goals

Electricity planning model: cost optimization

Methods: Optimization modelling

New user-friendly application (SEPP-Sustainable Electricity Power Planning) consisting of four optimization models for electricity power planning:

Strategic electricity power planning for long-term capacity expansion, solving a mixed integer linear problem (MILP) (GEP-generation expansion problem);

Unit commitment process, relying on a complex mixed integer non-linear problem (MINLP) for solving the short-term optimization of the available resources (SP- scheduling problem);

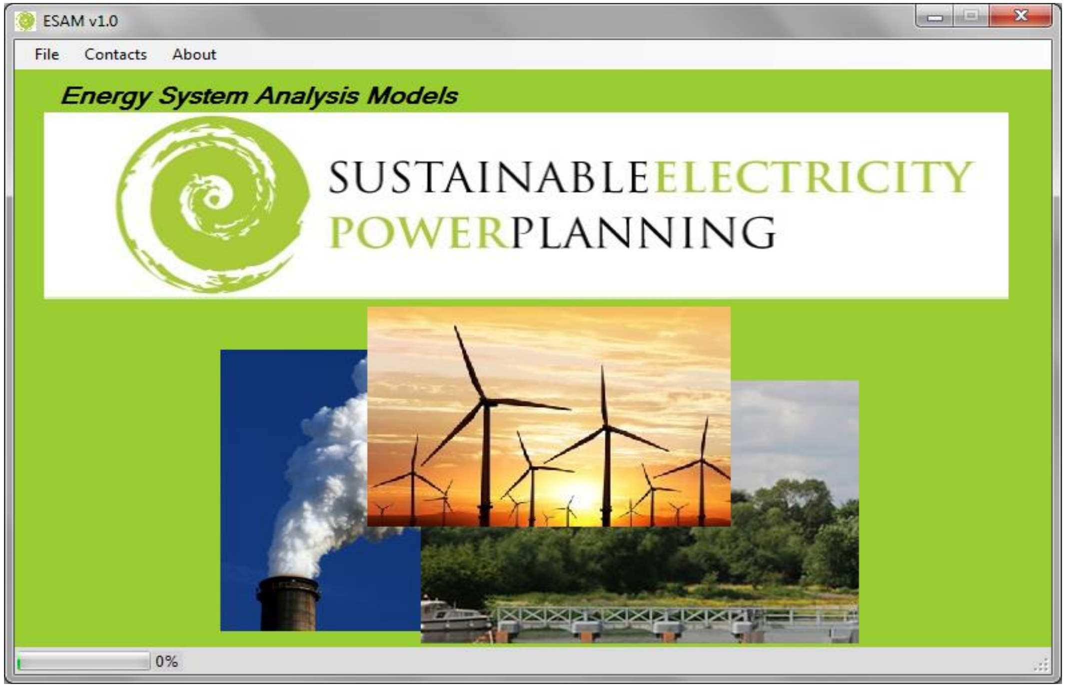
A simplified approach of the scheduling problem relying on non-linear problem (NLP) (SSP-Simplified scheduling problem);

An integrated approach that combines the generation expansion problem with the scheduling problem, relying in GEP and SSP models and resulting in a MINLP (IP- Integrated problem).

Electricity planning model: cost optimization

Optimization models are translated in GAMS environment using best suited solvers and are presented in the user friendly SEPP interface.

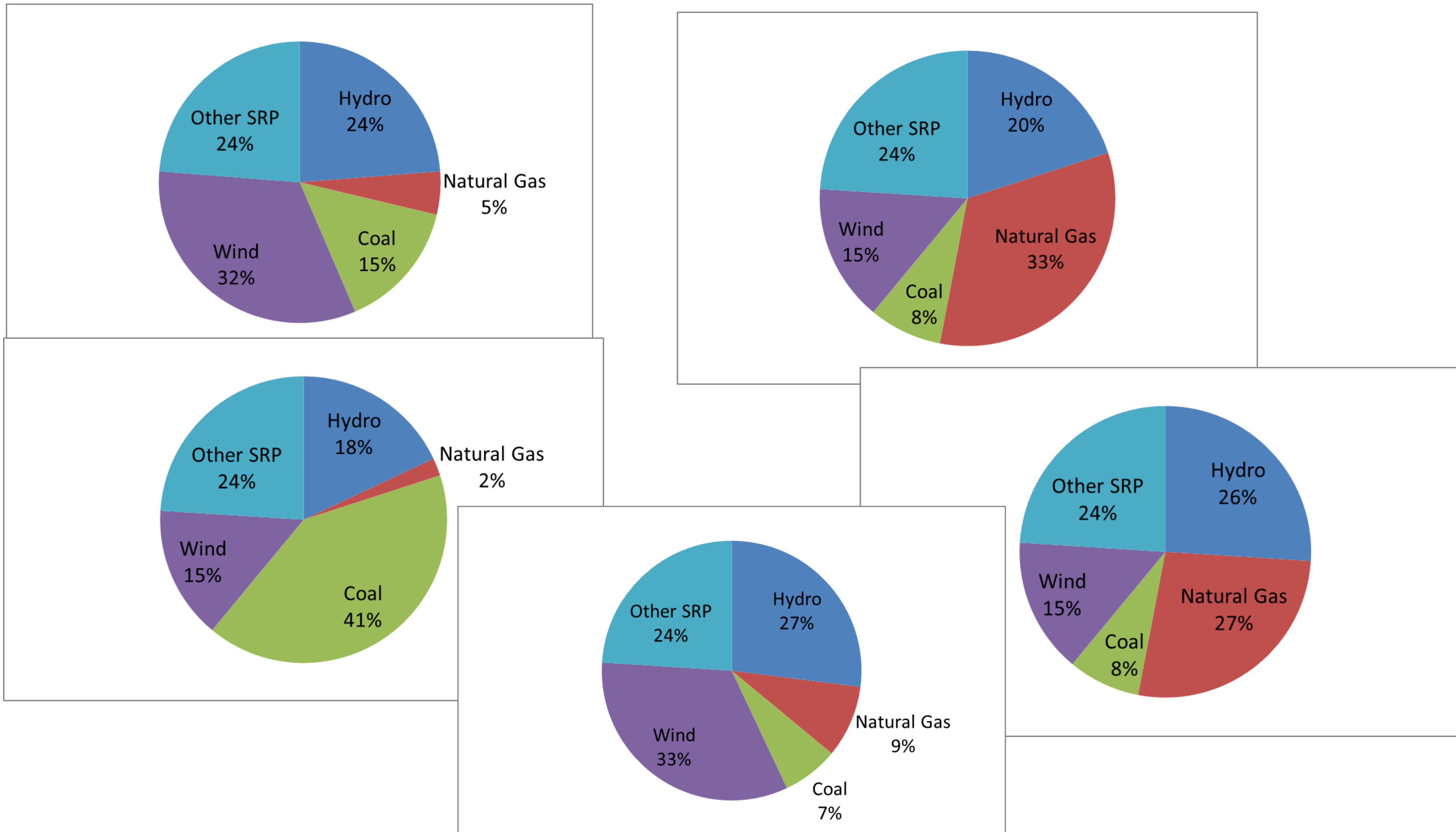
Tool developed in Visual Basic. To run it the users must have installed MSExcel and have access to GAMS.



http://sepp.dps.uminho.pt/

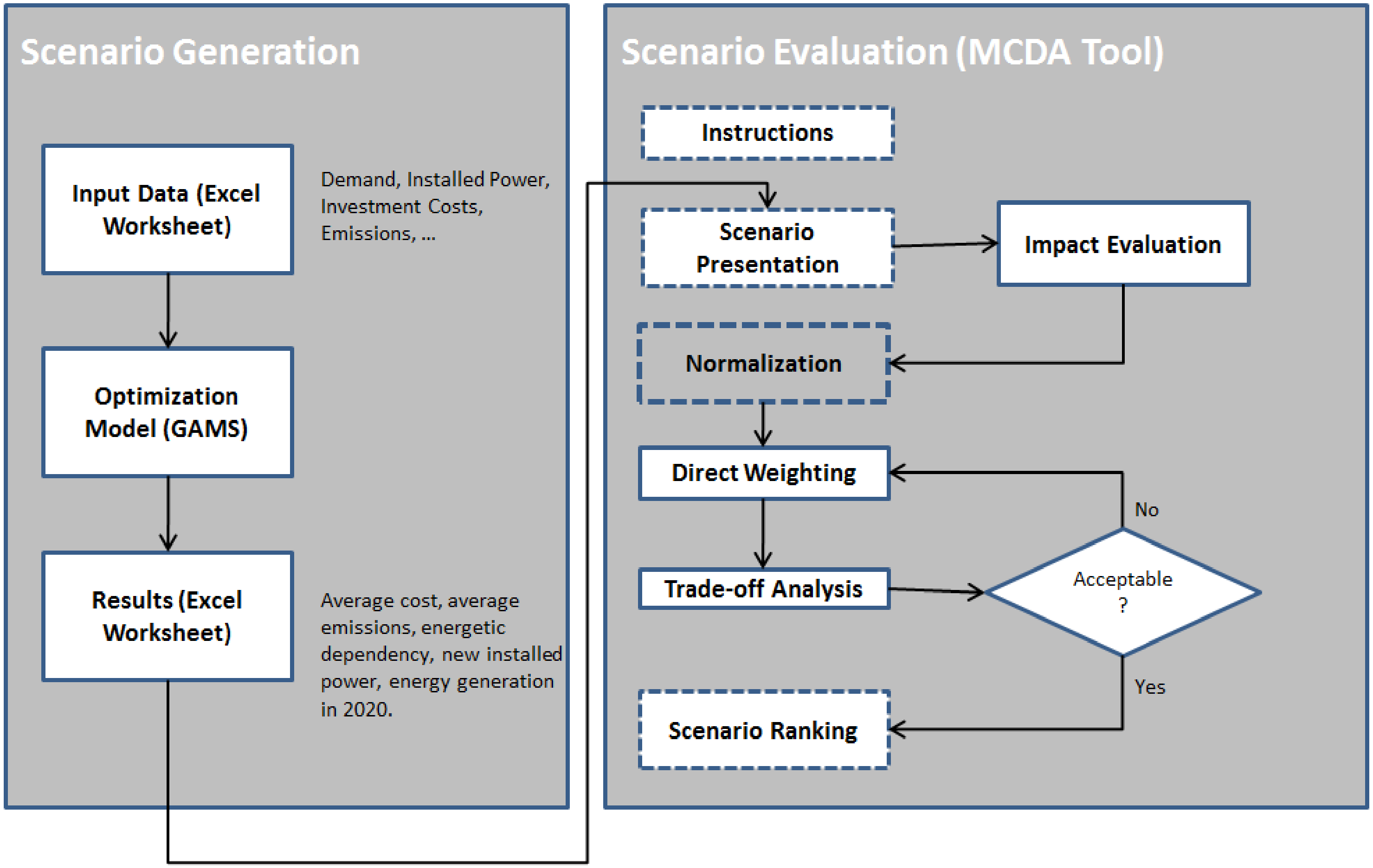
Electricity planning model: cost optimization

Example for Portugal



Multicriteria model: scenarios evaluation

Methods: Interviews with experts. Quantitative analysis.



Multicriteria model: scenarios evaluation

New user-friendly application built in excel allowing for direct weighting and trade-off analysis relying on experts/stakeholders feedback.

SUSTAINABLE ELECTRICITY
POWER PLANNING

Multi-Criteria Decision Analysis (MCDA) Tool for Electricity Power Planning

Fernando Ribeiro fernandor@dps.uminho.pt
Paula Ferreira paulaf@dps.uminho.pt
Madalena Araújo mmaraujo@dps.uminho.pt

CGIT, Department of Production and Systems, School of Engineering, University of Minho

The present work was developed under project Sustainable Electricity Power Planning (http://sepp.dps.uminho.pt/)

Objective: This Excel file implements a multi-criteria decision methodology to evaluate and rank five scenarios for the Portuguese power generation system in 2020. The evaluation is done by weighting 13 criteria.

This Excel file is divided in 5 sheets:
1 - Initial sheet (this sheet)
2 - Scenarios for the Portuguese power generation system in 2020
3 - Instructions
4 - Impact and Criteria Weighting
5 - Results

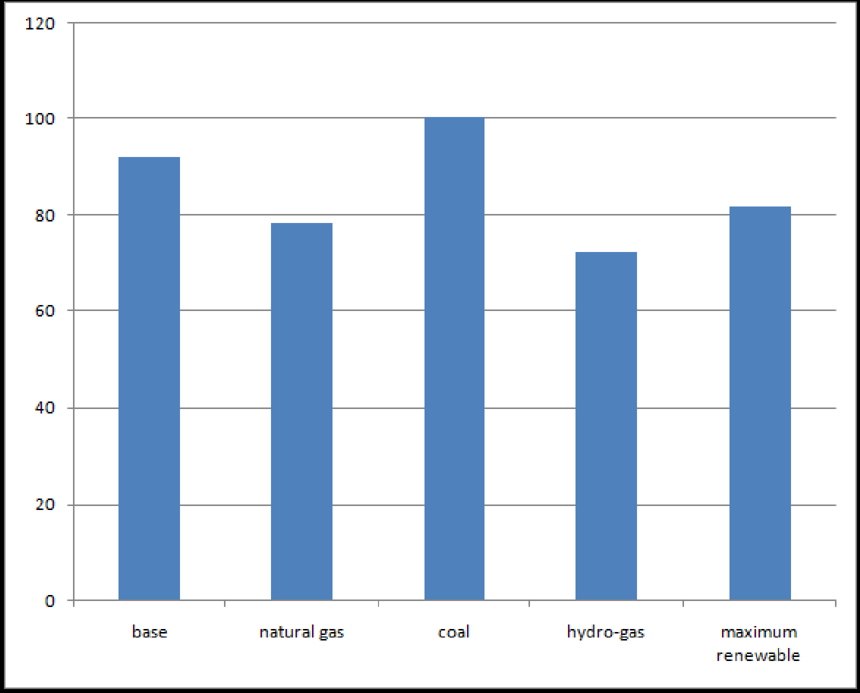
http://sepp.dps.uminho.pt/

Multicriteria model: scenarios evaluation

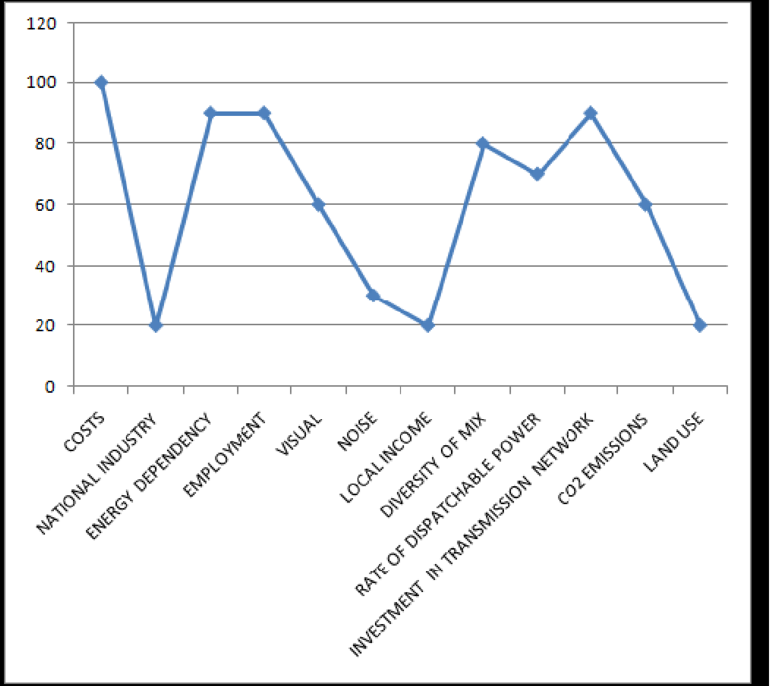
nr.	Criterium	Scale		Scenarios					Criteria weight
				base	natural gas	coal	hydro-gas	maximum renewable	
		Min (worst)	Max (best)	New MW: coal 700, hydro 1000, wind 4400, other SRP 1180	New MW: natural gas 2360, other SRP 1180	New MW: coal 2550, other SRP 1180	New MW: natural gas 2050, hydro 2000, other SRP 1180	New MW: hydro 2000, wind 4400, other SRP 1180	Min (0=not important), Max (100=very important)

2

RANKING

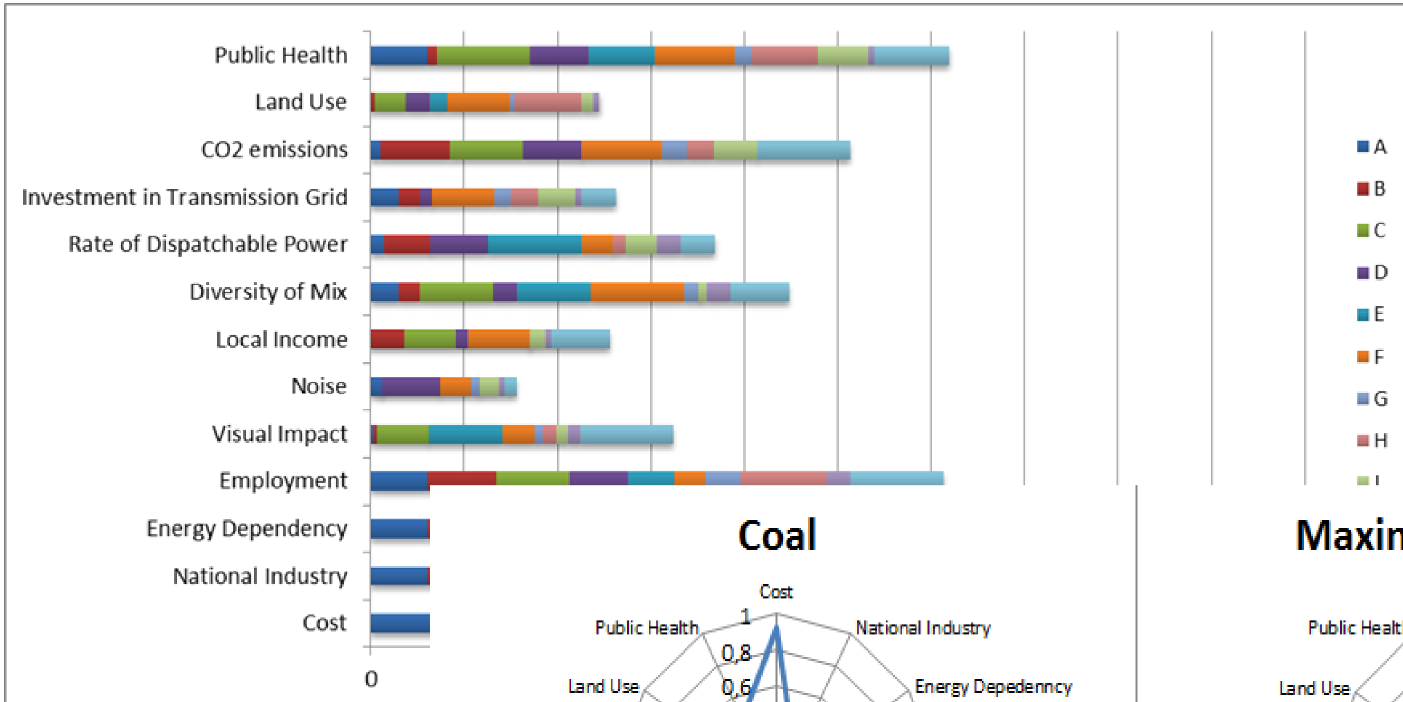


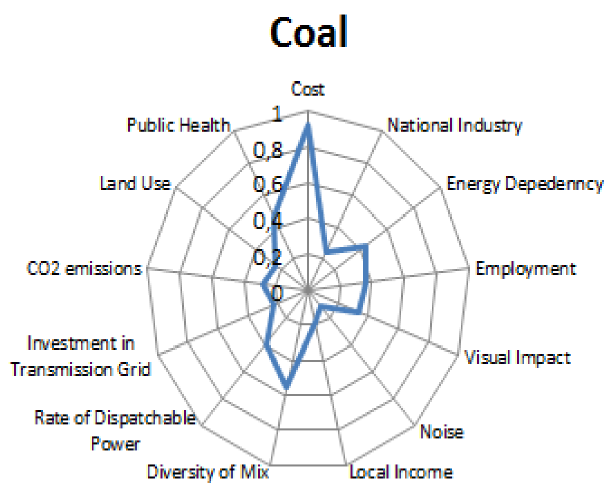
WEIGHTS

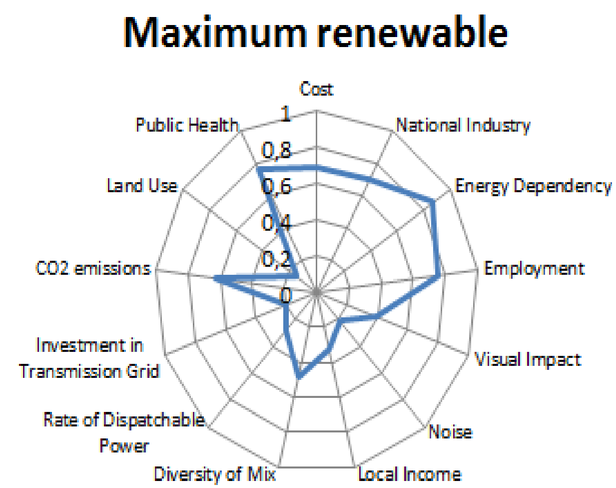


Multicriteria model: scenarios evaluation

Example for Portugal





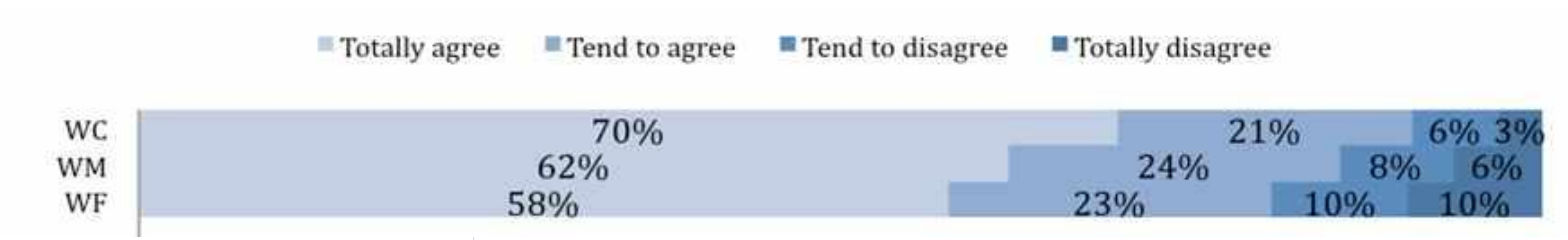


Social acceptance model: public opinion

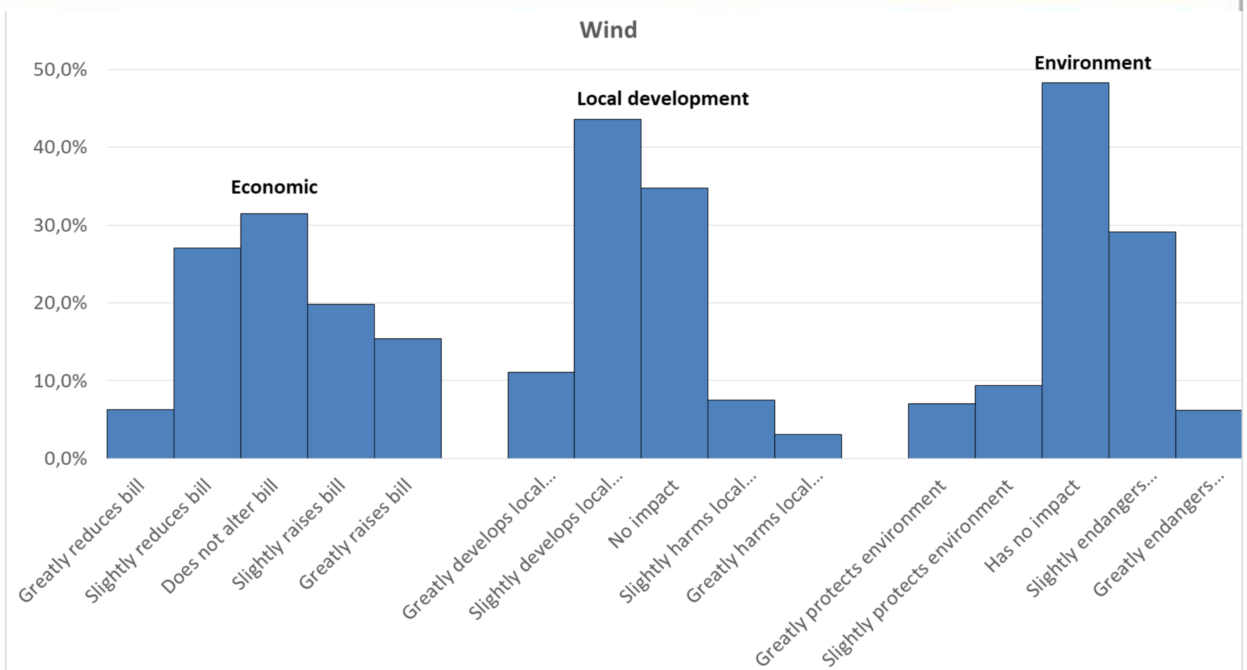
Methods: Questionnaire to population. Statistical analysis.

Country analysis

Public awareness and acceptance towards renewable energy sources



Example for Portugal (Wind)



Social acceptance model: public opinion

New user-friendly application built in excel translating prediction models of expected perception and attitudes towards Renewable Energy Sources.

Based on large scale survey of the Portuguese population and relying on regression models.

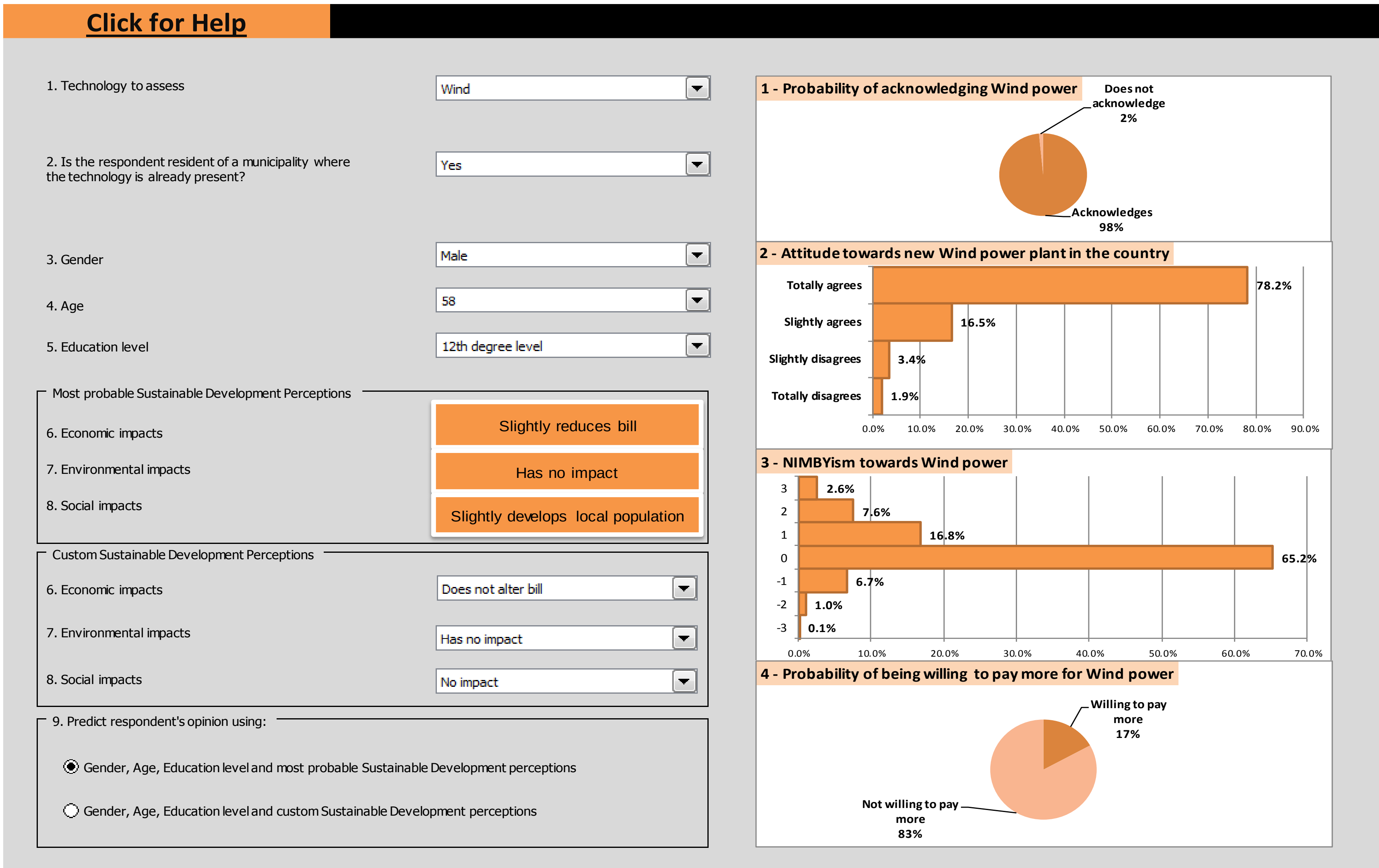
The model allows for NIMBY assessment and addresses 4 technologies: wind, hydro, biomass and photovoltaic.

The proposed methodology and regression models can be adapted to different technologies and populations, provided that surveys are previously conducted and statistical analysis of the results are conducted.

http://sepp.dps.uminho.pt/

Social acceptance model: public opinion

Example for Portugal



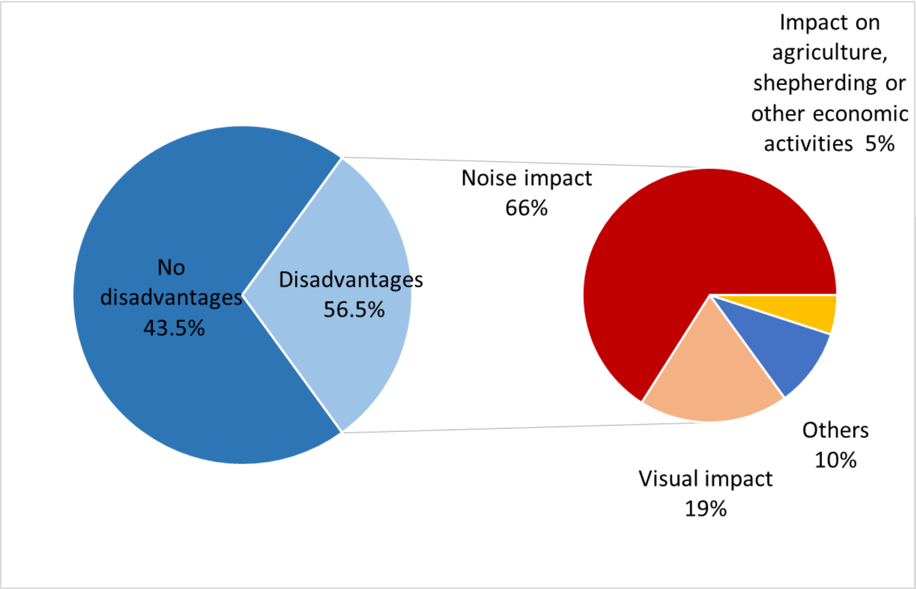
http://sepp.dps.uminho.pt/

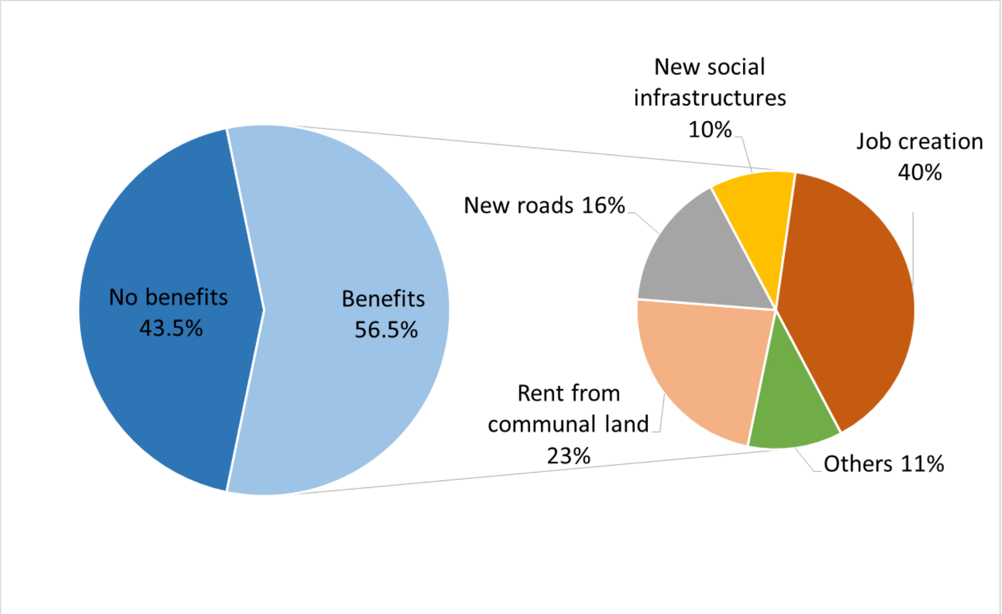
Social acceptance model: public opinion

Methods: Case study. Interviews with local key stakeholders'. Questionnaire to population. Statistical analysis.

Local analysis: the case of wind power

Example for Portugal





Conclusions

Designing a sustainable energy plan, is a multidisciplinary process and implies addressing and integrating technical, environmental, economic and social dimensions.

The integration of the relevant dimensions of sustainable energy planning poses an important challenge to researchers and goes beyond the scope of a single discipline.

A **multidisciplinary approach is required** to ensure the adequate expertise from all-encompassing fields of research.

Conclusions

This study proposed a possible framework in which all these dimensions are included and fully integrated,

merging mathematical evidence based on optimisation procedures with value judgments and public opinion.

Methods used:

- Optimization modelling
- Interviews
- Multicriteria analysis
- Cases studies
- Questionnaires
- Statistical analysis

The research demonstrated the applicability of the new framework for the case of Portugal. Work is on-going with other countries, namely Algeria and Brazil, for the extension of the

Acknowledgment

The author wish to acknowledge the support of ALGORITMI research Centre at University of Minho. This work has been supported by COMPETE: POCI-01-0145-FEDER-007043 and FCT – Fundação para a Ciência e Tecnologia within the Project Scope: UID/CEC/00319/2013.