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MULTICRITERIA DECISION AIDING FOR SELECTION OF PHOTOVOLTAIC PLANTS ON FARMING FIELDS IN CORSICA

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ABSTRACT: Corsica knows an unprecedented photovoltaic plant projects flow since its energetic strategy was turned to renewable energy. Concerned public institutions needed specific tools to select the most relevant projects among numerous one with transparent and advise way.

A multicriteria decision aiding method is developed in this aim in order to select projects among sixteen ones (whole PV power: 93.5 MWp) on farming fields in Corsica. The study follows all the multicriteria methodology steps which are criteria and constraints definition, criteria weights sets calculations, thresholds and concordance level determination and the chosen multicriteria model, that is ELECTRE-IS, implementation. Thus, considering different points of view from the ecological to financial one, eight criteria, one of which being optional, have been defined whereas three constraints were determined. The reviewed cards packs methodology applied to the third party allows building six weights sets while the same third party determined a concordance level of 2/3. Thanks to this methodology, based on the criteria sets and according to weights and concordance levels given by the third party, four projects (27.1 MWp) have been selected among the sixteen initial ones, the robustness of these results being tested through all criteria weights sets and different concordance levels applications.

Keywords: PV planning, multicriteria approach.

1 INTRODUCTION

Since Corsica benefits of a high solar potential estimated of 1400 TEP/Ha/yr (Poggi and Notton, 2005) and specific and profitable purchase conditions for photovoltaic electricity : a 20 years guaranteed tariff of 40 cts/kWh against 30 c€/kWh in continental France, the island is one of the most attractive region in France. Thus investing in a photovoltaic plant has a profitability rate of about 6.5% (ADEME, 2006). In this context, the island knows an important photovoltaic plant private project offer, which cumulated potential power attains 257 MW, knowing that the installation potential is 46 MW_c. The "Collectivité Territoriale de Corse" (CTC) and the "Chambre d'Agriculture Départementale de Haute Corse" (CA2B) are among the public institutions that are solicited for their opinion about each photovoltaic plant project. They have expressed the necessity of a multicriteria evaluation for each plant project. Thus, the CTC has built a photovoltaic development charter and a project evaluation process that have been voted on June the 29th, 2009 by the Corsica's assembly whereas the CA2B, which has to give her opinion particularly on projects that are susceptible to be implanted on farming fields, ordered university of Corsica an evaluation survey on 16 projects with the view to base her opinion on rigorous arguments.

2 STUDY PROBLEMATIC AND METHODOLOGY

Institutional actors and decision-makers, who are even more interrogated to judge each project relevance and feasibility, have the aim to give transparent and informed opinions to industrials. This study deals with a concrete selection problematic of photovoltaic plant

projects among 16 projects that have been built and submitted by industrials to local decision-makers. Priorities in our case are:

- Use conflict risks have to be evaluated. Indeed, planed installations are supposed to be placed on farm fields and could potentially take up 311 Ha of cultivated ground.
- A 30% limit of renewable energy sources production has to be respected, resulting from a regional-scaled non interconnected electrical network stability guarantee demand. This ratio corresponds to a 100 MW_c renewable production limit in the Corsican's case, but a recent decree set the renewable production limit at about 83MW_c. Existing plants (three wind farmers) produce already 18 MW_c, and accepted wind farmer and PV projects represent 19 MW_c so that only 46 MW_c renewable energy can be integrated by the network nowadays, whereas the projects set represents a 93.5 MW_c potential cumulated power only for the Haute-Corse county, in our study's framework, going beyond the maximum calculated for the whole Corsican region.
- Territorial electricity production over-abundance has to be avoided: geographic concentration risk of energetic offer has to be considered to avoid sudden energetic production falls due to climatic or technical factors. The projects set is dispersed on three restricted geographic zones and it concerns only four electrical link posts. The projects intended for being linked to the electrical network through the same link post have been treated simultaneously in order to fulfil the abundance shunning demand, so that

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recommendations are expressed for each electrical post.

- Social acceptability has to be taken into account: negative and positive impacts due to such installations on local population must be studied (visual, financial impact).
- Ecological impact must be evaluated: photovoltaic plants are supposed to represent sustainable alternatives for electrical production, but such important plants have also an ecological cost that must be evaluated to ensure their real ecological benefits.

Finally, projects evaluations are based on files, criteria are informed from a simple lecture of the files and without field visit, so that the study is built on meso-evaluations in her main part.

3 CONSTRAINTS AND EVALUATION CRITERIA

Three pre-selection constraints (Table 1), or “*acceptability or eligibility conditions that actions have to satisfy imperatively to candidate for the decision or/and the multicriteria study*” (Oberti, 2004) have been defined, translating the third party’s and the different actors imperatives.

Table I: Constraints definitions

Constraints	Definitions
C ₁	Plants dismantling guarantee: plants dismantling must be guaranteed in the exploitation contracts.
C ₂	Respect of constraints linked to area's ecological classification: concerned areas must not be classified Natura 2000 or wetland
C ₃	Constraints linked to area's topography: areas' slopes must not exceed 10%

According to information obtained in the projects files that have been studied, the projects filled up all these conditions.

‘*Tool created to evaluate and compare potential actions from a point of view.*’ (Roy, 2000), criterion is the central point of a multicriteria decision aiding study. Seven evaluation criteria have been elaborated to compare projects from different points of view: energetic, economic, ecologic visual or territorial use whereas an eighth one, the annual additional incomes for communal budget per inhabitant intervenes, is optional.

Table 2 presents the pertinent criteria built for this specific study and listed by the Haute-Corse chamber of farming.

Table II: Criteria for plants projects evaluation

Point of view	Code	Criteria title	Criteria creation principle	Scale terms	Preference way
Energetic	g ₁	Net production	Energy production evaluation	GWh annual	Maximize
Geo-economic	g ₂	Ratio of rent area unoccupied by the installation	Ratio between free area of productive land and the total	%	Maximize
Ecological	g ₃	Ecological potential degradation	Weighted sum	Points	Maximize
Visual Impact	g ₄	Relevance of visual impact presentation in the files	Weighted sum	Points	Maximize
Visual Impact	g ₅	Observers-plants minimum distance	Measures from cartography	km	Maximize
Territorial use	g ₆	Use conflicts risks	Weighted sum	Points	Maximize
Financial effect	g ₇	Economic activity and inhabitants’ financial aid for RES facilities	Weighted sum	Points	Maximize
Financial effect	g ₈	Financial incomes at communal level	Ratio between professional duties evaluation and communal population	€/yr/inhab	Maximize

Five criteria among the seven key ones are evaluated from notation obtained thanks to evaluation tables built according to three factors:

- the study third party's priorities ;
- The available information given in the projects files
- Indications supplied from the literature.

4 MULTICRITERIA OUTRANKING AGGREGATION AND PRINCIPAL RESULTS

The performances tables' information aggregation, thanks to outranking multicriteria model, allows the selection of the more restricted alternatives sub-set including the best compromised ones and those that must not to be eliminated.

4.1 Thresholds

The two alternatives a_i and a_k comparison, according to g_j criterion, leads to a relation that covers from an indifference situation to a strict preference in one of these alternatives' favor, justifying a pseudo-criteria discrimination thresholds based model use whereas a veto threshold that fixes a bad performance compensation limit of an alternative on a criterion by a good one on other criteria can be defined.

4.2 Criteria relative weights

The actors express the relative importance of the criterion g_j through its relative weight or vote power that is a coefficient $w_j \in]0;1[$ with the normalisation relation

$$\sum_{j=1}^m w_j = 1$$

4.3 Outranking kernel and preference between alternatives

An outranking hypothesis $a_i S_s a_k$ applied to (a_i, a_k) is defined as follow: " a_i is not worst than a_k " or " a_i outranks a_k ". S_s relation can be illustrated by an outranking graph named

$G_s = (A, U_s)$ with A the tops or nodes set, the alternatives in this case and U_s the a_i to a_k oriented bows set when $a_i S_s a_k$ is verified.

In order to select the most restrictive alternatives subset, ELECTRE 1S model looks for the outranking graph's kernel $A'_s \supseteq A$ verifying the two intern and extern stability conditions (respectively

$$\forall a_i \in A'_s, \forall a_k \in A'_s, a_i R_s a_k \text{ and}$$

$$\forall a_i \notin A'_s, \exists a_k \in A'_s : a_i S_s a_k)$$

5 FINAL SELECTION AND PROJECTS RECOMMENDATIONS

A performance table sums up the usefulness information set for a multicriteria calculation, except for a few intern technical or economical parameters that are outranking model's own. This table is usually composed of three informational parts: each alternative evaluation on each criterion, criteria relative weights and thresholds.

The multicriteria model ELECTRE 1-S (Figueira et al., 2005) application leads to determine an outranking final graph kernel, a set composed of selected projects. This model has been applied to 72 cases, combining:

- Four electrical link posts;
- six criteria relative weights sets: two aim sets have been depending on the criteria set integration of the eighth criterion or not, from which four other weights sets have been built thanks to $\pm 5\%$ variations of the Z factor.
- A majority level of 2/3, defined by the CA2B, and two of the nearer values to test the results stability.

Finally, four among the sixteen photovoltaic plant projects studied for the Haute-Corse County have been selected thanks to the outranking model ELECTRE 1-S application. Table 3 sums up the selected projects.

6 CONCLUSION

The ELECTRE-IS model application allows concluding about selection or not of each project in 18 cases, considering two criteria sets, each one is combined with three weights sets, and the three concordance values.

A project is definitively acceptable if it is unanimously selected (Figure 1) whereas some other projects that are accepted only in specific cases are rejected.

Table III: Selected projects set

Electrical link posts (Ha)	Selected photovoltaic projects	Power (MWp)	Occupied surface
Ghisonaccia	a_{12}	4.5	17.4
Cervione	a_{14}	8.0	23.0
Oletta	a_{11}	3.5	14.3
Taglio	a_4	11.1	41.5
Total	4 projects on 16	27.1	96.2

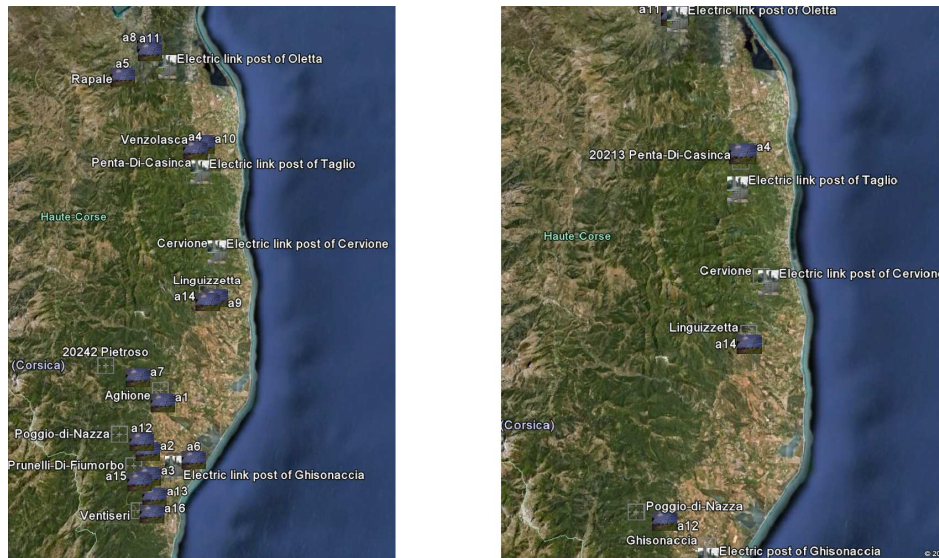


Figure 1: Initial projects set localization (left) versus final projects set localisation (right)

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