SUSTAINABLEELECTRICITY POWERPLANNING

Multi-Criteria Decision Tool to Support Electricity Power Planning

Fernando Ribeiro

Paula Ferreira

Madalena Araújo

PTDC/SEN-ENR/099578/2008

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Multi-Criteria Decision Support 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 the Sustainable Electricity Power Planning project (http://sepp.dps.uminho.pt/)

The Excel file sent in annex 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.

The Excel file is split in 5 sheets:

1 INITIAL SHEET

2 SCENARIOS

3 INSTRUCTIONS

4 IMPACTS AND CRITERIA WEIGHTING

5 RESULTS

The "**2 SCENARIOS**" sheet presents information of the five scenarios. These were created using a linear programming model described in http://sepp.dps.uminho.pt/Relatorio_SP1.pdf.

In the sheet "**4 IMPACTS AND CRITERIA WEIGHTING**", 13 criteria are presented.

1. Cost (€/MWh): values are calculated in the above mentioned model. Cost represents the sum of the annualized costs of new installed units, as well as operation and maintenance of all units (including fuel), divided by the total amount of produced energy in the planning period. It is considered that costs of units installed in the past are totally depreciated. The user is given all the values for each considered scenario.

2. National Industry (ordinal): for the construction of generation infrastructures the use of industry of different sectors is required. This criterion is related to the impact on the dynamics of national industry under each scenario. The user will evaluate the impact of each scenario according to his perceptions.

3. Energy Dependency (%): share of electricity produced from imported primary energy (coal and natural gas). The user is given all the values for each considered scenario.

4. Employment (number of jobs): estimated values of direct and indirect jobs in each scenario, for the construction and operation of the power plants. To estimate the impact of each scenario values from the literature were used[1]. It was assumed that per each 500 MW of new installed power, 2500 jobs would be created in the case of coal, 2460 jobs in the case of natural gas, 5635 jobs in the case of wind and 2500 jobs in the case of hydro power plants. Values are given but user may choose to alter them according to his perception.

5. Visual impact (ordinal): The establishment and the functioning of new power units can cause changes on the landscape thus having a visual impact. The user will evaluate the impact of each scenario according to his perceptions.

6. Noise (ordinal): The normal functioning of new generation infrastructures can have noise impact. Although noise can be measured, the individual perception is very subjective. The noise level was estimated for each scenario taking into account the ExternE Project valuation for this impact for each technology[2]. Values are given but user may choose to alter them according to his perception.

7. Local income (ordinal): Income obtained as compensation for the establishment of new generation infrastructures can have a positive impact in local populations, associations and municipal income. The user will evaluate the impact of each scenario according to his perceptions.

8. Diversity of mix (ratio): The expression used to measure the diversity of the mix was based on the ShannonWiener[3] index. The expression assumed five sources for electricity

[1] http://www.sciencedirect.com/science/article/pii/S030142150700537X

[2] http://www.externe.info/externpr.pdf

[3] http://ideas.repec.org/p/soz/wpaper/0813.html

production: coal, natural gas, hydro, wind and other SRP. The user is given all the values for each considered scenario.

9. Rate of dispatchable power (%): Computed as the ratio between the total installed power of dispatchable technologies (hydro power with reservoir, natural gas and coal power plants) and the total installed power of the system. The user is given all the values for each considered scenario.

10. Investment in transmission grid (ordinal): The establishment of new electricity power infrastructures may imply additional investments in the transmission system. To estimate these values the scenarios with higher wind power levels were assumed to have the highest costs, given the geographical dispersion of wind farms. The next higher costs were assumed to be related to hydro power penetration. Finally, thermal (coal and natural gas) power plants are assumed to require no additional investment. The user will evaluate the impact of each scenario according to his perceptions.

11. CO2 emissions (t/GWh): Computed as the ratio between CO2 emissions released by all power plants during the overall planning period and the total electricity produced. The user is given all the values for each considered scenario.

12. Land use (x1000 km^2): The required land for new infrastructures can imply land use. Literature data was used to calculate and assign possible values for each scenario[4]. The user is given all the values for each considered scenario.

13. Public Health (ordinal): The new infrastructures of electricity production can have direct and indirect health impacts. The public health impact was estimated for each scenario taking into account the ExternE Project[5] valuation for this impact for each technology. The user is given all the values for each considered scenario.

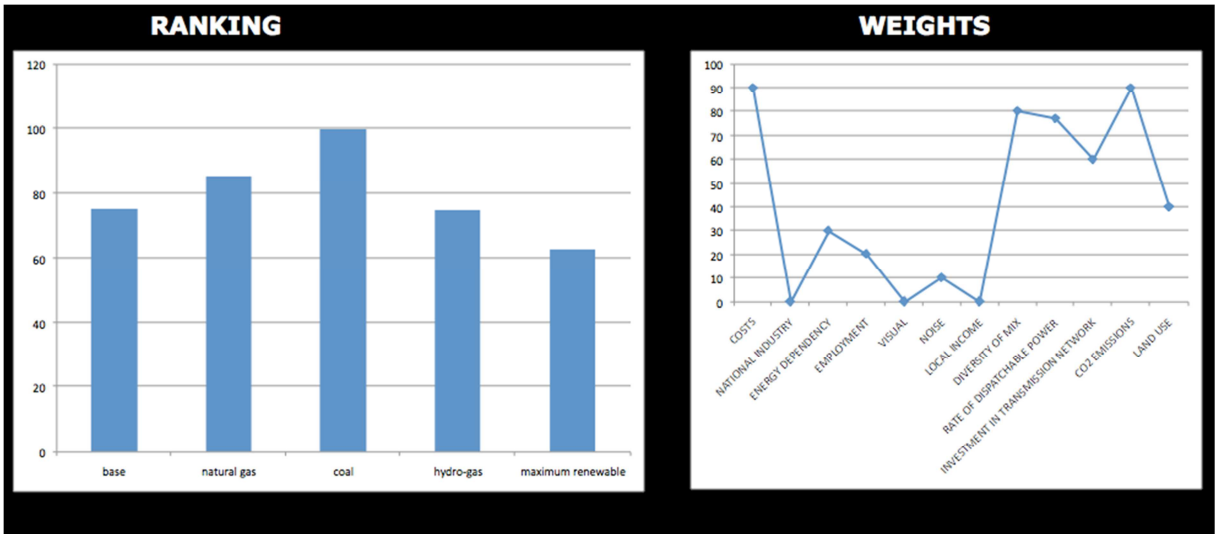
In the same sheet "**4 IMPACTS AND CRITERIA WEIGHTING"** the user is asked to weight each criterion, between 0 and 100, according to its importance. It is not necessary to assign "0" or "100" to any criteria. We suggest beginning with the Cost criterion as all the following criteria are compared to this one.

Please consider the additional information presented in sheet "3 **INSTRUCTIONS**", where the underlying trade-off analysis is outlined.

[4] http://www.sciencedirect.com/science/article/pii/S030142150700537X

[5] http://www.externe.info/externpr.pdf

In the sheet "**5 RESULTS"** you will find two plots that inform you of the ranking of the scenarios.



In the example plotted above, the left plot shows the ranking of the scenarios. This example shows that the preferred scenario is the "coal" one, followed by the "natural gas". The plot on the right shows that two criteria, costs and CO2 emissions, were assigned 90 points, while three others were seen as unimportant and were assigned the value "0".

The used methodology assumes an additive value function. The impacts assigned in the sheet "**IMPACTS AND CRITERIA WEIGHTING**" are linearly normalized to values between 0 (worst) and 1 (best). These values are then multiplied by the weight you assigned to the criterion.

THANK YOU FOR YOUR COLLABORATION!