AN INTEGRATED MULTI-CRITERIA PLANNING MODEL FOR THE HYDROPOWER SURPLUS UTILIZATION IN PARAGUAY

ABSTRACT

The formulation of energy policy and its evaluation planning are not an easy task. Normally, they are accomplished by considering just a techno-economic criterion. However, the scope of the analysis has evolved to a multi-criteria one due to the complexity of the issue and the requirement to assess the criteria under risk and uncertainty. The requirement to simultaneously meet multiple criteria is a current challenge for energy policy-makers that need to articulate plans according to multiple objective functions that incorporate many tradeoffs among different points of view. Under this context, this paper presents a multi-criteria decision analysis (MCDA), based on an analytic hierarchy process (AHP) model, of the sustainable use of the hydropower surplus for society's overall benefit in Paraguay. We analyze four policy options based on economic, technical, social, environmental, and political feasibility criteria. These options are: (A1) ceding the Paraguayan hydropower surplus to Brazil (business as usual - BAU); (A2) selling this surplus after 2023 at the Brazilian wholesale power market; (A3) installing an electro-intensive aluminum factory; and (A4) encouraging the development of small industrial parks with an accumulated electricity demand of 1100 MW. We find that A4 is the best option. As energy end-use is of extreme importance in driving energy transitions, the results suggest that that A4 can generate positive spillovers for the overall society. The effectiveness of applying MCDA /AHP analysis to support policy-making for hydropower transitions in emerging economies is discussed.

Keywords: Energy Transitions, Policy Making under Uncertainty, Hydropower Surplus Utilization, Multi-Criteria Decision Analysis (MCDA), Analytic Hierarchy Process (AHP)

1. Introduction

Paraguay's energy sector differs from other developing countries given its high sustainable hydropower capacity. Nevertheless, the current energy matrix shows a significant participation of non-sustainable energy sources and limited electricity penetration. Thus, we perform an AHP-MCDA for analyzing different energy policy strategies in order to take advantage of the electric power surplus to boost a sustainable socio-economic development.

2. Literature Review

In the assessment of energy planning, MCDA methods have been extendedly used for optimizing the allocation of energy resources (Pohekar and Ramachandran, 2004): preference ranking organization methods of enrichment evaluations (Goumas and Lygerou, 2000), elimination et choix traduisant (Beccali *et al.*, 2003), and the multi-utility theory attribute (Voropai and Ivanova, 2002). How to use MCDA methods in an emerging economy for energy planning is not always straightforward given the lack of case studies and unique opportunities that are local to every country. This study fills that gap by showing the use of AHP in an energy planning context for an emerging economy like Paraguay.

3. Hypotheses/Objectives

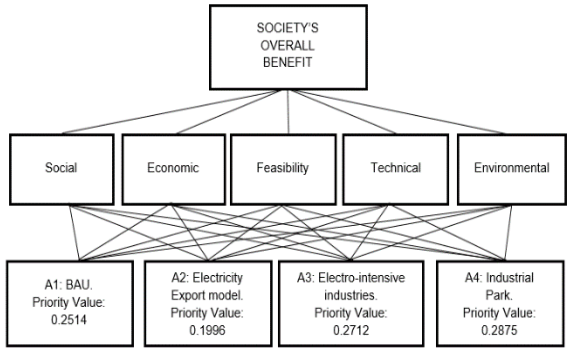
This paper presents an AHP-MCDA in order to find the most adequate energy policy for the sustainable use of the hydropower surplus for society's overall benefit in Paraguay.

4. Research Design/Methodology

We asses four alternative energy policies: (A1) ceding the hydropower surplus to Brazil (business as usual - BAU); (A2) selling the surplus after 2023 at the Brazilian wholesale power market; (A3) installing an electro-intensive aluminum factory; and (A4) allowing the development of small industrial parks with an accumulated electricity demand of 1100 MW. The criteria used (and performance indicators) are economic (historical and

average GDP levels), technical (expected cost of energy not supplied by estimating the performance of each alternative conducting optimal power flow calculations), environmental (greenhouse gasses emissions based on historical data), political feasibility (policy risk levels based on expert knowledge), and social (number of generated jobs according to historical data and different scenarios) criteria. The alternatives and criteria were established by a pool of experts from different backgrounds. The aggregation of opinions was accomplished during interviews, expert panels, and workshops.

5. Data/Model Analysis



	Technical				Environmental				Economic				Social				Feasibility			
	A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4	A1	A2	A3	A4
A1	1	1	1/2	3	1	1	2	3	1	1/2	1/2	1/3	1	1	5	9	1	2	2	4
A2	1	1	1/2	2	1	1	2	3	2	1	1/2	1/2	1	1	5	9	1/2	1	1/2	2
A3	2	2	1	3	1/2	1/2	1	2	2	2	1	1/2	1/5	1/5	1	7	1/2	2	1	3
A4	1/3	1/2	1/3	1	1/3	1/3	1/2	1	3	2	2	1	1/9	1/9	1/7	1	1/4	1/2	1/3	1
CI	0.01716				0.0038				0.02660				0.08947				0.01716			

6. Limitations

The main problem is the lack and poor access to information about energy end-use in Paraguay. This problem was a key one when developing the model factor. If we could start the process again, we would perform more quantitative rather than qualitative analysis (e.g. more energy surveys).

7. Conclusions

This paper proposes a new approach based on the AHP methodology for analyzing efficient energy strategies on the end-use of hydropower surplus in Paraguay. The criteria are classified under economic, technical, social, environmental and political feasibility. It is concluded that the best alternative is to use the energy surplus to promote small domestic industries (A4). As energy end-use is of extreme importance in driving energy transitions, the results suggest that that A4 can generate positive spillovers for the overall society. The main contribution is an analytical model for decision-making in energy policy. As a matter of fact, our model was adopted by the government agency responsible for the energy sector in Paraguay. Further works seeks to extend our model based on an ANP approach.

8. Key References

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