Renewable energy financial decisions: a multicriteria approach

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Grupo Multicriterio Alcoy

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Líneas de Investigación: MCDM and financial decisions; MCDM and renewable energy decisions; Socially Responsible Investments

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Portfolio optimization based on downside risk: a mean-semivariance efficient frontier from Dow Jones blue chips

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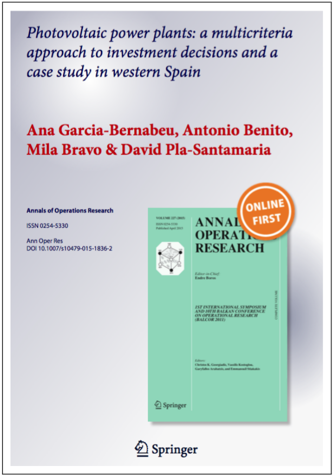
Keywords

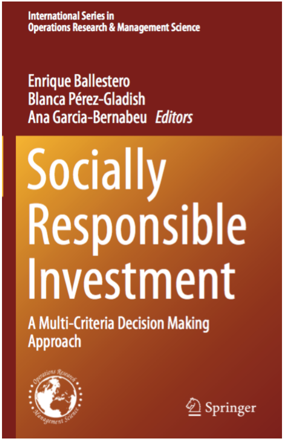
Banking management and funds –Portfolio selection –Downside risk – Efficient frontiers – Semivariance – Dow Jones

Our Research

- Compromise programming
- Renewable energy
- Guaranteed prices
- Stochastic cash flows
- Multicriteria decision making analysis



Our Research



- **Part I**. Critical Issues in Ethical Investment
- **Part II**. Goal Programming and SRI Funds
- **Part III**. Compromise Programming and SRI Funds
- **Part IV**. Other Decision-Making Support Methods

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Motivating the problem

- Research on new financing techniques for RE projects has gained interest in recent years due to the rising awareness of environmental issues.
- MCDM methodologies are widely used in RE investments.
- There is a lack of research on the financial aspects of RE projects (Ludeke-Freund and Loock, 2011)

Renewable Energy Decision-Making

Selecting the right source of energy to invest in is an issue which involves many factors, policies and situations, so renewable energy decision-making can be considered as a multiple criteria decision-making (MCDM) problem.

Purposes

What kind of Renewable Energy (RE) project configuration do lenders prefer to finance?

I. To propose a **AHP-VIKOR** model considering financial and non-financial perspective to rank a portfolio of RE projects.

II. To develop an **illustrative example** of RE projects by using the proposed MPDM model with empirical information.

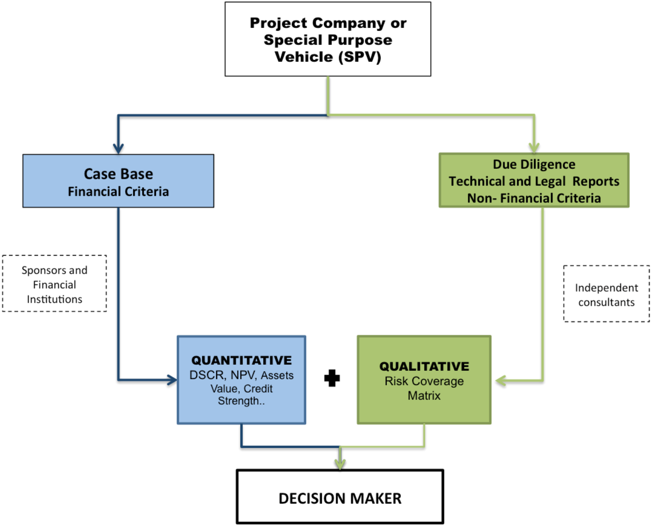
Users

- Banks
- Corporate planners (Sponsors)
- Individual or Institutional investors
- Fund managers
- Financial consultants
- Energy economists
- Energy researchers in universities

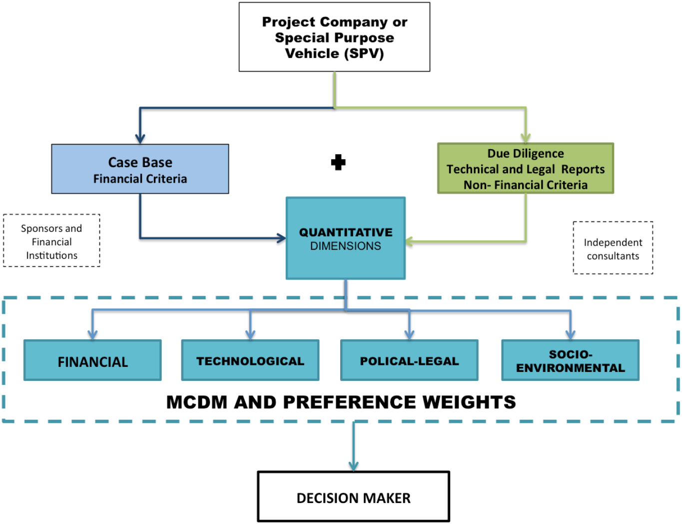
MCDM model

1. Decision criteria and dimensions
2. First step: Normalization
3. Second step: AHP–Preference weights
4. Third step: VIKOR and scoring

Decision Criteria: Traditional esqueme



Decision Criteria: Our proposal



Dimensions and criteria

Table: Dimensions D_1-D_4 and their corresponding criteria

D_1	Financial	D_2	Technological	D_3	Political-Legal	D_4	Socio-Environmental
C_{11}	DSCR	C_{21}	Source Variablity	C_{31}	Country Risk	C_{41}	Contribution to the employment
C_{12}	Net Present Value	C_{22}	Fuel Cost	C_{32}	Support from the administration	C_{42}	Social acceptance
C_{13}	Asseet Value	C_{23}	Processing complexity	C_{33}	Currency risk	C_{43}	Negative impact in environment
C_{14}	Credit Strength of Sponsors						
C_{15}	Credit Support						

First step: Normalization

When the criterion is **the more the better** the normalized N_{ij} value is computed by:

$$N_{ij} = \frac{C_{ij} - C_{jmin}}{C_{jmax} - C_{jmin}} \quad (1)$$

If some criterion was **the more the worse**, then, this could be converted into "the more the better" N_{ij} normalized value by the following equation:

$$N_{ij} = \frac{C_{jmax} - C_{ij}}{C_{jmax} - C_{jmin}} \quad (2)$$

We propose the use of the variable D_{ih} as the average of the N_{ij} values for the criteria included.

$$D_{ih} = \sum_{h=1}^{m} N_{ij}/n \quad i = 1, 2 \ldots m \quad (3)$$

Second step: AHP preference weights

- Hierarchy structure: goal of the decision problem, criteria/dimensions, and alternatives
- Relative importance: Saaty Rating Scale

Table: The Saaty Rating Scale

Intensity of importance	Definition	Explanation
1	Equal importance	Two factors contribute equally to the objective
3	Somewhat more important	Experience and judgement slightly favour one over the other
5	Much more important	Experience and judgement very strongly favour one over the other
7	Veru much more important	Experience and judgement very strongly favour one over the other. Its importance is demonstrated in practice
9	Absolutely more important	The evidence favouring one over the other is of the highest possible validity
2,4,6,8	Intermediate values	When compromise is needed

Source: Own elaboration based in (Saaty, 1980).

Third step: Vikor scores

$$L_{pj} = \left\{ \sum_{i=1}^{n} \left[w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right]^p \right\}^{1/p} \qquad 1 \leq p \leq \infty,\ j = 1, 2, \ldots, J \qquad (4)$$

When the p metric is equal to 1, namely, L_1 metric allows to obtain the S_j value as follows:

$$S_j = \sum_{i=1}^{n} w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \quad R_j = \max_j \left[w_i \frac{f_i^* - f_{ij}}{f_i^* - f_i^-} \right] \qquad (5)$$

$\min S_j$ is considered as the "majority" rule $\min R_j$ is the "opponent´´.

$$Q_j = v \frac{S_j - S^*}{S^- - S^*} + (1 - v) \frac{R_j - R^*}{R^- - R^*} \qquad (6)$$

Empirical information, application and results

(a) Information on RE projects
(b) Dimensions and Criteria
(c) AHP-VIKOR methodology
(d) Results

Information on RE projects

Table: Basic information on the RE projects opportunity set

No	Project	Type	Power	Investment	Country
P_1	ENCE	Biomass	50	135	Spain
P_2	Alconera	Photovoltaic	15	120	Spain
P_3	Solarpack	Photovoltaic	25	83	Chile
P_4	Paracuru	Wind	24	260	Brazil
P_5	Guanacaste	Wind	75	25	Costa Rica
P_6	Malaspina	Wind	50	81	Argentina
P_7	Aura Solar	Photovoltaic	300	100	Mexico
P_8	Pedrado Sal	Wind	24	11	Brazil
P_9	Artilleros	Wind	65	107	Uruguay
P_{10}	Les Borges	Biomass	22	153	Spain

Dimensions and criteria

Table: Dimensions D_1-D_4 and their corresponding criteria

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10
C11	1.00	0.80	0.25	0.50	0.00	0.35	0.50	0.25	0.75	0.50
C12	0.46	0.33	0.40	0.41	0.00	0.58	1.00	0.08	0.67	0.07
C13	0.56	0.62	0.79	0.00	0.60	0.80	0.71	1.00	0.68	0.48
C14	0.00	1.00	0.50	0.25	0.75	0.25	0.25	0.00	0.50	0.25
C15	0.25	0.63	0.88	0.00	1.00	0.13	0.38	0.38	0.63	0.25
C21	1.00	1.00	0.60	0.20	0.00	0.20	0.20	0.20	0.40	1.00
C22	1.00	0.75	0.00	1.00	0.25	0.50	1.00	1.00	1.00	0.00
C23	1.00	0.50	0.75	0.00	0.00	0.50	0.00	0.25	0.50	0.75
C31	0.86	0.86	0.29	0.57	0.00	0.43	0.57	0.43	0.71	1.00
C32	1.00	1.00	1.00	0.33	0.33	0.00	0.33	0.33	0.33	1.00
C33	0.67	0.33	0.00	1.00	0.67	0.33	1.00	0.67	0.33	0.00
C41	0.11	0.23	0.55	0.81	0.09	0.00	1.00	0.77	0.62	0.30
C42	0.80	0.20	0.20	0.80	0.80	1.00	0.60	0.80	0.80	0.00
C44	1.00	0.57	0.00	0.86	1.00	0.43	1.00	0.57	0.86	0.14

AHP-VIKOR. First step: Normalization

Table: Normalized Dimensions D_1-D_4

	D1	D2	D3	D4
P1	0.45	1.00	0.84	0.64
P2	0.68	0.75	0.73	0.34
P3	0.56	0.45	0.43	0.25
P4	0.23	0.40	0.63	0.82
P5	0.47	0.08	0.33	0.63
P6	0.42	0.40	0.25	0.48
P7	0.57	0.40	0.63	0.87
P8	0.34	0.48	0.48	0.72
P9	0.64	0.63	0.46	0.76
P10	0.31	0.58	0.67	0.15

AHP-VIKOR. Second Step: AHP Preference weights

$$\text{AHP dimensions matrix} = \begin{pmatrix} 1 & 3 & 6 & 9 \\ 1/3 & 1 & 1 & 3 \\ 1/6 & 1 & 1 & 5 \\ 1/9 & 1/3 & 1/5 & 1 \end{pmatrix}$$

AHP Preferences weights

$w_1 = 0.604 \quad w_2 = 0.171 \quad w_3 = 0.173 \quad w_4 = 0.053 \quad CI = 0.08$

AHP-VIKOR. Third Step: VIKOR scores

Table: RE projects and theirS_j and R_J values

	S_j	R_j
P1	0.3172	0.3023
P2	0.1100	0.0466
P3	0.4048	0.1552
P4	0.7722	0.6040
P5	0.5986	0.2806
P6	0.6375	0.3481
P7	0.3133	0.1479
P8	0.6573	0.4565
P9	0.2170	0.0986
P10	0.6693	0.4996
max	0.7722	0.6040
min	0.1100	0.0466

AHP-VIKOR. Third Step: VIKOR scores

Table: Values of Q_j for different v levels

	0	0.25	0.5	0.75	1
P4	0	0	0	0	0
P10	0.187	0.179	0.171	0.163	0.155
P8	0.265	0.242	0.219	0.196	0.174
P6	0.459	0.395	0.331	0.267	0.203
P5	0.580	0.501	0.421	0.342	0.262
P1	0.541	0.578	0.614	0.651	0.687
P3	0.805	0.743	0.680	0.617	0.555
P7	0.818	0.787	0.756	0.724	0.693
P9	0.907	0.890	0.873	0.855	0.838
P2	1.000	1.000	1.000	1.000	1.000

Solar Pack: Pozo Almonte Chile

Les Borgues: Termosolar - Biomasa Spain

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Conclusions

- One of the most effective way to reduce greenhouse emissions is to **promote RE investments**.
- The **problem** of financing RE projects becomes a crucial issue for public and private decision makers.
- **Project Finance** is a recent method **widely used in RE projects** (off-balance financing, cash flow related lending, risk sharing).
- **MCDM models** offers a **method** to rank RE projects to be financed from multiple criteria.
- **Financial, Political-Legal, Technological and Socio-Environmental dimensions** are considered in the decision making process.
- This research can be a first step towards **understanding lenders preferences for RE projects**.

Further research

- To better define and measure some of the criterion.
- To make a sensitive analysis for different dimensions and criteria.
- To apply the proposed methodology to other opportunity sets.

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Next Challenge

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